8 Ice and Physical Oceanography

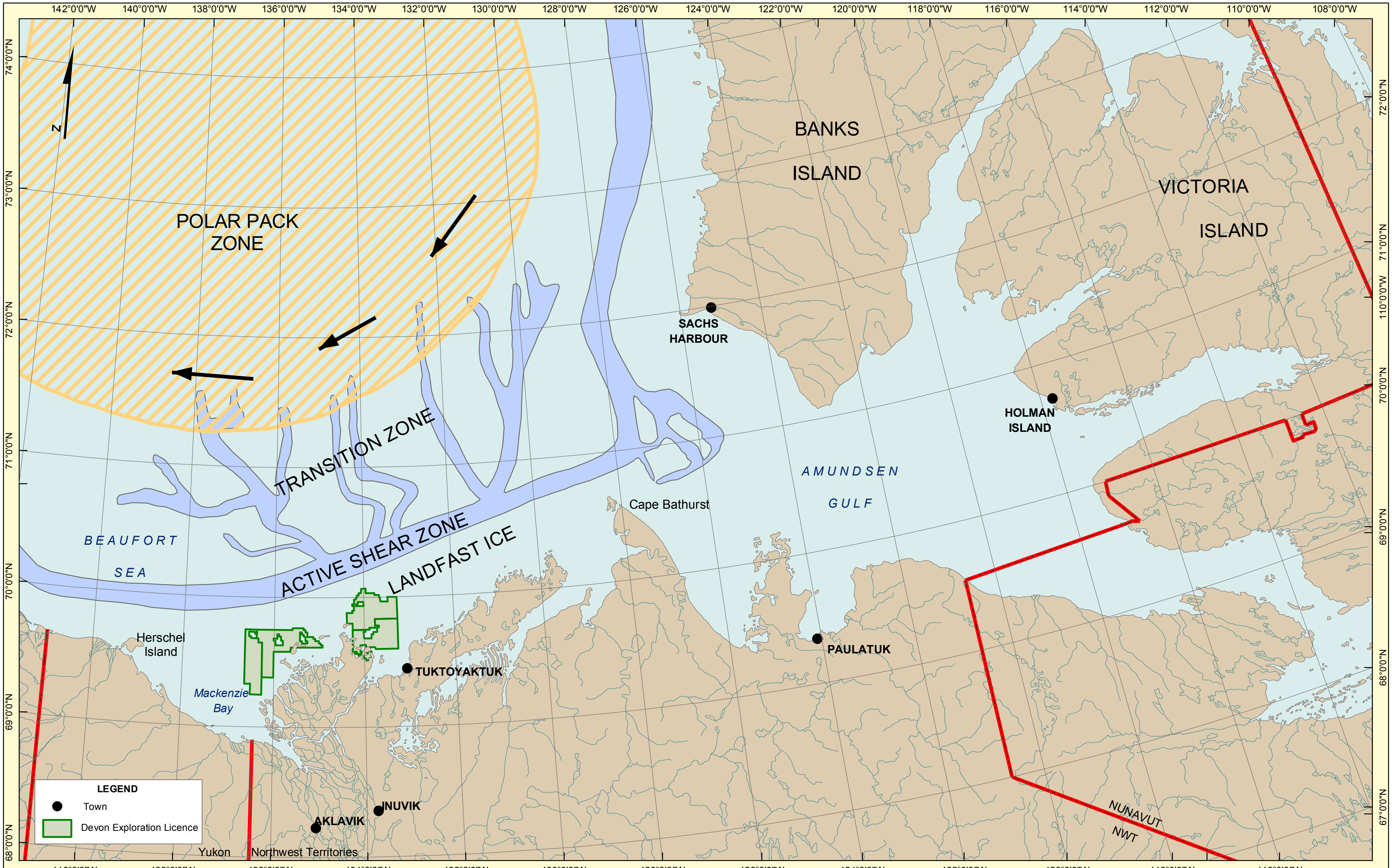
Ice, ocean waves and currents are key attributes of the physical environment of EL 420, affecting habitat conditions and human activities in the area. Program interactions with ice, ocean waves, and currents are also important considerations in Program planning and design. Effects of the Program on ice and the physical ocean environment are discussed in this section. Effects of ice and physical oceanography on the Program are discussed in Section 21: Effects of the Environment on the Program.

8.1 Baseline Conditions

Baseline information on sea ice and physical oceanographic conditions in and around EL 420 was obtained from the following sources:

- a review of the data, reports and papers produced from past industry, government and other studies of Beaufort Sea ice and oceanography, spanning the period of exploration activity from the early 1970s to the late 1980s
- an analysis of landfast ice formation, extent and breakup patterns in the Program area, from 11 years of recent National Oceanic and Atmospheric Administration (NOAA) satellite imagery (1991 to 2002) (Wright and Canatec 2002)
- an ice reconnaissance in mid-February 2003, involving ice observations at Devon's nine preliminary offshore drill targets and ice movement measurements at three sites (Wright and Spedding 2003; ASL 2004)
- observations of sea ice, weather and ocean conditions in the Beaufort Sea and some recent variations in these conditions, obtained from the traditional knowledge of northern residents

During freeze-up, winter and breakup periods, three ice zones are evident in the region (Figure 8-1): the landfast ice zone, the seasonal (i.e., transition) pack ice zone, and the permanent polar pack. From late October to late November, landfast ice begins to form in the shallow nearshore waters of the Beaufort Sea, including the majority of EL 420. The outer edge of the landfast ice progresses northwards in a series of discrete steps caused by periodic winds from the north that cause ridging in the thin, growing ice. Some of these ridges ground on the seafloor and, with time, stabilize the ice cover at increasing distances away from the coastline. The outer edge of the landfast ice normally stabilizes near the 20-m water depth contour in late December to mid-January. In the western portions of EL 420, these dates are more variable depending on wind conditions in the late fall and early winter of any given year (Table 8-1). Landfast ice is quite stable. The surface of landfast ice is generally quite smooth out to water depths of six to ten metres, becoming progressively rougher with pressure ridges and rubble, at increasing depths (Figures 8-2 and 8-3).



devon

KA036 - A Schematic Illustration of the Landfast Ice, Seasonal Pack Ice and Polar Pack Ice Zones in relation to EL420
March 30, 2004

Area of Detail

0 30 60 90 120
Kilometres

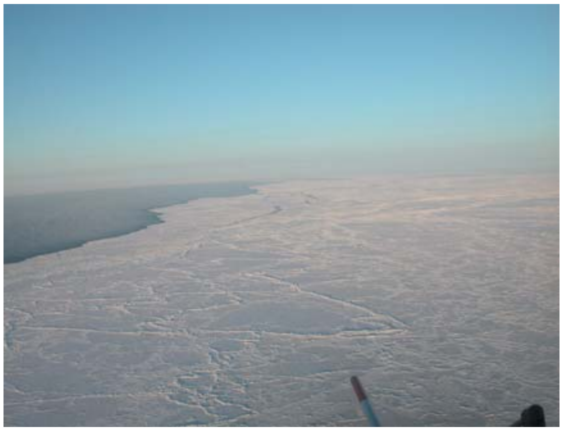
Data Sources:
Digital Chart of the World
AMEC
Projection: Universal Transverse Mercator Zone 8 (NAD 27)

Figure 8-1

Schematic Illustration of the Landfast Ice, Seasonal Pack Ice and Polar Pack Ice Zones in the Vicinity of EL 420

Tiggak

Paktoa

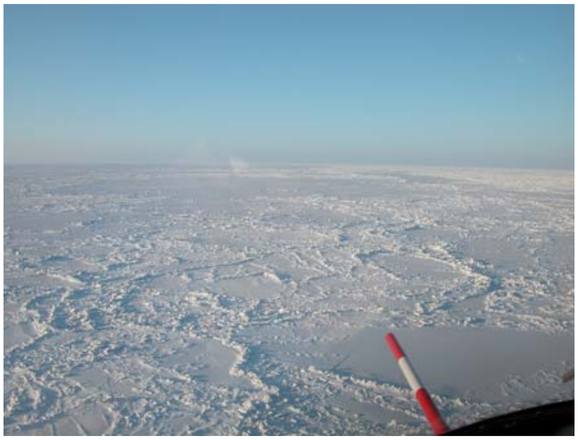


Outer Edge of Landfast Ice, Northwest of Paktoa

Figure 8-2 Typical Views of the Landfast Ice at Three of Devon's Drilling Targets in the Western Part of EL 420, in mid-February 2003

Tuwak

Nayak South



Outer Edge of Landfast Ice, North of Nayak South

Figure 8-3 Typical Views of the Landfast Ice at Three of Devon's Drilling Targets in the Eastern Part of EL 420, in mid-February 2003

Breakup of the landfast ice normally begins in mid-June to early July (Table 8-1), with total ice clearance in water depths to about 20 m by late July. Across the southern Beaufort Sea, the open-water season usually lasts for about three months, from mid-July to mid-October. Wave heights are typically low (one metre or less). Extreme storm waves (up to five to six metres) can occur during severe fall storms but are rare, since wind fetches are limited by ice. Ocean currents are generally small, in the range of 0.2 m/sec or less. The Mackenzie River outflow has a strong influence on currents, particularly in the western parts of EL 420, creating current flows that are typically towards the northeast, with maximum values in excess of 0.5 m/sec at peak discharge, in early summer.

During the open-water season, heavy pack ice can move into the nearshore waters of the Beaufort Sea under the influence of strong winds from the north. These ice intrusions result in the high degree of variability in the length of the open-water season that is observed from year to year. Heavy pack ice generally grounds in 12–15 m of water and does not significantly affect the shallower inshore waters where most of EL 420 is located. In these shallow areas, any drifting pack ice generally consists of small floes (i.e., tens of metres to several hundred metres in diameter) with ice thickness and ridging that are not excessive.

Date ranges for the first occurrence and break up of landfast ice at each of Devon's nine potential offshore drilling sites are summarized in Table 8-1. These date ranges determine the schedule for spray ice pad construction and subsequent drilling activities.

Table 8-1 Date Ranges for Landfast Ice Occurrence at Drill Targets (1991–2002)

Target	Date Range[1] for Initial Occurrence of Landfast Ice at Drill Target	Date Range[2] for Disappearance of Landfast Ice from Drill Target
Tuwak	October 20 to January 3	June 21 to July 14
Nayak South	October 23 to February 1	June 17 to July 14
Kekertak	October 23 to January 2	June 21 to July 14
Pullen North	October 16 to December 16	June 21 to July 19
Nipterk North	October 20 to January 20	June 17 to July 14
Omat	October 20 to January 20	June 13 to July 14
Minuk East	October 20 to never[3]	June 17 to July 19
Paktoa	October 20 to February 16	June 2 to July 19
Tiggak	October 20 to February 16	June 1 to July 19

Notes: 1 From the date of the first satellite image that shows landfast ice cover at a drill target
2 From the date of the first satellite image that shows that a drill target is free of landfast ice cover
3 In winter 1998–1999, landfast ice did not form at this site

These data show that landfast ice can form anywhere from late October to mid-February, depending on the particular location and year. The timing of breakup is somewhat more consistent, varying between early June and mid-July, depending on the location and year. Further details are provided in Wright and KAVIK-AXYS Inc. (2004) and Wright and Canatec (2002).

Local residents have reported a variety of recent observable changes in weather and ice characteristics (Krupnik and Jolly 2002; Riedlinger and Berkes 2000; Section 18: Traditional Knowledge and Land Use), such as:

- generally warmer air temperatures in both summer and winter
- different wind patterns, in particular, more winds from the east
- thinner ice offshore and melting of permafrost onshore
- more variability in freeze-up and breakup time frames

- narrower landfast ice zones and more and wider leads at the landfast ice edge
- fewer ice intrusions from the polar pack and longer open-water seasons

Several studies have been conducted on the potential effects of climate change on Beaufort Sea ice conditions (e.g., Crocker and Carrieres 2000a, 2000b; Falkingham et al. 2001; Melling 2002, pers. comm.), but they do not indicate statistically significant variations in recent versus past Beaufort Sea ice conditions. While potential effects of climate change on Beaufort Sea ice conditions are of long-term interest, they are not likely to affect the Program, given its timing and duration (i.e., four years between 2005 and 2009).

Devon examined 11 years of satellite imagery (1991-2002) to compare landfast ice growth, extent and breakup patterns with historic data from the 1970s and 1980s (Wright and KAVIK-AXYS Inc. 2004). The conclusions of this analysis are:

- Landfast ice occurrence dates are slightly later in recent years, in water depths of 10 m and more, in the western part of EL 420. The later dates correspond with higher net winds from the east and south during freeze-up and early winter (as measured at Tuktoyuktuk). This is consistent with observations by local residents.
- Positions of the landfast ice edge in recent years lie within the expected boundaries, as defined by older data. All of Devon's potential drilling sites are located in the landfast ice except Minuk East, in about 14 m of water, which was slightly beyond the outer edge of the landfast ice zone in 2001/02. Landfast ice is expected to cover Devon's potential drilling sites in all but the most exceptional of winter seasons.
- The range of ice breakup dates at the drilling sites is considerably narrower than the range seen in landfast ice formation dates, and well within the ranges observed in the 1970s and 1980s.

In recent years, there is a trend towards shorter landfast ice seasons at the Paktoa site, related to more easterly and southerly winds in some years, which tend to delay the occurrence of landfast ice.

Concerns have been expressed about the effect on operations of open-water leads or large fractures in the ice cover during winter. These occurrences are only seen in deeper water areas (15–20 m), in unusual circumstances, near the northern boundary of the landfast ice. Devon's lease areas should not be affected by any major ice fractures, except perhaps under unusual circumstances in the deeper western sites.

It has been suggested that a significant reduction in ice thickness has been seen in the Beaufort Sea over the last decade. Available data and an ongoing ice thickness measurement program in the seasonal pack ice north of Tuktoyaktuk (Melling 2000) and spot measurements in the landfast zone (Wright and KAVIK-AXYS Inc. 2004), do not indicate significant changes in sea ice thickness in recent years.

8.2 Impact Assessment

Ice, ocean waves and currents are identified as VECs because they are key attributes of the physical environment of EL 420. Program interactions with ice, ocean waves and currents are also important considerations in Program planning and design. Measurable parameters used to determine Program effects are shown in Table 8-2.

Because there are no scientifically defined methodologies to predict or assess the potential effects of Program activities on sea ice and physical oceanographic conditions, qualitative comparisons and experience-based judgments are used to assess program-related and cumulative effects. Potential Program effects are characterized using the effect attributes in Table 8-3.

Table 8-2 VECs and Measurable Parameters for Ice and Physical Oceanography

VEC	Measurable Parameters
Landfast ice cover	• timing of formation/breakup • maximum extent • thickness • roughness
Landfast ice movements	• magnitudes, directions, patterns
Waves	• heights, periods, patterns
Currents	• speeds, directions, patterns

Table 8-3 Effect Attributes for Ice and Physical Oceanography

Direction	
Negative	Change in the VEC is persistent and beyond the bounds of natural variability
Neutral	Change in a VEC is not discernable within the bounds of natural variability, on either regional or local scales
Magnitude	
Low	Effect on VEC is observable, but well within the bounds of natural variability
Moderate	Effect on VEC is observable, but beginning to approach the boundaries of natural variability
High	Effect creates changes in VEC that lie outside the bounds of natural variability
Geographic Extent	
Local	Effect discernable within a few hundred meters to two kilometres of the drill site (or marine activity in the case of pre-operations – for example, a ship transit)
Regional	Effect discernable beyond two kilometres
Duration	
Short term	Effect will occur only during one drilling season, or for short time periods during that season (for example, in the case of waves)
Medium term	Effect will occur across seasons and years during the drilling program
Long term	Effect will persist beyond the drilling program

An effect is significant if it is negative, high, regional and the duration of the effect is medium to long term.

Possible year-to-year modifications in the ice and physical oceanographic regimes as a result of the Program are not expected to be discernable in the context of natural variability. The scale of program-related activities and facilities is not significant in the context of the physical oceanographic processes and ice regime of the southern Beaufort Sea (Table 8-4) and no mitigation measures are required. Therefore, Program effects on ice and physical oceanography are predicted to be not significant.

8.3 Mitigation Measures

Because no significant effects are predicted, no mitigation measures are required.

8.4 Residual Program Effects and Significance

No significant residual effects on ice and physical oceanography are expected from the Program. .

8.5 Cumulative Effects and Significance

No significant residual effects are predicted. There is no known existing or reasonably foreseeable future offshore activities or facilities near EL 420, with effects on ice and physical oceanography that would overlap with the Program. Therefore, cumulative effects are expected to be not significant.

Table 8-4 Program Effects on Ice and Physical Oceanography

Potential Effect	Interaction with VEC	Level of Effect				Effect Significance	
		Direction	Magnitude	Extent	Duration	Program-related Effect	Cumulative Effect
Pre-operations and Operations							
Effect of platform mobilization, supply and setdown on waves and currents	Program effects are comparable to routine marine operations	Neutral	Low[1]	Local	Short term	Not significant	Not significant
Presence of platform and grounded ice pad on: • timing of freeze-up • growth and extent of landfast ice • timing and pattern of landfast ice breakup • ice thickness • ice roughness • ice movement	Program effects are very localized in a large scale, highly variable natural ice environment	Neutral	Low[2]	Local	Short term	Not significant	Not significant
Closure							
No effects	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Notes: 1 After setdown of the SDC or LTD, waves and currents will be amplified in the local area within several hundred metres of the structure.

2 No influence on the timing of freeze-up, the growth and extent of the landfast ice cover, or on the timing and pattern of landfast ice breakup in spring

No influence on the thickness, roughness or movement of the landfast ice cover regionally

The ice will be rougher within a few hundred metres of the ice pad for all structures due to ridge and rubble formation during ice movement events

Winter ice movement patterns may be altered within 1 km to 2 km of the platform

8.6 Monitoring

Monitoring programs are summarized in Table 8-5.

Table 8-5 Monitoring Programs for Ice and Physical Oceanography

Potential Effects	Program Objectives	General Methods	Reporting	Implementation
No significant residual effects	• Provide information for Program planning and scheduling • Check platform stability • Ensure operational safety	• Routine ice, weather and wave observations and forecasts, regional and drill site-specific • Ice interaction, ice force and platform performance measurements and observations at the specific drilling location • Pre-defined operational decision-making and safety alert systems	As specified by the DPA	Existing regional forecasting systems and program-specific systems by Devon
	• Check impact predictions	• Performance monitoring for platform stability	As specified by the DPA	Devon

9 Geology, Terrain and Sediments

Geology, terrain and sediment are key attributes of the physical environment of EL 420 affecting subsea habitat conditions and Program operating conditions.

9.1 Baseline Conditions

EL 420 overlies four physiographic regions (Figure 9-1), consisting of alternating submerged plateaus and troughs (O'Connor 1982):

- the Mackenzie Trough and the Kringalik Plateau in the Western Block
- the Akpak Plateau and Kugmallit Channel in the Eastern Block

In general, trough regions have been infilled with a greater thickness of soft silts and clays, while plateau regions have coarser grained, higher strength silts and clays. From an engineering perspective, the latter are preferred for drilling platform foundations. Klohn-Crippen (2003) completed a geotechnical investigation of the shallow seabed sediments at eight sites within EL 420 to confirm foundation conditions for design purposes.

Subsea permafrost is widespread throughout the Beaufort Sea, reaching a thickness of up to 700 m in some areas. In shallow waters, the top of the permafrost zone might be only a few meters below the seabed. The zone of overlying unfrozen surficial sediments increases as the water depth increases (AMEC 2002). The Eastern Block of EL 420 falls within the continuous ice-bonded sediments zone, while sediments in the Western Block range from little or no, through discontinuous to continuous, ice-bonded conditions. Devon will use refrigerated KCl drilling mud that can be chilled to –1˚C without freezing, to reduce the potential for thawing of permafrost during drilling.

The Beaufort Sea is considered seismically active, although the intensities of earthquakes tend to not be extreme (magnitude $M<4$). Historical data do not indicate that earthquakes have occurred in the immediate vicinity of EL 420. The design of the drilling platforms and the drilling Program operations take into account potential seismic activity. Program activities will not exacerbate the effects of natural seismic activity on seabed integrity in the area.

Gas hydrates are a crystalline form of gas molecules encased within a sphere of water molecules. The most abundant gas molecule present is methane. It is expected that gas hydrates may be present beneath portions of EL 420. Use of chilled drilling muds and other drilling procedures will alleviate potential effects of shallow sediment instability and subsidence in and around the drilling platform caused by permafrost degradation and gas hydrate release.

9.2 Impact Assessment

Because the scale of Program-related activities and facilities is very small in the context of the geology, terrain and natural processes affecting sediments in the Program area (Table 9-1), effect attributes (e.g., direction, magnitude, geographic extent) were not evaluated for geology, terrain and sediments. No unique landforms have been identified in the immediate vicinity of the nine offshore drill sites. Potential localized effects of drilling on permafrost and related seafloor stability will be effectively addressed by Program design (Table 9-2). Therefore, the Program will have no significant effects on these components. The effects of earthquakes on the Program are discussed in Section 21: Effects of the Environment on the Program.

Table 9-1 Program Effects on Geology, Terrain and Sediments

Potential Effect	Level of Effect	Effect Significance: Program-related Effect	Effect Significance: Cumulative Effect
Pre-operations			
• Sediment disturbance due to platform liftoff • Sediment compaction and disturbance due to platform setdown	• No discernable effect due to very small area affected (less than 0.0002% of the LSA) and highly dynamic and variable substrate conditions in the landfast ice zone of the Mackenzie Delta	Not significant	Not significant
Operations			
Effects of drilling on: • Subsea sediments (drill cuttings) • Unique landforms • Sea floor stability (permafrost thawing and release of frozen gas hydrates, seismic activity)	• No discernable effect on subsea due to highly dynamic and variable substrate conditions in the landfast ice zone of the Mackenzie Delta • No effects on unique landforms • Potential effects on sea floor stability effectively addressed by Program design and mitigation (Table 9-2)	Not significant	Not significant

9.3 Mitigation Measures

Mitigation measures to address effects on geology, terrain and sediments in the Program area are provided in Table 9-2.

Table 9-2 Mitigation Measures for Effects on Geology, Terrain and Sediments

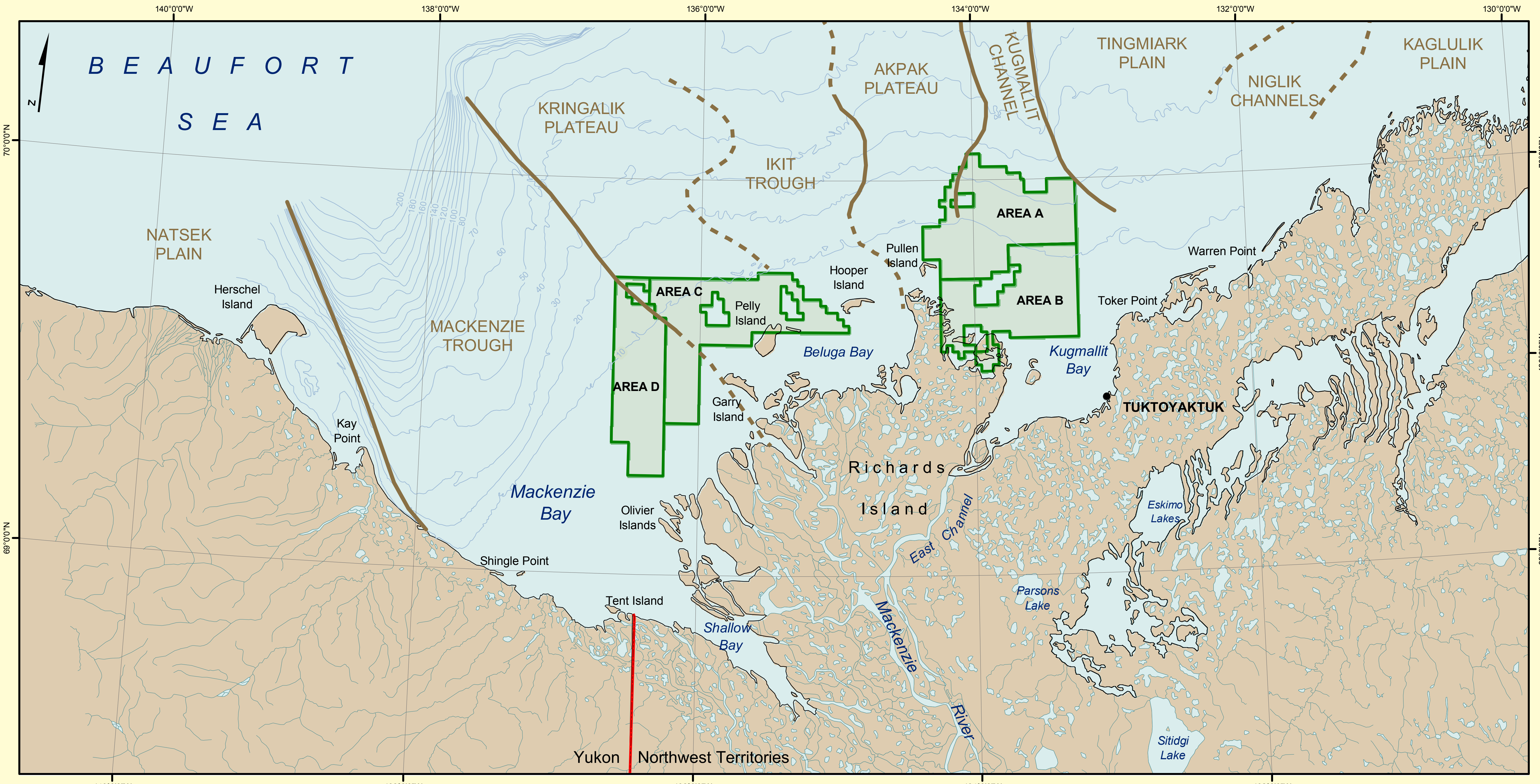
Potential Effect	Mitigation Measures
• Potential localized effects on seafloor stability during operations	• Geotechnical investigation to determine sediment and seafloor characteristics • Geotechnical design to address site specific issues (e.g., seismicity and stability issues) • Refrigerated KCl drilling mud to maintain low temperatures and prevent permafrost degradation • BOP and diversion system to help control any unexpected gas releases from hydrate-bearing sediments • Earthquake design standards
• Potential degradation of unique landforms	• Wellsite surveys prior to drilling to confirm that these or other unique landforms are not present. If features are identified at or near the drill site, the platform location will be adjusted as much as is operationally possible to avoid affecting these features.

9.4 Residual Program Effects and Significance

Residual Program effects on geology, terrain and sediments are expected to be not significant.

9.5 Cumulative Effects and Significance

No other activities with significant effects on subsea geology, terrain and sediments are planned near EL 420 during the Program; therefore, cumulative effects on geology, terrain and sediments are expected to be not significant.



devon

Devon Exploration Licence

KA036 - Map Surf. Geol.
March 3, 2004

Area of Detail

0 10 20 30 40
Kilometres

Data Sources:
Devon Canada Corporation
M.J. O'Connor & Assoc. (1986)
Projection: Universal Transverse Mercator Zone 8 (NAD 27)

Figure 9-1
Physiographic Regions of the Canadian Beaufort Sea

9.6 Monitoring

Because no significant residual effects are expected, no monitoring, other than standard monitoring of drilling operations, is recommended. As noted in Table 9-2, Devon intends to conduct wellsite surveys and additional geotechnical investigations prior to the start of the winter drilling Program. These surveys will serve to:

- optimize the location of the wellsite to avoid potential drilling hazards and unique seabed features
- identify potential shallow drilling hazards that could affect the safety and efficiency of the actual drilling operations
- identify geological/geotechnical conditions that could affect the integrity of the drilling platform

10 Coastal Processes

Coastal processes include factors that affect the morphology of shorelines, such as:

- composition of shoreline materials
- waves, wind and ice that contribute to shoreline erosion processes
- longshore current patterns that affect movement of sediments and eroded material along the shorelines

Shoreline environments can have unique habitat or cultural attributes (e.g., heritage resources, traditional use sites), and they can be sensitive to disturbance.

10.1 Baseline Conditions

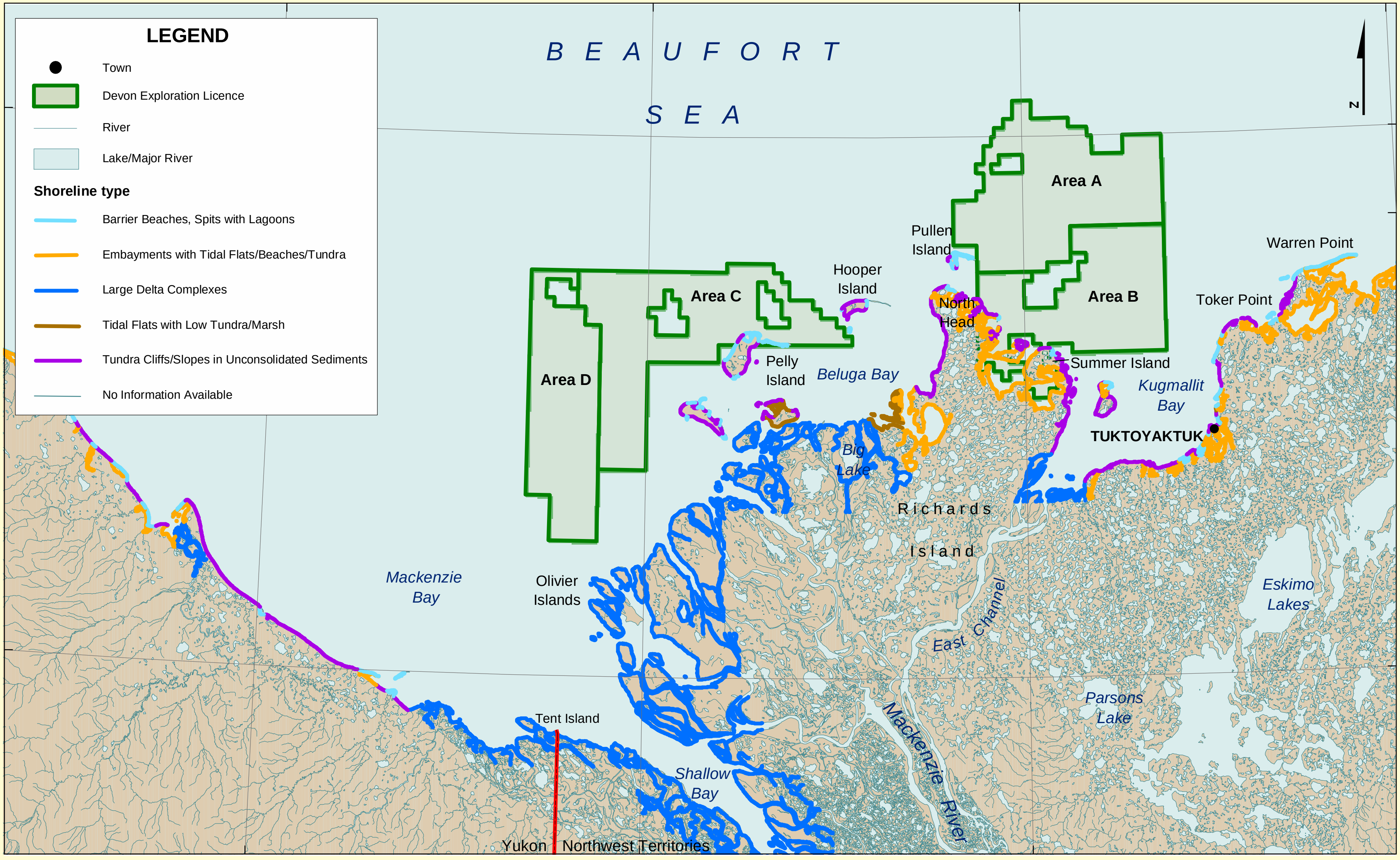
Shoreline types, erosion and accretion rates and longshore sediment transport are all important components of coastal processes in the Mackenzie Delta region. The shoreline types in the Mackenzie Delta area are summarized in Table 10-1 and their distribution is shown on Figure 10-1. Longshore sediment transport in the RSA is primarily eastward. Much of the shoreline in the RSA is eroding. Traditional knowledge from interviews with community members from Tuktoyaktuk and Aklavik identified the erosion of shorelines in the study area as a concern (Section 18: Traditional Knowledge and Land Use).

The Environmental Atlas for Beaufort Sea Oil Spill Response (Dickins Associates 1987) presents an assessment of shoreline sensitivity for the RSA. The islands located within the LSA have been given a low ‘Shoreline Environmental Sensitivity’ ranking. Other shorelines further away from offshore project activities, e.g., North Head and Summer Island have a moderate sensitivity ranking.

Table 10-1 General Descriptions of Shoreline Types Found in the Mackenzie Delta Area

Shoreline Type	Typical Height	Typical Material Type
Barrier beaches, lagoons and spits	Low, easily overtopped by waves	Sand, gravel, cobbles
Embayments with tidal flats, beaches or tundra	Low, easily overtopped by waves	Tidal flats: silt, peat and sand overlying glacial till or glacial sand deposits Beaches: sand and gravel Tundra: glacial till and glaciofluvial and morainal sand and gravel deposits
Large delta complexes	Low, easily overtopped by waves	Silt, sand and minor gravel fluvial deposits
Tidal flats with low tundra or marsh	Low, easily overtopped by waves	Silt, peat and sand overlying glacial till or glacial sand deposits, might contain ground or massive ice
Tundra cliffs and slopes in unconsolidated sediments	Higher, less likelihood of wave overtopping	Mainly silt and clay, with some sand and gravel strata

Sources: Based on Monroe (1972) and Dickins et al. (1987)



devon

KA036 - Map Shore types
Coastal Processes
August 11, 2004

Area of Detail

0 10 20 30 40
Kilometres

Data Sources:
Dickins et al. (1987)
Forbes & Lewis (1984)
Monroe (1972)
Projection: Universal Transverse Mercator Zone 8 (NAD 27)

Figure 10-1
Distribution of Shoreline Types in the RSA

Shoreline processes are affected by ice and open-water conditions, which are in turn subject to variation because of global climate change. Comparisons of ice formation and breakup data for the period 1991/1992 to 2001/2002 to similar data from several previous decades suggest there may be a trend towards shorter landfast ice durations, particularly over the past several years (Wright and KAVIK-AXYS Inc. 2004). The shorter seasons are believed to result from a delay in establishing landfast ice because more frequent east and south winds occur during freeze-up, which may be related to climate change. Although there has been a slight trend towards lower degree-day values at Tuktoyaktuk in recent years, measurements of ice thickness suggests no statistically significant change in the thickness of the seasonal ice pack north of Tuktoyaktuk (Wright and KAVIK-AXYS Inc. 2004).

10.2 Impact Assessment

The level of Program effects on coastal processes are characterized in terms of magnitude, direction, duration and geographical extent of the impact, according to criteria listed in Table 10-2. Low magnitude effects of any duration and moderate effects of short-term or mid-term duration are not significant. Long-term effects are significant. High magnitude effects of any duration are significant.

Table 10-2 Effect Attributes for Coastal Processes

Direction	
Negative	Change in VEC is persistent and presents a management challenge (e.g., accelerated erosion affecting valued shoreline use, facility or habitat)
Neutral	Change in VEC is not discernable within the bounds of natural variability, on either regional or local scales
Magnitude	
Low	Effect on VEC is <1%
Moderate	Effect on VEC is 1–5%
High	Effect on VEC is >5%
Geographic Extent	
Local	Effect discernable within a few hundred metres to two kilometres from the source of impact
Regional	Effect discernable a beyond two kilometres
Duration	
Short term	Effect will occur for <1 year
Medium term	Effect will occur for 1–5 years
Long term	Effect will occur for 5–10 years
Frequency	
Intermittent	Impact occurs intermittently and sporadically over assessment period
Continuous	Impact occurs continuously over assessment period

There will be no effects on coastal processes during periods with ice cover. During open-water periods, platform towing vessels and marine and river barge traffic could affect wave activity and cause minor erosion along some shorelines. The possible effects of the Program on coastal processes were evaluated by comparing wave energies associated with movement of supply barges and movement of drilling platforms with natural background wave energies in river channels and in the Beaufort Sea.

Towing of the platforms to the drill sites is not expected to have any effects on shoreline processes because the sites are generally far from shore (greater than 5.5 km) and activities are short term in duration. No measurable increases in wave energy are expected at the nearest shorelines.

Mobilization of the SDC or LTD, using high-powered tugs, will create additional wave energy. However, these activities will be of short duration (i.e., days) and will be some distance from shoreline. As a result, the incremental wave energy reaching the shoreline would not measurably affect shoreline erosion rates (i.e., small in comparison to the baseline conditions).

While barge activity associated with platform supply operations will create measurable waves, they will be of short duration and less total energy than waves produced by winds over the open-water season (i.e., near Inuvik). The effects of the supply barge movements on the shoreline of the Mackenzie River would not be measurable in relation to the baseline conditions.

Supply and equipment barges for the ice island will be allowed to freeze into the landfast ice and unloaded later for transporting equipment to the drill site by ice road. Staging sites will be located in a sheltered location (e.g., on the leeward side of offshore islands such as Garry, Pelly, Hooper or Pullen islands). No equipment will be brought onshore. The water depth in these areas is expected to be shallow because sediment deposition is typically predominant on the leeward side of the islands. Thus, tugboats and barges will be at some distance from the shoreline where wave energies are normally low, and there will be no adverse effect on the coastline of the islands. If a barge staging area is required, a site selection process will be conducted involving consultation with HTCs and Inuvialuit co-management agencies.

The effects of routine Program activities on coastal processes are summarized in Table 10-3.

Table 10-3 Program Effects on Coastal Processes

Potential Effect	Interaction with VEC	Level of Effect[1]					Effect Significance[2]	
		Direction	Magnitude	Extent	Duration	Frequency	Program-related Effect	Cumulative Effect
Pre-operations								
LTD and SDC mobilization	Increased wave energy due to high powered towing vessels with potential shoreline erosion	Neutral	Low	Local	Short term	Intermittent	Not significant	Not significant
Increased supply barge traffic from Inuvik	Increased wave energy with potential erosion of river banks	Neutral	Low	Local	Short term	Intermittent	Not significant	Not significant
Barge staging adjacent to offshore islands for ice island platform	Increased wave energy affecting island shorelines	Neutral	Low	Local	Short term	Intermittent	Not significant	Not significant
Operations								
No effect	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Closure								
No effect	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Notes: 1 Based on criteria in Table 10-2
2 Based on criteria in Section 10.2

10.3 Mitigation Measures

Potential effects are low magnitude and mitigation measures are not required. If a barge-staging site is required for the ice island option, an evaluation of candidate sites (Table 10-4) will be conducted that addresses characteristics such as depth, sediment movement and shelter from storm surges. Information gathered from consultation with local communities, HTCs and Inuvialuit co-management agencies will also play a role in the final site selection.

Table 10-4 Mitigation Measures for Effects on Coastal Processes

Potential Effect	Mitigation Measures
Barge staging adjacent to offshore islands for ice island platform	• Evaluate candidate sites (depth, sediment movement, shelter from storm surges, etc.). • Consult and use information from local communities, HTCs and Inuvialuit co-management agencies

10.4 Residual Program Effects and Significance

Residual Program effects on coastal processes are expected to be not significant.

10.5 Cumulative Effects and Significance

No other activities with significant effects on coastal processes are planned near EL 420 during the Program; therefore, cumulative effects on coastal processes are expected to be not significant.

10.6 Monitoring

Because no significant effects are expected, no monitoring programs are required.