Concrete Gravity Based Structure

Coastal Labrador Natural Gas Extraction

Midterm Report

IMV Atlantic Projects

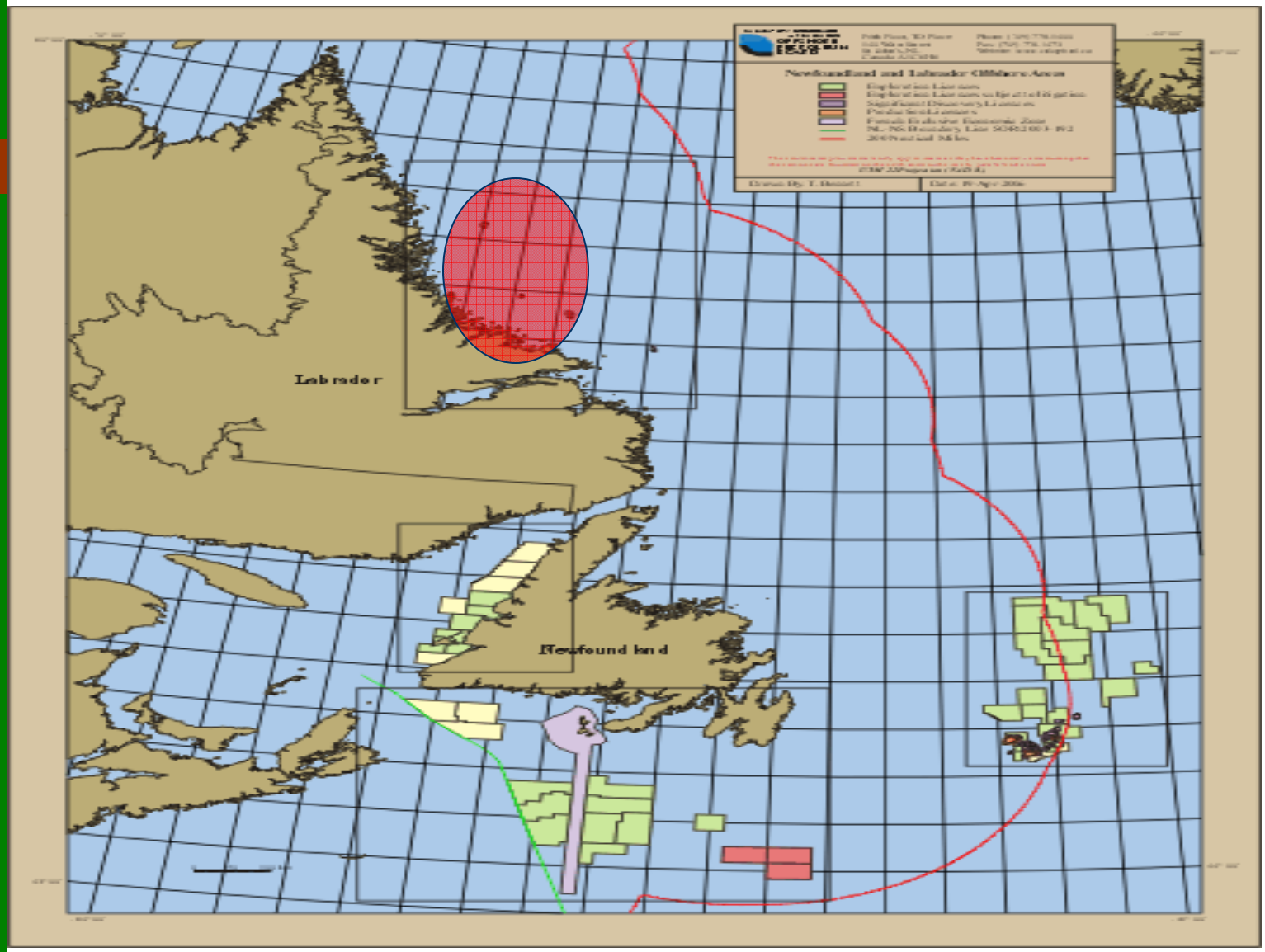
PROJECT SCOPE

Develop a Design Basis Memorandum, preliminary conceptual design, and cost estimate for an offshore Gravity Based Structure (GBS) for the extraction of Natural Gas from the Coast of Labrador

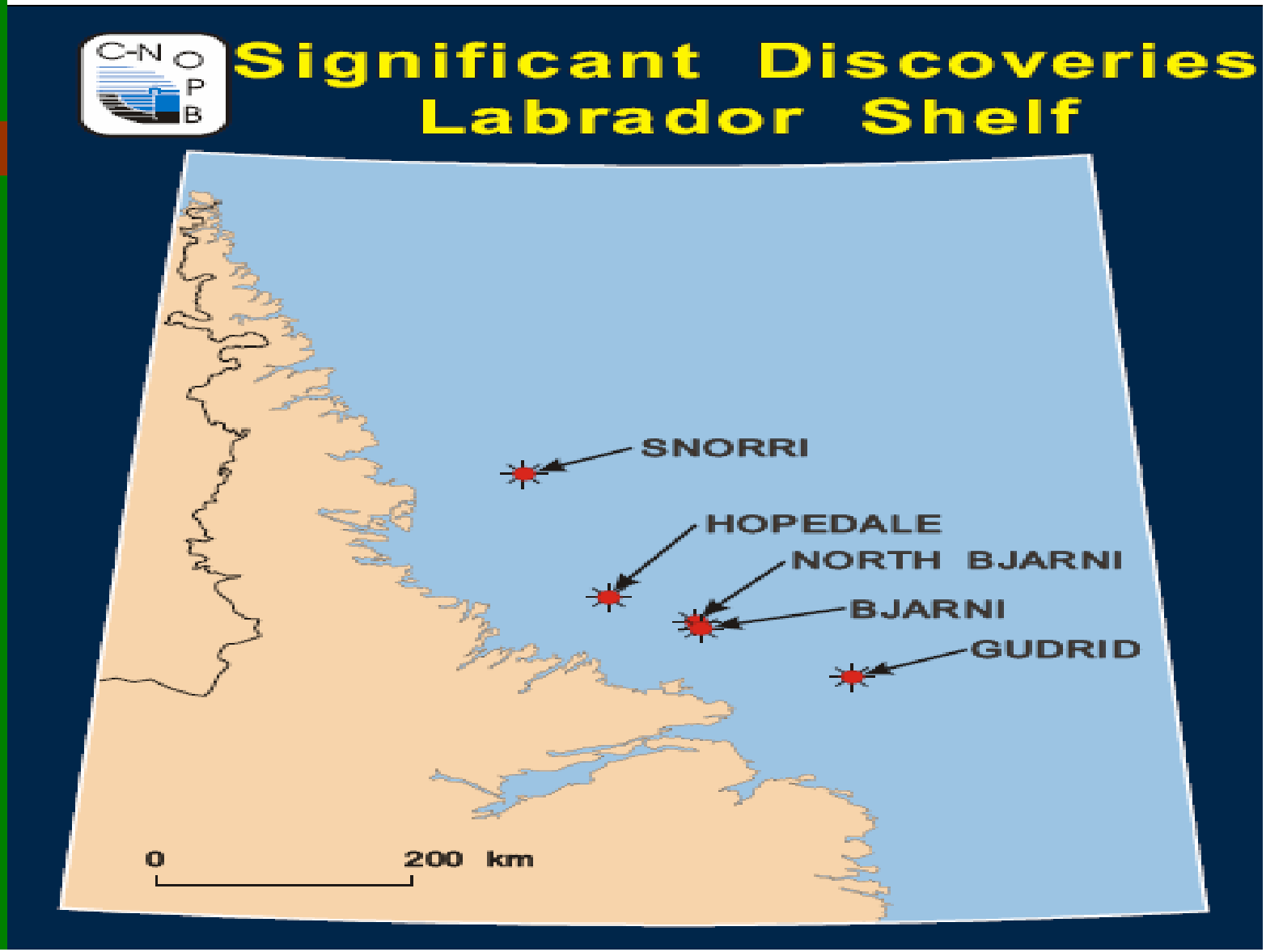
PRINCIPLE OBJECTIVES

- Design Basis Memorandum
  - Geotechnical Parameters
  - Environmental Design Criteria
- GBS Design Options
  - Advantages/Disadvantages
  - Preliminary Quantities
- Preferred Option Report
  - Quantities/Cost Estimates

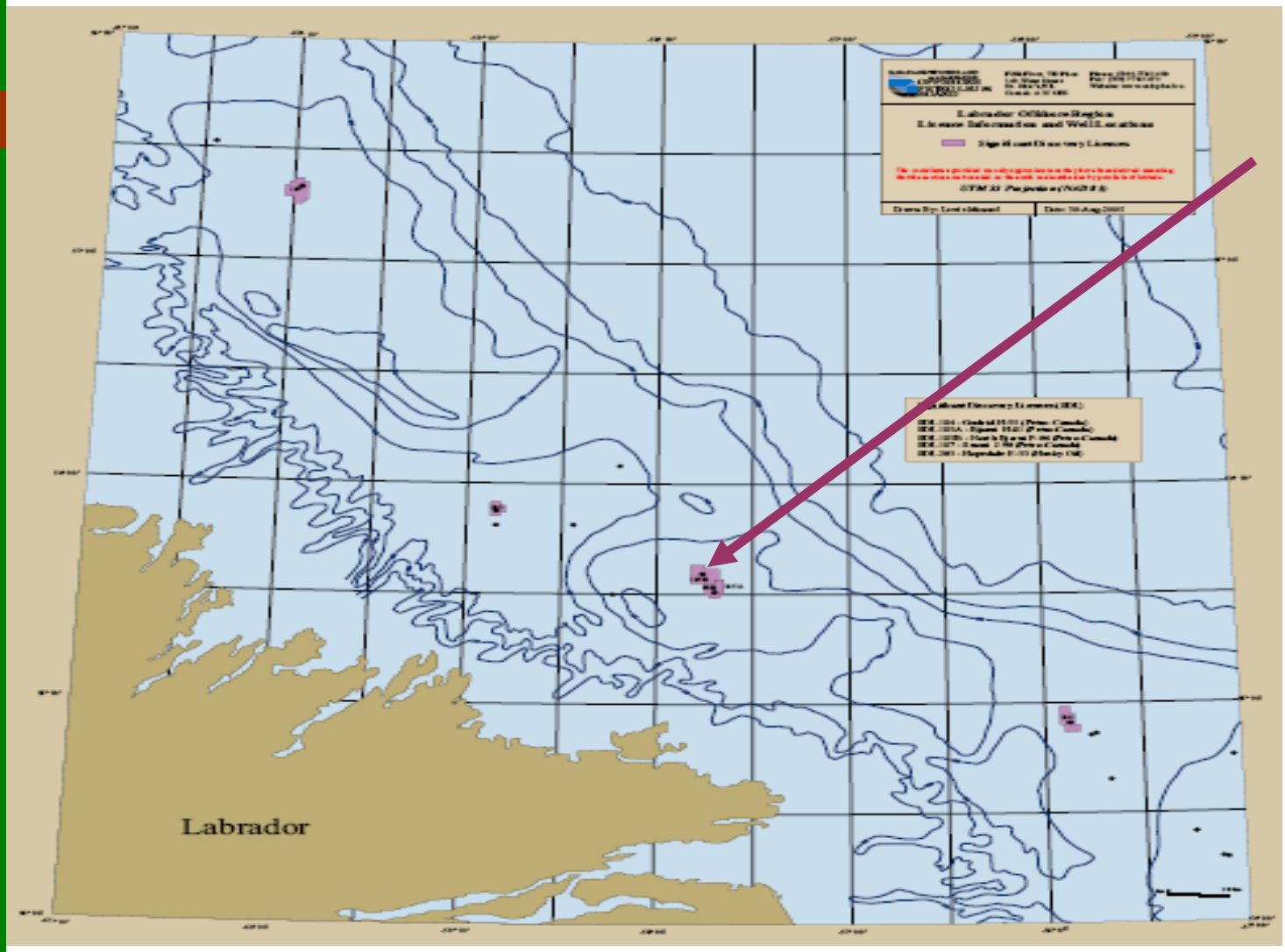
AREA OF OPERATION



PROBABLE GBS SITES



GBS SITE CHOSEN



WHAT THEY THINK IS THERE

CANADA-NEWFOUNDLAND and LABRADOR OFFSHORE PETROLEUM BOARD

Petroleum Reserves[1] and Resources[2] - Newfoundland Offshore Area

Field	Oil		Gas		NGLs[3]	
	$10^6 m^3$	*million bbls*	$10^9 m^3$	*billion cu. ft.*	$10^6 m^3$	*million bbls*
Grand Banks						
Hibernia	197.8	*1244*	50.6	*1794*	32.2	*202*
Terra Nova	56.3	*354*	1.3	*45*	0.5	*3*
Hebron	92.4	*581*	-	-	-	-
White Rose	45.0	*283*	76.7	*2722*	15.3	*96*
West Ben Nevis	5.7	*36*	-	-	-	-
Mara	3.6	*23*	-	-	-	-
Ben Nevis	18.1	*114*	12.1	*429*	4.7	*30*
North Ben Nevis	2.9	*18*	3.3	*116*	0.7	*4*
Springdale	2.2	*14*	6.7	*238*	-	-
Nautilus	2.1	*13*	-	-	-	-
King's Cove	1.6	*10*	-	-	-	-
South Tempest	1.3	*8*	-	-	-	-
East Rankin	1.1	*7*	-	-	-	-
Fortune	0.9	*6*	-	-	-	-
South Mara	0.6	*4*	4.1	*144*	1.2	*8*
West Bonne Bay	5.7	*36*	-	-	-	-
North Dana	-	-	13.3	*472*	1.8	*11*
Trave	-	-	0.8	*30*	0.2	*1*
Sub-Total	**437.3**	*2751*	**168.9**	*5990*	**56.6**	*355*
Labrador Shelf						
North Bjarni	-	-	63.3	*2247*	13.1	*82*
Gudrid	-	-	26.0	*924*	1.0	*6*
Bjarni	-	-	24.3	*863*	5.0	*31*
Hopedale	-	-	3.0	*105*	0.4	*2*
Snorri	-	-	3.0	*105*	0.4	*2*
Sub-Total	**0.0**	**0**	**119.6**	*4244*	**19.9**	*123*
Total	~~437.3~~	~~2751~~	~~288.5~~	~~10234~~	~~76.5~~	~~478~~
Produced[4]	98.9	*622*	0.0	*0*	0.0	*0*
Remaining	**338.4**	*2129*	**288.5**	*10234*	**76.5**	*478*

[1] "Reserves" are volumes of hydrocarbons proven by drilling, testing and interpretation of geological, geophysical and engineering data, that are considered to be recoverable using current technology and under present and anticipated economic conditions. Hibernia, Terra Nova, and White Rose are classified as reserves.

[2] "Resources" are volumes of hydrocarbons, expressed at 50% probability of occurrence, assessed to be technically recoverable that have not been delineated and have unknown economic viability.

[3] Natural Gas Liquids

[4] Produced oil reserves also include a small quantity of natural gas liquids. Produced volumes as of December 31, 2005

GEOTECHNICAL

North Bjarni Site Conditions

- 2.2 Trillion Cubic Feet of natural gas
- Located 100km off the Labrador coast at a water depth of 150m
- 10-40m layer of sediment on the ocean floor

GEOTECHNICAL

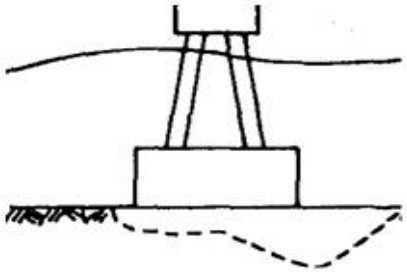
Design Considerations

- Large design loads necessitate large foundations
- Lateral load is a substantial fraction of the vertical load, therefore the overturning moment is very large
- There is a major cyclic component of loads
- Large settlement due to soft seabed deposits near sea floor

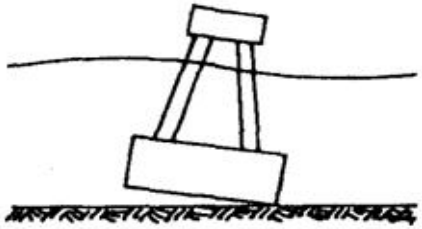
GEOTECHNICAL

Foundation Failure

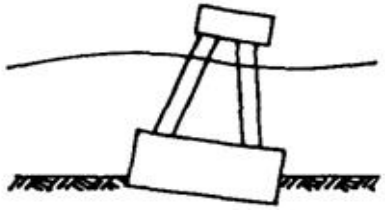
Modes of Foundation Failure



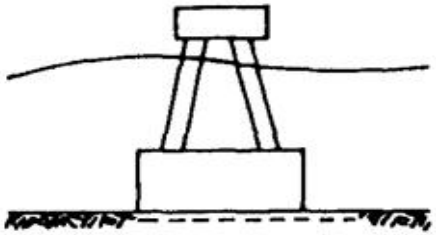
BEARING CAPACITY



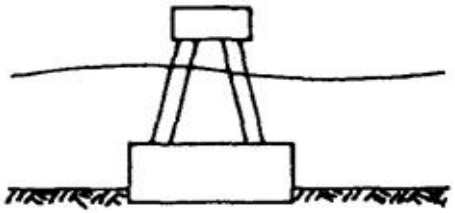
OVERTURNING



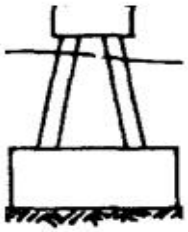
DIFFERENTIAL SETTLEMENT



SLIDING



EXCESSIVE SETTLEMENT



LIQUEFACTION

ENVIRONMENTAL DESIGN CRITERIA

- ***WAVE LOAD DATA***
  - 100 yr Wave Height ***30m***
  - Associated Wave Period ***16-19 secs***
  - Wave is classified as an intermediate wave

    (Linear Wave Theory)

ENVIRONMENTAL DESIGN CRITERIA

- ***WIND SPEEDS (100 yr Return)***
  - 1-Hour Mean Wind Speed 44m/s
  - 3-second gust 61m/s

ENVIRONMENTAL DESIGN CRITERIA

- ***PACK ICE DATA***
  - Measured Depths of up to 8m
  - Multi-year floes
  - Flexural Strength measures up to 0.7MPa
  - Local Strength Parameters 10.0MPa
  - Global Strength Parameters 2.4MPa
  - Crushing Failure

ENVIRONMENTAL DESIGN CRITERIA

- ***DESIGN ICEBERG***
  - Petro-Canada *Bjarni/North Bjarni "Production Perspectives Study" (1983)*
  - 20,000,000 Metric Tonnes
  - Tabular Shape, 55m deep, 636m wide
  - ~2700MN Force on Impact with structure
    - Hibernia – 1300MN
  - ~335GN·m Overturning Moment
    - Hibernia - 84GN·m

GBS DESIGNS

MULTIPLE LEGGED STRUCTURES

- Ability to withstand moderate ice conditions
- Inability to withstand the load of an iceberg
- Slender legged shapes provide little to no storage
- Predominant in North Sea

GBS DESIGNS

MULTIPLE LEGGED STRUCTURES

TROLL A

- *Location: North Sea*
- *Structure Height: 472 m*
- *Ocean Depth: 303 m*
- *Structure Weight: 656,000 Te*

GBS DESIGNS

STEPPED CASSION STRUCTURES

- Good stability against overturning
- Geometry causes failure of ice features and energy dissipation at controlled rate
- Concurrent construction of major parts possible
- Constructability issues due to geometry

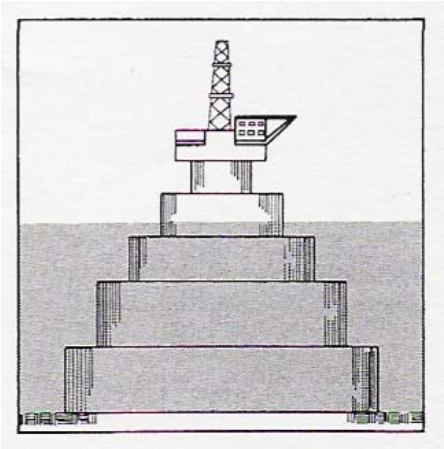
GBS DESIGNS

STEPPED CASSION STRUCTURES

STEPPED STRUCTURE

Conceptual Design

- *Location: Beaufort Sea, Labrador Sea*
- *Ocean Depth: 50-200 m*



GBS DESIGNS

CONICAL STRUCTURES

- Wide base provides stability
- Offers reduced area at water surface
- Inclined edge reduces ice loads
- Curved walls allows distribution of environmental loads
- Geometry reduces maximum storage

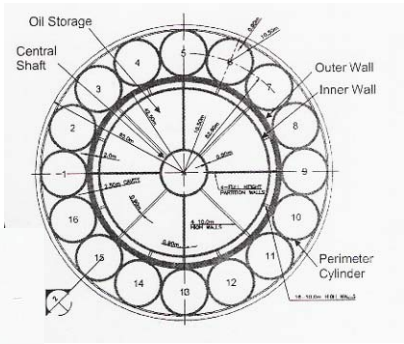
GBS DESIGNS

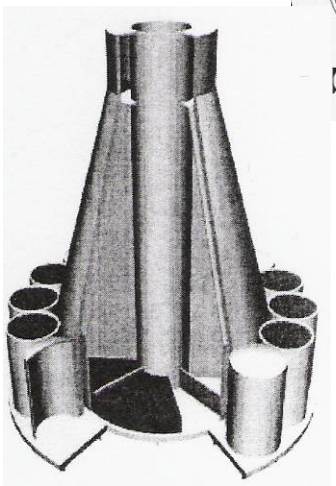
CONICAL STRUCTURES

GRAND BANKS GBS

Conceptual Design

- *Location: Atlantic Ocean*
- *Ocean Depth: 80 to 120 m*
- *Silo shaped cylinders provide flotation and ballast*





GBS DESIGNS

CYLINDRICAL STRUCTURES

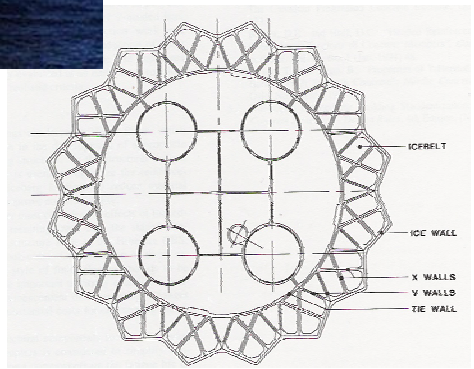
- Provide greater stability during construction and tow out
- Attract higher wave and iceberg loads
- Greater mass resists larger ice features
- Large flat roof causes design and constructability issues

GBS DESIGNS

CYLINDRICAL STRUCTURES

HIBERNIA

- *Structure Height: 224m*
- *Ocean Depth: 111 m*
- *Structure Weight: ≈ 1.1 million Te*
- Unique wedge shaped outer wall



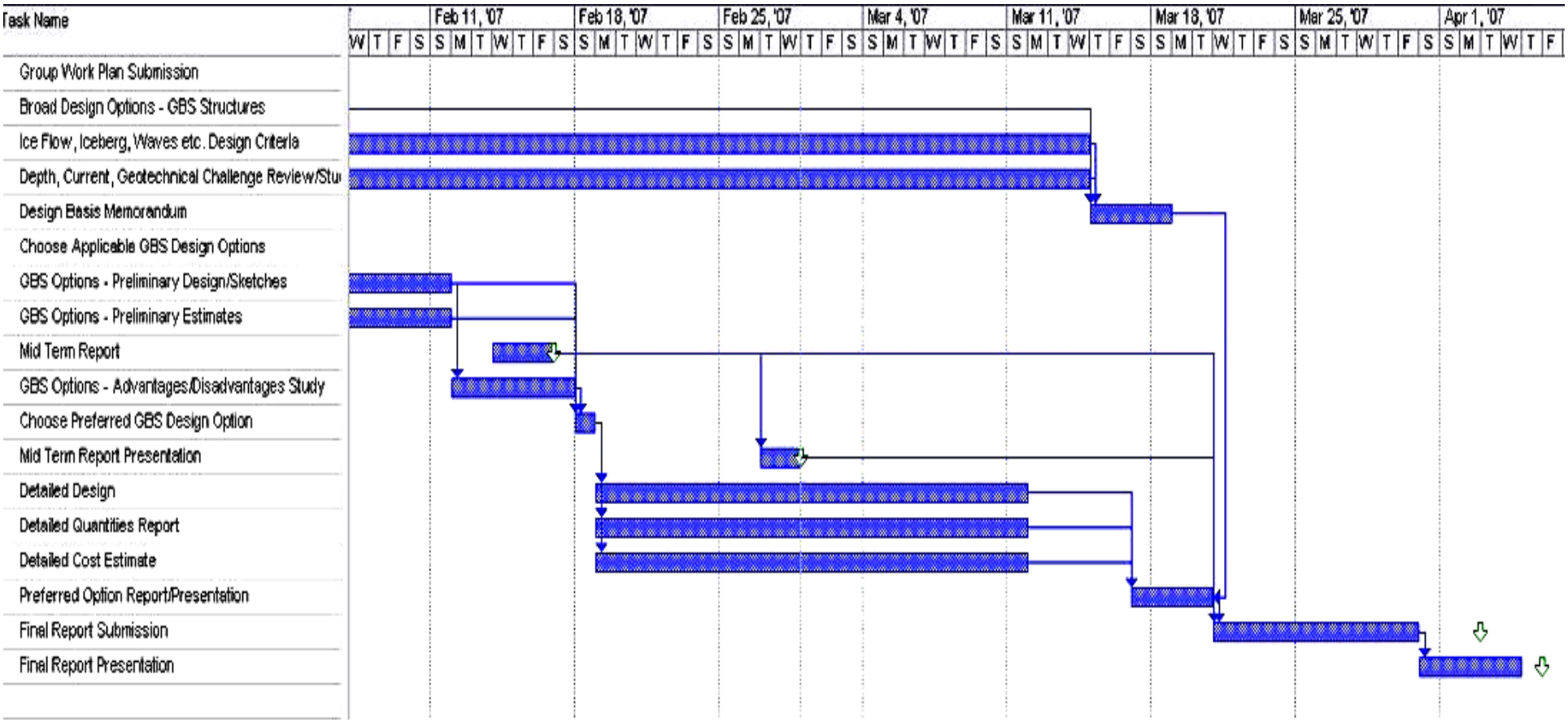
FINAL REPORT

Outline

- GBS Design Possibilities
- Design Basis Memorandum
  - Methodology
  - Conclusions
- Conceptual Design Options *(Site Specific)*
  - Advantages/Disadvantages
- Preferred Option Report
  - Quantities/Cost Estimates

PROJECT SCHEDULE

Outstanding Items



Thank You!

Questions/Comments

End of Show

CELEBRITIES IN ENGINEERING

An Updated Version

STAY TUNED!

Control the pet population, have your pet spayed or neutered!