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Technical Memo

To	**Martin Donnelly, TCPL**	Date	**28 February 2006**
		Job No.	**142829**
From	**Jorgito Tseng**	File	**142829 A 400**
Copy	**Charlie Birt, Keith Dunbar, Sandwell**		

Reference: **Influence of LNG Terminal on Ile Verte Ice Bridge and the Port of Gros-Cacouna Harbour Entrance**

Background

Cacouna Energy, formed by TransCanada PipeLines Limited and Petro-Canada, is proposing to develop and construct a liquefied natural gas (LNG) import terminal in the Parish of St.-Georges-de-Cacouna, Québec, on the south shore of the St. Lawrence River. This proposed development will be located approximately 15 km northeast of Rivière-du-Loup, Québec, at a site on Gros-Cacouna Island and on land owned by the Government of Canada (Transport Canada) and currently zoned for industrial use.

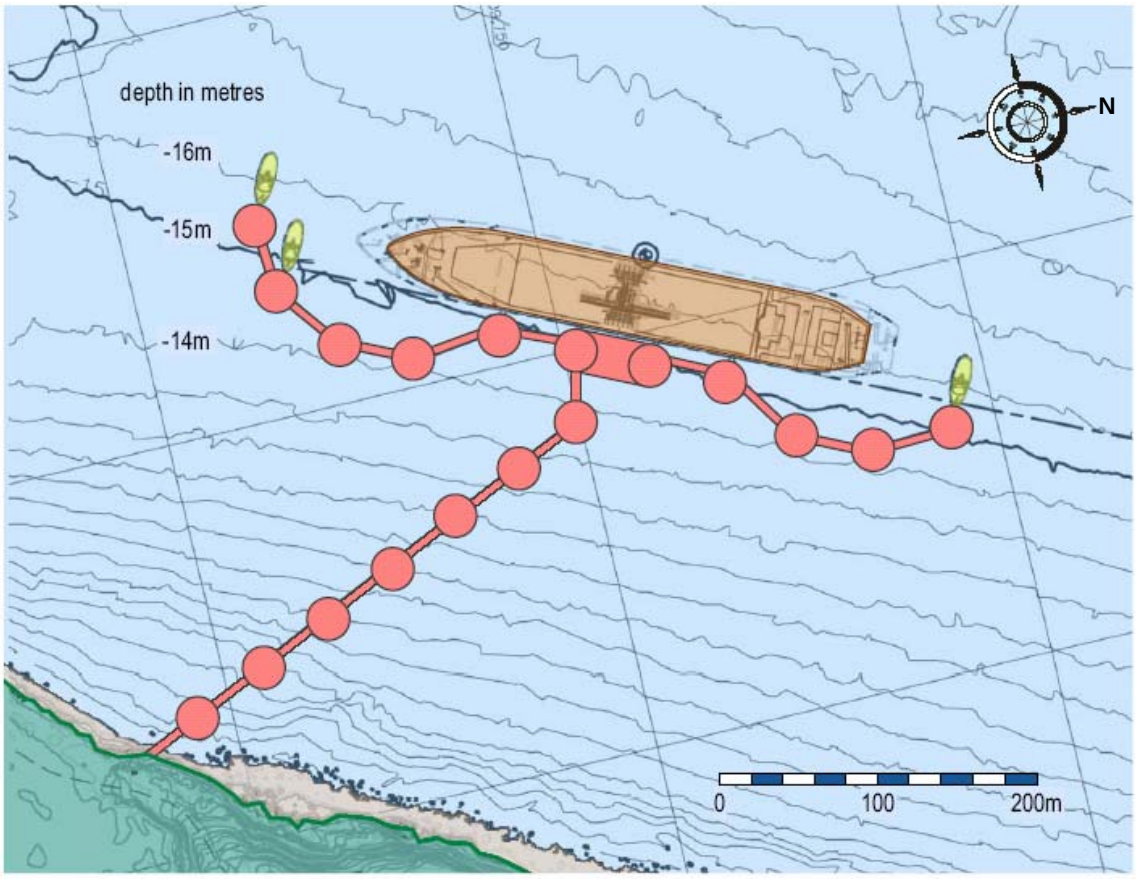
The proposed marine facility consists of a single berth to receive and unload LNG carriers in the size range of 70,000 cu.m. to 216,000 cu.m. The expected rate of arrival of the LNG carriers is once every 6 days on average.

As part of the marine facility design process, the influence of the presence of the berth structures on the local river ice dynamics, and therefore on the Ice Bridge at Ile Verte and the harbour entrance to the adjacent Port of Gros-Cacouna, is assessed to confirm the preliminary conclusions reached at an earlier stage of concept development that such impact will be acceptably minimal. This technical memorandum has been prepared to address this design consideration.

Proposed Marine Structures

The proposed berth arrangement for the Cacouna Energy dock is shown in Figure 1. The marine structures consist of breasting and mooring dolphins, ice deflection piers and an access trestle connecting the unloading platform to the shoreline. The dolphins, piers and trestle supports are 25 m diameter sheet pile caissons. The berth will be located in 15 m of water, approximately 325 m offshore, and aligned parallel to the ebb and flood currents.

Figure 1 Marine Terminal General Arrangement



Assessment Approach

To address the influence of the planned marine structures on the local river ice conditions, the potential use of the ice forecast model developed by the Institut des Sciences de la Mer de Rimouski (ISMER) at the Universite du Quebec a Rimouski (UQAR) was initially considered. However, because of limitations in the resolution of the ice model as recognized by the model developers, a decision was made to form a Panel of Ice Experts that would offer knowledge based consensus opinions on the subject.

The Panel of Ice Experts consisted of individuals with a range of expertise in different ice discipline areas, marine personnel with in-ice operating experience in the Cacouna area and people with local knowledge (see Table 1). Brian Wright coordinated the Panel's efforts and received input from its members through a combination of written correspondence, telephone conferences and face to face meetings. The procedure that was employed to obtain opinions from the Panel members involved:

- providing each expert a description of the ice conditions and the subject design consideration of the influence of the planned marine structures on the Ice Bridge at Ile Verte and the harbour entrance to the adjacent Port of Gros-Cacouna

- allowing each expert to deliberate and form opinions independently
- conducting individual interviews thereafter to collect the opinions of the experts
- collating the opinions received into a draft technical note to summarize the consensus views
- circulating this draft technical note back to all of the experts for a second review
- compiling a final summary technical memorandum with any additional comments included

The consensus opinions of the Panel, which represent its joint views on the pertinent issues of ice dynamics, are summarized below. It is important to note that the various Panel members offered different ice expertise, and that all members could not speak to all aspects of the questions posed with the same level of authority. This was considered the strength of the Panel, since different perspectives were raised during the deliberation. When a particular Panel member did not have an opinion on a specific point, it was simply acknowledged as such.

Table 1 Panel of Ice Experts

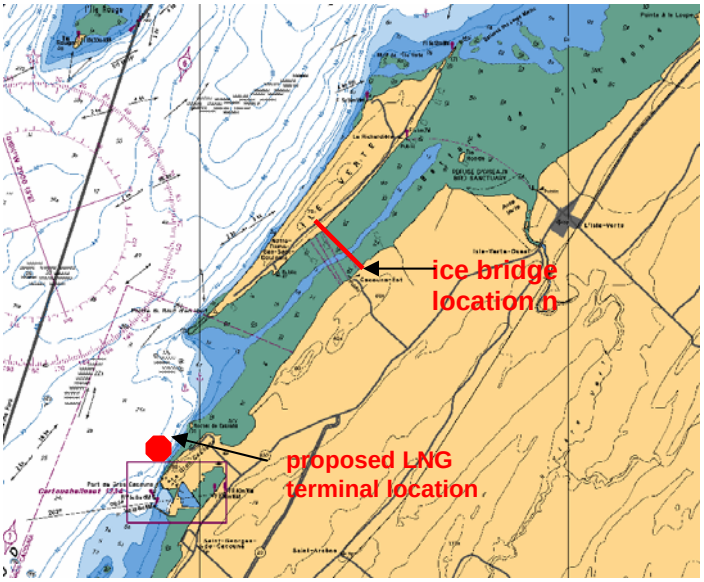
Name	Affiliation	Areas of Expertise
B. Wright	B. Wright & Associates Ltd.	ice conditions ice management
D. Masterson	Sandwell Engineering Inc.	ice behaviour ice forces terminal design
G. Timco	National Research Council of Canada	ice behaviour ice forces
V. Koutitonsky	University of Quebec at Rimouski (ISMER)	ice conditions monitoring at Gros-Cacouna
S. Senneville	University of Quebec at Rimouski (ISMER)	ice and ocean modeling
B. Morse	Laval University	river ice engineering
J. Leclair	Canadian Coast Guard – Quebec Region	ice conditions vessel operations in ice
S. Neth	Canadian Coast Guard – Quebec Region	ice conditions vessel operations in ice
H. Goulet	Canadian Coast Guard – Quebec Region	ice conditions vessel operations in ice
R. Laberge	Transport Canada - Port of Cacouna (retired)	local knowledge

Local Ice Conditions

Ice conditions and movements in the general Gros-Cacouna area are quite well known, based on historical ice chart information, various site-specific ice data acquisition projects and in-ice vessel operations near the Port of Gros-Cacouna. The pack ice cover that is present near Gros-Cacouna is highly variable, but generally not severe. Ice concentrations range from 0 to 9+/10^{ths} and, at any given location, can vary over time scales of a few minutes to a few hours. The majority of the ice cover is typically comprised of thin ice types (less than 30 cm thick), with brash ice and small floes being common. However, some first year ice types (generally in the 30 cm to 70 cm thickness category) and large ice floes (hundreds of metres to several kilometres in size) can also be seen as winter progresses. Ridges, rubble fields and rafted ice areas are additional features that are interspersed throughout the ice cover.

Off the entrance to the Port of Gros-Cacouna and at the LNG terminal site, the ice cover is in near continuous motion, under the influence of winds, currents and tides. The semi-diurnal tides in the area cause complete reversals in the ice drift direction (up and down the river) twice per day. Although ice pressure events occasionally occur, significant ice pressure situations are infrequent and typically of short duration (a day or less). The presence of a persistent fast ice zone along the coastline is uncommon off Gros-Cacouna, except for a narrow band of grounded ice (10 to 20m wide) in the shallow water immediately adjacent to the shore. However, there are periods when the near-shore ice may remain quasi-stable over hours to days, with the pack ice shearing past it farther offshore. The only true fast ice that is consistently seen in the general area forms in the constricted shallow waters between Ile Verte and the shoreline. A reference map is shown in Figure 2.

Figure 2 Map of the General Area of Interest

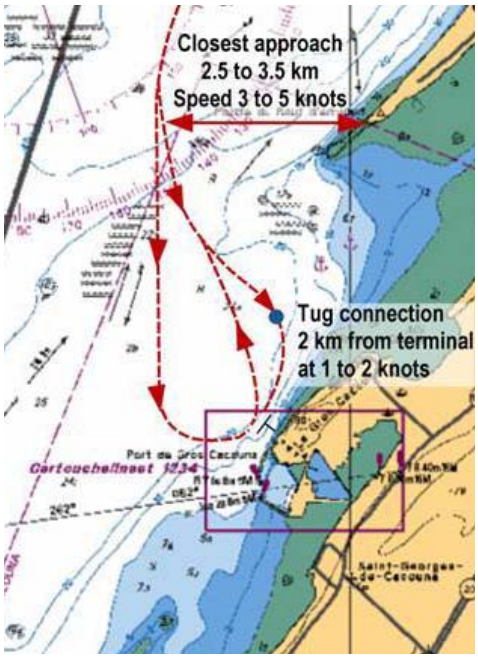


Ice Bridge to Ile Verte

It is the opinion of the Panel of Experts that there will be no adverse impact of the LNG terminal on the ice bridge to Ile Verte and, in fact, no influence on it whatsoever. This opinion is based upon a knowledge of the ice processes at play, along with the experiences gained from past vessel operations near Gros-Cacouna. The primary factors that underlie this opinion include:

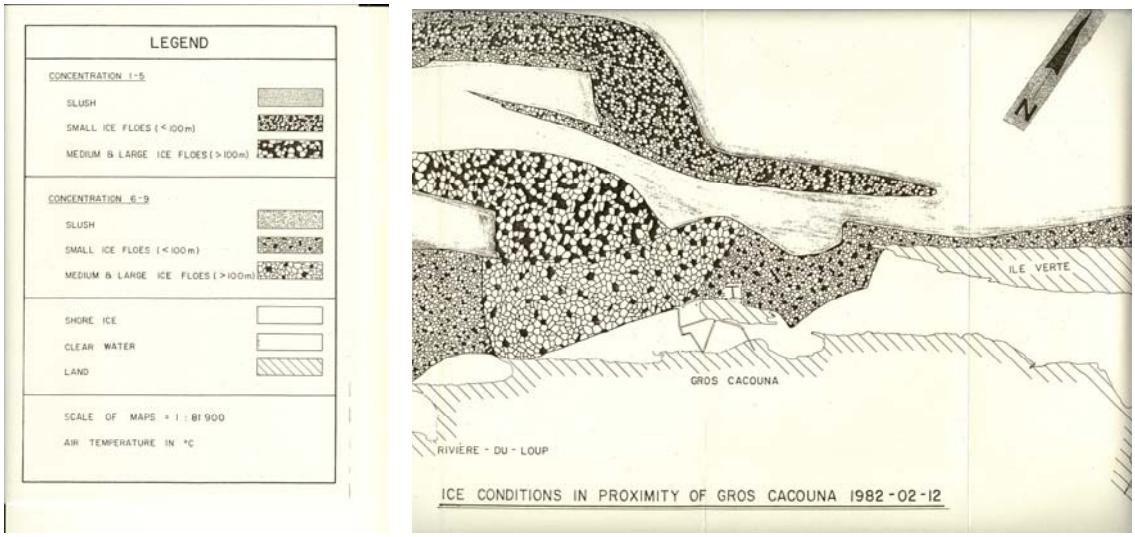
- the fact that the ice bridge (and the fast ice area that "protects it") is distant from the proposed terminal location, with the actual ice bridge being about 8 km to the NE
- that the LNG carrier and the support tug transits will not come close to the fast ice area (or shallow waters near it) during approaches to and departures from the terminal (see Figure 3 which shows that the planned routes are no closer than about 2.5 to 3.5 km to the western tip of Ile Verte)

Figure 3 Distance between LNGC Transits and South West Tip of Ile Verte



- that the LNG carriers will be moving at slow speeds and will not create any significant bow or wake waves that could propagate towards and interact with the fast ice edge
- the fact that stable fast ice perennially forms in the shallow constricted waters between Ile Verte and the shoreline, across large areas to the SW and NE of the ice bridge (an example of the extent of the fast ice area lying shoreward of Ile Verte is shown in Figure 4, based on site specific air photo observations of the ice cover taken in February, 1982, showing also that the ice bridge lies well inside the western boundary of the persistent fast ice zone)

Figure 4 Representative Example of the Stable Fast Ice Area between Ile Verte and the Shoreline in Winter



- the fact that most of this fast ice is grounded at low tide, and parts of its SW "entrance" are pinned by grounded rubble formations
- the fact that sizable waves that propagate towards this fast ice area during open water periods in winter have not caused any significant deterioration of it
- the fact that past in-ice ship operations near Gros-Cacouna have had no known effects on the fast ice area between Ile Verte and the coast or its interior ice bridge

Entrance to the Port of Gros-Cacouna

It is the opinion of the Panel of Experts that there will be no adverse impact of the LNG terminal on ice conditions around the entrance to Gros-Cacouna harbour. The primary factors that underlie this opinion include:

- the fact that the ice cover around Gros-Cacouna is very dynamic, with its (primarily tide related) movements and shears resulting in changes in ice conditions at the terminal site and around the entrance to the existing port over time scales of tens of minutes to hours
- that the terminal's dolphins and access trestle support piers will be largely transparent to moving pack ice in many situations and, as such, it is not expected to typically "attract or aggregate" ice (except locally at times - see comments below)
- that the range of naturally occurring ice conditions and situations that are now seen in the general area will encompass those observed when the LNG terminal is in place except perhaps on highly localized scales

- that four ice-capable support tugs will be present around the terminal that can be used to manage any adverse ice situations that may arise
- that the presence of the terminal will likely create a triangular fast ice zone that may extend a few hundred metres upstream of it, similar to what is seen at the Ultramar terminal near Quebec City (a schematic illustration of the type of quasi-stationary ice rubble wedge that is expected to form between the proposed marine structures and the existing breakwater is shown in Figure 5)
- the presence of this type of stable fast ice wedge should generally be beneficial for tanker berthing operations at the LNG terminal, but it should not extend as far upstream as the harbour entrance and ,if it does at times, ice management with the support tugs could be used to reduce its size quickl

Figure 5 Schematic Illustration of Fast Ice Zone Expected to Form on the Upstream Side of the LNG Terminal

Influence on Local Ice Conditions

The question of how the LNG terminal would affect ice movements and ridge building between the jetty and the shoreline is addressed in this section. The Panel acknowledges there will be some influence of the new installation on the local ice conditions, at least from time to time. However, naturally occurring ice conditions are highly variable at the site where the terminal will be located, with a wide variety of pack ice, open water and ice shearing motion situations being observed. It is considered unlikely that the terminal's presence will change any overall aspects of the ice dynamics seen around the site.

Figure 6 shows two views of the proposed terminal site taken about 5 hours apart during a field reconnaissance project in mid February, 2005. Semi-diurnal tidal influences can result in significant changes in ice conditions over time frames of a few hours. As shown in Figure 5, the

transition from a high ice concentration situation on site (the upper photo) to an open water situation on site (the lower photo) occurred within 5 hours.

Figure 6 Two Views of Conditions at the Proposed Terminal Site in Late February 2005

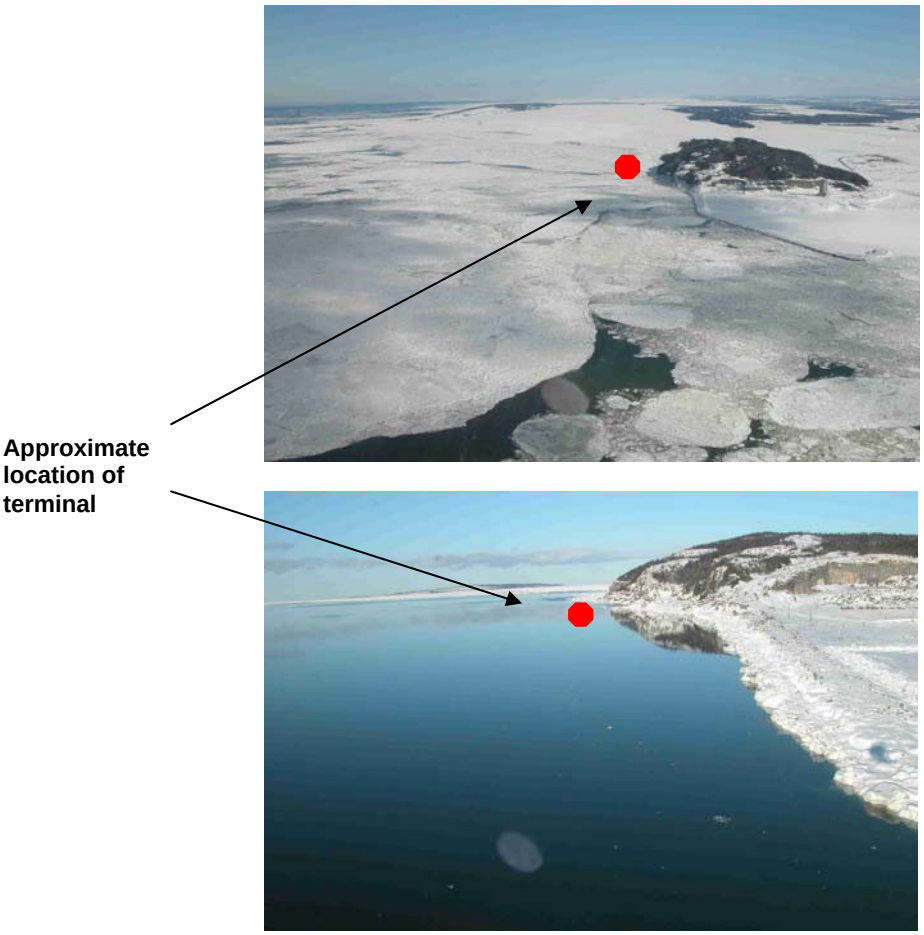
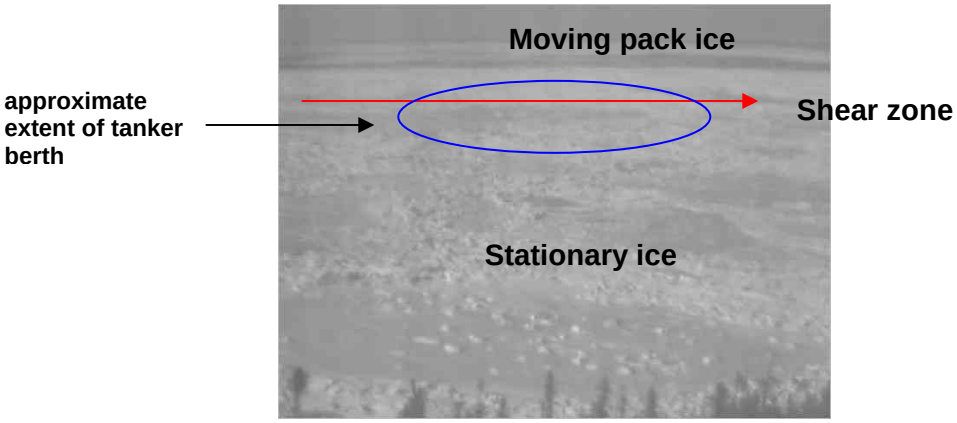


Figure 7 provides a "snapshot" of one of the many possible shear ice motion situations in the general vicinity of the site that were documented by a time lapse video camera over the winter of 2005.

Similar changes in ice conditions are expected to be seen over short time frames when the terminal is in place. It is the opinion of the Panel that any changes in near-shore ice conditions due to the presence of the terminal will be localized and transient, and of little consequence to the ice environment, when compared with the range of variations that naturally occur.

Figure 7 Video Frame of the Terminal Site from Early February 2005



It is likely that fast ice (or quasi-stationary ice) may form in the local area between the shoreline and the terminal's mooring dolphins (on the inside and downstream side of the jetty), at least on an intermittent basis, as it does on occasion during the winter now (i.e. without the terminal in place). Should these conditions hinder the operation of the terminal, the support tugs could be used to break and clear this ice quickly, as required. The formation of this fast ice is not considered to have any impact on the ice conditions beyond the immediate terminal area.

Summary

In summary, the Panel does not anticipate any adverse effects of the LNG terminal and its associated marine operations on the ice bridge to Ile Verte, vessel access to the Port of Gros-Cacouna or the type of ice conditions that are seen near the terminal site.