Environmental Impact Statement

Long Harbour Commercial Nickel Processing Plant

Volume 1

The Project

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1.0 Introduction

This volume of the Environmental Impact Statement (EIS) describes the Long Harbour Commercial Nickel Processing Plant (the Project) proposed by Vale Inco Newfoundland and Labrador Limited (Vale Inco NL) to be located in Long Harbour, Placentia Bay, in the Province of Newfoundland and Labrador (Figure 1.1). It examines the alternatives that were considered, the construction, operation and decommissioning of the proposed plant; details of the processing technologies under consideration, and the physical environment within which the Project will function. Because of their importance in the design and planning stages, the environment and its effects on the Project are also considered.

Figure 1.1 Project Location

A description and a summary are provided of Vale Inco NL policy and practice with respect to environmental management, climate change, emergency preparedness, occupational health and safety, human resources and community relations. In particular, the community consultation undertaken for the Project is described in detail. As a conclusion to this volume, the Valued Ecosystem Components (VECs) are described as the basis for the assessment in subsequent volumes of the EIS.

1.1 The Proponent

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Voisey's Bay Nickel Company Limited (VBNC) was established in 1995 and became a wholly-owned subsidiary of Inco Limited (Inco) in 1996. Companhia Vale do Rio Doce (CVRD), based in Brazil, acquired Inco in October 2006. On January 7, 2007, Inco Limited became a wholly-owned subsidiary of CVRD and changed its name to CVRD Inco Limited. On November 29, 2007, CVRD adopted the name Vale and CVRD Inco Limited changed its name to Vale Inco Limited. On the same date, VBNC adopted the name Vale Inco Newfoundland & Labrador Limited (Vale Inco NL).

Vale is the largest mining company in the Americas and one of the three largest diversified mining companies in the world, with operations on five continents. It is the world's largest producer and exporter of iron ore and pellets, and an important global producer of manganese and ferroalloys. The company also produces copper concentrate, bauxite, potassium, kaolin, alumina and aluminium, and invests heavily in minerals research including coal and nickel. It also holds stakes in the steel industry, as well as logistics and electric power generation to support its operations. Vale Inco Limited is now the world's number one nickel producer, and has plans to build and expand the company. Vale fully supports the Voisey's Bay Project and endorses Vale Inco Limited obligations under the *Voisey's Bay Development Agreement* (http://www.nr.gov.nl.ca/voiseys/legal.htm).

Vale Inco Limited headquarters are in Toronto. Management responsibility for all existing and future Vale nickel projects has been transferred to Vale Inco Limited. More information on Vale Inco Limited is available at www.inco.com. Information on Vale Inco NL can be found at www.vbnc.com.

2.0 Project Overview

Vale Inco NL is proposing to construct, operate, and eventually decommission a commercial nickel processing plant (the Project) in a safe, healthy and environmentally sound manner that will benefit all stakeholders, in accordance with the terms of the *Voisey's Bay Development Agreement.* This Agreement requires the establishment of a commercial nickel concentrate processing plant using hydrometallurgical technology, provided that this technology can be shown to be technically and economically feasible. The hydrometallurgical technology (Hydromet Plant) will process nickel concentrate into a finished nickel product. If this technology is not technically or economically feasible, a hydrometallurgical nickel Matte processing facility would be constructed to meet the commitment to process nickel in the province.

In developing the Hydromet process for Voisey's Bay concentrate, Vale Inco is using a step-by-step research and development approach. The first step was to prove that each separate chemical process works individually at a laboratory scale. This has been successfully completed. The second step involved the construction and operation of a 1/10000 scale mini-pilot plant to ensure that the process steps could be interconnected into a continuous process. The mini-pilot plant was constructed in 2003 and operated until May 2005. The final step involved the construction and operation of a 1/100 scale Demonstration Plant to allow for fine-tuning and optimization of the process, using Voisey's Bay concentrate.

The Demonstration Plant was registered for environmental assessment with the federal and provincial governments in 2003. Following release from environmental assessment, construction began at Argentia in May 2004, and operations began in October 2005. The key mission is to prove and fine-tune all processing steps to confirm technical and economic feasibility of the Hydromet process and to help designers select the most appropriate materials for construction and specifications for major pieces of equipment.

The Demonstration Plant has been operating for more than two years. Vale Inco has gained considerable knowledge about the optimization of the process (including effluent treatment) and the composition and behaviour of air emissions, effluent and residue produced by the Hydromet process. Vale Inco has successfully implemented an environmental management system at the Demonstration Plant.

The other technology under consideration, referred to as a Matte Plant, would use a hydrometallurgical process with nickel Matte from an out-of-province smelter as the input material and produce a finished nickel product. The Agreement stipulates that the technology must be selected (Processing Decision) by November 15, 2008.

Once the feasibility of the hydrometallurgical technology has been established, Vale Inco NL will construct the Hydromet Plant with a design capacity of approximately 50,000 tonnes per year (t/yr) of finished nickel product, together with associated cobalt and copper products. Should the Hydromet Plant not prove to be technically or economically feasible, Vale Inco NL would construct a Matte Plant on the same site with the same production capacity. Production operations are scheduled to continue for 15 years to match the existing known reserves of the Voisey's Bay mine, and in conformance with the *Agreement*. The duration of operations beyond 15 years would be dependent upon securing either additional reserves at Voisey's Bay or additional feed from another source.

This Environmental Impact Statement addresses and seeks approval for both the Hydromet Plant and the Matte Plant technologies. The Project will be located partially on a brown-field site (Tier 1 Port Site) on the south side of Long Harbour, and partially on a green-field site (Tier 2 Plant Site) above Long Harbour on the south side (Figure 2.1). It will include a pipeline to supply process water from Rattling Brook Big Pond and an effluent discharge pipe and diffuser into Long Harbour. The Hydromet Plant will include associated pipelines and a residue storage area at Sandy Pond. The Matte Plant would include associated pipelines and an above-ground residue storage area to the southeast. Figure 2.1 shows the general layout of the Project.

2.1 Purpose of the Project

Inco acquired the Voisey's Bay nickel, copper and cobalt deposit from Diamond Fields Resources Inc. in 1996, and developed the optimum approach to mining and processing the deposit. The mine/mill Project was released from the environmental assessment process in August 1999, with construction starting at Voisey's Bay in 2002. Production began in late 2005.

The concentrate produced at Voisey's Bay is currently being processed in Vale Inco Limited facilities outside of the province. However, the Newfoundland and Labrador *Mineral Act (RSNL M–12)* requires that a person holding a mineral lease in the province complete primary production, in whole or in part, in the province, of a mineral ore extracted or removed under that lease, subject to certain economic considerations. The *Voisey's Bay Development Agreement* requires Vale Inco NL to build a Hydromet Plant or suitable alternate facility in the province. There is a worldwide shortage of processing facilities producing finished nickel from concentrate. Construction of a commercial nickel-processing plant will increase global nickel-processing capability to meet growing demand.

2.2 Purpose of the Environmental Impact Statement

Voisey's Bay Nickel Co. Ltd. submitted a Project Description and Project Registration for a Commercial Processing Plant on March 16, 2006. This single document was submitted simultaneously to the Canadian Environmental Assessment Agency and the Newfoundland and Labrador Department of Environment and Conservation. On May 11, 2006, the provincial Minister of Environment and Conservation determined that an Environmental Impact Statement was required for the registered Undertaking. A Study is also required for the Project pursuant to the *Canadian Environmental Assessment Act*.

Figure 2.1 General Layout (viewed from the north)

Guidelines (Appendix D) for this Environmental Impact Statement (EIS) were issued on October 23, 2006, pursuant to the Province's *Environmental Protection Act* and the *Canadian Environmental Assessment Act* (CEAA).

On November 3, 2006, Fisheries and Oceans Canada (DFO) and Transport Canada (TC) issued a Screening Scoping Document (CEAR Reference Number 06-01-23173) in which the two departments outlined their responsibilities under the CEAA as Responsible Authorities, indicated their intention to use the EIS to complete a screening level environmental assessment, and set out the scope of the Project for the federal environmental assessment.

This EIS meets the requirements of the Guidelines and goes beyond the factors to be considered in Section 16(1) of the CEAA. Additional factors considered in this EIS are consistent with a higher level of review, and include all of those factors set out in Section 16(2) of CEAA, including the purpose of the Project, alternative means of carrying out the Project, the need for follow-up programs, and the capacity of renewable resources likely to be significantly affected by the Project to meet present and future needs.

This EIS is being submitted for the purpose of assisting the Minister of Environment and Conservation to determine the acceptability of the Project. It is also being submitted to support the federal environmental assessment. The EIS provides a description of the Project that is consistent with the Scope of Project as laid out in the Guidelines and in the Screening Scoping Document. The scope of this environmental assessment is also consistent with the requirements as laid out in these documents.

2.3 Legislation, Policies and Permitting / Regulatory Agencies

The Project will be subject to the following primary environmental legislation.

Government of Canada	*Canadian Environmental Assessment Act* *Canadian Environmental Protection Act* *Fisheries Act* *Species at Risk Act* *Navigable Waters Protection Act* *Transportation of Dangerous Goods Act*
Government of Newfoundland and Labrador	*Environmental Protection Act* *Water Resources Act* *Endangered Species Act* *Occupational Health and Safety Act* *Boiler, Pressure Vessel and Compressed Gas Act* *Dangerous Goods Act* *Public Health Act* *Urban and Rural Planning Act*

2.4 The Prospective Site and Study Area

The Town of Long Harbour-Mount Arlington Heights is situated on the north side of Long Harbour, Placentia Bay, Newfoundland and Labrador (Figure 1.1). The Project will be located on the south side of Long Harbour (see Figure 2.1 and Topographic Map Argentia 1 N/5 at the following approximate coordinates: 47°25'N and 53°49'W). The Hydromet Plant general layout (comprising 34.7 ha) is shown in Figure 2.2. The Matte Plant features (36.6 ha) are shown in Figure 2.3. The entire Project Area, including access roads and residue storage areas, is shown in Figure 4.1.

The Port area of the site (Tier 1) and surrounding area was used as an industrial site from 1969 to 1989 by Albright and Wilson Americas Limited (AWA). The site occupied 77 ha on the south side of Long Harbour (production operations covered approximately 20 ha); it had a workforce of 400 and an annual production rate of 50,000 t of elemental phosphorus. The site was decommissioned in the mid-1990s after undergoing an environmental impact assessment, and is now owned by Rhodia Canada, Inc,. and the Long Harbour Development Corporation (LHDC).

The decommissioned site includes a wharf, a paved access road, several buildings (administration, steam, and mud residue buildings), buried service lines, several landfills, a secure hazardous waste disposal area, a slag stockpile and construction debris. Some portions of the site (e.g., the hazardous waste disposal area) are not suitable for development. Vale Inco NL has conducted due diligence and has selected areas that are considered appropriate for industrial use.

Long Harbour Development Corporation has subleased its portion of the former AWA site to Marex Inc., which has been demolishing the existing facilities. Newco Metals, a scrap metal dealer, also operates at the plant site. The scrap is barged out from the existing wharf, which has also been used by Marex Inc. to receive salt for distribution around the province. Canadian Coast Guard (CCG) vessels occasionally dock at the wharf. A sunken vessel adjacent to the wharf will be removed by the Long Harbour Development Corporation in accordance with government regulations prior to Vale Inco NL acquiring the site.

The access road to the site and the land proposed for plant facilities on Tier 2 are owned by the Government of Newfoundland and Labrador.

2.5 Other Existing Activities in the Area

Other activities within Placentia Bay include the North Atlantic Refining Ltd. oil refinery, the Newfoundland Transshipment Ltd. terminal, the Marine Atlantic Ferry terminal, the Port of Argentia, the Kiewit Offshore Services Marystown Shipyard, the Cow Head Fabrication Facility, commercial fisheries (including several aquaculture operations) and associated seafood processing plants.

A variety of tourism, cultural, and commercial activities take place in the Long Harbour area. Key cultural and tourism facilities include Castle Hill National Historic Park, the O'Reilly House Museum, and active archaeological digs in Placentia. Other sites include the Cape St. Mary's Bird Sanctuary, about 70 km south, and Ship Harbour, the site of the signing of the Atlantic Charter in 1941, about 44 km by road or approximately 10 km in a straight line from the Project Area. An international airport, major cultural facilities, international hotels, shopping and central government services are available in St. John's, about 100 km away.

The Project Area and immediate vicinity were surveyed for the presence of historic and archaeological resources (GPAL, 2006). No aboriginal or historic resources were found.

2.6 Other Proposed Developments in the Area

Two other major industrial projects are proposed for construction in Placentia Bay.

Newfoundland and Labrador Refinery Corporation (NLRC) has proposed construction of an oil refinery at Southern Head, between North Harbour and Come by Chance, at the head of Placentia Bay. The oil refinery is proposed to have an initial production capacity of 300,000 barrels per day with the option to expand to 600,000 barrels per day. Primary products of the oil refinery would be gasoline, kerosene/jet fuel, ultra-low sulphur diesel and refining by-products. An Environmental Impact Statement and six Component Studies were delivered to both levels of government in July 2007.

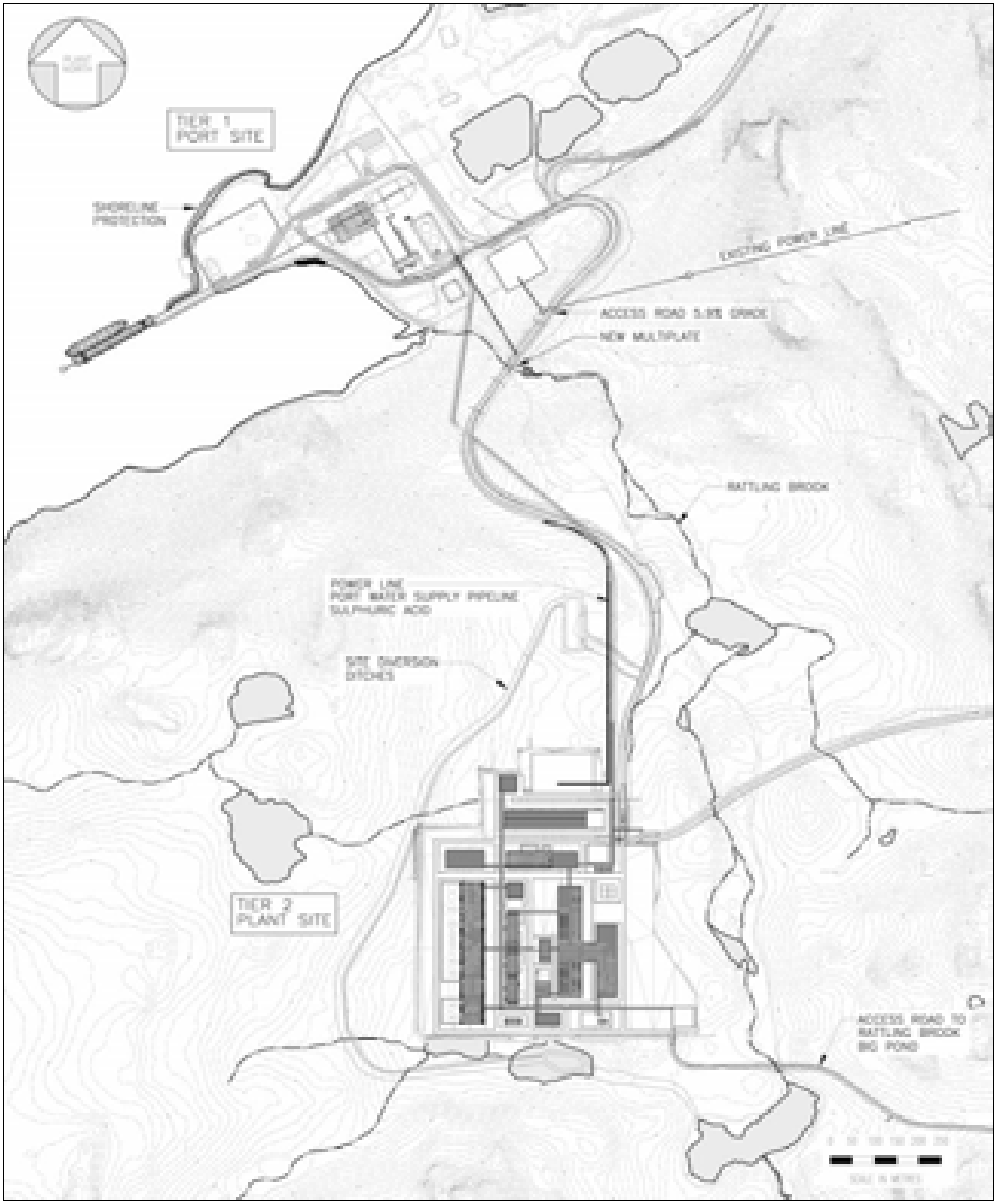

Figure 2.2 Hydromet Plant Site Layout

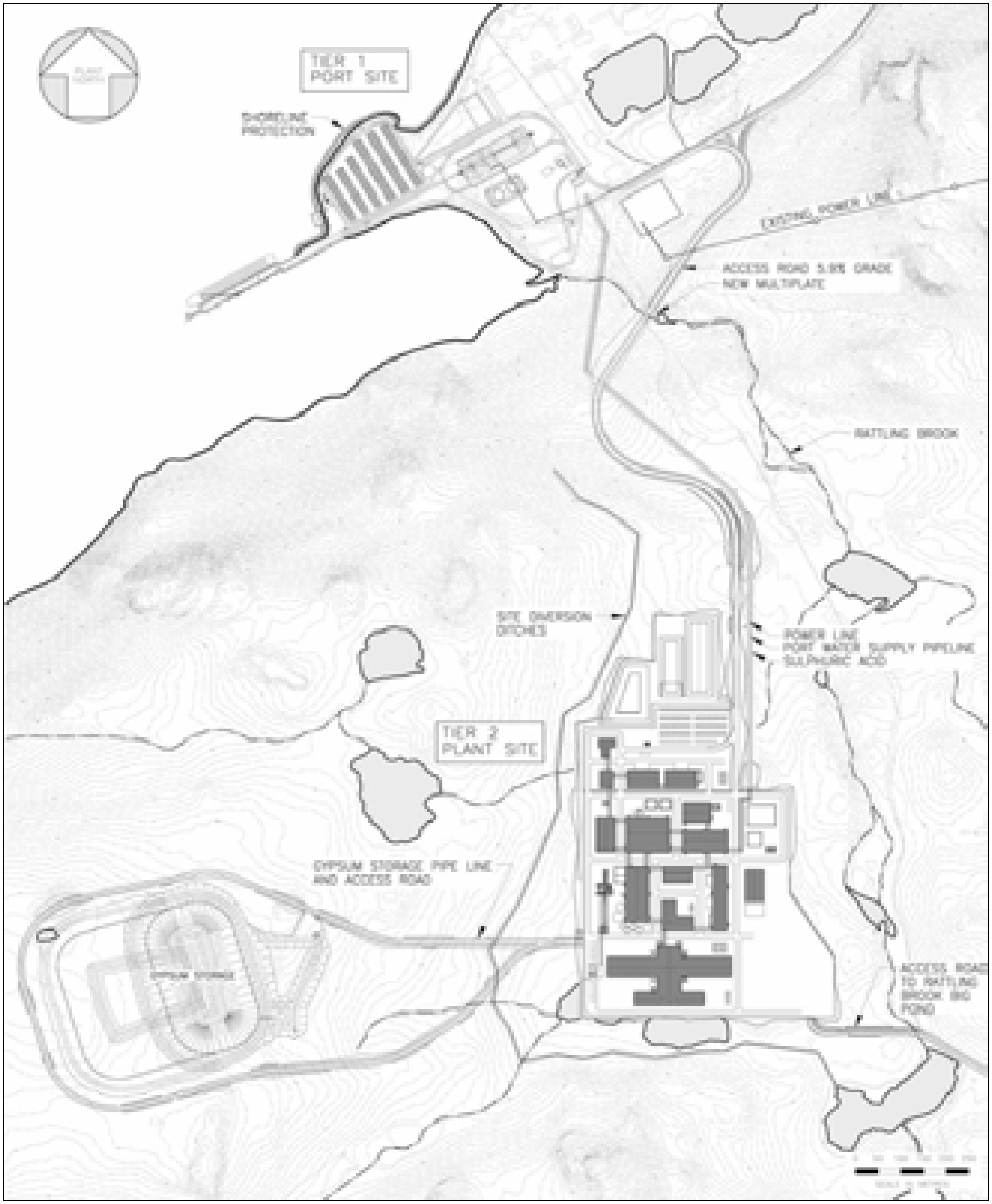

Figure 2.3 Matte Plant Site Layout

Newfoundland LNG Ltd. has proposed construction of a Liquefied Natural Gas (LNG) Transshipment and Storage Terminal near the head of Placentia Bay at Grassy Point, Arnold's Cove. The trans-shipment terminal would provide storage and offloading for larger LNG vessels, for transfer to smaller LNG carriers and distribution to the northeastern United States and Canada. The project was released from further provincial Environmental Assessment, subject to conditions, in January 2007.

2.7 Project Phases and Schedule

The Project phases and key dates are:

- Construction 2008 – 2011;
- Operation 2011 – 2026; and
- Closure and Decommissioning 2026 – 2031.

Planning (including environmental assessment) is under way. Construction will take 42 months, commencing in 2008 (designated as Year 1 of the Construction Schedule) and reaching completion by 2011 (Figure 2.4). Operations will commence by the fourth quarter of 2011. Decommissioning and Closure will take approximately five years.

Construction will begin once the Project is released from Environmental Assessment and all necessary permits and approvals are in place. Provided regulatory approval is received in 2008, detailed design, procurement and onsite construction works can commence the same year, allowing the completion of construction on schedule. Operational training to support production start-up is scheduled to begin in early 2010.

Production operations are scheduled to continue for 15 years to match the existing known reserves of the Voisey's Bay mine, and in conformance with the *Agreement*. The duration of operations beyond 15 years would be dependent upon securing either additional reserves at Voisey's Bay or additional feed from another source. An extended operating life could be achieved, although such a possibility is not within the scope of this environmental assessment. Any such plans, if and when developed, would be subject to all applicable approval processes in place at that time.

Current plans are to decommission the facility at the end of the planned 15-year operating life, such that decommissioning will commence in 2026. Decommissioning will include rehabilitation of the land and water areas disturbed by the Project, and is anticipated to take up to five years.

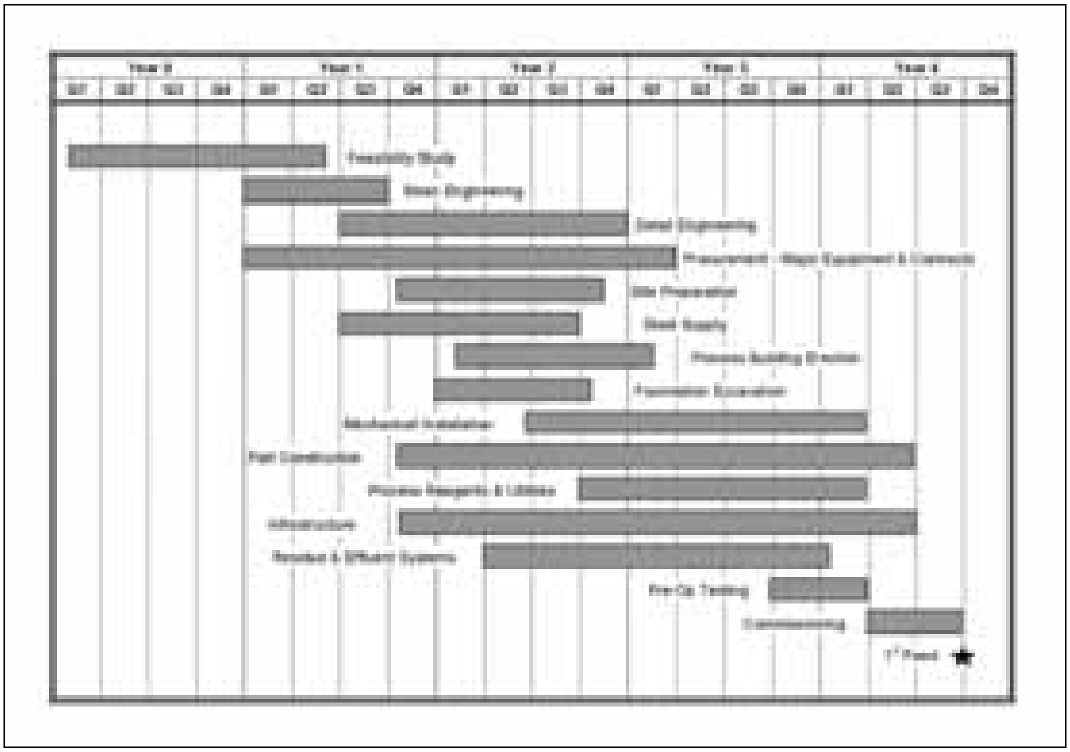

Figure 2.4 Summary Construction Schedule

3.0 Alternatives

This Chapter presents and discusses the alternatives to and within the Project. The EIS is required to describe the alternative methods of carrying out the undertaking, as well as the alternatives to the undertaking. The Guidelines for the EIS and the Federal Environmental Assessment specifically request information on alternatives for residue treatment and disposal, for both the Hydromet Process and the Matte Process. Where only one alternative is viable or possible, supporting argument is provided.

Vale Inco NL has identified one alternative to the Project and several alternatives in Project design, including processing technologies, site locations and residue disposal.

3.1 Alternatives to the Project

The sole alternative to proceeding with the Project was identified as the "no project" alternative: i.e., that no nickel processing facility would be constructed in the province by Vale Inco NL, a scenario that would potentially allow the Government of Newfoundland and Labrador to terminate the mining lease of the Voisey's Bay nickel deposit, removing 50,000 t of nickel per year from the world market.

This alternative would result in no economic benefit to Newfoundland and Labrador, to Canada or to Vale Inco NL. It would forego all of the direct and induced construction and operation jobs associated with the nickel facility.

3.2 Alternatives within the Project

Several alternative processing technologies have been considered for the Project, including pyrometallurgy and bio-leaching. Alternative sites throughout the province have been examined, and residue storage alternatives have been considered to identify feasible, secure and environmentally suitable sites.

Each of these within-Project alternatives is presented and discussed in this Chapter. Note that, for the purposes of this EIS, the Hydromet Plant versus the Matte Plant are not considered alternatives; rather, both fall within one Project and are assessed in this EIS.

3.2.1 Processing Technologies

One alternative would be to produce nickel from concentrate using pyrometallurgical technology instead of hydrometallurgical processing technology. Pyrometallurgy uses high temperatures (in the order of 1,300°C) to transform concentrate into oxidized metals, which are then refined to recover the metals. Concentrate is fed into a flash smelting furnace along with oxygen. Sulphides in the ore are oxidized, with the sulphur liberated as sulphur dioxide gas, leaving an oxidized mineral known as Matte. Iron in the concentrate is oxidized to form iron oxide and removed, together with silicates, as slag. The molten Matte containing the desired metals is then fed to converters, where the remaining iron and sulphur are oxidized with air at high temperatures. The Matte from the converters proceeds to a refinery to recover the metals.

A technical and economic feasibility analysis was conducted of using pyrometallurgical technology to produce finished nickel products using Voisey's Bay nickel concentrate. The analysis concluded that it was not economically viable to construct and operate such a facility based solely on the Voisey's Bay mine/mill production capacity. A pyrometallurgical facility requires more energy to operate than a hydrometallurgical facility, and would require large blocks of electricity. While such a facility can be operated within regulatory limits, its very nature (high temperature, high volumes of gases) means that it would produce significantly greater quantities of air emissions (sulphur dioxide, particulate matter containing heavy metals, and greenhouse gases) than would a hydrometallurgical process. The pyrometallurgical option was rejected for economic and environmental reasons.

Another alternative processing technology, bio-leaching, is experimental and not commercially proven for nickel recovery. It has only been applied to base metals such as nickel and cobalt at a bench-scale level. Difficulties with metal recovery from the resulting solutions have not yet been economically resolved. Bio-leaching generates a large quantity of acidic and ferric waste water. The sulphuric acid in the waste water stream is not easily recoverable; the liquid waste stream must be neutralized, generating large quantities of waste solids with high pH, posing disposal challenges. The quantities of residues and neutralizing agents required would be much larger than for either the Hydromet Plant or the Matte Plant, and the costs of such processes is high. In addition, the commercial feasibility of the bio-leaching process could not be established within the time frame stipulated in the *Voisey's Bay Development Agreement.* The bio-leaching alternative was rejected for these reasons.

3.2.2 Site Selection

In 1996, after conducting a province-wide investigation of 15 potential sites, Inco selected the former U.S. Naval Base at Argentia as the preferred site for development. Since that time it has been determined that a smelter-refinery complex is not economical for the quantity of nickel to be produced, and a hydrometallurgical processing option was selected as the preferred technology. The change of processing option results in the production of a different type of residue, one that necessitates underwater rather than aboveground storage. As a result of this change, Long Harbour was evaluated and selected as the site for the commercial nickel processing facility.

Long Harbour has an ice-free port that can operate year-round, and offers easy access to major North Atlantic shipping lanes. It has the same socio-economic footprint as Argentia. The workforce would be drawn from the same area as Argentia. It has the same infrastructure (schools, hospitals, healthcare, shopping) and draws from the same local business community.

The Project footprint will include two areas or Tiers, and has access to adjacent sites for water supply and residue storage. The water supply source, Rattling Brook Big Pond, has no access for road vehicles and hence is not readily accessible to the public. The proposed underwater disposal area, Sandy Pond, is even less accessible. For the Matte Plant, a suitable gypsum residue storage site is available to the southwest. A source of electrical power is located adjacent to the Long Harbour site, at an existing Newfoundland and Labrador Hydro substation.

3.2.3 Residue Storage Alternatives

The Hydromet process for nickel concentrate produces two residues: an autoclave leach and an iron hydroxide–gypsum residue. Both residues require neutralization. The Matte process produces a gypsum filter cake that is neutralized and contains little iron.

The residues produced will require environmentally acceptable long-term storage. The storage options available for these residues are underwater or above ground. Hydromet residues offer the possibility of separate or combined storage of the two wastes.

The selection of a preferred option for the storage of the residues from the two processing technologies involved extensive examination of the chemical and physical characteristics of the residues themselves. Candidate sites were selected and evaluated based on technical, socio-economic and environmental criteria.

3.2.4 Hydromet Process Residues

The Hydromet Plant will process approximately 269,000 t/yr of nickel concentrate resulting in approximately 381,000 t/yr of combined residue, comprising 242,600 t/yr of neutralized leach residue and 138,400 t/yr of neutralized iron hydroxide-gypsum residue. The neutralized leach residue contains about 25 per cent by weight of elemental sulphur, creating a potential for acid generation in the presence of oxygen and water. It is therefore essential to reduce or eliminate access of oxygen to the residues, usually by placement under a water cover. The other residue is basically a gypsum (calcium sulphate) material containing most of the iron removed from the processing of the concentrate. It does not contain elemental sulphur and it is not subject to acidification or metal remobilization in solution.

For the Hydromet Plant, a specific study was undertaken to address the options and decision-making processes to identify the optimum method and location for the long-term storage of the residues resulting from the processing of concentrate (Vale Inco NL 2008). Several aspects were considered: the chemical and physical characteristics of the residues, their behaviour in the environment, the methods considered for long-term storage, the closure strategy, the potential site locations for storage, the site selection criteria and evaluation process, the site selected and the reasons for the selection.

Storage of the iron hydroxide-gypsum residue above ground and separately from the neutralized leach residue would require two storage sites; this would increase the size of the Project footprint as well as Construction, Operation and Closure costs. Combining the two residues takes up about 10 per cent less volume and enhances the stability of both products. By combining the residues, the acid generation potential is noticeably reduced; hence the consideration of storage options was based upon this approach. The combined residue was considered for above-ground storage (sub-aerial), deposited as a slurry or as a paste, and under water storage (sub-aqueous), either separately or combined.

Sub-aerial deposition has severe technical challenges. The residues will need to be transported as a slurry. At a disposal site, the residues will settle and consolidate slowly since the material will tend to retain water. Conversion to a drier paste is possible and would slightly reduce water content; it has few other advantages, and the significant disadvantage of requiring the installation of a paste plant near the disposal site. The option of removing the sulphur from the residue before storage was examined and found to be technically unfeasible. A significant portion of the residue (10 to 30 per cent) comprises finely divided orthorhombic elemental sulphur. Exposure of the residue (combined form or not) to sub-aerial conditions results in the oxidation of the elemental sulphur to sulphuric acid, with the development of severe acidity and associated leaching and release of high concentrations of metals. While the combined residue will have an elevated pH at the time of deposition, over time the elemental sulphur will oxidize. Tests performed on residue produced at the Hydromet Demonstration Plant confirm that the material will have an extremely high net acid-producing potential. The rate of release of metals (iron, copper, nickel) steadily increases, even after three years, at a rate that is two orders of magnitude greater than for sub-aqueous storage. As a consequence, land-based sub-aerial disposal (as paste or slurry) would result in a long-term chronic acid-generating condition, which requires drainage control, treatment and constant monitoring. The consequences would be severe, long-lasting and unacceptable environmental conditions; consequently sub-aerial land-based disposal was ruled out as an option.

Storing the neutralized leach residue or the combined leach residues sub-aqueously will substantially reduce the rate of oxidation of the elemental sulphur. In addition, closure of the underwater storage site can be significantly less complicated than the land-based option, which would possibly require capping to prevent sulphur oxidation. The optimum selected approach, therefore, is to combine the two residues and dispose of them under a water cover.

Attention was focused on the identification and evaluation of candidate sub-aqueous sites, including natural water bodies as well as engineered (land-based) containment locations. Natural water bodies have the advantage that existing topography provides containment capacity and the presence of surface water is evidence of low seepage potential. Within the Project Area, however, there is no single natural water body with sufficient capacity to contain all the residue material; thus all candidate natural water bodies would require some form of engineered structure to meet capacity requirements and to develop a securely contained facility. Engineered (land-based) containment locations have the advantage of reducing environmental effects on the natural aquatic environment. Within the Project area, however, all sites with suitable topographic features also contain some quantity of aquatic habitat (streams and small ponds/pools).

It is possible to select a land-based site with no regard for topographic features, relying on excavation to create a suitable sub-aqueous storage area. Candidate locations include steep slopes and some hilltops. The nature of the terrain is such that overburden and bedrock removal would be required to produce a sufficiently large storage area. This would require drilling and blasting. While some portion of the excavated material (in the order of 23 million m^3) might be used in aspects of Project Construction, the majority of the material would need to be placed in a suitable disposal location within reasonable haul distance. Despite these challenges, and in order to provide a complete and thorough assessment of all candidate sub-aqueous sites, a purely land-based containment location was selected and included in the evaluation process.

Twelve potential disposal sites were selected (seven land-based and five natural water bodies; see Figure 3.1) and evaluated to the same level of detail (Vale Inco NL 2008). All were examined with respect to environmental, technical, socio-economic and financial criteria, using an approach similar to recently completed alternatives analysis (SRK 2006 in Vale Inco NL 2008). Environmental aspects were given the highest weighting in this assessment approach. Table 3.1 presents the master summary table from the evaluation.

Sandy Pond received either the best or second best ranking in each master category. Sensitivity analyses comparing different weightings of the four master criteria always resulted in Sandy Pond being ranked as the preferred site environmentally and technically. As a result, Sandy Pond was selected as the site for long-term sub-aqueous storage of the combined residues from the Hydromet Plant.

The selected site (Figure 3.2) is about 3.2 km from the Tier 2 processing complex. Three earth-fill dams will be required to provide residue containment over the design life of the Project. The key positive features of Sandy Pond are that it has the smallest watershed area and footprint (the site is located at the top of a watershed requiring only one small stream diversion) and that its development would have minimal social impact (the site is not visible from local communities and is used very little for recreational activities). It is isolated and has limited access from existing roads. It is most favourable for closure considerations (easy-to-maintain water cover, relatively low dams, small storage area of about 74 ha, thick residue deposit with relatively small surface area, and relatively low potential environmental impact should the dams fail).

The current design includes a 15 per cent capacity contingency factor, which can accommodate any additional residue generated during the operating life as a consequence of processing any feed material that might be sourced from locations other than Voisey's Bay. The Sandy Pond design can be expanded in storage capacity. The dams are designed to be ready for practical and stable raise, if required. The storage capacity can be doubled by a moderate dam raise of about 8 m.

A major issue is the protection afforded fish and fish habitat under the *Fisheries Act* of Canada. The Department of Fisheries and Oceans (DFO) operates on the "No Net Loss" principle – i.e., any loss of productive fish habitat has to be offset in an acceptable manner such that there is no net loss in capacity. Fish habitat can be altered or destroyed only by authorization of the Minister or otherwise approved under the *Fisheries Act*, and will be granted only if an acceptable Fish Habitat Compensation Plan is in place and a binding agreement is reached on its implementation. To allow for the deposition of deleterious substances into Sandy Pond, Environment Canada and DFO have determined that the *Metal*

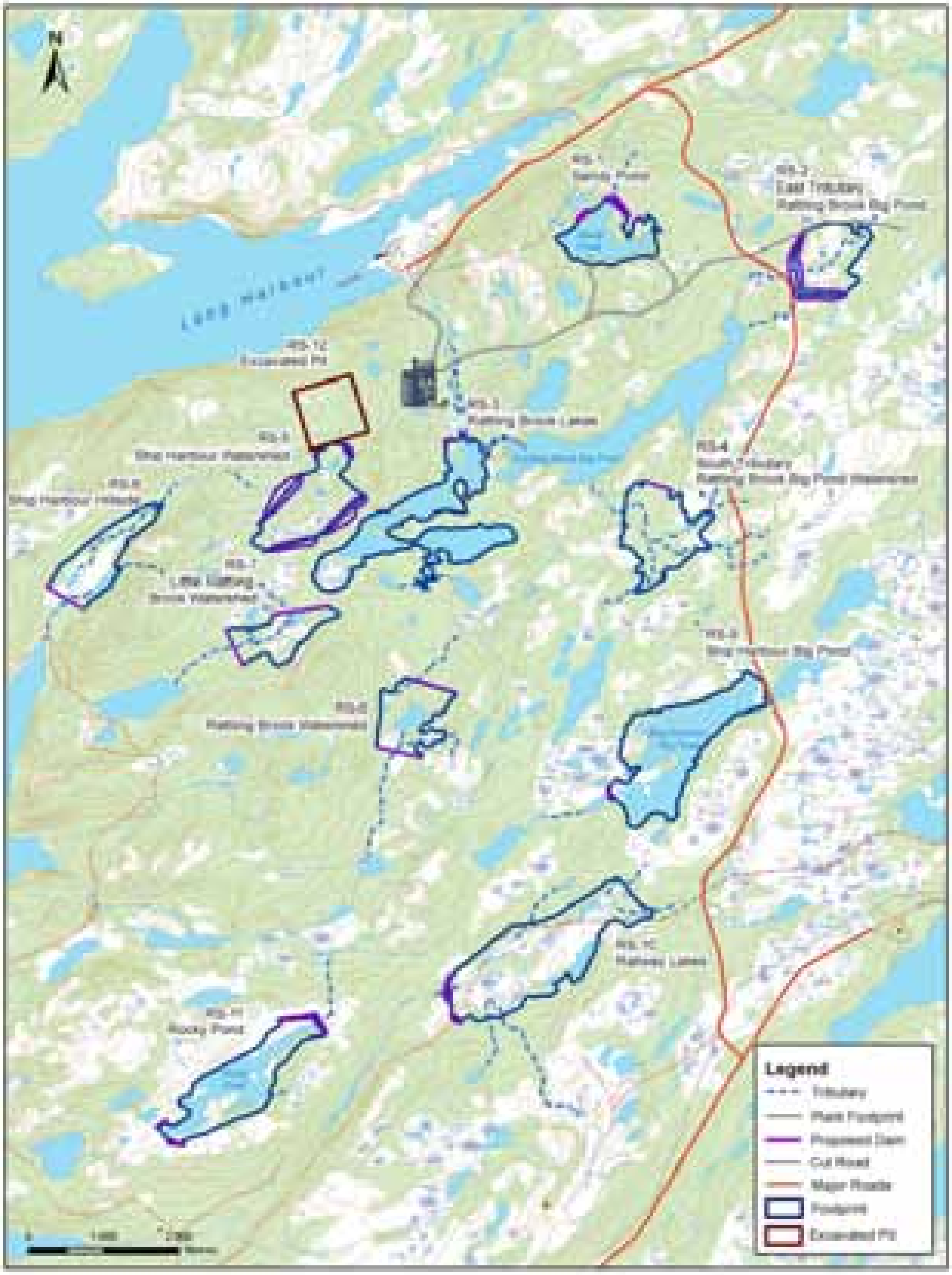

Figure 3.1 Hydromet Residue Storage Options

Table 3.1 Alternatives Evaluation – Residue Disposal Sites

Options Analysis		Site Number	RS-1	RS-2	RS-3
		Site (Location) Description	Sandy Pond	East Tributary - Rattling Brook	Rattling Brook Lakes
Category	**Counter**	**Criteria**			
ENVIRONMENTAL	1	Distance from Plant Site	4	3	5
	2	Total Watershed Area	5	2	2
	3	Quantity of Aquatic Habitat Disturbed	3	3	2
	4	Quality of Aquatic Habitat Disturbed	3	5	3
	5	Quantity of Terrestrial Habitat Disturbed	3	1	1
	6	Quality of Terrestrial Habitat Disturbed	3	3	2
	7	Dam Failure Consequences	2	0	2
	8	Compensation Effort and Monitoring	4	3	3
	9	Water Quality	3	2	2
	10	Post Closure Rehabilitation	2	1	3
	11	Dam Reliability	5	3	3
		Environmental Score	**37**	**26**	**28**
TECHNICAL AND OPERATIONAL	1	Dam Design Details	4	2	4
	2	Ratio of Dam Volume to Residue Storage Capacity	5	3	5
	3	Dam, Storage, Quarry and Access Road Footprint	5	3	2
	4	Construction Risk	4	2	3
	5	Operational Risk	4	4	2
	6	Closure Risks/Uncertainty	4	2	4
		Technical and Operational Score	**26**	**16**	**20**
ECO-NOMIC	1	Total Capital and Operating Cost	4	0	5
		Economic Score	**4**	**0**	**5**
SOCIO-ECONOMIC	1	Percieved Community Response	3	2	1
	2	Visual Impact	5	1	5
	3	Resource Use and Recreation	4	4	2
		Socio-Economic Score	**12**	**7**	**8**
		Overall Score	**79**	**49**	**61**
		Maximum Environment Weighting	55		
		Maximum Technical and Operational Weighting	30		
		Maximum Economic Weighting	5		
		Maximum Socio-Economic Weighting	15		
		Ranked Environment Score	37	26	28
		Ranked Technical and Operational Score	26	16	20
		Ranked Economic Score	4	0	5
		Ranked Socio-Economic Score	12	7	8
		Environment Ratio	0.67	0.47	0.51
		Technical and Operational Ratio	0.87	0.53	0.67
		Economic Ratio	0.80	0.00	1.00
		Socio-Economic Ratio	0.80	0.47	0.53
		Ratio Score	**3.14**	**1.47**	**2.71**
		Overall Ranking	**1**	**12**	**2**

Table 3.1 Continued

RS-4 South Tributary - Rattling Brook	**RS-5** Ship Harbour - Watershed	**RS-6** Ship Harbour - Hillside	**RS-7** Little Rattling Brook - Watershed	**RS-8** Rattling Brook - Watershed	**RS-9** Ship Harbour Big Pond	**RS-10** Railway Lakes	**RS-11** Rocky Pond	**RS-12** Excavated Pit
4	5	3	4	3	3	1	1	5
2	5	5	5	2	2	3	2	2
3	4	3	3	3	3	2	3	5
3	0	0	0	0	0	0	0	5
0	0	1	2	2	2	0	1	0
3	1	3	4	3	2	2	2	3
0	2	4	3	0	0	0	1	2
3	3	4	4	3	1	2	2	5
2	2	2	2	2	2	2	1	2
0	0	1	1	1	3	1	3	0
3	3	1	3	3	5	3	4	4
23	**25**	**27**	**31**	**22**	**23**	**16**	**20**	**33**
2	1	3	2	3	5	4	4	4
4	2	4	3	4	5	5	5	5
3	3	4	4	4	1	0	2	0
4	4	2	2	4	3	3	3	4
3	4	3	4	4	3	2	3	5
2	2	2	2	2	4	4	4	3
18	**16**	**18**	**17**	**21**	**21**	**18**	**21**	**21**
3	0	1	1	3	4	3	3	0
3	**0**	**1**	**1**	**3**	**4**	**3**	**3**	**0**
2	1	0	2	4	0	3	2	3
1	5	0	1	5	1	3	1	5
3	4	4	4	4	1	3	3	4
6	**10**	**4**	**7**	**13**	**2**	**9**	**6**	**12**
50	**51**	**50**	**56**	**59**	**50**	**46**	**50**	**66**
23	25	27	31	22	23	16	20	33
18	16	18	17	21	21	18	21	21
3	0	1	1	3	4	3	3	0
6	10	4	7	13	2	9	6	12
0.42	0.45	0.49	0.56	0.40	0.42	0.29	0.36	0.60
0.60	0.53	0.60	0.57	0.70	0.70	0.60	0.70	0.70
0.60	0.00	0.20	0.20	0.60	0.80	0.60	0.60	0.00
0.40	0.67	0.27	0.47	0.87	0.13	0.60	0.40	0.80
2.02	**1.65**	**1.56**	**1.80**	**2.57**	**2.05**	**2.09**	**2.06**	**2.10**
8	**10**	**11**	**9**	**3**	**7**	**5**	**6**	**4**

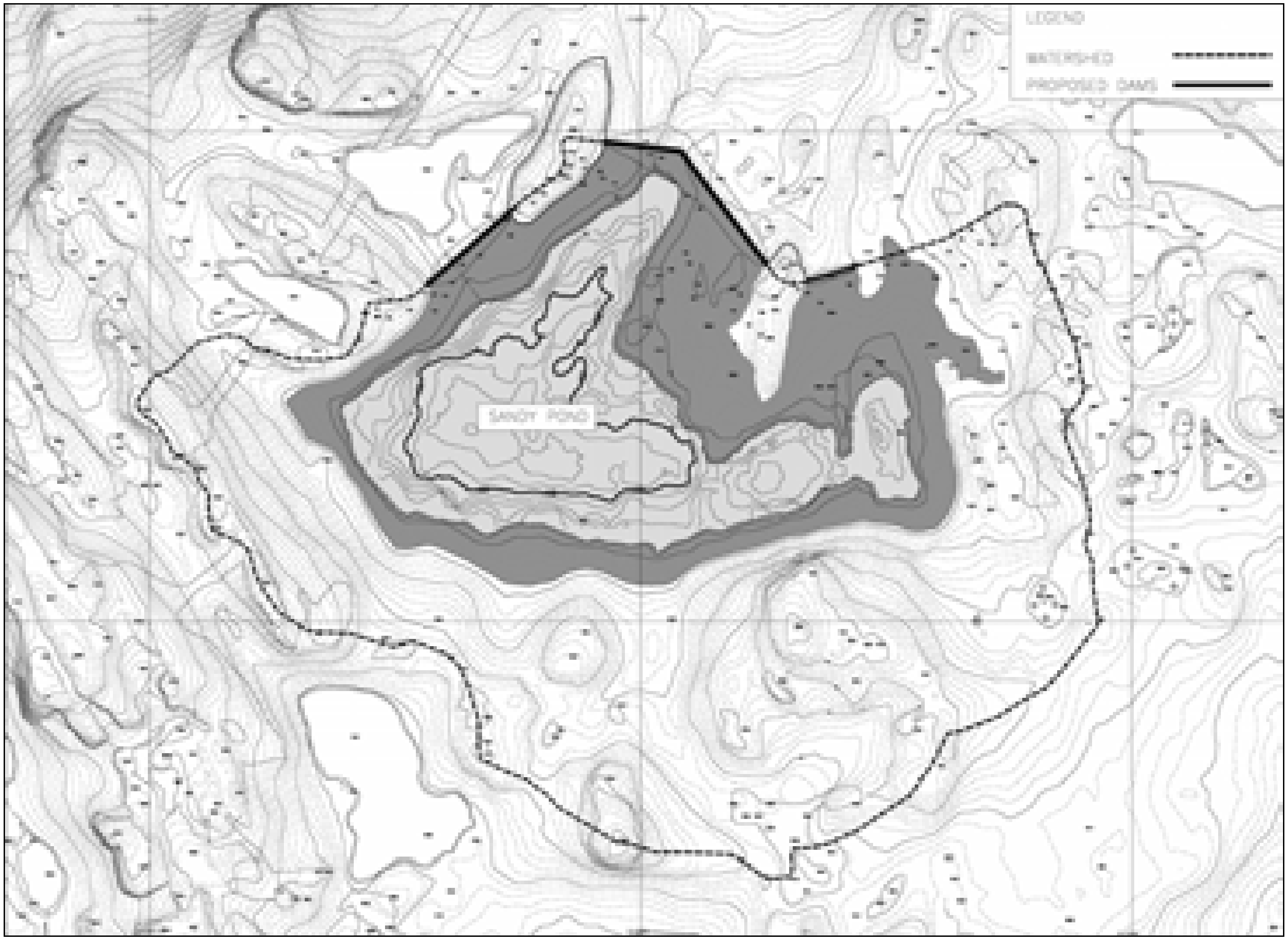

Figure 3.2 Sandy Pond

Mining Effluent Regulations (MMER) must be amended so that they apply to Hydromet facilities. A second amendment will then be required to list Sandy Pond on Schedule 2 of the MMER.

The loss of fish habitat as a result of site preparation and dam construction at Sandy Pond will be balanced by habitat gains elsewhere. Vale Inco NL will quantify the extent of harmful alteration, disruption or destruction (HADD) of fish habitat and will work with DFO to develop an appropriate fish habitat compensation program. This stepwise process includes consideration of possible habitat compensation options, development of a compensation strategy, development of a detailed compensation plan, public consultation, issuance of legally binding Compensation Agreement, authorization of HADD, and a monitoring program.

3.2.5 Matte Process Residue

Residue from the Matte Process does not contain elemental sulphur, and there is no requirement to inhibit oxidation. Aboveground storage would be the preferred option. The vast majority of gypsum produced by other industrial processes, e.g., gypsum residue from phosphate plants and from coal-electric plant sulphur dioxide scrubbing processes, is disposed of above ground in gypsum stacks, either as dry or wet stacking. Dry stacking means that the gypsum is transported and stacked at the same moisture content as the produced filter cake; wet stacking involves pulping the cake with water to form an approximately 25 per cent slurry that can then be pumped to a storage area.

Because of the wet weather conditions at Long Harbour, the ready availability of water, the ability to transport the slurry via pipeline and the lower costs as compared to dry stacking, the method selected for Matte Process residue storage would be wet stacking.

The wet-stack (Figure 2.3) would have a total footprint of about 20 ha enclosed by a 4-m high containment berm and would rise about 30 m above the surrounding terrain.

3.2.6 Marine Effluent Line Routing

Two overland routes were evaluated, one along the high-elevation ridge paralleling the shoreline and the other along the shore, near the water's edge and above the high-tide level. An overland pipe route requires the construction of an access road for operational inspection and maintenance.

The rolling terrain on the ridge would require a pressure pipe to carry effluent to a point of discharge opposite the proposed diffuser near Shag Rocks. This routing was deemed to be difficult to construct and maintain. Steep slopes from the ridge to the shore line, at a headworks structure, would add complications, additional concrete works, and costs. An additional pumping installation would be required with associated power and pumping costs.

A route along the shoreline would be at the toe of the steep slopes; this would require blasting, and the route would be vulnerable to slope stability problems requiring potentially costly geotechnical engineering solutions. The line would have to follow the irregular alignment of the coastline, which would complicate fittings and fastenings. This option would have similar cost, construction, and maintenance issues as the ridge route and would require extensive shoreline protection works.

The selected underwater route is a gravity-fed system that does not require a pumping station and avoids the limitations and uncertainties associated with the alternative overland routes.

3.2.7 Dredging

Dredging is required to provide adequate clearance for the unloading and loading of vessels at low tide. This involves removing a limited depth of sediment down to a bed level of 15 m over an area of approximately 2 ha (see Figure 6.1). In addition, a small amount of material must be removed to allow for construction work associated with modification to the supports of the wharf structure. The options include suction dredging and clamshell bucket dredging.

A suction dredge would typically be used for a large-scale dredging operation, and since the dredged material is moved as slurry, the resulting water discharge would contain appreciable amounts of sediment that would require some form of settlement prior to returning the water to the harbour. Even with settlement, the recycled water would contain a residual level of suspended solids, causing a potential sediment deposition affecting the local marine environment. Use of pure suction dredging is not practical based on the seabed conditions (medium dense sands and gravels with cobbles overlying dense till). Using a cutter suction dredge is possible, but the presence of cobbles would require a large dredge. To limit turbidity, the volume of water drawn in by the cutter suction would need to be in excess of 80 per cent, and likely closer to 90 per cent. This would result in a relatively larger volume of water for treatment and recycling.

Since the required dredging is limited in volume, a clamshell bucket dredge was selected as the most appropriate method. Equipment is readily available and the method is suitable for small-scale operation. Additionally, the bucket dredge can handle boulders, scrap steel and debris known to be present in the area near the wharf. Turbidity caused by using conventional marine dredging with a clamshell bucket or excavator can be mitigated by using best management practices, including installation of a turbidity curtain around the work area.

3.2.8 Construction Accommodations

One alternative to a conventional, land-based accommodations facility constructed near the Project Site is a floating (mobile) self-contained barge or ship, which would be moved by water to site and either berthed at the existing dock or moored in the harbour. The existing dock will not be available for berthing, since construction will be ongoing in and around it, (See Figure 6.1), and dock space will be needed for Construction-related shipping. Mooring locations in Long Harbour would involve difficulties in provision of suitable worker access to the Project Site. As well, there would be no "legacy" value in this alternative (e.g., provision of facilities for community use upon completion of Construction). For these reasons, use of a floating accommodation facility was rejected.

4.0 Project Layout and Main Components

The site layout illustrated in Figure 4.1 includes the main features of both the Hydromet and Matte facilities. The site will be located on two elevations. Tier 1, at an elevation between 3 and 10 m, will include the wharf and an area that will be used primarily for unloading and loading ships, container and product storage, staging and storing of equipment, a storage building, acid storage tanks and a port operations administration building. For the Hydromet Plant, Tier 1 will also include a lime kiln and fuel storage tanks. For the Matte Plant, the lime kiln and fuel tanks would be located on Tier 2.

Tier 2 has an average elevation of approximately 106 m and lies to the west of Rattling Brook and down gradient from Rattling Brook Big Pond. This site will contain all the major processing facilities and buildings, storage areas, laboratories and administrative offices.

The main features of the Port Site are shown in Figure 4.2 (Hydromet) and Figure 4.3 (Matte). The Plant Site features are shown in Figure 4.4 (Hydromet) and Figure 4.5 (Matte). Port facilities will include:

- Port facility including a wharf, an area for staging and storing of equipment and containers, and storage facilities for raw materials, reagents, wastes, and finished products;
- Lime kiln to convert limestone into lime for effluent neutralization (Hydromet only);
- Concentrate and limestone grinding process building (Hydromet only);
- Conveyor systems;
- Storm water capture system, sewage treatment system and general port buildings;
- Sulphuric acid storage tank(s) and fuel tanks;
- Underwater discharge pipe into a diffuser in Long Harbour; and
- Port operations office, lunch room and change house.

The Plant Site facilities will include:

- Lime kiln to convert limestone into lime to be used for effluent neutralization;
- Processing complex where the feed (concentrate or Matte) is pressure leached in acid solution to separate iron and sulphur from nickel, copper and cobalt;
- Solvent extraction building to extract the nickel, copper and cobalt for refining;
- Complex for the refining of nickel, copper and cobalt;
- Oxygen plant;
- Boiler plant to provide steam for heating;
- Cooling tower to cool and recycle cooling, and some process, water;
- Diesel and No. 2 fuel oil storage tanks;
- Electrical substation;
- Administration, change house, warehouse, workshops and utility buildings; and
- Control room and analytical laboratory.

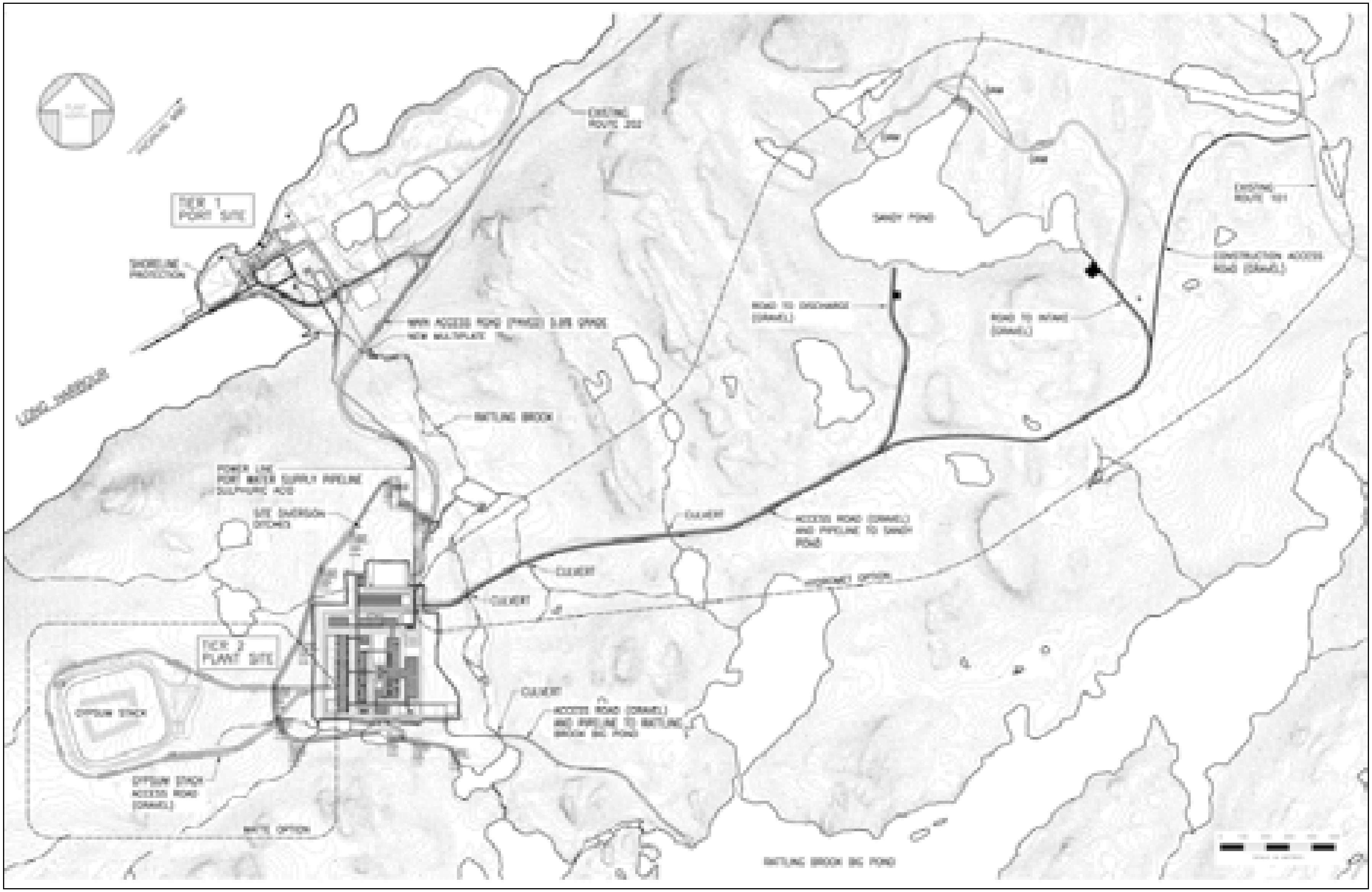

Figure 4.1 Overall Project Site Layout

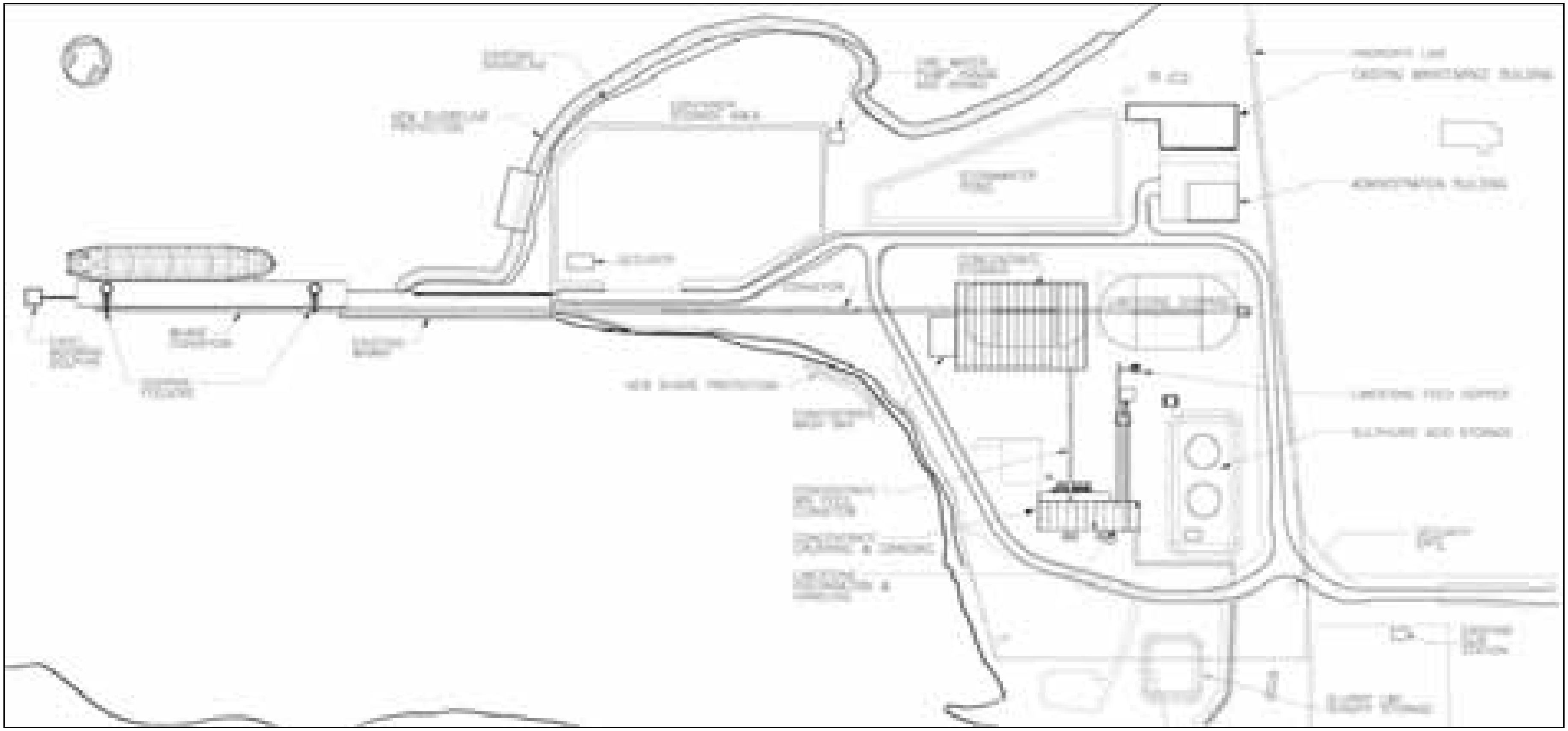

Figure 4.2 Port Site – Hydromet

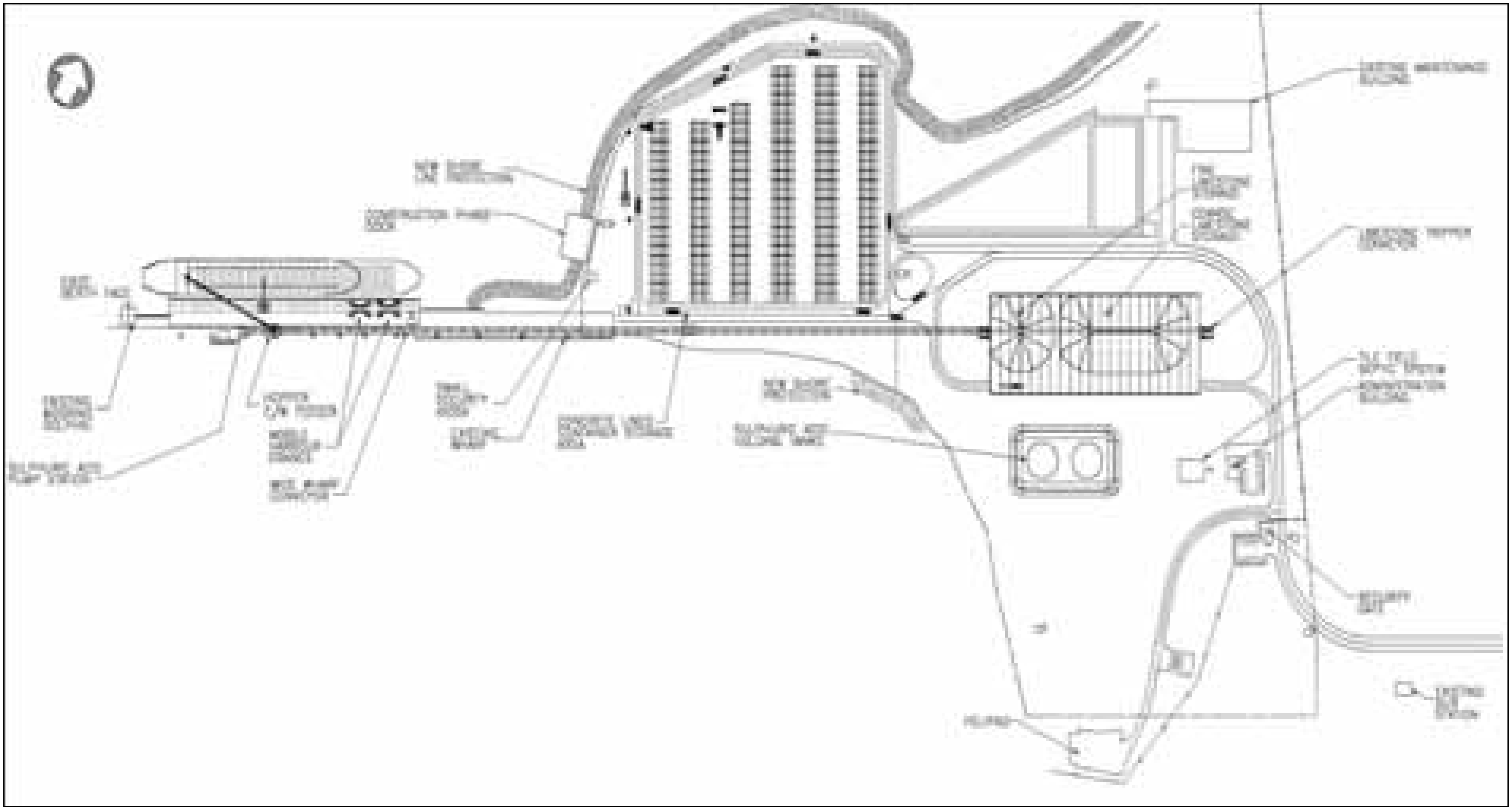

Figure 4.3 Port Site - Matte

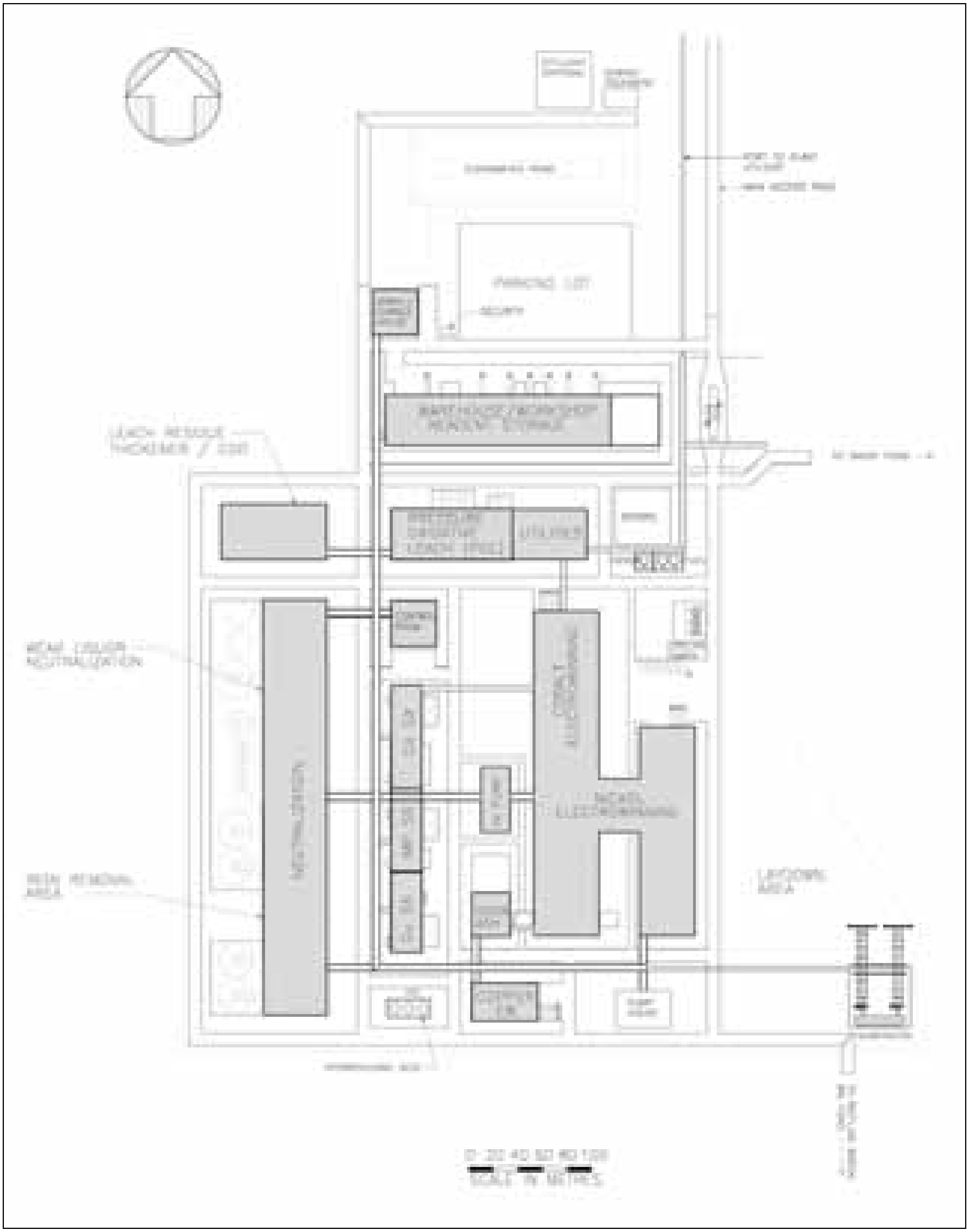

Figure 4.4 Tier 2 Site Plan – Hydromet Plant

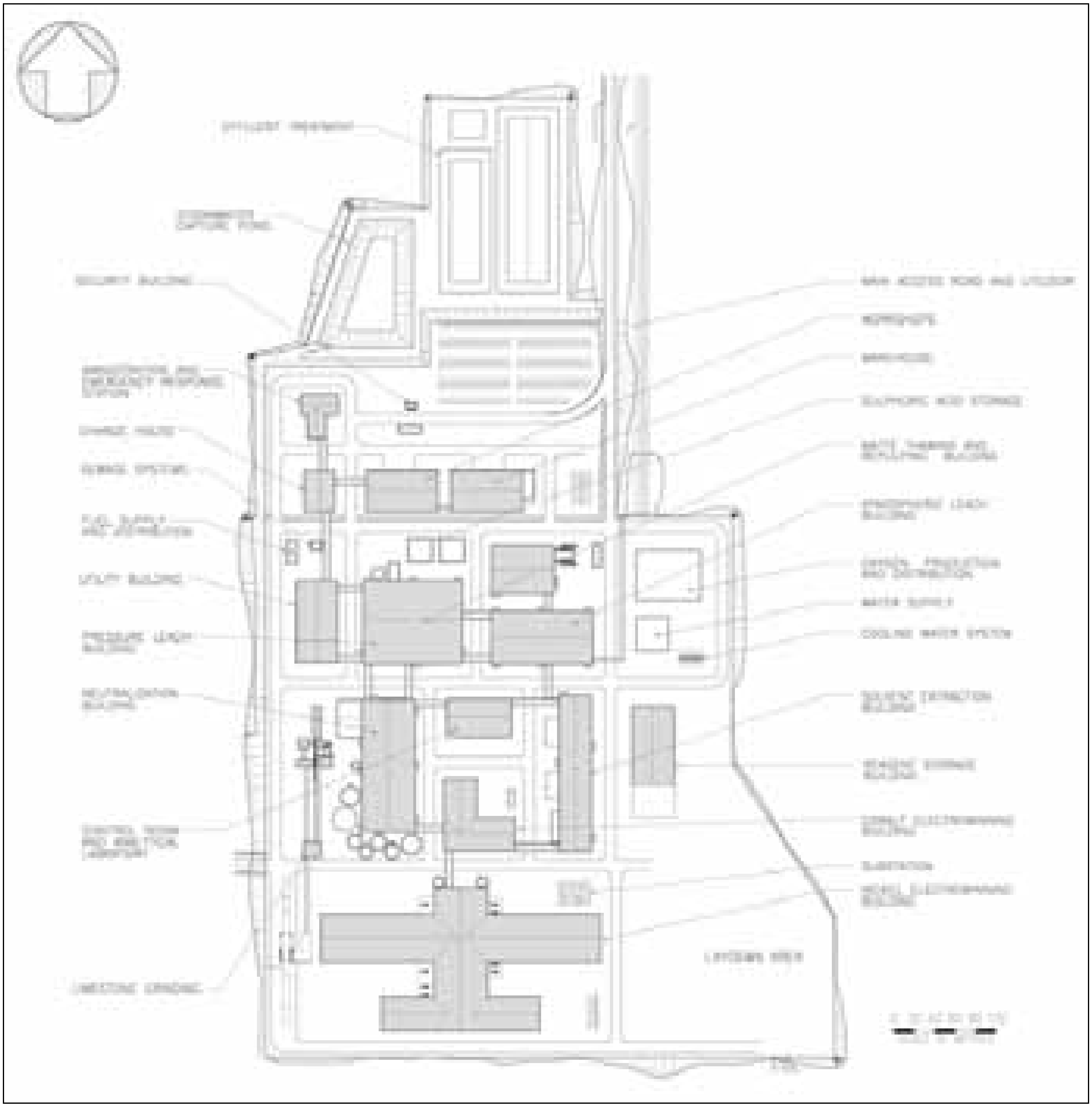

Figure 4.5 Tier 2 Site Plan – Matte Plant

There are several auxiliary components of the facility beyond these primary sites:

- Water supply system including a water control structure at Rattling Brook Big Pond and pipeline to the plant;
- Residue storage area (Sandy Pond for underwater storage of combined residues for the Hydromet Plant, an aboveground storage area for residue storage for the Matte Plant);
- Pipelines to and from the residue storage area;
- Pipelines to carry concentrate slurry, sulphuric acid, and lime and limestone slurries from Tier 1 to Tier 2 (Hydromet only);
- Access roads (between Tiers 1 and 2, between Tier 2 and the residue storage area and Rattling Brook Big Pond);
- Power lines between the substation and the sites;
- Pipeline utilidor and pipe racks between Tier 1 and Tier 2;
- Other site infrastructure including parking, water storage tank and pump houses, water distribution system, effluent treatment plant, sewage treatment plant, surface water drainage system, power distribution equipment, security fencing and access control building;
- Constructed storm-water pond and effluent discharge polishing/cooling ponds; and
- Standby diesel generators.

Tiers 1 and 2 will occupy a total area of about 65 ha. A further 85 ha will comprise the residue pond and pipeline. Above ground residue storage (Matte Plant) would occupy an additional 40 ha area.

Process water will be obtained directly from Rattling Brook Big Pond, located about 2 km southeast of the site. A pump house and a pipeline will be constructed to pump water to the Plant, which will be at approximately the same elevation as the pond. A flow control structure will be constructed on Rattling Brook Big Pond to provide the flows required for fish habitat maintenance in Rattling Brook.

Access roads will be constructed to Sandy Pond and between the Plant Site and Rattling Brook Big Pond. Treated effluent will be discharged through a 6-km line to a diffuser in Long Harbour.

A 3.8-km pipeline will be constructed to carry neutralized Hydromet slurry residue to Sandy Pond and return clarified water to the processing facility. Three dams will provide sufficient capacity to contain all settled residue. The dams will be designed so that they can be raised to increase capacity. Decant water will be pumped back to the Plant Site on Tier 2, where excess water will be treated and discharged into Long Harbour. Runoff from the Plant Site will be collected in storm-water ponds on each Tier.

In the case of the Matte Plant, waste gypsum slurry would be transported by a pipeline to a storage site about 1.3 km southwest of the Plant Site. The storage site would be surrounded by a 4-m high containment berm. Excess water (run-off and leachate) would be collected in an adjacent clarification pond, from which the effluent would be carried by a return pipeline back to the Plant, with excess water treated and discharged into Long Harbour.

The existing wharf will be repaired and upgraded to accommodate a single 32,000 DWT vessel, with additional berthing for smaller support vessels.

The existing road to the Port Site will be upgraded and extended, and new local access and driveways constructed as necessary. A 3-km road will connect Tier 1 to Tier 2. Existing buildings, with the exception of a maintenance shed on Tier 1, will be demolished. Demolition material will be removed and disposed of by licensed third-party contractors.

Electrical power (a connected load of approximately 94 MW for Hydromet and approximately 74 MW for Matte) will be obtained from the provincial grid. Newfoundland and Labrador Hydro has indicated that sufficient capacity is available to provide the necessary power.

The proposed nickel processing plant, including auxiliary facilities, is planned to operate continuously, 24 hours a day, at about a 90 per cent operating factor.

5.0 Physical Environment and the Project

Placentia Bay is a diverse and productive ecosystem that has been of economic, social and cultural importance for centuries. It contains large seabird colonies of international significance, relatively large populations of Bald Eagles and river otters, a number of Atlantic salmon rivers, and important human enterprises such as the commercial fisheries (including aquaculture), an oil refinery and transshipment terminal, shipyards, ports and tourism facilities. The ecosystem is composed of a number of inter-related physical, chemical, biological and human components.

5.1 Physiography and Geology

The Island of Newfoundland is divided into two physiographic regions, the Canadian Appalachian and the Atlantic Coastal Plain. The Canadian Appalachians are further divided into the Atlantic Uplands and the Carboniferous-Triassic Lowlands (Fader et al. 1982). The geomorphology of these regions is primarily the result of Quaternary glaciations.

The Atlantic Uplands is the largest geomorphic unit of the Appalachian Region, consisting of a southeasterly dipping peneplain of Precambrian and Paleozoic bedrock. This surface extends into offshore areas along the south coast of Newfoundland and generally coincides with areas of rough topography. Glacial erosion has resulted in over-deepened transverse troughs in some places.

The Atlantic Coastal Plain is underlain by Mesozoic and Cenozoic coastal plain sediments. The characteristic landforms that developed across this surface (mesas, cuestas and deep incised valleys) formed during a period of subaerial erosion when sea levels were comparatively low. St Pierre Bank is a typical bank of the Atlantic Coastal Plain region (and the southwestern-most bank of the Grand Banks of Newfoundland), with its shallowest point (31 m) occurring at its northwest corner, but in general being less than 115-120 m deep (corresponding to low sea levels 14,000–15,000 years ago). Halibut Channel is an extension of Placentia Bay; it borders the eastern side of St Pierre Bank, and separates it from Green Bank further to the east (Fader et al. 1982; Wade and MacLean 1990).

The Project site is situated on the southern side of Long Harbour on the Avalon Peninsula. Precambrian bedrock of the Musgravetown Group, which underlies the proposed Plant Site and Sandy Pond, consists of volcanic flows and tuffs, and pyroclastic and clastic sedimentary rocks of the Bull Arm, Big Head and Maturin Ponds Formations. Bedrock structures are characterized by open folds with NNE-SSW-oriented axes that generally run sub-parallel to the eastern shoreline of Placentia Bay. These lithologic units are cut by younger fault systems that are oriented NE-SW, such as the fault at the head of Long Harbour and another that intersects Ship Harbour, running through and defining the general NE-SW orientation of Rattling Brook Big Pond and a series of smaller ponds connected to it (King, 1988).

The bedrock within the Project Area is overlain by glacial till, locally consisting of relatively thin till blankets (about 1.5 m thick), hummocky tills (with local topographic relief of between 2 and 10 m), ridged tills (where till ridges are oriented parallel or perpendicular to Late Wisconsinian ice flow directions), and glaciofluvial sands and gravels (Batterson et al. 2006).

Lying above Tertiary and older bedrock in the marine environment are unconsolidated Quaternary sediments deposited during and subsequent to the Late Wisconsinian glaciation. In recent years, the Geological Survey of Canada (GSC) has been using digital multibeam bathymetric surveying techniques as a primary reconnaissance tool for marine geological mapping. Although little published information is available for Long Harbour, multibeam images and a preliminary interpretation of the seabed geology has been obtained for the area (John Shaw, GSC, pers. comm.; Shaw et al. 2006).

Two principal acoustic units occur within Long Harbour, one a hard, ice-contact sediment, possibly glacial till, that forms ridges on the seabed, and the other a soft postglacial mud unit. Toward the mouth of Long Harbour, the hard ridges are oriented NNE-SSW, which may reflect the similar trending bedrock structures on each side of, and presumably underlying, the harbour. Alternatively, these ridges may have been formed parallel to the flow direction of Late Wisconsinian ice, which was centred on Collier Bay Brook on the Avalon isthmus (Batterson and Taylor 2003).

Toward the head of the bay, just seaward of the Long Harbour pier, is a shallow shelf, at -16 m elevation, that is interpreted as a Holocene submerged fluvial delta composed of prograded gravel and sand. This was formed during a low stand of relative sea level. Along the Long Harbour shoreline is a submerged erosional platform, down to the lowstand depth of -16 m.

5.2 Coastal Geomorphology

The shoreline along Placentia Bay is heavily influenced by major storm events, particularly hurricanes, and their associated waves. Because the angle of approach of major storm waves is variable, shoreline sedimentary processes can vary significantly at different times at the same location. Nevertheless, Catto et al. (2003) have developed a classification system of Newfoundland’s eastern shorelines based on substrate, sediment, width and profile, and have evaluated various stretches of coastline in terms of vulnerability to erosion.

In general, the eastern Placentia Bay shoreline running from Little Harbour to Argentia (Figure 5.1) is assessed as having moderate to high sensitivity to coastal erosion (Long Harbour is assessed as high), with the exception of Fair Haven, where the beach has a very high vulnerability. Rocky headlands, gravel pocket beaches and rock platforms are the dominant shoreline types.

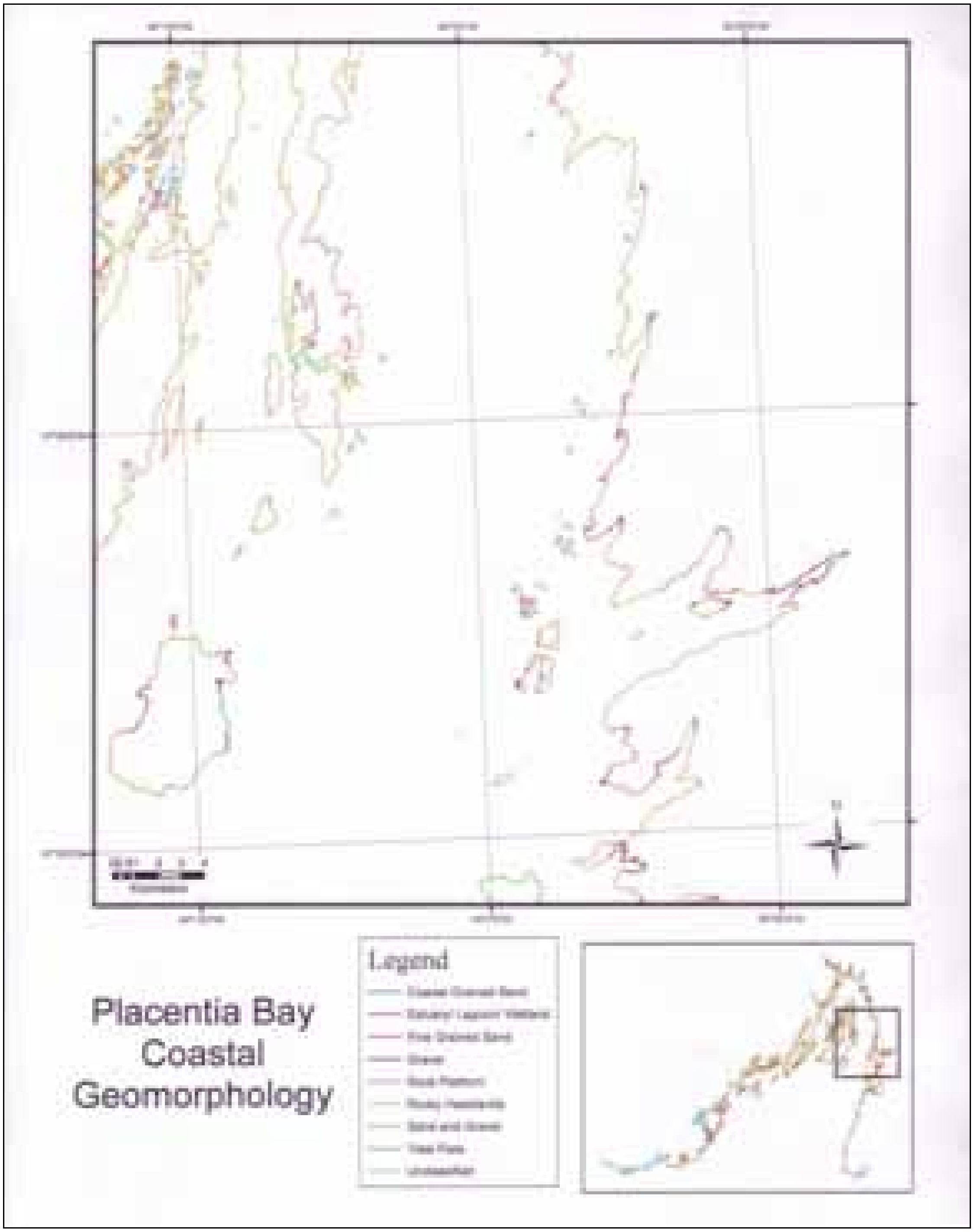

Figure 5.1 Shorelines of Eastern Placentia Bay from Little Harbour to Argentia (including Long Harbour)

Note: The shoreline along this stretch of coast is dominated by rocky headlands, gravel pocket beaches and rocky platforms with minor sand and gravel beaches. The southern shoreline of Long Harbour is dominated by rocky headlands, followed by gravel pocket beaches and rock platforms. Minor sand and gravel beaches and an estuarine/lagoon wetland is found at the mouth.

Source: Ollerhead, unpublished data.

5.3 Seismicity

Eastern Canada is located in a stable continental region of the North American plate and, as a consequence, has a relatively low rate of seismic activity typical of passive continental margins. Nevertheless, earthquakes have been recorded along the eastern continental margin, including the Grand Banks earthquake of November 1929 (epicentre at 44.69° N latitude, 56.00° W longitude, 20 km depth).

Earthquakes can pose hazards to structures and activities. These effects may include ground shaking, surface faulting, regional scale subsidence and uplift, seabed liquefaction, and effects such as slides, slumps and turbidity currents. They may also include tsunamis and possible damage to floating structures due to acoustic shock waves (Keen et al. 1990). For this reason, it is important to evaluate the risk posed by seismic activity.

In Canada, the evaluation of regional seismic hazard for the purposes of the National Building Code (NBC) is the responsibility of the Geological Survey of Canada (GSC). Seismic hazard maps prepared by the GSC are derived from statistical analysis of past earthquakes and from advancing knowledge of Canada's tectonic and geological structure. Seismic hazard is expressed as the most powerful ground motion expected to occur in an area for a given probability level. Contours delineate those regions likely to experience similar ground motions. Figure 5.2 indicates relative seismic hazard across Canada.

The seismic hazard maps and earthquake load guidelines included in the NBC are used to design and construct buildings to be as earthquake-proof as possible. While the provisions of the building code are intended as a minimum standard for human protection, they may not prevent serious damage to individual structures.

Canada has been divided into earthquake source regions based on past earthquake activity and tectonic structure. The relation between earthquake magnitude and the average rate of occurrence for each region is weighed, along with variations in the attenuation of ground motion with distance. In calculating seismic hazard, scientists consider all earthquake source regions within a relevant distance of the proposed site. The Project site is located in an area with relatively low seismic hazard (Figure 5.2).

5.4 Physical Oceanography

The following sections outline the bathymetry, currents, temperature and salinity characteristics, waves, ice conditions and storm surges in Placentia Bay in general and Long Harbour in particular. More comprehensive data can be found in the Component Study (Oceans 2007).

5.4.1 Placentia Bay Bathymetry

The Placentia Bay coastline is irregular with a large number of bays, inlets and islands. Large islands (Merasheen, Long and Red islands) are located in the middle of the inner section of the bay together with other smaller islands. The bathymetry of Placentia Bay is also very irregular, with many banks and

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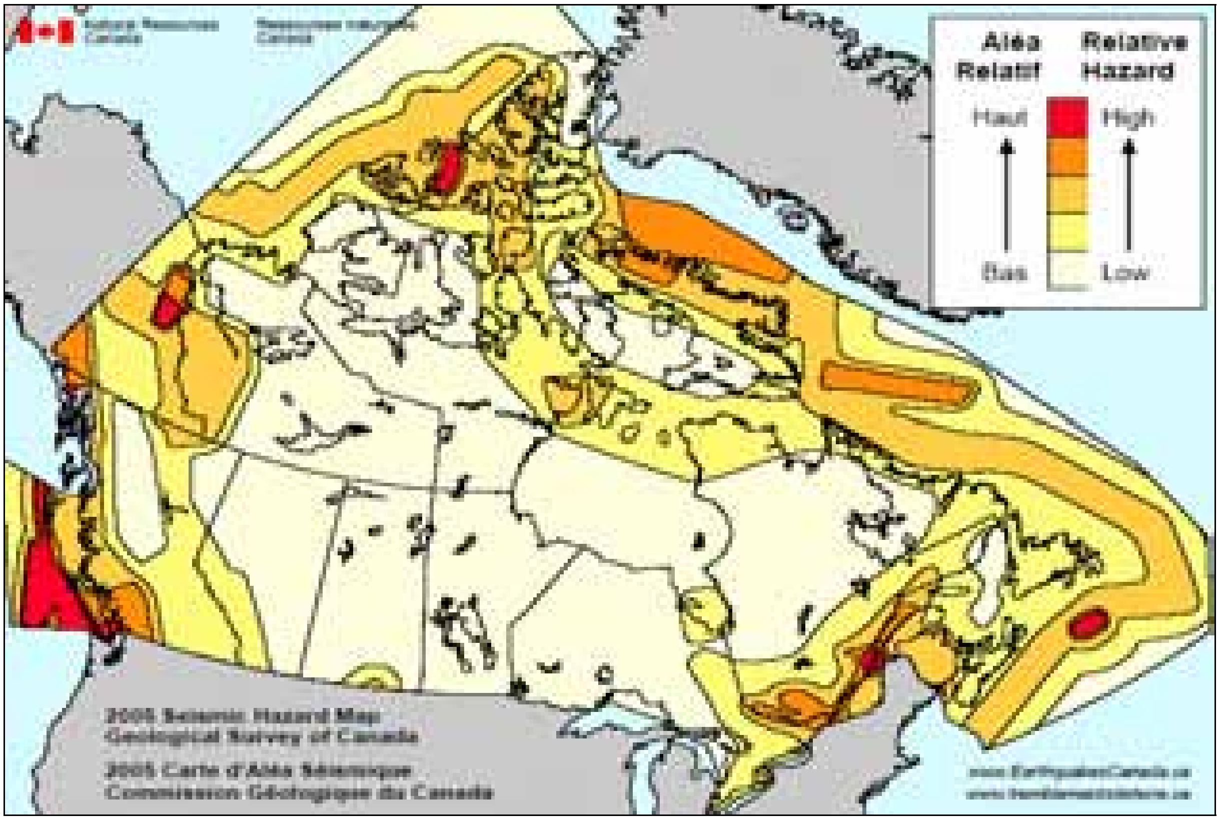


Figure 5.2 Seismic Hazard Map of Canada

Source: NRCan (2006).

troughs (Figure 5.3). The water depth at the mouth of the bay is approximately 200 m. There is a deep channel on the eastern side with water depths extending to approximately 300 m in some locations. A deep channel south of Merasheen Island, with a maximum depth of 350 m, is oriented in a northwest/southeast direction across the bay. White Sail Bank, Merasheen Bank, and Bennett Bank are located on the southern side of this channel. In general, the water is shallower on the western side of the Bay than on the eastern side, with the exception of these deep troughs.

5.4.2 Long Harbour Bathymetry

Long Harbour is situated on the eastern side of the bay, east of Merasheen Island and Red Island (Figure 5.4). The water depth in the harbour mouth near the southern side is approximately 70 m, and the mean water depth is approximately 50 m. Between Shag Rocks (located near the mouth of the harbour) and the northern shore there is a bathymetric ridge with a water depth of approximately 20 m. In the centre of the harbour, between Shag Rocks and Crawley Island, water depths vary between 40 m and 70 m. At Crawley Island the harbour splits into two branches, St. Croix Bay to the north and the main portion of Long Harbour to the south. The outer section of St. Croix Bay has a mean water depth of approximately 40 m, and the inner section has a mean depth of approximately 20 m. Long Harbour has a mean depth

Figure 5.3 Bathymetric Structure of Placentia Bay

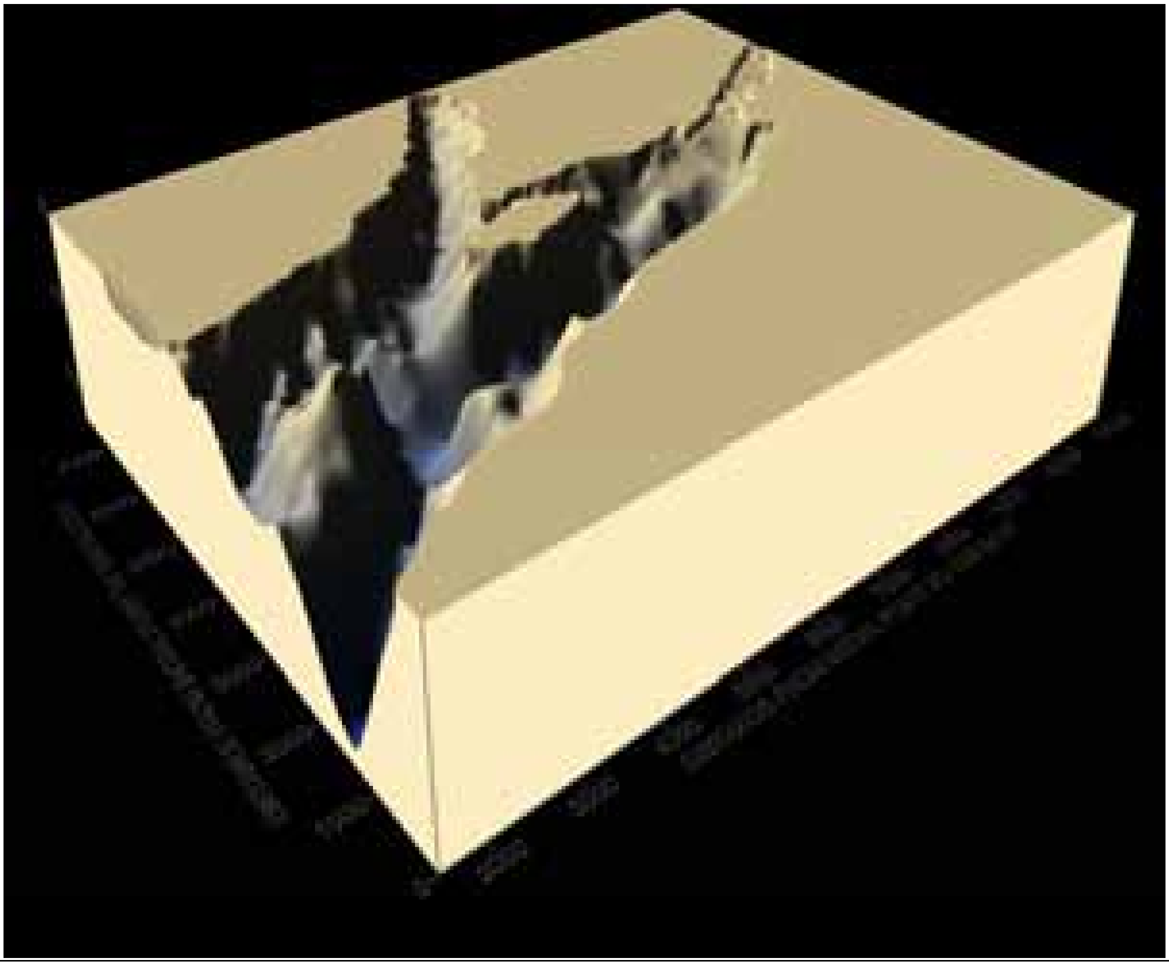


Figure 5.4 Bathymetric Structure of Long Harbour

of approximately 30 m, with the exception of a bathymetrical mound in the middle of the area where water depth varies between 13 m and 17 m.

5.4.3 Currents in Placentia Bay

Studies published by Memorial University of Newfoundland (MUN) and the Bedford Institute of Oceanography (BIO) suggest that currents in Placentia Bay follow a cyclonic (counter-clockwise) circulation pattern. They describe the eastern side of the bay as dominated by currents flowing into the bay, while at the western side the currents are usually flowing towards the open ocean. The MUN data (1999) for near-surface waters clearly show a persistent counter-clockwise flow around the bay. A cross-bay current flow has also been described, with currents flowing predominantly toward the east on the eastern side of the bay, and towards the west on the western side.

A summary of weekly mean magnitudes and directions indicates that the cyclonic circulation pattern around the bay is fairly stable in the near-surface waters. The mean circulation for depths of 20 m (Schillinger et al. 2000) is shown in Figure 5.5. The axes at the base of the arrows in these figures indicate the standard deviation of the current along the direction of maximum variance, and perpendicular to it.

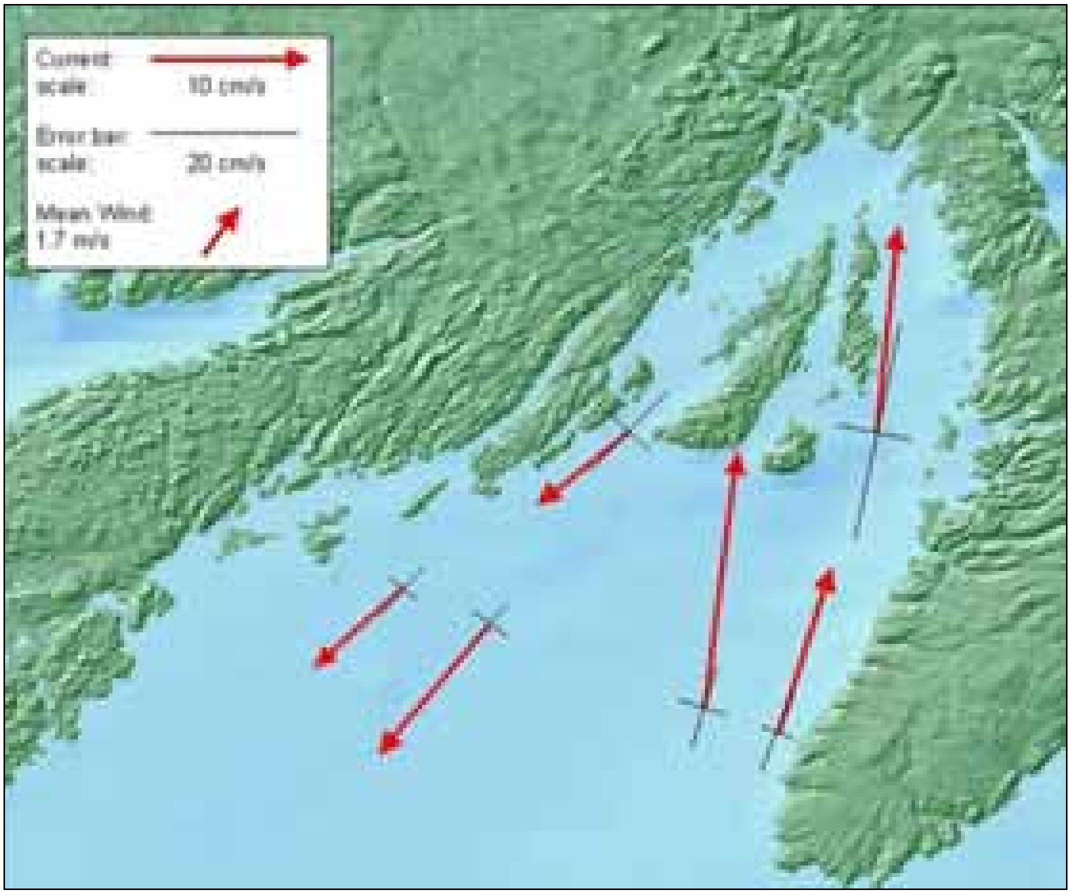


Figure 5.5 Mean Circulation in Placentia Bay at 20 m

Source: Schillinger et al. (2000).

The currents measured on the eastern side of the bay had a residual flow of 17.6 cm/s near the mouth and 15.6 cm/s at a location outside Long Harbour, with maximum current speeds of 75 cm/s and 78.7 cm/s, respectively. On the western side the residual current was 7.1 cm/s, and the maximum speed was 49.7 cm/s. The maximum current speed measured in 1998 (10 m depth) was 58.0 cm/s on the eastern side of the bay and 61.6 cm/s on the western side.

The counter-clockwise flow in the bay was predominant at depths from 36 m to 55 m. At 100 m and deeper, however, this pattern of flow was no longer a dominant feature. On the eastern side of the bay, at a depth of 110 m, the flow was mainly in a northeast and east direction during March and April, and then switched to east and southeast in May and June. At 180 m on the western side of the bay the flow remained in a predominantly southwest direction.

Outside Long Harbour, at a depth of 104 m, the flow was mainly towards the north in April and towards the southwest in May; the flow had similar characteristics west of the southern tip of Merasheen Island, predominantly towards the northeast in April, towards the southwest in May and early June, and then northeast until the end of the sampling record.

The data were analysed to determine the contribution of tides to the overall flow. The results of the harmonic analysis showed that the lower frequency components on the synoptic scale (order of days) contributed to the overall current flow. This contribution was particularly important in the surface water outside Long Harbour, and at measured locations on the eastern side of the bay.

An analysis of the BIO data collected during winter and fall 1988 also supports the existence of a counter-clockwise flow in the near-surface waters that persists during both seasons. However, the BIO data do not support a persistent counter-clockwise cyclonic flow at depths of 49 m and 56 m. The counter-clockwise cyclonic flow was observed in winter but not in fall, when the flow was in the opposite direction, with south-southwest currents observed on the east side of the bay and east-southeast currents at the head of the bay.

A statistical summary of the average and maximum speeds from the BIO data is presented in Table 5.1. The maximum current speeds tend to be higher near the surface. The maximum current speed of 74.8 cm/s occurred on the east side of the bay at a depth of 22 m during the winter sampling period.

The overall contribution of the tidal currents to the total current variability was approximately 15 per cent, with a minimum contribution of 8 per cent near the surface on the east side of the bay and a maximum contribution of 33 per cent at a depth of 49 m at the head of the bay.

Table 5.1 Statistical Summary of Current Speed from the BIO Data Set

LOCATION	SEASON	DEPTH (M)	AVERAGE SPEED (CM/S)	MAXIMUM SPEED (CM/S)
East	**Fall**	23	13.4	57.0
		56	10.3	45.1
	Winter	22	12.1	74.8
		60	13.2	57.8
North	**Fall**	16	12.1	44.5
		49	8.8	52.0
	Winter	25	8.4	29.4
		63	6.1	17.9
West	**Fall**	21	9.1	37.3
		54	8.7	32.8
	Winter	15	11.5	43.4

5.4.4 Currents in Long Harbour

The circulation pattern is the combined result of tides, winds and the Labrador Current. Since the variability due to tides is no greater than 15 per cent of the total variability, the other factors dominate. Winds in the area are predominantly from the southwest during all seasons, which would contribute to a counter-clockwise pattern in the near-surface waters. The inshore branch of the Labrador Current follows the bathymetric contours around the Avalon Peninsula. North of Green Bank, the direction of the bathymetric contours shifts from an east/west orientation into Placentia Bay and becomes the major contributor to the overall current variability. A portion of the north-northeast flow following the bathymetric contours on the east side of Placentia Bay would continue to follow the contours into Long Harbour and would be the major contributor to the overall current circulation in the harbour.

Current measurements in Long Harbour were made by BIO over a 29-day period at three locations during summer of 1969, and by Oceans Ltd. at five locations during summer and fall 2006. The locations of the current meter moorings are shown in Figure 5.6.

The data demonstrate a complex current system not unusual for a coastal inlet with irregular bottom bathymetry. Analysis of the current data in conjunction with Conductivity, Temperature and Density (CTD) data collected throughout the harbour showed that the circulation in Long Harbour was mainly driven by the circulation in Placentia Bay. Tidal measurements and analysis of tides from the current meter records showed that tides played a minor role. Winds played a modifying role, both directly and indirectly. The winds are strong enough on a daily basis in Long Harbour to play a direct role in the creation of wind-driven currents in the top few metres. Since winds are predominantly from the southwest (into the bay), there is a tendency for the wind-driven currents to push water against the shore and reverse direction at deeper levels. Reversals in currents were measured by an acoustic Doppler current profiler (ADCP) deployed in 32 m of water west of the existing wharf.

Reversals in currents are also produced by internal waves whenever there are internal density boundaries, a source of energy such as the wind, and bathymetric features such as the mound in the central region of the southern arm. The mean currents at the location of the ADCP were low, varying from 3.9 cm/s at a depth of 6 m to 2.7 cm/s at a depth of 26 m.

Trites (1969), using surface drogues at a depth of 6 m, showed that wind direction influences the amount of Placentia Bay water entering Long Harbour. When the winds are from the northeast, directed out of the harbour, there is a strong outflow of surface-layer water on the north side of Long Harbour and a small inflow of surface water on the south side. When the winds are from the southwest (the dominant direction) there is a strong inward flow on the south side of the harbour.

Current data collected at a depth of between 6 and 7 m in the southern arm of the harbour are shown in Figure 5.7. South of Crawley Island, the current flows towards the east along the southern shore. West of the existing wharf, the current flows in all directions. East of Crawley Island, the flow is towards the southwest, following the bathymetric contours around the eastern side of the island.

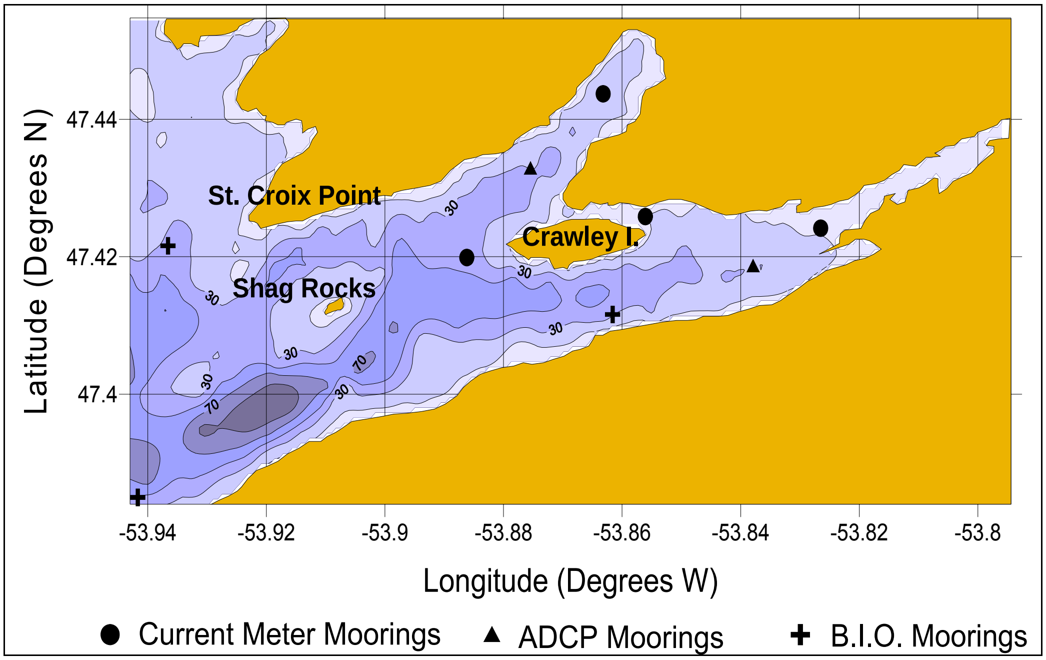


Figure 5.6 Locations of Current Meter Moorings in Long Harbour

The surface currents are toward the northeast in St. Croix Bay because of the predominantly southwest winds (Figure 5.8). The flow had two preferred directions at the entrance to St. Croix Bay, northeast and southwest. The mean current speed was 3.3 cm/s and the maximum speed was 20.3 cm/s.

The general circulation pattern in the outer section of Long Harbour is shown in Figure 5.9. The BIO data from 1969, measured at the southern entrance to the harbour at a depth of 72 m, show that the current is flowing into the harbour on the southern side. The current measurements by Oceans Ltd. at a depth of 25 m west of Crawley Island show that the current is mainly towards the northeast, with a mean speed of 5.7 cm/s and a maximum speed of 28.9 cm/s. At the northern entrance to the harbour, the BIO data measured at 4 m depth had a mean speed of 8.8 cm/s and a maximum speed of 38.8 cm/s, directed towards the northwest, out of the harbour. The current measurements indicate that, in general, the flow is directed into the harbour on the southern side and out of the harbour on the northern side, with an exchange between north and south taking place between Shag Rocks and Crawley Island.

5.4.5 Water Properties

Temperature and salinity data were collected by MUN, April-June, 1998 and 1999. Temperature increased and salinity decreased from April to June (Hart et al. 1999) in the upper 50 m of the water column throughout the bay. The increase in temperature was attributed to general atmospheric warming from spring to summer, and the decrease in salinity was due to local river runoff and increased precipitation during spring. This pattern was reversed at depths greater than 55 m. The temperatures decreased from April to June and the salinities increased. The temperatures ranged from 0.1°C in April

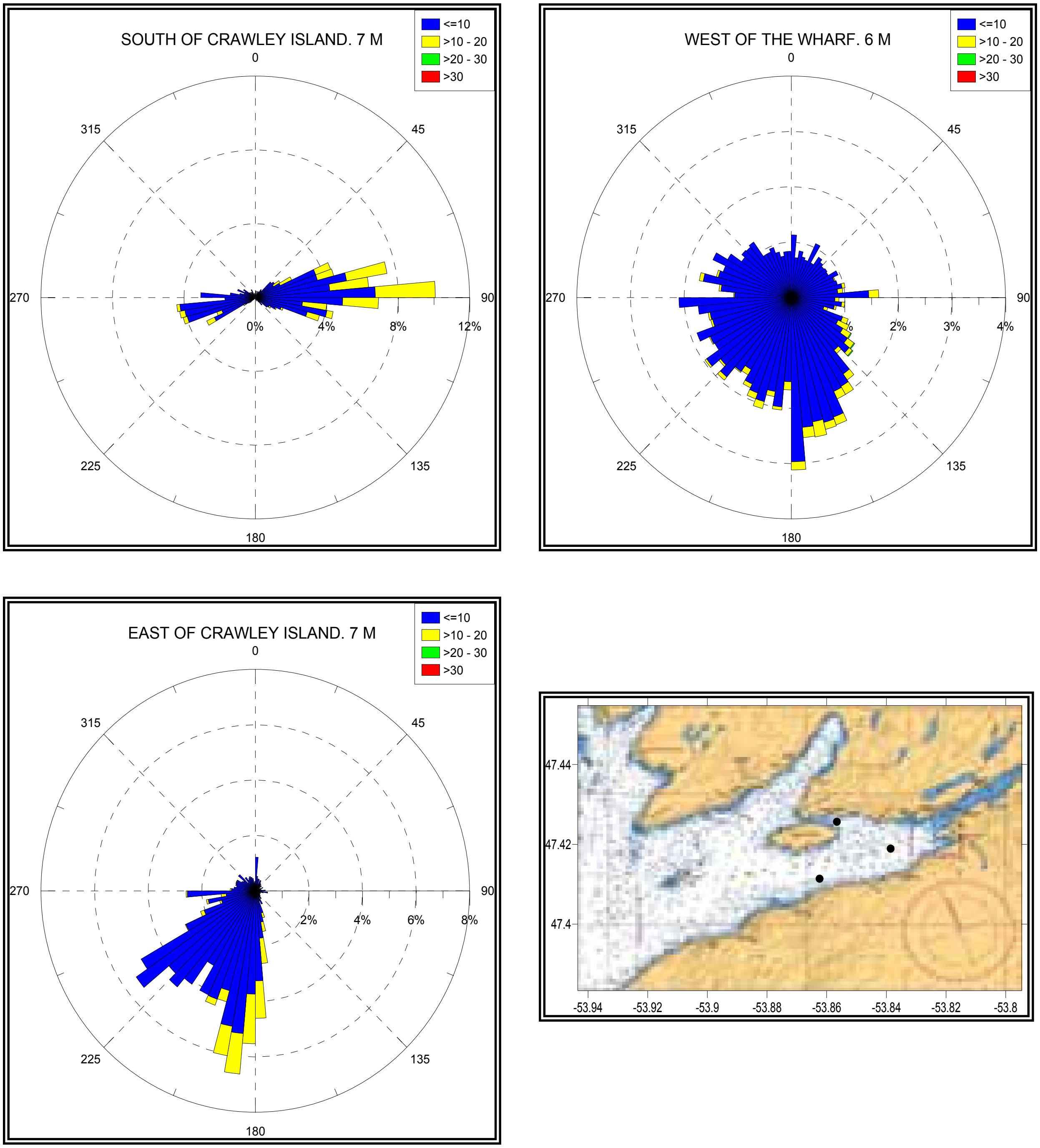


Figure 5.7 Rose Plots of Current Speeds and Directions in the Southern Arm of Long Harbour, and Sampling Sites

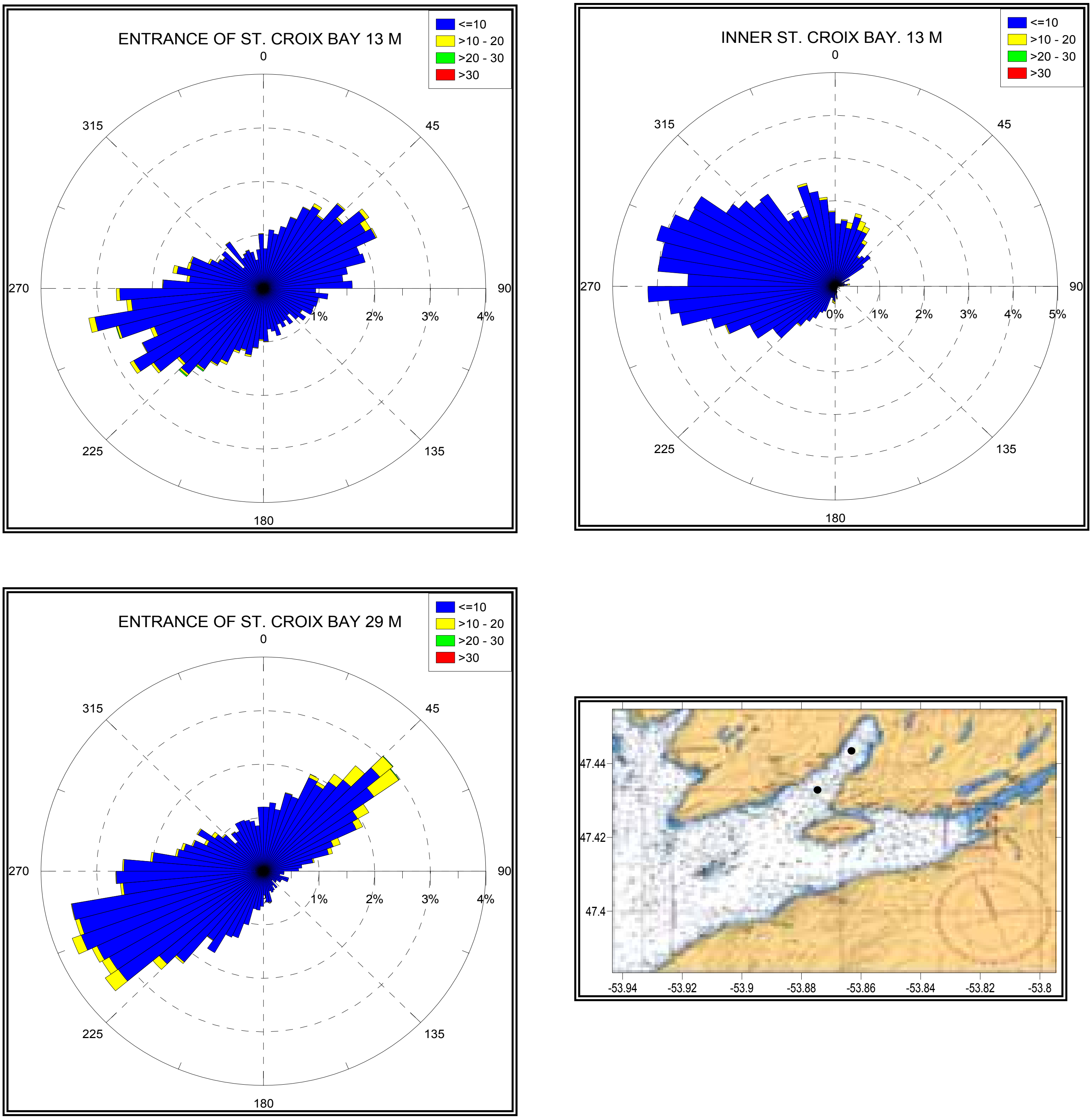


Figure 5.8 Rose Plots of Current Speeds and Directions in St. Croix Bay, and Sampling Sites

to 11.2°C in June for near-surface depths (Hart et al., 1999). At deeper levels the temperatures ranged from 1.2°C to -0.5°C.

Additional information on the spatial distribution of temperature and salinity in Placentia Bay was obtained from BIO. Figure 5.10 shows the warming trend that takes place during the summer season. The surface temperatures varied between 13°C in the middle of the bay to 19°C at the head of the bay in August. Figure 5.11 shows the decrease in salinity as summer progresses, and the lower salinity caused by river runoff in June at the head of the bay and near the shore. Temperature decreases and salinity increases between June and August at a depth of 100 m. The coldest water (-1.3°C) is present near the mouth of Placentia Bay.

Limited amounts of CTD data are available for the winter months. In general, during winter the horizontal fields of temperature and salinity appear to display a great degree of homogeneity. The temperature varied between -0.8°C near the mouth of Placentia Bay to 0°C near the head of Placentia Bay and along the western shore at the surface during February. On the eastern side of the bay the surface temperature varied between -0.4°C and -0.6°C. Similar characteristics were observed at deeper levels. The salinity was slightly higher at the mouth of the bay and along the eastern shore than elsewhere, corresponding to the lower water temperature.

Temperature-salinity (TS) profiles of the water properties at the mouth of Placentia Bay, and for Labrador Current water northwest of Green Bank, display water properties that are almost identical, which means that the water entering Placentia Bay is Labrador Current water.

CTD measurements were conducted by Oceans Ltd. in Long Harbour on May 17, July 11 and August 16, 2006 (Oceans Ltd. 2007). The most significant feature is the presence of a deep mixed layer to a depth of approximately 25 m, below which exists a sharp pycnocline between 25 m and 30 m, and then a weak stratified water mass near the bottom. The local wind mixing in Long Harbour only extended to depths between 4 m and 8 m. Figure 5.12 compares the water structure within Long Harbour to that in Placentia Bay. The depth profiles indicate that the 25 m mixed layer in Long Harbour is water transported from Placentia Bay.

The mass transport from Placentia Bay to Long Harbour serves as an efficient flushing agent, replacing water in the outer section of the harbour in a relatively short time. The flushing time of water above 20 m is calculated to vary between 10 and 15 days during summer (Oceans Ltd. 2007).

The Vale Inco NL oceanographic studies by Oceans in 2006 (LGL 2007) indicated an area of oceanographic mixing between Shag Rocks and Crawley Island. As a result, a general area about 5 to 6 km off the existing wharf (Figure 7.8) was selected as a suitable outfall location: the treated effluent would be well mixed with surrounding water, and any potential contaminants would not be returned into inner Long Harbour or accumulate in the water or sediments of the harbour or of Placentia Bay.

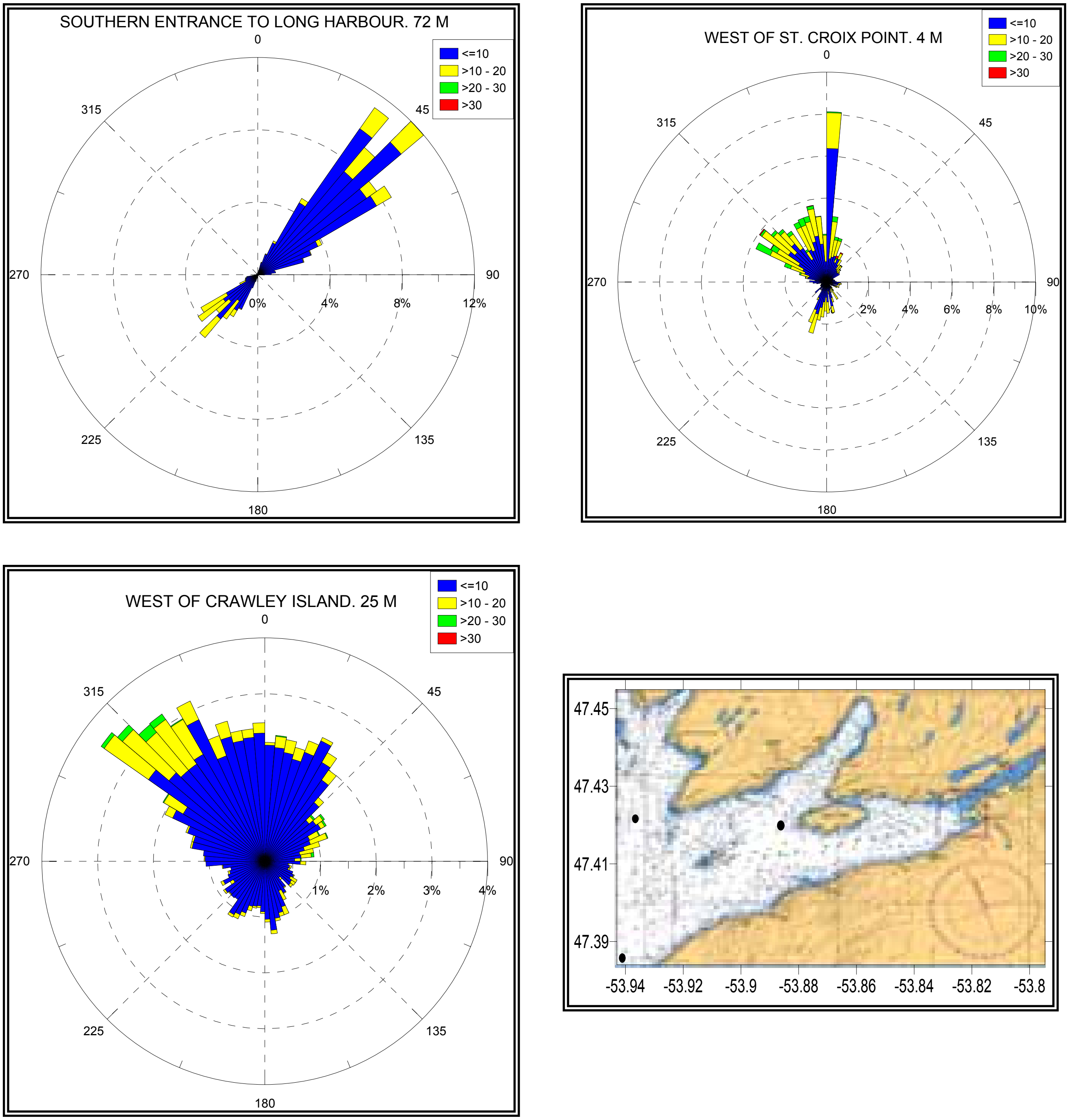


Figure 5.9 Rose Plots of Current Speeds and Directions in the Outer Section of Long Harbour, and Sampling Sites

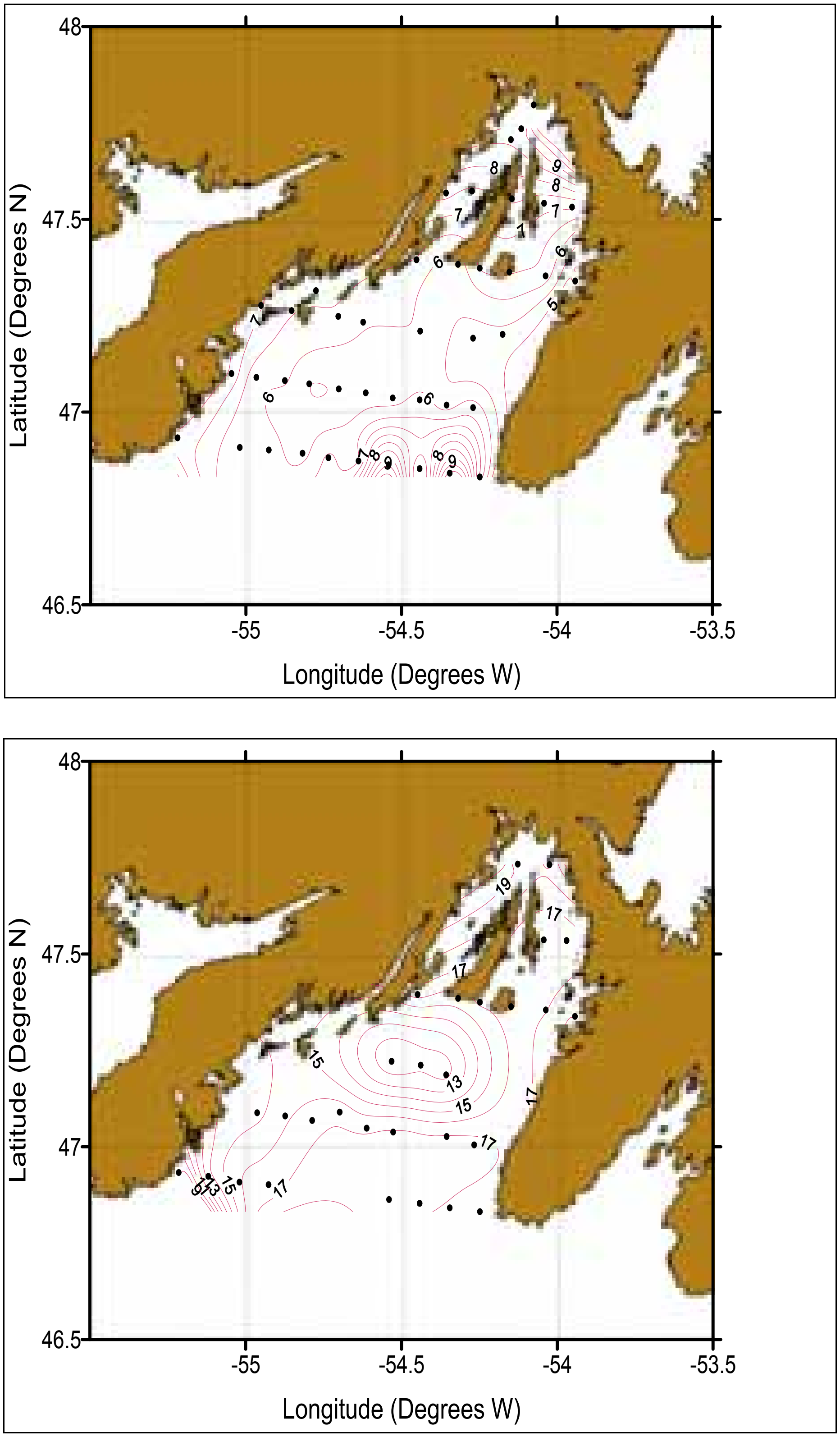
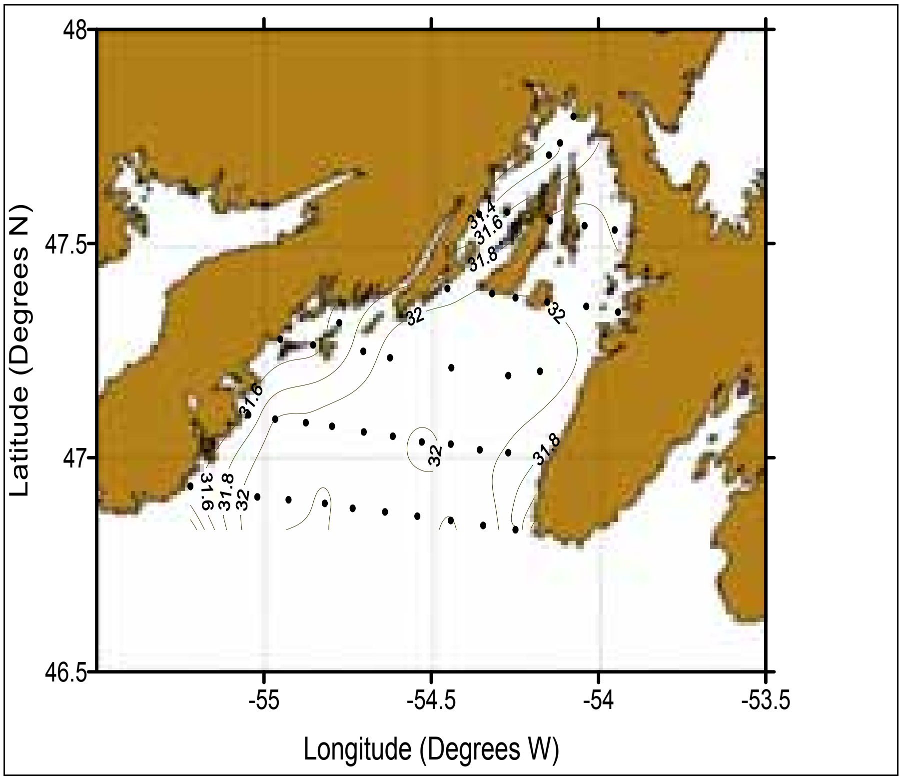


Figure 5.10 Temperature (°C) Distributions in June (above) and August (below), 1998



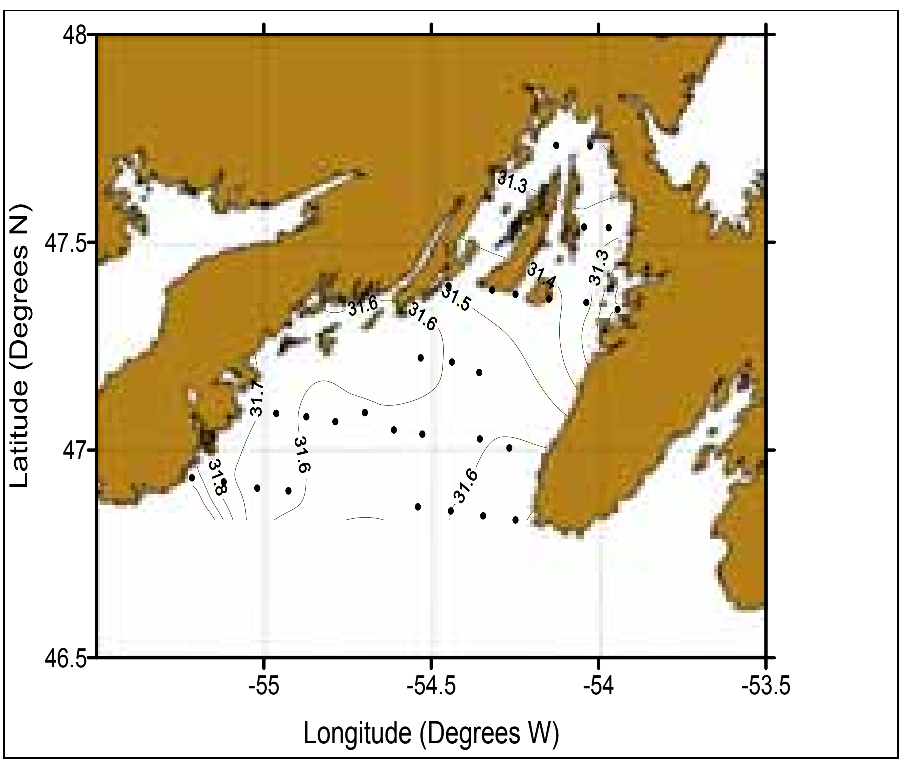


Figure 5.11 Surface Salinity (psu) Distribution in June (above) and August (below), 1998

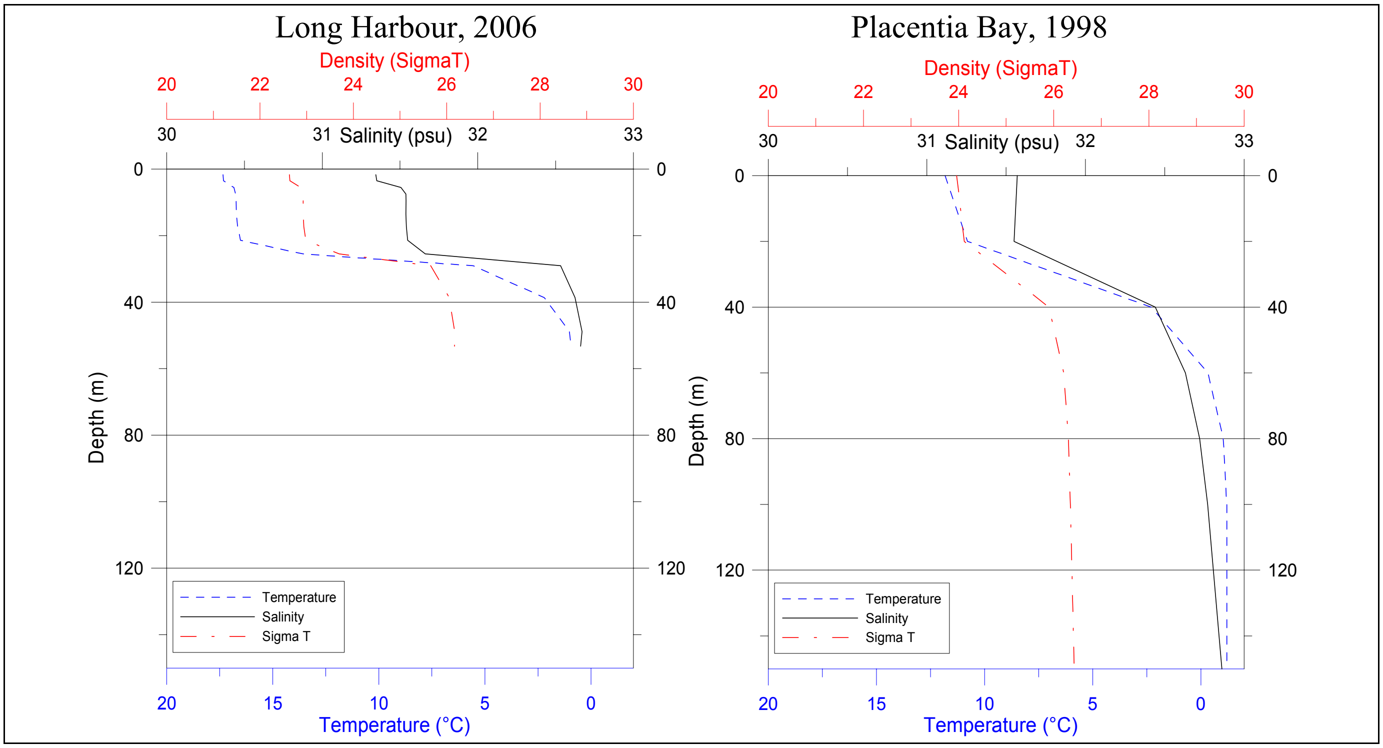


Figure 5.12 Water Structure in Long Harbour and Placentia Bay

5.4.6 Wave Climate

There are four parameters for describing wave conditions. Significant wave height is defined as the average height of the 1/3 highest waves, and its value roughly approximates the characteristic height observed visually. Maximum height is the greatest vertical distance between a wave crest and adjacent trough. Spectral peak period is the period of waves with the largest energy levels. The characteristic period is the period of the 1/3 highest waves as reported in ship observations contained in the Atmospheric Environment Service (AES) AES40 data set.

A swell is a wave system not produced by wind blowing at the time of observation. Swells are created at some distance and propagate to the vicinity of the observation area. Swell waves travel out of a stormy or windy area and continue in the direction of the winds that originally formed them. The swell may travel for thousands of miles before dying away. As the swell advances, its crest becomes rounded and its surface smooth. Sea state may be composed of the wind wave alone, swell alone, or the wind wave in combination with one or more swell groups.

In the absence of long-term wave measurements for Placentia Bay, hindcasted wave data from the AES40 Grid Point 5616 were used for analysis. The wave climate in Long Harbour was modeled using wind data from Long Harbour and Argentia (Oceans Ltd. 2007).

Fetch, the maximum unobstructed distance of open water over which the wind can travel, is an important factor in the formation, size and power of waves. The majority of wave energy at Grid Point 5616 is from the south, because it is located in the mouth of Placentia Bay where the waves are fetch-limited in a clockwise direction from west to east. The rose plot from the AES40 data (Figure 5.13) shows that the majority of wave directions are from the southwest to south, with 36 per cent of the wave energy coming from the south and 29 per cent from the southwest.

Significant wave heights in Placentia Bay are greater during the winter months, with the mean monthly values reaching 2.2 m in December and January. Since winds are predominantly from the west and northwest during the winter months, wind waves are generally fetch-limited. As a result, mean significant wave heights in Placentia Bay during the winter are lower than would be expected in the open ocean. Lower significant wave heights occur in the summer, with a mean monthly significant wave height of only 1.2 m. Mean significant wave height values from the SmartBay buoy recently deployed in Placentia Bay are similar to the AES40 data shown in Table 5.2. The highest significant wave height of 9.2 m from the.AES40 data set occurred twice, in 1963 and 1976 (Table 5.2).

The SmartBay buoy recorded a maximum significant wave height of 9.1m with an average period of 11.3 seconds on January 27, 2007, as a 952 mb low pressure passed directly over the area. Wind speeds recorded at the buoy were moderate southerly at the time and not significant enough to account for the extreme significant wave height recorded during this event. Storm surge resulting from the low pressure passing directly over the buoy would account for some of the height and a significant portion would be attributed to swell energy propagating into Placentia Bay.

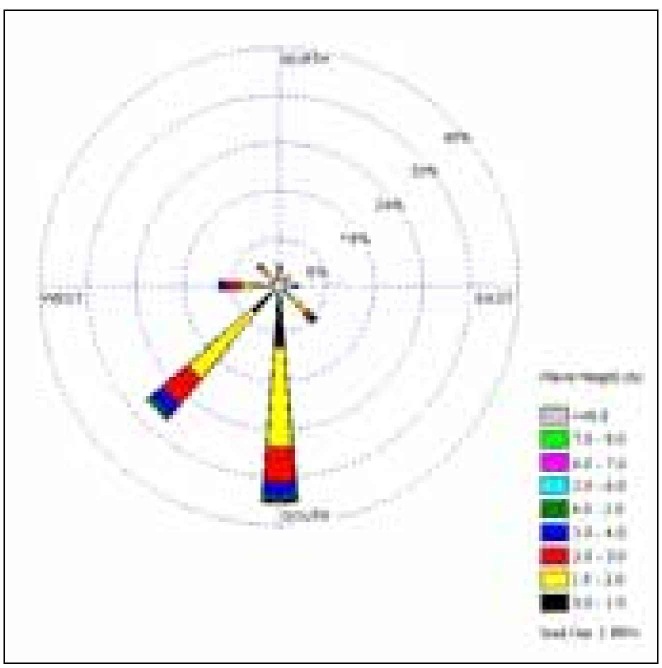


Figure 5.13 Annual Wave Rose from the AES40 Grid Point 5616

Table 5.2 Mean Monthly Significant Wave Heights and Maximum Significant Wave Heights in Placentia Bay

	Significant Wave Height (m)		Maximum Significant Wave Height (m)	
Month	**AES40**	**Smart Bay**	**AES40**	**Smart Bay**
January	2.2	2.1	8.8	9.1
February	2.1	N/A	8.8	N/A
March	1.9	N/A	9.2	N/A
April	1.6	N/A	6.5	N/A
May	1.3	N/A	6.0	N/A
June	1.2	N/A	4.1	N/A
July	1.2	N/A	4.5	N/A
August	1.2	N/A	5.5	N/A
September	1.4	1.5	6.8	6.2
October	1.6	1.8	8.3	5.6
November	1.9	1.4	7.1	3.7
December	2.2	2.5	9.2	5.7
Note: SmartBay data is from September 01, 2006, to January 31, 2007.				

The second highest significant wave height of 6.2m with a mean period of 9.6 seconds recorded by the SmartBay buoy occurred on September 13, 2006. During this event, the remnants of Hurricane Florence moved slowly northeast, crossing the Avalon Peninsula early in the evening on that day. Winds speeds recorded by the SmartBay buoy reached 80.9 km/hr from the east-northeast. As with the previous low, the majority of this energy was swell propagating into Placentia Bay from the south.
An annual histogram of the frequency distribution of significant wave heights is presented in Figure 5.14 and the percentage occurrence of significant wave height for each month is shown in Table 5.3 and Figure 5.15; the figure shows that 47 per cent of significant wave heights lie between 1 and 2 m. There is a significant decrease in frequency of wave heights above 2 m, and only 9.8 per cent of the wave heights exceed 3 m. Wave heights greater than 5 m are very rare and make up less than 1 per cent of the data set.

The spectral peak period of waves varies with season, with the most common period varying from seven seconds in the summer months to 11 seconds during the winter. The most common peak spectral period in February is 11 seconds, occurring 14.8 per cent of the time. The most common peak spectral period annually is seven seconds, occurring 17.1 per cent of the time. The peak spectral period reaches above 11 seconds 9.1 per cent of the time. These longer spectral peak periods usually occur during the winter months.

A scatter diagram of the significant wave height versus spectral peak period is presented in Table 5.4, which shows that the most common wave has a significant wave height of 1 m, with a peak spectral period of seven seconds. The second most common wave has a significant wave height of 1 m and a peak spectral period of eight seconds. The 9 m significant wave heights typically coincide with peak spectral periods between 13 and 15 seconds; however, these heights occur very infrequently.

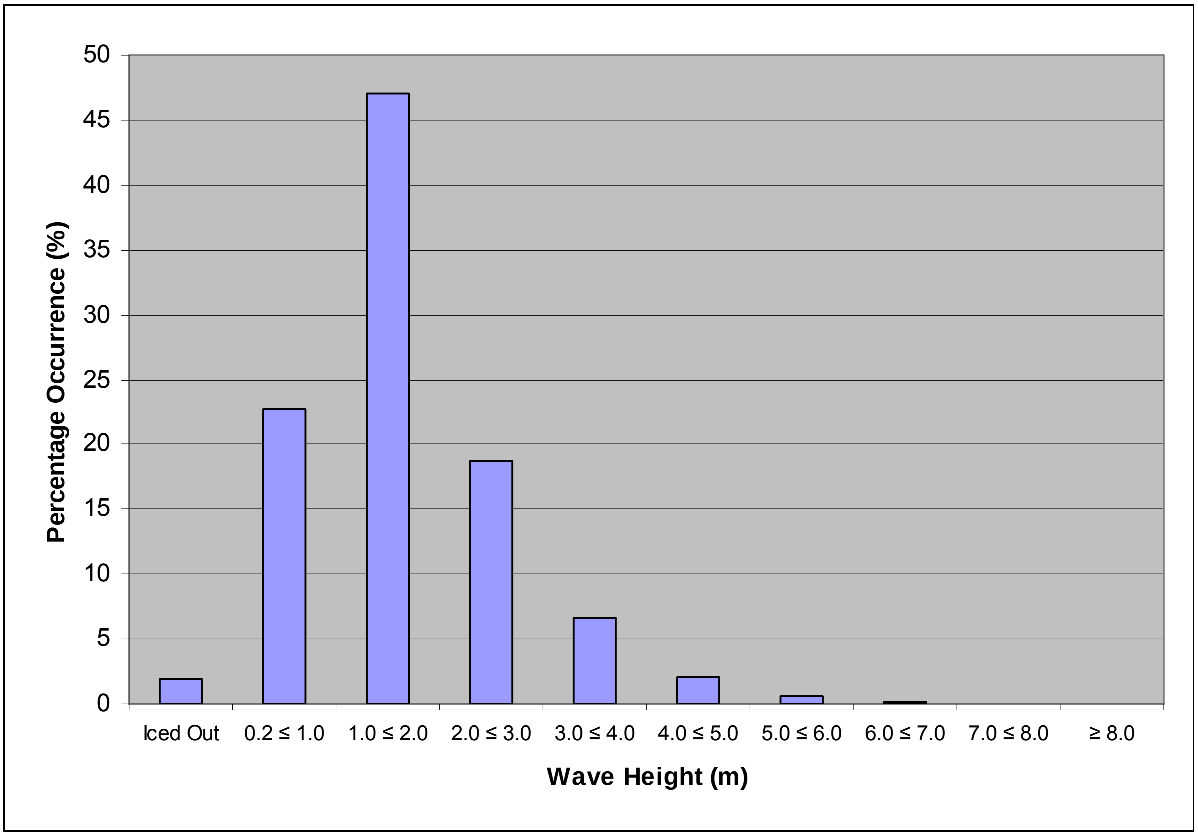


Figure 5.14 Frequency of Occurrence of Annual Significant Wave Heights at Grid Point 5616

Table 5.3 Percentage Occurrence of Significant Wave Heights at Grid Point 5616

Month	Significant Wave Height (metres)										Total
	0.0 - 0.9	**1.0 - 1.9**	**2.0 - 2.9**	**3.0 - 3.9**	**4.0 - 4.9**	**5.0 - 5.9**	**6.0 - 6.9**	**7.0 - 7.9**	**8.0 - 8.9**	**9.0 - 9.9**	
January	7.71	37.90	31.45	14.62	5.28	2.20	0.62	0.13	0.08		100
February	9.45	40.51	29.39	13.78	4.59	1.62	0.45	0.17	0.04		100
March	15.29	42.45	27.18	10.72	3.12	1.08	0.12	0.02		0.02	100
April	22.34	48.45	22.03	6.12	0.96	0.09	0.02				100
May	39.84	47.99	9.91	1.94	0.26	0.03	0.02				100
June	43.32	48.94	6.85	0.85	0.03						100
July	42.50	52.23	4.71	0.44	0.13						100
August	43.55	50.08	5.76	0.55	0.05	0.02					100
September	32.85	52.32	12.20	1.90	0.60	0.08	0.05				100
October	22.29	52.76	18.98	4.73	0.87	0.19	0.13	0.03	0.02		100
November	15.13	46.90	25.65	8.27	2.83	0.93	0.27	0.02			100
December	10.29	40.24	29.52	12.90	4.82	1.63	0.44	0.11	0.03	0.02	100
Year	25.65	46.82	18.43	6.29	1.93	0.65	0.17	0.04	0.01		100

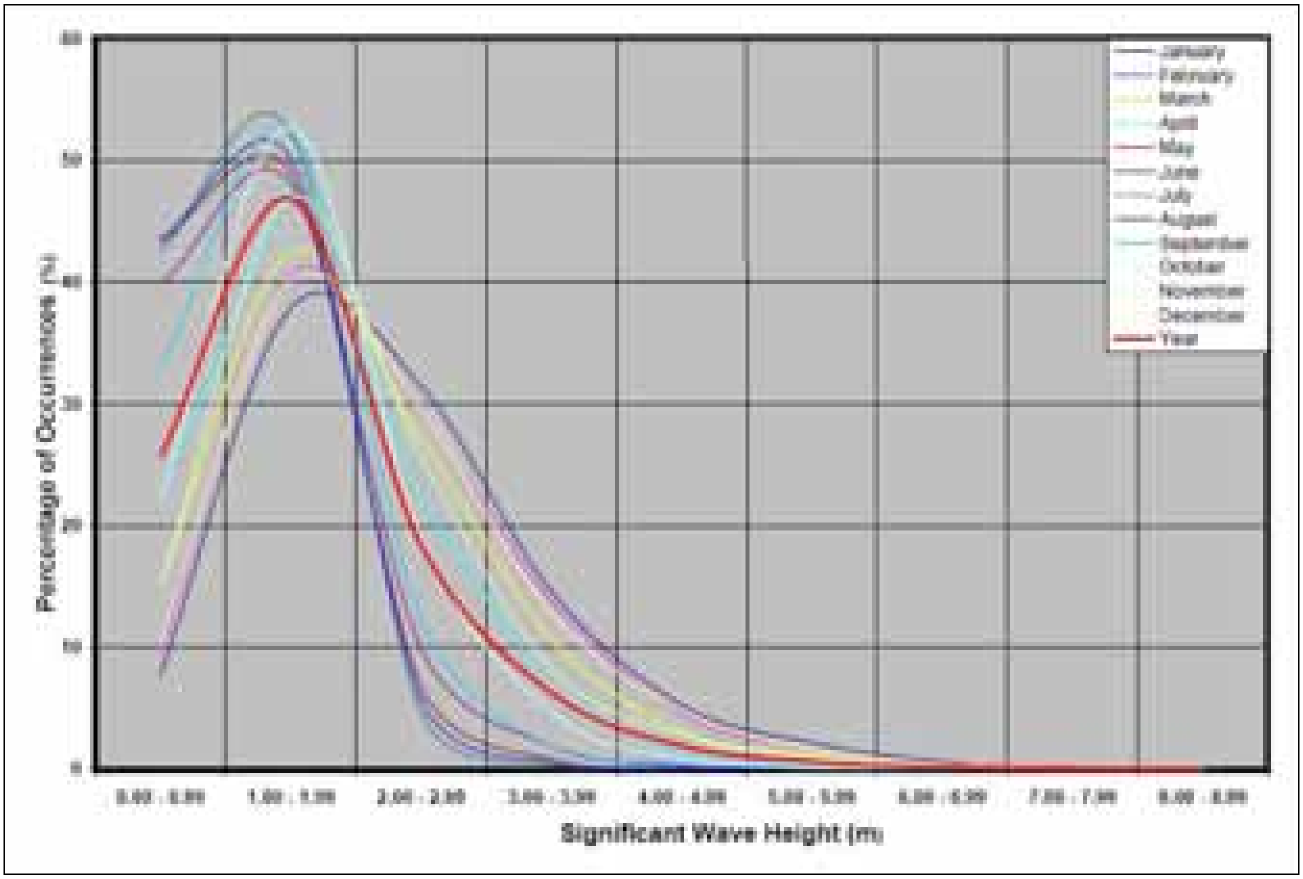


Figure 5.15 Percent Occurrence of Significant Wave Height by Month at GP5616

5.4.7 Extremal Wave Analysis

Extreme wave values were calculated from the MSC50 dataset. These results are an improvement on the AES40 data for modeling the Canadian East Coast, since they provide significantly higher resolution while including shallow water physics. As well, the spatial resolution was increased to 0.1° and the temporal resolution to 1 hour. These improvements over the AES40 reduce the uncertainty in any climate or design data statistics produced from the hindcast database (Swail, 2006). Extreme wave estimates were calculated for return periods of 1, 10, 25, 50 and 100 years from the MSC50 database and compared to estimates from the AES40 database using a Gumbel distribution and peak-over-threshold method. Grid point 11365, located at 46.9°N; 55.0°W from the MSC50 database and grid point 5616, located at 46.875°N; 55.000°W from the AES40 database were used to make a comparison between these two databases. A sensitivity analysis showed that the Gumbel distribution had a good fit using 269 storms from the MSC50 database and 158 storms from the AES40 database, corresponding to a significant wave height threshold of 5.5 m for both databases. Due to the higher resolution of the MSC50 database, a greater number of storms were found to meet the threshold value. Since the values in the AES40 database were only for every 6 hours, waves that reached 5.5 m between the time-steps were not included in the extreme analysis. The increase in the number of storms in the MSC50 database translates into an increase in wave energy, resulting in higher extreme waves. Annual extreme significant wave height, extreme maximum wave height and associated peak period estimates for both the MSC50 and AES40 databases are presented in Table 5.5.

Table 5.4 Per Cent Frequency of Occurrence of Significant Combined Wave Height and Peak Spectral Period at Grid Point 5616

		Significant Combined Wave Height (m)													**Total**
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	
Peak Spectral Period	**0**														0.00
	1														0.00
	2														0.00
	3	0.16													0.16
	4	4.30	0.11												4.41
	5	8.51	1.92	0.01											10.44
	6	4.41	7.75	0.14											12.31
	7	9.04	4.89	2.46	0.04										16.42
	8	8.48	2.40	1.87	0.51	0.01	0.00								13.28
	9	6.89	3.51	1.14	0.62	0.09	0.00								12.26
	10	3.82	4.37	1.28	0.51	0.22	0.03								10.23
	11	2.02	3.10	1.65	0.46	0.19	0.05	0.01							7.50
	12	1.14	1.32	1.40	0.58	0.21	0.08	0.02	0.00						4.75
	13	0.67	0.48	0.54	0.51	0.17	0.10	0.03	0.01	0.00					2.52
	14	0.31	0.16	0.18	0.15	0.13	0.05	0.02	0.01	0.01					1.02
	15	0.12	0.03	0.02	0.03	0.02	0.01	0.00	0.00	0.00					0.23
	16	0.11	0.02	0.01	0.01	0.00	0.00								0.15
	17	0.04	0.00			0.00	0.00								0.05
	18	0.00													0.00
	19	0.00													0.00
	20														0.00
		50.02	30.08	10.71	3.42	1.06	0.34	0.08	0.02	0.01	0.00	0.00	0.00	0.00	95.73

Source: AES grid point 5616. 46.875N 55.00W, 1954 to 2004.

Table 5.5 Extreme Wave Estimates for Placentia Bay

	MSC50 Grid Point 11365			**AES40 Grid Point 5616**		
Return Period (years)	**Significant Wave Height (m)**	**Maximum Wave Height (m)**	**Associated Peak Period (m)**	**Significant Wave Height (m)**	**Maximum Wave Height (m)**	**Associated Peak Period (m)**
1	7.3	13.2	12.6	6.6	12.3	12.5
10	9.2	16.5	13.6	8.2	15.2	13.9
25	9.9	17.7	13.9	8.8	16.3	14.4
50	10.4	18.7	14.2	9.3	17.2	14.8
100	11.0	19.6	14.4	9.8	18.0	15.1

5.4.8 Joint Probability of Extreme Wave Heights and Spectral Peak Periods

An environmental contour plot Figure 5.16 shows the probability of the joint occurrence of significant wave heights and the spectral peak periods using the methodology of Winterstein et al. (1993). The wave heights were fitted to a Weibull Distribution and the peak periods to a lognormal distribution. The values for the significant wave height estimates and the associated spectral peak periods are given in Table 5.6. The 100-year extreme wave height using the Weibull Distribution on the complete data set was 10.1 m as compared to 9.8 m using a Gumbel Distribution on a selected number of storms.

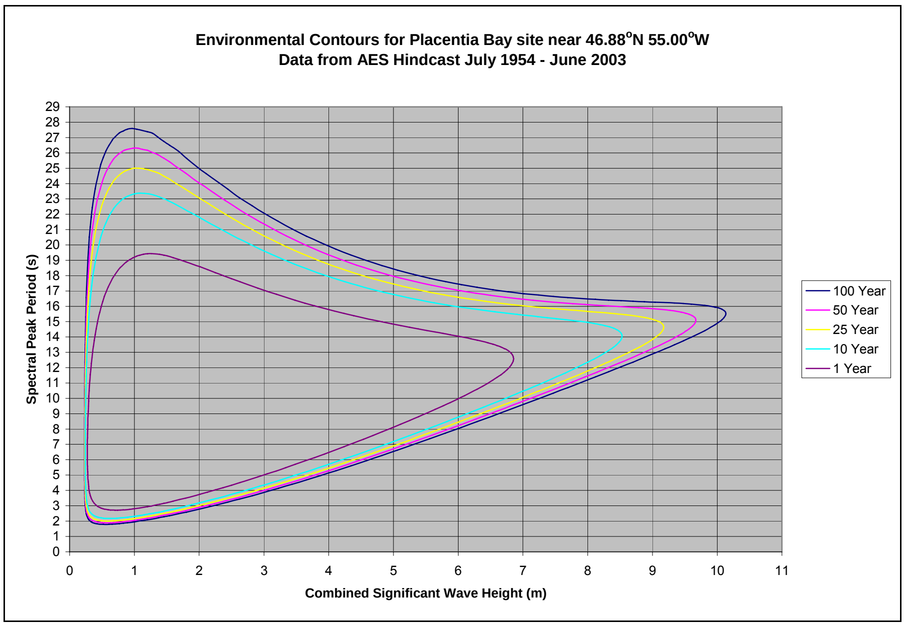


Figure 5.16 Environmental Contour Plot for Placentia Bay

Table 5.6 Extreme Wave Estimates and Spectral Peak Periods for all Months Combined

Return Period (years)	Significant Wave Height (m)	Spectral Peak Period (s) Median Value	Peak Period (s) Lower limit	Peak Periods (s) Upper Limit
1	6.9	12.6	9.7	16.3
10	8.5	14.1	11.7	17.0
25	9.2	14.6	12.4	17.3
50	9.7	15.1	13.0	17.6
100	10.1	15.5	13.5	17.8

5.4.9 Sea Ice in Placentia Bay

A weekly analysis of the Canadian Ice Service 30-Year Frequency of Presence of Ice in Placentia Bay reveals that ice is present in Placentia Bay only from mid-February until late April. A graph of the frequency of occurrence of sea ice in Placentia Bay is presented in Figure 5.17. The predominant type is either new (recently formed, having a thickness of less than 10 cm), grey (young ice between 10 and 15 cm thick) or grey-white (young ice 15 to 30 cm thick). The likelihood of ice in Placentia Bay is highest during the week beginning February 26, at which time there is 4 per cent chance that 11.5 per cent of the bay will be covered, a 42.6 per cent chance of 7 per cent coverage, and a 45.7 per cent chance of 10 per cent coverage.

During March, first-year ice (young ice with a thickness between 0.3 and 2 m) either forms within the bay or flows around the Avalon Peninsula and enters the bay. By the week of March 19, first-year ice is predominant and remains until the week of April 23. The presence of sea ice within Placentia Bay begins to decrease during the week of April 2, and insignificant amounts remain after the week of April 23.

5.4.10 Sea Ice in Long Harbour

The frequency of occurrence of sea ice in Long Harbour is presented in Figure 5.18. Sea ice is no longer present in Long Harbour after the week of April 2.

5.4.11 Icebergs

An analysis was performed to assist in determining the potential threat to shipping posed by icebergs in Placentia Bay using International Ice Patrol (IIP) Iceberg Sightings Database, 1974-2003, as the primary data source (NSIDC 1995).

Figure 5.19 shows the positions of all icebergs within Placentia Bay from 1974 to 2003. Only 30 icebergs have been sighted inside the bay over those 30 years. Sightings occurred more frequently on the eastern side of the bay. Environmental factors such as iceberg concentration, ocean currents and wind determine if icebergs will move into the bay. There are not enough sightings to establish an iceberg drift pattern within the bay. It should also be noted that these sightings occurred in only seven years; the bay was iceberg free for 23 years.

Iceberg sightings in Placentia Bay appear to be limited to years when there was a high concentration of icebergs below 48°N, although this does not necessarily indicate the presence of icebergs in the bay. Iceberg sightings were limited to March, April, May and June.

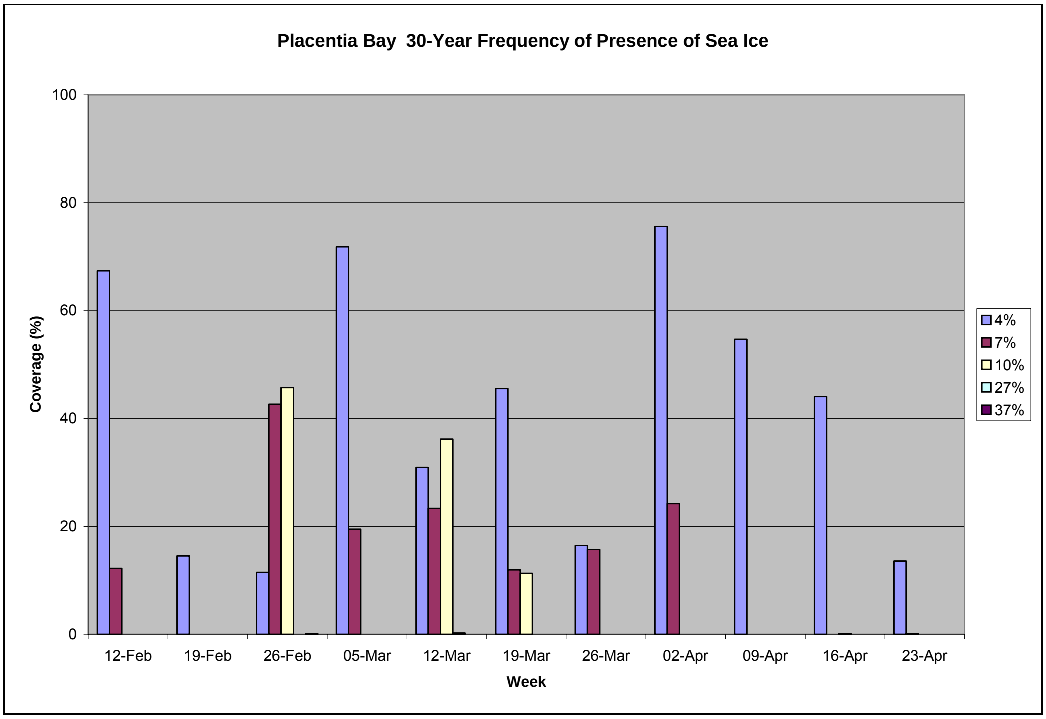


Figure 5.17 Frequency of Presence of Sea Ice in Placentia Bay (1971-2000)

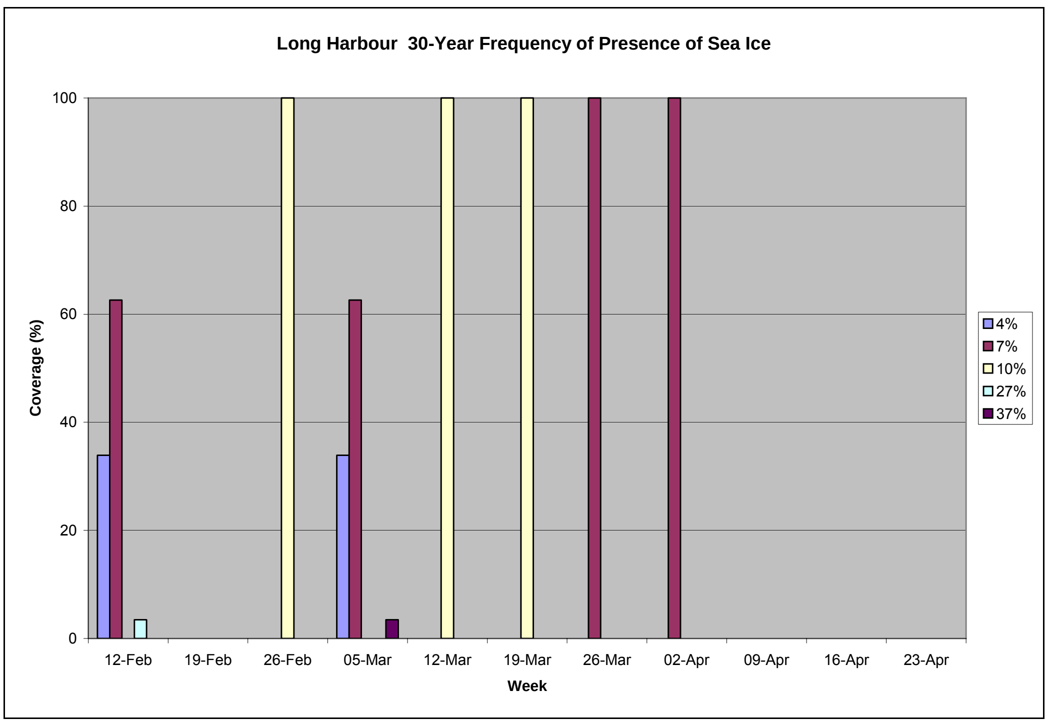


Figure 5.18 Frequency of Occurrence of Sea Ice at Long Harbour (1971-2000).

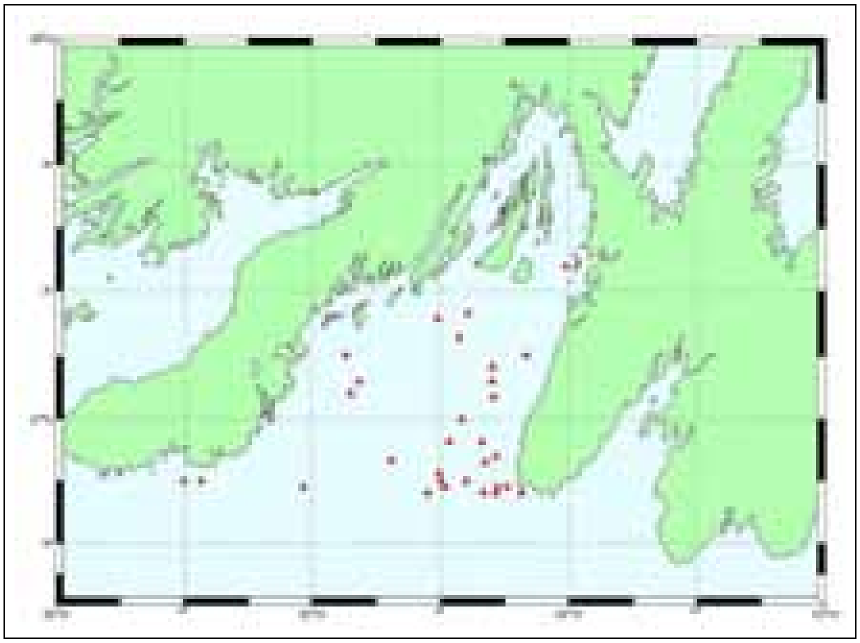


Figure 5.19 Iceberg Sightings in Placentia Bay, 1974 – 2003

Source: IIP.

5.4.12 Storm Surges

A storm surge is a pronounced increase in sea level associated with the passage of storm systems, and defined as the difference between the observed water level and the predicted astronomical tide. This is typically the result of wind stress and low atmospheric pressure.

A study of extreme storm surges in the northwest Atlantic, using a 40-year hindcast (Bernier and Thompson 2006), showed a 40-year return period storm surge of 0.7 m for the south coast of Newfoundland. The height could exceed 0.7 m near the shoreline because of shoaling and funnelling effects in shallow or restricted areas.

The Center for Marine Environmental Prediction at Dalhousie University maintains a Flooding Forecast Service for Atlantic Canada; their model results are used by Environment Canada in issuing storm surge warnings. The model results have been available for Argentia since January 2003. The observed storm surge values since January 2003 show many occasions when the sea level exceeded the tidal level by more than 0.5 m, and two occasions (February 2003 and January 2004) when the sea level was approximately 0.9 m and 1.0 m, respectively, above the tidal height.

The tidal heights for various stations in Placentia Bay are presented in Table 5.7 (DFO 2007). The tidal heights are referenced to chart datum.

Figure 5.20 and 5.21 show the recorded sea level and storm surge heights, along with output from the storm surge forecast model for February 2003 and January 2004.

Table 5.7 Placentia Bay Tidal Data

	Mean Water	Range (m)		High Water (m)		Low Water (m)		Recorded Extremes (m)	
Port		Mean Tide	Large Tide	Mean Tide	Large Tide	Mean Tide	Large Tide	Highest High Water	Lowest Low water
Argentia	1.3	1.6	2.5	2.2	2.6	0.6	0.1	3.1	-0.3
Burin		1.5	2.2	2.1	2.1	2.3	2.4		
South East Bight		1.3	2.1	2.0	1.8	2.4	2.2		
Tacks Beach	1.1	1.6	2.4	2.0	2.0	2.1	2.0		
Woody Island	1.2	1.6	2.5	2.1	2.1	2.2	2.1		
North Harbour	1.4	1.7	2.5	2.4	2.3	2.3	2.3		
Come By Chance	1.4	1.6	2.5	2.3	2.3	2.4	2.3		
Arnold's Cove	1.4	1.7	2.5	2.4	2.3	2.3	2.3		
Long Harbour	1.5	1.7	2.7	2.5	2.5	2.4	2.3		
St. Bride's	1.2	1.6	2.5	2.1	2.1	2.1	2.0		

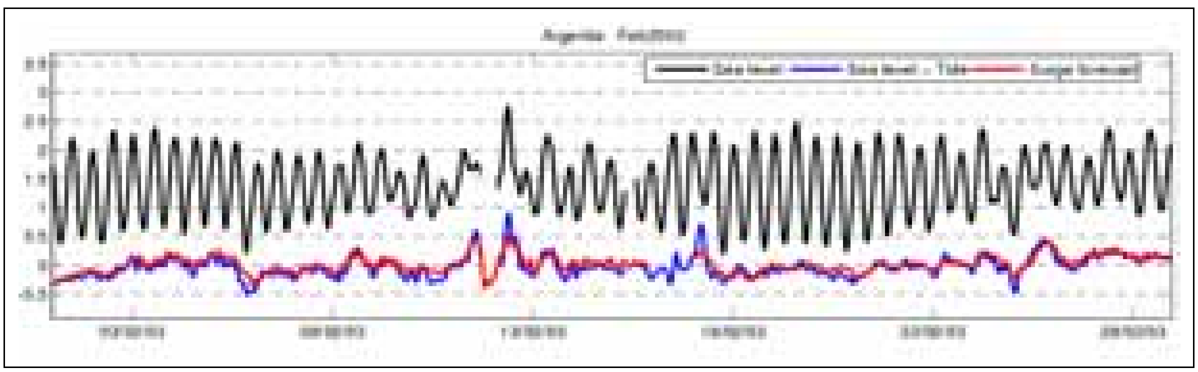


Figure 5.20 Plot of Observed Sea Level along with Forecasted and Actual Storm Surge for Argentia, Newfoundland in February 2003

Source: http://eero.ocean.dal.ca:8080/cmep_ca/

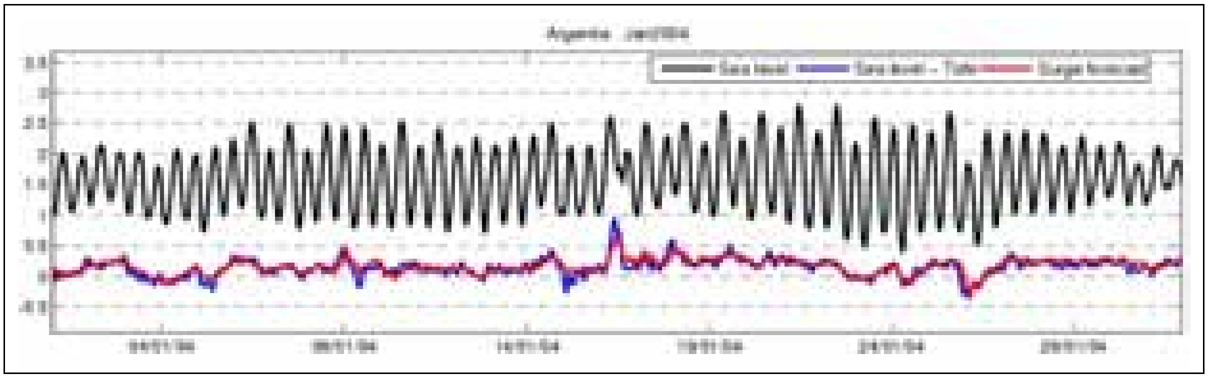


Figure 5.21 Plot of Observed Sea Level along with Forecasted and Actual Storm Surge for Argentia, Newfoundland in January 2004

Source: http://eero.ocean.dal.ca:8080/cmep_ca/

On January 16, 2004, a low pressure area deepened to 951 mb along the south coast of Newfoundland, moving inland to lie over central Newfoundland by afternoon. The low pressure area slowed over Newfoundland, resulting in a prolonged period of strong to gale force winds from the south to southwest over Placentia Bay. These winds created a storm surge near 1.0 m in height in Placentia Bay, resulting in the sea level at Argentia rising to 2.6 m due to combined tidal and storm surge heights.

Negative storm surges associated with offshore winds can result in a pronounced decrease in water level below the astronomical tide level. These events are of concern to mariners since they can create unusually shallow water if they occur near low tide. In December 2006 a negative storm surge of -0.7 metres was recorded at Argentia, the result of an intense low pressure system passing west of Placentia Bay. As the system passed, strong to gale-force northerly winds were generated over the bay, resulting in offshore winds forcing water out of the bay.

5.5 Climate

The Island of Newfoundland has a maritime climate, with the ocean having a moderating effect on temperature. In general, maritime climates experience cooler summers and milder winters than do continental climates, and have a much smaller annual temperature range. A maritime climate tends to be fairly humid, resulting in reduced visibilities and low cloud, and receives significant amounts of precipitation. The Newfoundland climate is governed by the passage of high and low pressure circulation systems, embedded in and directed by the prevailing westerly flow that occurs in the upper levels of the atmosphere in the mid-latitude regions. This westerly flow is the consequence of the normal tropical-to-polar temperature gradient, the intensity of which determines the mean strength of the flow and the amount of energy available for the low pressure systems to draw on. During winter, when the temperature gradient is strongest, low pressure systems are generally more intense and tend to move faster than in the summer months.

Two main winter storm tracks, one from the Great Lakes Basin and the other from the Cape Hatteras–Cape Cod coastal area, direct low pressure systems toward Newfoundland and the Grand Banks (Bursey et al. 1977). The principal area of development of these low pressure systems extends from about Cape Hatteras to the waters around Newfoundland. The intensity of these systems ranges from relatively weak features to major winter storm systems, with many producing gale- to storm-force winds by the time they reach Newfoundland.

Tropical cyclones often move northward out of the influence of the warm waters south of the Gulf Stream, passing near the Island of Newfoundland. Once the cyclones move over colder waters they lose their source of latent heat energy and often begin to transform into fast-moving and rapidly developing extra-tropical cyclones, producing large waves and sometimes hurricane-force winds. Since 1950, 46 per cent of Atlantic Tropical cyclones transitioned into the extra-tropical stage. This extra-tropical transition occurs in the lower latitudes in the early and late hurricane season and at higher latitudes during the peak of the season (Hart, 2001).

Intense low pressure systems frequently become captured and slow down or stall as they move through the region. This may result in an extended period of little change in conditions that may range, depending on the position and overall intensity and size of the system, from relatively benign to severe.

Rapidly deepening storms occur south of Newfoundland in the vicinity of the warm water of the Gulf Stream. These explosively deepening oceanic cyclones, known as weather bombs, are defined as storms that undergo central pressure falls greater than 24 mb over 24 hours. Hurricane-force winds near the center, the outbreak of convective clouds to the north and east of the center during the explosive stage, and the presence of a clear area near the center in the mature stage (Rogers and Bosart 1986) are typical of weather bombs. These systems often pass near Placentia Bay.

There is a general warming of the atmosphere during spring due to increasing heat from the sun. This spring warming is greater in the north than at the equator, resulting in a decrease in the north-south temperature gradient. Storms tend to be weaker and more infrequent during the summer. Furthermore, the weaker tropical-to-polar temperature gradient in the summer results in the storm tracks moving farther north, with most storm systems passing over the Gulf of St. Lawrence and Labrador. As a result, gale or storm force winds are relatively infrequent over Newfoundland during summer.

Wind and wave climate statistics in Placentia Bay were extracted from the AES40 North Atlantic wind and wave climatology data set compiled under contract to Environment Canada. This data set consists of continuous wind and wave hindcast data in six-hour time steps for a 50-year period from 1954 to 2004, on a 0.625° latitude by 0.833° longitude grid. In this study, Grid Point 5616, located at 46°52´N; 55°00´W, was deemed to be most representative of conditions within Placentia Bay.

Air temperature, sea surface temperature, wind speed and direction, precipitation types and visibility statistics for Placentia Bay were compiled using data from the International Comprehensive Ocean-

Atmosphere Data Set (ICOADS). This material provides a 30-year subset of global marine surface observations from ships, drilling rigs and buoys covering the period 1976 to 2005.

Other relevant data sets include the Canadian Center for Marine Communications weather buoy deployed at 46°59´N; 54°41´W in Placentia Bay in August 2006 as part of its SmartBay Demonstration Project. This buoy provides a continuous data set of average wind speed, wind direction, air temperature, sea temperature, relative humidity and atmospheric pressure at 20-minute intervals. As well, a weather station was installed on the wharf in Long Harbour and was in operation from May 2006 to February 2007.

The locations where data were collected are shown in Figure 5.22.

Figure 5.22 Locations of the Climate Data Sources

5.5.1 Wind

Placentia Bay experiences predominantly southwest to west wind flow throughout the year. Westerly winds prevalent during the winter months begin to shift counter-clockwise during spring as the tropical-to-polar temperature gradient weakens, becoming generally southwesterly during summer. As autumn approaches, the tropical-to-polar temperature gradient strengthens and the winds shift slightly, becoming predominantly westerly again by late fall and into winter.

Low pressure systems crossing Newfoundland are more intense during winter. As a result, mean wind speeds tend to peak during this season. With the exception of those measured at the St. Lawrence weather station, mean wind speeds peak during the month of January (Table 5.8). The ICOADS data set recorded the highest January mean wind speed of 45 km/hr, while Long Harbour recorded the lowest January mean wind speed of 19.1 km/hr. It should be noted that the ICOADS winds are reported from ships as estimates or measured from anemometers at varying heights, without adjustment to the standard reference height of 10 m.

Winds measured at the Long Harbour climate station are lower during the winter months than at the other land stations located around Placentia Bay. Much of this difference is due to local topography.

A number of factors can contribute to the modification of winds by local topography. In Placentia Bay, coastal convergence (the convergence of land and sea winds resulting in stronger winds near the shore), is common. Also, the abundance of small river valleys along the coast, combined with the many large islands located throughout the bay, result in channelling – an increase in wind speeds caused when the wind is forced through a narrow opening.

Table 5.8 Mean and Maximum Wind Speed (km/hr) Statistics for selected locations in Placentia Bay

Month	AES40		COADS		Argentia		Long Harbour		Oceans Ltd*		SmartBay Buoy**	
	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean
January	90.5	35.7	103.7	45.0	109.1		72.0	19.1	N/A	N/A	33.0	20.7
February	95.3	34.4	107.4	42.8	110.9	27.0	79.1	18.9	N/A	N/A	N/A	N/A
March	99.8	32.0	113.0	38.6	87.0	25.4	72.0	19.1	N/A	N/A	N/A	N/A
April	74.6	27.1	96.3	27.4	93.0	22.8	53.0	17.8	N/A	N/A	N/A	N/A
May	75.4	21.3	57.4	21.1	84.1	19.8	64.1	16.3	57.8	19.6	N/A	N/A
June	68.0	19.4	55.6	27.8	74.1	19.6	55.0	16.1	49.3	20.6	N/A	N/A
July	63.9	18.4	61.1	24.5	78.0	18.9	53.0	15.7	55.2	21.7	N/A	N/A
August	61.2	20.3	64.8	23.5	80.0	19.3	55.9	15.9	43.5	18.7	N/A	N/A
September	85.1	24.0	59.3	26.7	89.1	20.7	63.0	16.3	64.1	19.6	44.6	25.6
October	102.4	28.6	100.0	30.3	103.0	23.7	70.9	17.2	58.7	19.4	62.2	26.9
November	86.4	31.9	87.0	31.1	100.9	25.6	72.0	18.5	59.1	21.1	42.8	17.8
December	89.5	34.7	77.8	33.5	108.0	28.0	74.1	18.9	63.9	26.3	39.1	16.7

Notes: *Oceans Ltd. data coverage is from May 18, 2006, to December, 2006.
**SmartBay data coverage is from September 28, 2006, to January 4, 2007.
N/A – no data available.

While the Long Harbour site is minimally affected by coastal convergence, local topography does have an influence. Westerly winds entering the mouth of Long Harbour are channelled into a predominantly southwest direction during winter. For this reason, southwest winds occur frequently at Long Harbour throughout the year. Similarly, local topography also dictates a secondary direction from the northeast in all seasons. Northeasterlies would not experience the funnelling effect that southwest winds experience. A wind rose of the annual wind speed from the Environment Canada data is presented in Figure 5.23 and a histogram of the wind speed frequency distribution in Figure 5.24. Monthly wind roses, along with histograms of the frequency distributions of wind speeds from the Environment Canada Long Harbour climate station, can be found in Oceans Ltd. (2007). These wind roses show the predominantly southwesterly wind direction at Long Harbour, and its secondary northeasterly direction.

A wind rose of the annual wind speed from the AES40 data set is presented in Figure 5.25 and the histogram of the frequency distribution of wind speeds in Figure 5.6. There is a marked increase in the occurrence of winds from the west to north in winter as opposed to summer, which is consistent with the wind climatology from other weather stations in the area.

These can be compared with data from Long Harbour (Figure 5.23 and Figure 5.24). The effects of channelling can be seen in the Long Harbour site as wind direction tends to follow the orientation of the harbour.

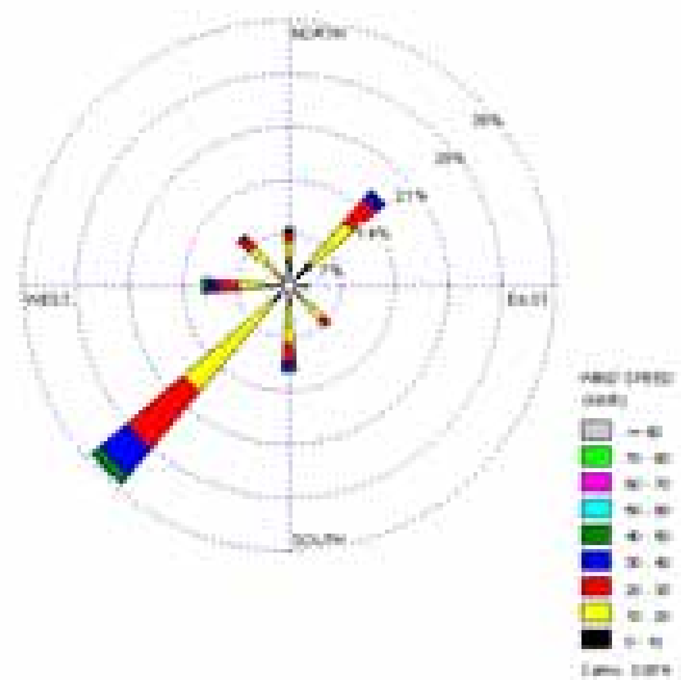


Figure 5.23 Annual Wind Rose from the Environment Canada Climate Station at Long Harbour

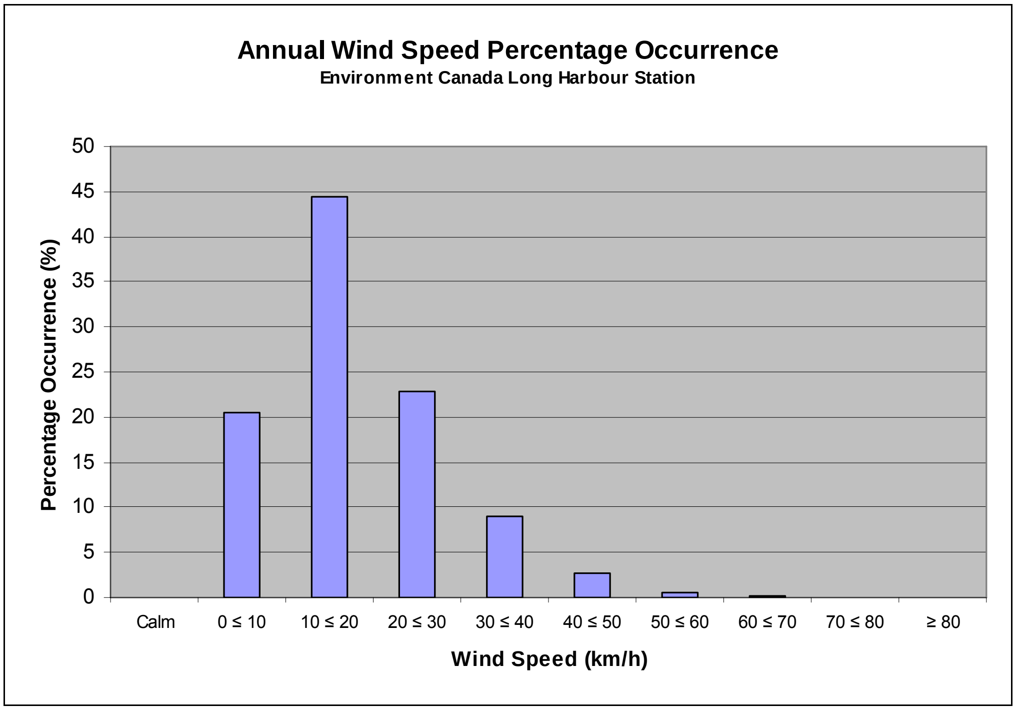


Figure 5.24 Annual Wind Speed Percentage of Occurrences from the Environment Canada Climate Station at Long Harbour

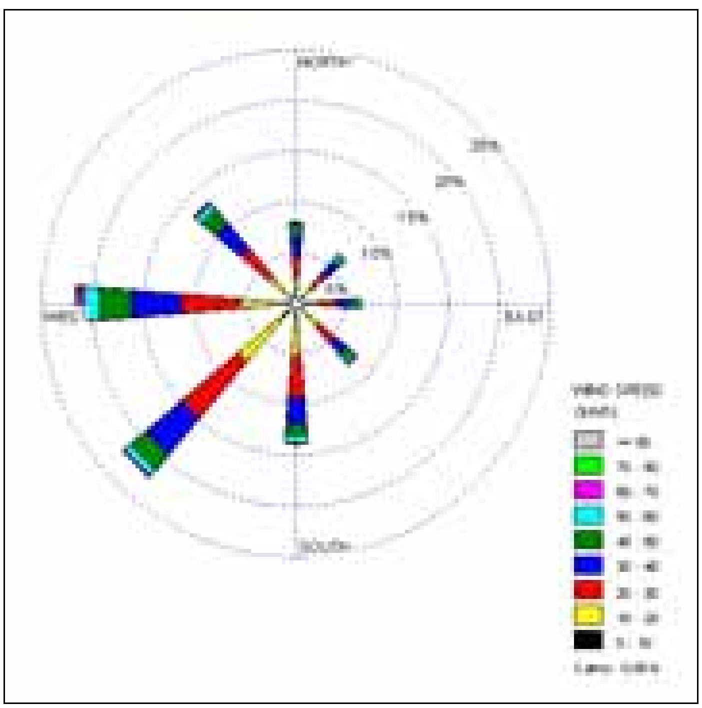


Figure 5.25 Annual Wind Rose from the AES40 Grid Point 5616

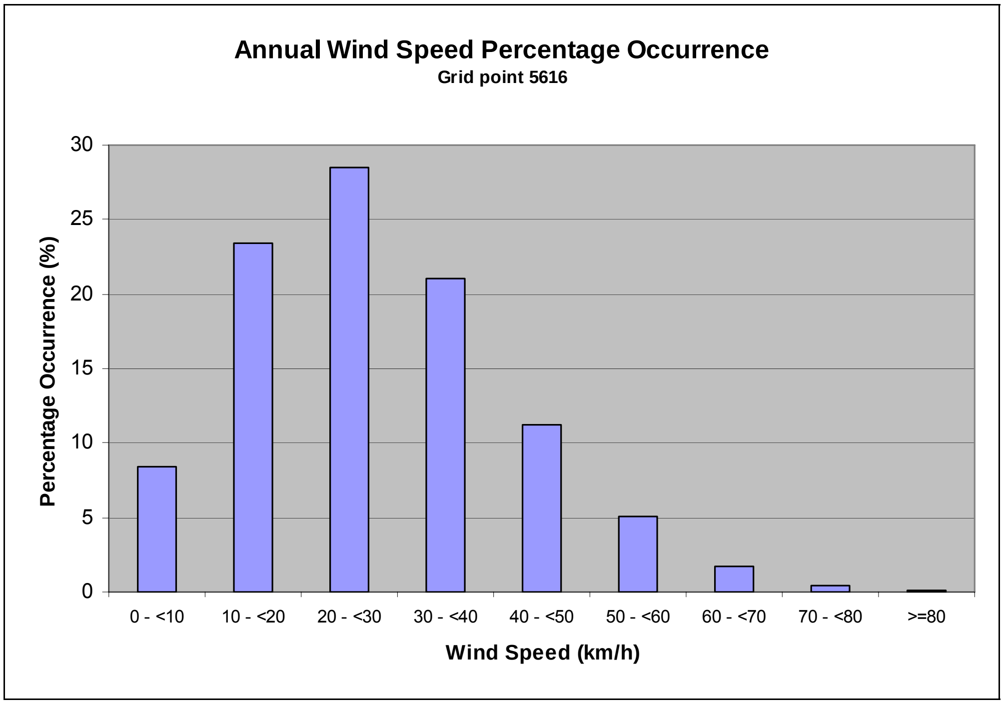


Figure 5.26 Annual Wind Speed Percentage of Occurrences from the AES40 Grid Point 5616

Intense mid-latitude low pressure systems occur frequently from early autumn to late spring. In addition, remnants of tropical systems have passed near Newfoundland between spring and late fall. Therefore, while mean wind speeds tend to peak during the winter, maximum wind speeds may occur at any time of year.

St. Lawrence recorded the highest wind speeds in Placentia Bay: 145 km/hr out of the west-southwest on February 22, 1967, and again on January 5, 1968 (Figure 5.27). During the same storm, the AES40 wind speeds peaked at 89 km/hr and Argentia wind speeds at 90 km/hr.

An extremal analysis was carried out for winds at the mouth of Placentia Bay using the AES40 data set for 50 years of data and Oceanweather's OMOSIS Software (Oceanweather Inc. 2001). Extreme value estimates for hourly winds using a Gumbel distribution on 158 storms were calculated for return periods of 1, 10, 25, 50 and 100 years with values of 80.6 km/hr, 92.5 km/hr, 96.8 km/hr, 100.1 km/hr, and 103.7 km/hr, respectively. The weather station data around Placentia Bay reported 10-minute mean wind speeds; the exception was Long Harbour, which reported hourly mean data. For comparisons with the weather station data, the hourly extreme wind speeds previously quoted correspond to 10-minute winds speeds of approximately 85.3 km/hr, 97.9 km/hr, 102.6 km/hr, 106.2 km/hr and 109.8 km/hr, respectively, using a conversion factor of 1.06 (U.S. Geological Survey 1979).

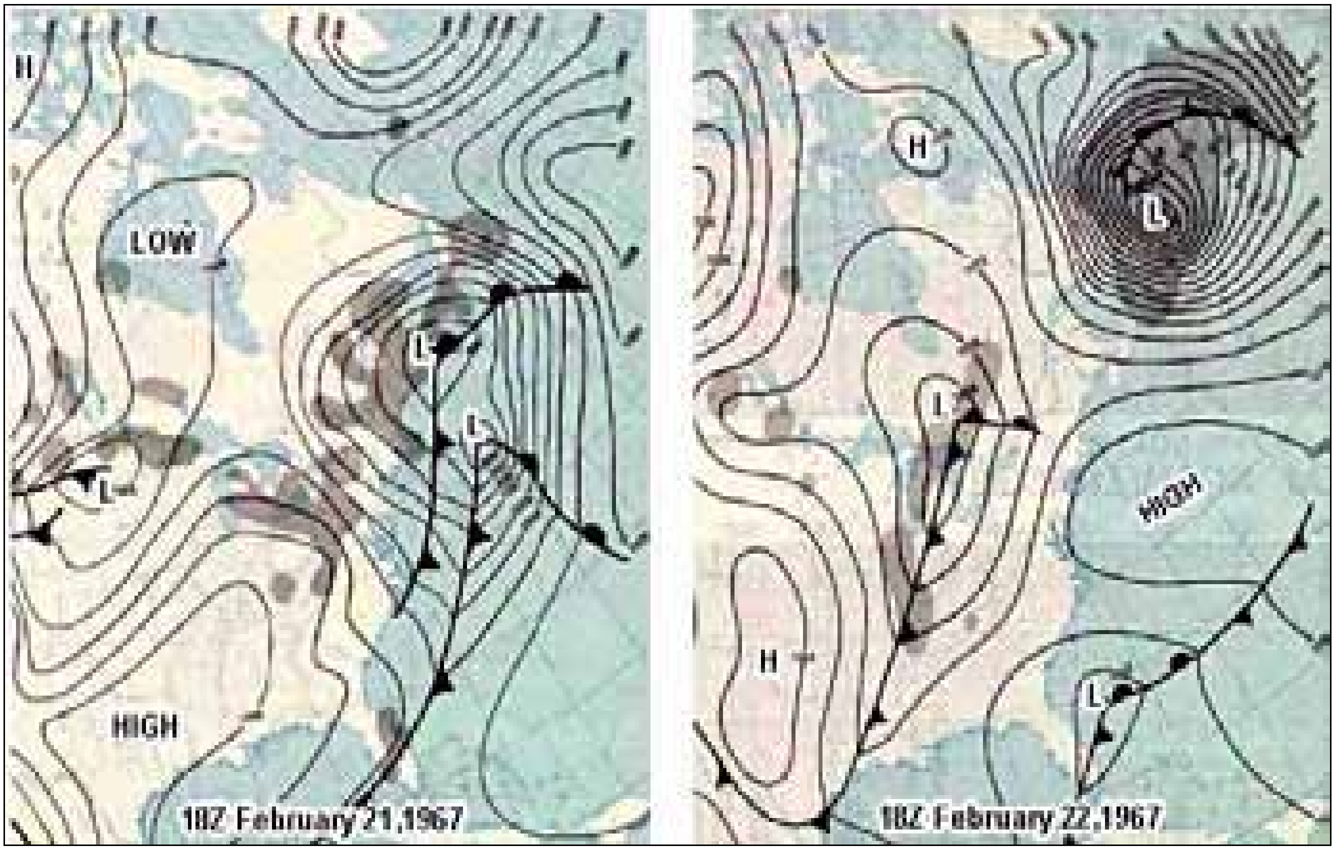


Figure 5.27 Explosive Deepening of a Mid-Latitude Low Pressure February 1967

The highest winds are usually the result of tropical cyclones or their remnants. The highest winds in a tropical cyclone tend to be concentrated in a narrow band near its centre, and since the storm centre rarely passes over a reporting station, the highest winds are usually not measured. Tropical cyclones develop and strengthen over warm tropical waters, typically from June to November; however, they have been known to develop as early as April and as late as January. These systems typically move east to west over the warm waters of the tropics. Systems that turn northwest maintain their strength from the warm waters of the Gulf Stream. As they move north, they pass over colder waters and begin to weaken. By the time these weakening cyclones reach Newfoundland, they are usually embedded into a mid-latitude low pressure system and their tropical characteristics are lost. On occasion, however, such systems maintain their strength as they approach Newfoundland. On October 19, 2000, Hurricane Michael made landfall along the south coast, west of the Burin Peninsula, as a Category One hurricane with a central pressure of 96.5 kpa. The St. Lawrence climate station reported north-northeast winds at 96 km/hr by the time the hurricane made landfall.

Hurricane Luis passed over or close to Long Harbour on September 11, 1995. According to the U.S. National Oceanic and Atmospheric Administration (NOAA) Coastal Services Center Archive (NOAA 2006), it had maximum sustained one-minute mean, 10 m wind speeds of 148 km/hr when it reached the Avalon Peninsula. This value converts to a mean wind speed of approximately 121 km/hr.

5.5.2 Air Temperature

The ocean has a moderating effect on air temperature along the Newfoundland coast, which is typical of a maritime climate. During the spring, sea surface takes longer to warm up than does the surrounding air; as a result, the water temperature tends to slow the warming of the air along the coast, resulting in cooler springs than would be experienced in a continental climate. In autumn, sea surface temperatures are generally warmer than the surrounding air, as air tends to cool faster than the ocean. This results in the sea surface temperatures typically being higher than air temperatures. The warm ocean reduces the rate at which the air temperature decreases, resulting in generally warmer autumns than would be experienced in a continental climate.

Seasonal temperature statistics for the various data sources in Placentia Bay are summarized in Table 5.9. On average, the temperature at Long Harbour was higher during summer than at any of the other stations, with a mean seasonal temperature of 13.9°C and a mean seasonal maximum temperature of 25.2°C. The Placentia weather station recorded the coldest mean seasonal air temperature of -3.1°C; the Long Harbour climate station had the coldest mean minimum temperature of -19.9°C. The coldest extreme minimum temperature of -25°C was recorded at Long Harbour on February 15, 1975.

The ICOADS (Table 5.9) data show that mean air temperatures over the bay are similar in value to those measured over the land, while mean seasonal maximum temperatures are much cooler and mean seasonal minimum temperatures are much warmer. The smaller temperature range of the ICOADS data illustrates the moderating effect that the ocean has on the surrounding air temperature.

Table 5.9 Seasonal Air Temperature (°C), Selected Placentia Bay Locations

	Winter	Spring	Summer	Autumn
ICOADS	-7.4 (-1.9) 4.6	-3.8 (0.3) 6.6	8.1 (12.3) 16.7	3.3 (8.5) 15.0
Argentia	-13.9 (-1.4) 12.3	-10.4 (2.0) 15.7	2.1(12.3) 22.7	-3.2 (8.4) 20.4
Long Harbour	-19.9 (-2.6) 13.5	-14.4 (2.8) 17.6	0.7 (13.9) 25.2	-6.7 (8.4) 22.4
Placentia	-18.0 (-3.1) 13.0	-11.4 (1.5) 14.4	2.0 (12.0) 23.0	-2.8 (8.1) 19.6
St. Lawrence	-16.7 (-2.4) 8.9	-12.9 (1.9) 16.1	1.8 (12.4) 23.9	-6.1 (7.7) 20.8
Marticot Island	-13.4 (-1.7) 7.0	-10.5(2.0) 14.0	2.0 (12.5) 19.9	-4.8 (8.9) 20.5

Note: Values presented as mean seasonal minimum; (mean seasonal); mean seasonal maximum.

5.5.3 Precipitation

The frequency of precipitation type was calculated using hourly data at Argentia, Placentia and St. Lawrence (Table 5.10), with each occurrence counting as one event. Long Harbour, however, recorded the occurrence of precipitation type on a daily basis. Therefore, at Long Harbour, if precipitation was recorded for only one hour, it would count as one day with precipitation. Furthermore, since Long Harbour was an automatic weather station and sometimes could not distinguish between precipitation types at or near 0°C, it is possible that the occurrence of freezing rain at the site is under-recorded. As a result, the frequency of precipitation type at Long Harbour is presented separately as Table 5.11.

Table 5.10 Seasonal Frequency Distribution (%) of Precipitation in Placentia Bay

		Rain / Drizzle	Freezing Rain / Drizzle	Rain / Snow Mixed	Snow	Hail	Total
ICOADS	**Winter**	11.9	3.2	1.1	39.7	0.4	56.3
	Spring	16.4	1.2	0.5	16.7	0.0	34.8
	Summer	14.3	0.0	0.0	0.0	0.0	14.3
	Autumn	26.7	0.0	0.0	1.3	0.0	27.9
Argentia	**Winter**	9.8	0.7	0.5	17.8	0.0	28.8
	Spring	13.9	0.4	0.5	8.6	0.0	23.4
	Summer	16.5	0.0	0.0	0.0	0.0	16.5
	Autumn	16.4	0.0	0.2	1.3	0.0	17.9
Placentia	**Winter**	8.0	0.8	0.3	17.4	0.0	26.4
	Spring	14.8	0.6	0.2	7.1	0.0	22.7
	Summer	18.8	0.0	0.0	0.0	0.0	18.8
	Autumn	17.1	0.0	0.1	1.7	0.0	19.0
St. Lawrence	**Winter**	8.0	0.9	0.1	20.2	0.0	29.2
	Spring	12.4	0.8	0.1	7.3	2.5	23.2
	Summer	13.4	0.0	0.0	0.0	0.0	13.5
	Autumn	14.7	0.0	0.1	1.6	0.0	16.5

Table 5.11 Monthly Frequency Distribution (%) of Precipitation at Long Harbour

	Rain / Drizzle	Freezing Rain / Drizzle	Snow	Total Precipitation
January	26.9	0.8	24.2	47.5
February	21.4	1.0	21.4	39.8
March	34.8	0.5	14.5	46.0
April	40.0	0.0	6.5	43.9
May	48.1	0.0	0.6	48.2
June	46.7	0.0	0.0	46.7
July	44.1	0.0	0.0	44.1
August	47.7	0.0	0.0	47.7
September	54.0	0.0	0.0	54.0
October	59.7	0.0	0.1	59.7
November	50.2	0.1	4.4	53.0
December	37.7	0.4	15.5	49.5
Total	42.7	0.2	7.2	48.4

Winter has the highest frequency of precipitation, with frequencies between 26.4 per cent and 29.2 per cent for the land stations and 56.3 per cent over the ocean. Snow accounts for the majority of precipitation during the winter months, occurring twice as often as rain at the land stations and 3.3 times more frequently over the ocean. Summer has the lowest frequency of precipitation, ranging from 13.5 per cent to 16.5 per cent.

Long Harbour experiences a high occurrence of days with precipitation (48.4%). The highest occurrence is in October, most of which is in the form of rain. The lowest occurrence is in February, when rain and snow occur at the same frequency (21.4%).

While rain occurs in all seasons, it is more frequent in autumn. The earliest observation of snow occurred in October; however, only one observation was recorded in the 30-year record at Long Harbour. Snow occurs in all months between November and May, peaking in January at 24.2 per cent of days. A low frequency of freezing precipitation occurs from November to March.

Argentia, Long Harbour and Placentia report similar values of mean annual total precipitation (Table 5.12), with Placentia reporting the least amount (1,324 mm) and Argentia recording the highest (1,398 mm). The majority (85-90 %) of the total recorded precipitation was in the form of rain. The maximum monthly rainfall amounts occurred in October at Argentia, Long Harbour and Placentia. The maximum daily rainfall amounts of 85.7 mm and 119.0 mm were recorded on October 17, 1981, at Argentia and Long Harbour, respectively. The Placentia weather station reported a maximum daily rainfall amount of 93.2 mm on August 23, 1975. The St. Lawrence station reported a maximum rainfall amount of 116.0 mm on September 10, 1995 coinciding with the passage of Hurricane Luis in the early morning hours of September 11, 1995.

Table 5.12 Precipitation Amount (mm) Statistics for the Environment Canada Climate Stations in Placentia Bay

	Argentia		Long Harbour		Placentia		St. Lawrence	
	Mean	**Maximum**	**Mean**	**Maximum**	**Mean**	**Maximum**	**Mean**	**Maximum**
January	126.4	170.8	127.4	202.1	106.1	183.7	132.8	203.4
February	84.4	155.7	111.6	207.7	86.7	185.4	124.7	234.0
March	113.0	228.1	110.0	218.4	105.3	138.1	122.4	210.8
April	79.2	143.9	101.9	240.9	103.3	177.5	113.7	233.1
May	94.9	143.1	92.7	157.2	81.8	129.7	118.1	228.6
June	124.0	193.7	112.8	249.2	96.6	148.9	127.8	341.3
July	107.9	196.8	92.3	223.4	81.1	110.4	106.8	200.8
August	112.9	176.0	110.5	343.6	157.4	200.4	118.2	399.2
September	139.3	185.6	124.5	222.7	100.4	158.8	148.6	248.0
October	136.9	280.5	148.0	311.2	172.1	249.2	145.9	265.9
November	110.5	177.0	125.9	208.4	141.1	227.9	147.4	248.6
December	129.5	227.8	118.5	168.2	102.7	163.8	134.9	263.2
Annual	1,398.0	1,704.8	1,387.2	1,619.9	1,324.0	1,488.7	1,550.0	1,940.8

Extreme one-day precipitation values for each year at Argentina, Long Harbour and St. Lawrence were used to compute an estimate of extreme precipitation for return periods of 2, 10, 25, 50 and 100 years. The Placentia data set was only five years and was not of sufficient duration to perform an extreme analysis. Also, since some of the years in the data set contained periods of missing data, it is possible that the data set did not contain the extreme precipitation event for that year. To determine whether the yearly values at each station were reasonable, the data set was quality-controlled using a Gumbel extreme value analysis and any outliers were subsequently removed from the data set. After performing the quality control, the values for each station were fitted to a Gumbel distribution. The extreme precipitation estimates for each station are presented in Table 5.13.

Table 5.13 Extreme Precipitation Estimates - Various Return Periods

Return Period	Argentia	Long Harbour	St. Lawrence
	Extreme Precipitation Estimate (mm)	Extreme Precipitation Estimate (mm)	Extreme Precipitation Estimate (mm)
2	51.4	57.39	62.24
10	80.6	87.66	91.36
25	95.2	102.89	106.02
50	106.1	114.19	116.89
100	116.9	125.41	127.68

Snowfall has occurred in Placentia Bay in every season, including summer. Mean snowfall amounts show that, on average, snow begins in October. Snowfall is recorded in all months between October and June, with the peak snowfall amounts occurring in January at each station. The maximum monthly snowfall of 176.8 cm was recorded at St. Lawrence during February.

The highest maximum one-day snowfall of 71.3 cm occurred at St. Lawrence on September 14, 1987. This value is twice as high as other one-day maximums reported in Placentia Bay. The other stations have reported maximum one-day snowfall events of 29.2 cm at Argentia, 35.6 cm at Long Harbour and 34.3 cm at Placentia. Overall, St. Lawrence experiences the highest precipitation amounts and has the highest monthly mean and monthly maximum for rainfall and snowfall, as well as the highest one-day snowfall amount.

Precipitation amounts were recorded at the Environment Canada Long Harbour climate station from November 1969 to November 1999. On average, 1,387.2 mm of precipitation falls on Long Harbour during a year with a maximum amount of 1,619.9 mm (Table 5.14). Included within these figures are a mean annual snowfall of 159.9 cm and a monthly maximum of 269.0 cm.

The monthly maximum precipitation amount occurred in August (343.6 mm) but, on average, October gets the most precipitation with a mean value of 148.0 mm. The daily maximum precipitation occurred in the form of rain on October 17, 1981 with a value of 119.0 mm.

More snow falls in January than in any other month at the Long Harbour climate station. The monthly maximum was 122.0 cm, and the monthly mean was 43.4 cm; however, the daily maximum amount of snow (35.6 cm) fell in March, with December as a close second (34.0 cm). Snowfall has been recorded from October to May, although over the 30-year period only one October snow event was recorded at Long Harbour.

Table 5.14 Precipitation Amount Statistics for the Environment Canada Climate Station at Long Harbour

	Daily Mean Precipitation (mm)	Daily Maximum Precipitation (mm)	Daily Standard Deviation (mm)	Monthly Mean (mm)	Monthly Maximum (mm)	Monthly Standard Deviation (mm)
January	8.7	53.8	9.6	127.0	202.1	43.2
February	8.9	68.0	10.4	111.6	207.7	52.7
March	7.7	80.2	8.7	110.0	218.4	47.9
April	7.3	82.0	8.8	101.9	240.9	55.6
May	6.1	55.0	7.8	92.7	157.2	35.5
June	7.6	92.4	10.9	112.8	249.2	55.1
July	6.8	63.0	9.1	92.3	223.4	44.5
August	7.5	78.5	10.6	110.5	343.6	56.4
September	7.4	68.0	10.8	124.5	222.7	39.0
October	8.0	119.0	12.1	148.0	311.2	69.0
November	7.4	66.4	9.3	125.9	208.4	38.7
December	7.6	41.0	7.9	118.5	168.2	27.2
Year	7.6	119.0	9.8	1,387.2	1,619.9	181.5

Freezing precipitation occurs when rain or drizzle aloft enters negative air temperatures near the surface and becomes super-cooled so that the droplets freeze upon contact with a surface. This situation typically arises ahead of a warm front extending from low pressure systems passing west of the area.

The percentage of occurrences of freezing precipitation was calculated using hourly data from the Environment Canada climate stations at Argentia, Placentia and St. Lawrence as well as from the ICOADS data set. At all land stations, the frequency of freezing precipitation was slightly higher in the winter months than during the spring; however, all recorded freezing precipitation occurred less than 1 per cent of the time at all land stations. The ICOADS data set (ship observations) had the highest occurrence of freezing precipitation, with 3.2 per cent in winter and 1.2 per cent in spring. It is unclear whether these values are accurate, or whether the higher amounts were due to ice accretion from sea spray on the vessels. No freezing precipitation occurred during summer and autumn.

The Long Harbour station did not record freezing precipitation at hourly intervals, but instead recorded days with freezing rain. Since it is unclear from this data set how long a freezing rain event lasted, Long Harbour was not included with the other stations when calculating freezing precipitation statistics. At the Long Harbour station, only 25 days with freezing precipitation were reported over a period of 30 years. These data are believed to be in error, because the manned observing stations in the area have reported a higher frequency of occurrence. In addition, automatic stations have not been reliable for reporting freezing precipitation, so a quantitative analysis of freezing precipitation was not possible for Long Harbour.

Spray icing can accumulate on vessels and shore structures when air temperatures are below the freezing temperature of water. Icing severity varies with water temperature, wave conditions and wind speed. Potential icing rates were computed (Figure 5.28) using wind speed, air and sea surface temperature observations from the ICOADS data set. From January 1975 to December 2005, a total of 892 vessel observations were used to calculate the percentage frequency of icing occurrence and severity in Placentia Bay.

Potential sea spray icing conditions start during December and occur 28.6 per cent of the time. As temperatures cool throughout the winter months, the frequency increases to a maximum of 49.2 per cent in February. Icing potential decreases rapidly after February in response to warming air and sea surface temperatures, and by April the frequency is less than 5 per cent.

Visibility, the greatest distance at which objects of suitable dimensions can be seen and identified, is identified by a variety of conditions and phenomena. Fog is the most frequent factor influencing visibility in Placentia Bay, persistent throughout the day during summer as long as there are southerly winds. The ICOADS data show that the frequency of fog is greatest between April and August. During the winter months, prevailing winds are generally from the west, off the continent, so that the air mass tends to be drier. Drier air, combined with sea-surface temperatures typically warmer than air, result in a marked decrease in the amount of fog formation within the bay during fall and winter; however, snow and blowing snow account for the majority of poor visibility reported during winter.

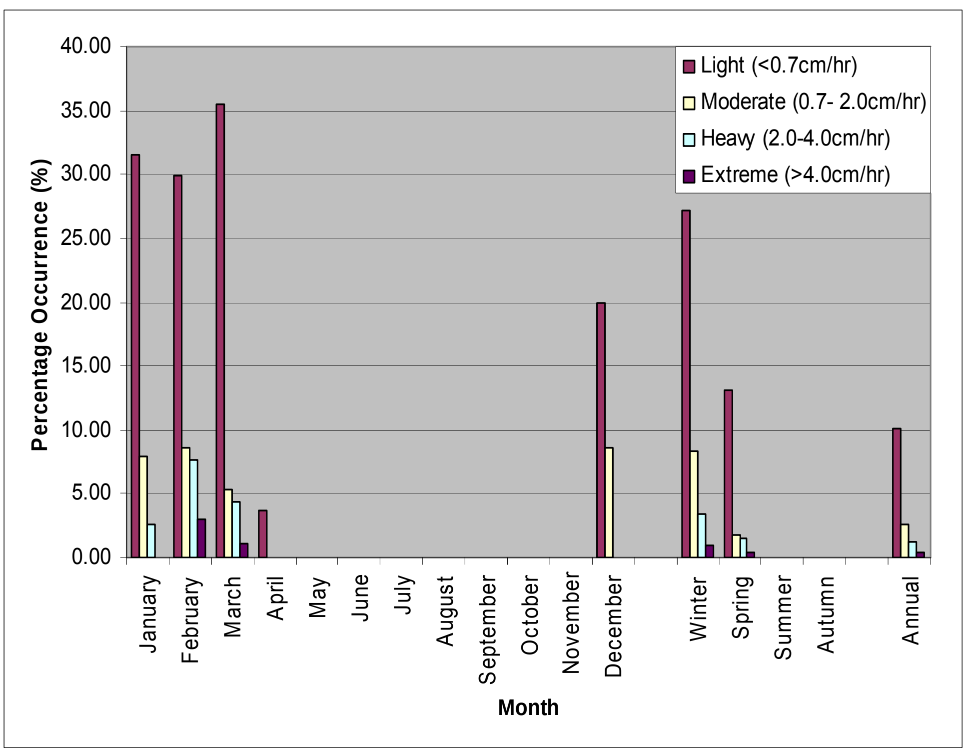


Figure 5.28 Percentage Frequency of Potential Spray Icing Conditions for Placentia Bay, January 1975 to December 2005

Observations from climate stations around Placentia Bay show that obstructions to visibility occur on a regular basis throughout the year, with good visibility (defined as visibility greater than 10 km) in the coastal communities of Argentia, Placentia and St. Lawrence occurring, on average, less than 50 per cent of the time. The incidence of fog at these stations is high during the summer months and peaks in the month of July, with visibility less than one kilometre occurring as much as 27.2 per cent of the time at St. Lawrence and 15.1 per cent of the time at Placentia.

Visibilities in the bay are better than at the land stations, with good visibility occurring 71.2 per cent of the time (ICOADS data). On average, fog occurs 11 per cent of the time throughout the year in Placentia Bay, with the peak occurring in July at 20.7 per cent of the time. A graph of monthly frequency distribution of visibilities from the ICOADS data set is presented in Figure 5.29.

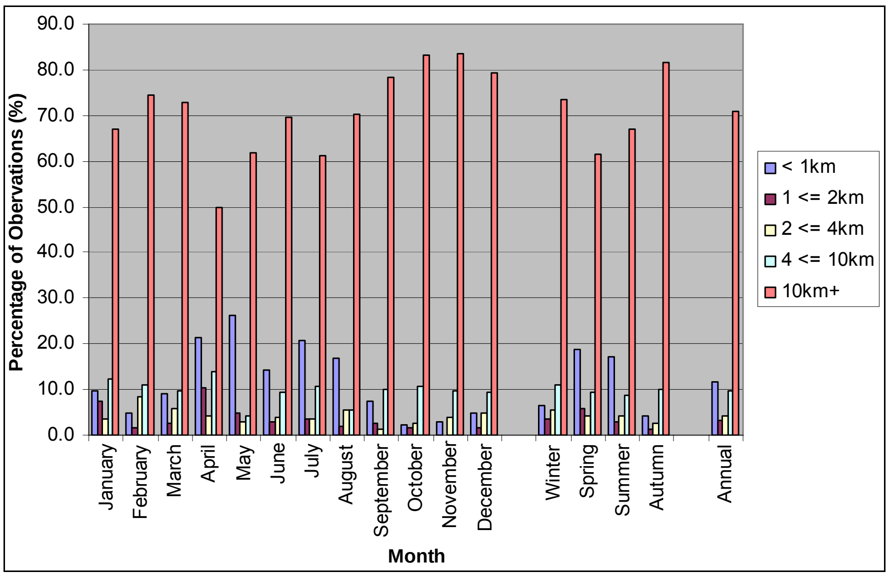


Figure 5.29 Frequency Distribution (%) of Visibility Recorded in the ICOADS Data Set

As visibility statistics were not recorded at Long Harbour, Argentia, 21 km southwest, was deemed to be the most appropriate station to represent visibility at Long Harbour. At Argentia, good visibility occurs, on average, only 40.9 per cent of the time (Figure 5.30). The incidence of fog is highest during the summer months and peaks in July, with a visibility of less than one kilometre occurring 11.9 per cent of the time. The predominant visibility at the Argentia station was 4 to 10 km and occurred, on average, 49.8 per cent of the time.

Ceiling is the height at which an observer on the ground can no longer see six-tenths of the whole sky. Since ceiling heights were not recorded at Long Harbour, Argentia was again deemed to give the best representation. At Argentia an increase occurs in the frequency of cloud ceilings below 100 feet (30.5 m) from February to July (Figure 5.31). After July, the frequency of this pattern is directly proportional to the occurrence of fog.

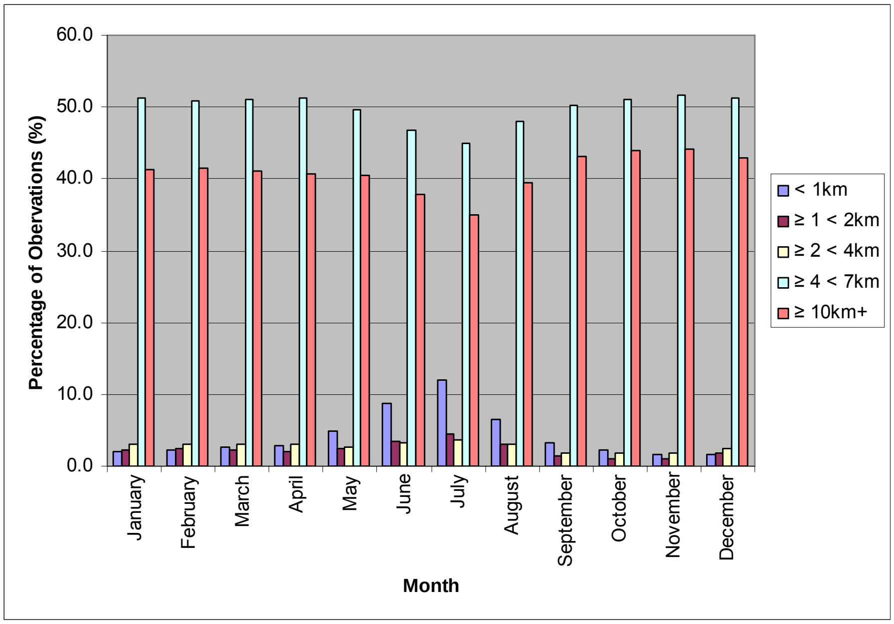


Figure 5.30 Frequency Distribution (%) of Visibility Recorded at Argentia

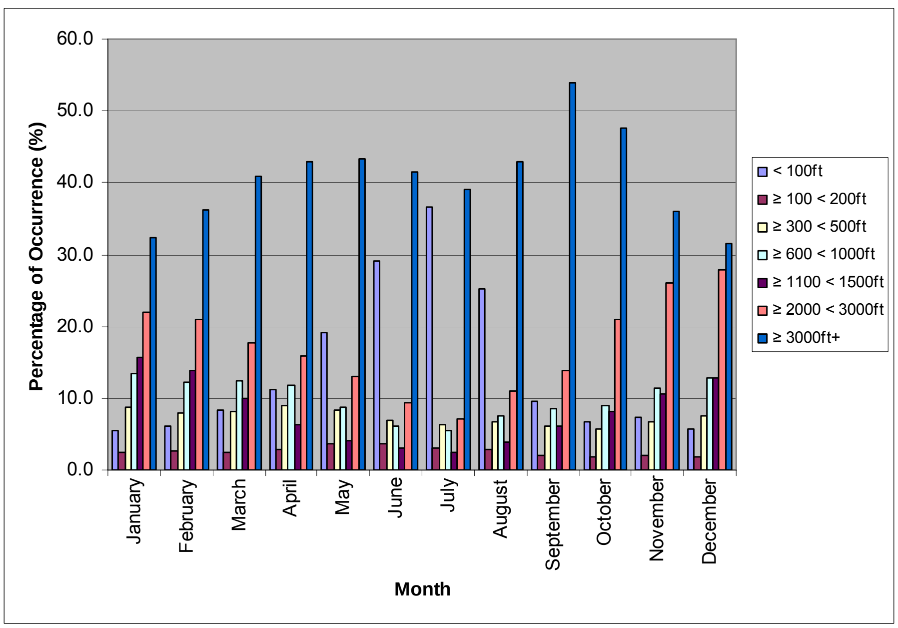


Figure 5.31 Percentage of Occurrence of Ceiling Heights Recorded at Argentia

5.6 Climate Trends

Climate is naturally variable and changes over time in response to atmospheric circulation patterns. Short-term meteorological variations are largely a consequence of the passage of synoptic scale weather systems: the energetics of these features vary seasonally in response to changes in the strength of the mean tropical-polar temperature gradient. Long-term changes occur in response to atmospheric circulation patterns in the Northern Hemisphere. There is a general consensus among the scientific community that greenhouse gas emissions have played a significant role in the climate during the past 50 years; however, the high degree of natural climate variation makes it difficult to identify long-term trends with any degree of certainty (Environment Canada 1997).

Most parts of Canada have experienced higher temperatures and increased precipitation in the past 50 years, although the rate of change is variable. In fact, some areas are experiencing a decreasing trend. Over the past century, the earth's temperature has increased by 0.6C° (IPCC 2001), while between 1895 and 1995 Canada's temperature increased by 1.1C° (Environment Canada 1997) with most of this increase occurring during the past decade. Globally, the 1990s were the warmest decade since 1861, and 1998 and 2005 are the warmest years on record. In general, North America was warmer and wetter than normal in 2005, the wettest year on record for Canada (Shein 2006). In Atlantic Canada, 2005 was the seventh warmest on record (+0.9C°) while precipitation amounts were near normal.

The Intergovernmental Panel on Climate Change (IPCC) has developed a number of plausible future climate scenarios. Two climate models, the Canadian Global Climate Model Version 2 (CGCM2) and the Hadley Centre Coupled Model Version 3 (HadCM3), produce output on a coarse grid not necessarily representative of site-specific change, as climate variables must be downscaled from the results to provide a plausible scenario on a smaller scale. A statistical downscaling technique was used to generate future temperature and precipitation values for the Project site.

5.6.1 Historical Trends

Since 1995 the number of hurricanes that have developed within the Atlantic Basin has been increasing, as is shown in Figure 5.32. This increase in activity has been attributed to naturally occurring cycles in tropical climate patterns near the equator called the tropical multi-decadal signal and typically lasts 20 to 30 years (Bell, 2006). As a result of the increase in tropical activity in the Atlantic Basin, there has also been an increase in tropical storms or their remnants entering the Canadian Hurricane Centre Response zone, and consequently a slight increase in the number of tropical storms entering the Study Area. It should be noted that the number of storms in 2006 and 2007 have shown a decrease, with only 10 tropical storms developing in the Atlantic Basin in 2006 and 17 in 2007. This time period is not of sufficient length, however, to determine whether this decrease will continue.

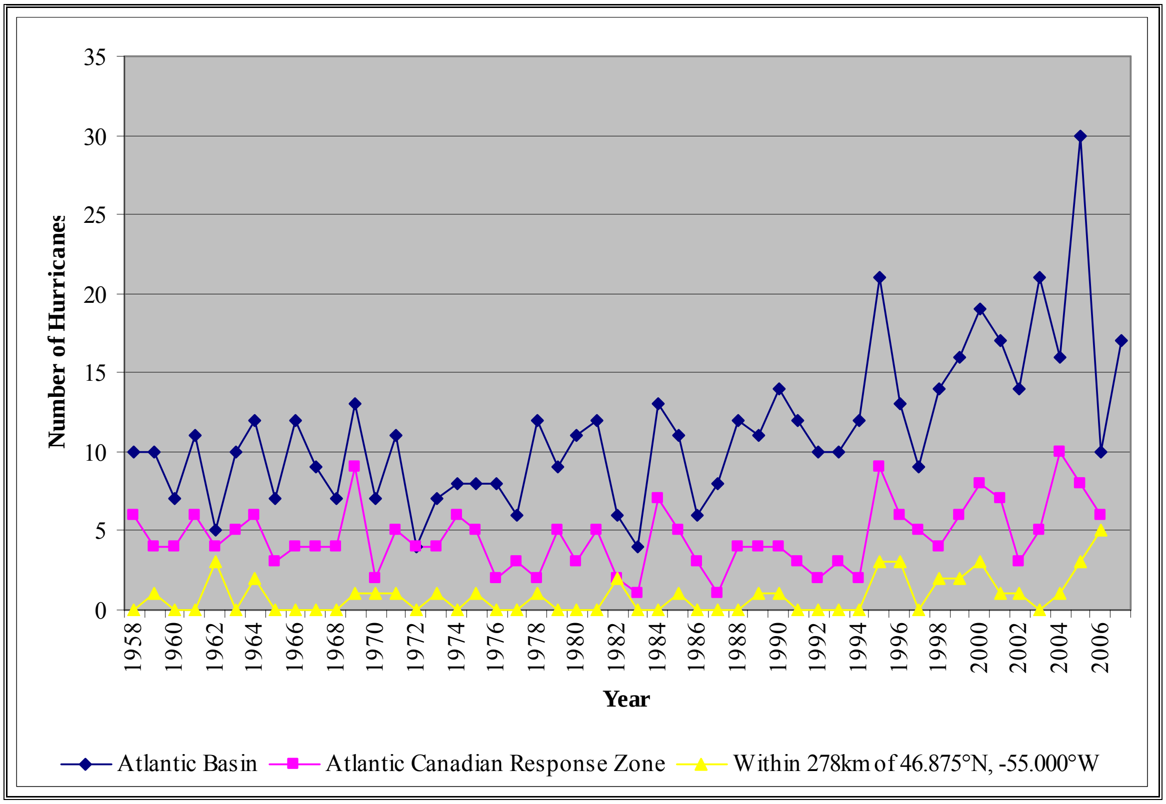


Figure 5.32 Frequency of Tropical Storm Development in the Atlantic Basin. 1958 – 2007

The semi-permanent area of relatively low pressure in the vicinity of Iceland and the sub-tropical high pressure region near the Azores are the dominant features of the mean sea-level pressure pattern in the North Atlantic. The relative strengths of these two systems control the strength and direction of westerly winds and storm tracks in the North Atlantic, and play a significant role in the climate of the Island of Newfoundland. The fluctuating pressure difference between these two features is the North Atlantic Oscillation (NAO).

A measure of the North Atlantic Oscillation is the NAO index, which is the normalized difference in pressure between the Icelandic low and the Azores high. A large difference in pressure results in a positive NAO Index and can be the result of a stronger than normal subtropical high, a deeper than normal sub-polar low, or a combination of both. A time-series of the winter (December, January, February) NAO index presented in Figure 5.33 shows a general trend toward an increasing NAO index between 1950 and 2006. This trend is also present in the summer (June, July, August) NAO index, albeit weaker.

Over the northwest Atlantic, a positive NAO winter index generally brings an increase in frequency and strength of westerly winds in the upper atmosphere, which tends to steer storm systems in a more west-to-east direction. This results in more storm systems coming off the continent, lower temperatures, increased precipitation and relatively stronger winds. Due to the weaker trend in the NAO index and other atmospheric patterns during the summer months, conclusions could not be drawn about correlations between summer NAO indices and temperature, precipitation and winds.

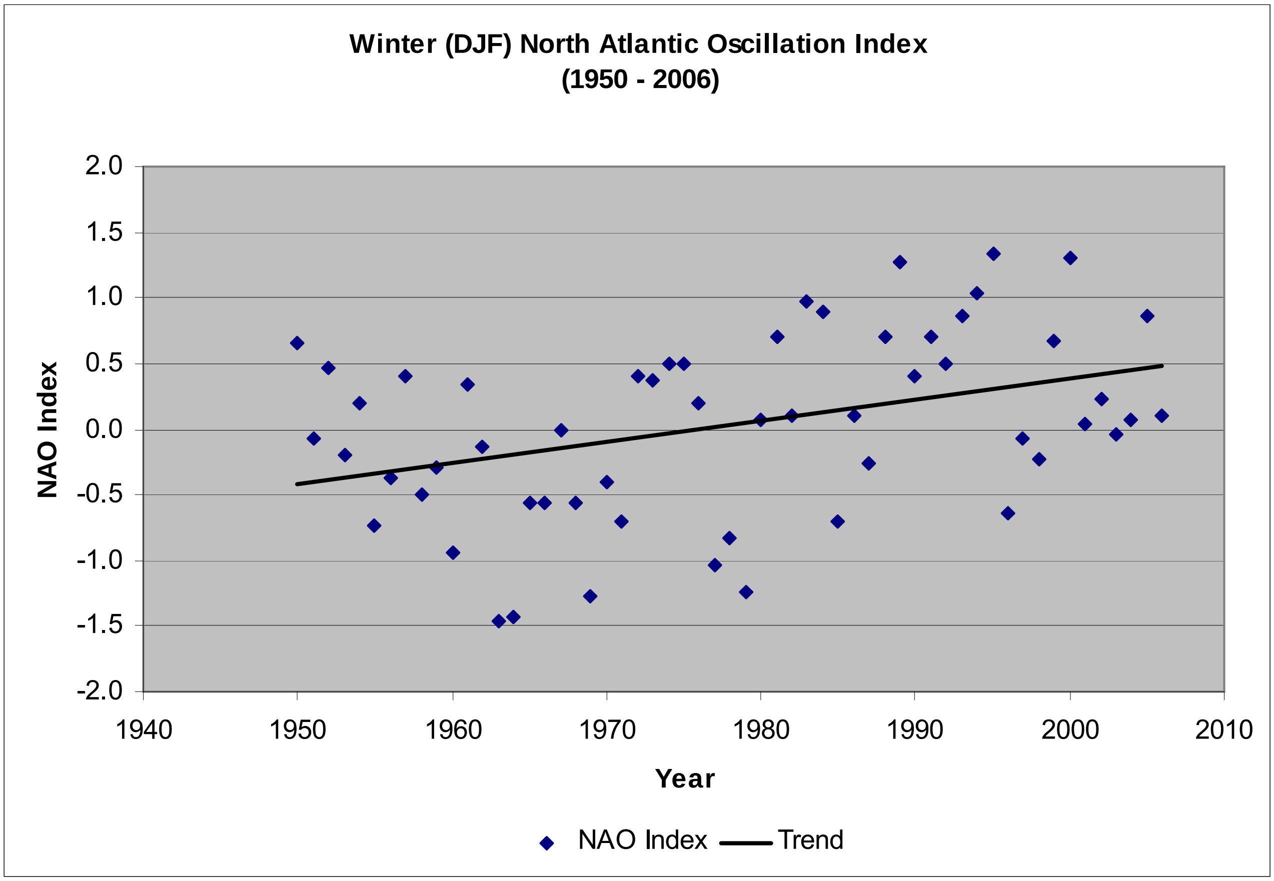


Figure 5.33 Winter North Atlantic Oscillation Index (1950 - 2006)

Observation data from Argentia, Long Harbour and St. Lawrence weather stations were the only data sets within Placentia Bay of sufficient duration to perform a trend analysis. A scatter plot of the seasonally-averaged NAO winter index recorded at these three stations, presented in Figure 5.34, shows a negative correlation between temperature and NAO index, while precipitation shows a positive correlation, as illustrated in Figure 5.35. The increase in precipitation is also attributed to the more westerly track of storm systems in seasons with a high NAO index.

Winter wind speeds at the three stations were also analyzed to discover whether a correlation could be determined. Seasonal mean wind speed values were computed using wind speed values taken at six-hour intervals. A trend analysis of the seasonally averaged NAO index against mean wind speeds shows a positive correlation for the Argentia and Long Harbour stations, indicating stronger winds with increasing NAO index. The St. Lawrence station shows an atypical negative correlation (Figure 5.36), most likely due to local topographic effects.

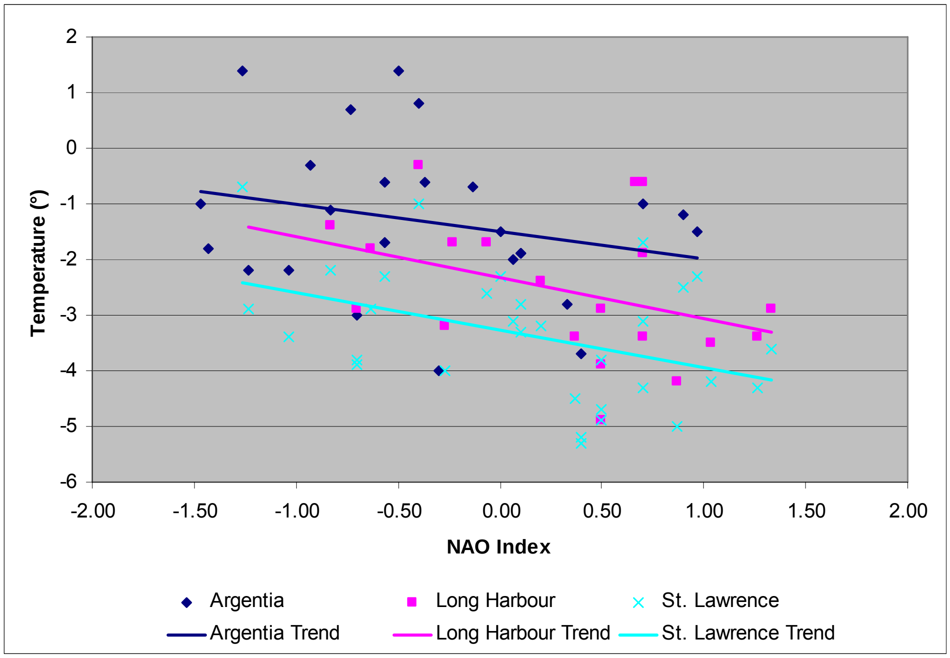


Figure 5.34 Scatterplot of Seasonally Averaged NAO Index vs Temperature for Various Sites in Placentia Bay for Winter

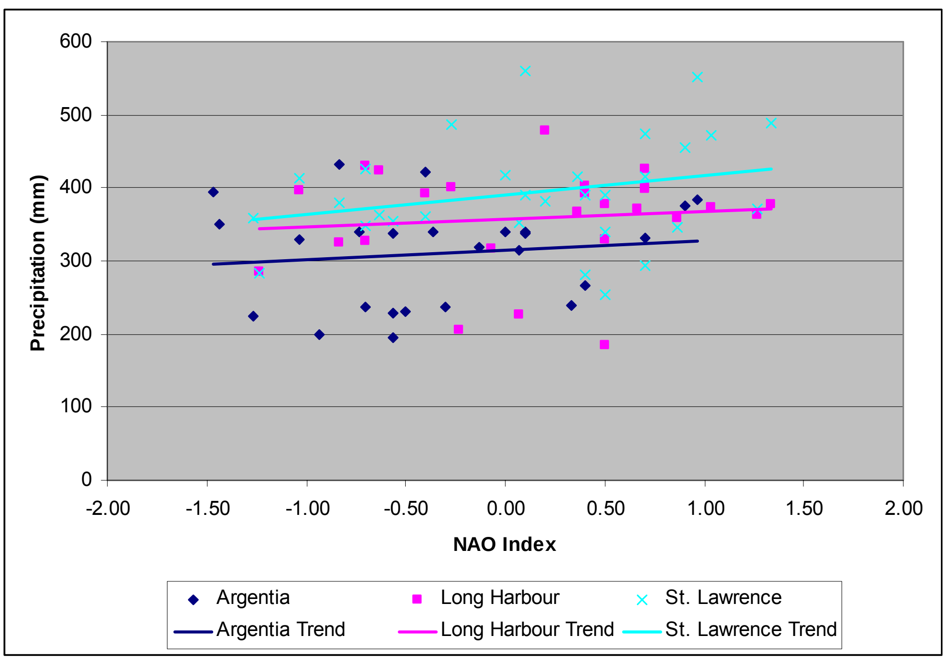


Figure 5.35 Scatterplot of Seasonally Averaged NAO Index vs Precipitation for Various Sites in Placentia Bay for Winter

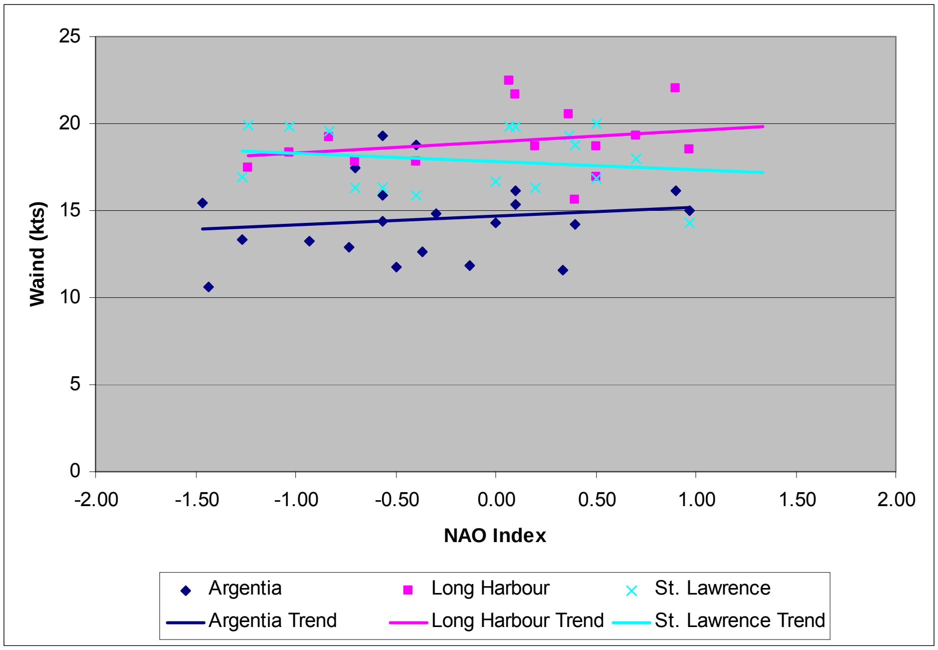


Figure 5.36 Scatterplot of Seasonally Averaged NAO Index vs Wind Speed for Various Sites in Placentia Bay for Winter

The seasonally averaged NAO index against mean wind speed and mean significant wave heights for Grid Point 5616 at the mouth of Placentia Bay for the winter months (Figure 5.37) shows that mean wind speeds increase with increasing NAO index in accordance with general expectations. Similar results apply to Argentia and Long Harbour.

Little correlation is observed with mean significant wave heights even though there was a positive correlation with wind speed. These results are typical of other studies done in the waters surrounding Newfoundland (Swail 1996; Swail et al. 1999).

While NAO index has a less direct effect on the climate of eastern Canada in summer, studies have shown that the index has an effect on the track of hurricanes in the North Atlantic. During seasons with a negative NAO index, hurricanes tend to a track parallel to lines of latitude, often ending up in the Gulf of Mexico and the Caribbean (Elsner 2003), while during seasons with a positive NAO index, they tend to curve northward (Elsner and Bosak 2004) along the Eastern Seaboard of the United States. An analysis of tropical storms entering the Canadian Hurricane Centre Response Zone shows that frequency decreases with increasing summer NAO index (J. Bobbitt pers.com.). Likewise, the number of tropical storms coming within 278 km of Placentia Bay also decreases during summers with a positive NAO index.

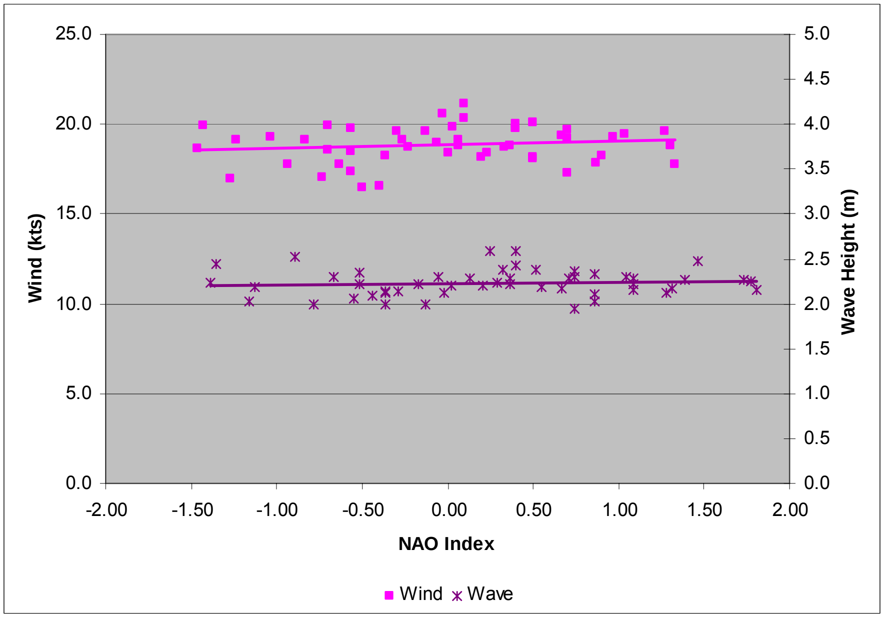


Figure 5.37 Scatterplot of Seasonally Averaged NAO Index against Wind and Wave Height at Grid Point 5616 (Winter 1954 – 2004)

5.6.2 Future Climate Scenarios

As noted, two climate models, the CGCM2 and HadCM3, were used to predict future temperature and precipitation change for the Island of Newfoundland.

These models predict a generally increasing annual mean temperature trend during the next 100 years (Figure 5.38). These trends are also observed in the seasonal model data. The HadCM3 model shows positive trends throughout the year.

An analysis of daily averaged precipitation shows only slight long-term changes over the next 100 years (Figure 5.39), with the CGCM2 model predicting a negative trend and the HadCM3 model showing a slight increase. A seasonal analysis of the CGCM2 data shows that most of this decrease occurs during the summer months, while spring and autumn show a slight positive trend. No trends were observable with the winter data. The HadCM3 model results were similar.

When referring to future climate change scenarios, the scientific community customarily refers to three periods: the 2020s (2010-2039); the 2050s (2040-2049); and the 2080s (2070-2099). Monthly, seasonal and annual analyses of these three periods are presented in Table 5.15. Values presented are predicted model changes from the base period (1971-2000). Temperature increases are generally expected in all three periods on annual, seasonal and monthly scales.

The models differ for precipitation predictions, with the HadCM3 model predicting less precipitation than the CGCM2 model.

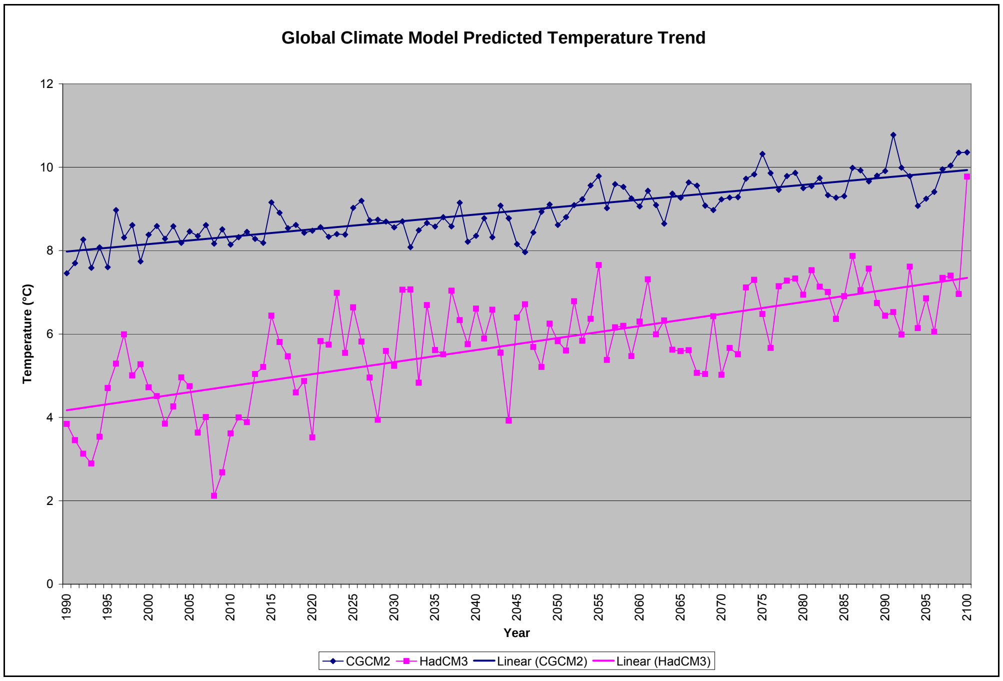


Figure 5.38 CGCM2 and HadCM3 Global Climate Model predicted Temperature Trend from 1990 – 2100

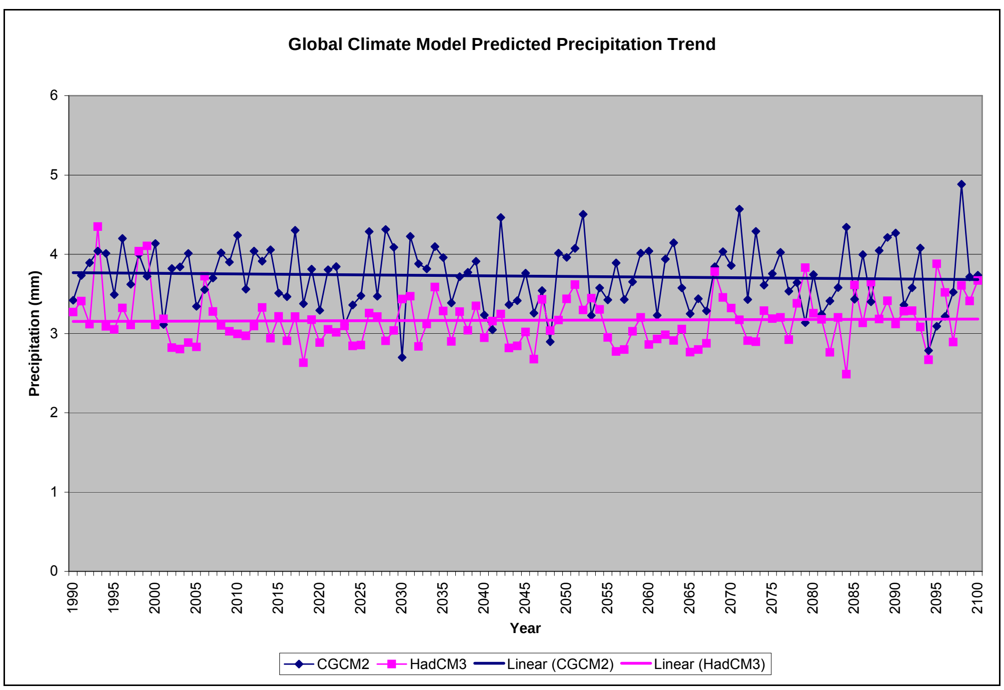


Figure 5.39 CGCM2 and HadCM3 Global Climate Model Predicted Daily Averaged Precipitation Trend from 1990 – 2100

Table 5.15 Projected HadCM3 and CGCM2 Changes for Temperature and Precipitation at Long Harbour, Newfoundland

	Temperature (C°)						Precipitation (%)					
	HadCM3			CGCM2			HadCM3			CGCM2		
Month	2020s	2050s	2080s	2020s	2050s	2080s	2020s	2050s	2080s	2020s	2050s	2080s
January	0.81	1.00	1.87	1.42	1.27	2.02	1.86	-7.32	3.86	0.94	0.33	6.22
February	0.37	1.34	1.47	1.58	-1.11	2.42	-11.48	-7.71	-12.20	-4.59	-7.42	5.32
March	1.22	1.74	2.12	1.44	2.15	2.28	-2.12	-8.57	11.39	5.09	10.23	5.56
April	1.58	2.27	2.65	1.15	1.82	1.92	-5.36	-4.02	9.37	2.48	4.51	-0.19
May	1.26	1.64	2.26	1.02	1.74	1.67	-19.63	-3.75	-12.84	11.97	3.03	13.35
June	1.23	1.75	2.39	0.86	1.26	1.53	-9.90	-7.70	-23.02	-1.27	-7.31	0.62
July	1.19	1.82	2.32	0.93	1.58	1.50	-14.12	6.70	2.17	-6.47	-20.05	-13.91
August	1.33	2.22	2.71	0.98	2.23	1.61	0.26	-1.50	-6.40	-1.42	1.15	-8.86
September	1.26	2.23	2.90	1.01	1.69	1.69	-2.68	-4.71	-3.07	0.75	-3.24	-16.53
October	1.20	1.84	2.20	1.16	1.66	1.91	-1.64	2.94	-4.53	5.77	-7.77	10.28
November	0.99	1.10	1.90	1.29	1.83	1.88	3.58	0.54	12.26	-2.80	4.30	-5.21
December	1.16	1.10	1.65	1.30	2.13	1.97	3.12	-3.06	2.25	4.77	-4.43	-4.18
Winter	0.78	1.13	1.65	1.43	0.82	2.13	-2.24	-6.04	-2.18	0.54	-3.75	2.35
Spring	1.35	1.88	2.34	1.21	1.90	1.96	-8.41	-5.72	3.44	6.29	5.82	7.11
Summer	1.25	1.93	2.47	0.93	1.69	1.55	-7.93	-1.07	-9.53	-3.28	-9.19	-7.67
Autumn	1.15	1.72	2.34	1.15	1.72	1.83	-0.05	-0.22	2.02	1.35	-1.61	-0.02
Annual	1.13	1.67	2.20	1.18	1.54	1.86	-4.27	-3.36	-1.40	1.12	-2.35	-0.32

The Statistical Downscaling Model (SDSM), developed by Wilby, Dawson and Barrow (2001), has been used to determine plausible future climate scenarios for sites in Atlantic Canada (Lines et al. 2006). Table 5.16 presents the predicted annual changes with respect to the baseline period (1971-2000).

Both of the downscaled (SDSM) models predict a general increase in annual mean temperature for the period 2010-2099. Both models show a general seasonal increase; however, the HadCM3 model results in the greatest mean temperature increase in summer, whereas the CGCM2 shows the greatest increase in autumn. Both models predict a cooling trend during February.

HadCM3 model precipitation predictions for the Island of Newfoundland show the greatest decrease in precipitation to occur during the 2020s; downscaled values show a general decrease in precipitation for the period 2010-2099 for Long Harbour, with a 3.41 per cent decrease by the 2080s. While the CGCM2 model predicts a slight decrease in precipitation by the 2080s, downscaled results show an increase in precipitation of 7.61 per cent for Long Harbour. In general, SDSM downscaled values differed from the CGCM2 and HadCM3 predictions and produce two conflicting trend predictions for precipitation.

Table 5.16 Projected SDSM Changes for Temperature and Precipitation at Long Harbour, Newfoundland

	Temperature (C°)						Precipitation (%)					
	HadCM3			CGCM2			HadCM3			CGCM2		
Month	2020s	2050s	2080s	2020s	2050s	2080s	2020s	2050s	2080s	2020s	2050s	2080s
January	0.07	0.07	1.05	0.76	1.27	1.73	-2.32	0.58	0.58	-0.27	2.80	2.82
February	-0.39	-0.41	-0.99	-0.50	-1.11	-1.10	-1.69	-0.60	-1.70	1.20	2.32	5.17
March	-0.03	1.20	1.41	1.59	2.15	3.24	2.35	0.82	-2.65	-1.41	-1.58	-1.61
April	0.43	1.01	1.53	1.17	1.82	2.61	-2.65	-4.61	-2.17	1.15	0.66	3.10
May	0.60	1.01	1.82	1.33	1.74	2.72	-3.62	-4.59	-4.00	3.60	4.03	9.01
June	0.77	1.36	2.11	1.02	1.26	2.36	1.60	2.28	-5.65	1.29	8.22	7.55
July	0.96	1.67	2.16	1.39	1.58	2.32	-0.51	-0.51	-7.88	2.27	4.69	6.65
August	1.40	2.30	3.46	1.81	2.23	3.58	-1.56	-3.46	-9.33	0.84	5.33	5.83
September	0.66	1.88	2.88	1.47	1.69	2.83	-0.54	-0.65	-3.83	-0.66	4.91	1.57
October	0.61	1.44	1.79	1.37	1.66	2.88	-0.80	-0.71	-3.83	8.47	12.69	24.80
November	0.84	0.98	2.59	1.28	1.83	3.08	-3.75	-0.53	3.09	4.17	11.28	9.52
December	1.81	1.91	3.06	1.49	2.13	3.66	2.09	-2.55	1.65	3.48	1.71	11.26
Winter	0.50	0.52	1.04	0.62	0.82	1.51	-0.61	-0.93	-0.09	1.70	2.35	7.01
Spring	0.33	1.07	1.59	1.37	1.90	2.86	-1.17	-2.43	-2.78	0.91	0.73	2.97
Summer	1.05	1.78	2.58	1.41	1.69	2.76	-0.14	-0.70	-7.74	1.95	6.07	7.00
Autumn	0.71	1.44	2.42	1.37	1.72	2.93	-1.45	-0.66	-2.06	3.80	9.26	11.91
Annual	0.64	1.20	1.91	1.20	1.54	2.52	-0.72	-1.08	-3.41	2.23	5.11	7.61

This indicates the difficulty of producing accurate models of long-term climate change effects. The Project design incorporates a reasonable and conservative approach over its operational period, anticipating a temperature increase of approximately 2 per cent and a variation in precipitation ranging between a 4 per cent decline and a 3 per cent increase. The Project design criteria (for physical plant, process, water cycle, storm-water runoff and residue disposal) encompass these predictions.

5.7 Effects of the Environment on the Project

A sound understanding of environmental conditions is an essential element in project planning and engineering design. In addition to the considerable body of available material, Vale Inco NL initiated several field programs to collect priority data for design input. By incorporating such data into design and planning, it is anticipated that the effects of the environment on the Project will be controlled and managed.

5.7.1 Marine Environment

Wind and waves may affect the Project by causing delays (mostly in regard to marine-related activities such as laying pipe or transporting cargo) or, in extreme cases, by contributing to accidental events. Extreme icing conditions can also hamper various operations. High precipitation will affect run-off conditions and open holding ponds. Extreme weather and wave conditions will be accommodated in Project engineering design and planning by following or improving all relevant building and construction specifications, codes and permits.

Storm surges are discussed in detail in Section 5.4. Storm surges of about 1 m (positive and negative) have been recorded at Argentia. The potential effects of storm surges in Long Harbour is considered and provided for in engineering design. Long Harbour is sheltered, so any storm surges, while they may affect water levels, probably would not be accompanied by large destructive waves.

Ice conditions (sea ice, icebergs, icing) based on historical data are described in Section 5.4. Because Placentia Bay is essentially free of sea ice and icebergs most years, and because the concentrate carrier is ice-strengthened for operations in Labrador, sea ice should not hamper marine activities.

As with other Newfoundland and Labrador waters, Placentia Bay is subject to icing of vessels from freezing precipitation and sea spray. February is the worst month: extreme icing occurs about 3 per cent of the time.

5.7.2 Climate Change

As discussed in Section 5.6, the forecast effects of climate change in the Project Area are modest. Annual average temperature is predicted to increase by 1.91-2.52 C^{o} over baseline (1980s) values. Precipitation predictions vary depending on the model parameters used, from a reduction of 3.41 per cent to an increase of 7.61 per cent over the baseline period (1980s).

These changes would not result in any change to design parameters for the Project, since such criteria are conservative and usually developed in terms of long period extremes (1:100 year to 1:1,000 year).

5.7.3 Terrestrial Environment

Seismicity of the Placentia Bay area is described in detail in Section 5.3. The seismic risk in Long Harbour is no greater than in other areas of Newfoundland and many areas in Canada. Provided that all structures are built to applicable building codes, and given the low probability of a major seismic event, the effect on the Project is considered to be negligible.

6.0 Project Construction

All construction activities will be planned to build the Plant within specifications, on schedule, within budget and without harm. There are eight major components of Construction and site development:

- Enlarging the existing wharf, demolition of non-essential buildings and infrastructure at Tier 1;
- Pre-stripping, clearing, excavation, site grading and levelling;
- Building access roads;
- Drainage works;
- Construction of Plant buildings and other facilities;
- Construction of Site roads, storm-water, water and sewage systems, and residue and raw material pipelines;
- Construction of dams for water supply and for underwater residue storage; and
- Construction of a marine outfall.

The Vale Inco NL owner's team will include, among others, a construction manager, site and industrial relations superintendents, site supervisors, safety coordinator, environmental coordinator, administrative support and site security. The Engineering, Procurement, Construction Management (EPCM) contractor will oversee the construction activities with a team that will include a construction manager, health and safety advisors, environmental advisor and assistant, quality manager, civil, mechanical, piping and electrical superintendents and supporting discipline inspectors. Field engineers will be provided for the various disciplines. There will also be a materials management coordinator, a cost controller, a document controller and administrative support.

6.1 Site Preparation and Support

Following release from the environmental assessment process, and once all the required government permits have been received, the construction team will mobilize, establish a presence at site and begin constructing access roads. One existing maintenance building on the port level (Tier 1) will be retained and will serve as headquarters for the construction management team. Mobile offices will be added as the team grows. As part of the earthworks, a space on the southeast corner of Tier 2 will be levelled to provide a laydown area for the staging and storage of construction-related equipment and material. Once work at Tier 2 is adequately advanced, the Construction Office will relocate to the Plant Site.

The existing office building, fire truck and ambulance bay, multiple concrete walls, pipe racks and conveyor gallery, as well as civil works such as existing parking lots, roads and pipelines, will be demolished. Existing water and sewer systems that serve businesses located at the port will be maintained or replaced. Sewer systems not required by these businesses will be demolished.

6.1.1 Site Grading and Leveling

The Plant Site is heavily treed with some boggy areas. Cover includes up to 400 mm of root mass/topsoil and between 400 mm and 600 mm of weathered glacial till. The varying thicknesses of glacial till consist of sand, gravel, cobbles and boulders with varying amounts of fines overlying bedrock. There are five major grading and levelling elements:

- Preparation of sites for all process and non-process buildings and related yard space;
- Containment of storm-water within the catchment area of the site and direction of the storm-water to holding facilities;
- Suitable foundation conditions for buildings, heavy equipment and machinery;
- 30-m buffer between the site and Rattling Brook to minimize potential impacts; and
- Snow stockpile area.

Construction at the site will be carried out on two fronts. Stick-build construction will cover all civil work up to and including closing in the buildings. Stick-build construction methods involve bringing all steel and equipment to the site and erecting or coupling the components on-site. Component construction will be used for process equipment. Modules and pre-assemblies will be constructed offsite at a fabricating facility, tested and pre-commissioned, and then transported to the site and placed in the process circuits.

The earthworks scope, including the processing complex on Tier 2 and the access roads, involves clearing approximately 43 ha, grubbing 120,000 m^3, and excavating 120,000 m^3 of unsuitable material, 200,000 m^3 of common material and approximately 840,000 m^3 of rock. Earthworks of approximately 260,000 m^3 will be required at Sandy Pond. Earthworks for the gypsum residue storage area (Matte Plant) would include approximately 180,000 m^3, of which about 40,000 m^3 could require blasting.

A storage area of approximately 5 ha will contain all clearing, grubbing and material unsuitable for construction. An estimated 250,000 m^3 of such material will be stored. Locations immediately south and east of the processing facilities on Tier 2 have been identified as potential storage areas.

Drainage control measures, including erosion and sediment control, will control suspended solid material transport by water and erosion of disturbed ground:

- Silt fence/curtains – for use across streams and ditches and at toe of fill embankments;
- Sediment traps to filter sediment-laden runoff from the site;
- Sediment basins to filter sediment-laden runoff at discharge points of drainage;
- Rock-lined ditches to control velocities in ditches and to encourage deposit of fines;
- Erosion mats on slopes to stabilize against washout; and
- Energy blocks in ditches to control velocity and capture sediment.

A detailed Construction Environmental Protection Plan will be prepared and implemented prior to the start of construction.

6.2 Construction Accommodations

Workers living within a reasonable traveling distance (100 km) will generally prefer to receive living and travel allowances and arrange their own accommodations. While most of the skilled workforce will be drawn from this area, there are relatively few accommodations available for workers outside this area. Consideration will be given to extending the acceptable distance for transportation allowances, enabling the majority of workers the opportunity to commute. Although Conception Bay South, Conception Bay North, Clarenville, Arnold's Cove and St. John's have a greater population than the Long Harbour area and are all located within 75 to 120 km of the site, Vale Inco NL has identified labour availability as a key risk for construction. Consequently, the company plans to provide accommodations in support of the Construction Phase, driven largely by the need to attract workers from out of the province.

The construction workforce will be operating on two shifts per day and could peak at approximately 1,700 during 2010. This peak workforce would not be available in the province and upwards of 30 to 40 per cent might have to be hired from outside. This would require accommodations to support approximately 500 people. In planning this support facility, Vale Inco NL recognizes that accommodation standards and amenities are key attractors for trades working on semi-remote and remote projects across Canada, and in order to be the construction site of choice, accommodations will have to be comparable to, or surpass, the standards set elsewhere.

The construction accommodations will be located in the vicinity of the intersection of Route 202 and Route 101, and will include a variety of amenities:

- Private rooms – single occupancy;
- TV in rooms;
- Private bathroom;
- Internet hook-up in rooms;
- Common dining room including custom culinary for immigrants as required;
- Commissaries at schedule intervals;
- Laundry facilities;
- Multi-media lounge;
- Internet café;
- Medical support;
- Bus shuttles to the work site;
- Parking lot for personal and company vehicles;
- Public telephones;
- Recreational facilities;
- Work-out room with time dedicated to women only;

- Gymnasium;
- Walking trails; and
- Games room.

The facility will be off limits to the public and access will be controlled by security. There will be a zero-tolerance policy towards alcohol, drugs and guns. Taxis will be permitted for drop-off and pick-up. Local businesses such as pizza shops will be permitted to drop off food deliveries and supplies, and will be encouraged to provide consumables, housekeeping, garbage removal, snow clearing, vending machines and other services. During Construction, site workers will be provided with proper (cold holding) storage locations for lunches as well as with suitable facilities for minor food preparation (heating) and dining.

The accommodations complex will be constructed in Year 1 to support the need for an increased workforce in Year 2. Approximately 50 people will be employed during construction of the facility and 45 during its operation.

Following completion of plant construction and demobilization of the workforce, the accommodation complex and support facilities will be removed from site by the operator and the site restored to its original condition. However, if there is a legacy value for the community of Mount Arlington Heights–Long Harbour, portions of the facility may be left in place and transferred to the community.

6.3 Marine Works

During expansion of the existing wharf (Figure 6.1) at least 60 pilings will be installed, 40 on the north side for the wharf extension and 20 on the south side to accommodate the conveyor system. Each piling will be installed 20 to 25 m into the sediment. Displaced sediment will be pumped from inside the pile and disposed on land in accordance with regulatory requirements.

Dredging in the area immediately adjacent to the existing wharf will remove an estimated 20,900 m^3 of infill sediment and some scrap steel to ensure safe docking. The dredging operation is required to provide adequate clearance for the unloading and loading of vessels at low tide. This involves removing a limited depth of sediment down to a level of 15 m over the indicated area (Figure 6.1). In addition, a small amount of material must be removed to allow for construction work associated with modification to the supports of the wharf structure.

Because dredging is limited in volume, a clamshell bucket dredge was selected as the most appropriate method. Such equipment is readily available and the method is suitable for small-scale operations. The dredge can handle boulders and scrap steel that may be present in the dredging area near the wharf.

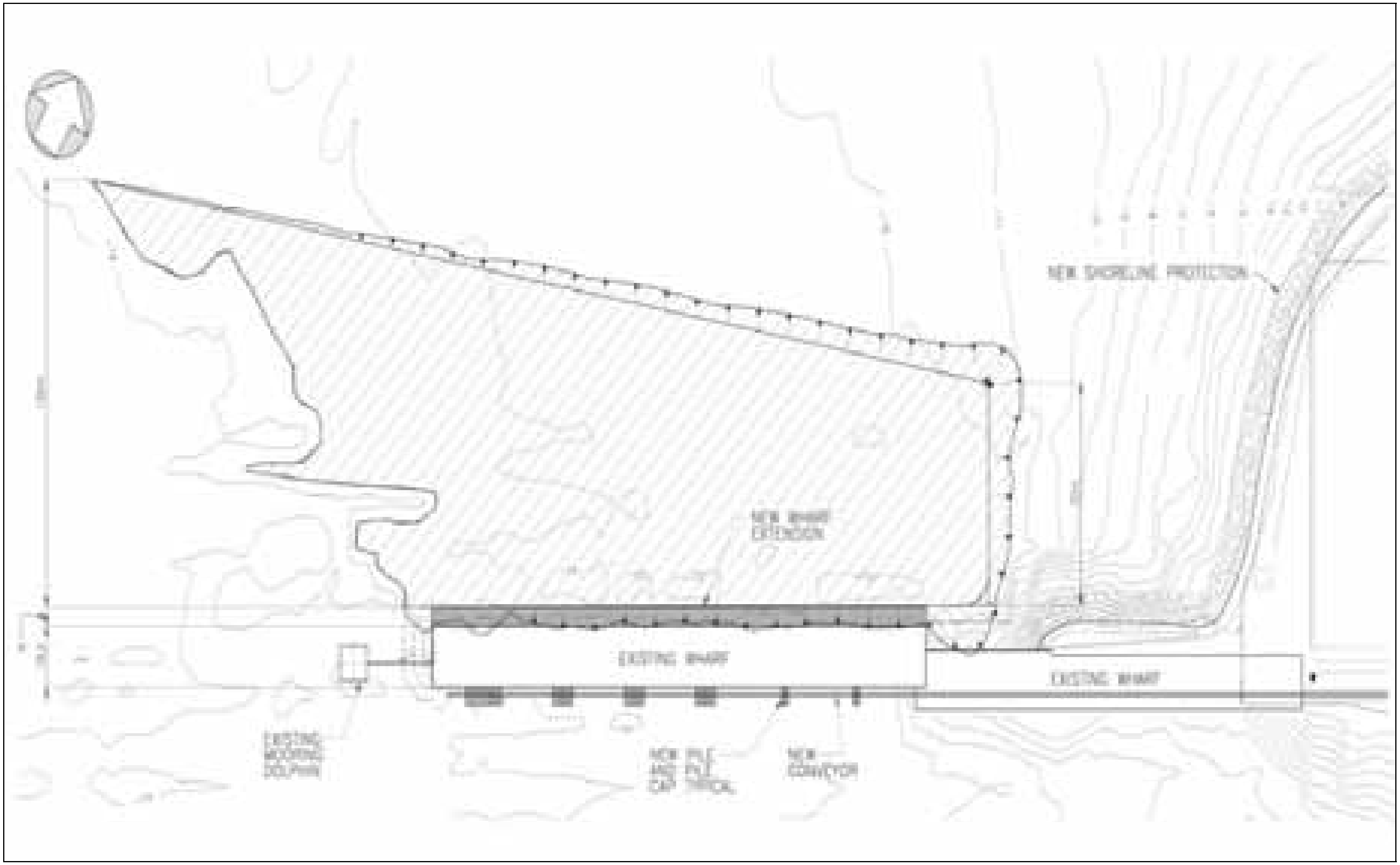


Figure 6.1 Marine Works

A portion of the dredge spoils may contain contaminants; hence provision will be made for characterization of all recovered material and for proper handling and disposal of any contaminated material. All dredge spoils will be disposed on land in accordance with regulatory requirements. The elemental phosphorus encapsulated in the existing dock will not be disturbed.

Substantial sections of the reclaim area on the foreshore and at the wharf toe will be upgraded to provide better shore and scour protection. Existing shoreline along much of the reclaim area is currently being eroded.

Shore protection for sheltered and shallow (≤3 m) areas will be provided by riprap (armour stone) and filter stone for approximately 350 m. This will cover an area of 2,800 m^2.

Shore protection for exposed and deeper (>3 m) areas will be provided by larger riprap and filter stone for approximately 450 m. This shore protection will cover an area of 4,500 m^2.

Scour protection to control erosion at the seabed from propeller wash will also be provided by larger riprap and filter stone. Scour protection will extend approximately 30 m beyond the face of the post-wharf expansion berth and up to the toe of the concrete crib. The area of armour stone in the dredged area will be approximately 6,000 m^2.

6.4 Water and Sewage

Temporary facilities for water and sewer services will be provided on-site for all workers. Potable water will be provided through a local water supply contract and distributed to key points around the site as construction evolves. Wash trailers will be provided by contractors to ensure appropriate levels of industrial hygiene. Temporary sewage disposal systems used during construction will comply with all health and safety regulations. Sewage will be handled by temporary portable toilets located around the construction site, and by underground holding tanks for the construction support trailers. All septic waste will be transported off site and disposed in an approved disposal site by a licensed contractor.

6.5 Waste Management

All domestic solid waste will be collected, properly stored, removed and disposed of in a licensed landfill site in a neighbouring community. The site and working area will be kept clean of all debris and garbage.

Materials such as paper, cardboard, wood, scrap steel and metal, and tires will be collected and offered for recycling. All materials not recycled will be disposed of in an approved facility, with permission of the facility operator. Waste accumulated on site prior to disposal will be placed in a secured location, and construction and demolition debris will be covered to prevent blowing dust and debris.

6.6 Power Supply

Temporary power for lighting and power tools will initially be provided by diesel generators. As construction progresses, temporary electrical connections will be made from the provincial grid. All temporary power will be arranged by individual contractors with permits as required by the utility and regulators.

The estimated electrical operating load for the Project is 80,000 kilovolt-amperes (kVA). Power will be supplied from the Newfoundland and Labrador Hydro bulk transmission system. The main incoming substation will have a minimum of two step-down transformers, each with sufficient capacity to carry the full Plant load.

Site primary distribution voltage will be 13.8 kV. Nickel electro-winning rectifiers and unit substations will be fed at primary distribution voltage. Unit substations will be either 13.8/4.16 kV or 13.8/0.6 kV as required. Double transformations will generally be avoided. Critical substations will be either in a primary selective or ring bus configuration; secondary selective configurations will be considered only where there is a sufficient concentration of load. Designated voltage buses will have a set of emergency diesel generators as a backup source.

6.7 Fuel Management

Transportation, storage and use of fuels at the construction site will be conducted in compliance with all relevant laws and regulations. Before transporting or storing fuel at the project site, contracted fuel suppliers will be required to provide a copy of a fuel spill contingency plan acceptable to Vale Inco NL. Contractors are required to ensure that fuel and other hazardous materials are handled by persons who are trained and qualified in handling these materials, in accordance with government laws and regulations, and in conformance with the Vale Inco NL Environmental Protection Plan. Refuelling protocols include:

- Use of leak-free containers and reinforced rip and puncture-proof hoses and nozzles;
- Use of hoses that have a design pressure rating of at least 150 per cent of the maximum head of the system;
- Attendance for the duration of the fuelling operation;
- Sealing all storage container outlets except the outlet currently in use;
- Smoking permitted in designated areas only and prohibited within 10 m of designated fuel storage areas;
- Fuel unloading facilities equipped with drip pans to collect hose drainage and drips;
- Fuel transfer lines equipped with check valves to prevent spillage;
- Fuel tanks to be self-dyked or be positioned over an impervious mat surrounded by an impervious dyke; located in areas where spills, should they occur, are least likely to flow towards water courses, water bodies, feeder streams, ditches or the ocean; fuel storage at least 100 m from any water body;

- Drums of fuel oil, if required at site, to be tightly sealed to prevent corrosion and rust; quantities on site during construction to be limited to that required for the current activity and minor equipment maintenance; and
- All storage facilities to be located away from construction activity, with secondary containment and regular inspection for compliance with regulations.

6.8 Excavation and Blasting

Excavation and blasting for construction of the Plant Site and the access road will be carried out over a 15-month period commencing in Year 1. Excavation and blasting for the construction of residue storage facilities at Sandy Pond will take place in Year 2. A total of approximately 1,420,000 m^3 of fill and rock will be removed. Concrete aggregates and other crushed material will be manufactured off-site by local suppliers.

Excavation and blasting would also be carried out at the Matte Plant residue storage site. The volume of material would total 180,000 m^3, of which about 40,000 m^3 could require blasting.

6.9 Pre-Stripping

Grubbing of the organic vegetation mat and/or the upper soil horizons, although they will be kept to a minimum, will be necessary within the Project footprint. Erosion control techniques and devices will be used to stabilize easily eroded areas. Topsoil and excavated overburden will be stored in separate stockpiles for later use. Any unsuitable material will be placed in an approved stockpile area. Runoff of sediment-laden water during grubbing will be minimized by using measures such as settling ponds, ditch blocks, interception ditches and filter fabrics. Erosion control measures such as rip-rap, filter fabrics, drainage channels, and gravel or wood chip mulches will be implemented in areas prone to soil loss.

6.10 Storm-Water Management

Historical precipitation and temperature data at Long Harbour (1969-1999) and historical pan-evaporation data at St. John's (1971-1996) were used to develop the project site climatic data. The project site 30-year continuous daily runoffs were generated through the QHM model using site-adjusted climatic data, (with consideration of the sub-watershed characteristics). Resulting runoff was calibrated using the nearby historical stream-flow records. Probabilistic events were simulated for short-duration (24-hour) and long-duration (annual runoff and 30-day spring runoff) hydrologic events.

The 24-hour rainfall depths for Probable Maximum Precipitation (PMP) and 1:100-year events were obtained from the St. Lawrence IDF data, since this station gives maximum estimates of extreme rainfalls in the Long Harbour area. This intense storm event was used to design the facilities where the peak flow rate is critical (e.g., Sandy Pond spillway, runoff discharge ditch).

Storm-water within property boundaries will be collected at containment/settling ponds and treated as necessary prior to discharge; storm water outside the boundaries will be diverted away from the work site. During construction, dewatering will minimize and control the release of sediment-laden water, which itself will be controlled through the use of filtration, erosion control devices, settling ponds, straw bales, geotextiles or other devices. The construction of storm-water management control facilities such as sedimentation ponds, site drainage ditches, and diversion structures and channels will be completed prior to site grading and pre-stripping.

An area of approximately 40 ha drains toward Tier 2 from the west. The runoff from half of this area flows into an existing pond west of Tier 2. The natural outlet of this pond will be maintained and the natural stream intercepted and directed south into another existing pond at the southwest corner of Tier 2. The remainder of the drainage area to the west of the site (approximately 10 ha) will be intercepted by a ditch running along the western perimeter and flowing north, to drain overland towards Long Harbour (Figure 4.1).

An area of approximately 100 ha drains into two ponds at the south end of Tier 2. An additional 30 ha is directed to these ponds from the west, as described above. Currently the ponds drain through Tier 2 into a tributary of Rattling Brook. A berm will be constructed to block this outlet and a channel will be constructed to redirect the flow directly into Rattling Brook.

6.11 Access Roads

Site access roads will be required between Tier 1 and Tier 2 and to the outlying structures including Rattling Brook Big Pond. For the Hydromet Plant access roads will be provided to the near and far sides of Sandy Pond. For the Matte Plant, an access road would be required to the gypsum residue storage area. Provision of a temporary access road to Sandy Pond from Route 101 is also planned during construction. Figure 4.1 shows the road network and water crossing locations.

Dry material will be moisture-conditioned or covered to prevent blowing dust. Dust control will be provided for temporary roads and construction activities, primarily by using water. Other agents such as calcium chloride may be used as required and where permitted.

There will be three road crossings of Rattling Brook, one a multi-plate bottomless arch and two culvert installations. All stream crossings will be designed and constructed to allow fish passage and to preserve aquatic habitat. All culvert installations will be sized to meet design flood conditions.

The primary entrance to the site will be constructed from Route 202 to the site security building, approximately 2.5 km. The new road will consist of 3.5-m lanes, two driving lanes and a climbing lane for slow traffic. The granular base for the road will be made up of Class A and Class B material. The finished surface for the road will be surface-course asphalt, and curbs and gutters will be installed at required locations. A three-lane multi-span culvert will be constructed over Rattling Brook to accommodate, at a minimum, CS 600 loading, or specific construction loads that may result from the delivery of modules. The 0.8-km access road to the Marine and Port Facilities from Route 202 will consist of two 3.5-m driving lanes. Construction will primarily involve road widening and relocation, new construction, ditching, and placement of granular material and asphalt.

Access roads to Sandy Pond (approximately 3.8 and 4.3 km) and to the water supply intake at Rattling Brook Big Pond (approximately 2 km) will consist of two lanes, surfaced with Maintenance Grade No. 3 gravel material. Construction will be accomplished primarily by cut-and-fill methods using local materials. The access road to Sandy Pond will need two culverts. For the Matte Plant, a similar access road would also be constructed to the residue storage area, approximately 2 km southwest of Tier 2, using cut-and-fill methods.

A single-lane, 4-m wide, rough-terrain road will be constructed for utility or off-highway vehicles to provide access to the slurry pipelines between Tiers 1 and 2. A culvert will be installed across Rattling Brook.

Site roads and driveways will be constructed to provide access to buildings and other site infrastructure. The main road access to the site will be provided from the northeast corner and will eventually lead into parking lots and the administration building area. The layout of on-site roads will be a function of the building/facility locations and their connections. On-site and internal roads will work around these areas in a block configuration to provide the most efficient layout.

Roads will be a combination of paved and gravel surfaces, depending on their function. Paved roads will be designed for medium to heavy-duty traffic loading and will generally consist of 50 mm to 100 mm asphalt over 250 mm to 400 mm of granular on compacted sub grade. Cross slopes of 2 per cent minimum will be provided for drainage.

A rough-graded construction road will be built to the Plant Site from Route 101, running along the south side of Sandy Pond toward Tier 2. This will provide access to the Plant Site borrow pits and rock quarries. Parts of an existing trail which runs parallel to the Plant Site next to Rattling Brook may also be widened for construction access.

6.12 Water Control Structure and Dam Construction

A water control structure will be required at the water supply source (Rattling Brook Big Pond), and dam construction at the residue storage area (Sandy Pond).

6.12.1 Rattling Brook Big Pond

The water supply control structure (Figures 6.2 and 6.3) constructed at the outlet will retain sufficient water in Rattling Brook Big Pond to supply the site with water, and to meet instream flow needs for protection of fish and fish habitat. DFO guidance will be sought for detailed design and placement, and the structure will be built in accordance with the Vale Inco NL Environmental Protection Plan. The structure will be an overflow weir-type, approximately 60 m long, with an access footbridge. A flow compensation facility will be incorporated into the dam and will consist of a pipe through the dam structure to maintain flow to Rattling Brook based on a minimum flow requirement of 0.3 m^3/s. Operating design water level ranges are as follows:

- Low water level – elevation 107.0 m;
- Normal operating level – elevation 109.0 m;
- Sill elevation of the weir – elevation 109.1 m; and
- Dam crest elevation – 109.6 m (design flood elevation for a 1:1000 yr. flood event).

The water supply intake location will be on the north shore of Rattling Brook Big Pond, approximately 200 m upstream from the dam.

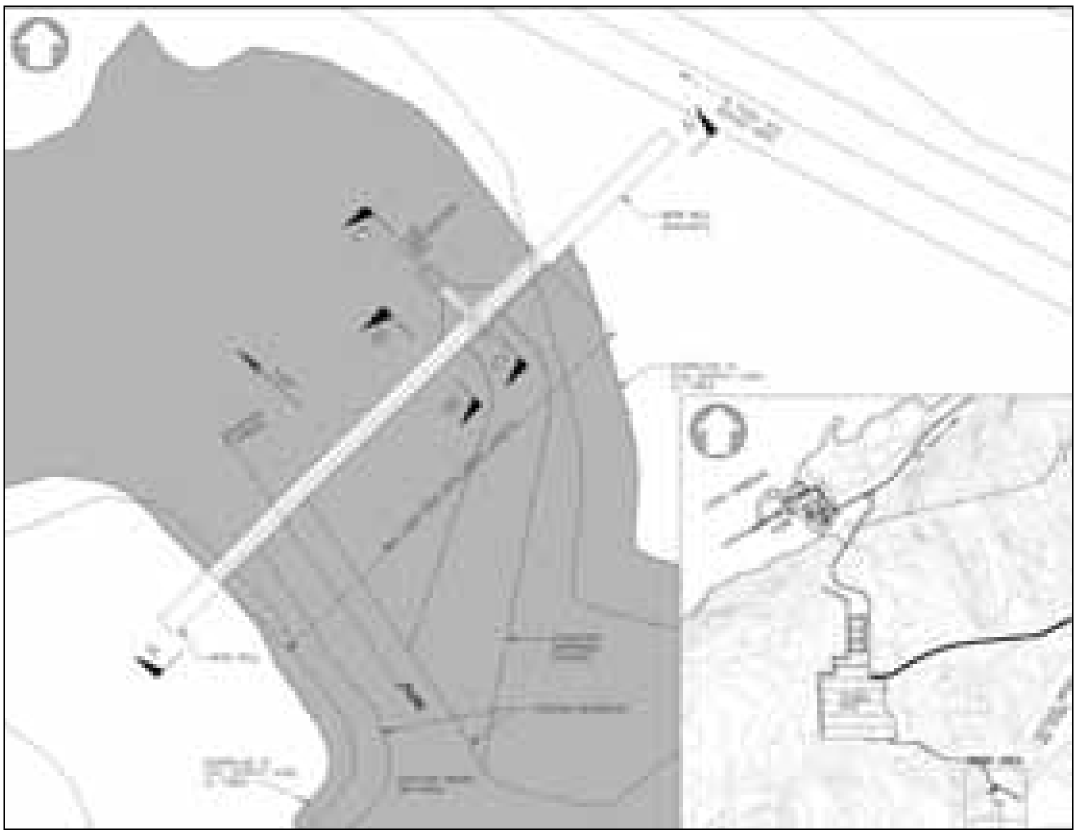


Figure 6.2 Water Supply Control Structure

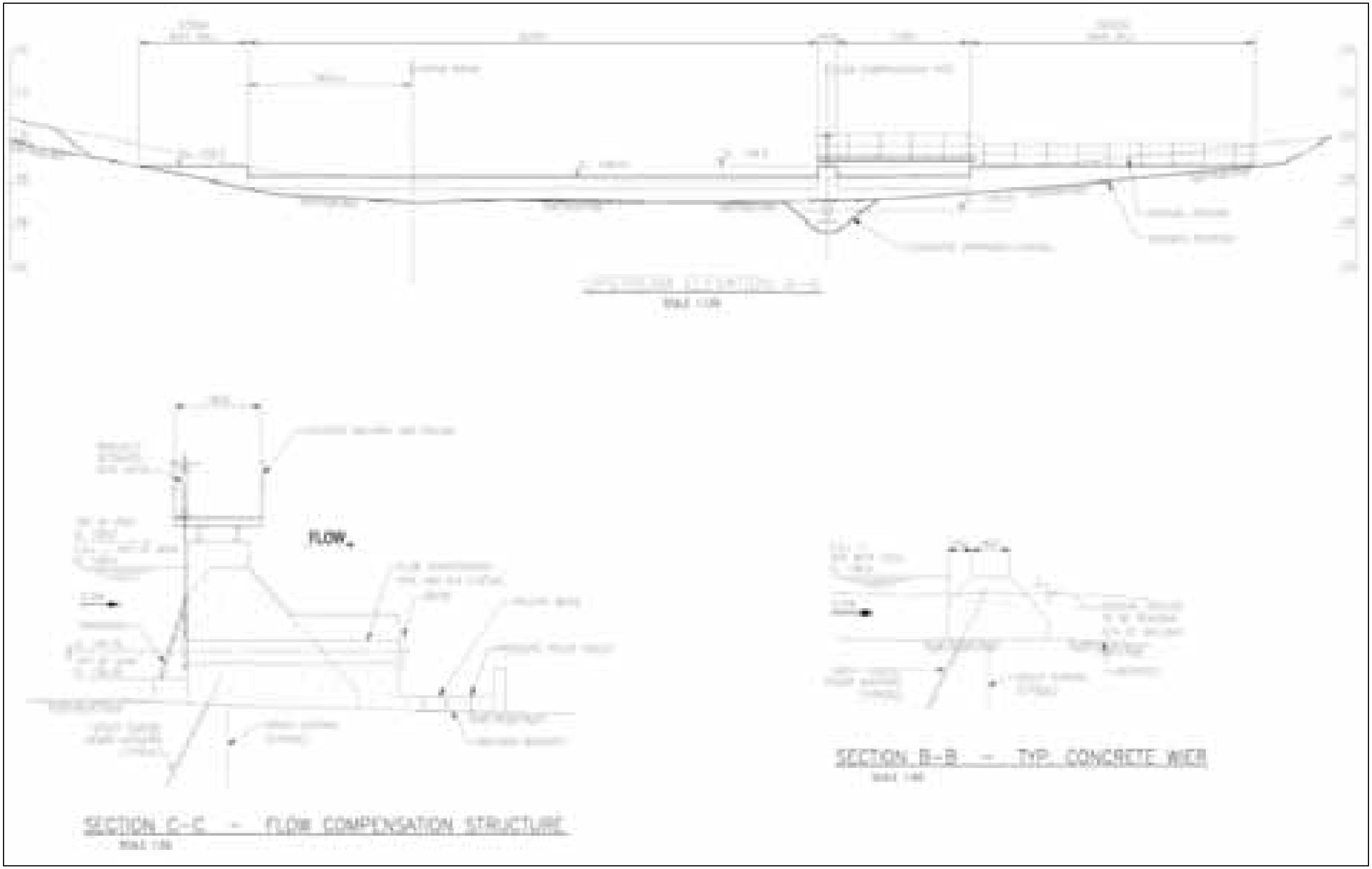


Figure 6.3 Cross-Sections, Water Supply Control Structure

6.12.2 Sandy Pond

Three earth-filled dams will be constructed at Sandy Pond to contain the residue (Figure 3.2). The dam dimensions are:

- Dam 1: 234 m long by 9.0 m high;
- Dam 2: 456 m long by 17.0 m high; and
- Dam 3: 232 m long by 9.0 m high.

A typical cross-section is shown in Figure 6.4. Cofferdams required to keep work areas dry will generally be about 3 m high with a crest width of 5 m. Runoff will be pumped at a constant rate of approximately 0.075 m^3/s during construction to keep the water level at around 126 m in elevation. The storage capacity between 126.0 m and 127.5 m is about 400,000 m^3, which is adequate to handle a 1:100-year runoff event.

All overburden materials and loose bedrock will be excavated from the dam foundation areas. The rock surfaces will be completely exposed using pressure washing or scraping and minor drilling techniques. Fracture patterns within the exposed rock surface will be mapped and evaluated. Conventional cement pressure grouting methods will be used to reduce the near-surface bedrock permeability, after which the bedrock surface will be prepared for placement of granular materials. The dams will be constructed in a series of lifts using conventional zoned embankment construction methods.

6.13 Pipelines

For the Hydromet Plant, the concentrate, lime, and limestone slurries will be piped from Tier 1 to Tier 2 within a contained area. Adjacent to this will be a pipe bench for potable process, effluent and fire water from Tier 2 for use at the Port. Sulphuric acid will also be piped from Tier 1 to Tier 2 along this bench using double–walled pipe. All pipelines will drain to a low point collection sump.

The residue pipeline from the Plant Site to Sandy Pond will be protected from road traffic, and process and operational control measures will be implemented to mitigate potential leaks. Low point collection ponds will be incorporated along the route and will have a capacity of 100 per cent of the associated section of pipe.

There will be four sets of pipelines associated with the residue storage:

- Two slurry transfer pipelines from the processing plant to the residue pond, one in operation and one standby;
- A decant water pipeline from the residue pond to the effluent treatment plant;
- An emergency bypass line from the effluent treatment plant to the residue pond; and
- Residue discharge and distribution pipes within the residue pond.

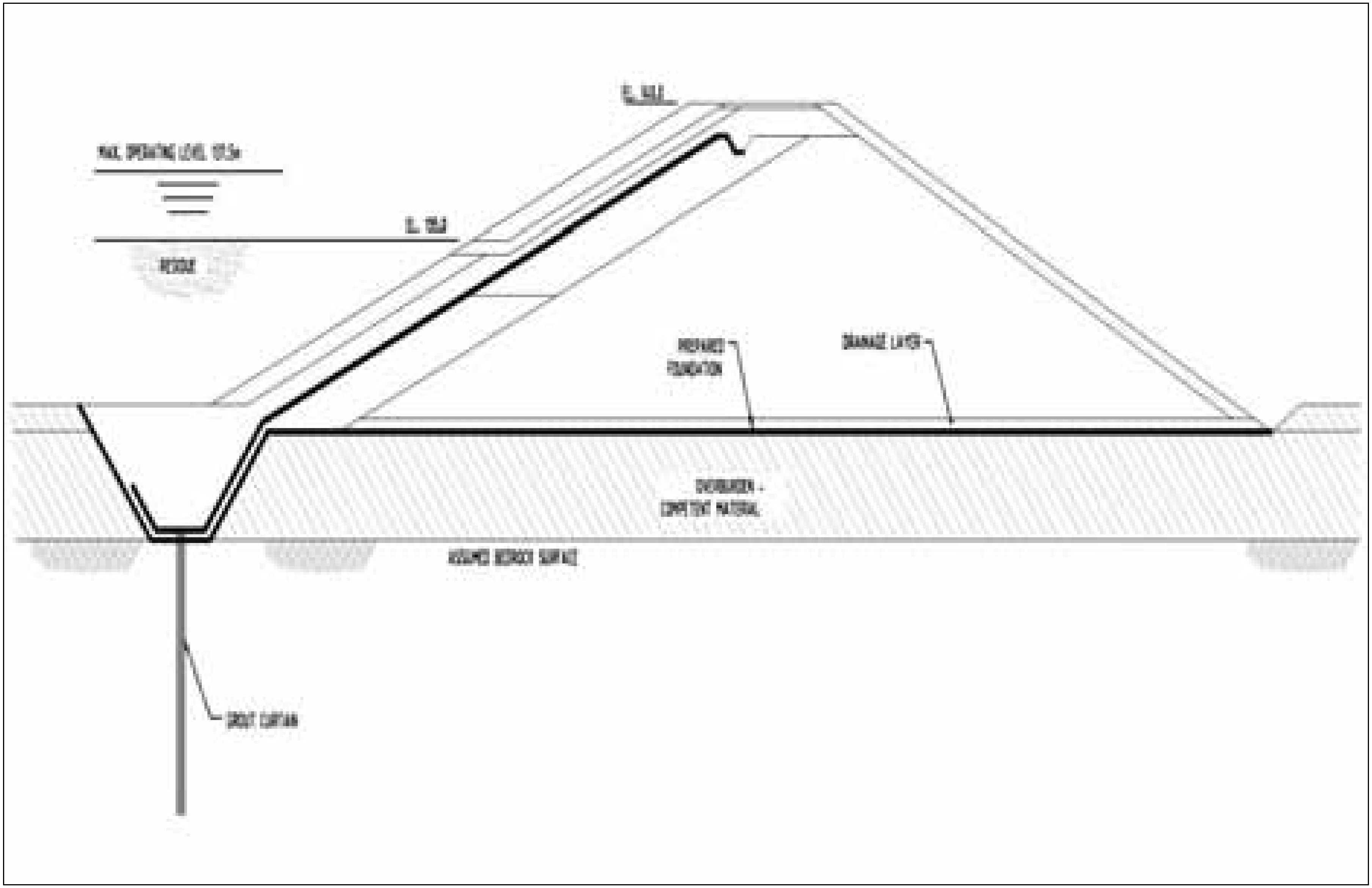


Figure 6.4 Dam Cross-Section

For the Matte Plant, a similar pipe bench would be required to route pipelines for potable, process, and fire water from Tier 2 for use at the Port Site. It would also include double-walled concentrated sulphuric acid pipe lines to transport material from Tier 1 to Tier 2.

A high-density polyethylene (HDPE) effluent discharge pipeline from the Plant Site will extend approximately 6 km underwater to a diffuser located east of Shag Rocks (see Figure 7.8). Installation and construction parameters will be as follows:

- Pipe diameter: 400 mm at shore end, 200 mm at diffuser end;
- Anchoring: concrete weights (1,500 in total) would be used to sink the pipe and hold it down on the sea bed – estimate size in the order of 750 kg each with approximate dimensions of 1,300 mm x 1,200 mm x 300 mm;
- Shoreline protection: some protection required at the head works and covering the pipeline over a length of approximately 20 m where the pipe enters the water to guard against damage or erosion due to ice and wave action;
- Grade: ranges from sea level to 60 m below at the end of the diffuser;
- Slopes: Slope on the pipe will follow the sea bed, which varies along the length; average slope is approximately 1 per cent;
- Operating pressures: will range from a head of 20 m (190 kpa, 28 psi) at the headworks to 80 m (780 kpa, 110 psi) at the ocean diffuser;
- Flow velocity: minimum of 0.6 m/sec to ensure cleansing, maximum under high-flow conditions up to 3 m/sec; the design flow range is 250 m^3/hr. to 1 866 m^3/hr.; and
- Diffuser length: 120 m.

6.13.1 Pipe Racks

Process piping between buildings on Tier 2 will generally be carried in elevated pipe galleries that will also serve as pedestrian corridors. Water supply lines will be carried in the pipe galleries and underground.

6.14 Quarries

Granular fill will be obtained from excavations in the construction area; rock fill materials will come from site-developed quarries or general excavation. Aggregates, expected to be provided from existing off-site quarries, will be stockpiled in approved locations with provision for control of silt laden run-off water.

6.15 Marshalling and Equipment Storage Areas

Owner-supplied plant material and equipment will be received during construction and initially handled at the warehouse facility on Tier 1, with easy access to Route 202. Separate laydown/ marshalling areas have been identified at each Tier. A secure fenced area will be located on the north side of the existing maintenance building and used for storage of specialty construction supplies. Other construction materials will be placed in the container storage area to the northeast of the wharf on Tier 1.

An area will be cleared at the southeast corner of Tier 2 for storage/laydown of equipment and construction materials required for Tier 2 construction. The area will be at least 30 m from any water body. Vehicles and equipment will follow established routes to the marshalling area. Any overflow will use the future Tier 2 parking area. The site for equipment marshalling will be located to minimize potential traffic hazards and ensure that incoming and outgoing vehicles can merge safely. Additional marshalling or storage areas, if required, will be sourced in the local area.

6.16 Buildings

Buildings will be constructed for a variety of purposes, including feed material storage and preparation, process operations including leaching, solvent extraction, electro-winning and neutralization, and support/services including workshops, security and administration. The general arrangement of buildings is shown in Figure 2.2 and 2.3.

6.17 Lighting

All buildings will include perimeter lighting with 400 W outdoor fixtures at 15-m spacing. Exterior lighting will be timer- or photocell-controlled. Lighting will also be provided at doorways and overhead doors.

Street lighting will be provided along the main access road to the site, but not to Sandy Pond, Rattling Brook Big Pond or, in the case of the Matte Plant, the gypsum residue access road.

Lighting will illuminate the Port Site to allow for safe operation of vessels, passage of crew and company personnel, and inspection of equipment, containers and warehousing. The container storage area on Tier 1 will use high mast poles and lighting covering the entire area. Street lighting will be provided through the restricted area on Tier 1 and the wharf. The operating area in the east portion of Tier 2 will be illuminated.

6.18 Labour Force

The Hydromet construction phase will create approximately 5,750 person-years of employment; the Matte Plant would create 4,950 person-years. Table 6.1 summarizes the estimated total labour demand by year. Vale Inco NL will work closely with contractors and building trade unions to identify a qualified skilled workforce from within the province and elsewhere to support the construction program.

6.19 Equipment, Construction Materials and Services

Contractors will be required to deliver construction equipment to the worksite in good operating condition, free of leaks, and with all appropriate emission filters. Equipment will be routinely inspected for leaks or mechanical conditions that might result in spills of fuel, lubricating oils or hazardous materials. Fuelling and routine maintenance operations will be conducted in accordance with appropriate standards and guidelines. Equipment use will be limited to approved locations, e.g., the worksite or established transportation routes. All vehicles and generators will have exhaust systems regularly inspected and mufflers will be required to be in good condition for noise abatement.

6.20 Transport of Workers and Materials

Vehicles and equipment will follow established routes when traveling to or from the site. All entrances and exits will be designed so that incoming and outgoing vehicles may merge safely with other traffic, and oversized modules will be provided with escorts as required. There will also be some marine transport to the site, and all ships used for Project-related shipping will comply with applicable shipping regulations. Vale Inco NL will require strict compliance with all environmental legislation and all vessels will operate in strict compliance with the Placentia Bay Vessel Traffic Management System. Up to three vessels per month (barges or ships) are expected to deliver material to the site during construction.

Road traffic during construction will include commuting workers and deliveries of material such as steel, concrete and a variety of consumables. Daily traffic volumes are projected in Table 6.2.

6.21 Transport and Handling of Hazardous Materials

All contractors will be required to observe strict compliance with the requirements of Workplace Hazardous Materials Information System (WHMIS) Regulations regarding employee training, use, handling, storage, disposal, labelling, and provision of Material Safety Data Sheets (MSDS), which will be required on delivery of materials. Transportation, storage, and use of hazardous materials will be conducted in compliance with government regulations. Hazardous materials will be packaged and shipped in strict compliance with regulations. All vehicles entering the site will be inspected at the gate to ensure that appropriate placards are in place and the security of the product is assured. All drivers will be required to show proof of certification.

6.22 Progressive Rehabilitation

Final grading will be undertaken immediately after completion of an activity rather than at the end of construction. As soon as possible following construction activities, the Vale Inco NL Environment, Health and Safety coordinator will identify areas requiring planting or seeding for re-vegetation, these will include areas adjacent to watercourses where erodible soil has been exposed, and where mechanical stabilization techniques are not judged sufficient to guarantee stability or prevent uncontrolled introduction of sediment into watercourses. Re-vegetation will also be considered for areas adjacent to existing roads where erodible soil has been exposed.

The work area will be cleaned up at the end of the construction phase according to applicable standards and regulations, so that any effects will be within acceptable limits. This will include proper disposal and/or recycling of all surplus construction materials.

Table 6.1 Construction Labour Estimates

Trades	NOC Code	Person-Years			
		Yr 1	Yr 2	Yr 3	Yr 4
Direct Trades					
Bricklayers	7281	n/r	10	20	4
Iron Workers	7264	80	140	120	50
Plumbers and Pipefitters	7251	35	75	150	125
Electricians	7241	40	80	130	100
Labourers	7611	60	125	125	100
Carpenters	7271	60	125	80	50
Millwrights	7311	10	50	80	60
Operating engineers	7421	60	70	60	40
Boilermakers	7292	15	60	80	70
Insulators	7293	n/r	n/r	10	6
Painters	7294	n/r	5	5	5
Sheet metal workers	7261	n/r	50	50	20
Instrument technicians	2243	n/r	n/r	80	60
Total Direct Trades		**360**	**790**	**990**	**690**
Indirect Trades					
Bussing	7412	6	12	16	11
Janitorial/Outhouse	6663	5	14	14	14
Bulks	7611	3	10	13	10
Water supply/Delivery	7611	2	5	5	5
Waste management	7611	1	3	4	4
Perm. plant maintenance	7445	n/r	2	5	3
Medical	3152	1	2	2	2
Security		12	17	17	17
Total Indirect Trades		**30**	**65**	**76**	**66**
Total Direct and Indirect Trades		**390**	**855**	**1,066**	**756**
EPCM		**265**	**350**	**300**	**108**
Owners		**80**	**103**	**99**	**84**
Operations		**0**	**0**	**215**	**410**
Total		**735**	**1,308**	**1,680**	**1,358**

Notes: Initial operations employment overlaps last two years of construction phase.
There will be similar employment by occupational group for the Matte Plant within plus or minus 5%.

- Subtotals and Totals rounded to full numbers.

EPCM – Engineering, Procurement and Construction Management

Table 6.2 Anticipated Daily Traffic Volumes

Year	Commuter Vehicles[1]	Concrete Trucks	Structural Steel Trucks	General Freight Trucks	Total for the Project[2]	Current Traffic Count[3]	Total, Current and Project
2008+	83[4]	8.8	0.6	0.4	93	1,001	1,094
2009	400	8.8	1.8	1.3	413	1,021	1,434
2010	470	7.6	0	3.3	482	1,040	1,522
2011++	198[5]	0	0	0.7	199	1,062	1,261

Notes:
[1]Vehicles per day assumes a schedule of 330 working days per year, except where noted.
[2] Estimated to nearest whole number.
[3] Estimated based on two per cent annual increase.
[4] Only last quarter (90 days) of 2008.
[5] Average commuter vehicles per day declines from 230 at beginning of 2011 to 150 by project completion.
+ Construction is expected to commence Q4 2008.
++ Construction is expected to conclude Q1 2011.

7.0 Production Operations

The Hydromet Plant will process approximately 269,000 t/yr of nickel concentrate to recover nickel, copper and cobalt, producing approximately 50,000 t of nickel, 3,710 t of copper and 2,450 t of cobalt.

For comparison, a Matte Plant would be designed to process approximately 92,000 t of nickel-bearing Matte supplied from an out-of-province base-metal smelter, producing 50,000 t of nickel and up to 420 t of cobalt. Up to 15,000 t of copper contained in copper sulphide cake would also be produced. Selenium and tellurium would be recovered as a by-product.

Because the source feed for the Hydromet Plant is less refined than the feed for a Matte Plant, a higher volume of feed is required to produce the same volume of nickel product. Similarly, the waste products from hydrometallurgical processing of concentrate are greater than would be produced by a Matte Plant, because the latter process represents a smaller portion of the full processing life-cycle from mined ore to finished product.

The concentrate feed in the Hydromet Plant contains a significant amount of iron, whereas iron is almost entirely removed in the production of Matte. Thus, while the Hydromet Plant generates a residue containing a significant amount of iron oxides, the Matte Plant would generate a residue that contains very little. In addition to different feed materials, the two designs use somewhat different processing techniques. The Hydromet process uses an aqueous chloride-sulphate medium, while the Matte Plant would use an entirely aqueous sulphate medium. The finished products from the Hydromet Plant are market-quality nickel, copper and cobalt. In the case of the Matte Plant, market-quality nickel and cobalt products would be produced, but the copper would be produced in the form of a copper sulphide cake and sent to other facilities for production of copper.

The main environmental differences between the two processes result from the types and quantities of residues produced and the method of their disposal. The Hydromet Plant produces an autoclave leach residue best stored under water so that the elemental sulphur, which is a component of the residue, will not subsequently oxidize to form sulphuric acid. It also produces a second residue made up of gypsum (calcium sulphate) and iron hydroxide. The Matte Plant would produce a relatively smaller volume of residue comprised almost entirely of gypsum, which would be stored above ground.

7.1 Hydrometallurgical Process

The hydrometallurgical processing of nickel concentrates has only recently been developed (mid-1990s) and the specific process for the Vale Inco NL nickel concentrate is still under commercial development. As described earlier, Vale Inco Limited has demonstrated that the process can produce nickel, copper and cobalt at a mini-plant scale, at its test facility in Sheridan Park, Mississauga, Ontario. The process is presently being further evaluated at the Demonstration Plant in Argentia.

The use of pressure oxidative leaching to separate metals within concentrate is at the core of the hydrometallurgical process. Subsequent purification steps lead to the generation of purified nickel, cobalt and copper streams, from which the metals are recovered by electro-winning, a large-scale form of electroplating or electrolysis. Iron and sulphur are removed as a residue during leaching. A gypsum residue is also generated during one of the impurity removal steps. The complete cycle applicable to the proposed Long Harbour facility is illustrated in Figure 7.1 and shown as a flowsheet in Figure 7.2. The estimated input quantities of materials and energy that will be needed for the Hydromet Plant are listed in Table 7.1; outputs are in Table 7.2.

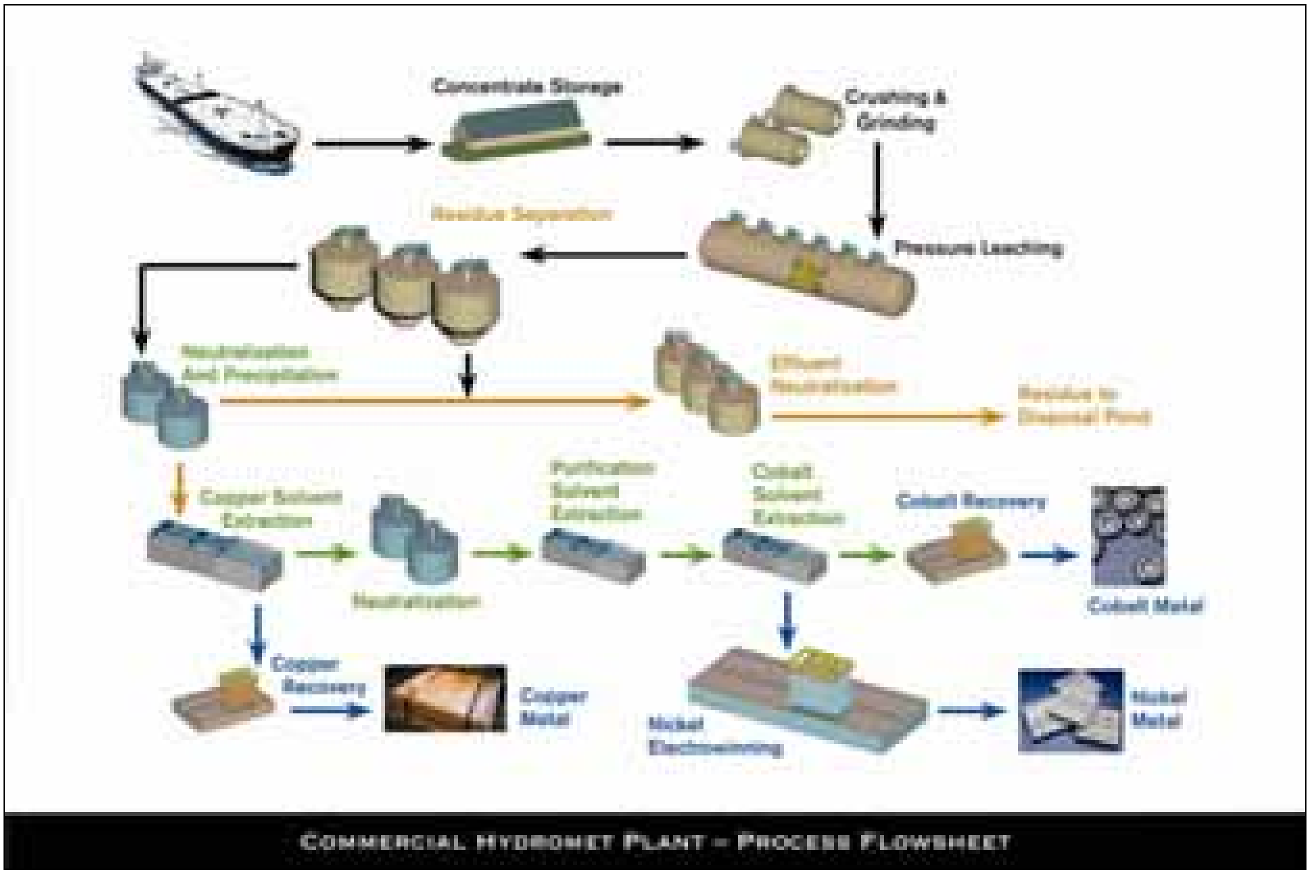


Figure 7.1 The Hydromet Process

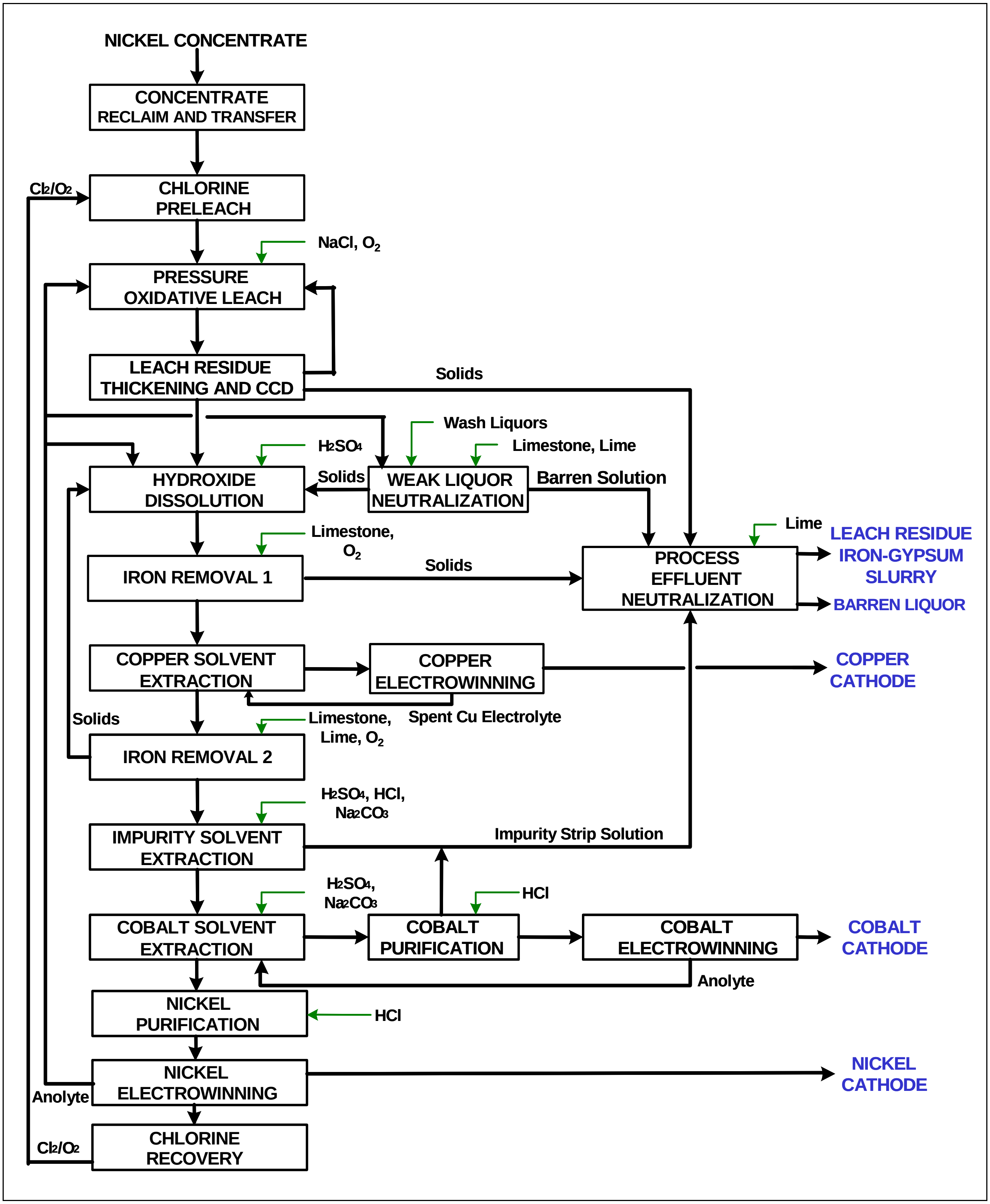


Figure 7.2 Hydromet Flowsheet

Table 7.1 Estimated Hydromet Plant Material, Water and Energy Input

Input	Quantity Per Year (tonnes except as noted)	
Nickel concentrate (containing approximately 19% Nickel, 42% Iron, 2% Copper , <1% Cobalt)	269,000	
Oxygen	154,000	
Sulphuric acid (98 wt% H_2SO_4)	35,000	
Hydrochloric acid (36 wt% HCl)	8,700	
Sodium carbonate (99 wt% Na_2CO_3)	11,400	
Coarse limestone (98 wt% $CaCO_3$)	121,000	
Boric acid (99 wt% H_3BO_4)	260	
Caustic soda (50 wt% NaOH)	539	
Sodium chloride	971	
Sodium hydrosulphide	1,100	
Sodium metabisulphite	906	
Sodium lignosuphonate	6,472	
Sodium laurel sulphate	5.1	
Flocculant	315	
Lewat TP 214	12.21	
LIX 84	34.8	
DEPHA	10.5	
Cyanex 272	3	
SX Diluent (Escaid 110; type of kerosene)	265,000	litres
Water	4,366,710	m^3
Electrical power	642,000	MWh (94 MW)
Diesel	472,500	litres
#2 Fuel oil	25,500	

Table 7.2 Estimated Quantities of Main Output from the Hydromet Plant

Output	Quantity per Year (tonnes except as noted)	
Nickel product	50,000	
Copper product	3,710	
Cobalt product	2,450	
Mixed residue	381,000	
Treated effluent to Long Harbour	7,220,000	m^3
Air Emissions		
Carbon dioxide	75,400	
Nickel	9,950	kg
Copper	1,790	kg
Cobalt	520	kg
Iron	4,690	kg
Limestone	15,070	kg
Calcium hydroxide	10,320	kg
Sodium carbonate	10,320	kg
Calcium oxide	2,780	kg
Total particulate	95,770	kg
Nitrogen oxides	93,700	kg
Sulphur dioxide	211,610	kg
Chlorine	40	kg
Hydrogen chloride	15,370	kg
Sulphuric acid	7,410	kg
Manganese	200	kg
Lead	70	kg
Escaid	0.3	kg

Nickel concentrate from the Voisey's Bay mine/concentrator is first crushed and wet ground to produce a slurry containing fine particles. The ground concentrate is then pre-leached at atmospheric pressure with chlorine gas recycled from the downstream nickel electro-winning process. The solids discharged from the pre-leach step are then further leached in an autoclave at elevated temperature and oxygen pressure in the presence of nickel anolyte recycled from the nickel electro-winning step. The pressure-leach process results in the dissolution of nickel, copper and cobalt into a mixture of sulphate and chloride solution. Most of the iron in the feed is converted to insoluble ferric oxide, while a large portion of the sulphide is converted to molten elemental sulphur. The remainder of the sulphide reacts with oxygen to form sulphuric acid, which then acts as a reagent in the leaching reactions.

The autoclave discharge is de-pressurized and cooled, solidifying the molten sulphur. The leach solution is separated from the leach residue in a thickener and forwarded to the downstream processes for the recovery of the valuable metals. The leach residue is washed with water in a series of counter-current decantation (CCD) thickeners. The washed and thickened leach residue slurry is neutralized by addition of limestone and lime to adjust the pH, blended with the iron hydroxide and gypsum residue from the downstream process, and then piped to a residue holding pond (Sandy Pond) for long-term storage. The overflow solution from the residue holding pond is piped back to the process plant. The pond effluent solution is blended with other process plant liquid effluents and neutralized further with limestone and lime to produce a solution that meets regulatory requirements. The neutralized solution is clarified before being discharged into the marine environment.

The autoclave leach solution is sent to the first iron removal circuit where nickel hydroxide, recycled from the downstream weak liquor neutralization step, is dissolved; most of the iron is precipitated by oxidation using oxygen and neutralization with limestone and lime. The precipitated iron hydroxide and gypsum are separated by thickening, followed by two stages of washing and filtration. The washed solids are re-pulped and blended with the neutralized leach residue slurry prior to disposal to the residue holding pond.

The iron-free leach solution is forwarded to a copper solvent extraction process where copper is separated to a strip solution from which pure copper cathodes is recovered by electro-winning. The copper-free solution (raffinate) discharged from the copper solvent extraction process is subjected to the second iron removal step where the remaining iron is precipitated using limestone, lime and oxygen and recycled to the first iron removal and nickel hydroxide dissolution circuit.

Minor impurities such as lead, cadmium, residual copper and iron are removed in an impurity solvent extraction process. The raffinate now contains essentially only cobalt and nickel.

Next, cobalt is recovered by solvent extraction and electro-winning to produce pure cobalt cathodes. The cobalt-free raffinate is then forwarded to the nickel electro-winning process, where about half of the nickel is recovered in the form of pure nickel cathodes, and the remaining nickel reports to the acidic spent solution (nickel anolyte). Chlorine gas, evolved during nickel electro-winning, is captured and recycled to the nickel concentrate pre-leach process described earlier. The nickel anolyte is recycled to the pressure-leach process, with a portion diverted to the nickel hydroxide dissolution step, described earlier, and a portion forwarded, as a bleed, to the weak liquor neutralization process. Here, the nickel anolyte and wash liquors from other plant operations are treated with limestone and lime to precipitate the nickel and other contained metals as hydroxides, which are separated by thickening and then forwarded to the nickel hydroxide dissolution step. A part of the metals-free (barren) thickener overflow solution is used to wash the leach residue and to repulp the iron/gypsum filter cake. The remaining barren solution is blended with the Sandy Pond return solution and then treated to meet effluent discharge regulations

7.1.1 Process Effluent Neutralization

Process plant liquid effluent and residue slurries will be collected in separate storage tanks. The liquid effluent will be pumped through two neutralization reactors in series, where the pH is raised to 9.5 using lime, resulting in the precipitation of dissolved metals. The effluent reactor discharge will be clarified before transfer to the barren liquor tank for reuse in either the plant or the constructed polishing/cooling pond. In the pond, final cooling and solids polishing will be effected prior to discharge. The residue slurry pH will be adjusted with lime in two stirred tank reactors and pumped to Sandy Pond, via a residue slurry storage tank, for residue disposal.

The Process Effluent Neutralization (PEN) circuit will be located in the Neutralization Building. The gases evolved from the reactor tanks will be scrubbed in a packed-bed scrubber using soda ash and vented to the atmosphere, and the scrubber bottoms will be recycled back to the PEN feed solution surge tanks. The area will be dyked and will have two sumps, one in the thickener/tank area outside and one in the dyked area within the building

7.1.2 Residue Storage and Water Recovery

The combined neutralized slurry from PEN will be pumped to Sandy Pond. The residue will be deposited as a slurry using floating pipelines at designed locations. In view of the low permeability values of the residue, deposition will initially be directed to the area upstream of the dams as an added seal against seepage. This location will allow about two years for the residue to reach the design top elevation of 135.0 m. Figure 7.3 shows the pattern for residue disposal for Year 1 and Year 5 of Operations.

A water cover of 1 m will be maintained above the residue to inhibit acidification of elemental sulphur contained in the residue. Liquid will be decanted off the pond and returned by pipeline to Tier 2, where it will be treated prior to discharge.

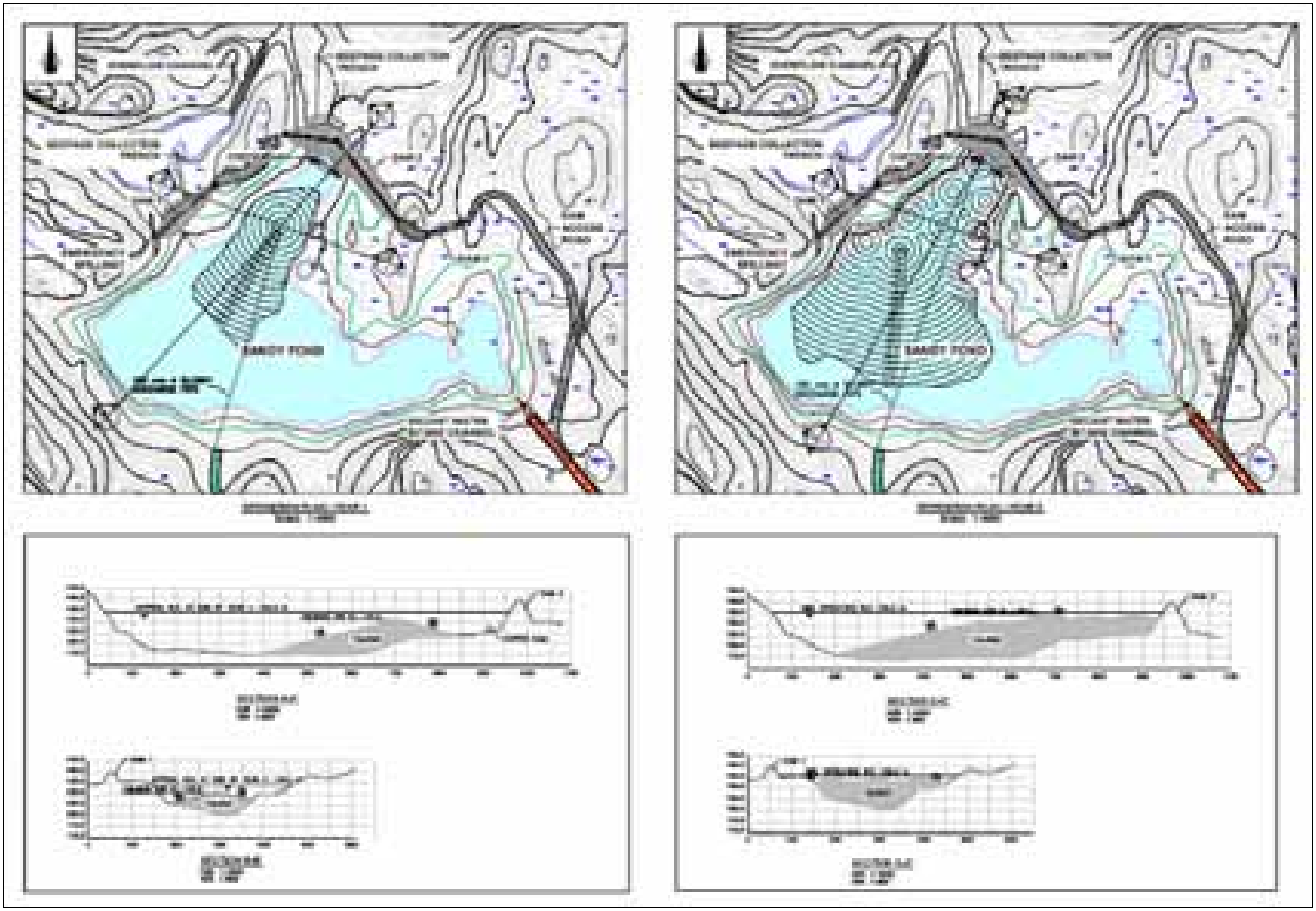


Figure 7.3 Residue Disposal Year 1, Year 5

7.2 Matte Refining Process

7.2.1 Matte Plant Process

The process for the recovery of finished nickel product from Matte feed is similar to that employed by several commercial hydrometallurgical plants in operation in South Africa and elsewhere. The nickel Matte would be produced from concentrate in a smelter, such as Vale Inco Limited smelters at Sudbury, Ontario, or Thompson, Manitoba.

The commercial Matte Plant would be designed to treat approximately 92,000 dry t/yr of sulphidic Matte containing nickel, copper, cobalt, iron and sulphur, along with a small amount of valuable platinum group metals (PGM). The plant would produce approximately 50,000 t/yr of nickel and 400 t/yr of cobalt, each as pure electro-won metal, and 15,000 t/yr of copper as a copper sulphide by-product.

7.2.2 The Process

The Matte Plant process consists of the primary steps shown in Figure 7.4. The overall process may be sub-divided essentially into two major processing circuits: one circuit for the dissolution of nickel and cobalt from the Matte in a series of leaching steps, leaving behind a leach residue containing copper (primarily in the form of copper sulphide) and iron; and the second circuit for the treatment of the nickel and cobalt-containing leach solution for the separate recovery of nickel and cobalt as pure electro-won metals. Matte processes for the separation and recovery of the nickel and cobalt from the leach solution are very similar, and in some respects identical, to those of the Hydromet process.

The nickel Matte would first be wet ground to produce a slurry containing fine solids. Four successive leaching steps are carried out on the ground Matte (solution purification, atmospheric leach, oxidizing pressure-leach and non-oxidizing pressure-leach) followed by a step to remove the selenium and tellurium.

In the solution purification step, significant portions of metallic nickel and cobalt contained in the ground Matte are dissolved by oxidative leaching in the acidic solution recycled from the subsequent atmospheric leach process and nickel solution recycled from the nickel hydroxide dissolution process, while copper and iron are precipitated. The copper and iron-free leach solution is separated and forwarded to the downstream metal-recovery processes. The discharge solids from the solution purification step are reacted further in the atmospheric leach step with oxygen and acidic solution recycled from the selenium and tellurium removal step and nickel anolyte to extract more nickel. The atmospheric leach discharge solution is recycled to the solution purification step as described above, while the solids slurry is forwarded to the oxidizing pressure leach step. Here the slurry is leached with nickel anolyte at elevated temperature and under oxygen pressure to primarily extract a portion of the copper and additional nickel into solution. The discharge slurry is forwarded to the non-oxidizing pressure leach step.

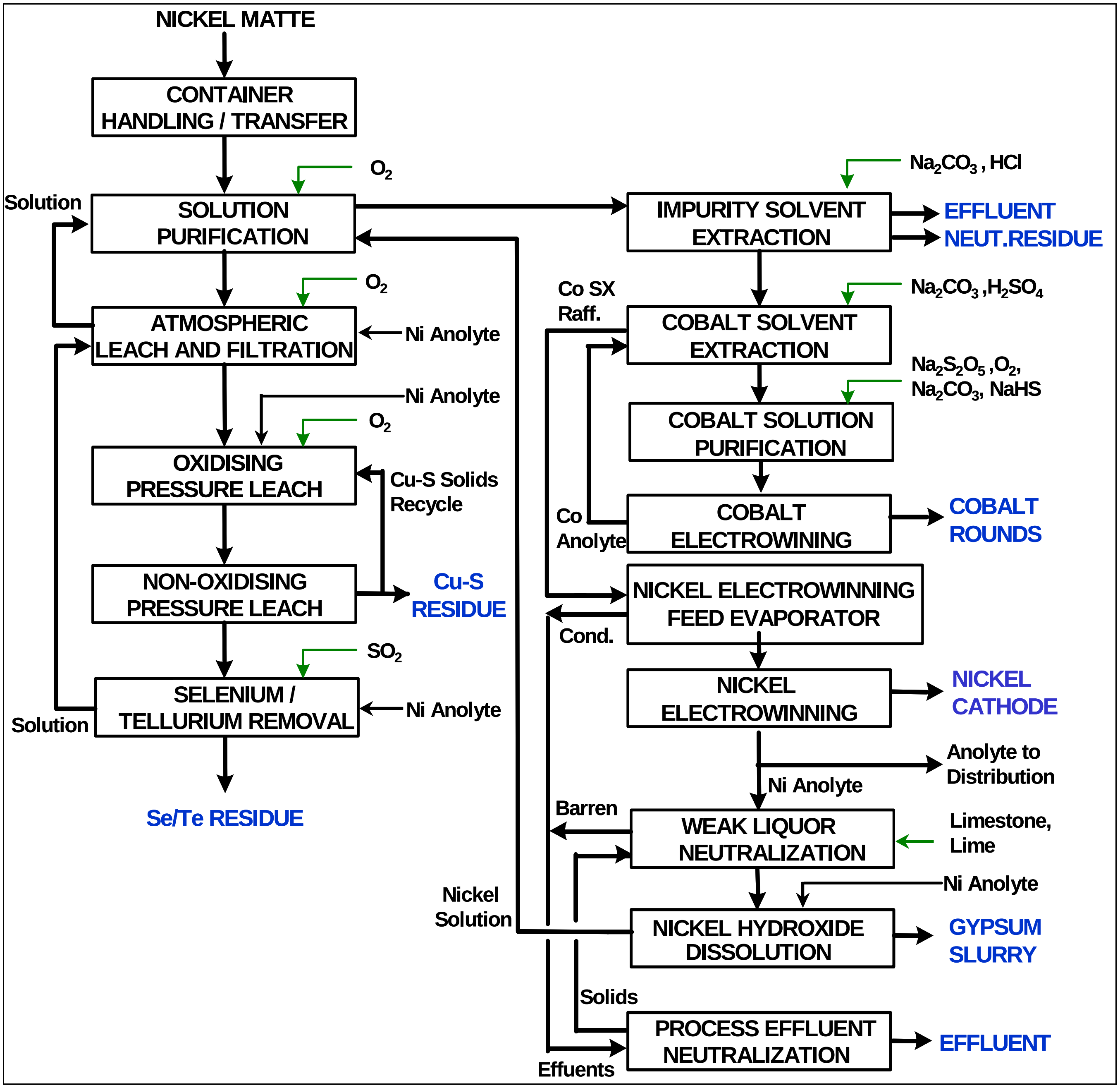


Figure 7.4 Matte Flowsheet

The remaining nickel contained in the oxidizing pressure leach discharge solids is leached in the non-oxidizing pressure leach process which operates at elevated temperature and under steam pressure. The nickel is extracted by reaction with copper contained in the solution part of the feed slurry. The solids discharged from the non-oxidizing pressure-leach process consist primarily of copper sulphide, iron oxides and essentially all the PGMs originating in the Matte feed. The solids are filtered and washed in two stages and then packaged and shipped off-site for further treatment. The leach solution is sent to the

Se/Te removal step, where selenium and tellurium are precipitated as copper compounds by the addition of aqueous sulphur dioxide. The precipitate is separated, washed and shipped to a selenium and tellurium recovery plant. The Se/Te-free solution is forwarded to the atmospheric leach step.

The nickel- and cobalt-rich solution from the solution purification would then be processed for the recovery of cobalt and nickel by the same processes used in the Hydromet Plant process. First the remaining minor amounts of impurities such as lead, copper and iron are extracted from the leach solution by solvent extraction. Cobalt is then recovered from the solution by solvent extraction and electro-winning to produce pure cobalt cathodes. The cobalt-free solution is forwarded to the nickel electro-winning process, where about half of the nickel contained in the feed solution is recovered as pure nickel metal cathodes, with the remaining nickel reporting to the acidic nickel anolyte. A portion of the nickel anolyte is treated with lime and limestone to precipitate the nickel as nickel hydroxide, with co-precipitation of gypsum. The precipitate is separated from the metals-free (barren) solution by thickening and filtration and then treated with the balance of the acidic nickel anolyte to dissolve the nickel. The nickel-rich solution is separated from the gypsum and forwarded to the solution purification step. After filtering and washing, the gypsum precipitate is slurried with the barren solution and transferred by a pipeline to a sub-aerial deposit. The solution run-off from the gypsum deposit would be returned to the process plant, blended with the remaining barren solution and then treated with limestone and lime to adjust the pH such that it meets regulatory requirements. The treated solution would then be discharged to the marine environment.

The estimated quantities of the main materials and energy that would be needed for the Matte Plant are shown in Table 7.3. The main outputs from the plant are listed in Table 7.4.

Table 7.3 Estimated Matte Plant Material, Water and Energy Inputs

Input	Quantity per Year (tonnes except as noted)	
Nickel Matte (approximately 54% nickel, 19% copper, 1% cobalt with the balance mainly iron and sulphur)	92,000	
Oxygen	53,000	
Sulphuric acid (98 wt% H_2SO_4)	58,100	
Hydrochloric acid (36 wt % HCl)	4,500	
Boric acid (99 wt% H3BO4)	194	
Soda ash (99 wt% Na_2CO_3)	9,900	
Caustic soda (50 wt% NaOH)	168	
Coarse limestone (98 wt% $CaCO_3$)	123,000	
Sulphur dioxide	1,100	
Flocculant	50	
DEPHA	9	
Cyanex 272	3	
Solvent extraction diluent	220,000	litres
Water	2,450,000	m^3
Electrical power	478,000	MWh (74 MW)
Diesel	472,500	litres
Fuel Oil #2 (steam generation)	30,500	

Table 7.4 Estimated Main Output from Matte Plant

Output	Quantity per Year (tonnes except as noted)	
Nickel	50,000	
Copper sulphide	24,700	dry basis
Cobalt rounds	400	
Gypsum residue	175,000	dry basis
Selenium / tellurium residue	535	dry basis
Residue from impurity strip solution neutralization	127	dry basis
Treated liquid effluent	2,585,000	m^3
Air Emissions		
Carbon dioxide		
Nickel	10,790	kg
Copper	1,620	kg
Cobalt	390	kg
Iron	2,650	kg
Calcium hydroxide	16,520	kg
Sodium carbonate	16,520	kg
Calcium oxide	3,740	kg
Total Particulate	74,110	kg
Nitrogen oxides	56,930	kg
Sulphur dioxide	205,200	kg
Hydrochloric acid	5,230	kg
Sulphuric acid	1,240	kg
Manganese	100	kg
Lead	30	kg
Escaid	0.4	kg

7.2.3 Process Effluent Neutralization

Process effluent neutralization removes residual metals from process effluent streams prior to discharge.

Very dilute liquors such as condensates and liquid from weak liquor neutralization are combined in the process effluent neutralization circuit, where the pH is adjusted to 10, using lime in a cascade of three reactors run at ambient temperatures. The resultant slurry, containing some metal hydroxides and gypsum, discharges to a thickener, where the solids are separated from the overflow liquid containing traces of metal. The solids are pumped from the thickener underflow to the weak liquor neutralization belt filter feed tank, where they combine with the weak liquor neutralization belt filter feed.

The metals-free liquid from the thickener overflow is pumped either to a gypsum residue re-pulp area or to the constructed polishing pond for further settling of solids and cooling prior to discharge. Washed gypsum residue from the gypsum filtration circuit is pumped to the gypsum stack. Tank ventilation is directed through the packed-bed scrubber to the atmosphere, and the resultant scrub liquor sent to the PEN reactors.

7.2.4 Gypsum Residue Storage and Water Recovery

The purpose of this area is to transfer gypsum slurry from the process effluent neutralization area to the residue storage area.

The gypsum filter cake from Gypsum Filtration is re-pulped with gypsum stack return water to a solids content of 25 per cent and pumped via Process Effluent Neutralization for storage as an above-ground deposit.

Gypsum stack drainage, including decant water and rain/snow melt runoff, is routed to a surge pond and pumped back to the process plant for re-pulping gypsum cake. The excess solution is sent to PEN.

The entire base of the gypsum storage area will have a double liner system consisting of: a clay barrier layer or reinforced geosynthetic clay liner; overlain by a textured HDPE liner; overlain by a fine gravel drainage layer; overlain by a textured HDPE liner.

7.2.5 Gypsum Slurry Pipelines

Gypsum slurry is piped from the plant to the wet-stack storage area using a high-density polyethylene pipeline. One standby/back-up pipeline is provided for redundancy and operational flexibility. The pipelines will be configured with valves for use as back-up to return water from the surge pond pump station. The pipelines will be installed on the surface at a slope that minimizes the potential for clogging. The pipeline will be flanged at approximately every 100 m to provide access for repair and cleaning. Both pipelines will be double-walled from the plant to the base of the gypsum stack, and will include a leak detection system monitored by operations personnel. The gypsum slurry pipelines will be extended up the south or east slope of the gypsum stack and into the rim-ditch as the gypsum stack is raised. Each gypsum slurry pipeline will have a valve and cleanout at the base of the stack.

7.3 Water Management

Water supply for the Plant will be drawn from Rattling Brook Big Pond at an average rate of 0.17 m^3/s. The flow regime in Rattling Brook will be decreased by about 10 per cent. To reduce these effects, a dam will be constructed at the outflow of Rattling Brook Big Pond. The existing average flow at the outlet of Rattling Brook to Long Harbour is 1.5 m^3/s (Figure 7.5). The existing minimum flow has been estimated to be near 0 m^3/s (i.e. dry); however, during Project Operation, a minimum flow of 0.3m^3/s will be maintained.

The Hydromet Plant will require about 4.4 million m^3 of water per year. The Matte Plant would require about 2.5 million m^3 per year.

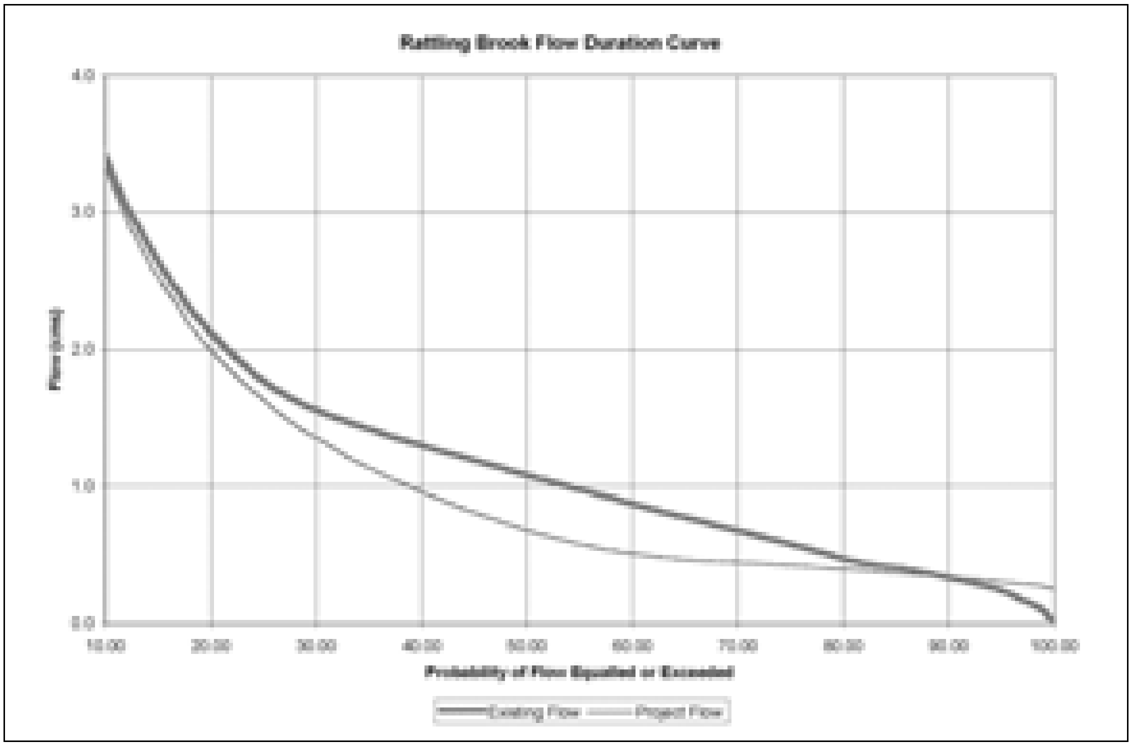


Figure 7.5 Rattling Brook Flow Duration Curve

A wet-well and pump station structure at Rattling Brook Big Pond will house a duplex pump arrangement. Diesel generator back-up power for the station will be located in a dedicated building at the site. Water will flow to the wet-well of the pump station, and then be pumped to the raw water storage via an aboveground pipeline. An on-site treatment plant will improve water quality to specification requirements, and provide raw water to the potable water treatment plant and process water systems. Water for solvent exchange and electro-winning will be subject to colour removal, while demineralized (softened) water will be taken from the potable water plant supply.

Fire, process and potable water will be provided to the Tier 1 site through individual pipelines. Water for fire-fighting may be provided by a salt-water system for Tier 1.

The water withdrawn from Rattling Brook Big Pond will be treated by increasing the alkalinity (with sodium carbonate Na_2CO_3 – soda ash) to reduce the water's potential for corrosion. Following alkalinity adjustment, the water will be distributed throughout the facility as noted below:

- Process water treatment: colour removal before distribution to solvent extraction and electro-winning processes;
- Potable water treatment: colour removal and chlorination before distribution to the demineralized water treatment plant and the potable water distribution system;
- Firewater: distribution in the firewater ring main; and
- Process water: distribution to all other plant processes.

7.3.1 Water Balance and Water Diversions

There are no water diversions planned other than for capture of runoff around Tiers 1 and 2. A preliminary water cycle for operation of the Hydromet Plant is shown in Figure 7.6. The Matte Plant water cycle is shown in Figure 7.7.

7.3.2 Storm Water

A 40-ha area drains toward the processing Plant Site from the west. This drainage area will be intercepted by a cut-off ditch running along the western side of the site and flowing north to drain overland towards Long Harbour. Perimeter ditches will be constructed around the Plant Site to intercept any remaining natural runoff draining towards the site.

All process effluent coming from the processing complex on Tier 2 will be neutralized and then treated in the polishing pond before discharge through the diffuser into Long Harbour. The polishing pond, to be located in the north end of the Plant Site, will be used to treat all effluent coming from the process plant. The pond capacity will be about 45,000 m^3, assuming a two-day retention time.

Roof drainage will discharge onto the ground via splash pads or directly from eaves. Runoff from the site will be conveyed to the main outlet through a combination of subsurface drainage, roadside ditches and underground storm sewers, and stored in the storm-water capture pond for treatment.

A system of site ditches and underground storm sewers, including surface and subsurface drainage components, will run north over the southern half of Tier 2. The subsurface drainage system will consist of perforated pipe covered with crushed stone. At the midpoint of the site, ditch inlets will convey runoff into the storm sewer system. Similarly, runoff from the north half of the site will be collected and directed to the storm-water capture pond, from which it will be discharged into Long Harbour through the main outfall pipe. A system of catch basins and storm piping will collect the main parking lot runoff and convey it to an oil and debris basin.

The Port Site will be divided into two storm-water management areas, the wharf area and the remainder of the port area. At the wharf area, runoff (including wash-water) may become contaminated, and will therefore be pumped to a holding tank and then to the concentrate storage building for use as process water. The storm-water collection system components, including catch basins, storm sewers, pump stations and storage tank, will be sized to accommodate a 1:100-year flood. For the remainder of the Port Site area, a storm-water collection system will direct runoff to a capture pond. This sedimentation pond, sized to contain the 1:25-year, 24-hour storm event (110 mm) without spilling and release water, is compliant with discharge regulations to the ocean via an outfall pipe. Storm-water collection system components, including ditches, ditch inlets, catch basins, storm sewers and pump stations, will be designed for the 1:25-year event. To minimize the amount of runoff to be handled at the Port Site, perimeter ditches will intercept any natural runoff draining towards the Port Site. An open drainage ditch

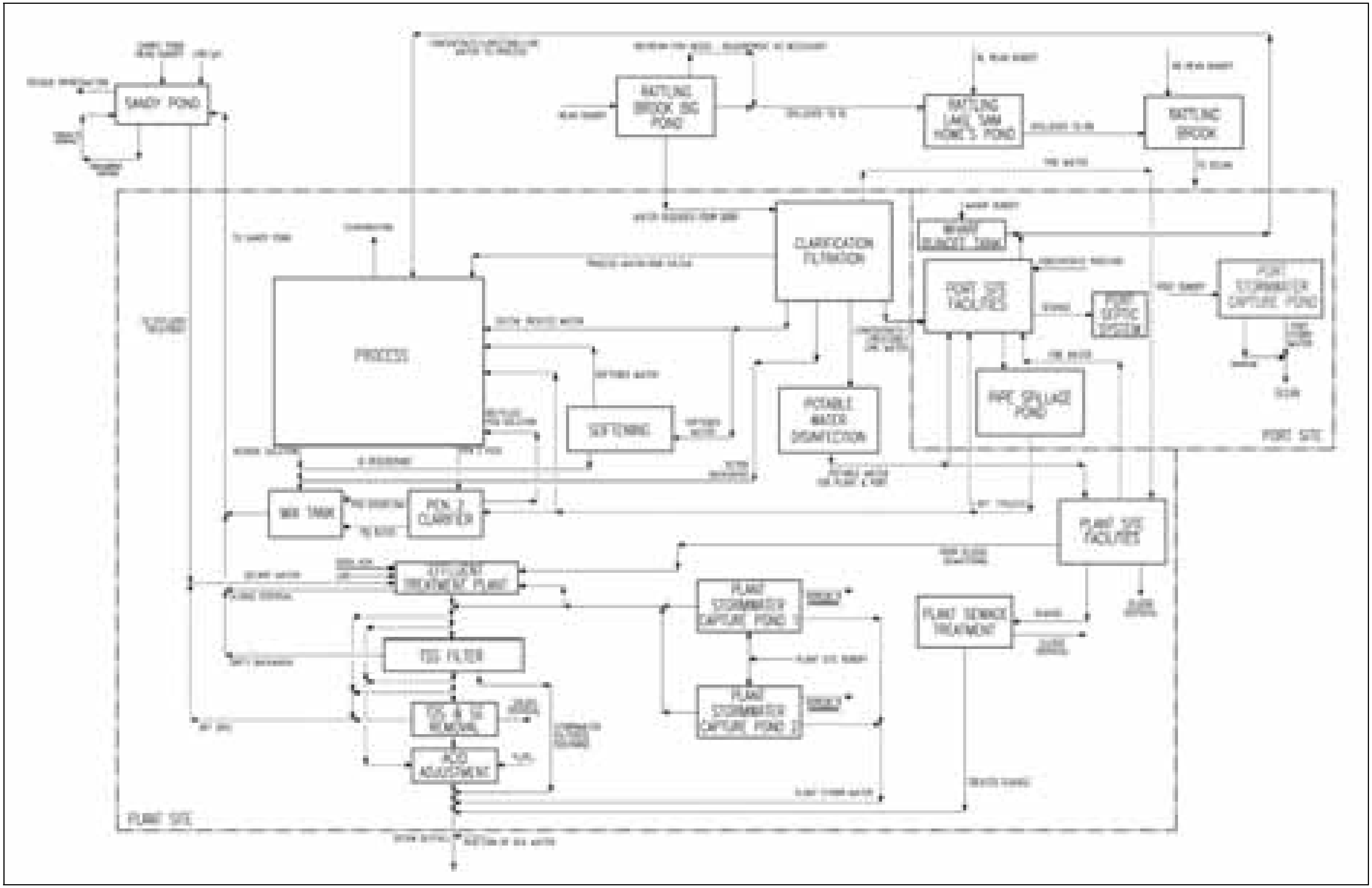


Figure 7.6 Hydromet Water Cycle

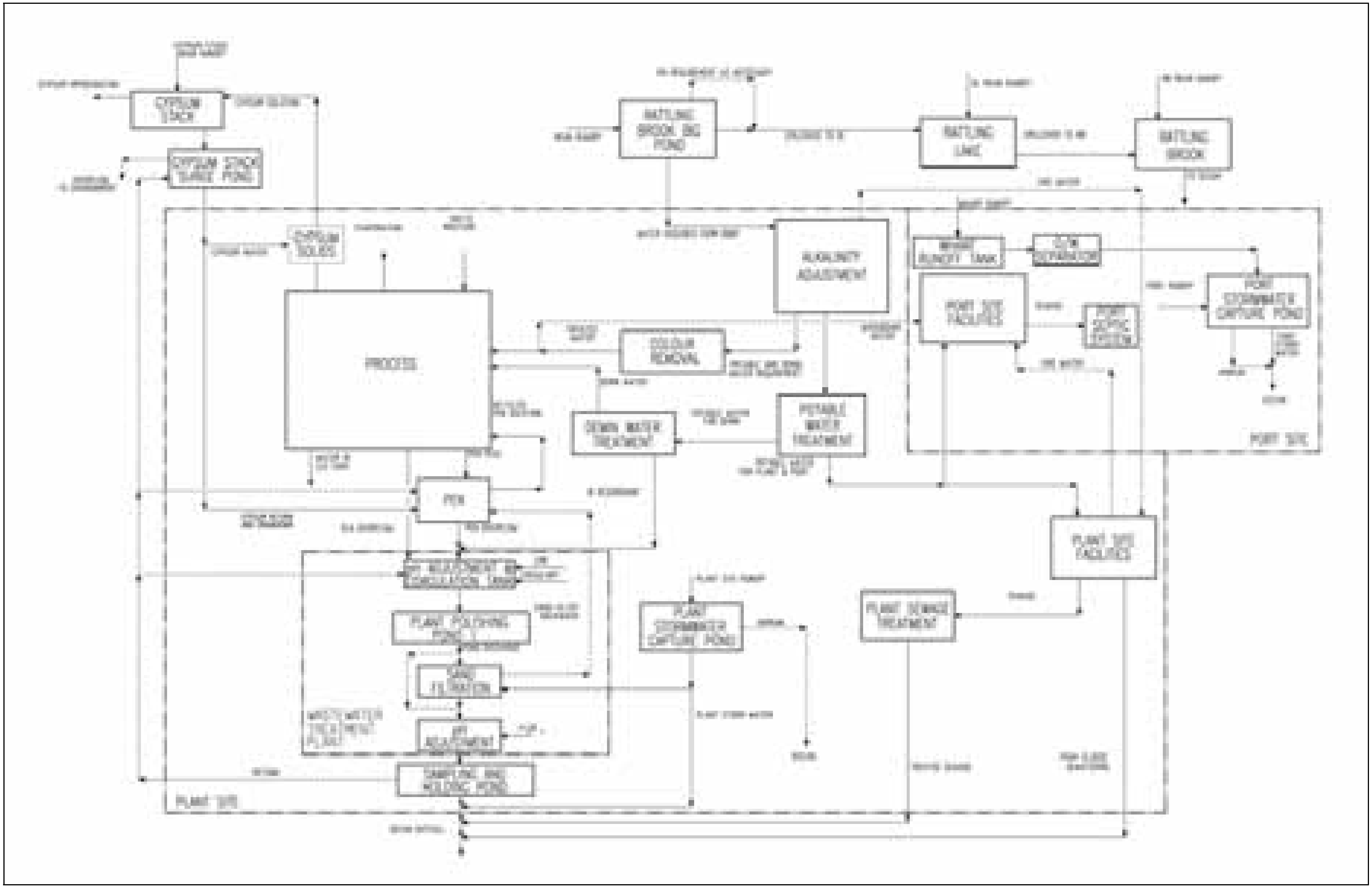


Figure 7.7 Matte Water Cycle

will be constructed along the eastern edge of the property to collect any storm water from the access road and the adjacent Rhodia property and direct it to the ocean. These drainage ditches will be designed to convey the 1:25-year event. Any drainage from the south will run naturally overland to the ocean via open ditching. Existing storm sewers from the Rhodia property will be redirected away from the Port Site area through a combination of ditches and storm sewers and discharged to the ocean.

Vehicle wash-bay water will be pumped to the water storage tank at the wharf. Concentrate vessel hold wash-water will be drained into the wharf sump pump system in summer and drained into a tanker truck and then barrelled for disposal in winter, due to the addition of glycol. Water collected from parking lots will flow through a collection basin to remove oils and solids, and then be directed into ditches for discharge into Long Harbour.

For the Matte Plant, a storm-water/process water surge pond along the east side of the gypsum storage area would have a pump station with one operating and one standby pump to return process water to the plant. The surge pond would have a staff gauge for direct reading of water level, a water level sensor with high- and low-level alarms, and an emergency overflow spillway to prevent overtopping of the perimeter containment dyke.

7.4 Waste Water and Effluent Treatment

All treated effluent will be discharged through a single outfall (Figure 7.8). The discharge pipe will extend approximately 6 km into Long Harbour and the diffuser installed at a depth of between 50 m and 70 m to take advantage of currents at the mouth of the harbour.

7.4.1 Sewage

The sanitary sewage system will collect waste from site buildings and transport it via a sewage lift station to the sewage treatment plant. The treatment system will include an equalization chamber, primary solids removal, secondary aerobic treatment and aerobic sludge stabilization. Stabilized sewage sludge from the treatment plant will be removed periodically to an off-site landfill by an approved waste disposal contractor. The treated sewage liquid effluent will be discharged through the outfall pipe and diffuser.

Domestic sewage generated at the facilities on Tier 1 will be collected and fed to a septic tank with a tile field. Sludge from the septic tank will be removed by an approved waste disposal contractor and disposed off site in a licensed facility.

7.4.2 Process Effluents

All effluent from the process plant will be neutralized and treated in the polishing pond, then monitored prior to discharge. To the greatest extent possible, aqueous solution from the PEN clarifier will be recycled back to the process; excess solution will be pumped, at a flow rate of 416 m^3/h, to a reactor tank for pH adjustment (if required) using lime. The reactor tank will also receive backwash from the ion exchange columns. From the treatment reactor tank, the effluent will be pumped to cooling/polishing ponds for solids settling and cooling. The two ponds (each approximately 80 m by 140 m), will operate in series. Periodically, one pond will be shut down for dredging; dredged solids will be transported and disposed of by a licensed handler using approved methods.

From the cooling/polishing ponds, effluent will be pumped to an in-line mixer, which adds acid to adjust pH as required. The treated effluent will then be discharged through the effluent pipeline and diffuser. Effluent from the sewage treatment plant, decant water from the potable water sludge handling system and discharge from the plant storm-water capture pond will also flow to Long Harbour via the outfall pipe.

If the effluent from the cooling/polishing ponds does not meet the discharge criteria, three options will be available for further action:

- Pump to the polishing pond sand filters, which remove any unsettled solids from the effluent and lower the total suspended solids;
- Recycle back to the treatment reactor tank where additional lime is added to raise the pH and precipitate any dissolved nickel; or
- Return for safe storage in Sandy Pond.

The polishing pond sand filters will treat effluent from either the cooling/polishing pond or the storm-water capture pond. If effluent not meet discharge criteria and require filtration, then the filters would treat the storm-water capture pond effluent while the cooling/polishing pond effluent would be recycled back to Sandy Pond.

The sand filters require periodic backwashing to remove captured solids. Backwash water is provided by a feed tank containing polished filtrate, and the backwash water discharges into a backwash water holding tank.

Decant water from Sandy Pond will be pumped from Sandy Pond and mixed with the neutralized process effluent just prior to the sulphuric acid in-line mixer, where acid is added to adjust pH. The combined treated process effluent and Sandy Pond decant water will then flow into polishing ponds before final discharge.

7.4.3 Solid Waste Management

All domestic solid waste will be collected, properly stored, removed and disposed of in a government-approved site. A 3-R program of reduction, reuse and recycling will be implemented at all facilities. All process waste solids, excluding residue, will be removed by approved waste disposal contractors and stored in licensed sites. Sewage sludge from the treatment plant will also be removed by an approved waste disposal contractor.

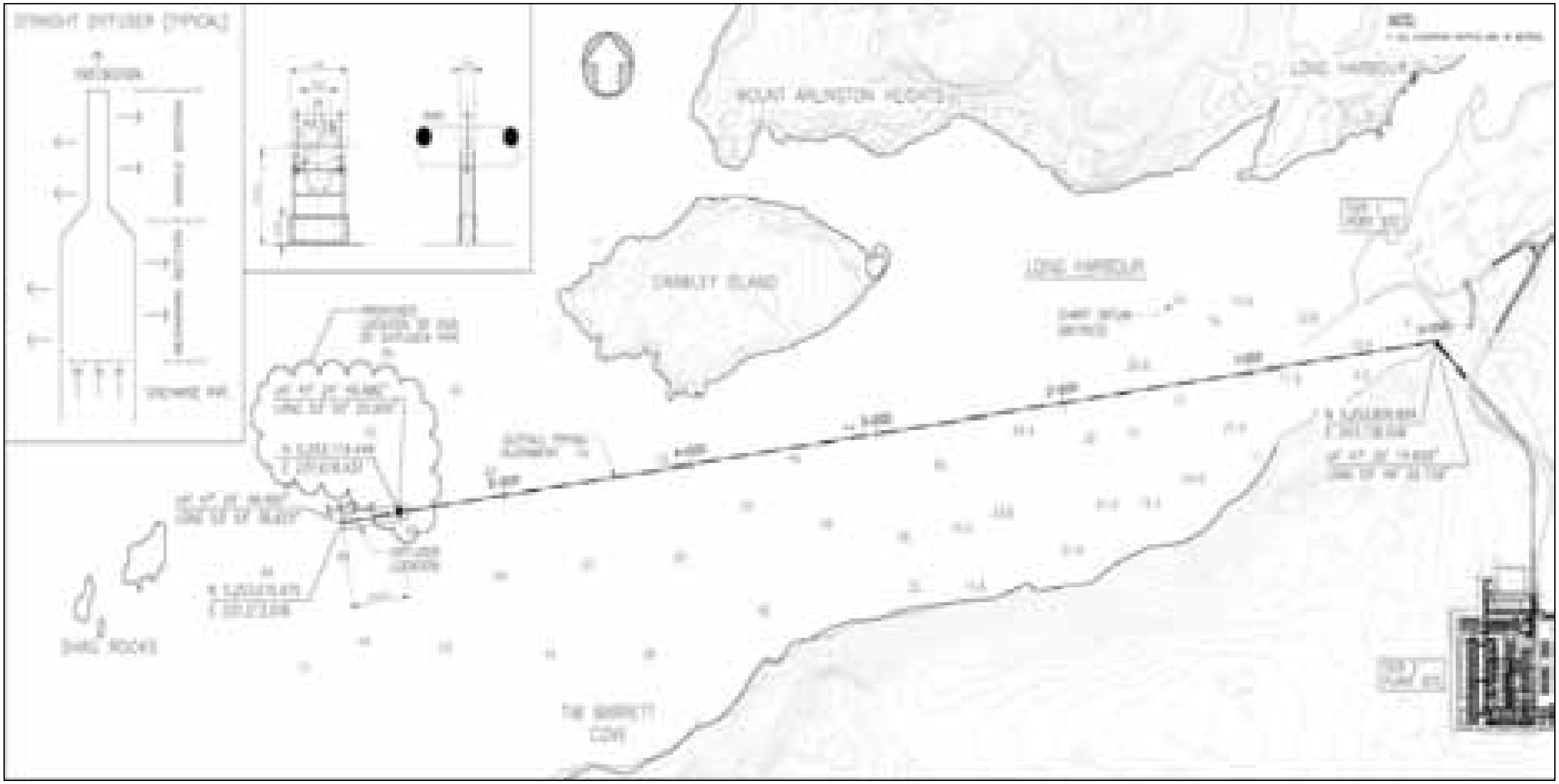


Figure 7.8 Outfall Pipe and Typical Details

7.5 Transportation

The facility will be serviced by land-based and marine-based traffic.

7.5.1 Road Transportation

Road traffic can be categorized as commuters, internal traffic and materials/supplies. Given the continuous nature of operations, site workers, contractors and visitors will create an estimated 300 vehicle movements per day. About one-tenth of this traffic will travel between the main gate and Tier 1 and the remainder to the main parking lot at Tier 2.

Internal traffic includes small trucks and rubber-tired machinery such as forklifts. With approximately 80 people per shift, it is estimated that 20 per cent will drive some form of vehicle for materials or maintenance plus the regular transport of bulk materials and supplies to and from the port, resulting in about 25 vehicles moving around the site. Of these, about six will be in motion at any one time over the 24-hour period.

Materials delivery to site and waste/product shipments from site will be by various types of trucks. At any time over the 24-hour operating day there will be about 1.15 trucks either coming, going, being offloaded, or being loaded with waste or product. At any time, while one truck is being loaded or unloaded, another truck is likely to be moving on site between its delivery/loading point and the main gate.

Flow would be similar for the Matte Plant.

7.5.2 Marine Transportation

During construction an estimated total of 40 transits (average of one per month) will be made by ships and barges delivering supplies and parts to the site. During operations, there will be an annual maximum of 25 inbound and 25 outbound ship movements of vessels up to approximately 30,000 DWT size. Bulk feed materials including concentrate, limestone and sulphuric acid will be delivered by ship. For the Hydromet Plant, an estimated 10 ships per year (in the 30,000 DWT size range) are expected to offload concentrate. Ships containing concentrate will arrive from Voisey's Bay, Labrador; ships containing Matte would arrive from outside the Province. During decommissioning there could be approximately five vessel trips to remove material from site. Bilge and ballast water from ships will be handled by third-party contractors.

7.6 Labour Force

Operations will require a variety of skilled people: management, engineering and technical operators, maintenance and administrative support. The labour force has been estimated at 450 for the purposes of environmental assessment.

7.7 Maintenance

Preventive maintenance and inspections procedures will include overall Plant, utilities and port facilities equipment inspections to assure reliability and environmental protection. There will be planned shutdowns and slowdowns to facilitate equipment repairs that cannot be done during full-stream production: equipment repairs, upgrades and internal/external inspections of components such as vessels, exchangers, pipes and pipelines, and other equipment subject to wear. The Maintenance Department will work with the Environmental, Health and Safety Department to develop a safety, environmental and preventive maintenance list that will ensure that all equipment is properly maintained and all documentation is archived.

When equipment is cleaned and flushed with water/steam during shutdowns, the flushed liquids will be contained within the individual area sumps and recycled to the process. If other solutions need to be used but are not compatible to the process and deemed hazardous, liquids will be stored and disposed of in accordance with regulations for the management of industrial hazardous waste. Solvents may be used for parts cleaning and, if so, will also be properly stored and disposed of accordingly. There may be situations where acid will be required to clean plates of exchanger tubes; any waste acid will be sent out for waste disposal through a certified hazardous waste contractor.

Oil and other fluids will be contained or stored in an approved holding tank built for that use. Used oils will be collected and disposed of in accordance with regulations for on-site storage, handling and transportation of dangerous goods. Approved facilities to accept such products off site will be used for proper disposal.

8.0 Rehabilitation, Closure and Decommissioning

Once the Operations phase of the facility has ended, the Plant will be properly closed and rehabilitative measures will be taken to ensure that the site and surrounding area are returned to an environmentally appropriate condition. Decommissioning is anticipated to take up to two years, with the exception of the residue storage pond and associated infrastructure (dams and pipeline from the residue storage pond to Long Harbour), which will be subject to ongoing long-term environmental monitoring, inspection and maintenance. The length of the monitoring period will be determined at decommissioning and following an assessment of the site, in consultation with the appropriate regulatory authorities.

Rehabilitation and Closure Plans are part of the Vale Inco NL Environmental Health and Safety Management System (EHSMS). Vale Inco NL views the development and implementation of its EHSMS from a life-of-Project perspective, to be revised and updated regularly and on an as-needed basis as the Project moves through construction, operation and decommissioning. EHSMS development and implementation is consistent with the Vale Inco NL commitment to continuous improvement, pollution prevention and stakeholder consultation. This will be accompanied by regular document review, revision and update.

In keeping with its Environmental Health and Safety Policy, Vale Inco NL is committed to progressive rehabilitation during the Operations phase. Rehabilitation will form an integral part of the operating plan and will be implemented progressively over the life of the project.

This section outlines the basic elements of the proposed Rehabilitation and Closure Plan, which is designed to restore, to an acceptable state, the biological, chemical and physical quality of the environmental resources affected by the operation and development of the Plant at Long Harbour.

The plan will conform to the Decommissioning Guidelines provided by Vale Inco Limited and will meet regulatory requirements for rehabilitation, and will primarily focus on the reclamation and rehabilitation of the facility and associated site infrastructure (including materials storage and handling facilities, residue storage areas, processing facilities, shipping facilities and other infrastructure).

The rehabilitative measures have generally been developed at a conceptual level for the purpose of environmental assessment. Additional assessment and engineering work will be required in advance of completing the plan. The draft Rehabilitation and Closure Plan will be submitted to the Assessment Committee for approval by the Minister of Environment and Conservation, Government of Newfoundland and Labrador, prior to completion of construction.

Specific objectives of the Rehabilitation and Closure Plan are:

- Restoration of affected landscapes to a stable and safe condition, which will protect public health and safety;

- Reduction or elimination of potential adverse environmental effects associated with each phase of the Project;
- Re-establishment of conditions that permit a productive use of the land and the natural resources of the area, similar to its original use; and
- Reduction of the need for long-term monitoring and maintenance by establishing, as quickly as practical, effective physical and chemical stability of disturbed areas.

The decommissioning principles that will guide the overall development and implementation of these objectives include:

- Establishing adequate background information to determine the extent and type of contamination, if present;
- Developing an effective strategy and techniques for conducting cleanup; and
- Conducting an audit of procedures and documentation of results in order to satisfy regulatory and corporate requirements.

The Rehabilitation and Closure Plan will be subjected to a general review annually and a detailed review every five years. The annual review must be conducted by the facility's next level of management. In addition, every five years, the Vale Inco Limited Integrated Management System requires that the Vale Inco NL manager of Environment, Health and Safety (or designate) review the Plan. Revisions will be made based on these reviews.

Upon decommissioning or rehabilitating a site or facility, a final report containing conclusions of the post-cleanup site assessment will be prepared and distributed for review and approval to facility management, corporate legal and corporate Environment Health and Safety departments. Vale Inco NL will plan and implement reclamation and rehabilitation activities in compliance with all applicable legislation, and will be consistent with Vale Inco Limited Environment, Health and Safety Policies. Provincial and federal statutes and regulations that will guide rehabilitation practices include:

- *Newfoundland Environmental Protection Act;*
- *Quarry Materials Act;*
- *The Occupational Health and Safety Act;*
- *Water Protection Act;*
- *Migratory Birds Convention Act;*
- *Fisheries Act;*
- *Lands Act;*
- *Forestry Act;* and
- *Navigable Waters Protection Act.*

The Vale Inco NL approach is to integrate rehabilitation into all phases of the Project. Rehabilitation planning begins prior to construction when considerations such as delineating and limiting the area of disturbance are incorporated into construction planning. Progressive rehabilitation is implemented as components or phases of the Project are completed.

8.1 Rehabilitation Overview

Rehabilitation of the Long Harbour commercial nickel processing facility will include:

- Removal and appropriate disposal of all hazardous chemicals, reagents and materials;
- Drainage and cleaning of process vessels, pipelines and equipment;
- Removal and appropriate disposal of all salvageable equipment, materials and supplies;
- Removal and appropriate disposal of all non-salvageable equipment, materials and supplies;
- Demolition and removal of all above-grade buildings, foundations and other infrastructure (e.g., wharves [except phosphorus encapsulated area], pipelines, power lines, sewage treatment facilities) no longer required once the facility has closed;
- Removal and appropriate disposal of all non-hazardous demolition debris;
- Assessment of soil, sediment and groundwater contamination in the area of buildings and other facilities, and implementation of appropriate remediation measures to address contaminated areas identified;
- Closure of the underwater residue storage area, stabilization of dams, installation of barrier or cap over waste if necessary, treatment of overflow as necessary;
- As applicable, closure of aboveground residue storage area; stabilization of dams; installation of cap over waste; treatment of drainage as necessary;
- Drainage and Closure of storm water and process water ponds;
- Removal of fencing, scarification of road surfaces, removal of culverts and stream crossings and restoration of natural drainage patterns wherever practical;
- Closure of active borrow pits and quarries;
- Revegetation, where appropriate, to control erosion;
- Long-term monitoring, care and maintenance of the phosphorus encapsulated in the dock;
- Potential long-term treatment of effluent from the residue disposal area; and
- A monitoring program to determine the effectiveness of the decommissioning.

8.2 Socio-economic Considerations

The cessation of operations of the facility will bring change to the workers, their families and the residents and businesses in nearby local communities. To help those facing change, Vale Inco NL will work with employees in advance of Closure to identify employment opportunities at other Vale Inco Limited facilities, outplacement services and counselling.

9.0 Accidents and Prevention

Vale Inco NL has a goal of zero accidents. This requires that accident prevention be assigned priority attention within the Environmental Health and Safety Management System. As well, a high level of response capability will be maintained throughout all Project Phases so that any failures in prevention can be dealt with efficiently. Plant personnel will maintain constant vigilance, undergo regular safety training, and be thoroughly familiar with the Environmental Protection Plan, the Occupational Health and Safety Plan, and all Emergency Response plans. Third-party contractors will be screened for compatibility with Vale Inco NL policies and procedures.

Hazardous materials at the site will include process reagents, motor oil, lube oil, engine coolant, hydraulic fluid, paints and solvents, propane, acetylene and cleaners. Hazardous materials will be stored throughout the site, the main locations being the Warehouse and Reagent Storage areas. The procedures and requirements of the WHMIS program and other applicable government regulations will be enforced.

The following discussion addresses potential accidental events and the measures that will be taken in planning to address each. As well, and in accordance with the Guidelines, a set of "plausible worst- case scenarios" have been developed to form the basis for impact assessment.

9.1 Spills within the Plant

Any spills from the Plant will be collected and returned to the process. A worst-case spill from one of the process buildings could involve the release of solvent extraction organics or acid solutions. It is unlikely that a spill of this type would go undetected. Plant staff would respond immediately and the release would be stopped and cleaned up. A release of this type would be reported directly to the plant manager and the appropriate regulator.

Some fuel for emergency generators and process chemicals will be stored on site. Storage tanks could fail as a result of spontaneous rupture or explosions, and spills could also result from human error during delivery (e.g., overfilling, leaving valves open). Storage tanks and facilities will be designed to conform to the Newfoundland Department of Environment and Conservation regulations with key design features including installation of impervious mats, containment dykes, and sump and collection systems. In the case of a tank rupture or leak, emergency response and clean-up procedures will be implemented. The likelihood of any oil escaping to the environment as a result of a tank failure is very low.

Spills may escape to the environment as a result of human error or faulty equipment during delivery. Such spills would probably be very small and the emergency response procedure would be implemented.

9.2 Land Transport

A variety of chemicals will be trucked to and from the plant. All transportation of chemicals will be by licensed third-party transporters operating under their own emergency procedures and responsible for first-level spill response and reporting. Vale Inco NL will screen contractors to ensure they adhere to applicable legislation and handling procedures.

9.3 Marine Transport

Concentrate and some chemicals will be transported by sea. All transportation of chemicals by ship will be by licensed third-party transporters operating under their own emergency procedures and responsible for first-level spill response and reporting. Vale Inco NL will screen contractors to ensure adherence to applicable legislation and safe handling procedures.

An assessment of the frequency of occurrence of major releases during marine transportation was based on published data acquired from the Transportation Safety Board of Canada (TSB), Det Norske Veritas Limited (DNV) and World Casualty Statistics 1995 (Lloyd's Register 1995). The literature indicates that the probability of a marine accident is proportional to the number of ship movements.

Based on TSB data, large commercial vessels travelling through Placentia Bay to Argentia have a probability of 3.86 accidents per 1,000 vessel movements. However, shipping accidents, as defined by TSB, include occurrences such as a ship hitting a wharf, grounding, ice damage, rudder damage and collision. Not all of these occurrences result in releases of vessel cargo. A review of shipping accident records for commercial vessels greater than 20,000 DWT over the past 10 years in Eastern Canada indicated that approximately 1 in 30 vessel accidents resulted in a major release. The probability of a major release was therefore estimated at 0.13 per 1,000 vessel movements. This conclusion is conservative, in part because of the marine traffic separation system and vessel traffic management (VTM) centre covering Placentia Bay. The separation system and VTM centre decreases the chance of a collision, one of the key contributors to major releases.

Information from DNV (Det Norske Veritas Limited 1997) based on British statistics and a study for a port in that country indicate the probability of a major spill as approximately 0.03 per 1,000 vessel movements. Information from Lloyd's Register indicated that the probability of a complete loss of a ship is in the order of 0.017 per 1,000 vessel movements. Based on these statistics, the overall probability of a major release scenario was averaged to be 0.08 per 1,000 vessel movements. The operating period for the Project (15 years) and the anticipated marine traffic volume (up to 25 inbound and 25 outbound vessels per year) produce a probability for a marine spill to be in the order of 0.00955 per cent.

Marine spill modeling was undertaken and focused on the hypothetical release of a large quantity of materials: soda ash and nickel concentrate. Ships' fuel was also considered (AMEC 2007d). Lime and limestone were not considered for marine spills at dockside, as transfer will be via conveyor.

Hydrochloric acid was not considered for marine spills since the planned method of transportation is by truck. Limestone spill effects were considered minimal.

9.3.1 Sulphuric Acid (H_2SO_4)

Concentrated sulphuric acid (98%) will be shipped by chemical tanker as a very dense liquid. Although sulphuric acid is commonly shipped, there have been few large-scale accidents. An Internet search reveals only two recent incidents of relevance: a barge roll-over in a Louisiana port and an emergency discharge in a shipping channel in Brazil. Thus it is not possible to assign a realistic probability to such an event. For purposes of impact assessment, the reasonable "worst-case scenario" developed is of a springtime release of full vessel cargo (7,500 t) as a consequence of a shipping accident at the mouth of Long Harbour. The loss of an entire cargo over a period of several hours is unlikely because of compartmentalization in acid transport ships. Even in the event of a sinking, release of cargo from the seabed would not be sustained at high rates.

At the port, sulphuric acid will be pumped from the transport vessel. The maximum accidental dockside release for sulphuric acid transfers could be about 225 t.

9.3.2 Ships' Fuel

No seaborne shipment of fuel is required for the Project; however, in the unlikely event that the ship is damaged in open water, its own fuel supply may be released. Spills modeled include release in Placentia Bay and in Long Harbour from a cargo vessel. An IFO 180 fuel mixture was assumed and the calculated maximum volume of bunker fuel transported is 2,180 m^3 (approximately 2,200 t). For perspective, this represents less then 1% of the oil cargo (16,000 barrels versus 2,000,000 barrels) carried by oil tankers transiting Placentia Bay.

9.3.3 Concentrate

The modeling exercise assumed that a reasonable "worst-case" would consist of the release of 30,000 tonnes of nickel concentrate. Due the density of the concentrate (4.2 kg/l), the particles would quickly reach the bottom and remain fairly stable on the seabed. Nickel concentrate deposits and consequent bottom accumulations were found to be reasonably stable at all locations. Nonetheless, strong storms could move a proportion of material spilled at the wharf. Overall, from a long-term perspective, the particles should stay and/or accumulate in sediment.

Matte would be shipped in bags packed in sealed containers; this precludes a significant spill. Nickel concentrate will be moved from the shipping vessel to the wharf using a single-crane clamshell bucket. For dockside release the volume was based on one single-crane clamshell bucket with a volume of 18 m^3. Spill skirts or tarpaulins would be provided for the hoppers or between the wharf and the vessel to prevent spills to the environment. Spill skirts are designed to catch only the overrun from the bucket, not an entire load.

A nickel concentrate spill would stay at the same location for many years (AMEC 2007d). The anticipated seabed deposit would be in the form of a dome of approximately 40 m in diameter and two cm in maximum height (Figure 9.1).

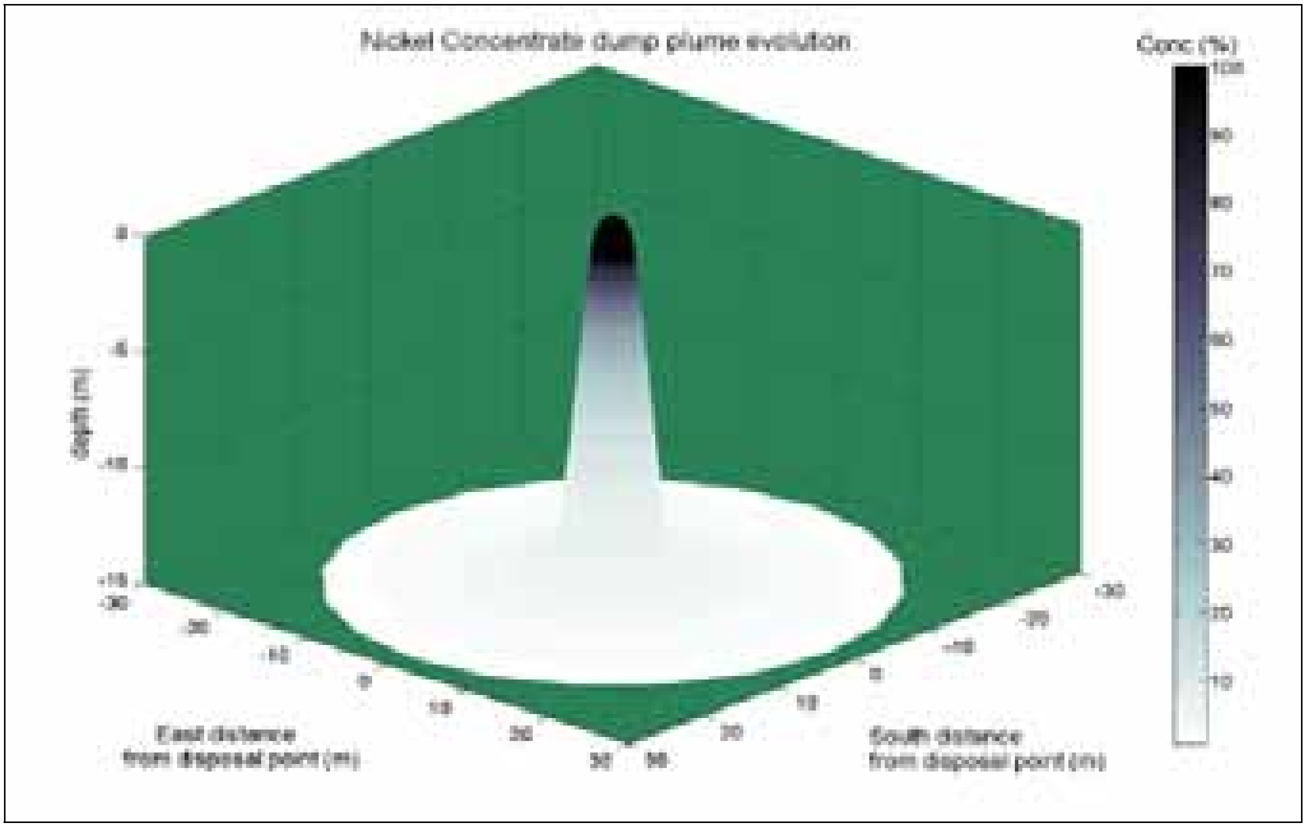


Figure 9.1 Typical Nickel Concentrate Spill at Dockside

9.4 Explosion and/or Fire

There are a number of situations that might result in explosion or fire at the Plant Site. During the Construction Phase, accidental ignition could occur through welding operations, sparks from cutting/grinding, and smoking (lighters, matches). Other potential sources of ignition, mainly occurring during Operations Phase, include autoclave vessel failure, poor grounding of electrostatic charges, hot bearings or mechanical heat generation in fuel pumps, and fuel discharge onto hot surfaces.

A fire could result in the release of toxic chemicals, including chlorine gas and by-products of solvent combustion, into the atmosphere. Fire in the organic reagent storage area could result in extensive equipment and building damage, with release of combustion products to the atmosphere. The worst case could include solvent extractants and diluent loss from the containment area, contaminating the storm-water drainage system and resulting in a fire.

Project design will incorporate fire prevention and suppression techniques throughout the Tier 1 and 2 facilities, with particular attention to detection in all areas where volatile chemicals are used. Fire protection systems and emergency response procedures will be implemented immediately upon detection of a fire. A certified, trained fire-fighting capability will be maintained on site.

9.5 Large Storms

An accidental release as a result of a large storm would be related to overtopping of containment structures. Natural run-off from upstream locations will be intercepted by diversion ditches and directed around the Plant Site to natural drainage channels. The diversion ditches will be designed to convey 1:25 year storm events, and rock lined to minimize erosion and prevent the transport of fines. Energy dissipation structures in the form of rock groins will be installed as required. The potential for flood is mitigated by the terrain, as the site slopes towards the storm-water pond and from there into the polishing ponds.

The design of Sandy Pond capacity is highly conservative. A four-year water balance model, developed to represent extreme flood conditions, was used to confirm that the storage capacity of containment ponds is sufficient to contain extreme floods, given the designed pumping rates. For this facility a sequence of two 1:100 annual runoff and 1:100 spring runoff events were combined to provide the design criterion. This highly conservative approach accommodates the potential increase in precipitation that may be attributable to climate change.

Overtopping would create the potential to release contaminated site run-off, to flood the access road, and to flood buildings.

Storms were also considered during the modeling of marine accidents.

9.6 Transportation Accidents

Vehicular accidents could result in spills of fuel or other hazardous material. Trucks will be used to transport hydrochloric acid, boric acid, caustic soda, fuel oil and specialty items such as lab chemicals. The severity of a spill would depend on the nature of the material, the location (e.g., a watercourse), the time of year (e.g., spawning of fish) and the volume. Emergency response and clean-up procedures would be implemented for all spills. Other potential accidents include vehicle/wildlife collisions on site roads.

9.7 Pipeline Failures

9.7.1 Slurry Pipeline Releases

Pipelines from the Tier 1 area to the Tier 2 Plant Site will transport material, including concentrate slurry, lime and limestone slurries, and sulphuric acid. The acid pipeline will be double-walled. All pipelines will be located within trenches or open culverts to contain and divert any pipeline spills. The pipeline routing generally follows the natural contours of the hillside in an S-shaped path upward, with two sections at grades of up to 7 per cent.

The pipeline is approximately 1,400 m long, and is expected to be 100 mm in diameter. Pipelines will be monitored at both ends to detect any loss of pressure and equipped with automatic shutdown systems. The exact nature of a pipeline release, where it might occur, the length of time before it is discovered and the weather conditions at the time of the release are variable. The nature of the material released would affect the amounts penetrating into the ground or remaining at the surface. Weather conditions at the time of the release would also affect the fate of the released material and the possible containment and cleanup.

9.7.2 Sandy Pond Residue Pipeline Releases

These pipelines will transport residue slurry and decant water. There will be an emergency outfall bypass line.

These lines will be built along the Sandy Pond access road and collection ponds will be constructed at low point locations along the pipe route. Pressure meters with automatic shutdown systems will be installed at both ends of the pipeline to monitor for potential spills/leaks. The pipelines will be inspected regularly, and any debris that collects in the collection ponds will be cleaned up in a timely fashion.

9.8 Effluent Treatment System Failures

A pipeline will convey treated water from Tier 2 to Tier 1 for discharge to Long Harbour. Flow rates will range up to a maximum of 1000 m^3 per hour during normal operation. The most likely potential release would be a partial release of 20 per cent of pipeline flow for one hour.

Possible causes of effluent treatment system failures can include:

- Chemical feed failure;
- Mechanical failure (agitator, pump);
- Instrumentation error;
- Operator error;
- Clarifier upset; and
- Polishing filter failure.

Depending on the stage of treatment, the effluent could be beyond specification, resulting in a volume of contaminated water being directed to the ocean. Release could result in a visible plume. An upset condition could cause high-temperature water to discharge to the ocean, but temperature would likely revert to background levels within 100 m of the diffuser. Failures within the effluent treatment system would be diverted to Sandy Pond.

9.8.1 Breaks or Damage to the Effluent Outfall Line and/or Diffuser

Failure of the effluent outfall line and/or diffuser could occur as a result of water hammer, storm events (waves) or vessel interaction. If the outfall line fails on land, the access road could be flooded and Rattling Brook could receive treated effluent. Outfall diffuser failure could result in concentrations of effluent at the ocean surface.

9.9 Dam Failures

The historical probability of failure of large embankment dams (excluding failure during construction) is 4.1 x 10^{-4} per dam-year. This is based on the period up to 1986 internationally, for 136 dam failures in an estimated 300,400 dam-years with 11,192 total dams.

The dams around the Sandy Pond residue storage facility will be built to meet the latest edition of the Canadian Dam Safety Association (CDSA) Dam Safety Guidelines. The structures are relatively small; however, if one should fail, there would be a release of pond water and residue. Flow modeling was conducted to evaluate the potential contamination of groundwater and the effect of various clean-up scenarios on groundwater quality.

AMEC (2007d) considered breakage in one of the three dams at Sandy Pond. Dynamic Flood Routing Analyses for each dam indicates that overtopping failure would produce the maximum flood and cover the greatest area, but fair-weather (normal condition flooding) failure would result in the most residue material released.

Both scenarios would see the release a mixture of residue material and flood water, which would overtop and likely wash out Highway 202 and subsequently run into Long Harbour. The released residue material flow would deposit along the flood path and contaminate the area and the downstream marine water.

An overtopping failure of Dam #1 (Figure 9.2) would result in a maximum inundation area of 60 ha with flood depths of up to 10.2 m. A mixture of water and residue material would be released at a peak rate of 1,300 m^3/s. The diluted residue material and water flood wave would overtop the small pond downstream of the dam, split into two directions, and then overtop Highway 202 and discharge into Long Harbour.

An overtopping failure of Dam #2 (Figure 9.3) would result in a maximum inundation area of 91 ha with flood depths of up to 10.2 m. A mixture of water and residue material would be released at a peak rate of 4,100 m^3/s. The released material would split into three flood paths, overtop and wash out Highway 202 and discharge into Long Harbour.

A fair-weather failure of Dam #1 would produce a maximum inundation area of 45 ha with flood depths of up to 8.7 m. A mixture of water and residue material would be released at a peak rate of 850 m^3/s.

The diluted residue material would follow the same route as for an overtopping failure but cover a smaller area, eventually discharging into Long Harbour.

A fair-weather failure of Dam #2 would produce a maximum inundation area of 76 ha with flood depths of up to 8.8 m. A mixture of water and residue material would be released at a peak rate of 2,600 m^3/s. The diluted residue material would follow the same route as for an overtopping failure but cover a smaller area, eventually discharging into Long Harbour.

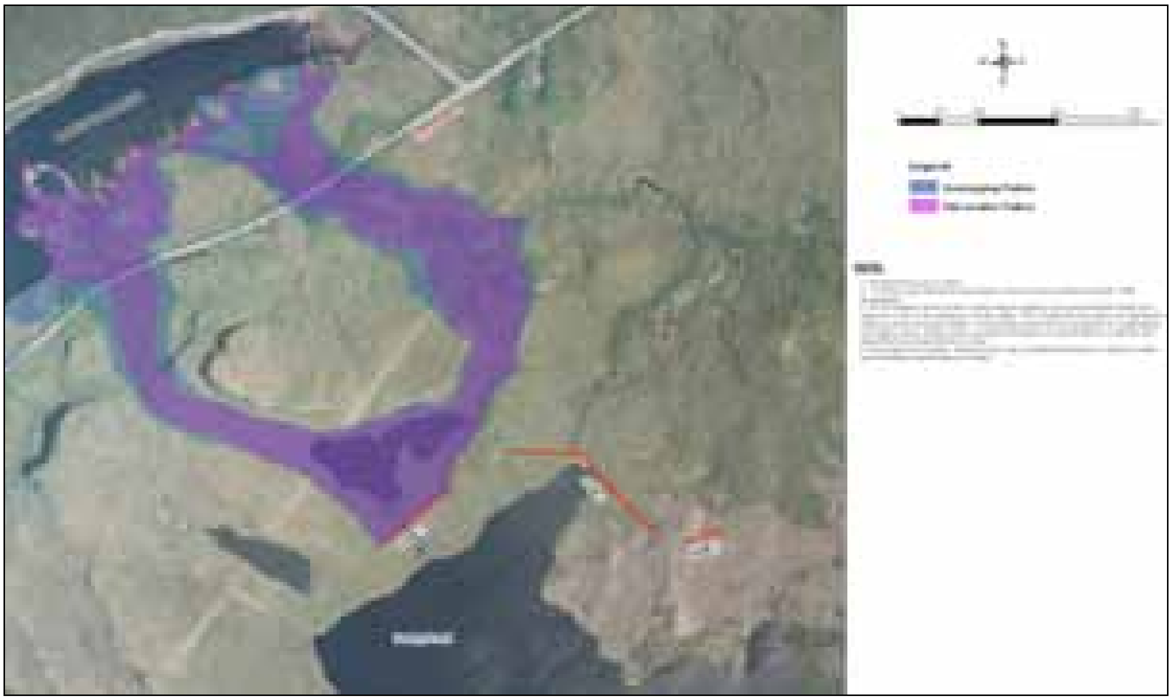


Figure 9.2 Sandy Pond Dam #1 Failure Flood Mapping

The results of the Dam #2 fair-weather failure modeling indicate that about 78,000 m^3 of solid residues would be deposited along the flood route and approximately 3.9 Mm^3 of water carrying some residue material flow would spill to Long Harbour. This spill scenario would produce the maximum residue runout of all the dam spill scenarios considered. It was this scenario that was selected for assessment.

The effect on groundwater of an accidental release from the residue storage area was simulated for copper and nickel, as these are the two primary contaminants of concern. The three cleanup scenarios that were considered are surface cleanup in one month, surface cleanup in six months, and surface cleanup in one year.

Results of the modeling show that the release would most likely have a noticeable effect on shallow groundwater only. Simulated contaminant plumes extend to a depth of between 5 m to 10 m below the water table. Contaminant mass loading of nickel from the affected groundwater into the adjacent stream (about 750 m north of Sandy Pond) and Long Harbour is expected to be more significant than similar mass loading for copper, due to the higher initial concentrations of nickel in the water-residue mixture and in water percolating through residue subject to full oxidation. Residue-soil cleanup occurring in one to six months after the accidental release significantly reduces mass loading of nickel into the stream and Long Harbour, as well as groundwater discharge concentrations, compared with the cleanup occurring in one year.

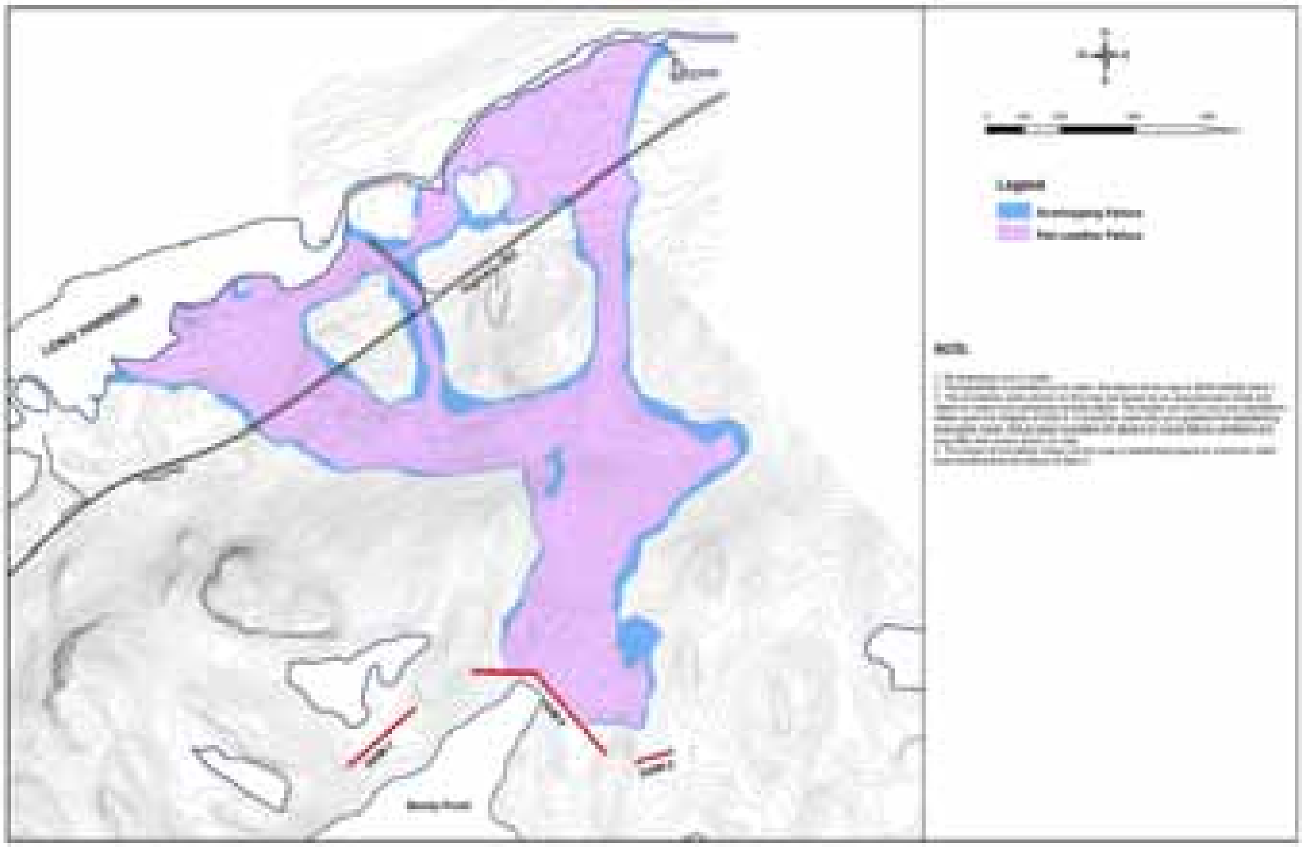


Figure 9.3 Sandy Pond Dam #2 Failure Flood Mapping

9.10 Accidental Chlorine Release

Accidental chlorine release was modeled by SENES (2007c) to examine one-minute and five-minute pipe ruptures releasing 25.6 kg and 59.2 kg respectively.

Based upon the modeling performed, it was found that the critical distance for these releases is in the range of 758 m to 3,400 m from the place of pipe rupture. For stable conditions it will take approximately 18 minutes from the time of release until the elevated concentrations reach the maximum Immediately Dangerous to Health and Life (IDHL) distance from the pipe rupture. The larger of the two releases was chosen for assessment.

9.11 Introduction of Invasive or Hazardous Species

Shipping is a potential pathway for the introduction of exotic species through ballast water or biofouling on ships' hulls. This is probably not an issue as most vessels will arrive at Long Harbour loaded with cargo and consequently large amounts of ballast water will not be on board. Many of the shipments will be by the concentrate carrier from Labrador, and not expected to carry any non-native species. A potential exception is the European green crab (*Carcinus maenas*), which is extending its range on both coasts of North America. It is a voracious predator of shellfish and a very efficient competitor.

A set of Shipping Protocols are in place for the Mine/Mill Site, including provisions to address ballast water exchange. Experience to date has shown that Vale Inco NL and its contractors have adhered diligently to the identified requirements. Vale Inco NL will require contractors and vessel charters to not dump bilge or foreign ballast water outside the allowable restrictions of the *Canada Shipping Act*. As required, special measures will be taken for ship movements between the mainland and Placentia Bay, especially with respect to any threat of invasive species introduction as a consequence of ballast water exchange in the Gulf of St. Lawrence. Advice will be sought through consultation with regulatory agencies including Canadian Coast Guard to address concerns about hulls as a vector for the introduction of aquatic invasive species.

All vessels involved in the Project will therefore be subject to ballast water exchange protocols that require mid-ocean transfers and other measures designed to prevent the transport and dispersion of invasive species.

9.12 Ship Collisions with Marine Mammals

Although most marine mammals typically avoid moving ships, there is some risk of collision. It is uncertain if vessel collisions with marine mammals have occurred in Placentia Bay. Large whales (no known blue or right whales) strand in Placentia Bay throughout all seasons of the year. In the absence of necropsies, it is difficult to ascertain the reasons for stranding. (W. Ledwell, Whale Release and Stranding Program, pers. comm.). Most lethal and severe injuries to large whales resulting from documented ship strikes have occurred when vessels were travelling at 14 knots or greater (Laist et al. 2001). Vanderlaan and Taggart (2007), using a logistic regression modelling approach based upon vessel strike records, found that for vessel speeds greater than 15 knots, the probability of a lethal injury (mortality or severely injured) approaches 100 per cent; the probability of lethal injury declined to approximately 20 per cent at speeds of 8.6 knots (Vanderlaan and Taggart 2007). In a review of 58 large whale/ship strikes in which the vessel speed was known, the average speed that resulted in mortality or serious injuries to the whale was found to be 18.6 knots (Jensen and Silber 2003). The frequency of ship strikes more than doubled when vessel speeds were between 13 and 15 knots, as opposed to 10 knots or less (Jensen and Silber 2003). While all sizes and types of vessels can collide with whales, most lethal or severe injuries are caused by vessels >80 m in length (Laist et al. 2001).

Fin whales are the most commonly reported whale to be stuck by vessels, followed by humpbacks and North Atlantic right whales (Jensen and Silber 2003; Vanderlaan and Taggart 2007). However, the North Atlantic right whale was the most commonly struck whale when considering the proportion per capita per year (Vanderlaan and Taggart 2007). Blue whales, fin whales and humpback whales were all stuck in similar proportions, but to a lesser degree than North Atlantic right whales (Vanderlaan and Taggart 2007). Minke, sei and sperm whales were not as frequently struck proportionally, but have been reported (Vanderlaan and Taggart 2007), and minke whales are quite common in Placentia Bay. Published accounts of ship strikes suggest that most crews do not see whales beforehand or see them at the very last minute (Laist et al. 2001).

While nearly all species of large whale have been victims of collisions with ships (Laist *et al*. 2001; Jensen and Silber 2003; Vanderlaan and Taggart 2007), right whales are especially vulnerable, likely because of certain characteristic behaviours during which they may be less aware of their surroundings. These behaviours include: surface active group (SAG) activity (individuals interacting at the surface with frequent physical contact); skim feeding (swimming slowly at the surface with mouth open); and logging (resting motionless at the surface), an activity frequently observed in nursing mothers (Knowlton 1997). Controlled exposure experiments in their summer feeding area in the Bay of Fundy showed that right whales did not respond to the playback of the sound made 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). The majority of documented right whale deaths, especially in recent years, were the result of ship strikes (Knowlton and Kraus 2001; Right Whale News 2005a, b; 2007).

During operations, it is estimated that there will be up to 25 vessel movements per year into Long Harbour, mainly bulk carriers and container ships with a maximum expected length of 223 m and a maximum draft of 11.75 m. These vessels will travel at a speed of ~15-16 knots upon entering Placentia Bay until they rendezvous with the pilot boat south of Red Island, where speed decreases to 8 knots. Bulk carriers and container ships could travel at a maximum speed of ~10 knots to within 5 nautical miles of the wharf, when they will decrease speed to 2 knots.

Based on available information, it is likely that most marine mammals (including seals, whales and otters) will avoid the immediate area around vessels, thereby minimizing the probability of collision. Vessels will avoid rapid changes in direction or speeds, thereby further reducing collision probability.

The risk of a bulk carrier or container ship colliding with a river otter and causing serious injury or mortality is very low. River otters are closely tied with coastal habitat where large vessels cannot navigate and will likely exhibit avoidance of at least a localized area where vessels are operating.

The vessel traffic associated with the Project is small relative to existing traffic (~500 vessels combined from the North Atlantic refinery at Come By Chance and the Transshipment Terminal at Whiffen Head) and traffic from the proposed oil refinery at Southern Head (425 vessels ranging from bulk carriers of 20,000 DWT to VLCC tankers of 350,000 DWT) and the proposed Newfoundland LNG Ltd. Grassy

Point Liquefied Natural Gas Transshipment and Storage Terminal (400 vessels). Larger vessels and those with a deeper draft pose a greater risk for collisions with large whales.

9.13 Prevention and Mitigation

Mitigation measures that could reduce the frequencies of these various accident scenarios have been reviewed. Appropriate design and operation safeguards and use of highest standard industrial equipment and procedures will be in place to reduce the probability of any such events occurring. Mitigation measures can be incorporated during process selection, design, construction and operations. Each of these items is discussed below.

9.13.1 Fuels and Fueling

Fuel and other hazardous substances will be handled, stored or disposed of only by persons who are trained and qualified to do so, in accordance with the manufacturer's instructions and government laws and regulations. Bulk storage tanks will be properly dyked to prevent release of spills or leaks. Waste oil will be handled and stored by a licensed disposal agent in accordance with the *Used Oil Control Regulations*, and be regularly disposed of to prevent accumulation.

Diesel and gasoline use, transportation and storage will be conducted in accordance with the NL *Storage and Handling of Gasoline and Associated Products Regulations* (2003). Bulk storage of gasoline/diesel will be conducted using industry approved vessels that are in a state of good repair and whose integrity is regularly inspected and maintained.

Hydrocarbon releases from machinery and vehicles can be avoided through regular maintenance to ensure they are in good working order and checking thoroughly for leakage. Other protocols include:

- Having operators present for the duration of refuelling;
- Positioning refueling equipment and vehicles at least 100 m from any water body, and over a non-permeable surface;
- Having basic petroleum spill clean-up equipment on-site, with adsorbents being used to recover any spills or leaks;
- Promptly containing and cleaning up all spills or leaks on land or in water;
- Reporting spills to the 24-hour environmental emergencies report system (1-800-563-9089) as required by the *Fisheries Act* (1985); or the 24-hour Spill Report Number (709-772-2083) for any spill in excess of 70 L;
- Not disposing of wastes in or near water bodies, with no burning of waste without a permit; and
- Testing as per criteria listed in Schedule A of *the Environmental Control Water and Sewage Regulations* under the *Water Resources Act* (2003), before discharge into a water body.

Fuel spill kits must include absorbent pads, loose absorbent materials such as dried peat, Speedi-Dry or sawdust, and a container for recovering the fuel/oil. Clean-up kits will be provided if there is a bulk fuel storage facility within the protected area, including at a minimum:

- Wajax fire pump and 100 m of hose;
- Two hand-operated fuel pumps;
- Six recovery containers such as empty drums;
- Four long-handled shovels;
- Two pick-axes;
- 15 m3 of impervious soil (a silt or clay bearing gravel);
- 50 m of low density rope;
- 10 m of containment boom;
- 25 absorbent pads; and
- Two 60-kg packages of loose absorbent material such as dried peat, Speedi-Dry or sawdust.

When any fuel spill occurs the flow will be stopped immediately if possible. This may entail repairing a leak, pumping out a tank or shutting off a valve. If oil is spilled onto soil, dyking may be necessary. If fuel enters water, absorbent booms or barriers such as fencing or netting with loose absorbent or straw will be used to contain the spill. If necessary, culverts may be blocked off by earth or wooden barriers to contain fuel, provided the threat of flooding is first addressed.

9.13.2 Process Mitigation Measures

Process-oriented mitigation measures include use of Best Available Control Technologies (BACT) and use of a closed system such that chlorine gas, when generated in the process, is contained and recycled reducing its release to the environment.

9.13.3 Design Mitigation Measures

Design-oriented mitigation measures that can be applied during the detailed design stage to reduce the probability of a major accident include:

- Use of containment berms around liquid material storage areas;
- Facility layout design to minimize potential interactions between incompatible materials;
- Use of BACT (e.g., alarms for high levels in tanks, automatic shut-offs at high-high level);
- Selection of appropriate materials for construction of the process equipment and storage facilities; and
- Total fail-safe design, with isolation valves to limit any spill.

9.13.4 Construction Mitigation Measures

Construction-oriented mitigation measures will assist in prevention/avoidance of major accidents. These measures include: ensuring the facility is constructed according to design; supervision and inspection during site development, equipment fabrication and construction; and instituting Environmental Protection Plans to address environmental issues related to the Construction Phase of the project.

9.13.5 Operations Mitigation Measures

The development and implementation of safe operating practices and standard operating procedures to reduce the frequency of occurrence of accidental releases will include:

- Safe operating practices for ships at dock (e.g., suspension of loading/unloading operations during adverse weather conditions);
- Safe operating practices in the processing areas (e.g., on-going training and updating of procedures);
- Use of designated shipping lanes in Placentia Bay;
- Adherence to a strict inspection and maintenance schedule;
- Operator training and education;
- Vessel offloading with enclosed conveyor for solids or pressure-controlled hose systems minimizing risk of spillage or release during transfer;
- Sulphuric acid pipelines double-walled in trenches to contain any pipeline spill or leak;
- Shipping dry chemical agents in bags or containers to be opened inside the plant;
- Storage tanks inside the plant containment areas with holding capacities exceeding the volume of the tanks; and
- Road transport of materials scheduled to avoid inclement weather or adverse road conditions.

9.14 Emergency Response

Emergency Response and Contingency Plans (ERCPs) will be prepared for all Project phases to assist in mitigating the environmental effects of accidents and malfunctions. In some cases (e.g., loss of fishing gear), compensation can be used to mitigate effects.

Vale Inco NL will conduct a hazard/risk assessment and prepare ERCPs for events such as hazardous material spills and emissions, fires and medical emergencies. An emergency plan will include, as a minimum, the following elements:

- Emergency and auditing policies;
- Communication system;
- Organization including roles and responsibilities;
- Notification hierarchy;

- Response and communication protocols;
- Key contacts;
- Plant protection officer checklists;
- Emergency response equipment;
- Designation of personal protective equipment;
- Level I (one building), II (plant complex), III (hazard beyond facility boundaries) emergency and false alarm checklists;
- Executive, environment and safety on-call checklists;
- Community emergency communication plan;
- Material Safety Data Sheets;
- Safe assembly area standards and procedures; and
- Leak detection systems.

The Vale Inco NL approach to emergency preparedness is exemplified by the emergency response plan for the Hydromet Demonstration Plant at Argentia. The fuel and hazardous materials emergency response plan (Table of Contents) for the Construction Phase of that facility is provided as an example.

The experience at the Hydromet Demonstration Plant has been very positive. Only two incidents were reported and the response, when required, was very effective.

Vale Inco NL will work with the Community of Long Harbour and the Department of Municipal Affairs, Fire and Emergency Services in developing an Emergency Preparedness Plan to ensure emergency response actions are effective and coordinated.

9.15 Accidents to be Assessed

Accident scenarios were analysed by AMEC (2007d) for accidental spills of acid, nickel concentrate, limestone, and fuel, as well as dam failures at the residue storage location. Two accidental releases of chlorine were modeled by SENES (2007c).

Accidents scenarios to be assessed for the EIS are shown in Table 9.1. These were selected to represent plausible worst-case scenarios that have the high potential to affect Valued Ecosystem Components.

Table 9.1 Accident Scenarios for Assessment

Accident Type	Size	Timing	Location	Rationale
Marine shipping accident – loss of sulphuric acid	7,500 tonnes at 0.1 m^3/s	Spring	Placentia Bay, entrance to Long Harbour	Marine transport of sulphuric acid is the largest movement of a hazardous substance associated with the Project.
Shipping accident – loss of loose concentrate	30,000 tonnes at 0.1 m^3/s	Spring	Placentia Bay, entrance to Long Harbour	Loose concentrate is a worse case than packaged concentrate
Shipping accident – loss of bunker C	2,180 m^3	Spring	Long Harbour	Shortest time to landfall; most potential to affect Bald Eagle concentrations
Large dam failure on Sandy Pond	n/a	Fall of Year 15	Tier 2, residue storage pond	Worst-case residue storage scenario
Pipe rupture - chlorine release	59.2 kg	Spring	Tier 2, Plant Site	Plausible worst-case air emissions

10.0 Sustainability Assurance

Vale Inco NL supports sustainable development, which seeks to enhance society through economic development and environmental responsibility, and believes that mineral products are essential for the development of a sustainable economy (Figure 10.1). Protection of worker health and safety, the health of surrounding communities and the environment are essential considerations in the management of its business.

The management of occupational hazards and environmental liabilities during all phases of the Project will conform to the corporate Health, Safety and Environmental Management System (HSEMS). The system will be consistent with the criteria defined in the OHSAS 18001:1999 *Occupational Health and Safety Management Systems - Specification* and the ISO 14001:04 *Environmental Management Systems - Specification with Guidance for Use.*

Vale Inco NL views HSEMS from a life-of-project perspective from Planning and Construction phases through Operations and ultimately Decommission and Rehabilitation of the site and facilities. The HSEMS will be dynamic, evolving to address changing needs throughout the project life cycle. Vale Inco NL will review and update the HSEMS and its elements regularly, as well as at important milestones in the Project life. The following key documents will be developed for the implementation of the HSEMS:

- Environmental Protection Plan;
- Greenhouse Gas Management Plan;
- Environmental Effects Monitoring Plan;
- Occupational Health and Safety Plan;
- Vessel Traffic Management Plan;
- Fisheries and Aquaculture Compensation Program;
- Rehabilitation and Closure Plan;
- Waste Management Plan; and
- Emergency Response Plan.

Mandatory Health, Safety and Environment (HSE) guidelines also apply to contractors working at the facilities. Implementation of these policy, guidelines and best practice documents are monitored through the Vale Inco Limited corporate HSE audit program.

10.1 Occupational Health and Safety

Vale Inco NL has among its highest priorities the health and safety of its employees and the communities in which it operates (Figure 10.1). This is reflected in policy guidelines that apply to and are implemented by all people working on the Project. Through all stages of development and operation, Vale Inco NL will not only meet but seek to surpass standards set by applicable legislation. Best

VALE INCO

Health, Safety and Environmental Policy

Vale Inco Newfoundland & Labrador Limited (Vale Inco NL) is committed to carrying out its business activities in a sustainable manner. This Policy sets forth Vale Inco NL's commitment to protecting the health, safety and environment of our employees and contractors, the communities in which we operate and to the customers of our products. It also sets forth our commitment to social responsibility. The Policy applies to all Vale Inco NL activities from exploration, mining, processing, refining, marketing through decommissioning and post closure.

To implement this Policy, Vale Inco NL will:

- Integrate sustainable development considerations into our business decision-making processes.
- Implement and maintain ethical business practices and sound systems of company governance.
- Uphold fundamental human rights and respect cultures, customs and values in dealings with employees and others who are affected by our activities.
- Actively participate in the social, economic and institutional development of the communities in which we operate.
- Provide development opportunities for employees and encourage their participation in the continual improvement of our health, safety, environment and social performance.
- Comply with regulatory requirements and company health, safety, environment and social responsibility management systems, standards, codes of practice and guidelines.
- Work together with stakeholders to:
  - improve our knowledge of the social and environmental impacts of our business activities
  - share and adopt improved technologies and best practices to prevent and minimize undesirable impacts through the life cycle of our products
  - assess risks and implement risk management strategies based on social concerns, valid data and sound science.
- Through our product stewardship commitment, facilitate and encourage responsible design, use, re-use, recycling and disposal of our products and by-products.
- Contribute to the enhancement of the environment through activities such as the protection and improvement of biodiversity and responsible land use planning.
- Engage our stakeholders through open and transparent communication and verifiable reporting.

Bob Cooper, President
Vale Inco Newfoundland & Labrador Limited

March 2008

Growing Together.

Figure 10.1 Vale Inco NL Health, Safety and Environment Policy

management practices are applied at all facilities and projects to minimize risks to occupational and public health and safety. Vale Inco NL works hard to nurture a strong safety culture in which workers take care of themselves and watch out for each other.

Vale Inco NL believes that all accidents are preventable. Safety targets are set because excellence can be achieved only with effort and by motivating the entire workforce to make safety a top priority. Through a variety of safety initiatives and a program of continuous improvement, Vale Inco NL is committed to achieve a goal of zero incidents.

All employees are responsible for accident prevention. The following safety principles define the Vale Inco NL commitment to achieving an injury-free and safe working environment:

- Everyone has the right to a safe environment.
- Safety will not take second place to any other management responsibility.
- Management is directly responsible for preventing injuries and occupational illness.
- Working safely is a condition of employment.
- All accidents can be prevented.
- All employees must be involved and supportive of the safety program.
- Training is an essential element for safe workplaces.
- Management must personally audit safety performance in the workplace.
- Safe work practices should be reinforced, and all unsafe acts and unsafe conditions must be corrected promptly.
- It is essential to investigate injuries and occupational illnesses, as well as incidents with the potential for injury.

10.2 Environmental Management

The Project has been planned to integrate environmental considerations in all aspects of the decision-making processes, from pre-feasibility studies through design, construction, operation, decommissioning and Closure. The following key environmental principles will be considered in each phase of the Project:

- Keep physical boundaries as small as possible and control watershed use.
- Reduce the size and extent of physical disturbance.
- Recycle resources such as water.
- Reduce the number of release points for the Project (such as water discharges).
- Identify and avoid environmentally sensitive areas.
- Plan all aspects of the Project for Closure.

Examples of "designed-in" mitigation measures that illustrate the application of these principles include:

Site Selection

- Long Harbour was selected as the site to minimize the environmental footprint – short pipelines, access roads and electric transmission lines.
- Residues are combined from the Hydromet Plant to minimize the environmental footprint.
- Residue storage locations for the Hydromet Plant and Matte Plant were selected to minimize environmental impact.

Design

- Underwater storage of combined residues was selected for the Hydromet Plant to avoid sulphur acidification of residue.
- Recirculation and recycling of process and effluent streams will be undertaken to the extent possible both to recover as much valuable metal as possible, and to reduce the demand for reagents and water.
- Real-time monitoring has been initiated and will be ongoing throughout the Project life to improve design capability. Monitoring sites include:
    - Water quality and quantity at Rattling Brook; and
    - Water level at Rattling Brook Big Pond.
- Air pollution control systems will include:
    - Baghouses for hygiene dust control – used predominantly at concentrate and limestone transfer and handling locations;
    - Scrubbers for venting gas streams and copper electro-winning cells – used to reduce aerosol mists, chlorine gas and particulate carryover from entering the environment;
    - Adequate building ventilation to ensure acceptable in-plant air quality;
    - Water-spray dust suppression, when required, for roads and for the Matte Plant residue storage site;
    - Instrumentation and monitoring equipment for measuring air quality and effluent characteristics.
- Access road drainage will be designed to direct runoff flow away from the Site.

Construction

- Construction practices will minimize stockpiling of materials to reduce fugitive dust emissions during construction.
- Buffer zones will be established and flagged prior to any disturbance activities.
- Natural vegetation will be left in place wherever possible.
- Temporary diesel generators and other equipment required during construction will be muffled to reduce noise.

- Fuel storage and distribution areas will be centralized and graded to direct storm-water runoff to an oil-water separator before being sent to a storm-water management pond.
- Drainage from areas of exposed fill will be controlled by grade or ditching and directed away from natural watercourses, wherever possible.
  - Surface water will be directed away from work areas by ditching.
  - Runoff from these areas will have silt removed by settling, filtration or other suitable methods.
  - The requirement for ditch blocks/check dams or sediment traps to intercept runoff will be established during design and confirmed during construction, and appropriate action taken.
- Preventive measures such as silt curtains will be in place to reduce suspended sediment entry into water bodies.
- Regular monitoring of construction activities for leaks and spills will be undertaken.
- Stream crossings will be protected according to provincial permits and regulations as well as guidelines issued by DFO.
  - Construction of stream crossings will follow accepted engineering and construction practices to accommodate runoff conditions and comply with regulatory requirements.
  - Culverts will be sized to handle a 25-year return period flood and aligned so that the original direction of flow is unaltered.
  - Approaches to crossings will be constructed with erosion-resistant materials such as rock or clean gravel. They will be at right angles to streams where possible.
  - Materials will be placed in streams to maintain or improve aquatic habitat. The materials will be clean, non-erodible and non-toxic to aquatic life.
- Dams will be designed and constructed to prevent dam failure. Mitigation procedures in the unlikely event of dam failure will be detailed in the Emergency Response Plan.
- Blasting activities will be in accordance with applicable (DFO) guidelines for the protection of fish and fish habitat.

Production Operations

- Secondary containment will be provided for all outdoor storage of petroleum products, reagents and chemicals. The sizing of the secondary containment structure will be 110 per cent of the capacity of the largest reservoir or 100 per cent of the capacity of the largest reservoir plus 10 per cent of all others, whichever is greater. All outdoor secondary containment structures will be lined with impermeable materials.
- All process equipment will be located indoors (other than some surge tanks, storage tanks, and thickeners). Spill control of indoor process equipment will be done locally by providing containment (berms or concrete curbs) and sumps. The containment for each process area will be 110 per cent of the volume contained by the largest piece of equipment. Contaminated water from periodic washdowns of local process areas or from washdown following spills will be returned to the process via local sumps.

- All equipment containing potential air contaminants will be routed through air pollution control devices prior to release to the air.
- All conveyors will be covered and transfer points vented through air cleaning prior to release to air.
- Dust collection systems will be in place at all material transfer points and material will be conveyed between locations in covered conveyors.
- Air emissions will be monitored to ensure that environmental regulations are met.
- Environmental control equipment will be monitored to ensure that operating parameters are met.
- Precautions will be in place to monitor and prevent the release of chlorine gas produced during the Hydromet process. Alarm systems and emergency safety procedures will be established to properly manage any accidental event involving chlorine.
- Liquid effluents will be monitored to ensure that regulatory requirements are met.
- Effluent treatment systems will include the following :
    - Sewage treatment plant,
    - Spill containment and treatment to ensure that site runoff is not contaminated,
    - Storm-water management pond (solids settling),
    - Polishing pond (solids settling, pH adjustment),
    - Sand filters and pH adjustment (as required for treatment of polishing pond, Sandy Pond, and/or storm-water management pond),
    - Instrumentation and monitoring equipment for maintaining effluent standards within regulatory requirements.
- All storm water within the boundaries of Tier 1 and Tier 2 will be collected and treated as necessary before discharge.
- All effluent will be treated, tested, and monitored, and then discharged through a common pipe and diffuser located so as to maximize dispersion by mixing.
- There will be no discharge to freshwater bodies, other than the residue storage area at Sandy Pond and parking lot drainage that has gone through an oil/debris separator.
- Solid waste sludge from the sewage treatment plant will be collected by a certified sludge disposal company, for disposal at an off-site, properly licensed commercial facility.
- Emergency response plans will be in place in the event of unplanned events such as a chlorine release from the Hydromet Plant.

Decommissioning

A Rehabilitation and Closure Plan will be developed to accomplish the following objectives:

- Restore affected landscapes to a stable and safe condition, which will protect public health and safety.
- Re-establish conditions that will allow a productive use of the land and the natural resources of the area, similar to its original use.

- Reduce the need for long-term monitoring and maintenance by establishing, as quickly as practical, effective physical and chemical stability of disturbed areas.

The Environmental Protection, Environmental Effects Monitoring, Rehabilitation and Closure, Waste Management and Emergency Response plans will provide details about the management of environmental factors for the life of the Project.

10.3 Climate Change

In keeping with the Vale Inco NL commitment to sustainable development, as described in the company's Health, Safety and Environment Policy, the company is incorporating energy efficiency into the design and operation of the Project and is aiming to reduce greenhouse gas (GHG) emissions that contribute to climate change.

Vale Inco NL recognizes the importance of addressing concerns about human influences on the global climate and the environment. As a subsidiary of Vale Inco Limited, a member company of the Mining Association of Canada (MAC), Vale Inco NL shares their commitment to action and continuous improvement of environmental performance. MAC has a long history of working together with industry and government toward finding solutions and taking action to address the risks of climate change. MAC has put considerable effort into reducing energy consumption and GHG emissions across the Canadian mining and metal industry and has been recognized by the Minister of Environment and Minister of Natural Resources with a number of awards.

The Canadian mining industry's GHG emissions are almost exclusively linked to energy consumed in the production process. The nonferrous metal smelting and refining sector accounts for a small percentage of the industrial energy used in Canada; just over 3 per cent in 2002 (MAC, 2004). There was a 7.7 per cent improvement in energy intensity (energy per unit of output) in this sector between 1990 and 2003. Over the same period, there was a 43.4 per cent improvement in total GHG intensity (GHG emissions per unit of output) in the nonferrous metal smelting and refining sector.

For Vale Inco Limited specifically, energy intensity has continued to improve with a further 12 per cent decrease in 2006 as compared to 2005. All Vale Inco Limited facilities are continuing to advance sustainability efforts and this includes corporate targets to further reduce energy intensity by 2 per cent over 2006 levels, and the development of a comprehensive long-term strategy for reducing the company's carbon footprint in an effort to support global activities required to address climate change. Beginning in 2007, Vale Inco Limited will voluntarily undergo external verification of their self-assessment results on energy and greenhouse gas emissions management. This will further demonstrate the company's commitment to this important environmental issue.

In adherence to MAC's *Strategic Planning and Action on Climate Change: A Guide for Canadian Mining Companies* and *Towards Sustainable Mining: Energy Use and Greenhouse Gas Emissions*

Indicators, Vale Inco NL will consider climate change in daily operating procedures and practices, and will implement the actions noted below:

- GHG emission inventory, measurement and monitoring;
- GHG emission control targets;
- Internal financial signals to encourage emissions reduction;
- Employee engagement and motivation; and
- Reporting on climate change activities internally, to stakeholders, governments and the public.

For the inventory, GHG emissions will be calculated from direct energy use, including fuels used at the Plant and facility activities such as on-site transportation. An inventory will be prepared for each Project Phase. Once engineering design is completed for Construction it will be possible to complete the task for this phase.

Vale Inco Limited is recognized as a leader in the development and implementation of new, more efficient and environmentally sound technologies. The hydrometallurgical technology proposed for this Project is an example. By availing of new technology and following environmentally sound practices during all phases of the Project, in keeping with the Vale Inco NL HSEMS, the company will do its part to minimize its contribution to climate change. A GHG Management Plan will be developed for Construction and Operations and submitted to EC for comment.

10.4 Emergency Response

The Vale Inco NL HSEMS prescribes the need for an Emergency Response Plan that includes procedures establishing a volunteer team of trained workers ready to assume responsibilities in the event of an emergency. During the construction and operations phases, Vale Inco NL and its contractors will deliver a range of safety training programs to workers, including hazardous materials handling, fall protection, first aid and advanced first aid, self-contained breathing apparatus training, safe operations of worker lifts, and aerial platforms and fire-fighting training.

Environment, Health and Safety staff will work closely with the training department to facilitate safety training programs on site with the assistance of outside agencies as required. An Occupational Health and Safety Committee in place at the Plant will include employee, contractor and management representatives who will work together for continual improvement in the workplace.

10.5 Human Resources

The success of Vale Inco NL depends primarily upon the combined capabilities of its employees, technology, resources, and customers. Vale Inco NL believes that employees, suppliers, customers, the public and shareholders all have a shared interest in this success, and that employee and Company interests can and must be aligned. To that end, Human Resources management activities are guided by the following principles:

- Fostering open and honest communications;
- Conducting business with integrity;
- Providing supportive management;
- Emphasizing quality in all aspects of work, and focusing on customer service, internally and externally;
- Promoting a climate of continuous improvement;
- Endorsing the concept of the learning organization and supporting staff in it;
- Supporting diversity in the workplace; and
- Respect for the individual.

10.5.1 Responsibility to Workers

Vale Inco NL insists on a work environment that offers opportunity and strives always to be fair, inclusive and respectful. "People Values" is the cornerstone upon which the Human Resource Policies and Procedures are built. through leadership and personal responsibility, employees can participate, contribute and grow with Vale Inco NL by:

- Providing and requiring safe conditions and practices;
- Acting fairly and with integrity in all we do;
- Meeting or exceeding customer expectations;
- Respecting others and their contribution;
- Supporting diversity;
- Working together;
- Practicing quality communications;
- Pursuing training, development and life-long learning; and
- Continuously improving everything we do.

These corporate guiding principles define Vale Inco NL responsibilities to its employees:

- Provide pay and benefits that are competitive in the employment markets from which employees are drawn and are intended to reward successful performance and be internally equitable;
- Provide opportunities for individual growth and career satisfaction, and assist employees to realize their full potential by providing appropriate training, development, educational and promotional opportunities;
- Observe all laws respecting non-discrimination or harassment on the grounds of race, ancestry, national origin, colour, ethnic origin, citizenship, creed, gender, sexual orientation, disability, marital status, family status or age; and

- Provide suitable work facilities and conditions with the objective of safeguarding the health, safety and general well-being of employees.

10.5.2 Human Resources Legislation

The *Labour Standards Act* specifies employment standards in Newfoundland and Labrador. Other applicable provincial worker-related law includes the *Labour Relations Act*, the *Occupational Health and Safety Act* and the *Workers' Compensation Act*. Vale Inco NL also complies with federal legislation where applicable.

10.5.3 Women's Employment

Vale Inco NL values gender diversity, in the belief that gender mix contributes to a healthy and productive workplace. Although efforts have been made generally to improve the participation of women in the workplace, inequity persists, particularly in science, trade and technology occupations. Addressing this challenge requires an integrated strategy in which all stakeholders have a role to play. The Company is aware of the need to participate, along with others, in developing concrete initiatives that address the underlying contributing issues. Vale Inco NL, recognizing that over time women will take up opportunities presented in non-traditional occupations, is working with governments, educational institutions, women's organizations and industry associations to advance gender diversity in the workplace, and to see that more women take advantage of employment opportunities in the Canadian mining industry.

Vale Inco NL has adopted and will continue to further its corporate commitment to advance the employment of women in occupations in which they are underrepresented. This will be achieved with the formal development and implementation of a Women's Employment Plan for the Construction, Operations, and Decommissioning phases of the Project. This plan will also contain initiatives designed to communicate and monitor the program. The Company already has in place a Women's Employment Plan and will build upon this existing strategy to further the advancement of women in the workplace. Prior to Construction, the completed plan will be submitted for approval by the Minister Responsible for the Status of Women and the Minister of Environment and Conservation.

Vale Inco NL will implement gender-based analysis for its operations and for contractors working at various locations. A gender-based approach ensures that the development, analysis and implementation of workplace design and policies are undertaken with an appreciation of gender differences, and the recognition of potential differential effects on men and women. This includes an understanding of the nature of the relationships between women and men, and the different social realities, life expectations and economic circumstances facing both. The analysis of gender information and demographics, as well as the identification of gender-related issues that affect the advancement of women in the workplace, are also incorporated in this approach.

Vale Inco NL has surpassed gender diversity targets for the operations phase in Argentia. The vast majority of these women are employed in non-traditional occupations, including engineering, process operations and laboratory analysis.

10.5.4 Training and Development

Vale Inco NL is committed to encouraging and maintaining a work environment that gives employees the opportunity to achieve their personal career goals, as well as the training and support they need to meet corporate business objectives.

Vale Inco NL recognizes the low participation rate of women in non-traditional occupations such as building trades and technology occupations. To help address this reality, the Company will support, where reasonably possible, efforts designed to increase the number of women who have the requisite skills. The Company will support post-secondary training organizations in their initiatives designed to encourage and recruit women into science, trades and technology-based programs that support its operations.

Protection of health, safety and environment is paramount. Vale Inco NL will ensure that health, safety and environment training is provided to all its workers. Training and orientation of visitors, new recruits and temporary student employees will also be provided. All contractors will be required to employ qualified workers who have received health, safety and environment training prior to starting work. Workers will also be required to undertake regular training exercises in emergency response procedures, to ensure readiness should unplanned events occur.

10.5.5 Succession Planning

The purpose of succession planning is to ensure that personnel of sufficient numbers and quality are available to fill business needs when required and to maintain alignment between business goals and human capital needs. Effective succession and career planning also permits the organization to maintain pace with changes in business, industry and the overall marketplace. Vale Inco NL is implementing a succession planning process that will achieve these goals:

- Addressing the needs of the organization as the workforce ages and employees leave;
- Assisting with preparing the organization for unexpected events;
- Ensuring that it has the right personnel to function at peak efficiency; and
- Enabling residents of Newfoundland and Labrador to advance to increasing levels of responsibility.

10.6 Community

Vale Inco NL believes that working in collaboration, consultation and cooperation with community groups and all levels of government is essential to achieving mutual goals and stimulating the development of sustainable communities that will thrive well beyond the life of one project.

Vale Inco NL is committed to maximizing local business opportunities, recognizing that there are long-term benefits associated with developing a strong base of local suppliers. It also plans to continue its strategic investment in communities in Newfoundland and Labrador, through financial contributions to and sponsorship of local programs. Vale Inco NL will continue to work with citizens and municipal leaders to address concerns about industrial benefits, training requirements, environmental effects and other issues that may arise.

10.6.1 Public Consultation

Public consultation is an integral part of the environmental assessment process as per Section 58 of the provincial *Environmental Protection Act* and Section 16 (1) of the *Canadian Environmental Assessment Act.* The formal public consultation sessions for this project used notification protocols consistent with the requirements provided in Appendix A of the EIS Guidelines.

This section describes the ongoing process of consultation with the public and government agencies. It highlights interests and concerns that arose during the process, both before and after Project Description/Project Registration in March 2006. Appendix C provides a comprehensive list of comments about the Project, organizes these comments into categories relevant to the environmental assessment, and indicates where relevant interests and concerns are addressed. Also presented is a listing of the various meetings and consultations held throughout the EA process.

The commercial nickel processing plant at Long Harbour is the final element of a four-stage research and development program to develop a viable hydrometallurgical processing facility for concentrate from the Voisey's Bay mine in Labrador. Vale Inco NL has been engaged in public consultation for a prolonged period and has in place several effective mechanisms for information exchange with a variety of interest groups and communities.

The construction and operation of a hydrometallurgical Demonstration Plant (Demonstration Plant) at Argentia required its own registration for environmental assessment and public consultations. VBNC presented information on the commercial plant development during public consultation for the Demonstration Plant; thus, the public consultation process for the commercial nickel processing plant began in 2003, well in advance of the formal submission of the Project Description/Project Registration in March 2006.

A range of consultation and disclosure methods used to encourage participation included:

- Public open house sessions;
- Public meetings and presentations (including Supplier Information Sessions),
- Meetings with government;
- Demonstration Plant tours;
- VBNC Community Liaison Committee;
- Information office in Placentia;
- Newsletter, brochures, panels and displays; and
- Direct mailing to householders.

10.6.2 Pre-Registration

Formal contact with the public and government departments began in late 2003. Between that time and submission of Project registration on March 16, 2006, VBNC engaged in nearly 30 consultation sessions with the public and all three levels of government, provided many tours of the Demonstration Plant, established an Information Office in Placentia to distribute information and offer an informal venue to encourage questions and discussion, and distributed two information brochures to local households to update residents on the Company's activities.

Between October 2003 and March 2006, the public was offered eight opportunities for information disclosure, in meetings and presentations. These included presentations on the environmental assessment at the Opportunity Argentia Conference in both 2003 and 2004, to the Newfoundland and Labrador Environmental Industry Association (NEIA) in 2004, and to the Placentia Area/VBNC Community Liaison Committee in 2004 and 2005.

The Placentia Area/VBNC Community Liaison Committee was formed in 2003 and has met quarterly since. Its goals are to foster communications between VBNC and local residents, and to address concerns and issues of mutual interest. Membership includes representatives of the communities of Placentia, Long Harbour, Fox Harbour, Ship Harbour and Point Verde; key community economic, educational and other groups (e.g., Argentia Management Authority, Argentia Area Chamber of Commerce, Avalon Gateway Regional Economic Development Association, College of the North Atlantic, and Newfoundland and Labrador Environmental Association); and representatives of various provincial and federal government departments.

VBNC held 10 meetings with federal government representatives of the Canadian Environmental Assessment Agency (CEAA Agency), Fisheries and Oceans Canada (DFO), Environment Canada and Transport Canada. Meetings with CEA Agency, Transport Canada and DFO addressed schedule and approach, as well as potential federal "triggers" under the *Canadian Environmental Assessment Act*. Subsequent meetings were held with DFO to discuss freshwater and marine baseline studies.

VBNC also held nine meetings with representatives of the provincial departments of Justice, Natural Resources Mines and Energy, and Environment and Conservation. Early discussions focused on the proposed schedule, approach, potential issues, plans for government and public consultation, and initial baseline studies. On March 13, 2006, VBNC also hosted an information session on the Project Description/Registration Document for federal and provincial regulators. Twenty-three people attended, representing three federal and four provincial departments.

VBNC provided numerous tours of the Demonstration Plant at Argentia during its construction and after its opening in October 2005. Several hundred people took advantage of this opportunity to learn more about the hydrometallurgical process and to view the facility. Visitors included media, representatives of educational institutions and environmental NGOs (non-governmental organizations), the Community Liaison Committee, government representatives (municipal, provincial and federal) and attendees of the 2005 Opportunity Argentia Conference.

VBNC has maintained a staffed information office in the Placentia Mall since mid-2004. Open during regular business hours, the information office provides the public with opportunities to access project information and to share concerns regarding any aspect of the company's operations.

VBNC published the first issue of its newsletter, *The Gossan,* in July 2003. It provided updates on the Voisey's Bay project and was circulated widely to employees, contractors and project stakeholders. It is also available for public viewing in electronic format at vbnc.com. The first article dedicated exclusively to the environmental assessment process for the commercial processing facility was presented in the July 2005 issue. In October 2005, a second article carried a brief update on Project Registration and ongoing baseline studies. To date, 14 editions of *The Gossan* have been published.

VBNC published and distributed two information brochures to all households in the region before Project Registration, the first, in January and the second in October 2005. While the focus was on the Demonstration Plant, each brochure included a set of questions and answers related to the commercial facility and the environmental assessment process.

10.6.3 Post-Registration

The second part of the public consultation process was initiated in conjunction with the submission of Project Description/Project Registration on March 16, 2006. Public meetings and presentations continued to play a significant role during this period. The company conducted additional open house sessions designed to disclose information about the proposed project to a wide audience, and to gather participants' feedback.

Five open house sessions were held between April and November 2006. The first was conducted in Long Harbour-Mount Arlington Heights on 19 April (afternoon and evening) at the request of the Town Council. This event was not an official open house session as outlined in the EIS Guidelines. Subsequent sessions designed to meet the EIS Guidelines were held as follows: September 20 in Long

Harbour-Mount Arlington Heights (afternoon and evening); November 21 in Ship Harbour (evening); November 22 in Placentia (afternoon and evening); and November 23 in Whitbourne (afternoon and evening). A total of 270 people attended the open houses.

The purpose of these sessions was to describe the proposed Project and the EIS process, as well as to solicit comments from attendees, who also had the opportunity to meet representatives from VBNC and the consulting firms that conducted the baseline studies and view some of the data collected. The majority of attendees were concerned with topics relating to employment and the environment.

Following each session, attendees were asked to complete an Exit Survey. The results of the 130 completed surveys were consistent with the observations made during the sessions, namely that employment and the environment were of primary interest.

VBNC also sought other opportunities for public consultation. From 2006 to 2007, VBNC delivered presentations to the Professional Engineers and Geoscientists of Newfoundland and Labrador (PEGNL), the Placentia Bay Integrated Management Planning Committee, the Isthmus Joint Council, and the Newfoundland and Labrador Environmental Industry Association. VBNC continued to offer presentations and attend meetings in local communities, including ongoing quarterly updates to the Placentia Area/VBNC Community Liaison Committee.

VBNC has maintained ongoing dialogue with federal government representatives of the CEA Agency, DFO, Environment Canada and Transport Canada. Meetings with these agencies focused on receiving feedback from the environmental assessment process and Project Registration, as well as discussions on schedule and approach. Communications with the provincial government during this period were mainly concerned with establishing the parameters and guidelines for the EIS.

VBNC continued to provide tours of the Demonstration Plant during the post-registration period. Tours were organized around two key 2006 meetings, one with environmental NGOs and the other with fifteen provincial and nine federal regulators. The majority of visitors were local residents or government representatives. In September 2007 the Company participated in the Hydromet Project Initiative conference, and offered additional Demonstration Plant tours to participants.

During the post-registration period, *The Gossan* continued to inform the public about the commercial processing plant and the environmental assessment process. Notification of Project Registration was given in the April 2006 issue. A brief update of development activities associated with the commercial processing plant appeared in October 2006.

The information office received hundreds of visitors, including many from local communities after Project Registration. Employment and business opportunities as well as potential environmental effects were the primary interest.

VBNC published and distributed an information brochure to all households in the region in April 2006, outlining the environmental assessment process and the company's decision to register a project that could use either type of processing technology (Hydromet or Matte). A second brochure was sent to local households in June 2007, including information on the commercial processing plant and the development schedule. The baseline studies program was also described and many of its component studies summarized, including those for Physical Oceanography, Groundwater Characterization, Terrestrial Baseline and Socio-Economics.

10.6.4 Public Interests and Concerns

Many questions and comments were generated by the consultation process. Additional input appeared in the EIS Guidelines as a result of communications between the provincial government, individuals and environmental groups.

Results received through the public consultation (listed in Appendix C) have been grouped into ten categories of comments and concern:

- Air Emissions and Human Health Effects;
- Availability/Accessibility of Information;
- Business Opportunities/Benefits;
- Employment Benefits;
- Fish/Wildlife Habitat;
- Ground/Surface Water Contamination;
- Marine Environmental Effects;
- Project Design/Description;
- Regional Quality of Life; and
- Residue Storage/Sandy Pond.

The majority of comments were about timing, scale, location, configuration, and selection of process technology. Many people also wanted to learn how VBNC would share information on employment and business opportunities, environmental effects, baseline studies and environmental monitoring.

Attendees were concerned about environmental effects, particularly as they might affect the fisheries and aquaculture industries. Residents questioned the use of Sandy Pond to store residue and the potential for this natural water body to release the residue into the surrounding aquatic, terrestrial or marine environments.

The public expressed concern about potential effects on the quality of life in rural communities including human health and recreational activities. Residents of the area own cabins and participate in outdoor recreation activities such as hunting, fishing, wood cutting, berry picking and camping and were concerned about how these activities might be affected. They wanted to participate in the Project's long-term employment and economic development, but not at the expense of clean air, water and land. They wanted to know that a thorough environmental assessment would address their concerns.

Employment and increased business activity was of interest to many participants. Residents wanted VBNC to ensure that business opportunities and economic benefits would be realized in the local community. There was some concern about the adjustment of municipal boundaries and the relative municipal benefits to the various communities in the region.

Public consultation sessions have been well attended, and provided an exceptional opportunity for dialogue between VBNC and those who will be most affected by the Project. All of the questions raised have been considered and, wherever appropriate, addressed within the EIS.

10.6.5 Ongoing Public Consultation

Consultations will continue throughout the environmental assessment process to provide information, to aid discussion and to solicit feedback, as well as respond to relevant issues and concerns. They include:

- Open house sessions to be held in Long Harbour-Mount Arlington Heights, Placentia, Ship Harbour and Whitbourne;
- Distribution of information brochures to households in Long Harbour, Placentia, Whitbourne and the adjacent area;
- Maintenance of an information office in the Placentia area;
- Press releases and media briefings;
- Newsletter updates; and
- Information sessions/discussions with the Community Liaison Committee and with municipal, provincial, and federal government representatives.

11.0 Valued Ecosystem Components

Environmental effects assessment in Canada is based on the Valued Ecosystem Component (VEC) approach, originally conceived by Beanlands and Duinker (1983). This approach focuses on those elements of the ecosystem of most interest and value to society. The selection of VECs is an important component of environmental assessment: it is not feasible or desirable to assess the effects of the Project on every species, pathway or human value that may apply. The process is intended to be part of planning that allows reasonable decisions to be made based upon a realization of the benefits of a project in contrast to the anticipated environmental effects.

In this EIS, the atmospheric, terrestrial, freshwater, marine and human environments were systematically analyzed during the VEC selection process. Selection as a VEC for detailed analyses required the satisfaction of at least four criteria:

- The component is of demonstrated value (e.g., economic, scientific, cultural or ecological) to society (or has particular value as a key indicator or surrogate for the component of most interest).
- Concern has been expressed about that component by the public and/or regulators during the environmental assessment process.
- There is potential for the component to be measurably affected by the Project.
- Data are available or can be collected in a reasonable timeframe to produce a credible analysis.

In the preparation of Guidelines, a committee of government officials consulted with regulatory agencies and resource managers, and input was solicited and received from the public. On that basis a set of VECs were identified and incorporated into the EIS Guidelines. As well, the consultation efforts have confirmed that the selected VECs address the suite of identified issues and concern.

For reference, Table 11.1 lists the VECs as assigned in the Guidelines. Also shown is their organization in the EIS. The alignment differs only slightly from the EIS Guidelines; however, all the required issues and concerns identified within the Guidelines have been addressed. The text below provides the rationale for the selected VECs and their organization.

11.1 Biophysical VECs

The biophysical VECs selected for detailed analysis and specified in the EIS Guidelines are described below in terms of their relevance to the Project.

Air Quality

Air emissions form a key pathway for affecting air quality during operations and airborne noise can affect sound levels in the area during construction.

Table 11.1 VEC Organization and Presentation

Guidelines VEC	EIS Organization of VEC		
	Title	Volume	Section
Air Quality	Air quality	2	4.0
Water Quality and Quantity (including wetlands)	Freshwater Resources	2	5.0
Fish and Fish Habitat (Including commercial fisheries and aquaculture)	Freshwater Fish and Fish Habitat Marine Fish and Fish Habitat Commercial Fisheries and Aquaculture	2 2 3	6.0 7.0 7.0
Avifauna (including raptors, waterfowl and marine birds)	Avifauna	2	8.0
Otter	Otter	2	9.0
Species at Risk (including wildlife, avifauna, rare vascular plants and lichens) listed under the Species at Risk legislation	Species at Risk	2	10.0
Economy, Employment and Business	Economy, Employment and Business	3	4.0
Services and Infrastructure (including health infrastructure)	Services and Infrastructure	3	5.0
Recreational Activities	Recreational Activities	3	6.0

Water Quality and Quantity (including wetlands)

Water resources will be required by the Project for a variety of uses. Extractions can reduce the quantity of water (especially fresh water) available for other (consumptive and non-consumptive) uses. Processes associated with the Project can alter water quality upon discharge (through regulated discharge or accidental event) to the environment. Key pathways for effects are runoff and air emissions.

Fish and Fish Habitat (including commercial fisheries and aquaculture).

This VEC comprises three sections, each of which is described below.

Freshwater Fish and Fish Habitat

Freshwater fish (with brook trout as the key indicator species) and their habitat is an important VEC because it provides recreation and food for humans as well as forage for certain birds and mammals. The freshwater stages of anadromous (e.g., sea-run salmonids) and catadromous (e.g., American eel) fish are also considered where relevant. There is potential for effects on fish and fish habitat from residue storage, water withdrawals and changes in water quality.

Marine Fish and Fish Habitat

Marine fish habitat is very broadly defined here to include components such as water and sediment quality, plankton, and benthos. The marine stages of anadromous (e.g., sea run salmonids) and catadromous (e.g., American eel) fish are also considered where relevant. Fish VECs are of prime concern from both a public and scientific perspective, locally, nationally and internationally. Individual species were selected to represent this VEC, as in most cases species can be grouped according to life cycle and habitat usage. Flounder and blue mussel species are most likely to be affected, and as such provide a conservative basis for the EIS. There is potential for effects on the marine environment from marine effluent, shipping and accidental events.

Commercial Fisheries and Aquaculture

The commercial fishery forms an important element in the societal, cultural, economic and aesthetic environment of Newfoundland and Labrador. This VEC is of prime concern from both a public and scientific perspective, locally, nationally and internationally. Aquaculture is also considered here because of its growing presence in Placentia Bay. Marine activities including shipping, shoreline and wharf construction, and effluent discharges all have the potential to interact with nearby commercial fishing and aquaculture operations.

Avifauna

Newfoundland supports some of the largest seabird colonies in the world and our waters host very large populations during all seasons. Shorebirds, waterfowl, raptors (Bald Eagle and Osprey) may be abundant at certain places and times. They are important socially, culturally, economically, aesthetically, ecologically and scientifically. Seabirds are a key component near the top of the food chain and are an important resource for bird-watching (one of the fastest growing outdoor activities in North America), the tourist industry, local hunting and scientific study. In addition, this VEC is more sensitive to contaminants in or on water, and is of prime concern from both a public and a scientific perspective, locally, nationally and internationally. There is potential for effects on the marine-related avifauna (represented in the EIS by Bald Eagle and Cormorant) from marine effluents and shipping and unloading/loading accidents.

Otter

River otter is the focal species here, as it pursues a marine lifestyle in Placentia Bay and is a resident top-level predator. These mammals are of prime concern from a public and a scientific perspective – locally, nationally and internationally. The main pathways for potential effects include disturbance (e.g., from noise) and exposure to contaminants with some potential for biomagnification due to their high rate of consumption of fish.

Species at Risk

This group has become a mandatory VEC in Canadian environmental assessments. The legally-defined "species at risk" are those listed as endangered or threatened, or of special concern on Schedule I of the *Species at Risk Act* (*SARA*) (e.g., wolffishes) and/or the provincial *Endangered Species Act* (e.g., boreal felt lichen and Red Crossbill). Consideration was also given to the COSEWIC listings as some of those species may be up-listed to *SARA* during the life of the Project. (COSEWIC, the Committee on the

Status of Endangered Wildlife in Canada, nominates species for listing under *SARA*.) Some species in Newfoundland and Labrador are captured in the VECs listed above; they are also discussed separately because of their special status.

11.2 Socio-economic VECs

The three socio-economic VECs have been addressed as per the EIS Guidelines. The scope of each has been defined in a manner that will focus the assessment on relevant matters.

Economy, Employment, and Business

Economy, employment and business encompasses aspects of the socio-economic environment that are important to all citizens. Some will benefit directly or indirectly from Project employment skills and experience. New industrial projects generally benefit the surrounding area as some people are directly employed and as employee and business spending generated indirect employment and effects throughout the local economy. Some effects may be negative; for example, wage inflation caused by the Project may adversely affect local businesses, while an increase in the cost of living may adversely affect those on low fixed incomes. However, all citizens and the economy as a whole will also benefit from the taxes and royalties that projects and their employees pay to different levels of government, which can use them to address a wide range of social and economic issues.

Services and Infrastructure

Services and infrastructure are important because citizens value the components that make up this VEC for their contribution to the quality of life. Employment stemming from the Project may result in higher incomes or lifestyle changes, or encourage in-migration, leading to increased demands on services and infrastructure. Where they are already operation at or beyond their capacity, and increased demand

could reduce the overall quality of services provided, until such a time as capacity issues can be corrected. Where services and infrastructure are currently underused, increased demand may have no effect, or a positive one through user pay and greater efficiency of use.

Recreational Activities

Recreational activities are important because such activities contribute to the physical and mental well-being of a broad range of individuals. Hunting, trapping, fishing, berry-picking, cutting firewood and some other such activities can also contribute to the economic well-being of residents. Parks, trails and historic resources are important to local tourism and hence the local economy.