SHANNON & WILSON
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

January 24, 2020

Mr. Marcus Zimmerman and Ms. Sam Cummings
Alaska DOT&PF – Southcoast Region
P.O. Box 196900
Anchorage, AK 99519

RE: DOCUMENT REVIEW REGARDING KING SALMON GROUNDWATER AQUIFERS

Shannon & Wilson, Inc. (Shannon & Wilson) was provided several documents by the Alaska Department of Conservation (ADEC) documenting groundwater aquifers in King Salmon, Alaska. The documents we reviewed are listed in the reference section at the end of this letter. Generally, the information presented in the reports is centered around the former King Salmon Air Force Station (AFS) located on the upper section of the Alaska Peninsula along the Naknek River between Naknek Lake and Kvichak Bay. Feulner (1963) reported the King Salmon study area is underlain by at least 300 feet of glacial outwash plain sediments. The sediments include stratified silt, sand and clay deposits. According to Ferrians (1965), King Salmon is in a section of the Alaska Peninsula where permafrost is generally absent.

In their *Final Uniform Federal Policy – Quality Assurance Project Plan for Site Inspections of Aqueous Film-Forming Foam Areas, King Salmon Divert (KSD), Alaska*, dated July 2019, CH2M provided the following discussion of the hydrogeology in the area surrounding the King Salmon AFS:

> *Intense glaciation occurred during the Pleistocene period over much of the Alaska Peninsula, which produced the outwash sediment underlying much of [King Salmon Divert] (KSD). At least three aquifer units are known to be present in the King Salmon area. These aquifers consist of unconsolidated, well-sorted to poorly sorted silty and gravelly sands, separated by aquitard units consisting of silty sands, silts, and clays. The aquitards separating these aquifers may be discontinuous (Science Applications International Corporation [SAIC], 1992).*
>
> *The shallowest aquifer, the A-Aquifer, is unconfined and comprised of moderately well-sorted sands and silty sands with discontinuous lenses of medium- to coarse-grained gravel at the base. The A-Aquifer outcrops in many areas within KSD, and the total depth to the A-Aquifer ranges from ground surface at water bodies and wetlands, to 45 feet below ground surface (bgs) along the northern margin of KSD. The saturated thickness ranges from 0 to 15 feet. Groundwater movement is generally toward local topographic lows and surface drainages such as wetlands,*

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*rivers, creeks, and ditches, and is most likely recharged by precipitation and surface water. Major drainages such as the Eskimo and Red Fox Creeks have eroded through the A-Aquifer. At the base of the A-Aquifer is a zone of lower hydraulic conductivity, consisting of a gravelly clayey silt and sandy silt, referred to as the A-Aquitard. The underlying A-Aquitard is from 7 to 22 feet thick (USAF, 2017b). The A-Aquitard has previously been reported to locally disrupt and modify the regional unconfined groundwater flow pattern (A-Aquifer) in some areas when encountered at its thickest points (*SAIC, *1992). Some drinking water wells downgradient of the KSD may be screened in the A-Aquifer.*

The top of the B-Aquifer has been encountered at depths ranging from 50 to 80 feet bgs. The known thickness of this aquifer ranges from 15 to 40 feet. The B-Aquifer is situated in interbedded sequences of silty sands, sandy gravels, and silty sandy gravels. A second aquitard (the B-Aquitard) is present at the base of the B-Aquifer. The thickness of this B-Aquitard is estimated at between 10 and 120 feet (USAF, 2017b). This unit is comprised of predominantly sandy clay (SAIC, 1992). Groundwater in the B-Aquifer is probably in equilibrium with the A-Aquifer; similar piezometric surface has been measured in adjacent A-Aquifer and B-Aquifer monitoring wells. Groundwater flow direction in the B-Aquifer is south towards the Naknek River. Numerous residential drinking water-supply wells are screened in this aquifer.

The C-Aquifer underlies the B-Aquitard at a depth of approximately 205 feet bgs. KSD water-supply wells are reported to terminate in the C-Aquifer, which is thought to be a confined aquifer. The aquifer thickness and flow direction are unknown for the C-Aquifer (Paug-Vik Services [PVS], 2009a). Limited data from water supply well No. 5 suggest that the thickness of C-Aquifer is at least 20 feet (SAIC, 1992).

The information CH2M summarized is consistent with many of the studies completed for the King Salmon AFS. These studies do not extent toward the river and may not reflect conditions off the facility. The two areas of interest for the Alaska DOT&PF – Southcoast Region King Salmon per- and polyfluoroalkyl substances (PFAS) Project (Charlie's Sport Shop and AC Store) are approximately ½ of a mile south of where the aquifer studies occurred (Figure 1). Based on the limited information available, including CH2M's description of the hydrogeology, our well log search, and our discussions with residents, we provided the following observations:

- The A-Aquifer is the most likely to be affected by PFAS contamination originating at the ground surface. As mentioned in the CH2M report, the B-Aquifer is probably in equilibrium with the A-Aquifer. This may explain the low-level detections of PFAS encountered in several private drinking-water wells presumed to be in the B-Aquifer.

- Wells in the area of the AC Store are likely finished in the upper portion of the B-Aquifer at depths no greater than 100 feet. The only well we have a boring log for is the AC Store. According to the well log, the AC Store well is completed to a depth at 60 feet and is likely screened in the B-Aquifer. According to the well log for the AC Store, clay was present in the upper 20 feet. Depths of the surrounding wells are based on owner-provided information; no logs are available for these wells. Some of the deeper wells near the AC Store have had low-level detections of PFAS, indicating vertical migration is occurring. The effect of the vertical migration has had on the deeper portion of the B-Aquifer is not known.
- Wells to the north of Charlie's Sport Shop are reportedly 150 to 250 feet deep; no boring logs are available for these wells. We assume they are finished in the C-Aquifer. Charlie's well is reportedly 65-70 deep.
- The well log from the DOD Marina (22787) located near the river southeast of the AC Store shows several aquifers and aquicludes; however, the depths and thickness are not consistent with the regional studies. The well is completed to a depth of 120 feet deep.
- Locals have stated the water quality in the C-Aquifer is poor due to high iron content.

We understand the goal of this review was to determine if drilling and installing deeper private wells would result in a permanent alternative-water solution for the properties affected by PFAS contamination above the Environmental Protection Agency Lifetime Health Advisory (LHA). Since deep subsurface data is limited in the area of the AC Store and Charlie's Sport Shop, we recommend additional explorations to assess the feasibility of extending the depth of these wells as a corrective action.

The additional explorations could consist of the following options:

- Drill a well deeper in the B-aquifer and collect groundwater samples for PFAS. This will allow us to assess the vertical gradient of PFAS contamination. In the absence of long-term data from the local wells, we cannot complete a trend analysis, we are unsure how the results change in with time and depth.
- Drill a well into the C-aquifer and collect samples for PFAS. It is possible the wells north of Charlie's Sport Shop are drilled into the C-Aquifer; these wells have low-level PFAS detections. We are unaware of wells in the C-Aquifer in the area of the AC Store.

In order to explore the two options listed above, we are proposing installation of either a 2-inch well (monitoring well) or a 6-inch well (drinking-water well). The installation of one over the other is described below:

- Installation of a 2-inch well would allow for collection of undisturbed soil samples and verification of the subsurface conditions, as the information presented in the reviewed

reports may not be valid in the affected areas. However, a 2-inch well is not sufficient for a permanent alternative-water solution. This well would be used as a long-term monitoring well and used to assess the concentration of PFAS over time. If the PFAS concentrations are favorable (as determined by invested parties) future work would include revisiting the site and installing a 6-inch well in close proximity to the 2-inch well.

- Installation of a 6-inch well would not allow for collection of undisturbed samples for precise verification of the subsurface conditions due to the drilling methods available for the installation of such a well. The subsurface would be approximated using the drill cuttings. A 6-inch well is sufficient as a permanent alternative-water solution. However, if the concentration of PFAS is unfavorable (based on discussions with all parties), this well could still be used as a long-term monitoring well.

Cost estimates and schedules can be provided to determine which option should be explored for these installations.

We appreciate the opportunity to continue working with you on this project. If you have any questions, please contact me at 907-458-3156.

Sincerely,

SHANNON & WILSON

Michael Jaramillo
Senior Chemist

MXJ:MSL/KRF/ARM

Enc. Figure 1 – Site Map

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REFERENCES

CH2M Hill, August 29, 1989, Installation Restoration Program Stage 1 Final Technical Report – Appendices A-J.

CH2M, July 2019, Final Uniform Federal Policy – Quality Assurance Project Plan for Sites Inspections of Aqueous Film-Forming Foam Areas, King Salmon Divert, Alaska.

EMCON Alaska, Inc., June 1995, Limited Field Investigation, King Salmon Airport, King Salmon, Alaska.

EMCON Alaska, Inc, August 1995, Installation Restoration Program – Remedial Investigation/ Feasibility Study at Fourteen Sites, King Salmon Airport, King Salmon, Alaska.

Engineering-Science, September 1985, Installation Restoration Program Phase 1: Records Search AAC – Southern Region.

Science Applications International Corporation, July 14, 1992, Preliminary Assessment, King Salmon Airport, King Salmon, Alaska

Science Applications International Corporation, September 1993, Aquifer Pumping Test – Eskimo Creek Site (SS11), King Salmon Airport, King Salmon, Alaska.

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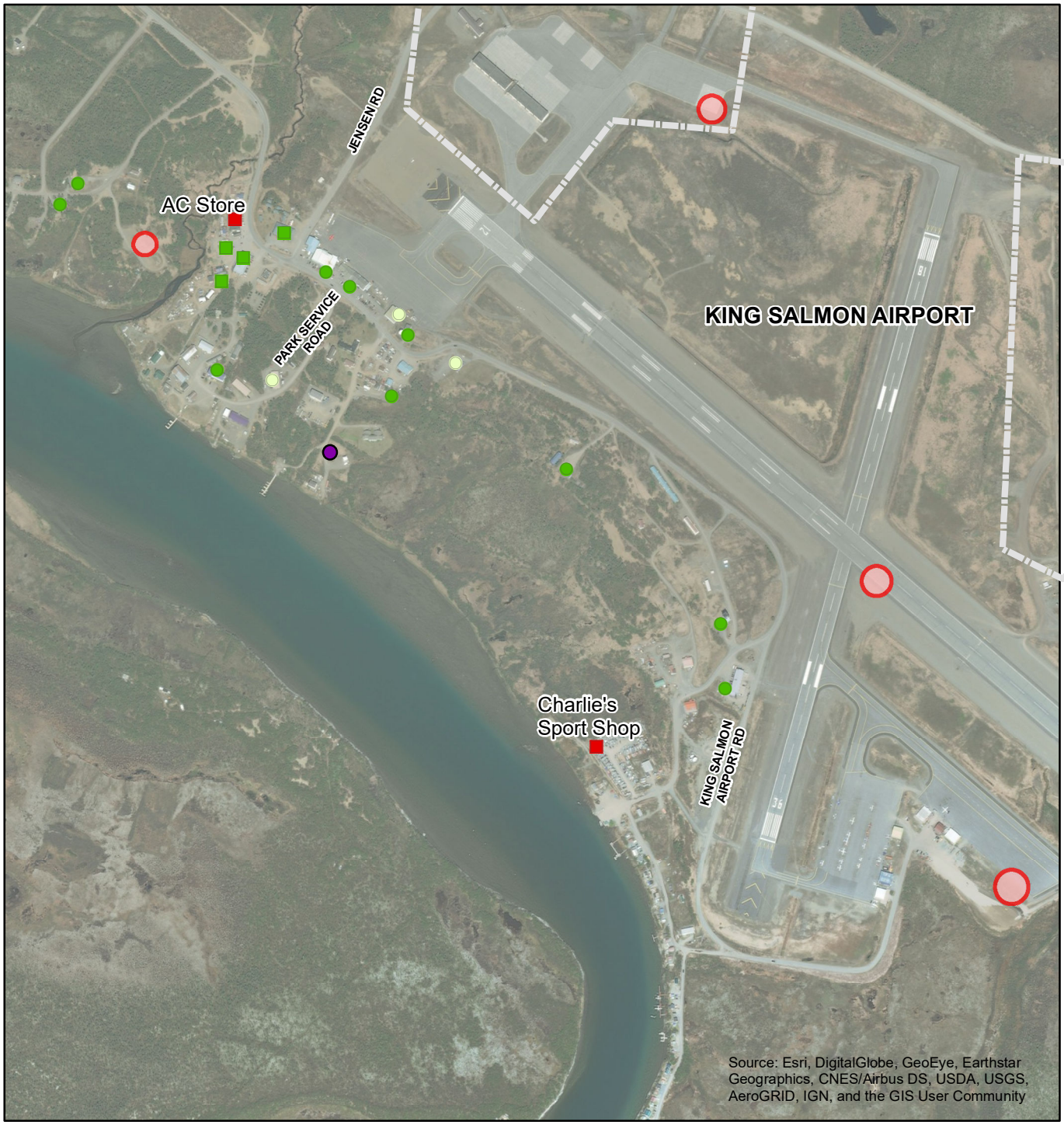

LEGEND

Wells sampled after April 2019; compared to EPA health advisory

- ≤17 parts per trillion (ppt)
- 18-69 ppt
- ≥70 ppt (over LHA)
- DOD Marina
- Extent of Air Force site investigation (approximate)

Wells sampled before April 2019; compared to former DEC action level*

- ≤17 parts per trillion (ppt)
- 18-65 ppt
- ≥65 ppt (over ADEC action level)
- Areas of known AFFF use

* Sum of PFOS, PFOA, PFHxS, PFHpA, and PFNA

0 0.2 0.4

Miles

N

King Salmon Airport
King Salmon, Alaska

SITE MAP
KING SALMON AIRPORT

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Figure 1