Husky Energy

REPORT

REPORT TITLE

WHITE ROSE

ENVIRONMENTAL EFFECTS MONITORING

DESIGN REPORT

Revised 2010

SUBMITTED TO

Canada-Newfoundland and Labrador Offshore Petroleum Board

5th Floor, TD Place

140 Water Street

St. John's, NL A1C 6H6

SUBMITTED BY

HUSKY ENERGY

SUITE 801, SCOTIA CENTRE

235 WATER STREET

ST. JOHN'S, NL A1C 1B6

COMMENTS IF APPLICABLE

White Rose Water Quality Monitoring Program (WR-HSE-RP-1584) and White Rose Environmental Effects Monitoring Design Report 2008 (Revision) (WR-RP-00041) are superseded by this new report.

Signature:			
Full Name and Title:		**Environmental Advisor**	**Manager, Health, Safety, Environment and Quality**
	Prepared By	Accepted By	Approved By

Date:	**19-Nov-10**	HDMS No.:	**004102816**	Report No.:	**WR-HSE-RP-2008**	Version No	**01**

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1.0 INTRODUCTION

1.1 Project Setting and Field Layout

Husky Energy, with its joint-venturer Petro-Canada, is in the process of developing the White Rose oilfield on the Grand Banks, offshore Newfoundland. The field is approximately 350 km east southeast of St. John's, Newfoundland, and 50 km from both the Terra Nova and Hibernia fields (Figure 1-1).

To date, development wells have been drilled at three drill centres: the North (N), Central (C) and South (S) drill centres. Drilling will occur at the North Amethyst (NA) drill centre in the summer of 2008. (Figure 1-2). These four drill centres are considered in the sections that follow.

Work to determine if drilling could occur to the West of the field is ongoing. Possible extension of the Environmental Effects Monitoring Program to include assessment of effects in the West, or at the South White Rose Extension drill centre are provided in Appendix A.

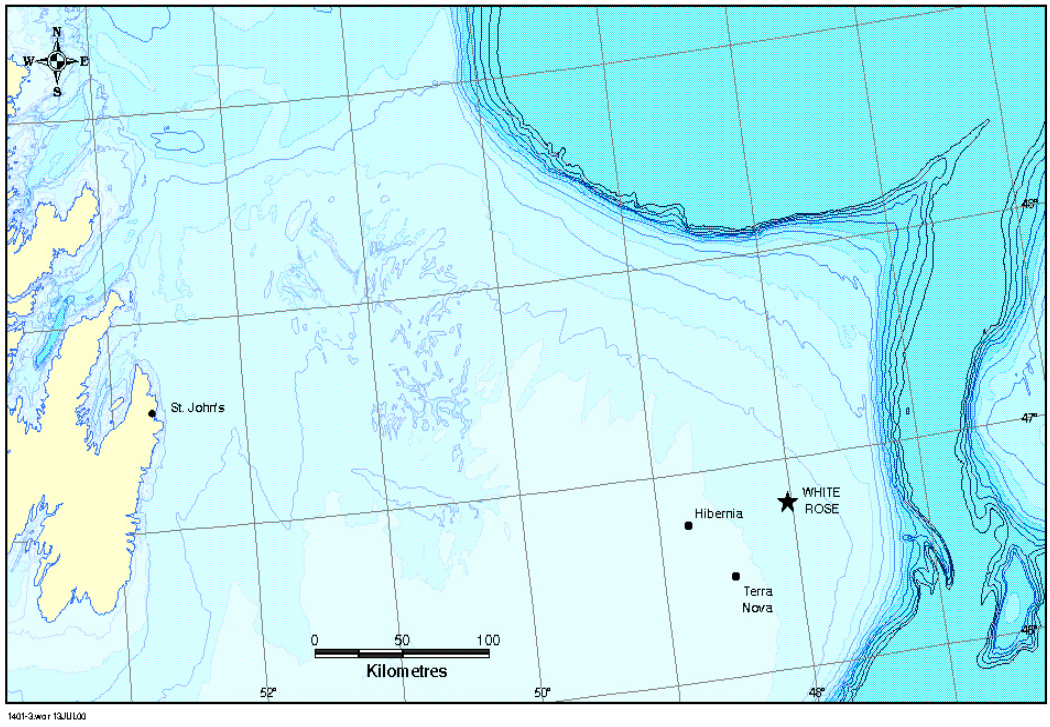


Figure 1-1 - Location of the White Rose Oilfield

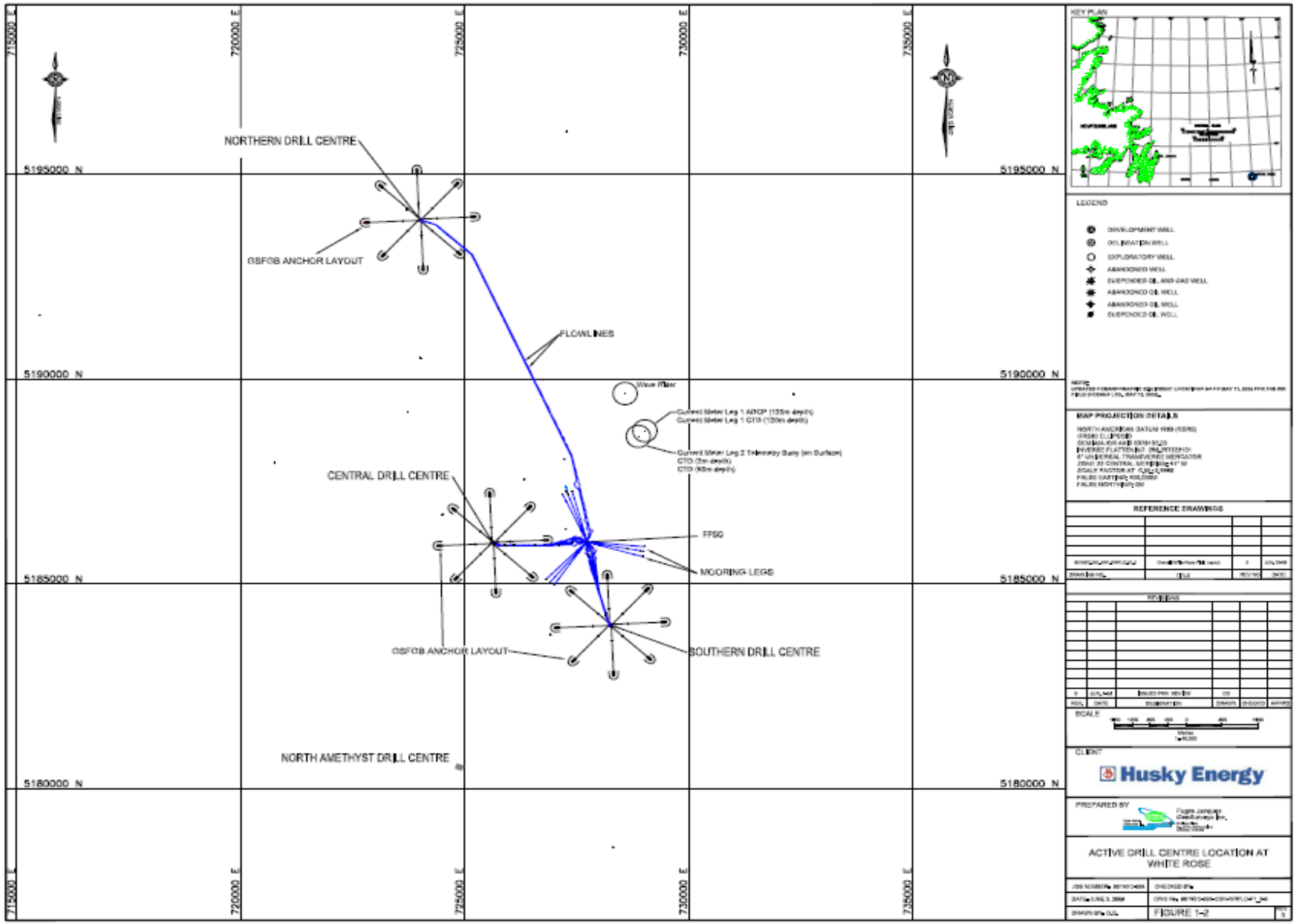


Figure 1-2 - Active Drill Centre Location at White Rose

1.2 Project Commitments

Husky Energy submitted a Development Plan Application (DPA) for White Rose to the White Rose Public Review Commission in March 2001. In its Environmental Impact Statement (Part One of the White Rose Oilfield Comprehensive Study (Husky Oil 2000)) submitted as part of the DPA, Husky Energy committed to develop a comprehensive environmental effects monitoring (EEM) program for the marine receiving environment. This commitment was integrated into Decision 2001.01 (C-NLOPB 2001) as a condition of project approval. The EEM program would test effects predictions made in the EIS, detect changes in the marine receiving environment, and determine whether the changes were caused by the White Rose project.

Also as noted in the C-NLOPB's Decision Report (Condition 38 - Decision 2001.01), Husky Energy committed, in its application to the C-NLOPB, to make the results of its EEM program available to interested parties and the general public. The C-NLOPB also noted that in correspondence to the White Rose Public Hearings Commissioner, Husky Energy stated its intent to make both EEM reports and environmental compliance monitoring information "publicly available to interested stakeholders in a timely manner". In fulfillment of Condition 38 noted above, Husky Energy will, in its Environmental Protection Plan, describe how it will make environmentally related information available to the public.

As stated in its Comprehensive Study (Husky Oil 2000), Husky Energy supports the concept of a regional EEM approach, noting that such an approach would have to involve all operators in the area. As such, Husky Energy has had and will continue to have discussions with its fellow operators on this subject and will report to the C-NLOPB on the outcome of those discussions, recognizing the C-NLOPB's interest in this area.

1.2.1 Additional Project Commitments

Since submission of the original EEM design, Husky Energy has revised its DPA. As a result, two additional conditions related to Environmental Effects Monitoring have been incorporated into Decision Report 2007-02 related to South White Rose Extension and Decision Report 2008-03.

Condition 2008–03.01

The Proponent, prior to commencing drilling operations at the North Amethyst drill centre, shall submit for the approval of the Chief Conservation Officer an amended Environmental Effects Monitoring program design.

Condition 2007-02.01

The Proponent, no later than six months prior to commencing drilling operations at the South White Rose Extension drill center, shall submit, for the approval of the Chief Conservation Officer, an amended Environmental Effects Monitoring Program Design that considers drilling and production activities associated with the South White Rose Extension drill center.

This document addresses both of these additional conditions and is updated to incorporate improvements made to the White Rose EEM program since it was first implemented in 2004 (see Section 1.4 for details).

1.3 Environmental Effects Monitoring Objectives

The EEM program is intended to provide the primary means to determine and quantify project-induced change in the surrounding environment. Where such change occurs, the EEM program enables the evaluation of effects and, therefore, assists in identifying the appropriate modifications to, or mitigation of, project activities or discharges. Such operational EEM programs also provide information for the C-NLOPB to consider during its periodic reviews of the Offshore Waste Treatment Guideline (NEB et al. 2002).

Objectives to be met by the EEM program are:

- Confirm the zone of influence of project contaminants;
- Test biological effects predictions made in the EIS;
- Provide feedback to Husky Energy for project management decisions requiring modification of operations practices where/when necessary;
- Provide a scientifically defensible synthesis, analysis and interpretation of data;
- Be cost-effective, making optimal use of personnel, technology and equipment; and,
- Communicate results to the public.

1.4 Supporting Information for EEM Program Design

The design of the White Rose EEM program provided in this document draws on a number of sources including:

- The White Rose EIS (Husky Oil 2000);
- Drill cuttings and produced water dispersion modelling (Hodgins and Hodgins 2000);
- The White Rose baseline characterization program (Husky Oil 2001);
- Input from the White Rose Advisory Group (WRAG);
- Stakeholder consultations; and
- Consultations with regulatory agencies.

This revised plan has also been updated, where appropriate, to include relevant actions issuing from discussions with various authorities on the EEM program since 2003. A full list of the actions taken on EEM design issues based on these discussions has been developed for Husky Energy's internal tracking purposes (Document Number: WR-HSE-RP-0726 HDMS # 004024588).

1.4.1 White Rose EIS

The White Rose EIS (Husky Oil 2000) made a series of predictions about potential project effects. These predictions were based on whether or not Valued Environmental Components (VECs) interacted with the project. A VEC-project interaction was considered to be a potential effect if it could change the VEC, or change the prey species or habitats used by the VEC. VECs identified for White Rose included: fish and fish habitat, fisheries, marine birds, marine mammals and sea turtles. The anticipated severity of effects on each VEC was ranked on a scale that considered relative magnitude (high, medium, low, negligible), geographic extent (less than 1 km^2, 1 to 10 km^2, 11 to 100 km^2, 1001 to 10,000 km^2, greater than 10, 000 km^2, or unknown), frequency (less than 10 events per year, 11 to 50, 51 to 100, 1001 to 200, or greater than 200 events per year, or unknown) and reversibility.

Effects on each VEC were assessed by a discipline expert who considered:

- The location and timing of the interaction;
- Drill cuttings and produced water chemical zone of influence modelling exercises for White Rose;
- The literature on similar interactions and associated effects (including the Hibernia (Mobil Oil 1985) and Terra Nova (Petro-Canada 1995) EISs);
- When necessary, consultation with other experts; and
- Results of similar effects assessments and especially, monitoring studies done in other areas.

Only EIS predictions on fish, fish habitat and fisheries are relevant to the EEM program proposed in this document. Husky Energy will monitor effects on marine birds, marine mammals and sea turtles through various other initiatives, including monitoring of occurrence of these species from project platforms and vessels using weather observers trained in these observations and, developing an action plan for recovering and releasing birds following collisions with project platforms. Details on these initiatives will be provided elsewhere. This document also only addresses project effects from development and regular operations at White Rose. Monitoring plans in the event of accidental events, including large oil spills, are addressed in Document Number EC-M-99-X-PR-00029-001.

In general, development operations at White Rose were expected to have the greatest effects on near-field sediment quality, through release of drill cuttings, while regular operations were expect to have the greatest effect on water quality, through release of produced water. Effects of other waste streams (e.g., deck drainage and domestic waste, bilge discharge) on sediment and water quality were considered small relative to effects of drill cuttings and produced water discharge. The anticipated distribution of drill cuttings and produced water (Section 1.4.1.2) was therefore central to determination of effects.

1.4.1.1 Summary of Biological Effect Predictions

Effects of drill cuttings on benthos were expected to be mild (low magnitude) within approximately 500 m of drill centres but fairly large (low to high magnitude) in the immediate vicinity of drill centres. However, direct effects to fish populations, rather than benthos (on which some fish feed), as a result of drill cuttings discharge were expected to be unlikely. Effects resulting from contaminant uptake by individual fish (including taint) were expected to range from negligible to low in magnitude and be limited to within 500 m from the point of discharge.

Effects of produced water (and other liquid waste streams) on water quality were expected to be localized near the point of discharge (see Section 1.4.1.2 for the chemical zone of influence of produced water). Liquid waste streams were not expected to have any effect on sediment quality and benthos and low magnitude effects on water quality and plankton. Direct effects on adult fish were expected to be negligible.

Further detail on effects and effects assessment can be obtained from the White Rose EIS (Husky Oil 2000). For the purpose the EEM program, testable hypotheses that draw on these effects predictions and on drill cuttings and produced water modelling (Section 1.4.1.2) are developed in Section 2.2.1.

1.4.1.2 Drill Cuttings and Produced Water Dispersion Modelling

Husky Energy modelled the potential dispersion patterns of drill cuttings and produced water (project discharges expected to have the greatest effect on environment; see Section 1.4.1) as part of its EIS (Husky Oil 2000). Based on this assessment, the zone of influence of drill cuttings, defined here as the zone where project-related physical or chemical alterations might occur, is not expected to extend beyond approximately 5 km from source. The zone of influence for produced water is expected to extend to less than 3 km from source. These dispersion pattern results were used to assess the spatial extent of effects in the EIS (see Section 1.4.1.1) and to establish the baseline survey grid. Model results will continue to be used as a point of reference for assessment of EEM results.

1.4.2 Baseline Characterization Program

The White Rose baseline characterization program was designed to provide information on existing conditions at White Rose before development drilling and construction began. Much like the EEM program, marine resources targeted for monitoring for this program were selected based on findings reported in the EIS (see Section 1.4.1.1 and also Section 2.1). The spatial layout of stations around White Rose for the baseline survey was established given the anticipated distribution of drill cuttings (Section 1.4.1.2). The overall finding from this survey was that the area surrounding White Rose is uncontaminated, notwithstanding prior exploratory drilling and current production operations in the Jeanne d'Arc Basin.

1.4.3 Stakeholder Consultation

1.4.3.1 White Rose Environmental Effects Monitoring Advisory Group

Husky Energy committed to organizing an "expert stakeholder group" to help develop the EEM program and potentially provide input into the ongoing interpretation of EEM results. Members of the WRAG included (in alphabetical order):

- Leslie Grattan, Consultant;
- Dr. Roger Green, University of Western Ontario;
- Dr. Doug Holdway, University of Ontario Institute of Technology;
- Mary Catherine O'Brien, Lawyer, Manager at Tors Cove Fisheries Ltd.;
- Dr. Paul Snelgrove, Memorial University; and
- Dr. Len Zedel, Memorial University.

The WRAG and the Husky Energy design team met on three occasions (July 22, September 8 and October 27, 2003) and also exchanged information throughout the design process. During the first meeting (July 22), the WRAG discussed the draft design document which had been previously provided for review. Most of the recommendations made by the WRAG were made during this meeting and remaining meetings were held either to clarify WRAG position or to bring additional information to the WRAG (including comments from the public and regulators on the EEM design). Minutes from WRAG meetings, along with a table of concordance summarizing discussion items and Husky Energy resolutions are provided in Appendix B.

1.4.3.2 Consultations with Regulators and Public Information Session

A public information session was held in St. John's on October 16, 2003. There, Husky Energy provided the public with a general overview of the EEM program and asked for feedback. A separate meeting was held with regulatory agencies to discuss the design. The consultation report issuing from these meetings is provided as Appendix C. This consultation report was also provided to the WRAG (Section 1.4.4.1) for discussion during the October 27th meeting.

1.4.3.3 Public Access to EEM Design Document

This EEM design document will be made available to the public once it is finalized, after regulatory review.

2.0 MONITORING STRATEGY

2.1 Marine Resources to be Monitored

The proposed EEM program is designed around the monitoring of those marine resources targeted during baseline data collection (and these follow closely from the

VECs assessed in the White Rose EIS (Husky Oil 2000)). In addition, given the similarity in production platform and project design (floating production, storage and offloading (FPSO) facility, risers, drill centres) between Terra Nova and White Rose (except for scale of project), the White Rose EEM program closely resembles the Terra Nova EEM program.

Specifically, data will be collected on sediment quality, water quality and commercial fish species. Proposed EEM components are summarized in Figure 2-1 - Environmental Effects Monitoring Components. Details are provided below.

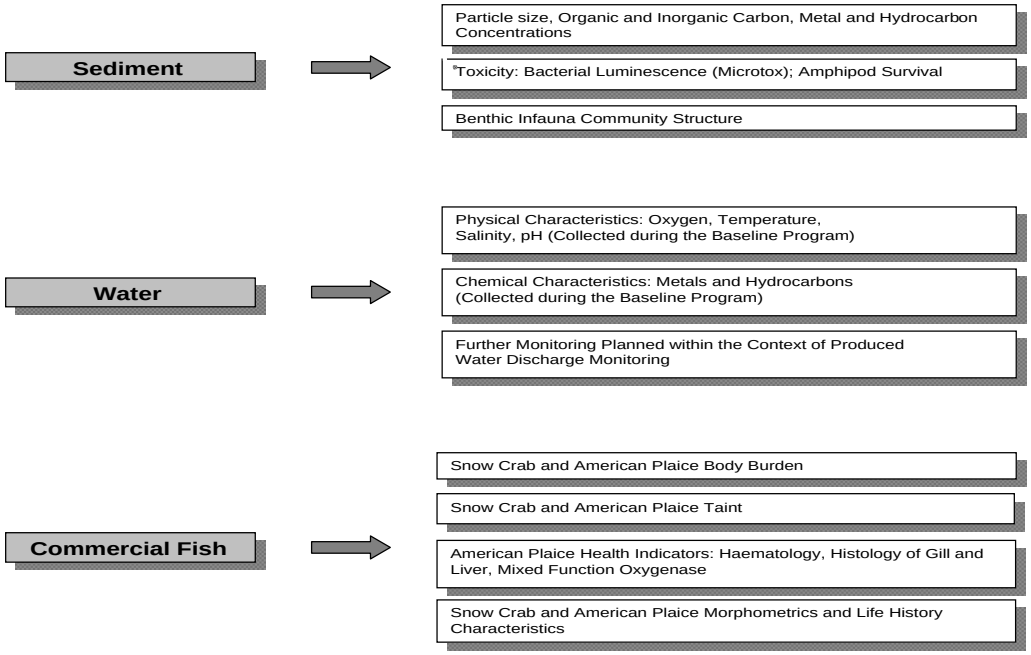


Figure 2-1 - Environmental Effects Monitoring Components

2.1.1 Sediment Quality

Husky Energy made a commitment in the EIS (Husky Oil 2000) to monitor contaminants in sediments and their effects on benthic organisms. Regulatory agencies identified oil contamination of sediments and effects on benthic organisms as a key indicator of sediment quality and the scientific community has routinely monitored sediment quality as part of monitoring programs. Sediments are the ultimate sink for persistent chemicals and particulate matter emitted from well development.

Methods to assess the quality of sediments and associated fauna have evolved from basic chemical analysis to more exhaustive studies that integrate physical, chemical and biological testing. Three general types of testing are currently used:

- Sediment Chemical And Physical Testing;
- Sediment Toxicity Testing; and
- Assessment of Benthic Infaunal Community Structure.

These tests constitute the Sediment Quality Triad (SQT), an integrative or weight-of-evidence approach (e.g., Long and Chapman 1985; Chapman et al. 1987; Chapman 1992). Assessment of all three SQT components provides more convincing evidence of the spatial extent and magnitude of contamination than would any single component.

The SQT approach has been applied to assess the status of sediments near offshore oil platforms in the North Sea (Chapman 1992) and in the Gulf of Mexico (Chapman et al. 1991; Chapman and Power 1990; Green and Montagna 1996). The project team has applied the SQT approach in numerous British Columbia studies of industrial and municipal discharges and contaminated sites, in the Voisey's Bay mine/mill baseline characterization, and the Terra Nova baseline and EEM programs. Sediment chemical and physical characteristics, toxicity and benthic infaunal community structure were measured in the White Rose baseline survey, and will be measured in the White Rose EEM program.

2.1.2 Water Quality

A water quality monitoring program was developed within the context of produced water discharge monitoring. This approach is consistent with the approach used in Section 2.1.1 for sediment quality monitoring. In both cases, the anticipated zone of influence of the most widely distributed project discharge (drill cuttings on the one hand and produced water on the other) is used to establish the location and type of samples to be collected.

To date, the following tasks have been accomplished toward the development of a water quality monitoring program:

- 2004 to 2005 – Development of a methodology to validate the White Rose produced water dispersion model. Report submitted to the C-NLOPB titled "Produced Water Monitoring at White Rose Phase 1: Plume Mapping and Model Validation.

- November 2005 – Field trials to test the use of rhodamine to map a produced water plume on the Grand Banks. Report submitted to the C-NLOPB title "A Rhodamine Dye Study of the Dispersion of Produced Water Discharged from the Terra Nova FPSO".

- 2006 – Workshop with invited experts to discuss field trial results and Husky Energy's overall approach to water quality monitoring.

- 2007 – Attendance and participation in the International Produced Water Conference held in St. John's in October 2007.

- 2007-2008 – Ongoing sampling of produced water to obtain detailed characterization information.

Husky Energy's current activities toward the development of a produced water monitoring strategy are aimed at better defining the zone of influence for produced water through constituent-based modeling. This approach will better assess the distribution and concentration of constituents of concern within the produced water stream and may result in the identification of natural tracers that could then potentially be used for *in-situ*

monitoring and model validation. Once these tasks are accomplished, Husky will assess the best available options, given constituent distributions and concentrations, to assess project effects on water quality. A more detailed description of this work is provided in the White Rose Water Quality Monitoring Program report, attached as Appendix K.

2.1.3 Commercial Fish

The public and regulators have expressed considerable concern about potential project-related effects on fish, which are, ultimately, the VEC of interest for this EEM program.

On the East Coast of Canada, in the Gulf of Mexico and in the North Sea, researchers have studied hydrocarbon fate and effects on groundfish and shellfish (Dey et al. 1983; Payne et al. 1983; Neff et al. 1985; Berthou et al. 1987; Strickland and Chassan 1989; Paine et al. 1991; 1992). The Hibernia and Terra Nova EEM programs include assessments of fish tissue chemistry (body burdens), taste and health (physiological, biochemical and histological indicators).

The White Rose EIS (Husky Oil 2000) states that a program to monitor tainting in fish will be implemented and a DFO position statement (DFO 1997) recommends that a well designed tainting detection program be initiated around development sites for assurance purposes. The DFO position statement also identifies bioaccumulation (i.e., contaminant body burden) as an issue. In the White Rose baseline survey, American plaice (*Hippoglossoides platessoides*) were collected for assessment of metals and hydrocarbon body burdens, health and taste. Snow crab (*Chionoecetes opilio*), another commercially important species, were also collected for assessment of body burdens and taste. These two species will continue to be collected and assessed in the EEM program.

2.2 Sampling Design

2.2.1 Monitoring Hypotheses

Monitoring, or null (H_o), hypotheses have been established as part of previous EEM programs on the Grand Banks. These hypotheses are implicit to the design and analysis models described in Section 2.2.2 (also see Appendices D and E on analysis, and power and robustness, respectively), and were made explicit in both the Hibernia and Terra Nova EEM programs to focus and guide interpretation and reporting of results. Null hypotheses differ from EIS effects predictions. They are an analysis and reporting construct established to assess effects predictions. Null hypotheses (H_o) will always state “no effects” even if effects have been predicted as part of the EIS. Therefore, rejection of a null hypothesis does not necessarily invalidate EIS predictions, nor should such predictions be considered a “compliance” target in this context.

The following monitoring hypotheses are proposed for the White Rose EEM program:

- Sediment Quality:
  - H_o: There will be no change in SQT variables with distance or direction from project discharge sources over time.

- Water Quality:

  - H_o: The distribution of produced water from point of discharge, as assessed using moorings data and/or vessel-based data collection, will not differ from the predicted distribution of produced water.

- Commercial Fish:

  - H_o(1): Project discharges will not result in taint of snow crab and American plaice resources sampled within the White Rose Study Area, as measured using taste panels.

  - H_o(2): Project discharges will not result in adverse effects to fish health within the White Rose Study Area, as measured using histopathology, haematology and MFO induction.

No hypothesis is developed for American plaice and snow crab body burden, as these tests are considered to be supporting tests, providing information to aid in the interpretation of results of other monitoring variables (taste tests and health).

2.2.2 Sampling Design

2.2.2.1 Sediment Quality

In the baseline survey carried out in 2000, three types of sediment quality stations were sampled:

- 28 transect stations, distributed regularly over the Study Area;

- 18 drill centre stations, located within 1 km of the proposed location of the three more central drill centres; and,

- Two Reference Areas, one (south-southeast) approximately 35 km from the development, and the other (northwest) approximately 85 km from the development.

The spatial layout of baseline stations is shown in Figure 2.2. For ease of review, station names used during baseline will not be used in subsequent programs. Station names during baseline collection involved a series of alpha-numeric codes identifying type of stations and approximate distance to drill centres. These baseline stations have now been assigned more concise codes. A table of concordance between baseline station names and new station names is provided in Table 2-1. Station deletions or additions noted in Table 2-1 are explained in the text that follows.

The objective of the baseline design was to provide stations representing a range of distances from sources of contamination (e.g., drill centres). This is a regression or gradient design, suitable for testing for increases or decreases in SQT variable values (=Y) with distance from source (=X). Regression designs are particularly suitable when there are multiple sources (e.g., drill centres). Distances (and if need be, directions) from each source are treated as multiple X variables (see Appendix D for details on data analysis). If contamination and effects occur, regression designs also provide a broad range of SQT variable values for assessing correlations among those variables.

Replication (=subsampling) within stations within year is unnecessary. Stations are the appropriate replicates for statistical analyses. The optimal strategy is usually to sample more stations as opposed to collecting more subsamples per station (Cuff and Coleman 1979). When the same stations are re-sampled over time, regression designs are Repeated Measures (RM) regression designs.

Table 2-1 - Table of Concordance between 2000 Baseline and EEM Sediment Station Names

EEM Transect Station Name	2000 Baseline Station Name	EEM Drill Centre Station Name	2000 Baseline Station Name
1	F1-1,000	C1	GH2-3
2	F1-3,000	C2	GH2-4
3	F1-6,000	C3	GH2-5
4	Not Sampled in 2000	C4	GH2-6
5	F2-2,000	C5	Not Sampled in 2000
6	F2-4,000	N1	GH3-3
7	F2-10,000	N2	GH3-5
8	F3-1,000	N3	GH3-6
9	F3-3,000	N4	Not Sampled in 2000
10	F3-6,000	S1	GH1-3
11	F3-18,000	S2	GH1-4
12	Not Sampled in 2000	S3	GH1-6
13	F4-2,000	S4	GH1-2
14	F4-4,000	S5	Not Sampled in 2000
15	F4-10,000	NA1	Not Sampled in 2000
16	F5-1,000	NA2	Not Sampled in 2000
17	F5-3,000	NA3	Not Sampled in 2000
18	F5-6,000	NA4	Not Sampled in 2000
19	Not Sampled in 2000	Removed from program	GH1-1
20	F6-2,000	Removed from program	GH1-5
21	F6-4,000	Removed from program	GH2-1
22	F6-10,000	Removed from program	GH2-2
23	F7-1,000	Removed from program	GH3-1
24	F7-3,000	Removed from program	GH3-2
25	F7-6,000	Removed from program	GH3-4
26	F7-18,000	Removed from program	F1-18,000
27	Not Sampled in 2000	Removed from program	F5-18,000
28	F8-2,000	**2000 Baseline Reference Stations**	
29	F8-4,000	Removed from program	SSE and NW Reference
30	F8-10,000		
31	Not Sampled in 2000		

Transect Stations

Twenty-six of the 28 transect stations sampled during baseline will be re-sampled in the EEM program. To accommodate the possible expansion of the field, four new transect stations (stations 4, 12, 19 and 27) will be added at 28 km from the centre of the development (Figure 2-3). The constraint used to establish location for these stations was that none of them should be closer than 20 km from the nearest drill centre. Because of these additions, two 18-km stations, sampled during baseline, will be deleted along the northeast-southwest axis (stations F1-18,000 and F5-18,000). However, 18-km stations along the northwest-southeast axis (direction of prevailing currents) will be retained. One additional sampling station (station 31) will be added for the EEM program: Station 30, because of proximity to a potential more northerly drill centre (see Appendix A for the location of potential drill centres).

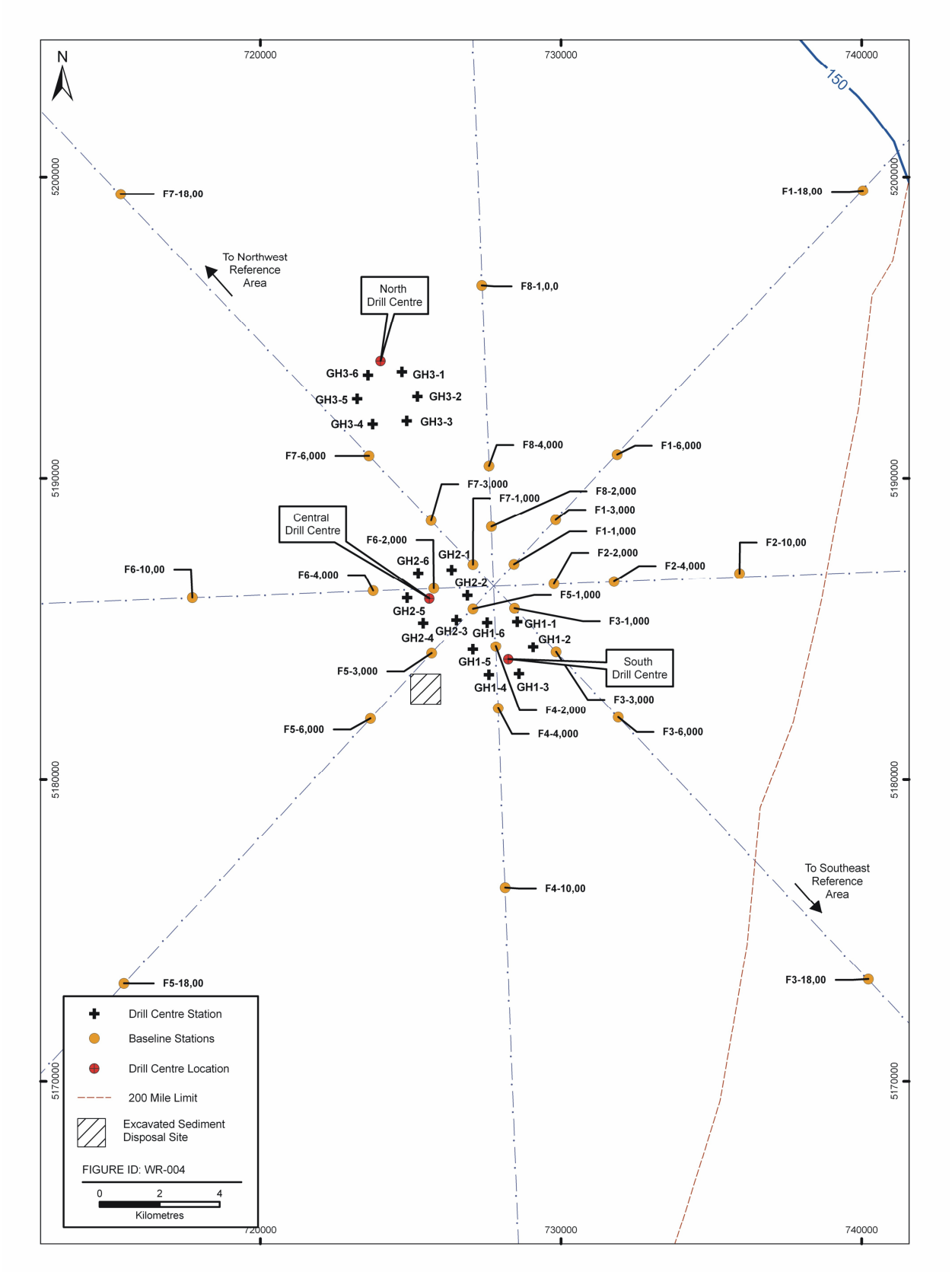


Figure 2-2 - 2000 Baseline Station Locations

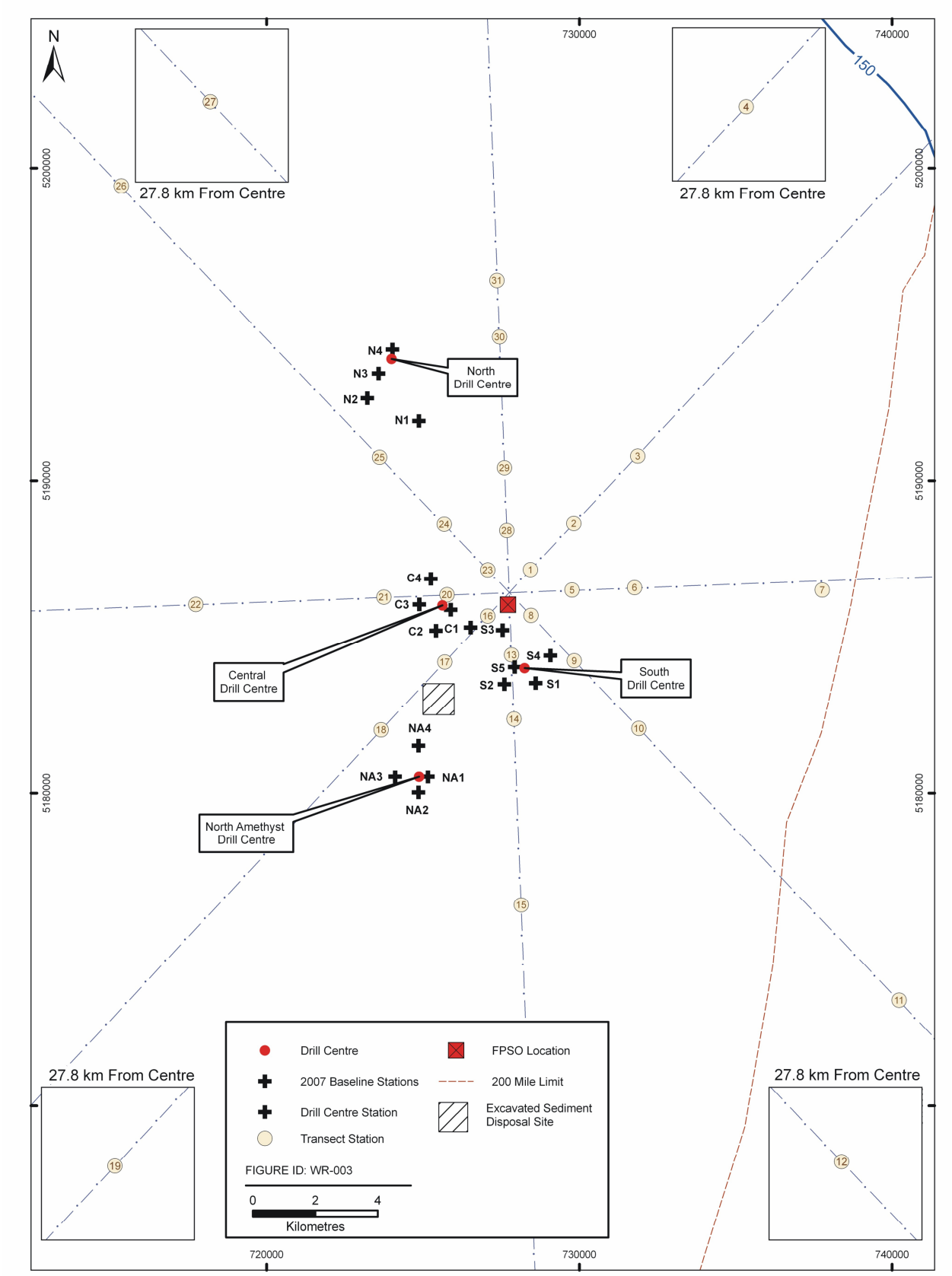


Figure 2-3 - EEM Program Station Locations and Study and Reference Areas

Reference Areas

Sediment samples were taken in each of two Reference Areas located approximately 85 km northwest and 35 km south-southeast of the proposed location of the FPSO.

The baseline survey indicated that physical, chemical and biological characteristics of sediments from the Northwest Reference Area differed substantially from sediment characteristics of other stations. The Northwest Reference Area was an outlier for most baseline analyses, and is unsuitable for future EEM sediment quality monitoring.

Sediment physical and chemical characteristics at the South-southeast Reference Area were reasonably similar to those at other stations nearer the development, but the South-southeast Reference Area benthic infaunal community was clearly different from communities elsewhere.

In the EEM program, the four remote 28-km transect stations will be treated as Reference Areas. Use of these 28-km stations as References was recommended by the WRAG based on knowledge of the zone influence of project contaminants in other areas (reported during the Offshore Oil and Gas Environmental Effects Monitoring Workshop held in Halifax in Spring 2003) and the anticipated distribution of project contaminants for White Rose (see Section 1.4.1.2).

Drill Centre Stations

In the baseline survey, there were six drill centre stations located 1 km from the proposed location of the N, C and S drill centres (Figure 2.2). The actual locations of these drill centres, especially the N drill centre, have shifted since baseline sampling, so these drill centre stations are no longer exactly 1 km from the drill centres (it should be noted that the baseline characterization program in fact assumed that the locations of these drill centres would likely move and the distribution of stations around proposed locations was designed to account for such movement. Once the final location of drill centres was known, then only the closer stations to the drill centre would be retained. See Appendix A for Husky Energy's general approach to sampling around potential drill centres). For the purposes of this report, distances for sample stations are distances from the centroids of the drill centre areas.

The N drill centre will be used for injection of gas and water to maintain pressure at the other drill centres, and not for oil extraction. Contamination and effects from that drill centre should be limited. Therefore, baseline stations GH3-1, 3-2 and 3-4 will be deleted from the proposed EEM program. Two baseline drill centre stations will also be deleted around the C and S drill centres. Baseline stations GH1-1 and GH1-5 around the S drill centre, and baseline stations GH2-1 and GH2-2 around the C drill centre, will be deleted. These four stations are further from the drill centres and closer to central transect stations than other drill centre stations. At present, it is not anticipated that the presence of subsea equipment will regularly interfere with sampling these remaining stations. Mobile offshore drilling unit (MODU) anchors and anchor lines may interfere with sampling, but only at the drill centre occupied by the MODU, and all stations will be accessible once drilling is complete.

None of the drill centre stations sampled in the baseline survey was within 500 m of the actual locations of the N, C and S drill centres. The only stations within 500 m of the

actual locations were transect stations F4-2,000 (now Station 13; 470 m from the S drill centre) and F6-2,000 (now Station 20; 160 m from the C drill centre). Therefore, one near-field station around each of the N, C and S drill centre will be added in the EEM program. These stations will be 300 m from the drill centre centroids. The 300 m distance was chosen to maximize exposure to drilling mud contaminants (i.e., provide a "worst-case" scenario), while taking into account the need to ensure safety and project operability.

In addition to the N, C and S drill centre, a new drill centre, the North Amethyst or NA drill centre, will become active in the summer of 2008. Baseline data around the NA drill centre were collected in 2007 (see Figure 2-3 and stations NA1, NA2, NA3 and NA4; and Appendix A). Since the final location of that drill centre was known, baseline data was collected at stations that will all be retained for the EEM program, with NA1 located at 300 m from the NA drill centre[1].

The locations and sample times for 300-m stations should be regarded as flexible and opportunistic. A minimum of 45 stations will now be re-sampled every EEM year[2], and regularly re-sampling another four near-field stations will provide little added value. Instead, the focus should be on extending distance regressions to low distances and presumably high exposure when possible (see Drill Centre subsection, above, for information on possible interference with sampling when active drilling is occurring).

If drill centres additional to the North Amethyst drill centre become active, Husky Energy's general approach to collection of baseline data for potential drill centres and expansion of the EEM program to include these drill centres once they become active is provided in Appendix A.

Summary

Distances from the nearest drill centre for the 48 baseline stations, and for the proposed EEM program are summarized in Table 2-2. Distance and GPS coordinates for each EEM station are provided in Appendix F. An assessment of the power and robustness of the EEM design is provided in Appendix E.

[1] EEM transect stations 14 and 18 were also sampled in 2007 to provide some indication of background variability.

[2] In some years, some of the near-field stations could be excluded if temporary sub-sea structures at White Rose prevent the safe collection of samples.

Table 2-2 - Distances to Nearest Drill Centre for Baseline and EEM Sample Stations

Distance from Nearest Drill Centre (km)	No. Stations					
	2000 Baseline Program			2008 EEM Program		
	Transect and Reference Stations	Drill Centre Stations	Total	Transect and Reference Stations	Drill Centre Stations	Total
• 1	2	8	10	2	14	16
>1-2	8	8	16	8	3	11
>2-5	10	2	12	11	1	12
>5-10	4	0	4	4	0	4
>10-20	4	0	4	2	0	2
>20	2	0	2	4	0	4
Total	30	18	48	31	18	49

2.2.2.2 Water Quality

Water samples were collected near the surface, at mid-depth, and near the bottom at 13 sediment quality stations during baseline. CTD data were collected at 25 sediment quality stations. These data will not be collected during the EEM program. This sampling was replaced with a sampling program developed as per the White Rose Water Quality Monitoring Program Report, attached as Appendix K.

2.2.2.3 Commercial Fish

The sampling design for American plaice and snow crab is an ANOVA design (see Appendices D and E for details), comparing two or more areas differing in exposure to contamination from the project. When only one Reference Area and one Study Area are sampled, the design is referred to as a Control-Impact or CI design. ANOVA and CI designs are more suitable for large mobile organisms such as fish and shellfish than gradient designs. Areas should be sufficiently separated to ensure that fish or shellfish do not freely move between areas, reducing or eliminating differences in exposure and effects. Based on suggestions from the WRAG, multiple Reference Areas will be sampled in the White Rose EEM program.

When samples are collected in multiple years, spatial one-way ANOVA designs comparing areas become spatial-temporal designs comparing years as well as areas.

Sample Areas

In the baseline survey, American plaice and snow crab were collected by trawl in the Study Area and from the Northwest Reference Area. In the EEM program, the Northwest Reference Area will be replaced by four new Reference Areas, centered on the four 28-km sediment quality stations (refer to Figure 2-3). Based on sediment chemistry, the Northwest Reference Area may not be comparable to the Study Area. Sampling four References will also provide an estimate of natural large-scale variance among Areas,

which will be important for assessing the environmental significance of any differences between the References and Study Area (i.e., potential effects) (Appendix D). Finally, it may be difficult to obtain adequate numbers of Reference American plaice or snow crab from a single Area.

Replication within Areas

In ANOVA designs, there must be replication within Areas. For the White Rose fish and shellfish survey, “replicates” are:

- Composites Of Several Individuals For Body Burden Analysis;
- Taste Panelists For Taste Analysis; and,
- Individual Fish for Health Assessment.

In a multiple-Reference, the true replicates are arguably Areas, specifically the multiple Reference Areas (Appendix D). However, if there are no significant differences among the Areas, statistical power or the probability of detecting effects (i.e., differences between Study versus Reference Areas) can be increased substantially by treating composites or individual fish within Areas as replicates (Appendix E). Furthermore, the taste tests, and specifically the triangle test, are designed to compare samples from two Areas or sources (=pair-wise comparisons), and Reference samples will be pooled for those tests. It would be difficult or impossible to make all possible pair-wise comparisons among the four References, and Husky Energy is not aware of any taste study that has attempted to do so.

Sample sizes for body burden analyses should ideally be at least 10 composite samples from the Study Area, with collection areas distributed relatively evenly between the northern and southern portion of the Study Area, and at least three composites from each Reference Area (Appendix E). However, if catches of American plaice and snow crab are low, six composites from the Study Area and two composites from each Reference Area should be regarded as the absolute minima required.

Similarly, samples sizes for fish health analysis should ideally be at least 60 fish from the Study Area, with collection areas distributed relatively evenly between the northern and southern portion of the Study Area, and at least 30 fish from each of the Reference Areas (Appendix E) if fish are larger than 25 cm (see below). If catch rates are low, 40 fish from the Study Area and 20 fish (25 cm in length) from each Reference area should be regarded as the absolute minimum required. More fish may be required if fish size is less than 25 cm, to allow sufficient tissue volume for health and body burden analyses.

Allocation of American plaice tissue in the White Rose EEM program to body burden, taste analyses and health assessment will follow the protocol developed in the Terra Nova EEM program. In the Terra Nova program, for American plaice:

- Only American plaice >25 cm are retained for analysis, unless catch rates are low;
- Trawls are conducted in each area until the required number of American plaice for health analyses have been collected;

- Bottom fillets from each fish are used for body burden analysis, and top fillets are used for taste analysis;

- Livers are split in half, with one half used for health assessment and one half used for body burden analysis (hence the need for American plaice >25 cm); and,

- Composites for liver and fillet body burden analyses are formed by combining fish tissue from one or more trawls. All fish in a trawl, rather than a subset of fish, are used for analyses. A minimum of five fish per replicate is required.

This approach matches composites used for fillet versus liver body burden analyses, and for fillet body burden versus taste analysis. The same livers used for body burden analysis are also used for health assessment, so one could compare health indicator means to body burdens for each body burden composite. The same approach can be used for snow crabs, which are captured in the same trawls as American plaice. For American plaice, and when sufficient tissue is available, samples from individual fish will be archived for additional body burden analysis if health analyses indicate a potential effect. This should be feasible for fillet samples, but tissue volume will often not be sufficient for individual analysis on liver.

3.0 WORK PLAN

3.1 Sediment Quality

3.1.1 Sample Collection Method

The sediment portion of the White Rose EEM program will be conducted in late August/early September, as was the sediment portion of White Rose baseline characterization program. Sediment samples will be collected using a large volume box corer designed to mechanically take an undisturbed sediment sample to a maximum depth of 60 cm over approximately 0.1 m^2 of seabed (Figure 3-1). Positional accuracy for sample collection at each station will be approximately 50 m. Three box-core samples will be collected at each station. Sediment samples collected for physical and chemical analysis, as well as for archive, will be a composite from the top 7.5 cm of all three core sampled (Figure 3-2). These will be stored in pre-labelled 250 ml glass jars at -20°C. Sediment samples collected for toxicity will be collected from the top 7.5 cm of one core and stored at 4°C in a 4-L pail (amphipod toxicity) and a Whirl-Pak (bacterial luminescence). Sediment samples for benthic community structure analysis will be collected from the top 15 cm of two cores and stored in two separate 11-L pails. These samples will be preserved with approximately 1 L of 10 percent buffered formalin.

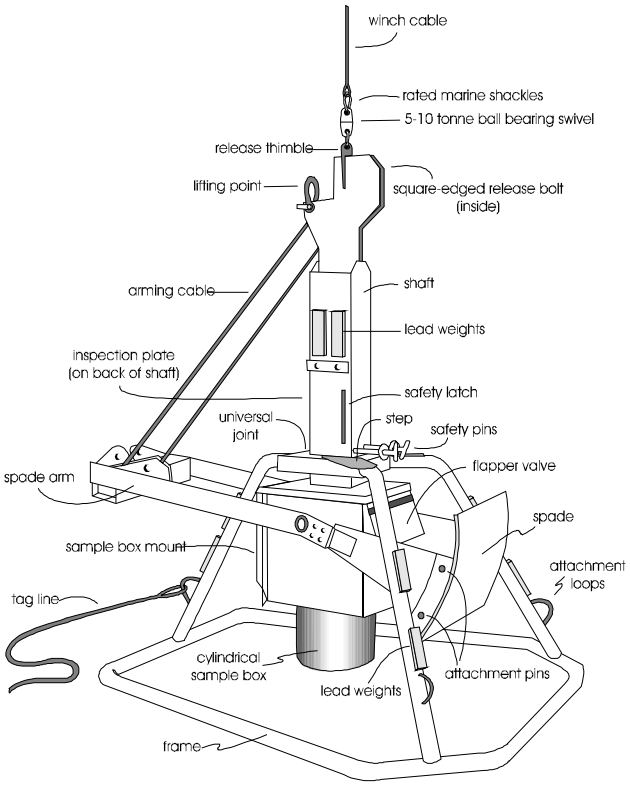
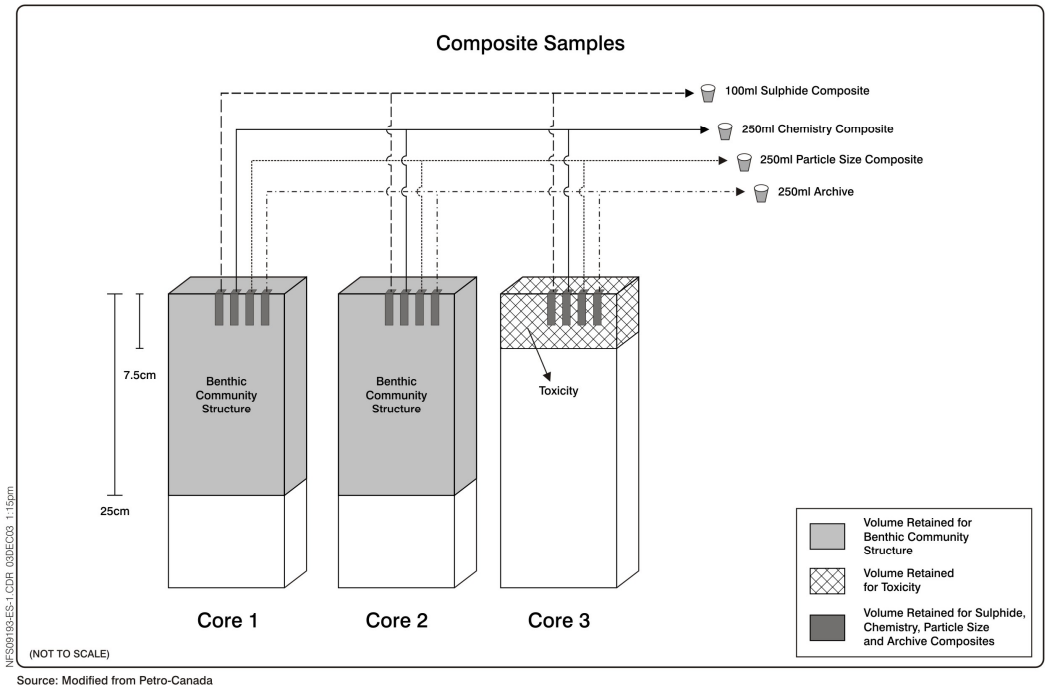


Figure 3-1 - Box Corer



Source: Modified from Petro-Canada

Figure 3-2 - Allocation of Samples from Cores

Sediment chemistry field blanks composed of clean sediment will be collected at 5 percent of sediment stations. Blank vials will be opened as soon as core samples from selected stations are brought on board vessel and will remain open until chemistry samples from these stations are processed. Blank vials will then be sealed and stored with other chemistry samples. Additional Quality Assurance/Quality Control (QA/QC) measures for sample collection and processing are provided in Appendix G (Appendix G details QA/QC for sample collections for all components of the EEM program, as well as QA/QC procedures for laboratory processing).

3.1.2 Sample Analysis

3.1.2.1 Chemical and Physical Characteristics

Sediment samples will be processed for particle size, hydrocarbons and metals. Specific chemical characteristics to be measured are listed in Table 3.1, as are detection limits since 2000. Methods summaries for extraction of chemical data are provided in Appendix H. Gravel, sand, silt and clay fractions of the sediments will be quantified. Methods summaries for extraction of particle size information are provided in Appendix I. The most recent updates to chemistry and particle size extraction methods will be provided with each EEM program report. Analysis will be conducted at a CAEAL certified laboratory.

Table 3-1 - Trace Metal and Hydrocarbon Analysis in Sediment

Variables	Method	2000 RDL[3]	2004 RDL	2005 RDL	2006 RDL	Units
Hydrocarbons						
Benzene	Calculated	0.025	0.025	0.025	0.03	mg/kg
Toluene	Calculated	0.025	0.025	0.025	0.03	mg/kg
Ethylbenzene	Calculated	0.025	0.025	0.025	0.03	mg/kg
Xylenes	Calculated	0.05	0.05	0.05	0.05	mg/kg
C_6-C_{10}	Calculated	2.5	2.5	2.5	4	mg/kg
>C_{10}-C_{21}	GC/FID	0.25	0.25	0.3	0.3	mg/kg
>C_{21}-C_{32}	GC/FID	0.25	0.25	0.3	0.3	mg/kg
PAHs						
1-Chloronaphthalene	GC/FID	NA	0.05	0.05	0.05	mg/kg
2-Chloronaphthalene	GC/FID	NA	0.05	0.05	0.05	mg/kg
1-Methylnaphthalene	GC/FID	0.05	0.05	0.05	0.05	mg/kg
2-Methylnaphthalene	GC/FID	0.05	0.05	0.05	0.05	mg/kg
Acenaphthene	GC/FID	0.05	0.05	0.05	0.05	mg/kg
Acenaphthylene	GC/FID	0.05	0.05	0.05	0.05	mg/kg
Anthracene	GC/FID	0.05	0.05	0.05	0.05	mg/kg
Benz[*a*]anthracene	GC/FID	0.05	0.05	0.05	0.05	mg/kg
Benzo[*a*]pyrene	GC/FID	0.05	0.05	0.05	0.05	mg/kg
Benzo[*b*]fluoranthene	GC/FID	0.05	0.05	0.05	0.05	mg/kg
Benzo[*ghi*]perylene	GC/FID	0.05	0.05	0.05	0.05	mg/kg
Benzo[*k*]fluoranthene	GC/FID	0.05	0.05	0.05	0.05	mg/kg
Chrysene	GC/FID	0.05	0.05	0.05	0.05	mg/kg
Dibenz[*a,h*]anthracene	GC/FID	0.05	0.05	0.05	0.05	mg/kg
Fluoranthene	GC/FID	0.05	0.05	0.05	0.05	mg/kg

[3] The RDL is the lowest concentration that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions. RDLs may vary from year to year because of methods improvement and because instruments are checked for precision and accuracy every year as part of QA/QC procedures.

Variables	Method	2000 RDL[3]	2004 RDL	2005 RDL	2006 RDL	Units
Fluorene	GC/FID	0.05	0.05	0.05	0.05	mg/kg
Indeno[1,2,3-*cd*]pyrene	GC/FID	0.05	0.05	0.05	0.05	mg/kg
Naphthalene	GC/FID	0.05	0.05	0.05	0.05	mg/kg
Perylene	GC/FID	0.05	0.05	0.05	0.05	mg/kg
Phenanthrene	GC/FID	0.05	0.05	0.05	0.05	mg/kg
Pyrene	GC/FID	0.05	0.05	0.05	0.05	mg/kg
Carbon						
Total Carbon	LECO	0.1	0.2	0.2	0.2	g/kg
Total Organic Carbon	LECO	0.1	0.2	0.2	0.2	g/kg
Total Inorganic Carbon	By Diff	0.2	0.3	0.2	0.2	g/kg
Metals						
Aluminum	ICP-MS	10	10	10	10	mg/kg
Antimony	ICP-MS	2	2	2	2	mg/kg
Arsenic	ICP-MS	2	2	2	2	mg/kg
Barium	ICP-MS	5	5	5	5	mg/kg
Beryllium	ICP-MS	5	2	2	2	mg/kg
Cadmium	GFAAS	0.05	0.05	0.05	0.05	mg/kg
Chromium	ICP-MS	2	2	2	2	mg/kg
Cobalt	ICP-MS	1	1	1	1	mg/kg
Copper	ICP-MS	2	2	2	2	mg/kg
Iron	ICP-MS	20	50	50	50	mg/kg
Lead	ICP-MS	0.5	0.5	0.5	0.5	mg/kg
Lithium	ICP-MS	5	2	2	2	mg/kg
Manganese	ICP-MS	2	2	2	2	mg/kg
Mercury	CVAA	0.01	0.01	0.01	0.01	mg/kg
Molybdenum	ICP-MS	2	2	2	2	mg/kg
Nickel	ICP-MS	2	2	2	2	mg/kg
Selenium	ICP-MS	2	2	2	2	mg/kg
Strontium	ICP-MS	5	5	5	5	mg/kg
Thallium	ICP-MS	0.1	0.1	0.1	0.1	mg/kg
Tin	ICP-MS	2	2	2	2	mg/kg
Uranium	ICP-MS	0.1	0.1	0.1	0.1	mg/kg
Vanadium	ICP-MS	2	2	2	2	mg/kg
Zinc	ICP-MS	2	5	2	5	mg/kg
Other						
Ammonia (as N)	COBAS	NA	0.25	0.3	0.3	mg/kg
Sulphide	SM4500	NA	2	0.2	0.2	mg/kg
Sulphur	LECO	NA	0.02	0.02	0.002	%(w)
Moisture	Grav.	0.1	0.1	0.1	1	%

Metals and hydrocarbons listed in Table 3-1 are those measured in the Terra Nova EEM program. This revised list of analytes benefits from lessons learned at Terra Nova. For instance, sulphur, sulphide and ammonia may affect sediment toxicity (Petro-Canada 2002). Also, 1 and 2-Chloronaphtalenes were not measured during the Husky baseline program, but added to the EEM program. With these additions, sediment chemistry analysis for the Terra Nova and White Rose programs are now identical.

3.1.2.2 Toxicity Testing

Sediment toxicity testing will use standardized and accepted Environment Canada (1998; 2002) procedures. Tests will include:

- Amphipod survival; and,
- Luminescent bacteria assays (microtox).

Both bioassays will use whole sediment as the test matrix. Tests will include sublethal and lethal endpoints. Tests with lethal endpoints measure survival, in this case amphipod survival, over a defined exposure period. Tests with sublethal endpoints measure physiological functions of the test organism, such as metabolism, fertilization and growth, over a defined exposure period. Bacterial luminescence, in this case, will be used as a measure of metabolism.

The amphipod survival test will be conducted according to Environment Canada (1998) protocols using the marine amphipod Rhepoxynius abronius, if this species is available. In 2003, the population of these marine amphipods from Whidbey Island (WA) crashed. Since this is the only North American collection site with sediment known to be contaminant-free, the use of an alternate species may be required if the population has not recovered.

Tests will involve five replicate 1-L test chambers with approximately 2 cm of sediment and approximately 800 ml of overlying water. Each test container will be set up with 20 test organisms and maintained for 10 days under appropriate test conditions, after which survival will be recorded. A sixth test container will be used for water quality monitoring only.

Negative sediment (clean laboratory control) will be tested concurrently, since negative controls provide a baseline response to which test organisms can be compared. Negative control sediment, known to support a viable population, will be obtained from the collection site for the test organisms. A positive (toxic) control in aqueous solution will be tested for each batch of test organisms received. Positive controls provide a measure of precision for a particular test and monitor seasonal and batch resistance to a specific toxicant. Amphipod survival will be assessed by comparison to i) the laboratory control and ii) survival at the reference sites (18-km station). Ancillary testing of total ammonia in overlaying water will be conducted by an ammonia ion selective probe and colorimetric determination, respectively.

The bacterial luminescence test will be performed with Vibrio fischeri. This bacterium emits light as a result of normal metabolic activities. The Microtox (Solid Phase) assay will be conducted according to Environment Canada (2002) guidelines. Analysis will be conducted on a Model 500 Photometer with a computer interface. A geometric series of sediment concentrations will be set up using Azur solid phase diluent. The actual number of concentrations will be dependent on the degree of reduction in bioluminescence observed. 18-km stations will be used as “clean” reference sediment against which to interpret responses. Reduction of light after 15 minutes will be used to measure toxicity.

Microtox analysis for baseline was conducted using the Environment Canada (1992) guideline, which differs from the 2002 guideline. Use of the new Reference Method will create some problems for comparisons among years, because the highest concentration of sediment to water tested will double, from 98,684 ppm to approximately 167,000 ppm.

All toxicity tests will be initiated within six weeks of sample collection as recommended by Environment Canada Guidelines (Environment Canada 1998; 2002).

3.1.2.3 Benthic Community Status

The composition of infaunal communities will be analyzed for two replicate samples collected at each sediment station. Infaunal community analysis will be used in conjunction with sediment chemistry and toxicity results to provide an integrated assessment of sediment quality, toxicity and effects on biota. There will be no sub-sampling for benthic community monitoring. All samples will be kept in 10 percent buffered formalin until they are sieved (0.5 mm sieve) and sorted at the laboratory. Samples for each station will be quantified and identified to the lowest possible taxa. Samples will be sorted separately.

The samples will be processed randomly. For processing, the samples will be poured on a sieve with a mesh size of 0.5 mm, then carefully washed using a water pressure low enough so that small or delicate animals are not damaged. Once the preservatives and fine-grained materials are removed, the animals will be picked from the remaining sediment. Initially, the washed sample will be placed in an enamel tray and the larger animals will be picked out under 2X magnification. Smaller animals will be picked out under at least 10X magnification. A count of heads will be done when fragments are encountered, and the whole sample will be examined in this way. All animals will be preserved in 70 percent alcohol and sieves will be rinsed thoroughly between samples.

Approximately 10 percent of the samples will be retained for re-examination to determine sorting efficiency. This will be recorded on a separate sheet and labelled “sorted debris”. A reference collection will be maintained in the laboratory at the time of sorting.

To determine wet weight biomass, all animals will be placed together on paper towels and blotted dry. The material will be weighed in a tiered plastic weighing dish to 0.1-mg accuracy. The volume of gravel and shell hash will be recorded for infauna samples.

3.2 Water Quality

The water quality component of the White Rose EEM program has been developed and approved by the C-NLOPB and the Board’s environmental and fishery advisory agencies. The entire White Rose Water Quality Monitoring Program Report is attached as Appendix K.

3.3 Commercial Fish

As with the baseline characterization program, the EEM program will focus on American plaice (a species common to all three oil and gas operations on the Grand Banks) and snow crab (a commercial species common in the White Rose development area).

Samples will be collected in June or July, when possible, to match baseline data collection time and assure that adequate sample sizes are collected. Samples will be collected in all areas. However, the presence of subsea infrastructure may interfere with sampling in the immediate vicinity of the development. Every effort will be made to sample as close to the development as possible, while still meeting safety requirements.

3.3.1 Sample Collection Method

American plaice will be collected in the Study Area (target sample = 60 fish, 10 trawls) and in each of four Reference Areas (target sample = 30 fish, three trawls per area). Samples will be collected with a Campelen trawl (towed at 3 knots for 15 minutes at a series of stations). If catch rates are high, American plaice larger than 25 cm will be selected from the catch at the Study and Reference Areas to allow splitting of livers between body burden analysis and fish health analyses. If catch rates are low, American plaice under 25 cm will be retained for analysis, but a larger number of these small fish may be needed to allow sufficient tissue volume for analysis (see Section 2.2.2.3 – Replication Within Areas). Samples will be handled in a consistent manner. All fish retained as samples will show no visible trawl damage or other wounds that could contaminate tissue. Liver and fillets samples will be frozen for taste tests (top fillet only) and body burden (liver and bottom fillet). Liver, gill, blood samples will be collected for fish health assessment.

Approximately 100 kg of snow crab will be collected using the Campelen trawl in the Study Area. Approximately 30 kg of snow crab will also be collected in each of the Reference Areas. Samples retained for analysis will have no visible trawl damage or other wounds that could contaminate tissue. Legs will be frozen for body burden analysis and taste tests.

Relevant life history and morphometric characteristics will be recorded for both American plaice and snow crab. Additional measurements on American plaice will include fish length, weight (whole and gutted), sex and maturity stage, liver weight, and gonad weight. Additional measurements for snow crab will include carapace width, shell condition, sex, chela height (males), and maturity, clutch size and egg stage (females).

All species, other than American plaice or snow crab, caught in trawls will be identified and enumerated.

QA/QC measures applicable to commercial fish collections and sample processing are provided in Appendix G.

3.3.2 Sample Analysis

3.3.2.1 Body Burden

Snow crab and American plaice tissue will be composited as detailed in Section 2.2.2.3 - Replication within Areas. Composites will be examined for trace metals and a suite of hydrocarbons. For American plaice and when sufficient tissue is available, tissue from individual fish will be archived for analysis on individuals in the event that health assessments show potential effects. The parameters to be analyzed on composites and individuals (when necessary) are listed in Table 3-2, along with detection limits since

2000. Methods summaries for extraction of these data are provided in Appendix J. The most recent updates to these methods will be provided with each EEM program report.

Table 3-2 - Trace Metal and Hydrocarbon Candidate Parameters

Variables	Method	2000 RDL	2002 RDL	2004 RDL	2005 RDL	2006 RDL	Units
Hydrocarbons							
$>C_{10}$-C_{21}	GC/FID	15	15	15	15	15	mg/kg
$>C_{21}$-C_{32}	GC/FID	15	15	15	15	15	mg/kg
PAHs							
1-Chloronaphthalene	GC/MS	NA	NA	0.05	0.05	0.05	mg/kg
2-Chloronaphthalene	GC/MS	NA	NA	0.05	0.05	0.05	mg/kg
1-Methylnaphthalene	GC/MS	0.05	0.05	0.05	0.05	0.05	mg/kg
2-Methylnaphthalene	GC/MS	0.05	0.05	0.05	0.05	0.05	mg/kg
Acenaphthene	GC/MS	0.05	0.05	0.05	0.05	0.05	mg/kg
Acenaphthylene	GC/MS	0.05	0.05	0.05	0.05	0.05	mg/kg
Anthracene	GC/MS	0.05	0.05	0.05	0.05	0.05	mg/kg
Benz[a]anthracene	GC/MS	0.05	0.05	0.05	0.05	0.05	mg/kg
Benzo[a]pyrene	GC/MS	0.05	0.05	0.05	0.05	0.05	mg/kg
Benzo[b]fluoranthene	GC/MS	0.05	0.05	0.05	0.05	0.05	mg/kg
Benzo[ghi]perylene	GC/MS	0.05	0.05	0.05	0.05	0.05	mg/kg
Benzo[k]fluoranthene	GC/MS	0.05	0.05	0.05	0.05	0.05	mg/kg
Chrysene	GC/MS	0.05	0.05	0.05	0.05	0.05	mg/kg
Dibenz[a,h]anthracene	GC/MS	0.05	0.05	0.05	0.05	0.05	mg/kg
Fluoranthene	GC/MS	0.05	0.05	0.05	0.05	0.05	mg/kg
Fluorene	GC/MS	0.05	0.05	0.05	0.05	0.05	mg/kg
Indeno[1,2,3-cd]pyrene	GC/MS	0.05	0.05	0.05	0.05	0.05	mg/kg
Naphthalene	GC/MS	0.05	0.05	0.05	0.05	0.05	mg/kg
Perylene	GC/MS	0.05	0.05	0.05	0.05	0.05	mg/kg
Phenanthrene	GC/MS	0.05	0.05	0.05	0.05	0.05	mg/kg
Pyrene	GC/MS	0.05	0.05	0.05	0.05	0.05	mg/kg
Metals							
Aluminum	ICP-MS	2.5	2.5	2.5	2.5	2.5	mg/kg
Antimony	ICP-MS	0.5	0.5	0.5	0.5	0.5	mg/kg
Arsenic	ICP-MS	0.5	0.5	0.5	0.5	0.5	mg/kg
Barium	ICP-MS	1.5	1.5	1.5	1.5	1.5	mg/kg
Beryllium	ICP-MS	1.5	1.5	0.5	0.5	0.5	mg/kg
Boron	ICP-MS	1.5	1.5	1.5	1.5	1.5	mg/kg
Cadmium	GFAAS	0.08	0.05	0.05	0.05	0.05	mg/kg
Chromium	ICP-MS	0.5	0.5	0.5	0.5	0.5	mg/kg
Cobalt	ICP-MS	0.2	0.2	0.2	0.2	0.2	mg/kg
Copper	ICP-MS	0.5	0.5	0.5	0.5	0.5	mg/kg
Iron	ICP-MS	5	5	15	15	15	mg/kg
Lead	ICP-MS	0.18	0.18	0.18	0.18	0.18	mg/kg
Lithium	ICP-MS	0.5	0.5	0.5	0.5	0.5	mg/kg
Manganese	ICP-MS	0.5	0.5	0.5	0.5	0.5	mg/kg
Mercury	CVAA	0.01	0.01	0.01	0.01	0.01	mg/kg
Molybdenum	ICP-MS	0.5	0.5	0.5	0.5	0.5	mg/kg
Nickel	ICP-MS	0.5	0.5	0.5	0.5	0.5	mg/kg
Selenium	ICP-MS	0.5	0.5	0.5	0.5	0.5	mg/kg
Silver	ICP-MS	0.12	0.12	0.12	0.12	0.12	mg/kg
Strontium	ICP-MS	1.5	1.5	1.5	1.5	1.5	mg/kg
Thallium	ICP-MS	0.02	0.02	0.02	0.02	0.02	mg/kg
Tin	ICP-MS	0.5	0.5	0.5	0.5	0.5	mg/kg
Uranium	ICP-MS	0.02	0.02	0.02	0.02	0.02	mg/kg
Vanadium	ICP-MS	0.5	0.5	0.5	0.5	0.5	mg/kg
Zinc	ICP-MS	0.5	0.5	0.5	0.5	1.5	mg/kg
Other							

Variables	Method	2000 RDL	2002 RDL	2004 RDL	2005 RDL	2006 RDL	Units
Percent Lipids/Crude Fat	PEI FTC/ AOAC92 2.06	0.1	0.5	0.5	0.5	0.5	%
Moisture	Grav.	0.1	0.1	0.1	0.1	0.1	%

3.3.2.2 Taste Testing

American plaice and snow crab samples will be delivered frozen to the testing laboratory for sensory evaluation, using taste panels and triangle and hedonic scaling test procedures. Frozen plaice samples will be thawed for 24 hrs at 2 °C, removed from plastic bags and homogenized in a food processor. Tissue will then be allocated to either the triangle taste test or the hedonic scaling test. Samples will be enclosed in individual aluminum foil packets, labeled with a predetermined random three-digit code and cooked in a convection oven at 82 °C for 11 minutes. Plaice samples will be served in glass cups at approximately 35 °C.

Frozen crab samples will be cooked, shucked of meat and stored overnight at 4°C. All meat will be homogenized in a food processor and allocated to either the triangle taste test or the hedonic scaling test. Crab will be served to taste panelists in glass cups at room temperature.

Each panel will include 24 untrained panelists who will be provided with score sheets (Figures 3-3 and 3-4) and briefed on the presentation of samples prior to taste tests. Panelists will be instructed that samples are being tested for uncharacteristic odour or taste and that grit, cartilage and texture should not be considered in their assessment. Panelists will also be instructed not to communicate with each and to leave immediately upon completion of the taste tests.

For the triangle test, panelists will be presented with a three-sample set (triangle) of samples and asked to identify the sample that is different from the others. Half of the panelists will receive sets composed of two samples from Treatment A (Study Areas) and one from Treatment B (Reference Areas). The other panelists will receive sets composed of one sample from Treatment A and two from Treatment B. There will be six possible orders in which the samples will be presented to panelists, after Botta (1994): ABB, AAB, ABA, BAA, BBA, and BAB.

The rest of the samples will be used for hedonic scaling tests. In this test, one sample from the Study Areas and one from Reference Areas will be presented to panelists. Panelists will be instructed to rate how much they like or dislike each sample on the form provided to them. A nine-point hedonic scale will be used, with ratings ranging from “like extremely” (9) to “dislike extremely” (1) (see Figure 3.4 for full range of ratings).

QUESTIONNAIRE FOR TRIANGLE TEST

Name:_____ Date/Time:_____

Product: American Plaice

Two the samples in the order indicated and identify the odd sample.

1. Taste the samples in the order indicated and identify the odd sample. You must choose one of the samples.

Code	Check Odd Sample
214	
594	
733	

2. Comments:

Figure 3-3 - Questionnaire for Sensory Evaluation by Triangle Test

QUESTIONNAIRE FOR HEDONIC SCALING

Name:_____ Date/Time:_____

Product: American Plaice

1. Taste these samples and check how much you like of dislike each one.

619	835
____ Like extremely	____ Like extremely
____ like very much	____ like very much
____ like moderately	____ like moderately
____ like slightly	____ like slightly
____ neither like or dislike	____ neither like or dislike
____ dislike slightly	____ dislike slightly
____ dislike moderately	____ dislike moderately
____ dislike very much	____ dislike very much
____ dislike extremely	____ dislike extremely

2. Comments:

_____

_____

_____

_____

_____

_____

_____

_____

_____

Figure 3-4 - Questionnaire for Hedonic Scaling

3.3.2.3 Fish Health

Fish health is a broad term that applies to a number of variables, including examination of tissues for pathological changes (histopathology), blood analysis (haematology), and enzymatic indicators of exposure to pollutants or stress (e.g., Mixed-Function Oxygenase (MFO)). As much as possible (see Section 2.2.2.3), fish health analyses will be conducted on the liver, gills and a blood sample of the same fish collected for body burden analysis.

Mixed-Function Oxygenase Induction

Fish liver samples will be thawed slightly on ice and a representative sample (approximately 1 g) will be taken from the same location on each organ. Each liver will be homogenized in four volumes of 50 mM Tris buffer (1 g liver to 4 mls 50 mM Tris using ten passes of a glass ten Broek hand Homogenizer). The homogenate will be centrifuged at 9,000X g for 10 minutes at 4ºC. The pellet will be discarded and the

supernatant (now known as S9) transferred to Eppendorf microcentrifuge tubes and frozen in triplicate at -80 C until assayed. In the event that a top fat layer appears, it will be discarded. It is important that samples from each site are held under the same storage and assay conditions.

Ethoxy-resorufin o-deethylase (EROD) activity will be assayed fluorometrically as described by Pohl and Fouts (1980) and modified by Porter et al. (1989) using a fluorescence spectrophotometer. The reaction mixture, final volume 1.25 ml, will consist of 53 nmol Tris-Sucrose buffer (50 mM, pH 7.5), 50 µl of S9 liver, and 2.25 nmol 7 -ER (150 µM ethoxyresorufin). The reaction mixture will be started by the addition of 0.16 mg NADPH (1.25 mg/ml). After a 15-minute incubation at 27ºC in a temperature-controlled waterbath, the reaction will be terminated by the addition of a 2.5-ml of ice-cold methanol. A methanol blank will be used and will contain the same components as the sample tubes, except for the addition of NADPH. Assay tubes will be vortexed and the protein precipitate removed by centrifugation at 3,600X g for 5 minutes. The fluorescence of resorufin formed in the supernatant will be measured in cuvettes (1-cm path length) at 585 nm using an excitation wavelength of 550 nm (slit width of 0.5 mm). The rate of enzyme activity in pmol/min/mg protein will be obtained from the regression of fluorescence against the standard concentrations of resorufin (enzyme activity is linear with time and protein concentration).

All liver samples used for MFO analysis will be treated and processed in the same manner so that any difference in MFO activity should only be due to sampling area and not affected by processing. In addition, when the liver is homogenized and the S9 homogenate prepared, it is frozen in triplicate so that there are three identical tubes of homogenate for each liver sample. This is very important because EROD activity decreases as the tissue thaws. If this occurs inadvertently, there are two other tubes of the same sample that can be used as backup.

Histopathology

Both liver and gill samples will be dehydrated in ethanol, cleared in chloroform, and embedded in paraffin wax. Samples will be sectioned at 6 microns and stained with Mayer's haematoxylin and eosin. Additional special stains may be done, if required, to assess various liver lesions. Each sample will be assessed microscopically and a colour photo taken of each section and any lesions observed.

Some of the more notable liver lesions to be looked for in the samples could include:

1. Non-specific necrosis;
2. Nuclear pleomorphism;
3. Megalocytic hepatosis;
4. Eosinophilic foci;
5. Basophilic foci;
6. Clear cell foci;

7. Hepatocellular carcinoma;

8. Cholangioma;

9. Cholangiofibrosis;

10. Increase in mitotic activity; and

11. Macrophage aggregates.

According to research carried out by the Environment and Ecosystem Sciences Section (DFO, Science, Oceans and Environment Branch, St. John's), there are generally six recognized stages used to read gill sections. A colour photograph will be taken of each stage and any tissue abnormalities. It must be kept in mind that the microscopic examination of gill sections is not a quantitative procedure, as all the gill lamellae do not conform to set patterns for each stage. Most times a judgement call is needed; consequently, the skill and experience of the person reading the gills is crucial to the correct interpretation of the samples. In addition, the presence and number of a variety of cells found in gill tissue will be recorded, including hypertrophic epithelium cells, chloride cells, and mucus cells.

Similar quality control procedures will be used as with the MFO samples. For both liver and gill tissue, a sample will be consistently taken from the same place on each tissue. In addition, serial sections will be made for each histology sample. This means there will be four sections from the same sample on each slide. If an abnormality is found in a section, then the other three sections will be checked for the same abnormality. If it is not found, then the abnormality will be considered an artifact of processing.

Haematology

Blood taken from each fish will be used for haematological assessment. Using the EBM method, all cellular components will be assessed for abnormalities. In terms of haematology analysis, standard routine procedures will be followed. Because blood cells do not disperse randomly on a slide when a blood smear is made, all sections of the slide will be assessed. The EBM method is a standard procedure that ensures the entire slide is checked and that cells in one particular area (i.e., the middle or the edges) are not missed.

4.0 IMPLEMENTATION PLAN

4.1 Sampling Platforms

The sediment survey will be conducted from a suitable supply vessel fitted with a temporary processing laboratory and supporting infrastructure. The commercial fish survey will be conducted from a DFO charter vessel.

4.2 Sampling Schedule

The first EEM survey was conducted in 2004. Surveys were conducted each year for the first three years (i.e., 2004, 2005, 2006, etc.). As per discussions with the C-NLOPB in

2008 (see Husky Energy 2008), surveys are to be conducted every two years there after. The commercial fish survey will be conducted in late spring/early summer, and the sediment survey will be conducted in late summer/early autumn.

4.3 Documentation

4.3.1 Survey Plan

Survey plans will be developed prior to the start of the EEM field surveys. Survey plans will provide the overall plan for the field surveys and contain specific information regarding field crew, sample locations, location coordinates, samples to be collected and priorities for the survey; essentially, the who, what, where and why of the program. The survey plan is intended as a general overview of the anticipated field operations for use by White Rose operations personnel, the vessel crew and the field survey team.

4.3.2 Survey Report

Survey reports will be developed once the sediment and commercial fish field surveys are complete. Survey reports will document the collection of samples by providing a summary of the field operations, including vessel, personnel, mobilization, survey coordinates, a detailed report of the survey activities, demobilization and reporting from the field. Survey reports will also append (as applicable) the sediment sample log, core description log, positioning report, daily field reports, any incident reports (e.g., damaged equipment, survey crew member injury), and tow start and finish coordinates.

5.0 REPORTING AND PROGRAM REVIEW

5.1 Reporting

Commercial fish and sediment quality data collected during the EEM program will be compared against baseline characterization data (and previous years' data for each subsequent EEM survey). The data will be reported in an interpretative document in a plain language format (to the extent possible) to facilitate the usefulness of the EEM program. The report will contain the following basic elements:

- An executive summary that will provide a précis of the report;
- An introduction that will provide an overview of the project description, EEM objectives, and the scope of the EEM program;
- A discussion of the methods used to collect the various types of data;
- The results will provide a comparison of data collected from previous programs and will address the effectiveness of the program in meeting the EEM objectives;
- The discussion will focus on any changes from previously collected data and a comparison with effects predictions in the EIS (husky oil 2000); and,
- The conclusion will highlight key results and identify opportunities for improvement in the program.

5.2 Decision Making

The EEM program is a component of Husky Energy's environmental management system. The EEM program will provide Husky Energy with the information necessary to make project-related decisions that may be required in the event that significant measurable effects are detected in the marine receiving environment.

5.3 Review and Refinement of Environmental Effects Monitoring Program

The EEM program will be reviewed after each year that data are collected. Husky Energy will continue to consult with the WRAG on its EEM program. Each of the steps in the program will be evaluated and, if necessary, refined to better meet the objectives of the EEM program. At present, it is anticipated that specific items for review will include:

- Sediment station additions/deletions and sample sizes and locations for commercial fish, particularly once drilling is complete;
- Specific tests performed on tissue and sediment samples;
- Specific analyses performed on data; and,
- Program frequency.

As the water quality component of the program becomes integrated with the sediment and commercial fish components of the program, specific items of that component will also undergo review.

Once finalized, after regulatory review, the EEM interpretative report will be made available in Adobe Acrobat file format on the Husky Energy website.

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7.0 Definitions and Acronyms

ANCOVA	Analysis of Co-variance
ANOVA	Analysis of Variance
APHA	American Public Health Association
BACI	Before-After Control-Impact
bbl	Barrel
CI	Control-Impact
C-NLOPB	Canada-Newfoundland Offshore Petroleum Board
CRM	Certified Reference Material
CTD	Conductivity, Temperature and Depth
DFO	Department of Fisheries and Oceans
EBM	Exaggerated Battlement Method
EEM	Environmental Effects Monitoring
EIS	Environmental Impact Statement
EQL	Estimated Quantitation Limit
EROD	enzyme activity referred to as 7-ethoxyresorufin O-deethylase
ES	Effect Size
FPSO	Floating Production, Storage and Offloading (facility)
H_o	Null (or monitoring) Hypothesis
kg	Kilogram
km	Kilometre
km^2	Square Kilometre
L	Litre
m	Metre
m^3	Cubic Metre
MFO	Mixed Function Oxygenase
mg	Milligram
ml	Millilitre
MODU	Mobile Offshore Drilling Unit
NEB	National Energy Board
NRC	National Research Council
OGP	International Association of Oil and Gas Producers
P	Statistical Power
PAH	Polycyclic Aromatic Hydrocarbon

PCA	Principal Component Analysis
QA/QC	Quality Assurance/Quality Control
RM	Repeated Measure
SBM	Synthetic-based Mud
SD	Standard Deviation
SPMD	Semi-permeable Membrane Device
SQT	Sediment Quality Triad
TEH	Total Extractable Hydrocarbon
TPH	Total Petroleum Hydrocarbon
TSS	Total Suspended Solids
VEC	Valued Environmental Component
W	Coefficient of Concordance
WBM	Water-based Mud

8.0 List of Appendices

Appendix A - Approach to Baseline Sampling Around Potential Drill Centres

Appendix B - Minutes from White Rose Advisory Group Meeting and Table of Concordance of Discussions

Appendix C - Consultation Report

Appendix D - Statistical Analysis

Appendix E - Statistical Power and Robustness

Appendix F - GPS Coordinates of EEM Sediment Stations and Distance to Drill Centres

Appendix G - Quality Assurance/Quality Control

Appendix H - Sediment Chemistry Methods Summaries

Appendix I - Sediment Particle Size Method Summary

Appendix J - Body Burden Methods Summaries

Appendix K - White Rose Water Quality Monitoring Program Report