Alaskan Arctic Pipeline Workshop
November 8 & 9 , 1999 - Anchorage, Alaska

Engineering Assessment of Double Wall versus Single Wall Designs for Offshore Pipelines in an Arctic Environment

Overview

PROJECT OBJECTIVES

To conduct an extensive, non bias engineering and environmental assessment, considering both pros and cons, of single versus double walled designs for offshore pipelines in an Arctic environment.

Primary goals:

- to compare the technical integrity of a single versus double wall pipe for Arctic conditions
- to assess the environmental robustness
- to identify life-cycle comparative costs
- to assess advantages/disadvantages, risks/challenges
- to identify what resources would be required to meet or mitigate those challenges

KEY PERSONNEL

NAME	PRIME CONTRIBUTION	AFFILIATION
Ryan Phillips	Project Manager	C-CORE
Jack Clark	Project Technical Director	C-CORE
Dan Begley	Environmental Issues	AGRA
John Greenslade	Regulatory Affairs	COLT
Alan Hanna	Permafrost Issues	AGRA
Shawn Kenny	Structural Integrity & Numerical Analysis	C-CORE
Nick Lenstra	Design and Construction Management	COLT
Ray McBeth	Arctic Experience	TRI OCEAN
Judith Whittick	Finance & Intellectual Property	C-CORE
Don Woody	Design and O&M Issues	TRI OCEAN
Grant Zelych	Mechanical Engineering	TRI OCEAN

PROJECT SCHEDULE

as of 8 November 1999

1a Literature review & background study

1b Designed vs Actual performance

2 Potential for construction & installation problems

3 Inspection

4 Risks with more complex design & construction

5 Quality assurance & quality control

6 Corrosion

7 Leak detection

8 Costs vs perceived risk mitigation

9 Long term operations & maintenance

10 Structural integrity

11 Secondary containment

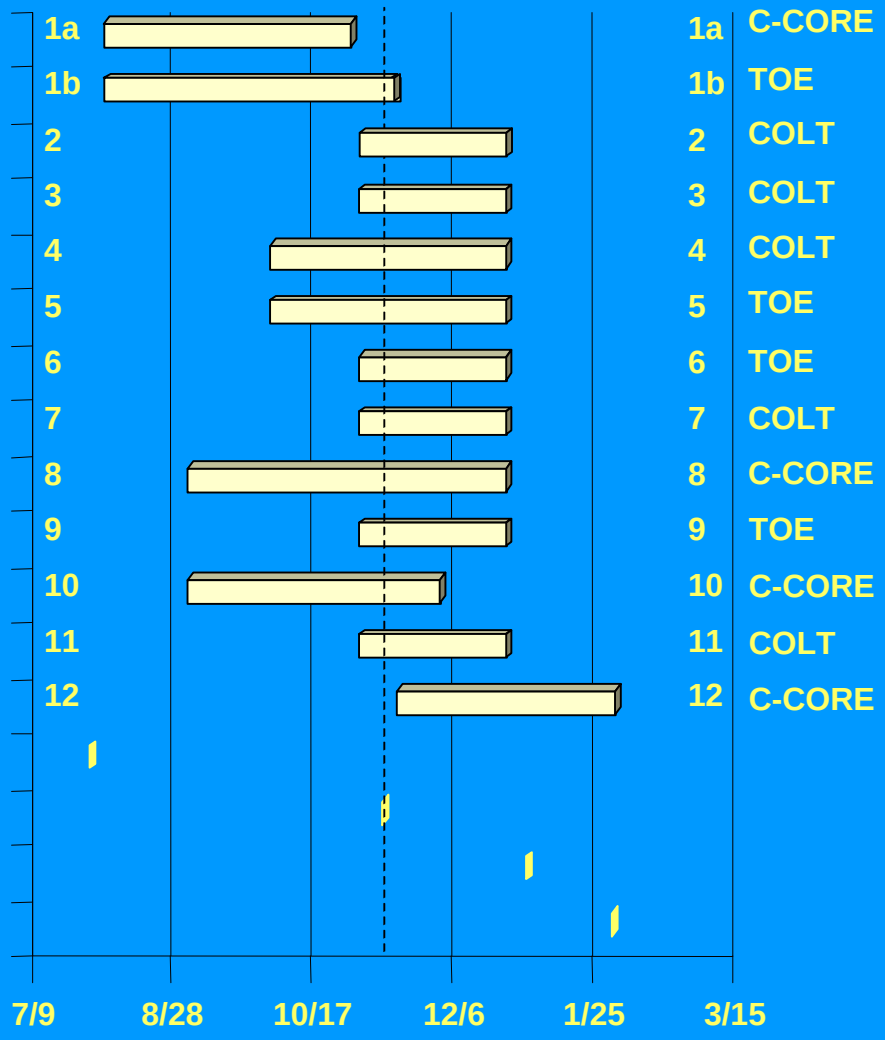
12 Final report

Kick off meeting

Project review meeting

Draft Final Report

Final project meeting



	ACTIVITY DESCRIPTION	Coordinator
1a	Literature review and background study	C-CORE
1b	Designed performance versus actual performance	TRI OCEAN
2	Potential for construction and installation problems	COLT
3	Inspection	COLT
4	Risks associated with more complex design & construction	COLT
5	Quality assurance and quality control	TRI OCEAN
6	Corrosion	TRI OCEAN
7	Leak detection	COLT
8	Costs versus perceived risk mitigation	C-CORE
9	Long term operations and maintenance	TRI OCEAN
10	Structural integrity	C-CORE
11	Secondary containment in the event of a leak occurring	COLT

SPECIFIC ISSUES & PROJECT CONSIDERATIONS

a State-of-the-art review of double walled pipelines

b Review engineering and environmental rationale for using a double walled pipe design for the Alaska Alpine Oil Pipeline Project's Colville River Crossing

c Assess past history and criteria for cased pipe under road and railroad beds to include GRI funded research

d Assess rationale for using and the operational performance of double walled pipe in other offshore applications, both national and international

e Review use of double walled pipe in onshore application, especially related to the petrochemical industry

f Review the proposed Alaska Liberty Island pull-tube concept

SPECIFIC ISSUES & PROJECT CONSIDERATIONS

g Review the U.S. Department of Transportation position on the use of double walled pipe

h Assess technical basis for failure of pipelines due to buckling in reference to the diameter and wall thickness relative to it's influence on selecting either a single or double walled concept

i Assess technical basis for pipe leaks or ruptures due to either corrosion and construction flaws relative to both a single and double wall pipe concepts

j Assess technical basis for potential rupture for both a single and double walled pipe design pipeline from external trauma

k Assess relative concerns for using non-destructive methods to test pipe welds during construction

SPECIFIC ISSUES & PROJECT CONSIDERATIONS

- **l** Assess hydrostatic testing of both pipe concepts
- **m** Review rationale and performance of Canadian Panarctic Drake F-36 subsea flowline project
- **n** Review rationale and performance of BPX's Troika towed bundle flowline project
- **o** Assess risks and reliability in terms of designing for leak containment versus designing for physical protection
- **p** Assess general trade offs between selecting either a single or double walled design concept

SPECIFIC ISSUES & PROJECT CONSIDERATIONS

- **q** Assess life cycle costs associated with between designing, constructing, operating maintaining, inspections both pipeline concepts versus integrity and environmental risks as well as other mitigating measures
- **r** Assess external loads on pipelines in the Arctic offshore versus other locations such as river beds, road and railroad beds as well as offshore in the Gulf of Mexico
- **s** Assess the use of plastic utiliduct pipe as the outer pipe of a dual pipeline system to detect or contain leaks
- **t** Assess use of pipeline risk management systems to mitigate potential leaks and resulting discharge

C-CORE

Independently Funded Research Centre of

Memorial University of Newfoundland

Solving Problems Related to Resource Development

C-CORE EXPERTISE

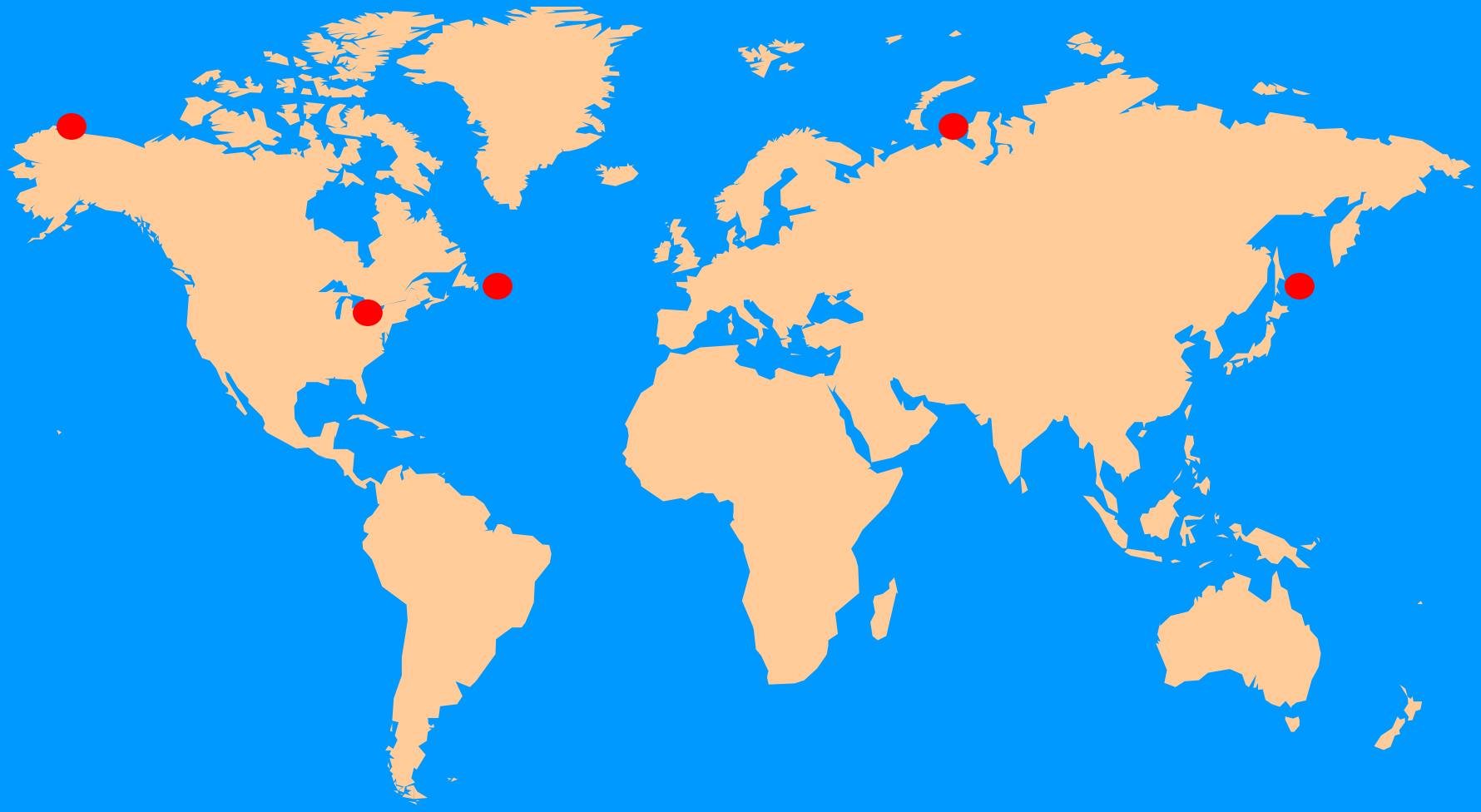
- Geotechnical Engineering
- Ice Engineering
- Centrifuge and Experimental Modelling
- Geophysics
- Remote Sensing
- Intelligent Systems
- Marine Robotics and Subsea Sensing
- Harsh Environments

Founded in 1975

Annual Turnover: CDN$5m (50% from International sources)

47 Full-time staff + 27 Undergraduate and Graduate Students

C-CORE PIPELINES IN ICE ENVIRONMENTS

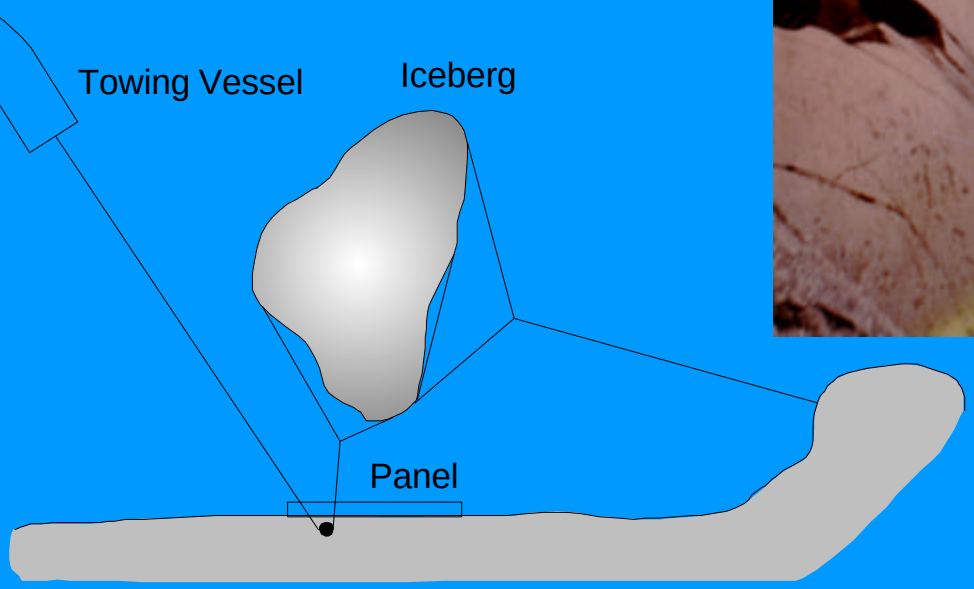


Recent C-CORE Project Locations

RECENT C-CORE PIPELINE PROJECTS

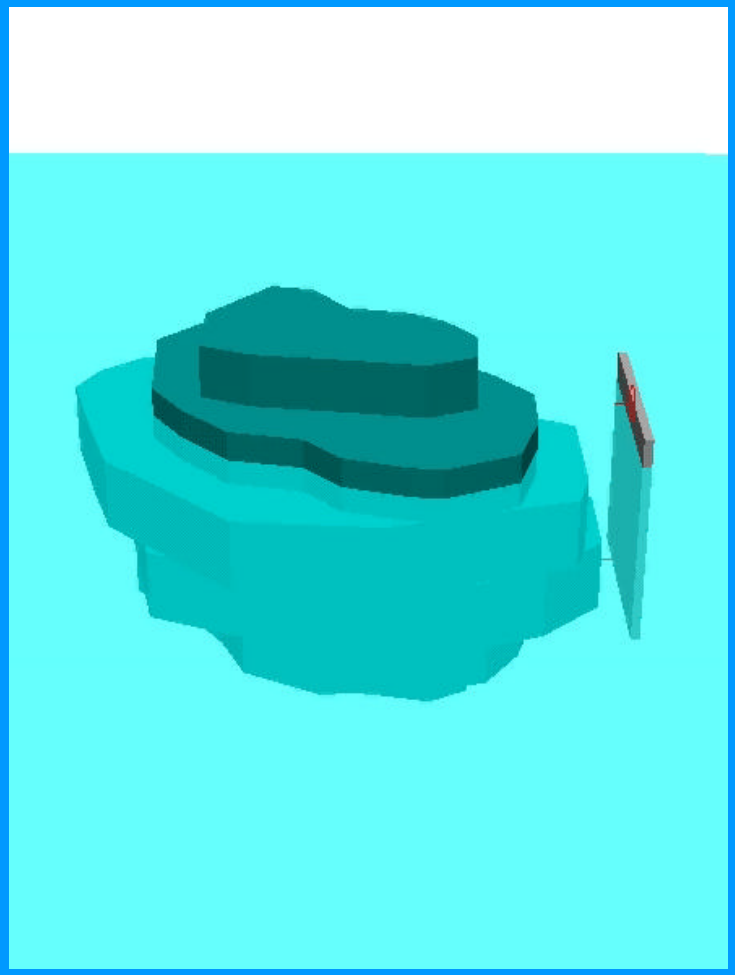
- International 3-year Full Scale Testing Program
- GSC Pipe Bending Study
- NGTL Dynamic Pipe Soil Interaction Modelling
- MMS Offshore Pipeline Study
- PRISE JF Program - 8 year project
- Site Specific Studies Investigating Ice Scour, Pipeline Stress and Risk Analysis
- 50% of C-CORE projects are international

C-CORE ICEBERG IMPACT EXPERIMENT

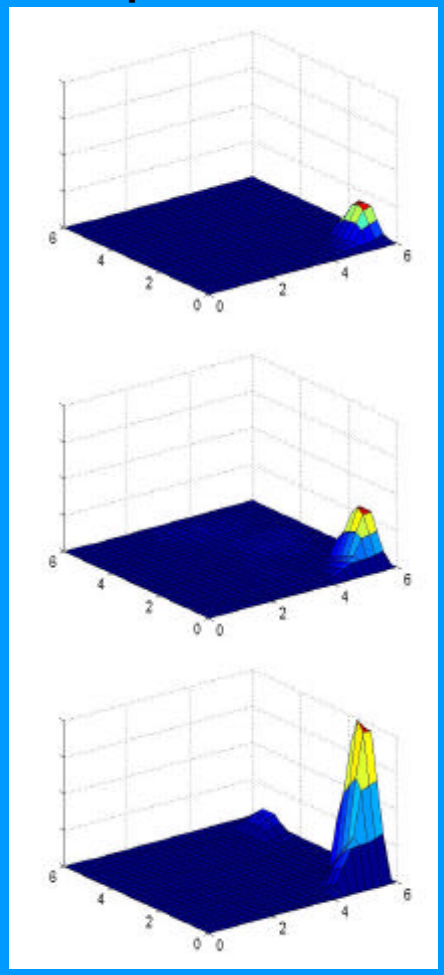


C-CORE ICEBERG IMPACT EXPERIMENT

3D Impact Analysis for Assessment of Experimental Results



Progression of Impact Pressures on a Panel



C-CORE ICEBERG IMPACT EXPERIMENT

SPONSORS

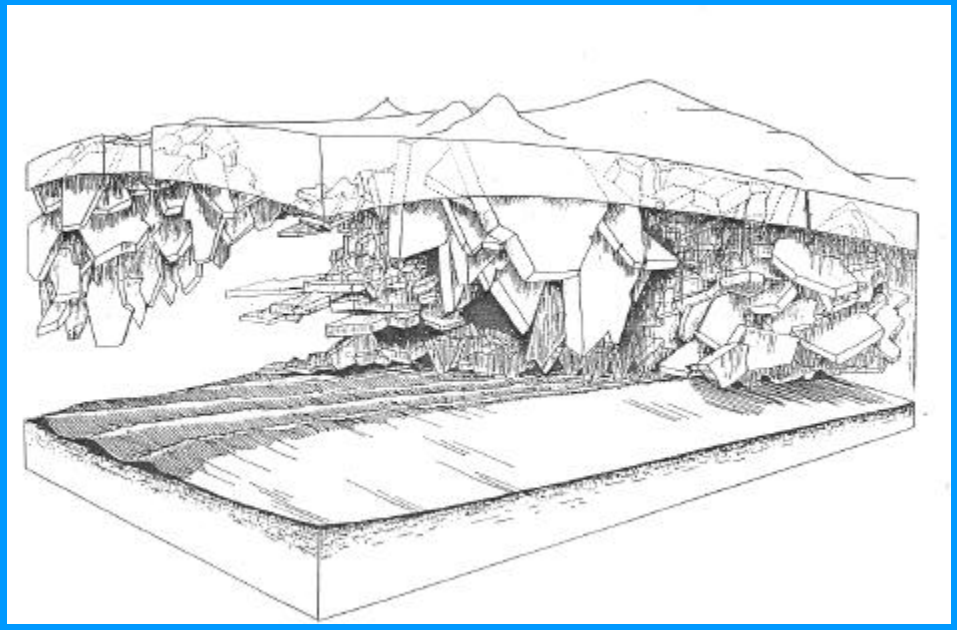
National Energy Board (Canada)
Canada Newfoundland Offshore Development Fund
Petro-Canada Resources
Mobil Research and Development Corp.
Chevron Canada Resources
Husky Oil Limited
Norwegian Research Council
NSERC

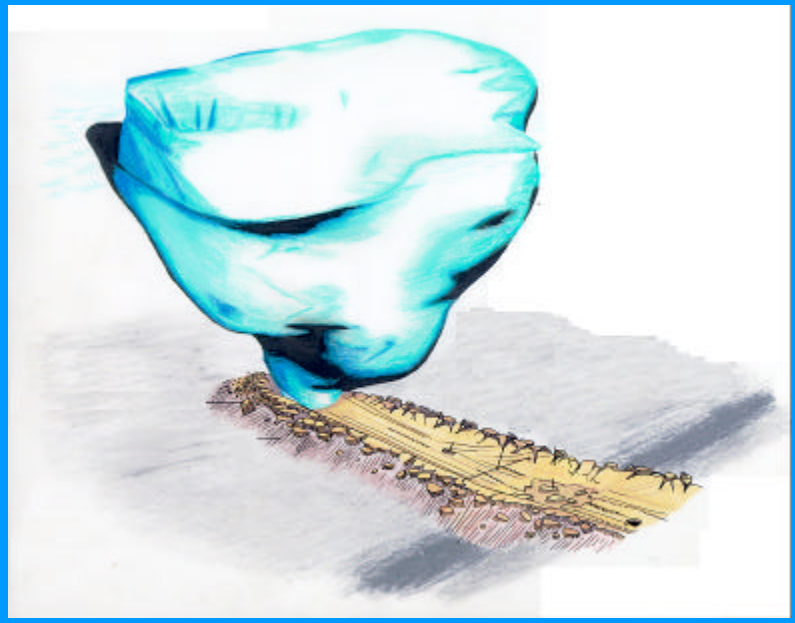
PARTICIPANTS

C-CORE
Mobil Research and Development Corp.
Memorial University of Newfoundland (Ocean Engineering Research Centre)
K.R. Croasdale Associates Ltd.
Norwegian Hydrodynamics Laboratory

PRESSURE RIDGE ICE SCOUR EXPERIMENT (PRISE)

Objective: ***'To develop the capability to design pipelines and other seabed installations in regions scoured by ice, taking into account the soil deformations and stress changes which may be caused during a scour event'.***





- JFP - Risk Framework
- Field Program Initiative
- Okhotsk Workshop '98
- Industry/government workshops

PRESSURE RIDGE ICE SCOUR EXPERIMENT (PRISE)

SPONSORS

ARCO Alaska
British Petroleum
Chevron Canada Resources
Exxon Production Research Co.
Gulf Canada Resources
Marathon Oil Company
Minerals Management Service
Mobil Oil Canada Properties
Mobil Research and Development Corp.
Petro-Canada
National Energy Board
NSERC
NRC (Norway)
Union Texas Petroleum

PARTICIPANTS

Andrew Palmer & Associates (UK)
Atlantic Geoscience Centre (Canada)
Concordia University (Canada)
Environmental Science and Engineering (USA)
Golder Associates (Canada)
Nixon Geotechnical Ltd. (Canada)
Norwegian Geotechnical Institute
University of Birmingham (UK)
U.S. Geological Survey
Woodward-Clyde Consultants (US)

C-CORE CENTRIFUGE MODEL TESTS

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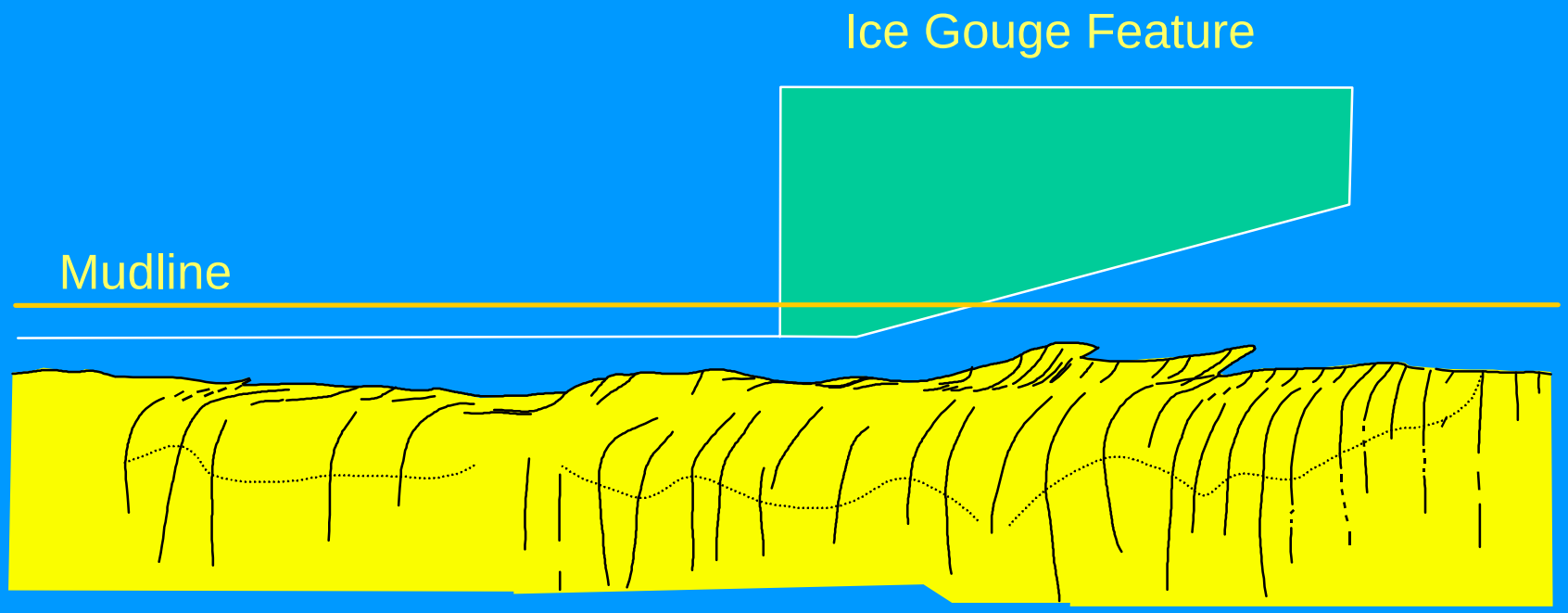
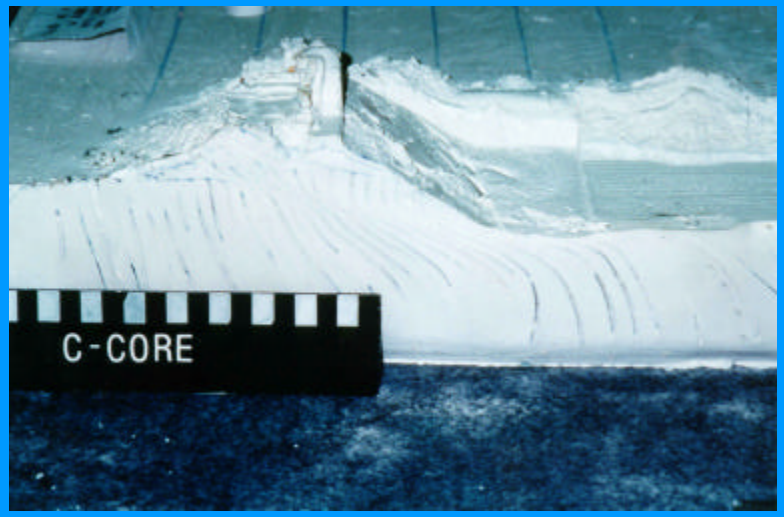
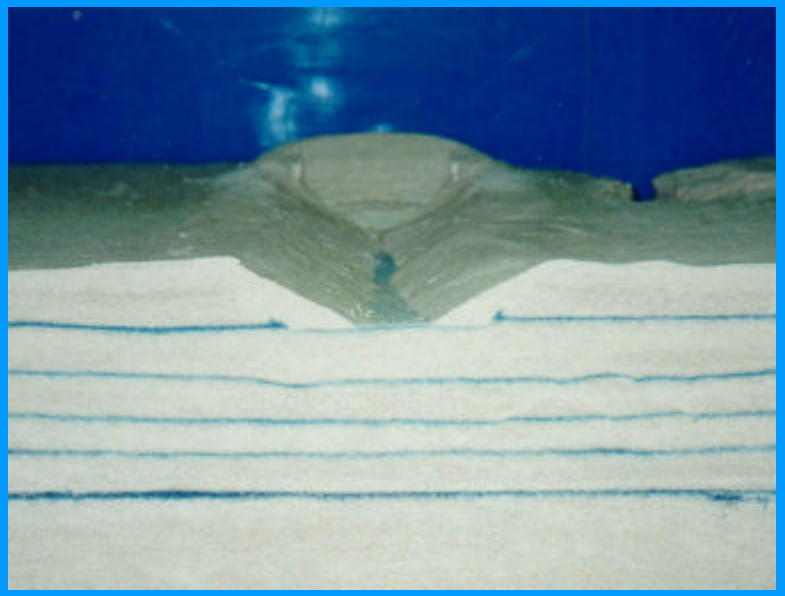


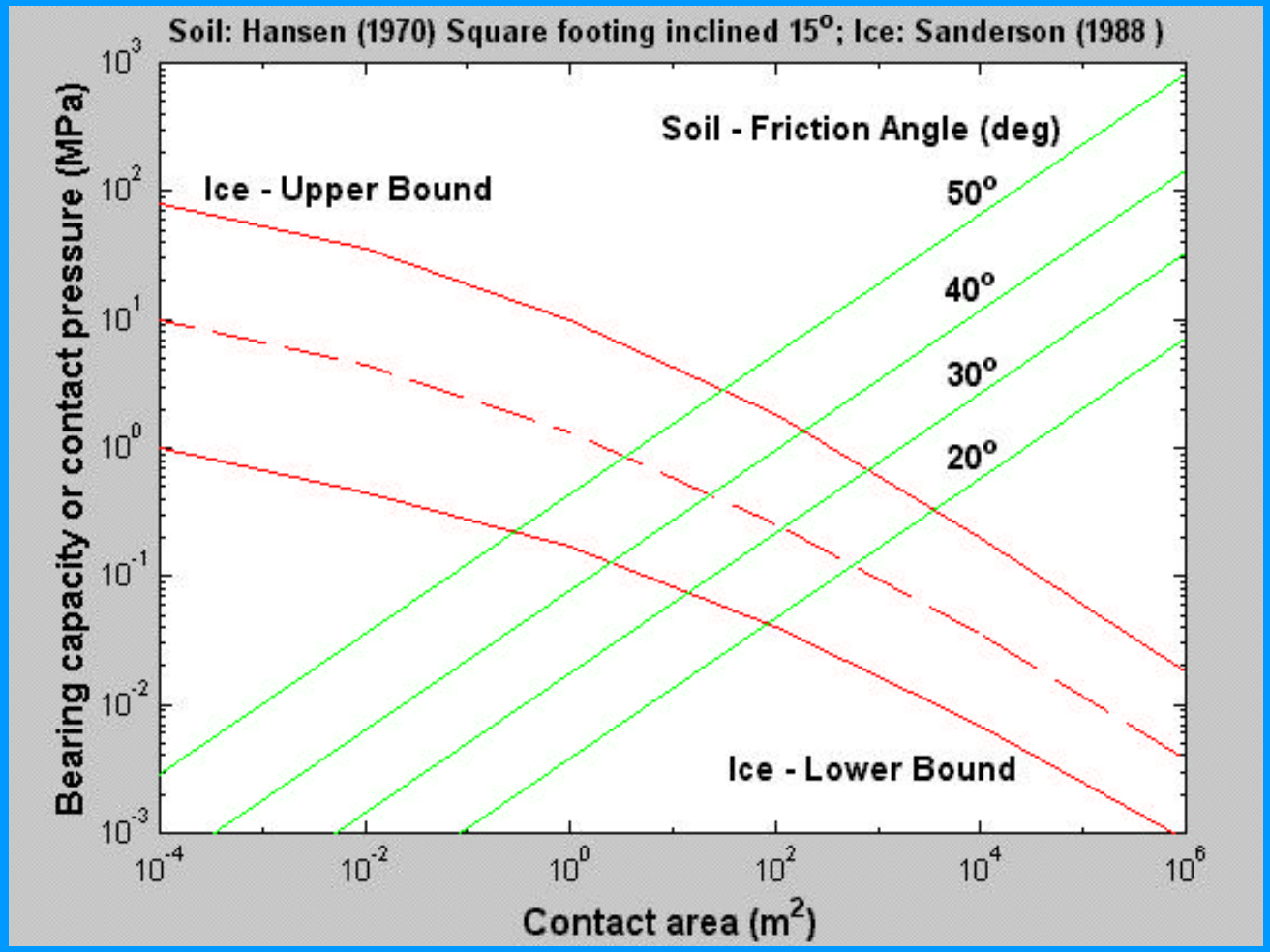
Characterization of Subgouge Soil Deformations

C-CORE CENTRIFUGE MODEL TESTS

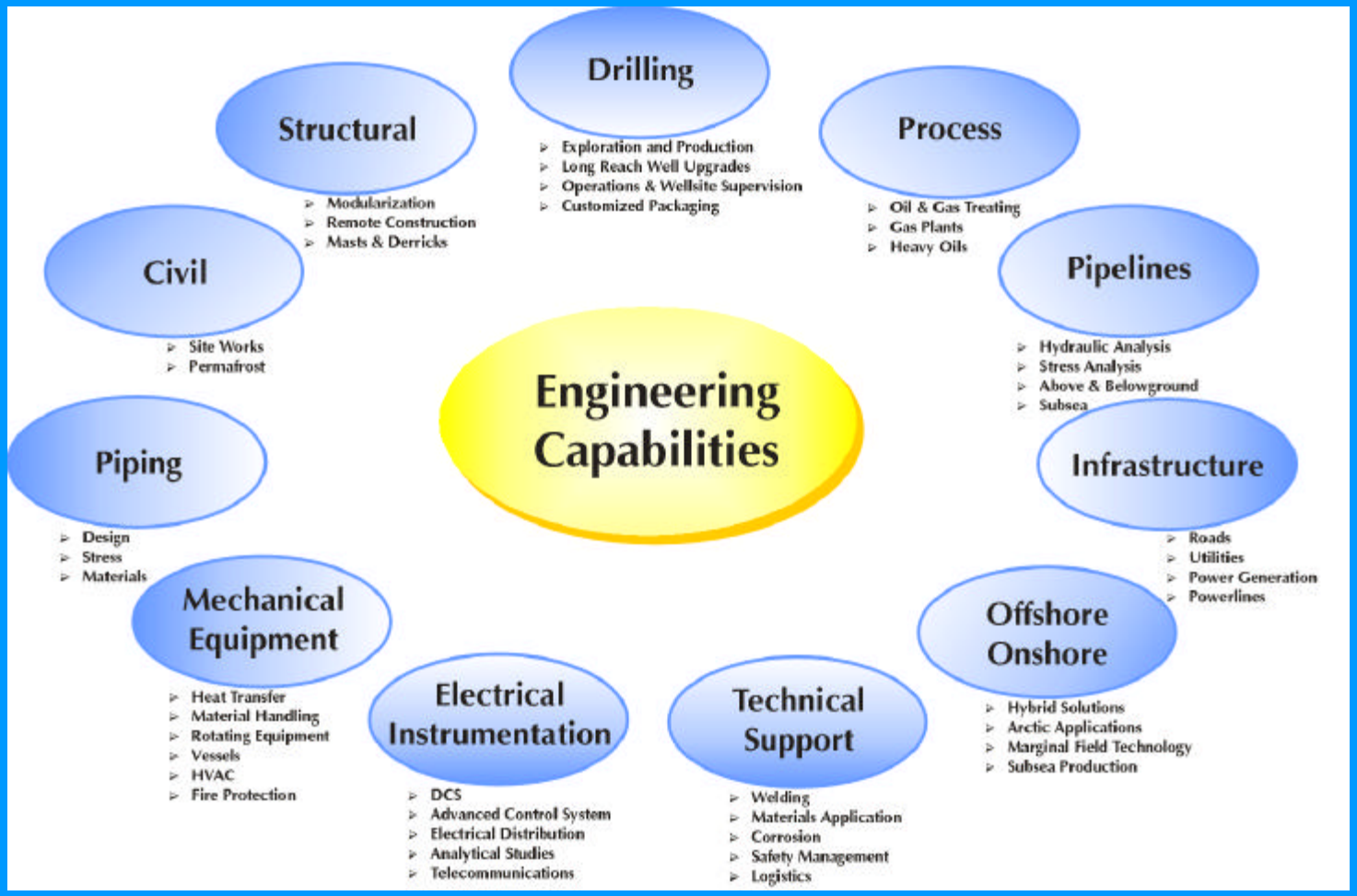




SOIL AND ICE STRENGTH AS A FUNCTION OF CONTACT AREA



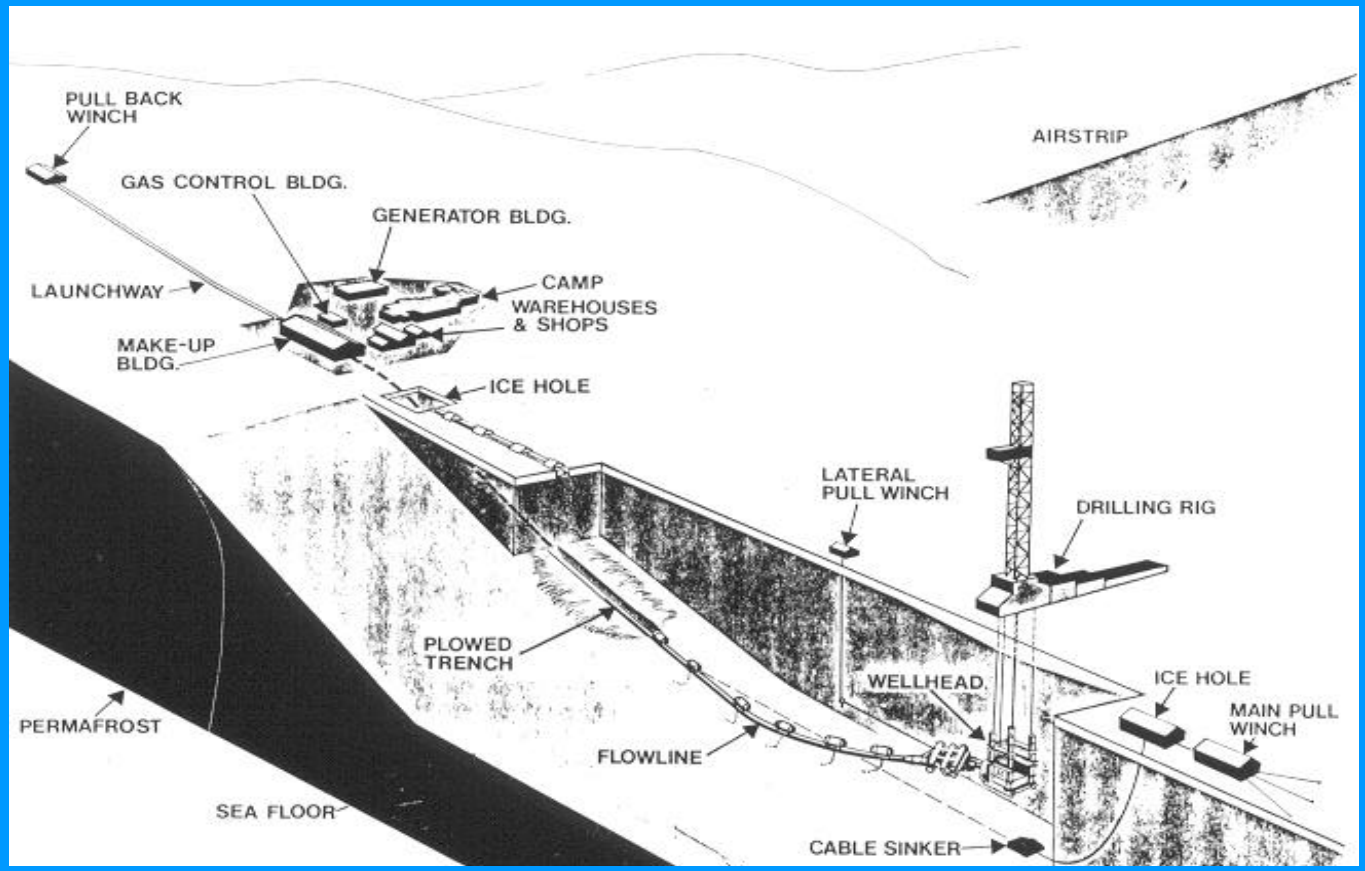
TRI OCEAN ENGINEERING



TRI OCEAN ENGINEERING

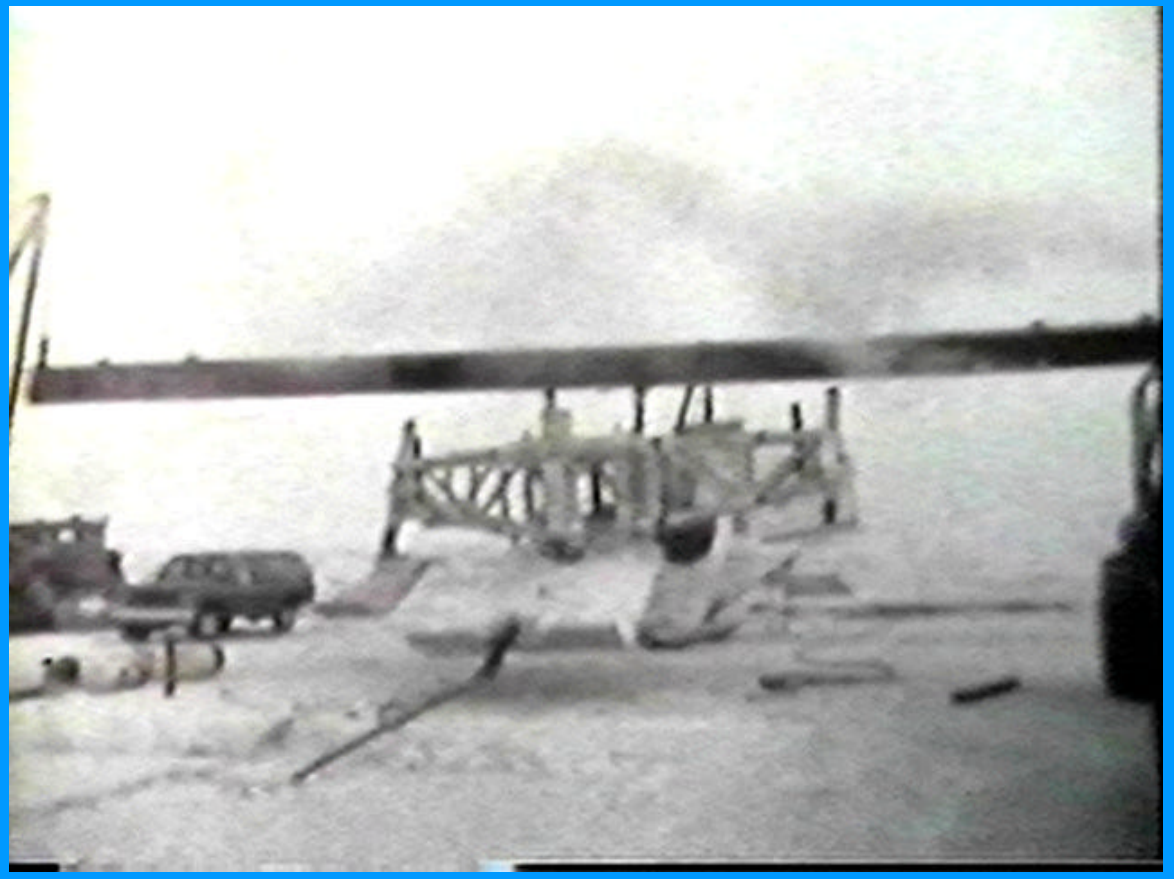
TRI OCEAN US and Canadian Projects

TRI OCEAN ENGINEERING



Drake F-76 Test Facilities

TRI OCEAN ENGINEERING

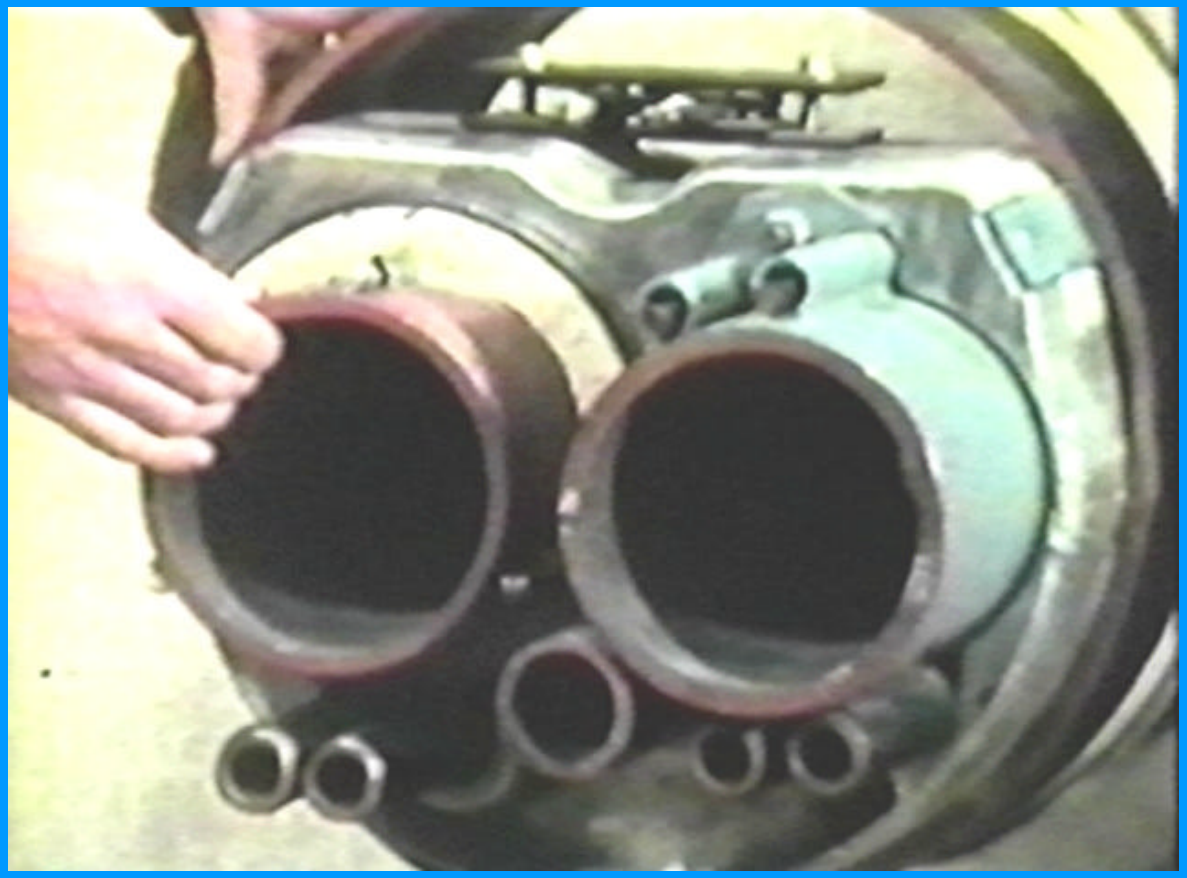


Drake F-76 Plow

TRI OCEAN ENGINEERING

Drake F-76 Pulling the Pipe Bundle

TRI OCEAN ENGINEERING



Drake F-76 Flowline Bundle

RECENT TRI OCEAN ENGINEERING PIPELINE PROJECTS

HEAVY OIL PIPELINE DETAILED DESIGN AND INSTALLATION

- Caroline gathering system expansion
- Greater than 3/4” wall thickness for HSE risk and corrosion risk mitigation

VANKOR SUBSEA PIPELINE

- Engineering analysis for pipeline design, route selection and shore approach for Vankor crude export pipeline, Kara Sea, Russia
- Heavy wall, single pipe construction methods and cost analysis

DRAKE POINT F-76 TEST FACILITIES

- Under-ice subsea pipeline abandonment of flowline, Northwest Territories, Canada
- Evaluation of current status and abandonment techniques

ABOVE VERSUS BELOWGROUND PIPELINE

- Conoco YK field in Russia
- Evaluation of economic, corrosion issues and cost

AGRA Earth & Environmental

AGRA Expertise

- Environmental Impact Assessment
- Environmental Protection Planning
- Environmental Testing/Analysis
- Contaminant Assessment
- Public Consultation
- Human Environment
- Geotechnical Engineering
- Permafrost Engineering
- Materials Engineering
- Water Resources
- Hydrogeology

- Wholly owned subsidiary of AGRA Inc.
- Full service environmental, geotechnical, and materials company offering engineering, scientific, and regulatory solutions
- Staff of more than 1,600 professionals operating from more than 65 offices throughout North America, and strategic international markets
- AGRA Inc. is one of Canada's largest international engineering, construction, environmental and technology corporations. AGRA employs approximately 7,000 people and operates 186 offices in 24 countries

RECENT AGRA PIPELINE PROJECTS

- Baydaratskaya Bay Crossing
- East Siberia to Far East Pipelines
- China - S.Korea - Japan Marine Pipeline
- Vancouver Island Gas Pipeline
- Norman Wells Pipeline
- Arctic Gas Pipeline
- Alaska Highway Natural Gas Pipeline
- Polar Gas Pipeline

PIPELINE ISSUES

- Corridor selection and hazard mitigation
- Stream and river crossing design
- Slope stability and debris flow
- Permafrost, geothermal and frost heave
- Human environment
- Offshore applications
- Geotechnical & soil/pipe interaction analysis
- Seismic hazard analysis
- EIA and EIS compliance reports

COLT ENGINEERING

Badami River Crossing

COLT ENGINEERING

Badami River Crossing

RECENT COLT ENGINEERING PIPELINE PROJECTS

BADAMI OILFIELD DEVELOPMENT PROJECT

- 25 miles of 12” - oil; 1415 psi, 35 miles of 6” - gas; 3300 psi
- Design, permitting and field support during construction
- DOT pipelines built in 1998 with combination of A/G and U/G
- Major river crossings were buried - 2 wet crossings
- Strain based design used for buried sections

Cold buried pipeline option for Badami

- Feasibility study and permit applications
- Comparable to the Norman Wells pipeline in Canada
- Successfully passed the Coastal Consistency Review

NORTHWEST EILEEN AND SCHRADER BLUFF

- Conceptual designs of various pipeline alternatives:
- Single phase and multi-phase; Conventional A/G
- Cold buried; Buried in a road; Laid on sleepers.

PROJECT MANAGEMENT PLAN