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GEOLOGIC HAZARDS IN AND NEAR PROPOSED STATE OF ALASKA OIL AND GAS LEASE SALE 80 (SHAVIOVIK)

by

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INTRODUCTION

The proposed Shaviovik state oil & gas lease sale occupies state onshore land between the Sagavanirktok and Canning Rivers, along the Kuparuk River, and small offshore areas near the mouths of the Kuparuk and Sagavanirktok Rivers (fig. 1). Geologic processes in this area will impose moderate constraints to exploration, production, and transportation activities associated with possible petroleum development but can be mitigated through proper siting, design, and construction.

Primary hazards within the lease area include earthquakes, frozen-ground phenomena, seasonal flooding, coastal erosion, and shore-ice movement. This report provides a brief summary of available information related to these hazards.

GENERAL GEOLOGY

West of 147°W, detailed surficial-geologic maps are available for all tracts on the coastal plain north of 70°N (townships 8N and higher)(Rawlinson, 1993). East of 147°W, detailed maps are also available for tracts between 69°45'N and 70°N (townships 5-7N, ranges 21-23E) (Carter and others, 1986; Rawlinson, 1993). In the southern and western portions of the proposed lease area, the only maps useful for hazards assessment are engineering-geologic strip maps along the Trans-Alaska Pipeline System (TAPS) route (Ferrians, 1971) and along a prospective transportation corridor (Yeend, 1973a, b).

The northern part of the lease area is underlain by predominantly fine-grained coastal-plain deposits. A typical stratigraphic section consists from top to bottom of 2-6 ft of organic-rich thaw-lake deposits, 3-25 ft of sandy alluvium with varying amounts of silt and gravel, and marine or fluvial sand and gravel of unknown thickness (Rawlinson, 1993). Lease tracts near the mouths of the Kuparuk and Sagavanirktok Rivers are underlain by silty, sandy deltaic deposits.

Higher terrain in the southern part of the area is underlain by Tertiary or Cretaceous sediments and sedimentary rocks (Ferrians, 1971; Rawlinson, 1993; Yeend, 1973a). Along the Canning River, higher terrain is underlain by bouldery till and coarse outwash gravels (Carter and others, 1986; Yeend, 1973b). Elsewhere in the southern part of the area, low, flat ground is underlain by fine-grained, organic-rich thaw-lake deposits and sandy alluvium.

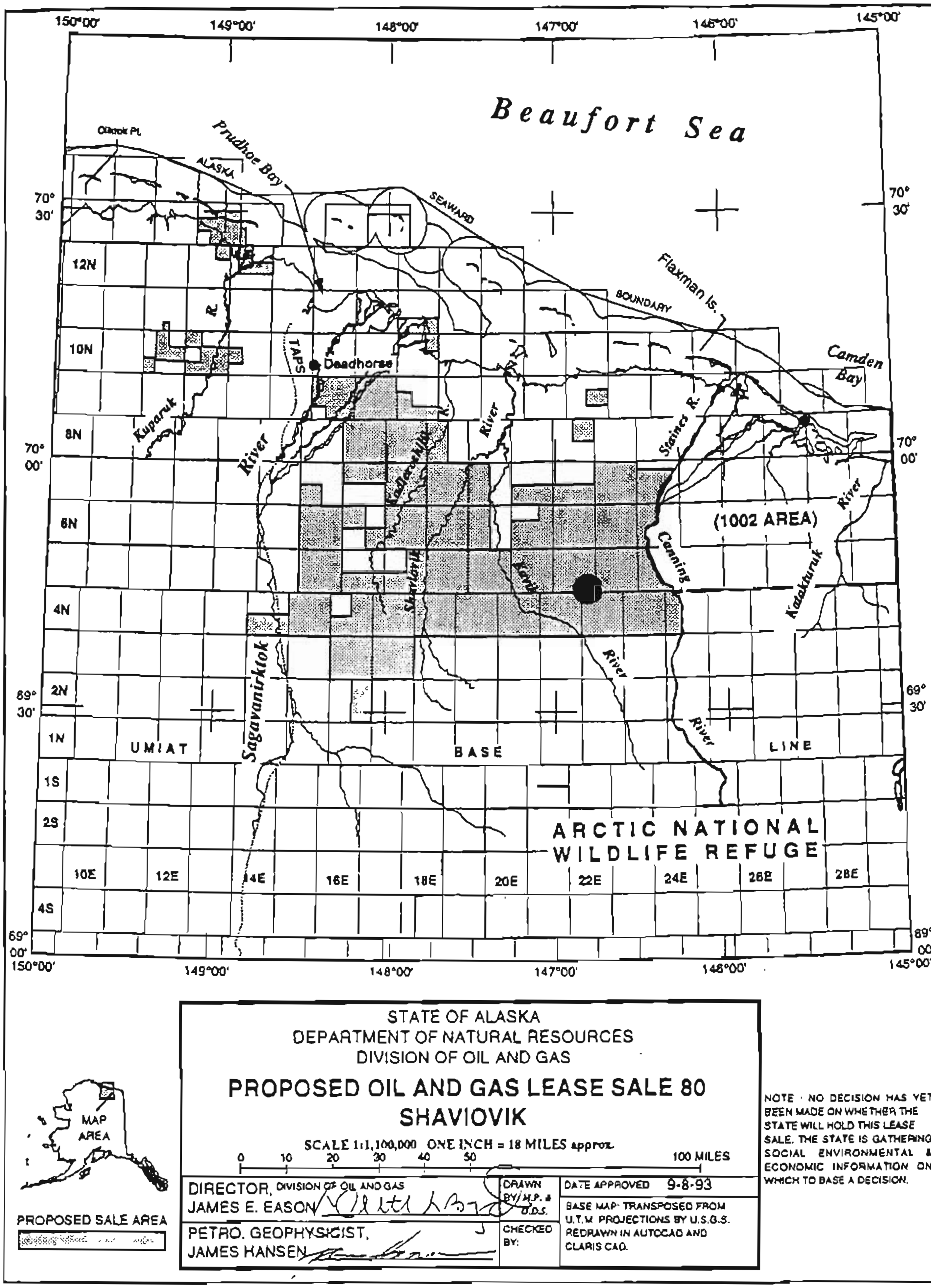

Figure 1. *Map of proposed State of Alaska oil and gas lease sale 80 (Shaviovik). Dot indicates approximate location of a magnitude 4.8 earthquake on December 4, 1993.*

EARTHQUAKES

Although northern Alaska is generally considered an area of low earthquake activity, there is a band of seismicity that extends south to north through the Arctic National Wildlife Refuge. The proposed Shaviovik lease sale area lies along the western margin of this seismic zone.

In the region of the proposed lease area, approximately 200 earthquakes were recorded between August 1965 and December 1993 (fig. 2). These included a magnitude 5.3 event offshore near Barter Island, about 70 mi northeast, in 1968 and a magnitude 5.1 event about 100 mi southwest of the area in 1969 (slightly west of the map area). A magnitude 4.8 earthquake occurred in or near the proposed lease area on December 4, 1993; location accuracy for this epicenter is poor (standard error 15 mi). The earthquake was strongly felt at Prudhoe Bay but no damage was reported. Most seismicity in the area is shallow (less than 20 mi deep), indicating near-surface faulting, but no active faults are recognized at the surface.

Thenhaus and others (1985) estimate a 10% probability of exceeding 0.05 g earthquake-

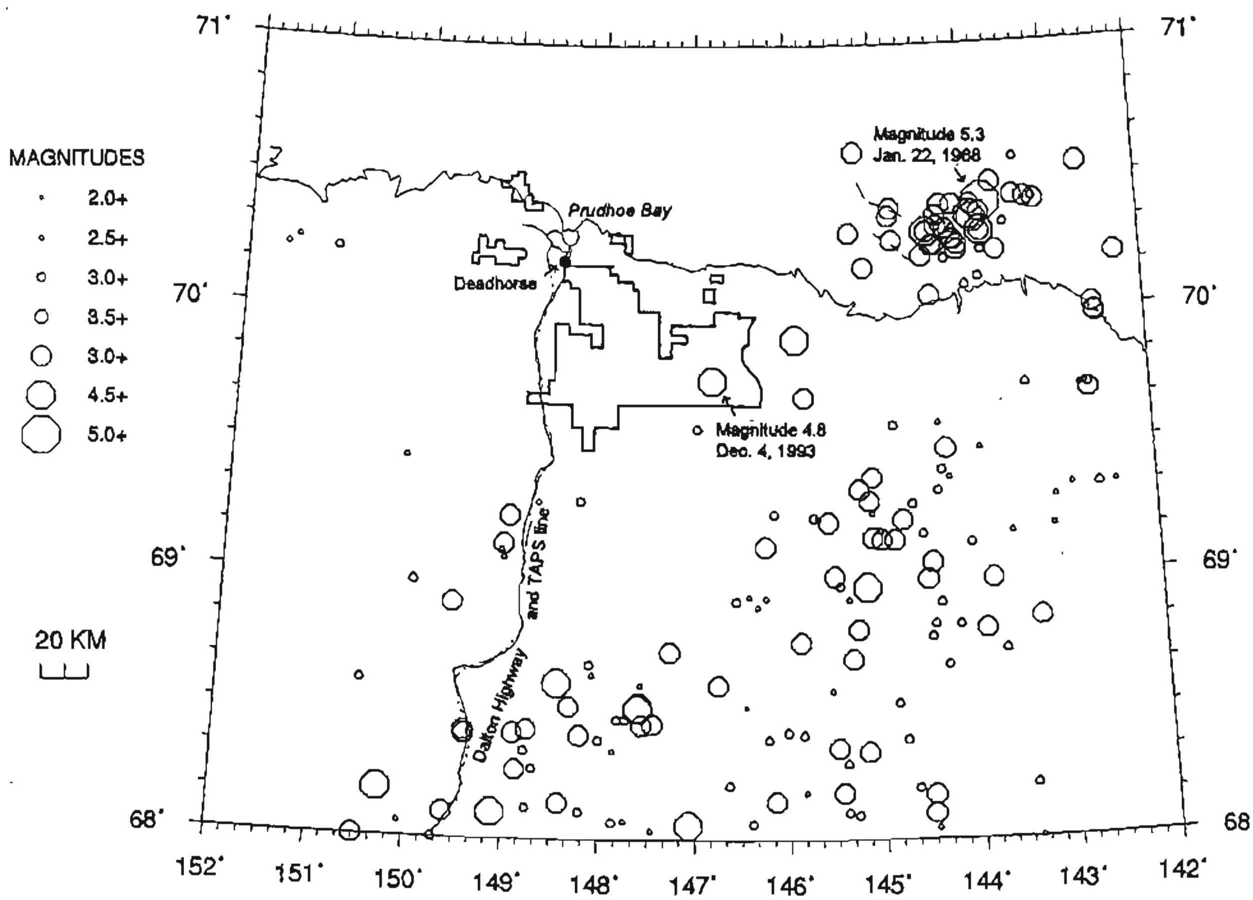

Figure 2. *Map showing recent seismicity in the eastern North Slope region, Alaska, and approximate boundaries of proposed state oil and gas lease sale 80 (Shaviovik). Circles indicate epicenter locations of all earthquakes recorded in the map area 8/15/65 to 12/17/93 (R. Hammond, Alaska Earthquake Information Center, 1/10/94).*

generated horizontal acceleration in bedrock during a 50-yr period in this area (for comparison, ground acceleration in Anchorage during the great 1964 earthquake was estimated at 0.16 g). Accelerations in areas underlain by thick, soft sediments are likely to be higher than in bedrock due to amplification. However, thick permafrost may cause the earthquake response of sediments to be more like bedrock, which would limit amplification effects and would also tend to prevent earthquake-induced ground failure, such as liquefaction. The effects of permafrost on earthquake response of sediments has not been documented.

The Shaviovik lease sale area lies within seismic zone 1 of the Uniform Building Code (on a scale of 0 to 4, where 4 represents the highest earthquake hazard). All structures in the area should be built to meet or exceed the UBC requirements for zone 1.

FROZEN GROUND

All areas are underlain by perennially frozen ground. Depth of seasonal thaw is generally less than 3 ft below the surface and 6 ft beneath active stream channels. Ice content varies from minor segregated ice to massive ice in the form of wedges and pingos. Ice content is highest in fine-grained, organic-rich deposits and lowest in coarse granular deposits and bedrock. Depth to the base of ice-bearing permafrost ranges from about 900 ft in the southern part of the area to 2,000 ft along the Beaufort Sea coast (Collett and others, 1989).

Thaw settlement will occur wherever a heated structure is placed on ground underlain by shallow, ice-rich permafrost if proper engineering measures are not taken to adequately support the structure and prevent building heat from melting the ground ice. Seasonal freeze-thaw processes will cause frost jacking of nonheated structures placed on frost-susceptible soils unless the structures are firmly anchored into the frozen ground with pilings or supported by non-frost-susceptible fill. Frost susceptibility is highest in fine-grained alluvium, colluvium, thaw-lake deposits, and coastal-plain silts and sands; moderate in alluvial-fan deposits and till; and lowest in coarse-grained flood-plain deposits, alluvial terrace deposits, and gravely bedrock (Carter and others, 1986; Ferrians, 1971; Yeend, 1973a, b). Proper siting, design, and construction can mitigate these frozen-ground problems, as has been demonstrated at Prudhoe Bay.

SEASONAL FLOODING AND ICING

Floods occur annually along most rivers and many adjacent low terraces due to seasonal snow melt and ice jamming (Rawlinson, 1993). Additionally, rivers in this area are subject to seasonal icing prior to spring thaw due to overflow of stream or ground water under pressure. In areas of repeated overflow, residual ice sheets often become thick enough to extend beyond the flood-plain margin. Large overflows and residual ice sheets have been documented on the Sagavanirktok, Shaviovik, Kavik, and Canning Rivers (Dean, 1984).

COASTAL AND RIVER-BANK EROSION

Most of the Beaufort Sea coast is subject to retreat by a thermo-erosional process that involves (1) thawing and removal of frozen coastal-bluff sediments by sea water, creating a niche at the base of the bluff, (2) collapse and slumping of overhanging bluff materials, and (3) removal of the materials by flowage, wave action, and ice movement. Most of the erosion occurs during storm surges (Reimnitz and Maurer, 1979). Erosion rates are controlled by grain-size of the bluff material, bluff height, ice content, bluff orientation, and degree of exposure to the open ocean (Reimnitz and others, 1988). Rates are highest along low bluffs composed of fine-grained, ice-rich sediments.

Coastal erosion rates in lease tracts along the Kuparuk River delta reach 23 ft/yr (Reimnitz and others, 1988). Rates of coastal retreat along the remainder of the lease area between Sagavanirktok and Canning Rivers range from 7 ft/yr in the west to 30 ft/yr in the east (Hopkins and Hartz, 1978).

A similar process is responsible for bank erosion along rivers in the region. Sediment cohesiveness is a major factor in determining bank erodibility; higher erosion rates occur in braided channels, which usually form in noncohesive sediment (Scott, 1978). Along the Sagavanirktok River, aerial photographs showed a maximum erosion rate of 15 ft per year during a 20-yr period, but less than 12 percent of the vegetated bank was affected. Most of the erosion appears to occur in small increments during breakup flooding and is concentrated in specific reaches where conditions are favorable for thermo-erosional niching.

ICE MOVEMENT

Strong winds occasionally force blocks of sea ice inland from the coast, causing a hazard to coastal facilities and the erosion and transport of large volumes of sediment. Ice-push rubble extends at least 60 ft inland over most of the Beaufort Sea coast and includes boulders exceeding 5 ft diameter (Kovacs, 1984). Structures located in offshore lease tracts will be subject to more frequent ice movements. However, these tracts are located well within the zone of relatively stable bottom-fast ice and will not be subject to the large-scale current-driven movement of pack ice that occurs farther seaward in the open Beaufort Sea (Craig and others, 1985, fig. 33).

CONCLUSIONS

Development in the proposed Cape Shaviovik lease area will be subject to moderate geologic hazards, including earthquake shaking, thaw settlement, and seasonal frost action. Coastal structures will be potentially affected by coastal erosion and movement of nearshore sea ice. Structures along rivers may be affected by seasonal flooding, local stream icing and bank erosion. All structures should be built to meet or exceed requirements of the Uniform Building Code for seismic zone 1. Additional precautions should be take to identify and accommodate special conditions such as unstable ground, flooding, and other local hazards. Proper siting and engineering will minimize the detrimental effects of these natural processes.

ACKNOWLEDGMENTS

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