State of Alaska

Department of Revenue

Commissioner's Office

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To: All members of the Legislature

From: Marcia Davis, Deputy Commissioner, DOR

November 1, 2007

Dear Members:

The attached excerpt from the 2006 Fall Revenue Sources Book outlines the various prospects and challenges facing heavy oil development in Alaska. Many have testified on this issue in committee hearings, and our department has received a number of inquiries regarding the role heavy oil might play in Alaska's future. I hope this information will provide additional insight into the complexities related to heavy oil development. If you would like additional information, you can find the complete version of this DOR report and other Revenue Sources books on the Department of Revenue's Tax Division website.

Sincerely,

Marcia Davis, *Deputy Commissioner*
Department of Revenue

3. Will Heavy Oil Do The Heavy Lifting for Alaska?

What is heavy oil? Where is it located and how much of the stuff is there? Why aren't the oil companies producing it now? These are some of the questions this section will attempt to answer. Like other crude oils, heavy oil can be refined and used to produce refined petroleum products such as gasoline and jet fuel. Physical problems make its production more challenging than other crude oils. The potential to produce and develop heavy oil has great promise for Alaska.

What is Heavy Oil?

Heavy oil is a type of crude oil which is very viscous and does not flow easily. The common characteristic properties are the following:

- High specific gravity[1] (very dense)
- Low hydrogen to carbon ratios (chemical characteristic)
- High carbon residues (much left after conversion to refined product)
- High contents of heavy metals, sulphur and nitrogen.

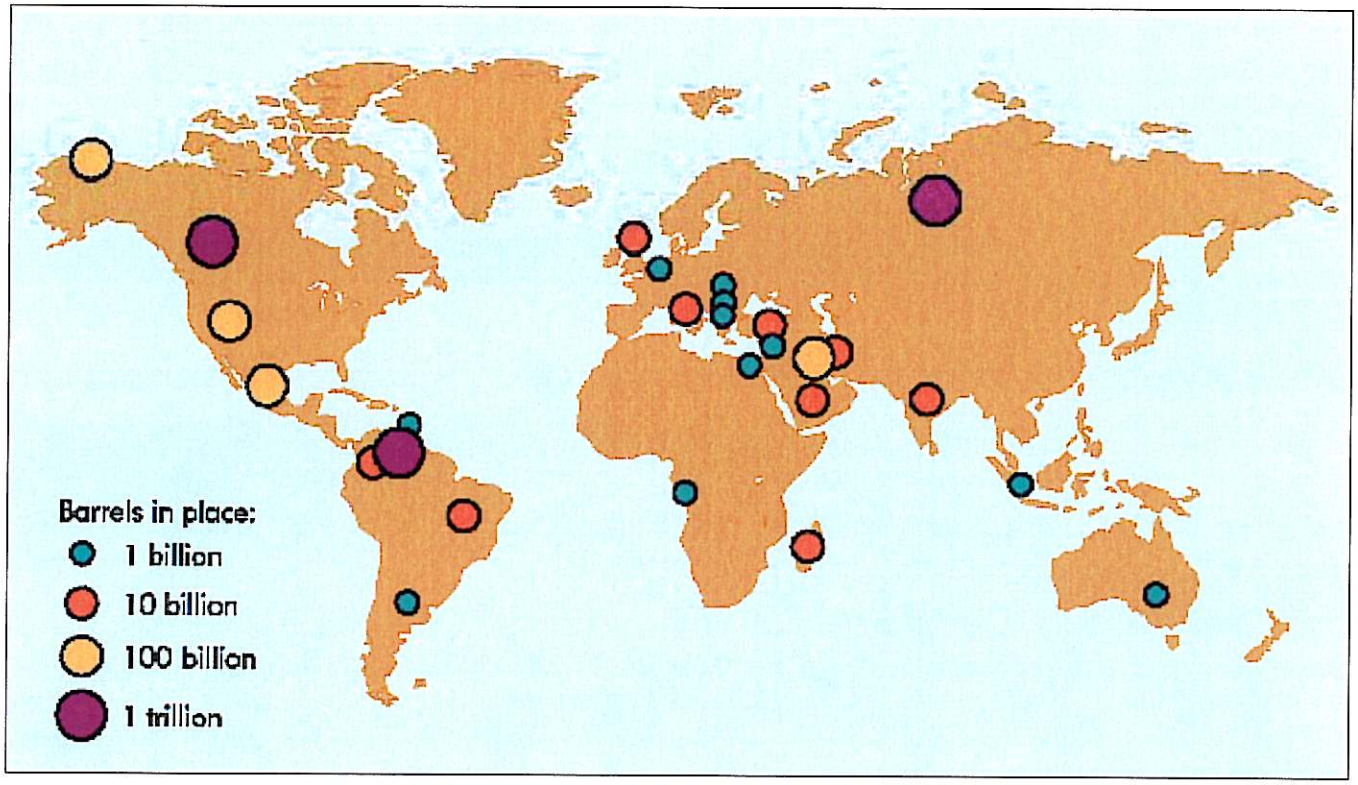
There is no one definition of heavy oil. The term heavy oil refers to oil with a high density and low American Petroleum Institute (API) gravity[2] due to the presence of a high proportion of heavy hydrocarbon fractions. This is technical jargon for saying the material is thicker than maple syrup and does not flow easily. The API gravity system implies that the higher the API gravity, the lighter the liquid, the easier it flows. Using numbers, some definitions classify crude oil as heavy if it has an API gravity of less than 25°, other definitions say it is less than 20°API. All these definitions refer to the crude oil at the surface. In terms of the ability of the oil to flow underground within the formation, heavy oils are generally those with a viscosity greater than 100 centipoise – a measure used to evaluate the ability of a liquid to flow at reservoir conditions. The higher the viscosity number, the slower the flow. Bitumen (very heavy liquid similar to chocolate syrup) has a rating greater than 10,000.

In Alaska, the real issue is not the API gravity, but the ability of the crude oil to flow, or its viscosity. While API

(1) The Specific Gravity of a substance is a comparison of its density to that of water. Imagine a gallon bottle filled with water, a second filled with feathers, a third filled with lead weights. There are equal volumes of material present, but the bottle with the feathers will weigh less than that containing water; the bottle with lead weights will weigh the most. In order of increasing specific gravity, these materials would be: feathers, water, and lead. Specific gravity can be measured precisely, or estimated by a comparison, as above.

(2) API gravity = [141.5 / Specific Gravity at 60° F – 131.5] This parameter has economic significance since it is the main quality criterion for crude oil pricing; the higher the gravity the higher the price of the crude oil.

Figure 3-1. Potential Heavy Oil Resources *Source: International Energy Agency, Resources to Reserves, November 2005, page 76.*



gravity provides a measure of its density (and economic value), it fails to incorporate the more difficult issues surrounding flow. From this perspective, a better descriptor of Alaskan heavy oil would be to call it viscous oil, as it relates to its ability to flow.

One of the major reasons Alaska's oil is viscous is because it is relatively close to the surface of the earth – where there is very thick permafrost. The oil is not located deep in the earth, where the temperatures are warmer, but within six thousand feet of the surface where temperatures are cooler, thereby reducing the oil's viscosity or ability to flow. For oil production in Alaska, API gravity isn't as important as is reservoir temperature. Hence, these deposits are sometimes referred to as viscous oil deposits, rather than heavy oil. Permafrost affects production, as it will cool oil traveling through the permafrost zone.

Worldwide Resources of Heavy Oil

Heavy oil is located throughout the world and the International Energy Agency estimates world heavy oil, or viscous oil resources at more than 6 trillion barrels with about 2 trillion barrels deemed recoverable (see Figure 3-1).

The three largest deposits are in Canada (about 1.86 trillion barrels), Russia, and Venezuela (each with about 1.2 trillion barrels). Alaska is in the next level with the potential for about 100 billion barrels of heavy oil resources. At this time, there are known Alaskan reserves of over 20 billion barrels of viscous oil with the possibility of billions more yet to be identified. The viscous oil in Canada is very similar to that of the viscous oil in Alaska – both are located in cooler climates and both do not flow well in their natural reservoirs.

There are currently five fields producing viscous oil in Alaska: Orion, Polaris, Schrader Bluff, Tabasco and West Sak. Four of these fields are shown in Figure 3-2 on the next page. Not shown is Tabasco, which is a Kuparuk River Unit satellite. Figure 3-3 on the next page reveals the subsurface formation in which the viscous oil lies. At this time, viscous oil is being developed from the oil formation titled "West Sak Schrader Bluff". No oil is being produced from the Ugnu formation.

The North Slope is underlain by permafrost which extends to about 1,800 feet in depth. The shallowest oil bearing formation, named Ugnu, is closest to the permafrost. The temperature in this formation is below freezing, its API gravity is 8° and it has a very high oil viscosity. The billions of barrels of reserves in this formation are not economical to produce now, but someday may be.

Figure 3-2. Alaska's Viscous Oil Reserves *Source: BP Exploration Alaska (Inc.) presentation to Alaska Department of Revenue, February 18, 2005.*

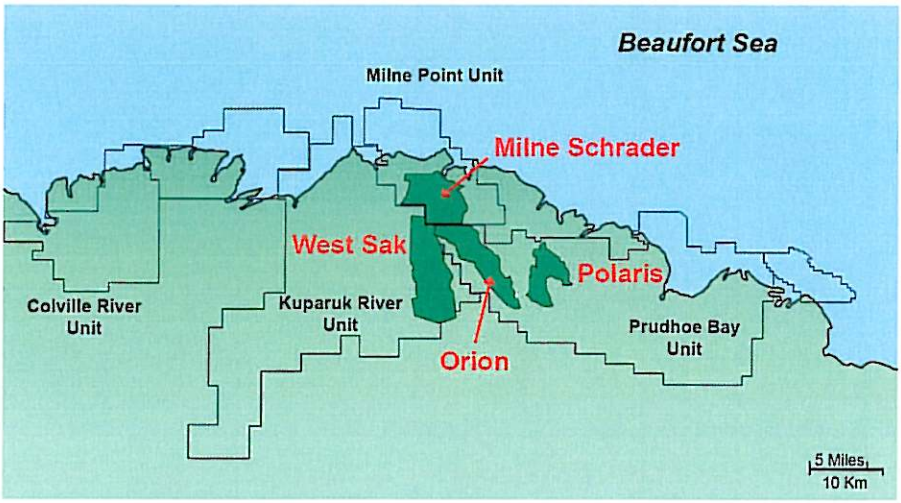
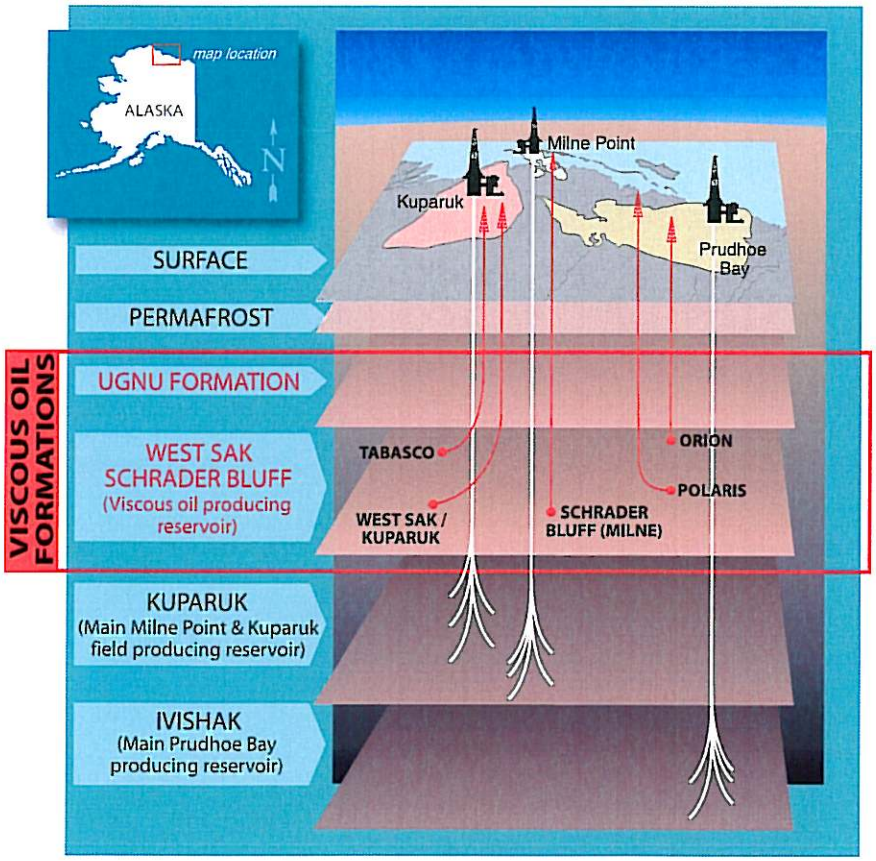


Figure 3-3. Alaska's Viscous Oil Deposits *Source: International Energy Agency, Resources to Reserves, November 2005, page 76.*



Developing Viscous Oil Resources

Developing viscous oil is difficult and expensive. Some heavy oils and bitumen are too viscous to flow at reservoir conditions. They are usually found at relatively shallow depths that are too deep to be mined. At such depths, temperatures are low, so that viscosity is high. They need special production technologies to facilitate their flow from reservoir to well head. Traditionally, these have been "steam flooding" techniques, which involve injecting hot steam to heat the oil in-situ, thereby reducing its viscosity and allowing it to flow. But the last ten years have seen the advent of many new approaches such as steam-assisted gravity drainage – see Figure 3-4 on page 24.

Also being used are techniques involving CO2 or natural gas injection. All of these techniques require facility and energy expenses that are well beyond the requirements for producing traditional oil reserves.

Another problem faced by Alaska's viscous oil producers is solid waste – significant solids (sand) are produced in conjunction with the oil and must be disposed. Some of the facilities on the North Slope were not developed with sand disposal in mind and must be periodically closed to remove the sand. As newer facilities are developed, they will likely integrate solid waste disposal.

While large-scale implementation of Steam Assisted Gravity Drainage (SAGD) and other techniques is just beginning, it is expected to significantly boost production over the next few years. Indeed, recent technology has improved the economics to the point where Canadian heavy oil and bitumen deposits can be produced through in-situ techniques at oil prices below

$20 per barrel (see Figure 3-5 on page 25). Current production of heavy oil and bitumen in Canada, for example, is close to 1 million barrels per day and could double by 2012.

The Outlook

At the time of this writing, about 5% of the oil produced in Alaska is considered viscous. Will this resource be developed to a larger extent in the future?

While this question cannot be answered unequivocally, there are several indicators that greater development of viscous oil on Alaska's North Slope is likely to occur. These facts are divided into two broad categories – the fiscal regime and technology.

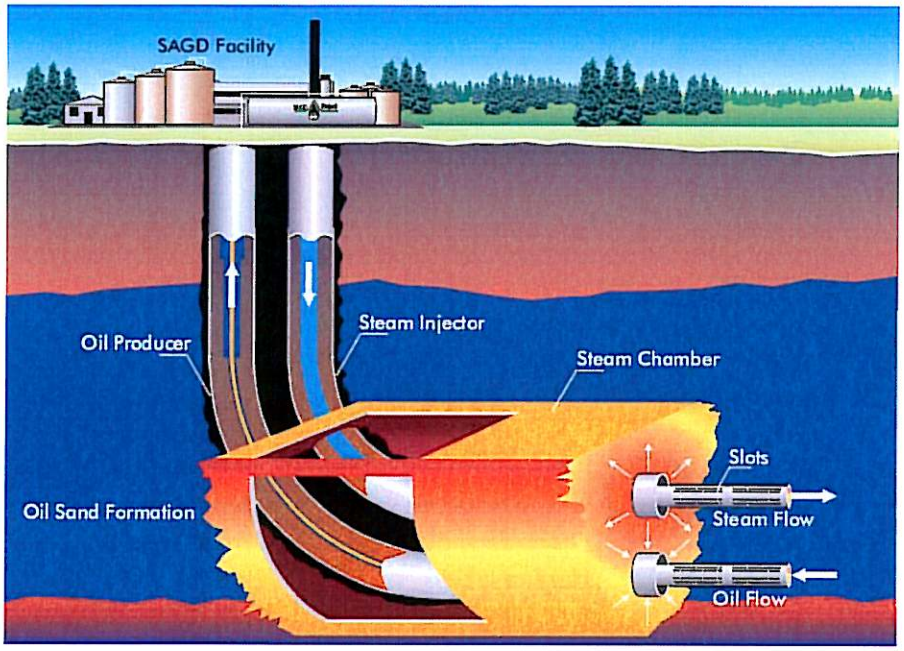
• Fiscal Regime – Canada's recent experience with oil sands and heavy oil bears witness to the powerful force of a stable and attractive tax and royalty regime, combined with higher oil prices, to catalyze fresh investment. With the passage of the new Petroleum Profits Tax (PPT) in Alaska, similar incentives are in place and are expected to stimulate investment. Companies will be able to claim deductions and earn credits for their higher costs of producing heavy and viscous oil that will lower their tax burden.

• Technology – the oil industry is continually developing new techniques and technologies to enhance oil production. Such technological advances are pushing back the frontiers of operating capability in difficult temperature and geographical situations.

Taken together, these two aspects paint a picture of future development of Alaska's viscous oil.

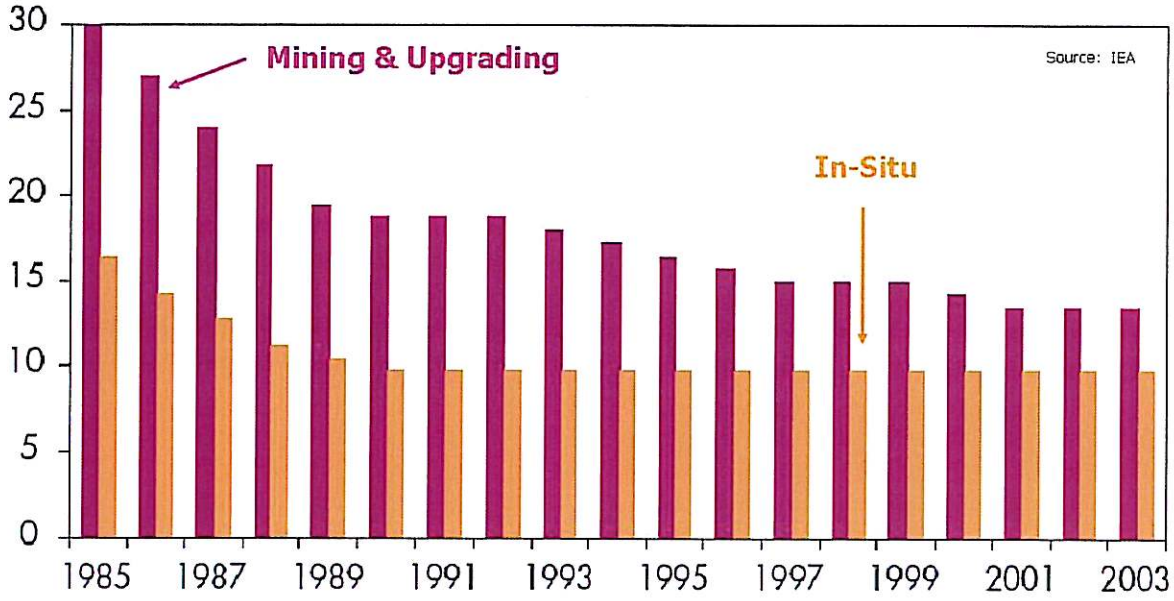
Finally, Alaska has the opportunity to take the lead in viscous oil research and create an Arctic Resources Research Center that could serve as a central research facility for heavy and viscous oil development worldwide. By engaging partners with heavy oil resources from around the world, Alaska could facilitate research and provide insights into viscous oil development and environmental issues to all involved. Judging by the size of the reserves in the colder climates, it appears organizations operating in Norway, Russia and Canada would be interested as potential partners.

Figure 3-4. Schematic of SAGD. *Source: International Energy Agency, Resources to Reserves, November 2005, page 76.*



Steam Assisted Gravity Drainage (SAGD)

The advent of precision-placed horizontal wells has led to development of SAGD. As Figure 3-4 shows, two horizontal wells are drilled, one above the other, the upper well for steam injection, the lower well for oil production. This dual-well system ensures efficient use of heat within a virtual "steam chamber", as well as the excellent recovery rate achieved by gravity drainage, in which gravity stabilizes the interface between oil and steam. Recovery factors can be as high as 60%. The intrinsic slowness of gravity drainage would mean low production rates if it were not possible to drill such long horizontal wells, one pair of which can drain a significant volume. The cornerstone in this very promising technique is the capability, developed by the industry over the past 15 years, to position horizontal wells very precisely over long distances. Because the wells are relatively shallow, moreover, drilling costs are sufficiently low to make large-scale developments with numerous wells affordable. SAGD has come into its own over the past three or four years and is now having a big impact on the economics of heavy oil production.

Source: International Energy Agency, Resources to Reserves, November 2005, page 80.

3-5. Oil Production Costs for Canadian Tar Sand (2004 dollars/ barrel) *Source: International Energy Agency, Resources to Reserves, November 2005, page 77.*