Engineering in Canada's Northern Oceans

Research and Strategies for Development

A Study for the Canadian Academy of Engineering

Canadian Northern Research Centres

- Inventory of Canadian Centres oriented towards Northern Research
- Can be divide into “Doers”, “Studiers” and “Coordinator/Funders”
- Most current and recent research is well documented and searchable on the internet.
- There is an extensive body of older and still relevant research that is not accessible over the internet.

Inventory of Canadian Centres

- **ArcticNet**
- **Centre for the North (CFN)**
- **Canadian Polar Commission (Government of Canada)**
- **Canadian High Arctic Research Station (CHARS)**
- **C-CORE, LOOKNorth & CARD (centres within C-CORE)**
- **Canadian Network of Northern Research Operators**
- **Arctic Institute of North America (at University of Calgary)**
- **NRC Arctic Program**
- **Program of Energy Research and Development (PERD)**
- **Polar Continental Shelf Program (PCSP)**
- **BREA Beaufort Regional Environment Assessment 2011-14**
- **Environmental Studies Research Funds (ESRF), CAPP supported**
- **The Canadian International Centre for the Arctic Region**

Doers – get their hands cold

- **ArcticNet**
  - Network of universities, well funded, science
- **C-CORE, LOOKNorth & CARD**
  - Engineering studies, desk and field
- **NRC Arctic Program**
  - Engineering R&D, desk and field
- **Canadian High Arctic Research Station (CHARS)**
  - Arctic science and technology
  - Under construction in Cambridge Bay

Studiers – shape policy

- **Centre for the North (CFN)**
  - Conference Board; links to Aboriginal communities
- **Canadian Polar Commission**
  - Government of Canada agency
- **The Canadian International Centre for the Arctic Region**
  - International coordination

Coordinator/Funders

- Canadian Network of Northern Research Operators
  - Logistics coordination
- Arctic Institute of North America (University of Calgary)
  - Extensive library
- Program of Energy Research and Development (PERD)
  - **$$$**
- Polar Continental Shelf Program (PCSP)
  - **$$$ in kind**
- BREA Beaufort Regional Environment Assessment 2011-14 (AAND)
  - **$$$**
- Environmental Studies Research Funds (ESRF), CAPP supported
  - **$$$**
- Petroleum Research Newfoundland & Labrador (PRNL)
  - **$$$$$$$$$$**

Canadian Arctic Expertise

Past Glories

- The study of ice and ice mechanics dates back to the early 1900s. Professor Barnes at McGill studied ice strength and ice loads on bridge piers.
- The National Research Council in Ottawa had ice experts who studies the possibility of reinforced ice to make aircraft carriers to defend the Atlantic convoys during WW2 (Habbakuk Project).
- The case histories have outlined how commencing on about 1970, Canadians were leaders in developing methods for offshore drilling in the Beaufort Sea.

Today's Situation

- Many of today's Canadian Arctic offshore engineers developed their skills in the first phase of Beaufort Sea exploration commencing in about 1970.
- At that time the Canadian oil companies were prominent in pushing the technology envelope.
- Today, with the exception of one, most Internationals headquarter their Arctic R&D in their home countries (e.g. Houston !).
- They do use Canadian expertise – but control it from their HQs

Today`s Capabilities

- A current survey indicates a total of about 120 Canadian Arctic ‘engineering` experts.
- Geographically they are distributed as follows
  - Vancouver and the island – 16
  - Calgary – 42
  - Ottawa -20
  - St John`s – 37
  - Other Canadian and International – 9

By Organization

- Oil Companies – 20
- Large Consulting Companies – 11
- Small Consulting Companies – 31
- Universities - 7
- Institutes - 25
- Government – 32

Codes and Standards

- Canadian code development
  - CSA offshore structures code (CSA-S470 series)
  - TC Arctic Shipping Pollution Prevention Regulations (ASPPR)
- Harmonized international standards
  - ISO 19906 Arctic offshore structures
  - IACS/IMO Polar Code

Canadian offshore structures code (S470 series)

- CAN/CSA-S471-92 General Requirements, Design Criteria, the Environment, and Loads
  - first limit-states, reliability-based offshore standard, with target safety levels, load and resistance partial factors
  - Canadian engineering expertise was the foundation of these standards

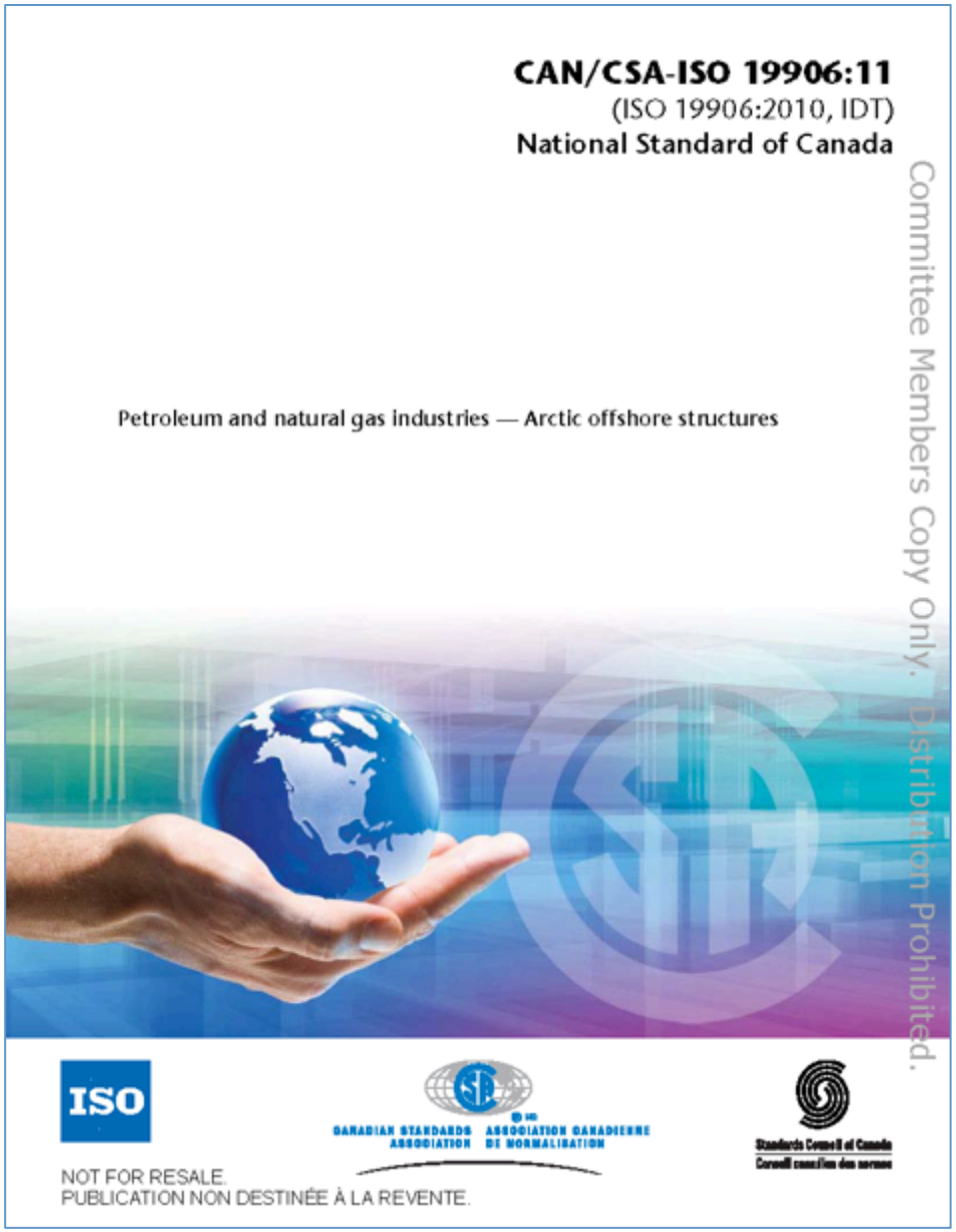
Arctic Shipping Pollution Prevention Regulations (ASPPR)

- Response to SS Manhattan voyages
- Regulate navigation in Canadian waters above 60°N latitude (1972)
  - Divided the Canadian Arctic into Shipping Safety Control Zones
  - Established a number of Arctic Class ships
  - Time table regulated when various ice class ships were allowed to enter each Control Zone
- Revised in 1989 and 1996
- 25 years of experience incorporated

Harmonized international standards

- CAN/CSA-ISO 19906:11 Arctic offshore structures
  - Canadian engineers played a leading role
  - Based on S471
- International Association of Classification Societies (IACS)
  - harmonized classifications for Arctic vessels
- International Maritime Organization (IMO)
  - is developing a mandatory International Code of Safety for Ships Operating in Polar Waters.
  - Based on IACS Polar Classes
  - Canadian engineers to the IACS and IMO effort

CAN/CSA-ISO 19906:11 Arctic offshore structures



Case Studies demonstrating Canadian Experience

- Voisey's Bay
- Arctic Islands; Exploration and Pilot Production
- Arctic Pilot Project

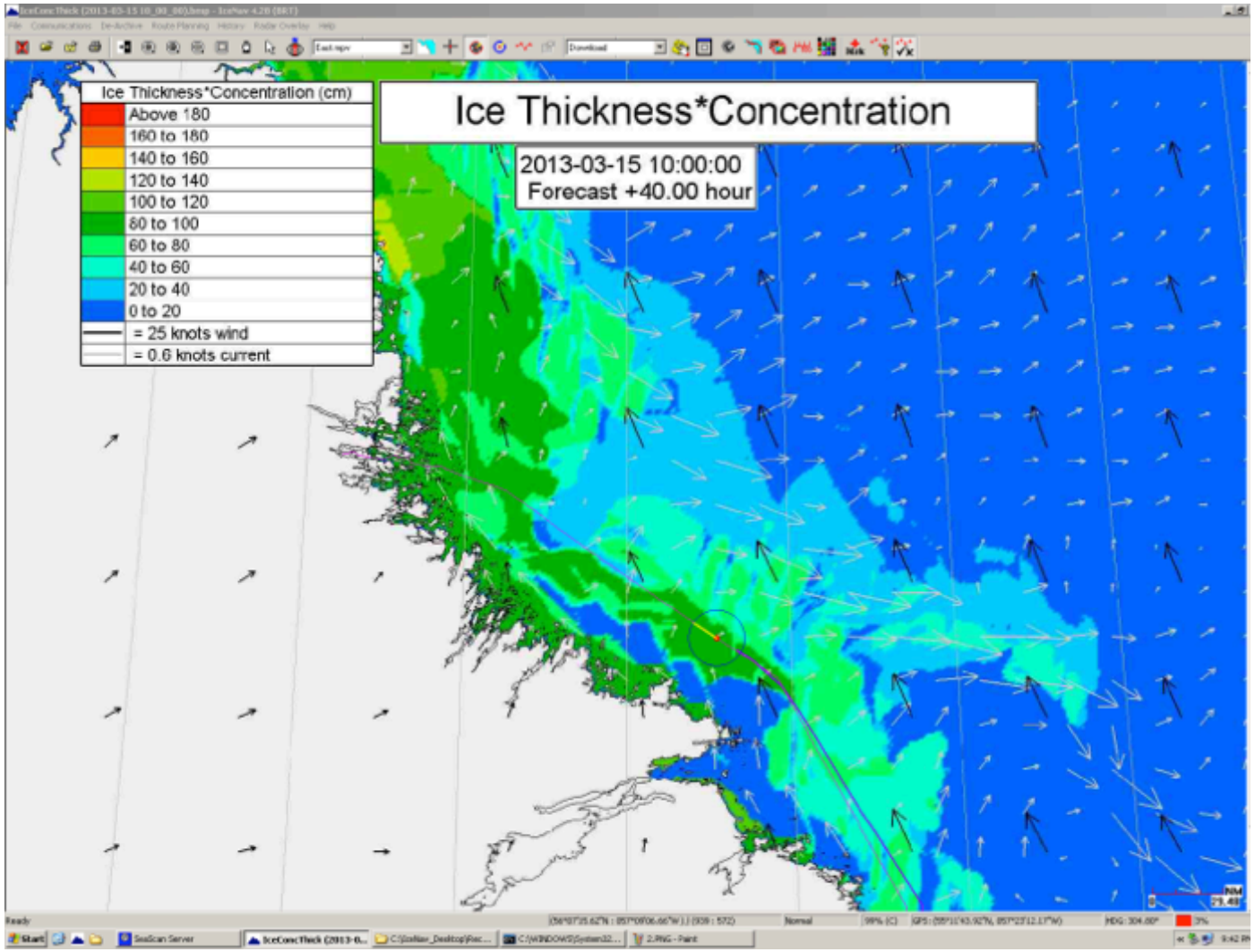
Voisey's Bay

- nickel deposit discovered 1993
- Purchased by INCO in 1996
- 6 years of negotiations
  - government of Newfoundland and Labrador
  - Labrador Innu and Inuit
- mine began operation in 2005 with the first concentrate shipped in October of that year
- ~ 30 year life of mine

Voisey's Bay

- Ice conditions
- Marine terminal
- Ship and shipping operation
- Shared use of ice cover
  - No shipping December 7 to January 21
  - Shipping in ice with 'bridge' Jan. 22 to April 6
  - Again April 7 to May 21
  - Communication of transit information to community

Voisey's Bay – ice conditions



Voisey's Bay – marine terminal

Voisey's Bay – Umiak I (PC4)

Voisey's Bay – 'bridge'

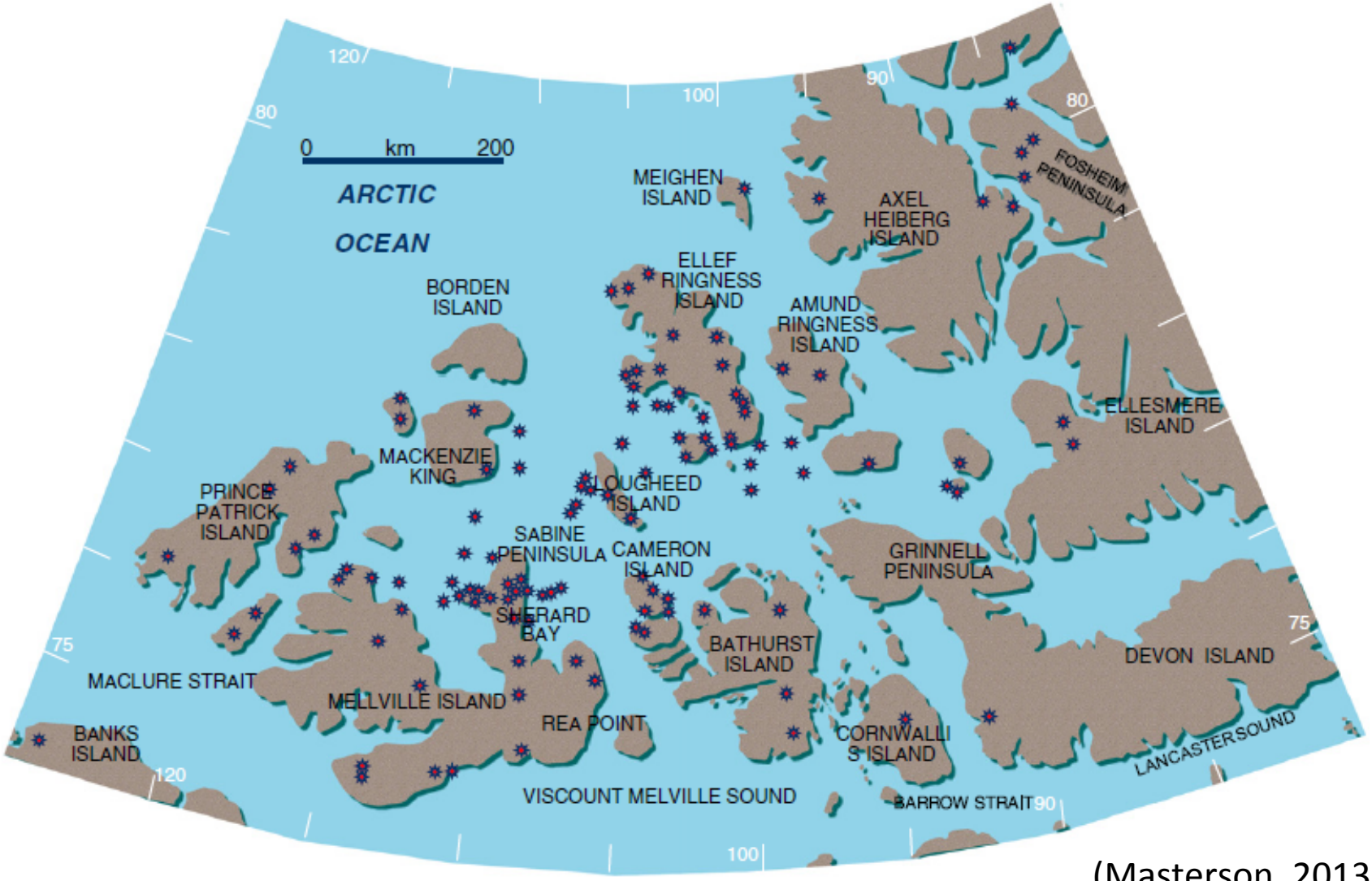
Arctic Islands; Exploration and Pilot Production

- Panarctic Oils exploration in Arctic islands
- 150 well, 38 offshore from thickened floating ice platforms
  - Pioneering engineering for use of ice to support operations (Hans Kivisild)
  - 1500 tonne rig on 6 m thickened ice for 3 months
- Extensive gas reserves discovered

Arctic Islands; ice platform well site

(Masterson, 2013)

Arctic Islands; well locations



(Masterson, 2013)

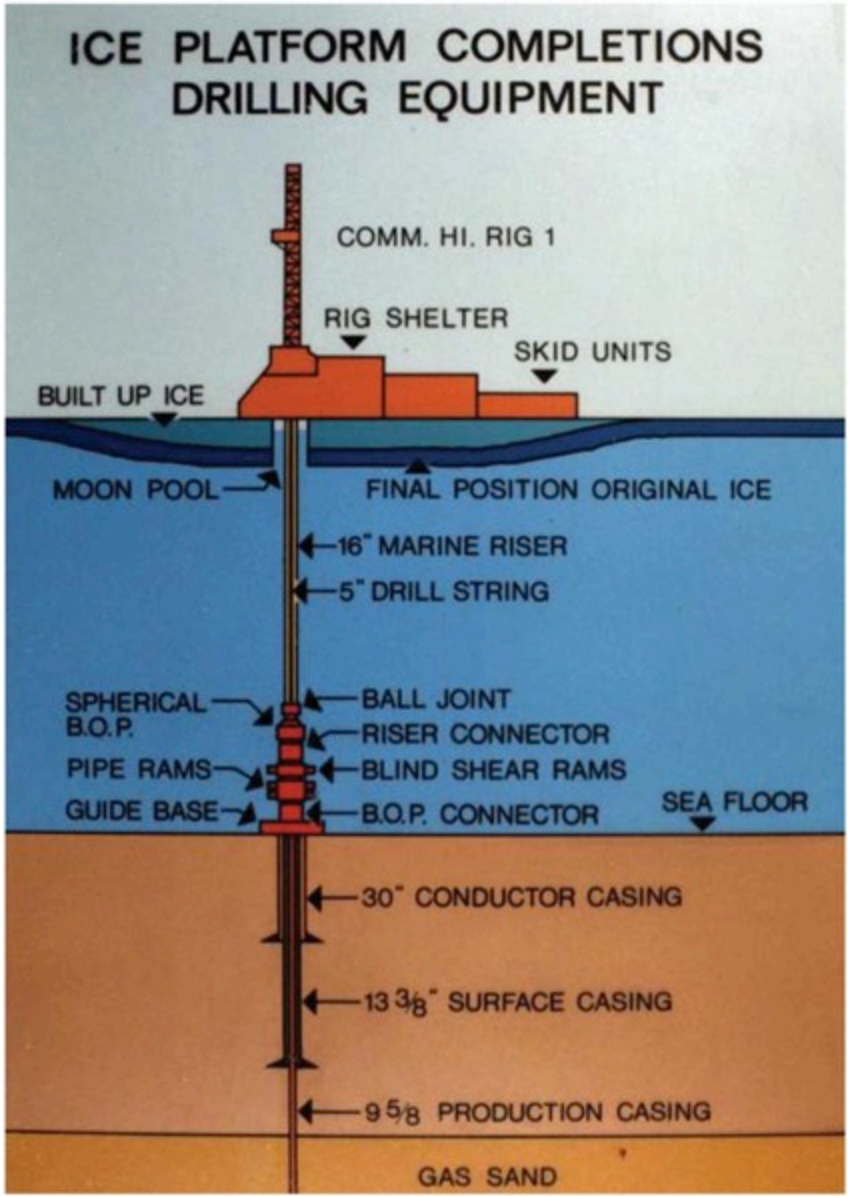
Significant Discovery Licences

Pilot Gas Production

Drake F-76 1978

Demonstrated offshore well completion

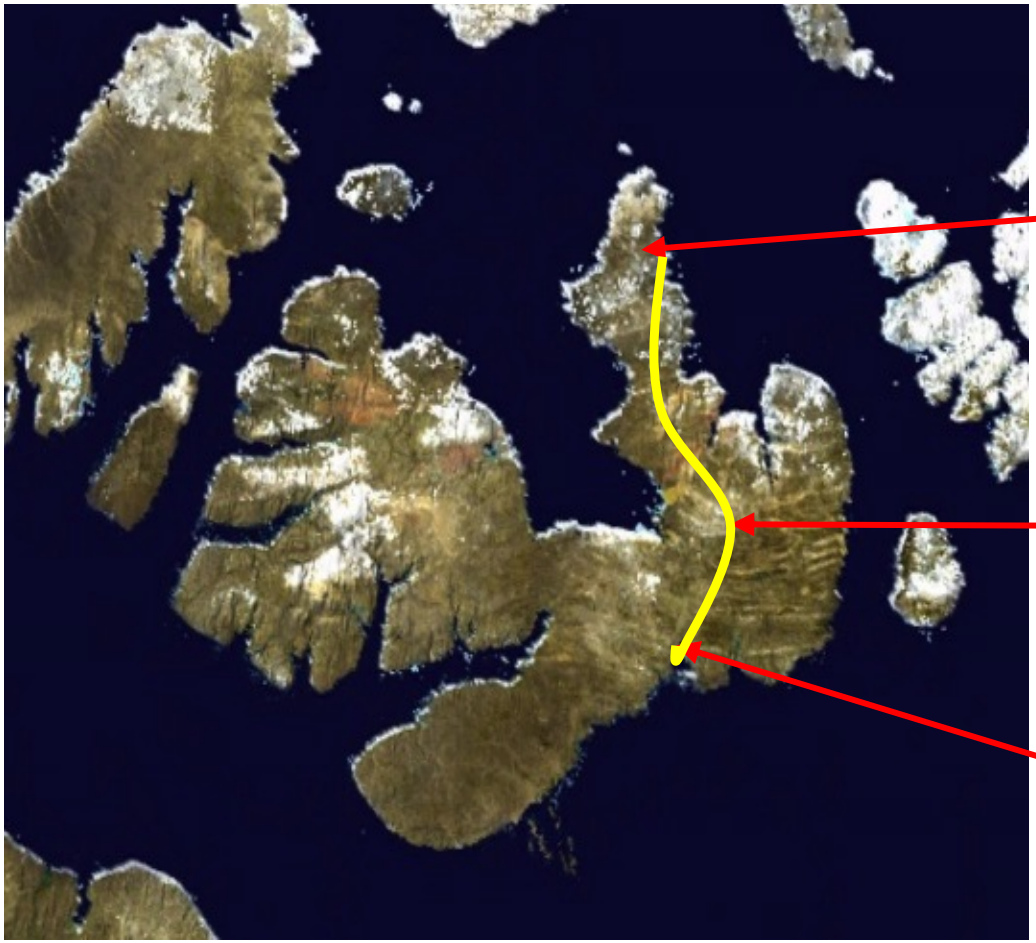
- Seabed BOP
- Flowline to shore
- Protection of shore approach from ice
- Trial production
- Plugged and abandoned 1995



Arctic Pilot Project

- PetroCanada led project in early 1980s
- Export LNG from Arctic Islands to East Coast markets
- Challenges for design and engineering
  - Northern marine terminal for year round use
  - LNG plant
  - Icebreaking LNG carriers
  - Tanker routing in ice

Arctic Pilot Project



Drake Point Gas Field

Gas Transmission Line

Bridport Inlet
LNG Plant, Storage & Loading Terminal

Arctic Pilot Project

- Project did not proceed but advanced technology
  - northern marine terminals for year round use
  - barge mounted plant for northern resource projects
  - simulation of arctic marine transportation systems
  - design of large icebreaking ships capable of carrying bulk liquid and dry cargoes
- Example of a visionary project leading to the advancement of technology and stimulating R&D closely coupled to needs

Mineral Resources

- North comprises 40% of land area
- Remote and largely unexplored
- Oil and gas; 1/3 of Canada's remaining resource in the North
- Significant mineral discovery and development already
- Great potential, but many challenges

Mineral Resources

Affaires autochtones et Développement du Nord Canada
Aboriginal Affairs and Northern Development Canada

Canada

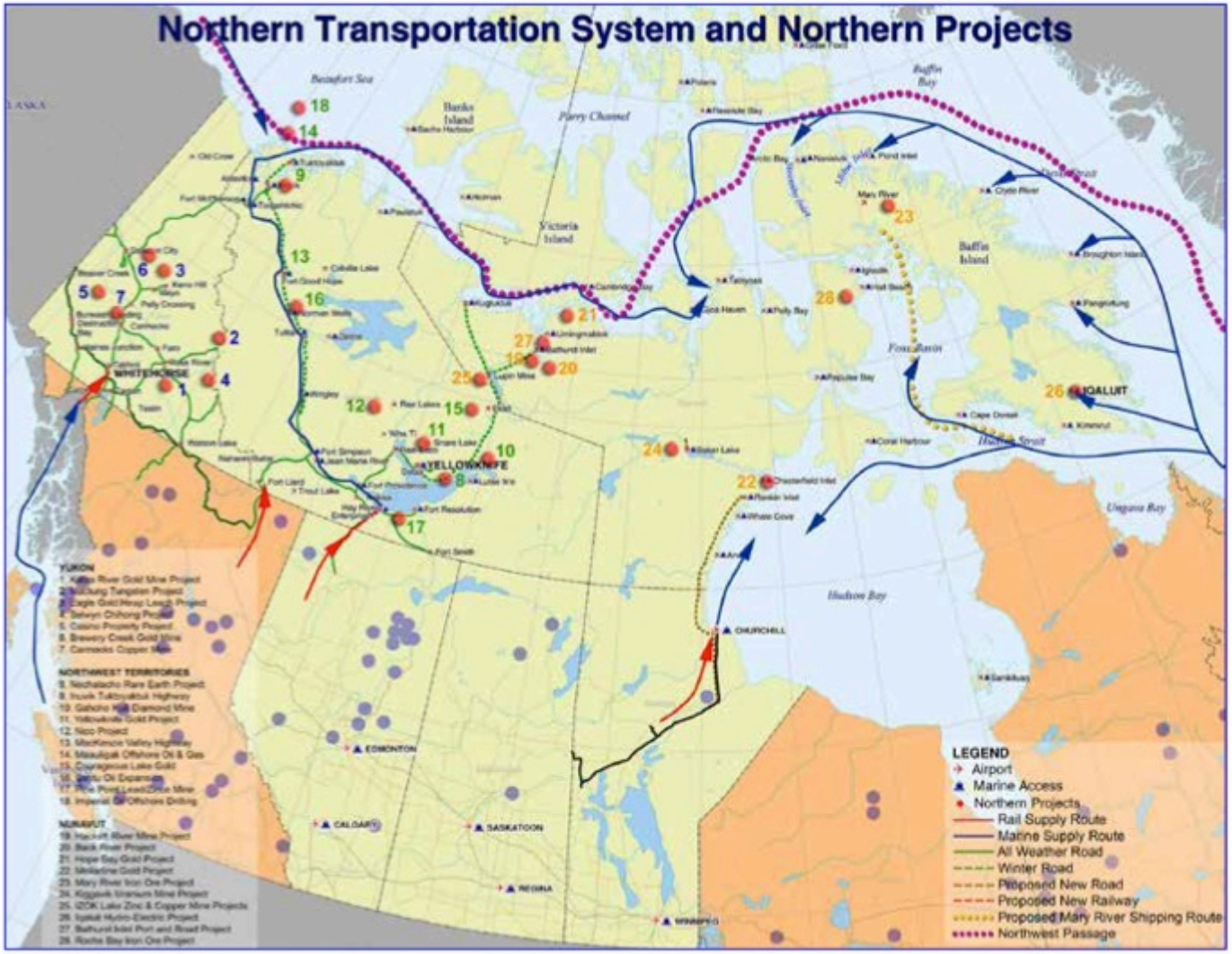
Mineral Resources

- All mines and hydrocarbon developments have a finite life
  - Cominco lead-zinc mine at Little Cornwallis had a life of about 20 years
  - Nanisivik 25 years
  - finite life has an impact on the infrastructure developed for the project, decommissioning expected.
- While there is great potential for resource development, there are many factors which determine whether a resource can be developed:
  - World price for commodity
  - Access to transportation **
  - Logistics support **
  - Environmental impact assessment **
  - Local socio-economic factors (local acceptance) **
  - Availability of skilled workforce **
  - Availability of financing and Insurance**
- Presence of a resource is just a small part of the chain towards possible development.
- Engineering and technology can positively influence many of these factors.

Port Infrastructure

- Marine transport critical for much of North
  - Meagre port infrastructure
  - Small craft harbour Pangnirtung
  - Very high tides in eastern Arctic
- Most resupply goes in over the beach
  - Slow and expensive
- Ports
  - Nanisivik; 13 m, no infrastructure
  - Churchill; 4 berths, 12 m, rail connection
  - Tuktoyaktuk; 5 m, oil terminal

Port & Transportation



Source: Transport Canada, Prairie and Northern Region.

Barriers to Arctic Development

- Transportation
- Infrastructure
- Energy
- People