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February 17, 2006

Captain Peter J. Boynton
Captain of the Port, Long Island Sound
120 Woodward Avenue
New Haven, Connecticut 06512

Re: Broadwater Energy LLC Docket USC6-2005-21865

Dear Captain Boynton:

Broadwater Energy LLC (Broadwater) hereby encloses a report prepared by Det Norske Veritas (DNV), dated February 13, 2006, in response to your letter dated December 21, 2005. A copy of your letter is included in the subject report.

The DNV report addresses the four questions in your letter, regarding:

(1) A comparison between the assumptions in the Sandia National Laboratory Report SAND2004-6258 (Sandia Report) and for the Broadwater FSRU and LNG carriers of a potential capacity of up to 250,000 m^3;
(2) A comparison of the potential spill volumes for the Broadwater FSRU and LNG carriers of a potential capacity up to 250,000 m^3 with the assumptions contained in the Sandia Report;
(3) An assessment of vapor dispersion results using the spill volumes in Question (2) with those of the Sandia Report; and
(4) A summary of historical atmospheric conditions for the Long Island Sound region.

Broadwater also is in receipt of your letter dated February 16, 2006 to the Federal Energy Regulatory Commission (FERC) requesting additional information with respect to Resource Report 13 in Broadwater's January 30, 2006 FERC filing in Docket No. CP06-54-000. The DNV report above addresses the vapor dispersion issue, which is typically the condition that generates the largest hazard zones. Another item mentioned in your February 16 letter to FERC is a thermal radiation analysis for accidental and intentional breaches of the cargo tanks. To facilitate the Coast Guard's review of Broadwater's application, Broadwater will provide the thermal radiation analysis at the earliest opportunity.

If there are any questions concerning the above provided above or in the attached report, please contact Mr. David Thomson of Broadwater at 713-241-8971.

Sincerely,

Bruce W. Neely
Attorney for Broadwater Energy LLC

cc: Lieutenant Commander Alan Blume
Chief of the Prevention Department, Long Island Sound

James Martin
Federal Energy Regulatory Commission

Ms. Magalie R. Salas
Federal Energy Regulatory Commission

Cooperating Agencies

DNV CONSULTING

Broadwater LNG: Response to U.S. Coast Guard Letter Dated December 21, 2005:

Report for TransCanada PipeLines Limited
Report no.: 70014347
Rev 1, 13 February 2006

MANAGING RISK DNV

Broadwater LNG: Response to U.S. Coast Guard Letter Dated December 21, 2005

for

TransCanada PipeLines Limited
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Client ref:

Report No.: 70014347

Subject Group:

Indexing terms:

Summary: The objective of this report is to provide comprehensive answers to the four US Coast Guard queries outlined in their letter (ref. 02) dated December 21, 2005. Broadwater Energy will review the DNV report and may mark certain information as Sensitive Security Information (SSI) in accordance with 49 Code of Federal Regulations (CFR), Part 1520.

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Date of issue: 13 February 2006

Project No: 70014347

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Contents:

1.0 Introduction

As part of the permitting process for Broadwater Energy's (henceforth, Broadwater) proposed Floating Production, Storage and Regasification Unit (FSRU) in Long Island Sound, the United States Coast Guard (henceforth, USCG) issued a letter in October 2005 (ref.07) containing queries directed at Broadwater. In response, Broadwater requested that Det Norske Veritas (USA), Inc. (henceforth, DNV) respond to the USCG based on DNV's risk analysis experience with LNG terminals The DNV response was issued in a report, "Broadwater LNG – U.S. Coast Guard Queries," dated November 16, 2005 (ref.01).

The USCG then issued a subsequent letter to Broadwater Energy (ref.02) outlining queries concerning the DNV report. The letter is attached to this report as Appendix I and the queries are summarized at the beginning of each section in this report.

The USCG stated that the issues outlined in their letter need to be addressed "in order for the Coast Guard to make an evaluation whether the Sandia Report is applicable to the site, the FSRU and the future generation of LNG carriers." Broadwater has requested that DNV issue this report in response to the USCG letter.

2.0 Objective

The objective of this report is to provide comprehensive answers to the four USCG queries outlined in their letter (ref. 02) dated December 21, 2005. Broadwater Energy will review the DNV report and may mark certain information as Sensitive Security Information (SSI) in accordance with 49 Code of Federal Regulations (CFR), Part 1520.

3.0 Query 1

3.1 Summary of Query

DNV has been requested to provide a qualitative comparison of the thickness and material strength of the outer and inner hull plating as well as the horizontal distance between the outer and inner hulls that was used for the Sandia Report versus the future generation of LNG carriers and FSRU. The future generation of LNG carriers to consider will have a capacity of up to approximately 250,000 m^3 and the FSRU will have a capacity of 350,000 m^3. This will form the basis to evaluate whether the breach sizes that were determined as part of the Sandia Report can be applied to the FSRU and the future generation of LNG carriers.

3.2 Response to Query

DNV Maritime was contracted to perform a study to respond to Query 1. DNV Maritime is one of the world's leading classification societies, and has worked to improve safety at sea since 1864.

The study was sub-divided into two tasks:

1. Qualitative comparison of particulars for different sized LNG carriers and the FSRU.
2. Collision vulnerability analysis, to determine side impact energies that can be absorbed for different sized LNG carriers and the FSRU before deformation of the tank shell is initiated.

DNV Maritime reviewed data on LNG carriers that they have available through previous project work in order to find vessels that are representative of the current standard for LNG carriers and the future generation of LNG carriers. Membrane carriers with 145,700 m^3 and 216,000 m^3 capacity, the FSRU with 360,000 m^3 capacity, and spherical carriers with 125,000 m^3 and 235,000 m^3 capacity are examined in this study. The drawings used by DNV Maritime are proprietary information belonging to the ship owner and cannot be made public. At the time of this study, the specific design for the Broadwater LNG carriers had not been determined; however, preliminary drawings for the FSRU were available. The project requested that DNV assume an LNG carrier capacity of 250,000 m^3. The following analysis is based on this information. Even if the final design varies in capacity, it is expected that the FSRU and future LNG carriers delivering LNG to the FSRU will have hull spacing and material thickness similar to the future generation of LNG carriers examined in this study.

3.2.1 Qualitative Comparison of Different Sized LNG Carriers

The FSRU and four different LNG carrier designs were evaluated and the general conclusion is that larger "future generation" vessels have thicker inner and outer hull plate thickness and a larger horizontal distance between the outer and inner hulls compared to smaller LNG carriers currently in service. Table 3-1 presents the particulars for the FSRU and four LNG carrier designs. The designs are further categorized by hull type (membrane carriers and spherical carriers).

Table 3-1 Vessel Design Particulars

	Membrane Carrier			Spherical Carrier	
LNG Carrier Capacity [m3]	**145700**	**216000**	**(FSRU) 350000**	**125000**	**235000**
L - length bp [m]	277.2	303.0	366	282.0	328.5
B - breadth [m]	43.4	50.0	60	41.6	55.0
D - depth moulded [m]	26.0	27.0	27	25.0	32.5
Dt- depth trunk [m]	33.7	35.1	37.14	-	-
Top of tank abv B.L. [m]	31.0	33.2	34.40	37.7	49.0
T - draft moulded [m]	12.3	12.5	12.3	11.5	12.5
Cb - Block coef	0.8	0.8	.96	0.7	0.8
Displacement [tonnes]	116941	151599	266048	99130	178247
Double bottom height [m]	3.2	3.4	3.5	1.4	1.6
Double side width [m]	2.2	2.6	4.8	2.4	3.0
Outer side plate thickness [mm]	17-18	16-21	15.5-21	19	18-20
Inner side plate thickness [mm]	14-18	18-19	15.5	14-18	14.5-16.5
Transverse frame space [mm]	2800	4105	4240	4180	4130
Cargo Tank dimensions					
L - length [m]	47.6	41.0	33.9	-	-
H - Height [m]	27.7	29.8	30.9	-	-
B - Breadth [m]	39.0	44.8	50.2	-	-
Tank diameter [m]	-	-	-	35	46
Approx. Volume of tank [m3]	43504	48174	44,850	22449	50965

As shown in Table 3-1, a 145,700 m^3 membrane carrier is expected to have a distance between the inner and outer hull (i.e., double side width) of 2.2 m while the 216,000 m^3 membrane carrier has a distance between the hulls of 2.6 m. The proposed 250000 m^3 membrane carrier is expected to have a double side width between that of the 216,000 m^3 carrier and the FSRU. The plate thickness and distance between the hulls are critical factors in determining the vulnerability (i.e., how likely there is a breach). This is further discussed in the following section.

3.2.2 Collision Vulnerability Analysis

A collision vulnerability analysis was performed to determine side impact energies that can be absorbed by different sized LNG carriers and the FSRU before deformation of the tank shell is initiated. The higher the impact energy that is required before deformation occurs, the less vulnerable the specific LNG carrier design is to collisions (Table 3-2).

The purpose of the analysis is to evaluate collision vulnerabilities for different sized LNG carriers and the FSRU. The results should not be used as absolute values. The impact energies should be viewed in context for comparison purposes only. The assumptions for these calculations are as follows:

- The bow of the striking ship is taken as infinitely stiff, i.e. no energy is absorbed in the bow (very conservative).
- The LNG carriers are considered in a "free float" condition with zero speed being hit by the striking ship in the flotation centre at 90 degrees angle to the side, hence moving sideways in the water with no rotation following the collision (conservative).
- The striking vessel is a 5,000 tonnes typical coastal vessel with a raking bow of 65.6 degrees. The raking bow shape is rather conservative, but the striking vessel itself should be representative for traffic in coastal waters. The speed of the striking vessel is based on engineering judgment and on average transiting speeds within coastal waters.

Using the assumptions above, the amount of energy the outer and inner hull could absorb before there was contact with the LNG tank was calculated as a function of striking ship energy and the displacement of both the striking ship and LNG vessel. The calculations were carried out with DAMAGE 5.0 computer code (ref. 08), which is widely used in the maritime industry.

Table 3-2 Collision Vulnerability Analysis

	Membrane Carrier			Spherical Carrier	
LNG Carrier Capacity [m3]	**145700**	**216000**	**FSRU 350000**	**125000**	**235000**
Striking ship					
Displacement [tons]	5000	5000	5000	5000	5000
Striking speed [Knots]	**3.48**	**4.83**	**8.62**	**5.75**	**8.47**
Striking speed [m/s]	1.79	2.48	4.43	2.96	4.35
Striking Energy [MJ]	8.8	17.0	54.1	24.1	52.2
Struck ship (LNG Carrier)					
Speed struck ship [Knots]	0.0	0.0	0	0.0	0.0
Speed struck ship [m/s]	0.0	0.0	0	0.0	0.0
Absorbed Collision Energy [MJ] before inner hull contact	**8.3**	**16.2**	**52.6**	**12.6**	**26.0**
Absorbed Collision Energy [MJ] before tank contact	**8.3**	**16.2**	**52.6**	**22.3**	**50.0**

Two critical indentation or deformation situations are shown:

- Inner hull contact: The stiff bow touches the inner hull. For membrane systems, deformation of the insulation system will then start with potential damage to the insulation system and ultimately causing LNG spill.

- LNG cargo tank contact: The spherical system is an independent system with a distance from the inner hull to the tank shell at equator of about 0.9 m. This allows for an additional 0.9 m of indentation before deformation of the tank shell is initiated.

Based on the above, the "critical" indentations are where the deformations of the tank system are initiated. Hence, the LNG cargo tank contact values should be used as the basis for comparisons.

From the results, it is clear that the larger carriers absorb approximately twice the collision energy compared to smaller carriers. A larger membrane carrier is able to absorb 16.2 MJ while the smaller membrane carrier can only absorb 8.3 MJ. The FSRU can absorb approximately 52.6 MJ. Collision energy can be directly related to breach sizes of carriers. Thus the more energy a carrier is able to absorb, the smaller the breach size.

The USCG requested that DNV perform a qualitative analysis, thus the numbers presented in this report should not be used as absolute values but should be used for comparison purposes.

Based on the above discussion it can be concluded that large LNG carriers in the 200,000 m^3 to 250,000 m^3 range and the FSRU at 350,000 m^3 will generally be less vulnerable to side impact collisions compared to smaller LNG carriers (capacities of 125,000 to 150,000 m^3).

Smaller LNG carriers (currently in service) are hence expected to experience larger breach sizes than larger (future generations of) LNG carriers given the same impact energies. The Sandia Report breach sizes are based on smaller LNG carriers and are therefore conservatively (based on equal impact energies) applicable to the proposed Broadwater FSRU and LNG carriers.

4.0 Query 2

4.1 Summary of Query 2

The results from the Sandia Report are based on spill volumes of approximately 12,500 m^3 from a cargo tank with a volume of 25,000 m^3 and an initial liquid height in the cargo tank above the breach of 15 m. The above cargo tank volume reflects an LNG carrier capacity of 100,000 to 125,000 m^3 depending on the number of cargo tanks. Further comparisons must be made to decide credible spill volumes and initial liquid heights above the breach for larger cargo tanks relevant for the FSRU and future LNG carriers.

4.2 Response to Query 2

The following section discusses the basis for the DNV consequence modeling which includes cargo tank volumes, liquid height in the cargo tank, and carrier size.

The DNV consequence modeling is based on site specific information while the Sandia study is based on generic data. The release rate is largely dependent on the amount of LNG head above the breach. A breach in both the FSRU and LNG carrier has been assumed to occur just above the water line. This assumption results in the largest LNG head and release volume and consequently the most conservative results. A simplification of the LNG head in a tank is illustrated in Figure 4-1.

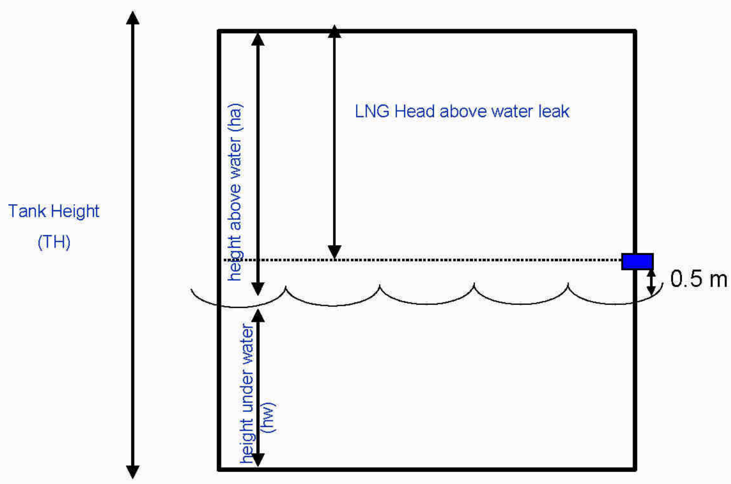

Figure 4-1 LNG Head above Water Leak

The Broadwater project is currently considering an FSRU with eight tanks that each hold a volume of approximately 45,000 m^3 of LNG. The LNG carriers that unload at the Broadwater facility may vary in size. This study attempted to be conservative in its assumptions; therefore, one of the largest sized carriers was chosen as a base case (250,000 m^3 carrier with six storage tanks). The tank volumes, release volumes and LNG head that have been used as the basis for the Broadwater site specific evaluations are presented in Table 4-1, together with the data use in the Sandia Report.

Table 4-1 Consequence Modeling Input

Consequence Input	Sandia	Broadwater FSRU	Broadwater LNG Carrier
Tank Volume (m^3)	25, 000	44, 850	42, 000
Release Volume (m^3) (above water release)	12, 500	35, 560	27, 300
LNG Head (m)	15	21	20.3
Draft (fully loaded) (m)	Not Specified	12.3	12

In order to be conservative on the amount of tank volume released, it was assumed that the FSRU tanks are 98% full and that the LNG carrier tanks are 95% full (this will be the case upon arrival of the carrier) during a release.

As can be seen from Table 4-1, Sandia assumed that 50% of the tank volume would be released. DNV calculated the release volume based on the amount of draft when the vessel is fully loaded and the LNG head above the release. This resulted in a larger release volume than assuming a uniform 50% of the volume is released.

There is uncertainty within the industry on determining total release volume for a large LNG leak. This is due to a number of phenomenon that are difficult to determine for such large scale leaks such as, possible water ingress into the tank, LNG or water ingress into the space between the inner and out hulls, cryogenic effects on the tanker hull, etc. The DNV site specific release volumes are larger than Sandia's since the Broadwater LNG tanks are larger than the tanks considered by Sandia.

Due to the increased tank size there is a larger LNG head which will result in a larger release rate and larger dispersion distances (dispersion cloud lengths are discussed in Section 5.2.3). It is possible that the future generation of larger carriers will be able to withstand a greater impact than existing carriers which could result in smaller hole sizes. If the FSRU or the Broadwater LNG carriers were exposed to the same impact energies as used in Sandia, then the hole size is expected to be smaller since the larger vessels are able to withstand a larger impact energy.

5.0 Query 3

5.1 Summary of Query 3

Sandia provides guidance for assessing hazard zones for accidental and intentional discharges of LNG. The size of the hazard zones are used as input to determine safety zones for the FSRU and LNG carriers. The USCG requests that this report provide a conclusive analysis on whether the Sandia hazard zones are applicable to the Broadwater FSRU and LNG carriers based on the Sandia methodology as presented in Appendix D of the Sandia Report.

5.2 Response to Query 3

The size of the hazard zones as described in the Sandia Report is a function of hole size, LNG head above the breach, release rate, volume released and weather conditions.

5.2.1 Hole Sizes

DNV and Sandia have performed extensive project work with LNG, examining possible breach sizes for LNG tanks. DNV issued a paper based on a joint industry project (ref.04) that identified the three most credible hole sizes for an accidental breach in an LNG tank as 250 mm, 750 mm and 1500 mm holes. This conclusion was a judgment-based approach developed by Classification engineers experienced in collision and grounding studies.

Sandia used 1120 mm (1 m^2 hole area) and 1600 mm (2 m^2 hole area) as nominal hole sizes for accidental scenarios. Sandia also focused on intentional acts where it is believed the hole sizes (diameters) can be larger. Sandia concluded that the nominal credible hole diameter for intentional acts is 2523 mm (5 m^2 hole area), as discussed in Chapter 5 of the Sandia report (ref. 03). Based on the findings in Section 3.2 (and the assumption that a given intentional act would apply the same impact energy to a larger carrier as it would to a small carrier), then the Sandia hole sizes can be considered a conservative assumption and are thus applied in this Broadwater study.

DNV has run dispersion modeling for the three Sandia hole sizes (diameters) combined with Broadwater project specific information, as presented in Table 4-1, in order to determine if the Sandia hazard zones are applicable to Broadwater.

5.2.2 Consequence Modeling Basis

For most credible scenarios (accidental or intentional), the thermal hazards from a spill are expected to manifest as a pool fire, based on the high probability that an ignition source will be available. In some instances, an immediate ignition source might not be available and the spilled LNG could therefore disperse as a vapor cloud. In congested or highly populated areas, an ignition source would be likely, as opposed to remote areas in which an ignition source might be less likely (ref. 03). The thermal hazard zones from a vapor cloud dispersion with late ignition have the potential of extending significantly longer than the thermal hazard zones from a pool fire. Hence this study focus on thermal hazard zones from vapor clouds with late ignition.

The basis for consequence modeling is presented in Table 4-1 of this report.

5.2.3 Consequence Modeling Results

Table 5-1 presents the results of both Sandia's consequence modeling and DNV's consequence modeling.

Table 5-1 Consequence Modeling Results

	Distance to LFL (m)						
Hole Size (mm)	Sandia	FSRU			LNG Carrier		
	F 2.33 m/s	F 2 m/s	D 3.5 m/s	D 7 m/s	F 2 m/s	D 3.5 m/s	D 7 m/s
1120	1536 m	1870 m	1030 m	1100 m	1890 m	1020 m	1090 m
1600	1710 m	2280 m	1390 m	1570 m	1990 m	1370 m	1560 m
2523	2450 m	3320 m	2050 m	2360 m	3290 m	2030 m	2340 m

Sandia used the Computational Fluid Dynamics (CFD) tool VULCAN to perform their modeling. DNV has used PHAST, a point source similarity model to perform dispersion modeling. Previous examination of both Sandia and DNV results demonstrated that PHAST results are generally more conservative than CFD results (ref 05). A CFD model takes into account topography and obstacles and changes in surface conditions. A similarity model does not take into account effects that will limit dispersion but is widely accepted by regulators and industry stakeholders in documenting industrial hazard zones. A CFD model is extremely detailed in its structure and thus time consuming to set up and requires specific modeling knowledge to provide reliable results. A similarity model is more practical to use and is validated for small scale LNG releases over water. A similarity model has been previously shown, however, to give conservative results for large scale releases, and in particular when dispersion takes place onshore. There is a degree of uncertainty in both the CFD model and PHAST when predicting large size LNG releases in F stability with low wind speeds. To date, there is a lack of large scale experiments with which the models can be calibrated. However, these are the industry's leading tools for dispersion modeling. Thus the results that are predicted by both PHAST and VULCAN can be considered best available knowledge to date.

As can be seen from the table above, the category F 2 m/s weather conditions result in a greater hazard distance than the Sandia results. This can be attributed to the larger volumes and higher LNG head used in the Broadwater modeling. Also the conservatism that is intrinsic to the PHAST model increases with the size of release because there are fewer field tests with which to calibrate the model.

The largest dispersion release from the FSRU has been calculated to extend 3320 m (2 miles) while the closest land is approximately 14,500 m, or 9 miles. The largest dispersion cloud for the LNG carrier is calculated to be 3290 m (2 miles) and the closest passage of the LNG carrier to land is at the race where the carrier will be approximately within 1610 m (1mile) from shore.

The most frequently occurring weather condition in the sound is D stability which occurs approximately 49% of the time (whereas F stability only occurs 15% of the time). The site specific weather conditions are discussed in further detail in Section 6.2.

As part of planned operations, LNG carriers may transit the Sound at night time when marine traffic is at a minimum.. F stability occurs only at night and accounts for approximately 30% of the night weather conditions. D stability accounts for 46% of the night weather conditions and D stability consequence results are in the same order of magnitude as the Sandia results.

It can be concluded that when establishing the hazard zones for Broadwater, the F stability results will provide the most conservative result. However, the results for D stability are the most probable results.

6.0 Query 4

6.1 Summary of USCG Query

The dispersion modeling performed and documented in the DNV Report of November 16, 2005, applies atmospheric data for Baltimore, Maryland, because of the lack of site specific atmospheric data. The USCG letter of December 21, 2005, states that it is not acceptable and that "the vapor cloud dispersion modeling should be based on site specific, seasonal environmental and weather factors…" for Long Island Sound.

6.2 Response to Query 4

DNV has acquired site specific weather data from the National Climatic Data Center (NCDC). The closest weather data station to the proposed FSRU and LNG Carrier Route locations that provides stability class information was the New Haven, Connecticut airport. New Haven is marked by a red "X" in Figure 6-1 and an approximation of the proposed LNG carrier route and FSRU location are drawn as black lines.

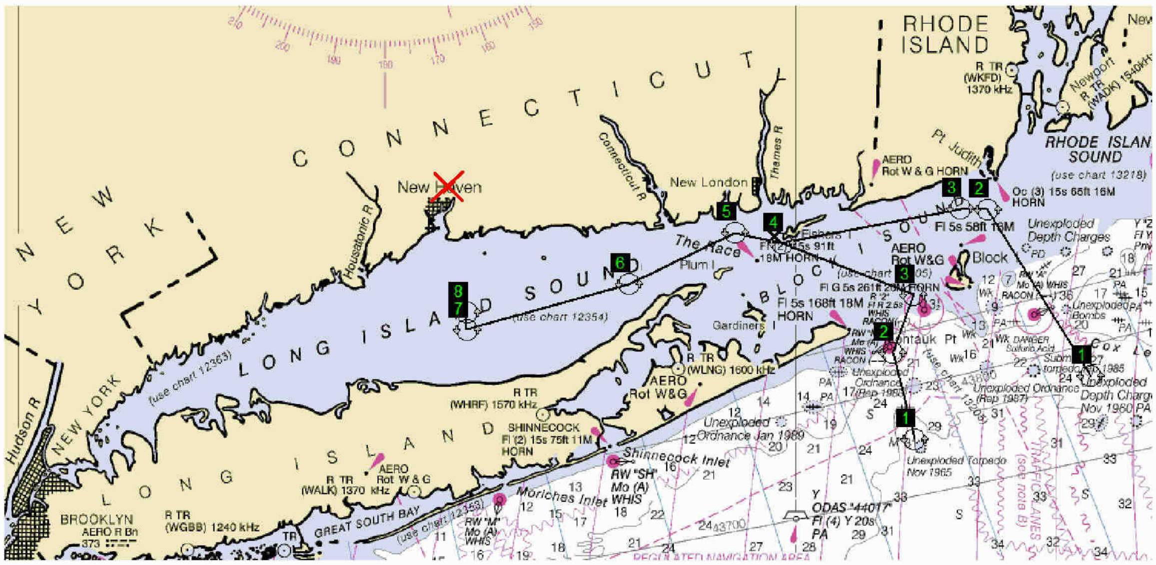

Figure 6-1 Location of NCDC nearest to LNG Carrier Route and FSRU

DNV received weather data over a ten-year time span, from 1995-2004 from NCDC.

6.2.1 Characteristics of Meteorological Data

The atmospheric stability is important to dispersion as it defines the amount of turbulent mixing that takes place. The six most common stability classes are given in Table 6-1.

Table 6-1 Atmospheric Stability

Stability Class	Description
A	Very Unstable – Sunny light winds
B	Moderately Unstable – Less sunny and more winds than A
C	Slightly Unstable – very windy/sunny or overcast/light wind
D	Neutral – little sun and high wind or overcast/windy night
E	Slightly Stable – less overcast and less windy than D
F	Stable – night with moderate clouds and light/moderate winds

Stability class F is the most conservative of the atmospheric conditions since there is limited mixing of the released gas with air under stable conditions. In Long Island Sound, the dominant atmospheric behaviors consist of "neutral" stabilities 70% of the time; there is very little "unstable" atmospheric condition.

The annual average data for 1994 to 2004 was used in this study. The data for an average day in the Long Island Sound is given in Table 6-2.

Table 6-2 Wind Rose Data

Direction	Stability Class and Wind Speed (% time of 1 day)						
	Day			Night			
	B 2.8 m/s	C/D 3.7 m/s	D 7.2 m/s	D 3.5 m/s	D 7.2 m/s	E 3.8 m/s	F 2 m/s
N	0.33%	3.80%	2.05%	2.24%	1.75%	1.65%	2.63%
NNE	0.19%	2.92%	0.93%	1.71%	0.44%	0.58%	1.02%
NE	0.16%	1.96%	0.41%	1.18%	0.23%	0.31%	0.52%
ENE	0.07%	1.06%	0.24%	0.74%	0.14%	0.19%	0.28%
E	0.12%	1.55%	0.43%	1.12%	0.28%	0.28%	0.40%
ESE	0.20%	1.33%	0.40%	0.65%	0.09%	0.20%	0.31%
SE	0.20%	1.55%	0.39%	0.60%	0.10%	0.19%	0.31%
SSE	0.39%	1.36%	0.19%	0.48%	0.08%	0.28%	0.46%
S	0.96%	3.82%	0.57%	1.17%	0.22%	0.80%	1.40%
SSW	0.72%	2.65%	0.71%	0.75%	0.29%	0.55%	1.02%
SW	0.39%	2.69%	1.24%	0.72%	0.48%	0.83%	0.63%
WSW	0.46%	3.04%	1.20%	0.80%	0.32%	0.89%	0.56%
W	0.29%	1.50%	0.54%	0.59%	0.45%	0.98%	0.99%
WNW	0.22%	1.60%	0.99%	0.53%	0.59%	0.83%	0.90%
NW	0.13%	1.89%	1.84%	0.74%	0.77%	1.17%	1.57%
NNW	0.11%	1.50%	1.59%	0.65%	0.84%	1.03%	1.60%
SUM	**5%**	**34%**	**14%**	**15%**	**7 %**	**10.5%**	**14.5%**

As can be seen from Table 6-2, stability class D is predominant in the Long Island Sound. From the data in Table 6-2, the three most common combinations of wind speed and stability class were determined. These three representative weather conditions for the Broadwater study are presented in Table 6-3.

Table 6-3 Representative Weather Conditions

Stability Class	Average Wind Speed	Percent of Day
F	2 m/s	15%
D	3.5 m/s	49%
D	7 m/s	21%

Other meteorological conditions include the following assumptions:

- Relative Humidity – 70% (recommended for releases over open water)
- Temperature – 20 C
- Surface Roughness Length – 0.3 mm (roughness length of open sea)

Sandia (ref. 03) presented results based on a stability class and wind speed of F 2.33 m/s. The DNV results for F 2/ms can be used for comparison purposes. It should be noted that the Sandia results represent smaller LNG tank sizes than the proposed Broadwater tank sizes. Also, the more likely scenario will be category D stability in Long Island Sound.

The dispersion distance results are presented in **Table 5-1** of this report.

7.0 Conclusions

By evaluating design data from different sized LNG carriers, it is clear that larger future generation LNG carriers and the FSRU have thicker inner and outer hull plate thickness and a larger horizontal distance between the outer and inner hulls compared to smaller LNG carriers currently in service.

Collision vulnerability analysis was performed for different LNG carrier design and sizes. The analysis indicates that the larger LNG carriers and FSRU are less vulnerable to collision damage than smaller sized LNG carriers. Hence, the smaller LNG carriers are expected to experience larger breach sizes than larger LNG carriers if they are exposed to the same impact energy. The Sandia breach sizes are based on smaller sized LNG carriers (capacity of 125,000 m^3) and are therefore conservatively (given the same impact energy) assumed to be applicable for larger sized LNG Carriers and the FSRU.

Both DNV and Sandia recommend a risk based approach which includes consequence calculations along with frequency estimates to determine overall risk for specific scenarios. This report only presents consequence evaluations.

A risk assessment combines factors such as initiating event frequency, probability of a given wind direction, probability of a given weather stability, etc to determine the likelihood of a defined consequence. The hazard zones presented in this report are based on the hole sizes that Sandia concludes are representative for intentional acts combined with site specific weather data and worst case spill volumes for future generations of LNG carriers and the FSRU. Frequencies for the various scenarios have not been addressed in this study.

It can be concluded that the Broadwater site specific consequence zones are larger than the Sandia hazard zones under worst case stability class F conditions. This is expected since the Broadwater FSRU and LNG carrier tank sizes and LNG head are larger than the Sandia LNG tank size and LNG head. However, F stability occurs only at night and accounts for approximately 30% of the night weather conditions and 15% of an average twenty-four hour day. If the most probable weather stability for Broadwater, stability class D, is considered then the Sandia hazard zones can be directly applied to the Broadwater facility.

8.0 References

01 DNV Report, "Broadwater LNG – US Coast Guard Queries," report no. 70012855, rev. 2 November 16, 2005. Report contains Sensitive Security Information

02 U.S. Coast Guard letter to Broadwater Energy, dated December 21, 2005, no. 16600/06-072, written by Peter J. Boynton of the U.S. Coast Guard.

03 "Guidance on Risk Analysis and Safety Implications of a Large Liquefied Natural Gas (LNG) Spill Over Water," Sandia Report SAND2004-6258, Sandia National Laboratories, December 2004.

04 "LNG Decision Making Approaches Compared," paper prepared by DNV- Pitblado, Robin; Baik, John; Raghunathan, Vijay. Presented at Mary Kay O'Connor Process Safety Symposium 2004

05 "Consequence Modeling of LNG Marine Incidents," paper prepared by Baik, John; Raghunathan, Vijay; Witlox, Henk presented at American Society of Safety Engineers conference, March 2005

06 DNV Report "Long Island Sound LNG FSRU: Public Safety Assessment," report no. 70004605, dated April 30, 2004.

07 U.S. Coast Guard letter to Broadwater Energy, dated October 5, 2005.

08 DAMAGE 5.0 computer code developed for "Joint M.I.T. Industry Project on Tanker Safety," developed by Wlodek Abramowicz, Bo Cerup Simonsen, Tomas Wierzbicki and Monique V. Sinamo.

Appendix I – US Coast Guard Letter to Broadwater Energy

U.S. Department of Homeland Security
United States Coast Guard

Commander
U.S. Coast Guard
Sector Long Island Sound

120 Woodward Ave.
New Haven, CT 06512
Staff Symbol: Prevention
Phone: (203) 468-4504
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16600/06-072
December 21, 2005

Broadwater Energy
Attn: Mr. Stephen Marr, Permit Application Manager
777 Walker Street, 22nd Floor
Houston, TX 77002

Dear Mr. Marr:

The Coast Guard has reviewed the report prepared by Det Norske Veritas (DNV) that was submitted on behalf of Broadwater Energy on November 18, 2005. This report, which is marked as containing sensitive security information, was provided in response to question 16 in our letter of October 5, 2005 that required Broadwater "to conduct modeling specific to the site, the proposed FSRU (floating, storage and regasification unit) as well as the future generation of LNG carriers and provide the analysis and the following results..." Based on our review, we have determined that the DNV report does not sufficiently validate the applicability of the Sandia National Laboratories Report SAND2004-6258 (Sandia Report) to the FSRU or to the future generation of LNG carriers.

The following issues must be addressed in order for the Coast Guard to make an evaluation whether the Sandia Report is applicable to the site, the FSRU and the future generation of LNG carriers:

1. Although its is understood that the structural design of an LNG carrier and the FSRU will be similar, insufficient information was provided in the DNV report to assess whether the breach sizes that were determined as part of the Sandia Laboratory's study can be used as inputs for the modeling required by our letter of October 5, 2005. Therefore, Broadwater must provide a qualitative comparison of the thickness and material strength of the outer and inner hull plating as well as the horizontal distance between the outer and inner hulls that was used for the Sandia Report and for both the FSRU and LNG carriers with a capacity of 250,000 m^3. Please reference the applicable ABS Rules used to determine the dimensions and materials for the FSRU. You may reference the appropriate rules of any member of the International Association of Classification Societies for the 250,000 m^3 LNG carriers.

2. The Sandia Report is based on spill volumes of approximately 12,500 m^3 of liquefied natural gas (LNG), which is approximately half of the contents of the cargo tanks on LNG carriers currently in service. This is not consistent with information regarding the capacity of the FSRU's LNG storage tanks provided by Broadwater Energy in the draft of Resource Report 13 that was submitted to the Federal Energy Regulatory Commission (FERC) in September 2005. It is also not consistent with the LNG storage tank capacity information provided in the DNV report. In addition, the DNV report does not establish whether the 15 meter initial height of the LNG above the breach that was used in the Sandia Report is appropriate for the FSRU or future generations of LNG carriers. Similarly, it does not establish the relationship between the dimensions of the LNG cargo tanks used for the Sandia Report and the expected dimensions of the LNG storage tanks on the FSRU or cargo tanks on future generation LNG carriers. As is apparent based on an examination of the equations in Appendix D of the Sandia Report, this information is a

required input for calculating factors related to LNG spill volumes and dispersion. In order to establish that the Sandia Report is applicable to the FSRU and 250,000 m^3 LNG carriers, the modeling required by our letter of October 5, 2005 must be based on the volume of the FSRU's LNG storage tanks as well as the expected volume of cargo tanks on 250,000 m^3 LNG carriers.

3. A critical element of the Sandia Report for assessing potential risks to public safety from LNG spills on water is the guidance related to the hazard zones for accidental and intentional discharges of LNG. The sizes of these hazard zones, which were determined based on thermal exposures, are also an important input for assessing the appropriate size of the safety zones that will be established around the FSRU and LNG carrier. Based on the information provided in the DNV Report, it is not possible to determine whether the sizes of the hazard zones in the Sandia Report are applicable to the FSRU or 250,000 m^3 LNG carriers. Refer to Appendix D of the Sandia Report for the analysis that must be conducted in order to establish whether the sizes of the hazard zones in Sandia Report are applicable to the FSRU or 250,000 m^3 LNG carriers.

4. Although we concur with your assessment that more stable atmospheric conditions do result in larger dispersion distances than unstable conditions, e.g., hurricanes or Northeastern gales, it is noted that the dispersion modeling was conducted using atmospheric data for Baltimore, Maryland. This is not acceptable. As stated in our letter of October 5, 2005, the vapor cloud dispersion modeling should be based on "site specific, seasonal environmental and weather factors…" Therefore, you must conduct this modeling using atmospheric data for central Long Island Sound.

This information is required as an input for both the safety and security assessment. Therefore, please provide your response in two parts: the first should contain information that can be released to the public; the second should contain information that is considered sensitive security information in accordance with 49 Code of Federal Regulations (CFR)., Part 1520. Be aware that much of the information in the DNV report does not appear to meet the definition of sensitive security information in 49 CFR § 1520.5. Therefore, Broadwater in coordination with DNV should review the report and remark it appropriately. A copy of the remarked report should be submitted.

Please contact Lieutenant Commander Alan Blume, Chief of the Prevention Department, at the above number if you have any questions regarding the requirements in this letter.

Sincerely,

PETER J. BOYNTON
Captain, U.S. Coast Guard
Captain of the Port, Long Island Sound

Copy: Mr. James Martin, Federal Energy Regulatory Commission
Docket USCG-2005-21863

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