

Project Description of Vertical Seismic Profiling at the Terra Nova Development

Prepared by



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1.0 Introduction

Petro-Canada proposes to undertake vertical seismic profiling (VSP) activities at its Terra Nova Development in the Jeanne d'Arc Basin (see Figure 1) in support of remaining delineation and production wells at Terra Nova. This document provides a Project Description of the proposed VSP activities that may occur for the duration of the life of the Terra Nova project. Vertical seismic profiling consists of an airgun array sound source, typically less powerful than those used during routine seismic surveys, deployed at locations near the rig with receivers placed in the well. The purpose of the technique is to tie in or ground-truth the geological data with geophysical information. The technique is described in detail below.

This document builds upon the environmental assessment (EA) of VSP activities at Terra Nova submitted in March 2004 (LGL 2004). The reviewer is referred to the EIS and associated documents for detailed information on the Terra Nova Development and associated activities, the biophysical environment, and the effects assessment for activities other than VSP (Petro-Canada 1996 a,b, 1997, 1998). Additional relevant information is also contained in the *Terra Nova Baseline Environmental Characterization Data Report* (Petro-Canada 1998).

2.0 Contacts at Petro-Canada

Relevant contacts at Petro-Canada for the VSP activities and related documentation include:

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3.0 Regulatory Context

'Check shots,' of which VSP surveys can be considered an extension (A, Kaderali, Husky, pers. comm.), are now required by the Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB or the 'Board'). The following is excerpted from the *Joint Guidelines Respecting Data Acquisition and Reporting* (C-NOPB and C-NSOPB 2003).

"A check shot survey is required for all exploration and delineation wells. The Board, in consultation with the operator, may request the operator to acquire a vertical seismic profile (VSP), where it would contribute to resolving uncertainty associated with seismic interpretation.

It is likely that geophysical surveys will be needed in some development wells to acquire additional control for the seismic interpretation of the field. In such instances, the Board may request that an operator conduct such survey(s) should they be necessary."

The Board is mandated by the *Atlantic Accord Implementation Act*. Offshore seismic on federal lands is now subject to screening under the *Canadian Environmental Assessment Act (CEAA)*. Because seismic survey activities have the potential to affect seabirds, marine mammals, and fish and fisheries, Fisheries and Oceans and Environment Canada are the primarily interested agencies. Relevant environmental legislation, in addition to *CEAA*, includes the *Fisheries Act*, the *Oceans Act* the *Migratory Bird Act* and the *Species at Risk Act*. As the VSP will be conducted from the drill rig with the assistance of a typical standby supply vessel, there are no new issues related to the *Navigable Waters Act* other than those already considered under the Terra Nova Development EIS.

4.0 Rationale

The VSP surveys are required to meet C-NLOPB and operator requirements. The surveys ground-truth the geological data with the geophysical data.

5.0 Alternatives to the Project

As the VSP surveys are a regulatory requirement by the Board and a technical requirement for operations, there is no alternative to them *per se*. However, there are alternatives within the project in the form of different types of VSP survey as described below.

6.0 Location and Water Depth

The locations of the VSP surveys are within the Terra Nova Development area about 350 km east-southeast of St. John's (Figure 1). Water depths in the Terra Nova area range from 90 m to 95 m.

7.0 Physical Site Conditions

Meteorological and oceanographic conditions are described in detail in Petro-Canada (1996 a,b) and are not repeated here.

8.0 Site layout

The site layout for the Terra Nova Development wells is shown in Figure 2.

9.0 Scheduling

VSP surveys typically occur during the summer season (although they could occur at any time throughout the year) and will continue on an as-needed basis for the life of the Terra Nova Development project.

10.0 Description of Activities

During the life of the Terra Nova project, Petro-Canada intends to conduct VSP activities at its wells at Terra Nova (see Figure 2) on an as-needed basis. In the current program with the *Henry Goodrich*, there are six more wells to be drilled. This is the current base case scenario and may change to include additional wells or drilling units as development drilling continues (J. Evans, Petro-Canada, pers. comm.). The VSP is used to measure acoustic waves between a well bore and the surface. It differs from surface seismic in that it has higher resolution and can provide wave fields *in situ*. This permits calibration of surface seismic data and provides "images" within the vicinity of the well bore that could otherwise not be defined by surface seismic data.

A VSP can be regarded as an extension of a 'checkshot survey'. Typically, the same source and downhole receivers are used for both types of survey. The difference is in the higher spatial sampling and longer recording time for VSPs versus checkshots. Acquisition times are dependent on the type of VSP and acquisition tool but they normally vary between 8-36 hours per well.

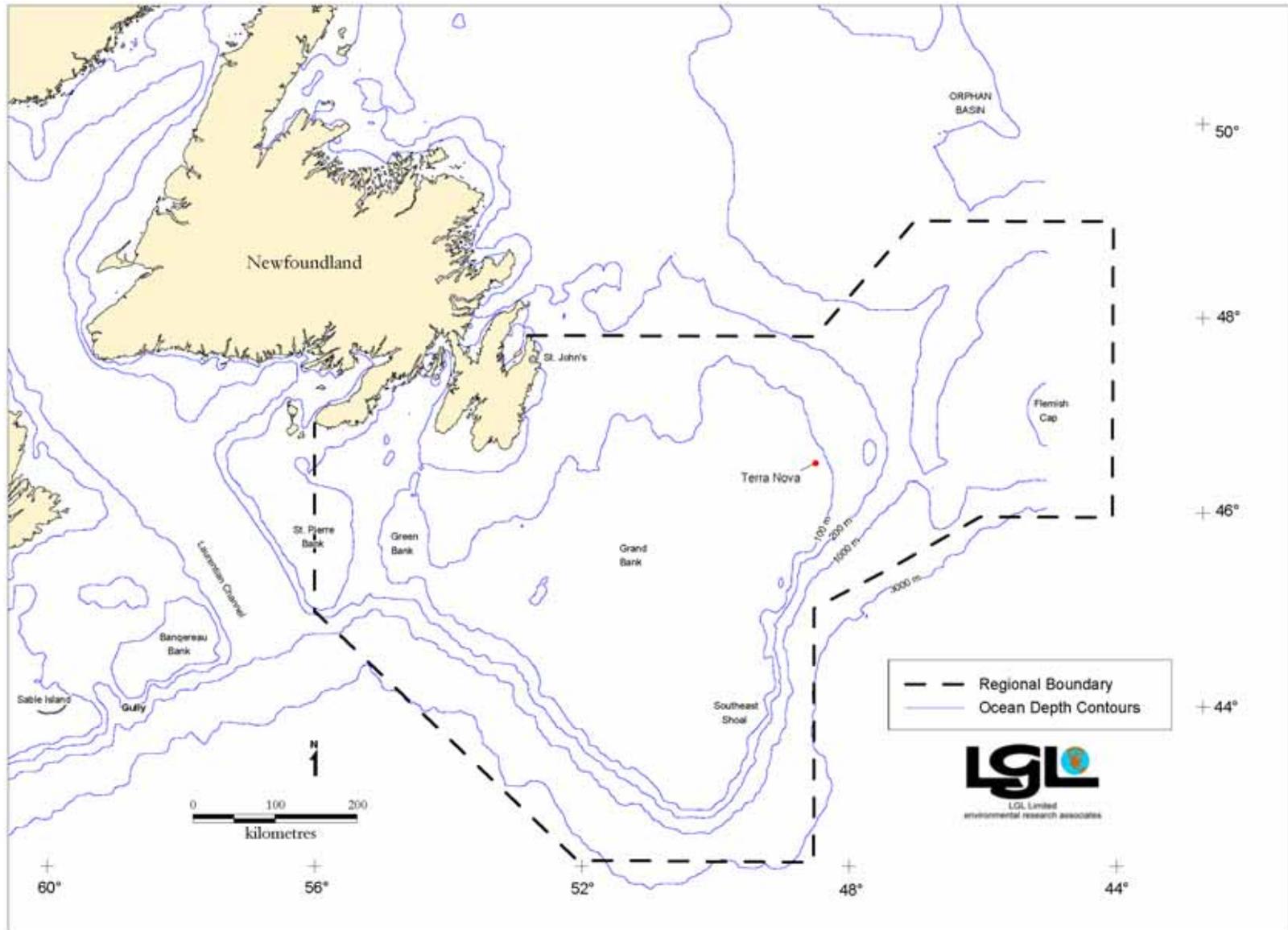


Figure 1. Location of Terra Nova Development and associated VSP activities.

10.1 Checkshots

A checkshot can be defined as measurement of travel time between the surface and a given depth. This is achieved by placement of a downhole geophone that records direct arrivals, at defined depths in a well. A hydrophone monitors the signature and timing of the source signal. Several shots are usually acquired at the same level (depth) and stacked in order to improve the signal-to-noise ratio. Checkshots are usually acquired at the tops of significant formations, at the top of the sonic log, above and below the casing shoe and at zones where the borehole is in bad condition.

Sonic logs are calibrated by reference to check shot surveys to correct the velocities obtained by the integration of the sonic interval transit times. The calibrated sonic log may then be used for the translation of surface seismic time into depth and for the generation of synthetic seismograms and for other applications.

10.2 ZVSP (Zero-offset VSP)

This is the basic type of VSP that is normally acquired for vertical or near-vertical wells. The source is placed at a fixed distance of between 40 m and 125 m offset from the wellhead. Wherever possible, the source is deployed from the drill rig.

10.3 DVSP (Deviated VSP)

This is a variation on the ZVSP above due to deviation of the well trajectory. For this type of VSP, the source is positioned at several (usually between one and three) fixed distances of between 40 m and the maximum horizontal displacement of the well. Wherever possible, the source is deployed from the drill rig. A vessel for the source may be used if the well trajectory is such, that offsets are required that cannot be attained from the rig.

10.4 OVSP (Offset VSP)

In addition to a ZVSP or DVSP, a VSP may be acquired in the same well with the source positioned in any direction at fixed distances between 500 m and 2.0 km from the wellhead. In this case, the source would be deployed off a vessel.

10.5 Walkaway VSP

For a Walkaway VSP the source is deployed at uniform intervals (between 15 m and 100 m) in particular directions from the wellhead for distances of up to 5.0 km. In the case of a Walkaway VSP only a limited number of receiver levels would be acquired (usually between 8 to 40) and in a particular zone only. The source would be deployed from a vessel in this case.

10.6 VSP Method Proposed for Terra Nova

The sound source to be used at Terra Nova will include a four sleeve-gun tuned array comprised of 2x 100 in³ and 2x 150 in³ guns for a total volume of 500 in³. The guns will be charged with nitrogen or compressed air, suspended at a constant depth of four to seven metres, depending on sea-state and operated at 2,000 psi pressure. The 0-to-peak source level is 8.45 Bar-m which converts to 238.5 dB re 1 µPa 0-P @ 1 m; maximum output occurs between 20 and 140 Hz (R. Dugal, Petro-Canada, pers. comm.).

The Terra Nova VSP surveys may range from a zero-offset VSP (i.e., fixed distance from the wellhead) with the source deployed from the rig to a walkaway VSP (uniform intervals up to 5.0 km from the rig). At each well, the survey would be a one-time event potentially occurring as early as July 2006 (and occurring over the life of the project) and extend for eight to 36 hours per survey.

Petro-Canada's preference is to use the Baker Atlas Multi-Level Receiver (MLR) tool as a receiver. The MLR tool is generally deployed with five receivers at a spacing of 15 metres between tools but can also be deployed with up to thirteen receivers if required. The MLR tool can be used in both open hole and cased hole environments. Alternatively, a Slim-Hole Receiver (SHR) tool is available if borehole conditions warrant its use. A normal job using the standard MLR configuration would result in the acquisition of up to 400 levels (R. Dugal, Petro-Canada, pers. comm.).

11.0 Species At Risk

The Terra Nova Development area is not known to contain any sensitive areas for species listed on Schedule 1 of the *Species at Risk Act (SARA)* but this issue will be examined in the EA to follow. Species that are legally protected under *SARA* (i.e., Schedule 1 'threatened' or 'endangered') and which may occur in the Project Area include the following:

- Blue whale (*Balaenoptera musculus*) (Atlantic population) – endangered
- North Atlantic right whale (*Eubalaena glacialis*) – endangered
- Leatherback sea turtle (*Dermochelys coriacea*) – endangered
- Northern wolffish (*Anarhichas denticulatus*) – threatened
- Spotted wolffish (*Anarhichas minor*) – threatened

12.0 Mitigations

Prior to the onset of VSP, the airgun array will be gradually ramped up. The smallest airgun will be activated first and then the volume of the array will be increased gradually over a recommended 20-min period (as described in Canning and Pitt 2002). An observer aboard the rig with the seismic source will watch for marine mammals and sea turtles 30 min prior to ramp-up. If a marine mammal or sea turtle is sighted within 1,000 m of the array then ramp-up will not commence until the animal has moved

beyond the 1,000 m zone. The observers will watch for marine mammals, sea turtles, and seabirds when the airgun array is active and note the location and behaviour of these animals. Any dead or distressed marine mammals or turtles will be reported immediately to the C-NLOPB and DFO.

13.0 Literature Cited

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Personal Communication

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