

November 23, 2005

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Attention: Robin Reich

Subject: Knik Crossing Project – Groundwater Resource Evaluation
Matanuska-Susitna Borough, Alaska
GeoEngineers File No. 12694-001-00

INTRODUCTION

GeoEngineers is pleased to provide this technical memorandum providing our evaluation of groundwater resources in the western Matanuska-Susitna (MatSu) Borough. The work was requested by HDR in support of their contract with the Knik Arm Bridge and Toll Authority (KABATA). The scope of work was developed in a meeting at HDR on November 14, 2005, and was authorized in an email communication on the same date.

PART I – KNOWN CONDITIONS

HYDROGEOLOGIC SETTING

The project area is generally bounded by the Little Susitna River on the west, Knik Arm on the south and east, and by the Parks Highway on the north. It is technically situated within the Susitna River Basin, whose drainage area constitutes more than half of the Cook Inlet watershed. The basin includes Mount McKinley in the Alaska Range; however, the project sub-basin is more closely tied to the headwaters of the Little Susitna River in the Talkeetna Mountains near Hatcher Pass.

Surface features within the project area are characteristic of the Cook Inlet – Susitna Lowland and include glacial retreat features such as outwash plains, ground moraines, drumlins, eskers and kettle lakes. Consequently, unconsolidated deposits in the project area include Quaternary-age alluvial and glacial material. These deposits are generally underlain by Tertiary-age sedimentary rocks of the Kenai Group.

Six ecoregions or areas with common, homogenous natural features have been defined within the Cook Inlet Basin by Omernik (1995). The western portions of Anchorage and the Kenai Peninsula are similar to the project area in terms of geology, soils, physiography, climate, vegetation, land use and land cover, and have therefore been grouped together within the Cook Inlet Ecoregion. The average annual precipitation in Wasilla is 17 inches.

GROUNDWATER RESOURCES

Information regarding groundwater resources in the project area has not previously been summarized in a regional study. The United States Geological Survey (USGS) is currently working on a regional potentiometric map of the MatSu Borough. Existing subsurface information in the vicinity of Point MacKenzie, Houston, Big Lake, and the southern portion of Wasilla provide the primary basis for assessment of regional conditions in the project area. Technical reports for other portions of the study area

were not readily available, however state on-line database information for wells ("WELTS") was also briefly reviewed for additional information. Following is a summary of the number of wells identified in WELTS by Township and Range within the study area:

Township – North	Range – West	Number of Wells
14	4	17
15	4	17
16	4	28
17	4	94
17	3	446
16	3	79
15	3	6
14	5	3
15	5	23
15	5	6
16	5	1

POINT MACKENZIE AREA

Point MacKenzie Groundwater Resources

Glacial and alluvial deposits in western Anchorage provide a significant potable water supply known as the Anchorage lowlands aquifer system. These unconsolidated materials are found at thicknesses of more than 1,000 feet. The northern boundary of this system is the Elmendorf Moraine, north of Ship Creek. This feature represents the terminus of the most recent glacial advance in the Cook Inlet area. Material to the south of the end-moraine tends to be well-sorted through glaciofluvial processes, resulting in greater hydraulic conductivity than the unsorted tills to the north. The Elmendorf Moraine is mapped as extending across Knik Arm approximately at Point MacKenzie Road. In this southern portion of the project area, unconsolidated materials are known to provide potable water from unconfined as well as confined aquifer resources. Four deep test wells were drilled by the MatSu Borough and the USGS in the early 1980s. A 398-foot-deep test well was drilled near Lake Lorraine, just north of Point MacKenzie. The well encountered three water-bearing zones separated by clay horizons. The hydrostatic water level for the deepest aquifer was monitored over a two year period and ranged from 104 feet below ground surface (bgs) to 106 feet bgs. Groundwater level monitoring also indicated a tidal influence of up to 2.0 feet in the deep test wells.

Unconfined aquifer yield in this portion of the study area is estimated by Glass (1983) to be 5 to 35 gallons per minute (gpm), while the confined aquifer yield may range widely from less than 1 gpm to more than 300 gpm.

Point MacKenzie Area Water Quality

Groundwater quality in the Point MacKenzie area varies widely. High salinity was reported in a 300-foot-deep well west of Horseshoe Lake, close to the Little Susitna River. Water samples were collected from three separate aquifers during test well drilling near Lake Lorraine. Results indicate increasing chlorides with depth, however concentrations meet drinking water quality standards (250 milligrams per liter

[mg/l]). The concentrations of total dissolved chlorides were 3.1 mg/l, 16 mg/l and 97 mg/l for samples from depths of 137 feet, 277 feet and 347 feet, respectively.

WASILLA AREA

Wasilla Area Groundwater Resources

Aquifers in the MatSu area are primarily situated within glacial deposits overlying sedimentary and low-grade metamorphic bedrock. Brabets describes these glacial deposit aquifers as "irregular in distribution and highly variable both in composition and in their ability to provide water to wells." Although unconsolidated sediments thicken with distance away from the mountains towards the coast and towards major river channels, the deposits also become finer-grained. The deposits are generally less than 200 feet thick, however a Palmer city supply well draws 500 gpm from an aquifer at a depth of 624 feet bgs. Other than this well, few high-capacity wells have been attempted in the Mat-Su valley. In general, it is reported that wells situated in the glacial deposits have proven adequate for domestic supply.

Wasilla Area Water Quality

Little information about water quality has been compiled for the Wasilla area. Community water for Wasilla is provided by four groundwater wells tapping multiple unconfined aquifers. The wells range from 146 feet to 250 feet in depth. Raw water quality is very good and the system does not require treatment other than routine chlorination.

HOUSTON AREA

Houston Area Groundwater Resources

Geology in the Houston area consists of glacial and fluvial deposits up to 180 feet thick, overlying Tertiary age sedimentary rocks. The glacial material in the Houston area primarily consists of till and glacial outwash deposits. These materials are generally overlain by windblown silt.

At the time of a 1987 state geological investigation of water well data from the Houston area, there were approximately 220 wells. About half of those wells were less than 90 feet deep. Well production rates ranged from about 2 gpm for domestic bedrock wells up to 250 gpm for the well serving the Houston Junior-Senior High School. Typical domestic supply from the glacial deposits has met expectations in the range of 10 to 50 gpm, while it is reported that yields as high as 1,000 gpm could be achieved through proper well design at locations near the Little Susitna River. Sandstone and coal layers at depth also provide potable water supply.

Houston Area Water Quality

Water quality concerns in the Houston area include incidental occurrences of high concentrations of hydrogen sulfide and conductivity, iron, total dissolved solids (TDS), and phosphorous.

BIG LAKE AREA

Big Lake Area Groundwater Resources

Hydrogeology in the Big Lake area was previously described in an overview of existing information by Hogan (1995). The community of Big Lake is situated in the northwest corner of the project area. This part of the Upper MatSu Valley is characterized by longitudinal bedrock hills and small narrow lakes. Surficial deposits near Big Lake are comprised of outwash sand and gravel, partly saturated gravel in

ground moraines, and windblown sediment. End moraine deposits of till are found near Big Lake and likely form a shallow groundwater divide. Unconsolidated material extends to depths of more than 60 meters, and possibly as thick as 300 meters in the Big Lake area; consequently, little is known of the geology of the underlying bedrock in this area. Both unconfined and confined aquifers provide potable water in the Big Lake area.

Outwash deposits form the primary source of aquifer material in the area – they consist of unconfined sheetlike deposits 1 to 30 meters thick and confined deposits up to 20 meters thick, situated beneath a confining layer of till. Higher yields are typical from the confined aquifer, up to 18 liters per second (l/s) compared to 0.3 to 3 l/s in the shallow deposits.

Big Lake Area Water Quality

Drinking water quality near Big Lake is generally good, however some wells contain constituent concentrations that exceed regulatory standards. These include TDS (as high as 1,430 mg/l), iron (as high as 7.2 mg/l), chlorides (700 mg/l), sulfates (130 mg/l) and manganese (0.46 mg/l).

OTHER GROUNDWATER QUALITY CONCERNS

Nancy Lake Area

Shallow groundwater close to the northwestern portion of the study area is reportedly brackish or salty. The water quality problem occurs in the vicinity of Willow and Nancy Lake, at depths as shallow as 50 to 100 feet bgs or nearly 180 feet above sea level. The cause for the salinity has not been determined, however it is believed to be due either to connate water (water trapped in the sedimentary rock at the time of its deposit) or it is due to inundation of the area by an ancestral Cook Inlet.

Arsenic

Conditions favorable to the occurrence of arsenic in groundwater are found throughout the study area. These include the presence of iron oxide and sulfide minerals in the aquifer materials, alkaline (high pH) groundwater, and phosphates and organic carbon. In a 2001 USGS study, several wells in the project area were identified with concentrations of arsenic between 10 micrograms per liter ($\mu\text{g/l}$) and 50 $\mu\text{g/l}$. Presently the maximum contaminant level for arsenic is 50 $\mu\text{g/l}$, however this U.S. Environmental Protection Agency (EPA) standard is due to decrease to 10 $\mu\text{g/l}$ by the end of January 2006.

Contaminated Sites

The Alaska Department of Environmental Conservation (ADEC) on-line databases were searched for incidents of "open" leaking underground storage tank sites and "active" contaminated sites located in Big Lake, Houston and Wasilla. No other location references from within the project area are used in the databases. The search resulted in the identification of seven sites in Big Lake, one site in Houston and 32 sites in Wasilla. The locations of the Wasilla sites were not researched to determine the number of sites situated within the project area.

PART II – POTENTIAL IMPACTS FROM DEVELOPMENT

ADEQUACY OF RESOURCE

Aquifer yield from unconsolidated sediments throughout the project area are reportedly adequate for existing residential development in the focus areas described above. The same density of residential

housing is anticipated as project-consequential growth into presently undeveloped areas in the study area. Wells completed in bedrock, however, are less reliable in their ability to provide an adequate supply for residential needs.

Groundwater quality is highly variable across the project area. New drinking water standards for arsenic may be exceeded in some portions of the project area. Locally, secondary (unenforceable, nuisance) contaminants including chlorides, iron, manganese, TDS and sulfates may also be of concern but are apparently not a widespread complaint.

IMPACTS TO RESOURCE

Potential impacts to the groundwater resources due to anticipated residential growth in the project area have not been determined. Identification of groundwater management areas, including scientific assessment of critical aquifer recharge areas, is not yet a common or legislated practice in Alaska. The principals in conducting such an assessment provide a framework for consideration of potential impacts to the groundwater resources in the project area.

Groundwater Quantity

An area-wide water balance is required in order to evaluate potential impacts to groundwater quantity resulting from residential development in the project area. An existing analysis could not be identified and has likely not been conducted. A generalized water balance was developed to evaluate the impact of residential development consisting of a family of four residing on a one-acre parcel. Considered parameters included average annual precipitation and conservative values for runoff, evapotranspiration and water demand. On the basis of this theoretical model, annual recharge and discharge are nearly equal - within 3 percent. The results support the adequacy of aquifers in unconsolidated material in the project area to sustain a safe yield for residential use.

Groundwater Quality

Potential impacts to groundwater quality due to development are related to aquifer susceptibility and vulnerability. Susceptibility is related to the natural ground conditions – at the most basic level, shallow, unconfined aquifers are more susceptible to potential contamination from sources such as septic leakage or fuel spills. Confined aquifers are generally less susceptible to impacts from development or accidental discharge of contaminants. Aquifer vulnerability is a combination of susceptibility and risk; for example, a well situated in unconfined material adjacent and downgradient to a gas station would be more vulnerable to contamination than the same well situated upgradient of that facility. Public water supply wells are required through the Safe Drinking Water Act to have a source water assessment that identifies a protection zone on the basis of the source susceptibility and vulnerability. ADEC lists 136 public water systems in Wasilla and 40 public water systems in Big Lake, Knik, Houston and Point MacKenzie for which source water assessments have been conducted. The locations for Wasilla were not researched to determine the number of those systems situated within the project area.

Point Sources

Transient contaminant point sources are a low risk along transportation corridors, as experienced by the Gold Creek fuel spill near Talkeetna in 1999. Fuel spills at gas stations, as well as accidental discharge at many maintenance or fuel storage facilities, also pose a more regular, but regulated risk to shallow groundwater supplies.

Non-Point Sources

Urban stormwater runoff impacts will be directly related to best management practices imposed by the Borough. Under the residential development scenario, street maintenance practices such as oiling roads for dust control could impact nearby shallow groundwater resources.

Single-family on-site wastewater disposal and small community leachfields constitute localized increased vulnerability of shallow aquifers to bacteria, viruses, nitrates and nitrites in areas with shallow groundwater. The risk is minimized through installation of systems in accordance with prescribed separation distances.

Other potential non-point sources of pollution that could impact groundwater quality include bacteria and nutrients from livestock or pet wastes, sediment from mining or construction, and fertilizers from agricultural areas.

Groundwater Recharge Areas

Regional hydrogeologic mapping has not previously been conducted for the MatSu Valley, although the USGS is presently completing such a study (Ted Moran, USGS, personal communication). Based on general geological conditions in the project area, recharge to unconfined aquifers is through downward percolation of precipitation. Recharge to deeper aquifers is by infiltration of groundwater through aquitards and "leaky" confining layers, by lateral migration from other aquifers, and/or by direct infiltration of precipitation where the till or other confining layers are absent. Groundwater recharge occurs over most of the land surface, with discharge occurring locally to low-lying areas such as lakes, streams and wetlands.

We appreciate the opportunity to be of service to HDR Alaska on this project. Please call if you have any questions concerning our report.

Sincerely,

GeoEngineers, Inc.



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