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ABSTRACT

To guard against thawing permafrost and associated thaw subsidence, the oil facilities in the Arctic are constructed on gravel pads placed on top of the existing arctic tundra, however the impacts of this infrastructure to the sensitive hydrology are not fully understood. Production in some of the older fields is on the decline; however oil exploration in the Arctic Coastal Plain is resulting in the discovery and development of new reserves. In the coming years, old sites will need to be decommissioned as production transitions to new sites. New facilities will also need to be designed and constructed.

Oil companies in Alaska have historically conducted operations under leases issued through the Alaska Department of Natural Resources. The leases stipulate that once resource extraction operations are completed, the facilities must be decommissioned and the sites restored, however they are often vague in their requirements and are variable in their specifics from lease to lease.

As the oil companies transition to the new sites, decisions must be made regarding what should be done with vacated gravel pads. The construction of gravel pads essentially destroys underlying arctic tundra. In undisturbed areas in the Arctic, the tundra itself creates an insulating layer that limits the seasonal thaw depth to around 0.5 m. Removal of this layer causes thaw depths to greatly increase impacting the stability of the ground and the hydrology of the surrounding area. Because of this impact, other possible restoration techniques are being considered, such as vegetating and leaving the pads in place.

Water movement is one of the major driving factors in the arctic contributing to permafrost degradation. Groundwater carries with it heat, which is transferred to the soil as the groundwater moves. Therefore, hydrology plays a major role in the stability of the arctic environment. This is especially relevant in areas where gravel pads exist. Gravel pads are anthropogenic structures that have significant water storage potential. Because of the unique conditions in the Arctic, pore-water flow through these gravel pads is not yet well understood.

The purpose of this study is to develop a more complete scientific understanding of the driving forces behind pad pore-water movement. This study expands on fieldwork from a prior hydrological field study conducted by others. The prior study is expanded through this work by developing an associated groundwater model to the gravel pad from the field study to examine the flow through it and the controlling factors for this flow. The study site used for this project is located in Prudhoe Bay and is the pad constructed for the very first production well in Prudhoe Bay in 1968.

This study demonstrates that it is the topography of the silt layer beneath the gravel pads that is the most significant factor controlling pad pore-water movement. The results from the modeling study will assist engineers and environmental scientists in better understanding the groundwater flow. This understanding will aid in the decommissioning and restoration process and help inform decision making in regards to the future of the existing pads. The results may also be used to inform the development of new infrastructure such that any new pads which are built may be constructed with their relationship to they local hydrology more in mind.

ORI MILLER BIO

Ori Miller is currently the assistant state dam safety engineer for the State of Alaska Department of Natural Resources. He completed his undergraduate degree in civil engineering in 2016 from the University of Alaska Fairbanks and also obtained a minor in history. He completed his masters degree also from UAF in water resources engineering in August 2019. His focus in his masters program was groundwater modeling on the north slope of Alaska. He has had experience working during the off season of school over the summers in between his graduate program doing environmental engineering for multiple firms. During his undergraduate degree, he was highly active within the local UAF student chapter of the American Society of Civil Engineers (ASCE). He served as an officer in the student chapter as the chapter secretary in 2014-2015 then the following year 2015-2016 as the vice president. During his ASCE service he was one of two student members invited to participate on the committee for the development of the 2017 state infrastructure report card. He is continuing his professional volunteer involvement post graduation by staying connected with the Anchorage professional chapter of ASCE and working on the new 2021 report card yet to be released. Outside of engineering, his hobbies are ballroom dancing, board gaming and reading a variety of both fiction and nonfiction and spending time with his fiancee Sarah.