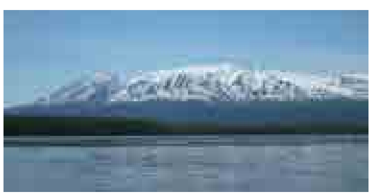
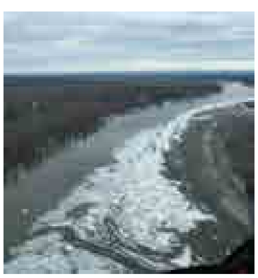
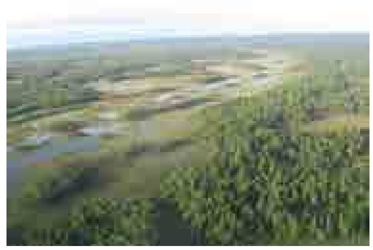
West Susitna Access Reconnaissance Study
West Susitna Access to Resource Development

Transportation Analysis Report







Appendix C: Geotechnical Reconnaissance Report

Geotechnical Reconnaissance Report
West Susitna Access
Mat-Su Borough, Alaska

December 2013

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1.0 INTRODUCTION

This report presents the results of our literature research and geotechnical engineering evaluation for the West Susitna Access project in the Matanuska-Susitna (Mat-Su) Borough, Alaska. The purpose of this study was to perform a geotechnical evaluation of several transportation corridors for the area between the Parks Highway and the Alaska Range. To develop the criteria for use in our evaluation, we reviewed existing geological and geotechnical information from the area. Included in this report are descriptions of the site and project, results of our literature research, and our evaluation of the corridors reviewed during our study. The results of our evaluation will be used to supplement other evaluation criteria, such as construction cost and environmental impacts, in an attempt to evaluate the viability of each corridor for development.

Authorization to proceed with this work was received in the form of a Subconsultant Agreement signed by Duane Hippe of HDR Alaska, Inc. on February 12, 2013. The work was performed in general accordance with the scope of services included in the Subconsultant Agreement.

2.0 PROJECT DESCRIPTION

The West Susitna Access Project is focused on evaluating alternatives for developing transportation corridors to connect road inaccessible lands west of the Parks Highway between Wasilla and Petersville. The overall goal of the project is to evaluate the viability of developing road access into the region to support what the State of Alaska (State) anticipates as potentially significant resource development in the form of timber, mining, oil and gas, and recreation. Given the wide variety of potential developments, there is no single target point for access corridors, but rather many smaller, focus areas within the region. As such, several corridors are being considered, each having different start and end points. It is envisioned that the new roadway or roadways could see a variety of traffic types depending on what is being accessed and whether or not it is a roadway dedicated for industrial use or open to the public.

Our studies included seven unique alignments as shown on the vicinity map on Figure 1. The seven alignments included in our review include the:

- South Peters Hills/Yenlo Hills Alignment,
- Skwentna Alignment,
- Deshka Alignment,
- Skwentna River Alignment,
- East Susitna Alignment,
- Susitna Crossing Alignment, and
- Beluga Alignment

Several of these alignments are combined to provide four alternatives and one variant as shown in the following table.

Alternatives	Corridor Segments
North Petersville	South Peters Hills/Yenlo Hills Alignment
North Skwentna	Skwentna Alignment Skwentna River Alignment
Middle Susitna-Skwentna River	Susitna Crossing Alignment East Susitna Alignment Skwentna River Alignment
Beluga	Susitna Crossing Alignment Beluga Alignment
Deshka Variant	Deshka Alignment

These alignments were generally selected to provide access for potential and existing mining, oil and gas, and forest resources within the region. To accommodate the preliminary nature of this study the project alignments were based on existing land feature mapping provided by the United Stated Geological and Geophysical Survey (USGS) and available topographic data. More detailed plan view maps of each alignment are included on the site plans in Figures 2 through 8 along with narrative descriptions in the sections below.

2.1 South Peters Hills/Yenlo Hills Alignment

The North Petersville Alignment (Figures 2a and 2b) consists solely of the South Peters Hills/Yenlo Hills Alignment and begins at Petersville Road which connects Trapper Creek with Petersville to the northwest. The South Peters Hills/Yenlo Hills Alignment heads west and south and crosses the Kahiltna River, Lake Creek, and the Yentna River to the northwest of the town of

Skwentna. The potential alignment continues west near the foothills of the Alaska Range and terminates after crossing the Skwentna River on the north side of the Tordrillo Mountains. This alignment crosses four major rivers or tributaries and several small drainages and low lying marshlands.

2.2 Skwentna Alignment

The Skwentna Alignment (Figures 3a and 3b) is one of two segments (along with the Skwentna River Alignment) that make up the North Skwentna Alternative. The Skwentna Alignment begins from Oil Well Road which heads south from the Petersville Road approximately six miles from the junction of the Glenn Highway and Petersville Road. The alignment trends to the west/southwest toward the town of Skwentna. The Kahiltna River, Lake Creek, and the Yentna River are the major river crossings for this alignment and several smaller drainages and/or low lying marshy crossings should be expected. The alignment passes through the town of Skwentna and then follows the south side of the Skwentna River until it terminates at the junction of the East Susitna Alignment and the Skwentna River Alignment.

2.3 Deshka Alignment

The Deshka Alignment (Figures 4a and 4b) is the sole alignment in the Deshka Variant and begins from Oil Well Road and heads south parallel to and east of the Yentna and Kahiltna Rivers. The Deshka Alignment crosses the Susitna River (east of Willow) and makes a sharp turn to the east to its junction with the road system near Willow. This alignment parallels the general northwest/southeast trend of the drainages and marshy low lying areas with its only major river crossing being the Susitna River.

2.4 Skwentna River Alignment

The Skwentna River Alignment (Figures 5a and 5b) is part of the North Skwentna Alternative (along with the Skwentna Alignment) and part of the Middle Susitna-Skwentna River Alternative (along with the Susitna Crossing Alignment, the East Susitna Alignment, and the Skwentna River Alignment). The Skwentna River Alignment begins at its junction with the Skwentna Alignment and East Susitna Alignment and follows the south side of the Skwentna River to its termination within the Skwentna River Valley in the Alaska Mountain Range. This alignment is generally at the base of the north side of the Tordrillo Mountains and is contained within the

Skwentna River valley. One major river crossing would be necessary at Hayes River which drains the Hayes Glacier within the Tordrillo Mountains.

2.5 East Susitna Alignment

The East Susitna Alignment (Figures 6a and 6b) is part of the Middle Susitna-Skwentna River Alternative along with the Susitna Crossing Alignment and the Skwentna River Alignment. The East Susitna Alignment begins at its junction with the Susitna Crossing Alignment and the Beluga Alignment and trends in a northwest direction to its junction with the Skwentna Alignment and the Skwentna River Alignment. The East Susitna Alignment is located on the western margin of the Yentna River valley along the base of Mount Susitna, Little Mount Susitna, and Beluga Mountain. To the east of this alignment lies the Yentna River valley and to the west lies the above mentioned mountains. This distinct change in topography is likely due to the Beluga Mountain Thrust fault upon which this alignment lies.

2.6 Susitna Crossing Alignment

The Susitna Crossing Alignment (Figures 7a and 7b) is part of the Middle Susitna-Skwentna River Alternative (along with the East Susitna Alignment and the Skwentna River Alignment) and part of the Beluga Alternative (along with the Beluga Alignment). The Susitna Crossing Alignment begins from West Little Susitna River Road in Big Lake, Alaska and trends to the northwest crossing the Little Susitna River, several marshy low-lying bogs, and the Susitna River (below its junction with the Yentna River). This alignment terminates at the junction with the East Susitna Alignment and the Beluga Alignment on the western flanks of Mount Susitna.

2.7 Beluga Alignment

The Beluga Alignment (Figures 8a and 8b), along with the Susitna Crossing Alignment is part of the Beluga Alternative which provides road access to Beluga, Alaska. The Beluga Alignment begins at the junction of the Susitna Crossing Alignment and the East Susitna Alignment and trends southwest following the western edge of the Susitna Flats State Game Refuge at the base of Mount Susitna. The alignment generally stays in the upland areas and skirts the marshy lowlands of the state game refuge. There would be several potential minor stream crossings and one major crossing at Beluga River. After the alignment crosses Beluga River, it curves to the east and then north to terminate in Beluga, Alaska.

3.0 LITERATURE RESEARCH

Literature research was conducted to find and evaluate the existing subsurface information available for the project area. The primary existing data sources reviewed for this work were existing geologic maps of the area by the USGS. This information, along with large scale landform and terrain evaluation supported by aerial photography provided by HDR was the basis for our evaluations of the access corridors. In general, coverage for the project area is sporadic, likely a result of the relative remoteness of the area. A bibliography of literature that is available for the project area is included in Section 9.0.

4.0 REGIONAL GEOLOGY

The Susitna Lowlands are bound on the north and west by the Alaska Range and bound on the east by the Talkeetna Mountains. The topography is generally flat to rolling hills and gains relief near the foothills of the Alaska Range. Numerous glaciers populate the mountains and extend down valleys to near the edges of the lowlands. Evidence indicates that at least five glaciations played a part in the landscape and deposits that form the lowlands. Glacially carved bedrock, moraines, drumlins, and kettle lakes are a few of the landforms found and continuous erosional processes are constantly reshaping the land. The following sections discuss the regional bedrock geology, soil stratigraphy, tectonics, seismicity, and permafrost conditions. Surficial geology along each of the alignments is shown in Figures 2 through 8. A brief legend to the mapped units is provided on Figure 9.

4.1 Bedrock Geology

Beneath the Quaternary surficial deposits, the bedrock geology consists primarily of Tertiary deposits of the Kenai Group overlying a pre-Tertiary basement complex. The Kenai group represents clastic forearc basin deposits of early and late Cenozoic tectonic cycles and the rocks are characteristic of a fluvial system. The Kenai Group consists of five major formations; the Sterling formation, the Beluga formation, the Tyonek formation, the Hemlock Conglomerate, and the West Foreland formation (from top to bottom). These five formations contain packages of sedimentary rocks including sandstone, claystone, siltstone, conglomerate, and coal beds; with the thickest coal beds in the Beluga and Tyonek formations. Parent rock for the sediments found within the Susitna lowlands include plutonic and metamorphic sources from the Alaska Range to the north and west and from the Talkeetna Mountains to the east.

In addition to the Tertiary sedimentary rocks, the project area also includes Tertiary granites and intermediate to mafic volcanic rocks. Cretaceous sedimentary, igneous, and metamorphic rocks are also found including turbidites, granodiorite, granite, and intermediate to felsic volcanics.

4.2 Quaternary Deposits

Potentially thick sequences of Quaternary sediments derived from glacial and erosional processes are likely present predominantly in the lowlands. Glacially derived soil (glacial drift) materials may consist of till, outwash, and glaciolacustrine sediments. Glacial till is typically randomly sorted and consists of relatively equal fractions of silt, sand, and gravel, along with some cobble- and boulder-sized particles. Outwash materials generally consist of cleaner sand and gravels that may be well or poorly graded. Glaciolacustrine deposits of fine sand, silt, or clay may also be present in localized areas that were once occupied by moraine or glacially dammed lakes.

More recent deposits of sand and gravel are likely present in localized areas throughout stream and river valleys or near alluvial fans as coarse sediments are carried from the nearby mountains. Steep slopes may be covered or skirted by talus as frost wedging pries the bedrock apart. In addition, ash layers have been observed up to 3 feet thick in some places and vegetation suggests that it may have fallen more than 100 to 200 years ago.

4.3 Tectonics and Seismicity

The project region is one of the most seismically active areas in the U.S. and historically subjected to relatively large earthquakes. According to the Alaska Earthquake Information Center, two large (greater than magnitude 7) earthquakes have occurred within or near the project area in 1933 and 1943. Several hundred smaller earthquakes have also been recorded since 1899. Regional seismicity is shown on Figure 10 and much of the information presented in this section is based on Alaska Division of Geology & Geophysical Surveys (DGGS) Miscellaneous Publication 141 (Koehler et.al. 2012).

On a large scale, the tectonics and active seismicity of the region are the result of ongoing north-northwest movement of the Pacific Plate relative to the North American Plate. The relative movement results in a region of right lateral strike-slip faulting along the eastern margin of the Gulf of Alaska and subduction along the central and western margins of the gulf. Along the eastern margin of the Gulf of Alaska (+ 250 miles southeast of the project area), the relative right-lateral movement between the plates is accommodated primarily by northwest-striking high-angle strike-slip faults (i.e., Fairweather and Queen Charlotte Faults). The right-lateral movement is translated northwest of the gulf into the interior of Alaska along the right lateral Denali Fault system (DFS), which extends through the southern Alaska Range to the north of the project area.

In terms of engineering significance, three broad seismic sources may present hazards in the project area. Nearest the project area, the DFS was responsible for the 2002, magnitude 7.9 Denali Fault earthquake. Associated surface rupture was documented for hundreds of kilometers along the fault trace. The Alaska-Aleutian Subduction Zone, a mega-thrust source at the interface between the North American and Pacific Plates was the source of the 1964, magnitude 9.2 Great Alaska Earthquake.

Other shallow crustal sources such as the Castle Mountain fault on the south end of the Susitna lowlands may also impact the project area. It is postulated that the Castle Mountain fault is capable of producing earthquake magnitudes up to 7.5. Displacement along the Castle Mountain fault is visible in the landforms across the Susitna flats. The relatively recent Pass Creek fault is centrally located in the Susitna lowlands with northeast to southwest trending surface expressions mapped west of Mt. Yenlo and the Kahiltna River. The fault has been identified as a northward dipping reverse fault with displacement of less than 0.2mm per year and most likely will be a source of earthquakes with magnitudes between 4.0 and 6.0. In addition, the Bruin Bay fault has been mapped along the base of Mount Susitna trending northwest toward Beluga Mountain along the mountain front. This fault is a high angle reverse fault with several hundred meters of displacement, but is not considered to be an active fault system.

Given the various sources of ground motions that are associated with this part of Alaska, the types of shaking during seismic events can vary significantly. In addition to the magnitude of the events, the peak ground accelerations as well as duration of shaking can have a significant impact on design of transportation features in this area. Seismic events along the Benioff zone of the Alaska-Aleutian Subduction Zone that lie directly beneath the project area are generated from very deep sources (typically greater than 120 miles below the ground surface). This shaking is caused by large scale rupture along the subducting and overriding plates and is typically characterized by relatively low peak ground acceleration, low frequency, and long duration seismic events. Such long duration shaking typically effect very large regions and can have significant impacts on soils sensitive to strength loss and liquefiable soils. Shallow-source earthquakes such as the Pass Creek Fault and other faults associated with the DFS tend to create high frequency, high acceleration, and relatively short duration shaking events. Such events can impart very high stresses of structures, can result in significant displacements along the surface expression of the fault, and can also result in localized soil strength loss and liquefaction. Lateral extent of shaking from these sources is typically limited to areas relatively close to the portion of the fault that ruptures.

4.4 Permafrost

Permafrost is defined as soil or rock beneath the ground surface where a temperature below 32 degrees Fahrenheit has existed for two or more years. Permafrost within the project area has been mapped as isolated masses of permafrost, discontinuous permafrost, or be generally free from permafrost. Most of the area along the Susitna River is likely generally free from permafrost. The isolated masses and discontinuous permafrost will likely be found in fine grained soils, whereas course grained soils may be free from permafrost. Thick surface layers of organic soils may also provide insulation for permafrost soils. Permafrost in the project area is likely to be relatively warm and will begin to degrade if the thermal regime is adversely impacted by modifications to the ground surface. Depths of permafrost are variable, especially in areas of discontinuous permafrost, and depend upon exposure, ground cover, soil characteristics, and other factors. The thickness of the active layer (the near-surface ground that undergoes an annual freeze-thaw cycle) is largely dependent on soil type, ground cover, and snow depth. In general, the active layer across the project is likely within the upper 10 to 20 feet below the ground surface.

4.5 Regional Geologic Processes

Regional geologic processes will also have a significant impact on the design and performance of transportation improvements in the project area. Such processes include stream icing, slope instability, flooding (through precipitation, snow melt, and glacial lake outbursts, etc.), and seismic influences (e.g. ground motions, liquefaction, lateral spreading, etc.). Many of these processes are complementary and should be evaluated separately as well as in relation to each other. For example, seismic influences such as liquefaction can cause damaging settlement, but can also contribute to slope instability and flooding. Similarly, flooding can produce damaging erosion and deposition of material, but can also instigate slope instabilities (in previously stable areas) through erosion. It is our opinion that the entire study area is subject to most, if not all, of these regional processes, however, some areas may be more prone than others. In general, the flooding, icing, and seismic influences will be more prevalent in low-lying areas and in areas near streams and floodways. Glacial outburst flooding will be difficult to predict, but can influence areas well outside of natural river floodways for relatively large distances below existing glaciers. Seismic influences will also more significantly impact areas adjacent to or on sloping ground, with greater severity on steeper gradients.

5.0 GEOTECHNICAL ENGINEERING CONSIDERATIONS

We developed a system of geotechnical criteria in order to evaluate the geotechnical conditions along each of the potential alignments. These criteria range from the availability and quality of borrow materials along the alignment, subgrade and foundation support, drainage, permafrost and other conditions. In essence, the geotechnical criteria included in our evaluation were selected because it is our opinion that they are the geotechnical criteria that will have the most significant impact on the design, construction, and cost of the project. We performed a broad-based evaluation of each proposed alignment using these criteria based on the subjective point value system described in the following table.

Criteria	Optimum Condition (1 point)	Poorest Condition (5 points)
Rock Borrow Availability	Majority of potential sources are likely less than 2.5 miles from alignment or spaced less than 2.5 miles along alignment	Majority of potential sources are likely greater than 5 miles from alignment or spaced greater than 5 miles along alignment
Rock Borrow Quality	Majority of potential sources likely to yield massive, durable rock	Majority of potential sources likely to yield poor quality, low durability rock
Soil Borrow Availability	Majority of potential sources are likely less than 2.5 miles from alignment or spaced less than 2.5 miles along alignment	Majority of potential sources are likely greater than 5 miles from alignment or spaced greater than 5 miles along alignment
Soil Borrow Quality	Majority of potential sources of available borrow likely to consist of Selected Material Type A or B	Majority of potential sources of available borrow likely to consist of Selected Material Type C
Foundation Support	Majority of structural foundations likely to be on non-erodible, competent bedrock	Majority of structures will likely to require deep foundations accommodating soft or liquefiable soils
Permafrost Conditions	No expected permafrost or majority of frozen soils are expected to be thaw stable	Significant extents of thaw-unstable permafrost conditions expected
Subgrade Support	Average subcut expected to be less than 2 feet below existing ground surface	Average subcut expected to be greater than 5 feet below existing ground surface or extensive subgrade improvement anticipated
Drainage	Average groundwater conditions expected to be deeper than excavation limits in cuts and greater than 10 feet below the ground surface in fills	Average groundwater conditions expected to be above excavation limits in cuts and near the ground surface in fills

Detailed descriptions of each criterion are provided in the sections below. These criteria were used to frame the engineering discussions for each potential alignment provided in Section 6.0. The point values assigned to each criterion for the proposed alignments are also provided in Section 6.0.

5.1 Rock Borrow Availability

Rock material source availability addresses the proximity of rock materials to the corridors studied for this project. Rock materials will be an important resource for the construction of the proposed access road and associated facilities and structures. Material produced from quarries can be used in a wide variety of applications from embankment development, concrete and/or asphalt aggregate, revetment, and surfacing material. The proximity of the rock materials is important because the distance that the material will need to be hauled during construction will have a direct impact on the cost of construction. If rock material is not available adjacent to the roadway, additional access roads may be needed to access potential sources which would also have an impact on the cost of the improvements and will increase the footprint of the project. For successful completion of this project, it will be essential that the final corridor selected will have multiple sources of rock material along its full length. These sources will ideally be located adjacent to the final road alignment and will require minimal development of access branch roads to access them.

5.2 Rock Borrow Quality

Borrow rock quality addresses the rock material types that will be available along each corridor for construction of the road and associated facilities. Rock material quality is important to the project because some of the uses for the rock will require the material to be durable (i.e. resistant to mechanical degradation). In general, rock material that is used in the construction of this project will need to meet the various durability requirements set forth in ADOT&PF standards depending on its application (aggregate, rip-rap, etc.). The highest quality, most durable materials should be used in the production of aggregates and rip-rap, while lower quality materials can be used in embankment construction as shot-rock fill. Typically, intrusive igneous rocks such as granite and diorite yield very high durability values. Extrusive igneous rocks (such as basalt) and lightly metamorphosed rocks (such as phylite) typically have somewhat lower durability characteristics. Highly metamorphosed rocks such as schist as well as sedimentary rocks usually have the lowest durability values. The selected corridor should have rock sources that produce high durability materials that can be developed into rock materials of a wide variety of sizes. High quality sources will reduce the construction costs by reducing the need to import higher durability materials from long distances.

5.3 Soil Borrow Availability

Soil borrow source availability addresses the proximity of soil materials to the corridors studied for this project. Soil borrow materials will be an important resource for the construction of the proposed access road and associated facilities and structures. Soil borrow materials will likely be most widely used to provide embankment fill materials and as structural fill for the roadway. It could also likely be used in producing fine aggregates and as structural fill around drainage structures, culverts, bridges, and in utility trenches. As with rock materials sources, the proximity of the soil borrow sources with respect to the proposed roadway will have a direct impact on construction costs. Sources that are farther from the proposed roadway will have longer haul times and will increase the footprint of the project. To complete the construction of this project, the final corridor selected will need multiple sources of soil borrow along its full length. As with the rock material sources, the soil borrow sources should be located adjacent to the final road alignment so that additional branch roads are not needed for access.

5.4 Soil Borrow Quality

Borrow soil quality addresses the soil material types that are available in the soil borrow sources along each corridor. While soil availability is important, the quality of the material that is available will also impact the cost of the project. Ideally, soil borrow used for this project will consist of clean (low fines content), well graded sand and gravel. Such material will most likely be found in outwash and/or alluvial deposits as well as some moraine deposits. This material would lend itself well to development of structural sections for the road as well as structural fill around bridge and culvert foundations. Poorly graded soils or soils with higher fines content (such as those found in glacial till or moraine deposits) may also be utilized, but their applications will be limited to deep embankment development. Regardless of the gradation of the soil fill used, it should not contain free ice, organic detritus, or a significant amount of plastic fines. Higher quality soil borrow resources along the project corridor will have a positive impact on the construction cost. The high quality materials will require less processing (washing, screening, etc…), and if they are located at regular intervals along the alignment, they will not need to be imported from long distances. Ideally, the final selected corridor will have multiple, high quality soil borrow sources along its full length.

5.5 Foundation Support

Foundation support addresses the overall likely subgrade support for structure foundations along the various corridors. From a foundation support standpoint, the most ideal condition is a foundation supported on shallow, competent bedrock. Less ideal conditions range from soft bedrock and/or dense soil support to thick deposits of soft and/or compressible mineral and organic soils that require deep foundations. Other less ideal conditions include thaw unstable permafrost and liquefiable soils. In general, the poorer the foundation support conditions are, the deeper the foundation systems will need to be to transmit structural loads to the subsurface. The cost advantages to selecting a corridor with ideal foundation support conditions is obvious in that shallower foundations require significantly less materials and effort to construct. Ideally, the corridor that is selected will traverse ground that lends itself to development of relatively shallow foundations on bedrock and/or dense, stable, mineral soils.

5.6 Permafrost Conditions

Permafrost conditions addresses the state and nature of frozen ground under the various corridors studied for this project. The proposed improvements will have an impact on the thermal regime that exists along each corridor that will likely result in warming of the ground under and around the new road. Based on the location of this project, it is likely that the majority of the ground beneath each alignment is not frozen continuously throughout the year. If permafrost conditions exist in a given area, it is more favorable if the soil consists of materials that do not lose a significant amount of strength when they are thawed. Such conditions will likely include shallow bedrock and dense soils that have low fines content. Unfavorable conditions include poorly drained soils, fine grained soils, and permafrost conditions with large amounts of segregated ice. Such soils are subject to long term creep under foundation and/or slope loading and typically lose a significant amount of strength when thawed. Having favorable permafrost conditions along the selected corridor will have a cost benefit as measures (such as insulation and refrigeration) will not need to be taken to maintain the thermal balance under the roadway and associated structures.

5.7 Subgrade Support

Subgrade support addresses the general support capabilities of the subsurface materials along each corridor considered for this project. In general, favorable subgrade support conditions consist of shallow bedrock and/or firm, well drained mineral soils. Poor conditions include thaw unstable permafrost and thick deposits of soft and compressible (mineral or organic) soils. Favorable subgrade support conditions will have a positive impact on construction costs in several ways. Firm subgrade support typically provides more ideal construction conditions and presents fewer constructability challenges since conventional equipment can be used. Furthermore, firm subgrade support circumvents the need for costly subgrade improvement such as excavation and replacement of unsuitable soils, and typically results in thinner embankments and structural sections. Additionally, ideal subgrade support conditions allow for steeper embankment slopes that require less material to construct, and result in a smaller project footprint.

5.8 Drainage

Drainage addresses the general surface and near-surface drainage characteristics of each corridor considered for this project. Well drained conditions are usually found in free-draining soils and in topography that is sloped to allow for the conveyance of surface water. Poor drainage is typically encountered in flat terrain with soils that do not allow for infiltration of surface water (such as in peat bogs or in permafrost terrain). In general, well drained ground conditions typically result in favorable support conditions for new roads and structures. Development of roadways in poorly drained areas result in higher costs associated with designing and constructing additional drainage provisions in the form of culverts and/or porous embankments. Additional costs may also be associated with development of embankments and structures with poor subgrade support in these areas.

6.0 ALIGNMENT-SPECIFIC ENGINEERING CONSIDERATIONS

In order to select the favored alignment, a general understanding of the geotechnical framework of each considered alignment (except for the South Alignment alternatives) is needed. The table below presents the results of our subjective evaluation of each alignment based on the geotechnical criteria discussed in Section 5.0.

Criterion	South Peters Hills/Yenlo Hills	Skwentna	Deshka	Skwentna River	East Susitna	Susitna Crossing	Beluga
Rock Borrow Availability	3	5	5	2	1	4	4
Rock Borrow Quality	4	5	5	2	2	2	2
Soil Borrow Availability	1	2	1	1	2	3	2
Soil Borrow Quality	3	2	2	1	2	3	2
Foundation Support	3	4	3	3	2	3	3
Permafrost Conditions	3	2	1	2	3	1	1
Subgrade Support	3	4	2	2	2	4	2
Drainage	2	4	2	1	2	4	2
Point Tally:	22	28	21	15	16	24	18

Each alignment has unique characteristics and crosses a wide variety of terrain and geological conditions. The discussions below highlight aspects of each alignment that are favorable for development, as well as those that may present a design and/or construction challenge. Because of the scale of this project and the fact that very limited subsurface information exists for this area, the information contained in the following sections should be considered preliminary and used for general planning purposes and route evaluation only. Further reconnaissance, explorations, and engineering analysis will be needed to identify specific borrow sources, identify an alignment route, and develop engineering recommendations for the project.

Regardless of the route or routes selected, a significant amount of design level explorations will be needed to provide the parameters for a final design. Geotechnical explorations should consist of standard soils and rock investigations and should also include an effort to map existing fault traces on the ground surface. In addition, a probabilistic seismic hazard analysis (PSHA) will need to be conducted to evaluate ground motion parameters that will be needed in the design of the project. Given the potential route lengths and seismic variability of the project area, it is likely that several PSHAs will be needed depending on the route or routes selected and the structural features to be constructed. The PSHA results will be used to provide ground motion design parameters and in evaluation of seismic effects such as liquefaction, soil strength loss, and slope stability evaluations.

6.1 South Peters Hills/Yenlo Hills Alignment

This alignment generally trends east to west and typically follows topographic highs where possible, particularly in the eastern half of the alignment. The long axes of landforms (ridges, hills, valleys, etc.) over which the alignment traverses largely trend northwest to southeast, reflecting the general flow of past glaciation in the region. Much of the eastern two thirds of the alignment is characterized by low (less than 100 feet tall) topographical highs separated by low, poorly drained, boggy areas. Because the eastern two thirds of the alignment's orientation does not follow the overall topographical orientation, there are many areas where the alignment must cross the topographic highs and lows which presents a challenge for developing stable roadways over variable support soils. This is especially true around the crossings of the Kahiltna and Yentna Rivers which flow in the bottoms of wide, glacially incised valleys. Given the variable terrain, it is anticipated that drainage along the alignment is generally good except for the interspersed wetland areas that will be crossed.

Soil availability along the alignment is anticipated to be relatively abundant along the alignment given terrain features. The alignment should be able to take advantage of numerous short cut sections that are likely adjacent to short fill sections over boggy areas. However, given the glacial origin of the soils, it is likely that the soil quality will be variable and could have elevated fines contents. However, glacial outwash and alluvial deposits (of which there are several mapped along the alignment) could yield potentially high quality, low fines content, well graded sands and gravels that could be used as structural fill for road sections. Rock materials are anticipated to be scattered relatively widely along the alignment, with more availability along the west end of the alignment. Much of the bedrock material along the alignment is mapped as metamorphosed sedimentary materials which tend to be somewhat lower quality on average. These materials may be reliably used for embankment/fill development and potentially aggregate for higher durability materials.

Foundation conditions at major river crossings along this alignment are not anticipated to be on bedrock, but are likely good given that much of the soils along the alignment have been glacially overridden. It is likely that major bridge structures will need to be supported by pile foundations, but piles will likely not need to be driven to great depths (more than about 60 to 80) feet to reach competent support soils. Unconsolidated alluvial or organic soils that are susceptible to liquefaction or consolidation are likely relatively thin at major bridge crossing locations.

The potential for permafrost along this alignment is likely the greatest in comparison to other alignments in this study. Permafrost soils can be expected in higher elevations and on the north side of topographic high areas. Some of the low, poorly drained, boggy areas may also be underlain by permafrost soils. In general, permafrost is likely relatively warm and deteriorating in this area which will result in ongoing settlements of roadways constructed over these soils. Other geologic hazards along the alignment consist of isolated areas of potentially liquefiable soils that may be susceptible to lateral spreading or seismically induced settlement near river features. In addition, although the surrounding terrain is generally relatively subdued along the alignment, there may be isolated areas of slope instability in soil slopes near deeply incised river channels (or river terraces near major rivers) that will need to be addressed in design.

6.2 Skwentna Alignment

The Skwentna Alignment generally runs east-west along lowlands around the Yentna and Skwentna Rivers. The topographic trend in this area is also mostly northwest to southeast and low-lying, boggy areas (though relatively small individually) are very prevalent along the alignment. Subgrade support is anticipated to be highly variable, and drainage in the boggy areas may be a challenge in design and construction. Soil borrow materials are anticipated to be relatively abundant over most of the alignment, and there is the potential for relatively high quality soil materials to be available, especially in glacial outwash and frequent alluvial/terrace formations that are mapped along the alignment. Rock sources are not anticipated to be readily available along this alignment.

Foundation conditions at major stream crossings at Indian Creek and the Yentna River are anticipated to be relatively good. Pile foundations will likely be needed at these crossings to support structures and the potential exists for significant thicknesses of alluvial material in these areas. While alluvial materials are generally good foundation soils, if they have low fines content and are not of sufficient density, they may be susceptible to liquefaction. Pile foundations are suitable to support structure in these conditions; however, they may need to be relatively deep (greater than approximately 80 to 100 feet) if potentially liquefiable soils are encountered.

Permafrost soils are not anticipated to be encountered along this alignment. The most likely geologic hazard anticipated along this alignment is likely associated with seismically induced ground failure. Sandy soils with low fines content (like those likely to be encountered in outwash and alluvial deposits) that are of insufficient density could liquefy under seismic shaking. Liquefaction will result in rapid soil strength loss which could cause differential settlement and lateral spreading. Most of these hazards will be able to be addressed by route selection and embankment design, but risk of damage to bridge foundations at stream crossings will be a more significant factor that will need to be addressed in design.

6.3 Deshka Alignment

The Deshka Alignment generally runs southeast to northwest from Willow to the existing Oil Well Road. In general, the alignment follows the dominant topographic orientation and, though it crosses ground that is similar to the Skwentna Alignment, it is oriented in such a way as to follow relatively low relief (less than 50 to 100 foot tall) ridges that parallel the Deshka River. Because of this orientation, we believe that the support conditions under new embankments will be relatively good consisting of mineral soils with relatively few and isolated areas where bog crossings are needed. We believe that soil borrow sources along the alignment are likely abundant, but most of the soils along the alignment are mapped as various glacial-type deposits that may not provide a reliable source of high quality (low fines content, well graded sands and gravels) soil borrow materials. We do not believe that rock borrow sources are available along this alignment.

Because of the alignment's orientation, few stream crossings will be needed; however, this alignment does include a Susitna River crossing just south of the mouth of the Deshka River. Based on existing geologic mapping, it is likely that the bridge crossing over the Susitna River will require pile foundations that may need to extend relatively deeply (greater than 100 feet) if the alluvial soils in this area are susceptible to liquefaction. Furthermore, scour depths in the Susitna River are likely relatively deep and the channel may migrate with time, which could also require piles to be driven deeply.

Permafrost soils are not anticipated on this alignment and geologic hazards are likely to be limited to potential liquefaction near the Susitna River.

6.4 Skwentna River Alignment

The Skwentna River Alignment generally runs east-west along the south side of Skwentna River. Based on geologic mapping, the alignment generally traverses well drained, alluvial terraces between the river and mountainous terrain to the south. It is likely that soil borrow materials along most of the alignment are abundant and of relatively high quality. In addition, rock materials in the highlands south of the alignment are also readily available and (based on mapping) appear to consist of a mixture of igneous and metamorphosed sedimentary rocks. In general, it is likely that the igneous materials will likely yield higher quality, more durable rock than the metamorphic rocks. High quality rocks will likely be suitable for aggregates while lower quality materials will be more suitable for embankment fill development.

The alignment contains one major stream crossing (Hayes River) and several smaller drainages flowing south to north into the Skwentna River cross the alignment. The foundation support conditions for these crossings will likely be relatively favorable and will likely consist of pile foundations in alluvial soils with the potential for shallow foundations on rock along the western end of the alignment. The major crossing at Hayes River approximately midway along the alignment may be able to be positioned in such a way as to take advantage of potentially shallow bedrock for foundation support on both sides of the river. Though it does not appear that bedrock is exposed at the ground surface, relatively shallow pile foundations may be able to be socketed into bedrock if it is shallower than 50 feet.

Permafrost soils may be encountered along the western half of this alignment where it comes within close proximity to mountain slopes to the south. However, given the anticipated relatively high-energy environment, alluvial soils that likely exist in this area, if permafrost soils are present, are likely thaw stable and should not be difficult to account for in the design. Other geologic hazards along this alignment consist of liquefaction potential of alluvial soils adjacent to the stream crossings.

6.5 East Susitna Alignment

The East Susitna Alignment travels southeast to northwest along the bases of Mount Susitna, Little Mount Susitna, and Beluga Mountain. Based on mapping, the alignment generally traverses the boundary between exposed or shallow bedrock in uplands to the southwest and various glacial deposits in the lowlands to the northeast. Mapping and landforms suggest that the soil deposits are variable ranging from glacial tills, outwash, and isolated alluvial deposits which should yield a variety of soil materials with variable quality. Given that most of the alignment traverses sloping terrain, it is anticipated that the ground is relatively well drained, except for a few isolated low-lying boggy areas near the middle and north end of the alignment. Mapping shows that most of the rock materials that comprise the hills to the southwest consist of metamorphosed volcanic and sedimentary rocks. Rock quality and durability from these types of rock can be highly variable, but at a minimum should provide materials suitable for embankment development.

Several minor stream crossings exist along the alignment. It is likely that many of these stream crossings will be able to be supported by shallow foundations on bedrock based on topography and existing mapping.

Given the alignment traverses a northeast facing slope, permafrost conditions could potentially be encountered within the corridor. In areas of shallow bedrock, permafrost will not likely impact design of the roadway, however, in glacial soils, permafrost conditions may require designs to address down slope creep of frozen soils. Thaw settlement may also occur if the permafrost soils are ice rich and/or thaw unstable. Additional geologic hazards may exist along the alignment, given its close proximity to relatively steep slopes. Colluvium deposits at the toes of natural rock slopes may be unstable if exposed during construction, or may introduce periodic instability during seismic or high rainfall events. Additional hazard along this alignment may be associated with potential faulting that may parallel the alignment. Based on topography, it appears that a fault may have formed the mountainous terrain west of this alignment, though no active faults are mapped in this area. If faulting is present and becomes active, seismicity could cause displacement along the roadway or associated structures. Additional explorations and evaluation should be conducted to more accurately locate or identify a fault in this location so that the alignment and associated features can be positioned so as not to straddle both sides of the fault's surface expression.

6.6 Susitna Crossing Alignment

The Susitna Crossing Alignment travels east-west between Burma Landing on the Little Susitna River and Alexander Creek west of the Susitna River. Existing mapping shows the alignment crossing is almost exclusively glacial moraine and kame deposits except for alluvial terrace deposits adjacent to Alexander Creek and the Susitna River. It is also evident from USGS mapping that the land between the Little Susitna and Susitna Rivers contains many scattered, low-lying, poorly drained, boggy areas. Though sources of soil or borrow along this alignment are anticipated to be readily available, the quality of the material yielded from sources (other than those in alluvium near the Susitna River) may be relatively low with elevated fines contents.

The only potential source for rock that is evident along the alignment is mapped as a granodioritic pluton on the west side of the Susitna River crossing.

Given the presence of interspersed boggy areas along this alignment, we anticipate relatively variable subgrade support conditions and frequent transitions between soft and firm subgrades. Foundation conditions for the crossing at the Susitna River appear to be relatively favorable with the potential for shallow bedrock on the west side of the crossing and alluvial soils on the east side. The crossing of Alexander Creek appears as though it will be supported by alluvial soils on both sides. As mentioned above, alluvial materials may be susceptible to liquefaction if they are not of sufficient density, but pile foundations should be readily developable at both crossings. Pile foundation depth will be dictated by anticipated loads, soil density, scour depth, and liquefaction potential, but will likely need to be at least 100 feet deep. It is possible that foundations on the west side of the Susitna River could be cast directly on shallow bedrock if soil overburden is thin at the chosen abutment location. It should be noted that significantly different foundation rigidity and seismic ground motions on either side of the Susitna River crossing may present complex loading during seismic events.

Permafrost soils are not anticipated along this alignment. Other geologic hazards along this alignment appear to be limited to potentially liquefiable soils near the river crossings as described above.

6.7 Beluga Alignment

The Beluga Alignment generally runs northeast to southwest between Alexander Creek and Beluga on the gentle slopes north of the Susitna Flats Game Refuge. Based on the topography of the area, it appears that the ground traversed by the alignment appears to be relatively well drained, except for the far southwest end of the alignment near Beluga River. Geologic mapping along the alignment suggests that the soils are predominantly of glacial origin including tills, moraines, and outwash deposits. There are also several alluvial and terrace deposits associated with stream crossings. Soil materials are expected to be highly variable with potential for high quality sand and gravel deposits scattered along the alignment. The only rock sources available along this alignment appear to be intrusive igneous rocks (granodiorite) on the northeast end of the alignment at the foot of Mount Susitna which should yield relatively durable, high quality materials.

Foundation support conditions at the several minor stream crossings and at Beluga River are anticipated to be relatively favorable. Piles will likely be used to support bridge structures, bearing on alluvial and/or glacial materials. As with other alignments, alluvial soils may be susceptible to liquefaction depending on density. The actual depth of pile foundations will depend on structural loads, scour, actual soil conditions, and liquefaction potential. However, we anticipate that pile foundations along this alignment will likely need to be on the order of 80 to 120 feet in depth.

The Castle Mountain Fault is mapped in this area and appears to follow a significant portion of the alignment. Examination of aerial imagery suggests a significant surface expression for the fault and care should be taken to provide offset from the fault in selecting a final alignment. Embankments and/or bridges that straddle the fault line could experience significant distress and lateral/vertical displacement in a seismic event along the liniment.

Permafrost soils are not anticipated along this alignment. Other geologic hazards along this alignment appear to be limited to potentially liquefiable soils near the river crossings as described above.

7.0 CONCLUSIONS

Based on our review of the existing data, it is our opinion that from a geotechnical standpoint, each corridor likely provides a viable option for accessing various areas within the project study region. However, the corridors are not equal in their feasibility and each corridor has some significant design and construction challenges that will need to be addressed. The following table summarizes specific geotechnical design considerations that may present challenges in developing the potential alignments.

Alignment	Favorable Conditions	Geotechnical Challenges
South Peters Hills/Yenlo Hills	• Readily available soil borrow materials • Rock borrow sources spread along length of alignment • Favorable foundation support conditions for river crossings	• Frequent wetland/boggy area crossings • Potential permafrost soils • Sloping river approaches • Potential constraints due to Pass Creek fault
Skwentna	• Readily available soil borrow materials • Potentially high quality soil borrow materials	• Frequent wetland/boggy area crossings • Potentially liquefiable soils adjacent to river crossings • No significant source of rock borrow material
Deshka	• Alignment follows orientation of terrain to avoid boggy lowlands • Readily available soil borrow materials • Potentially high quality soil borrow materials	• Potentially liquefiable soils adjacent to river crossings • Potentially unstable river channel at Susitna River crossing • No significant source of rock borrow material
Skwentna River	• Readily available soil borrow materials • Potentially high quality soil borrow materials • Readily available rock borrow sources • Favorable conditions for river crossings	• Potential permafrost soils
East Susitna	• Readily available soil borrow materials • Readily available rock borrow sources	• Potential permafrost soils • Potential colluvial deposits • Potential constraints due to Castle Mountain fault
Susitna Crossing	• Favorable foundation conditions for Susitna River crossing	• Frequent wetland/boggy area crossings • No significant source of rock borrow material • Potential structural implications for Susitna River bridge related to variable support conditions on either side of river • Potential constraints due to Castle Mountain fault
Beluga	• Readily available soil borrow materials • Potentially high quality soil borrow materials	• No significant source of rock borrow material • Potential constraints due to Castle Mountain fault

Note that the table above only considers geotechnical issues for development of the corridors and should be considered applicable only to general corridor selection. Additionally, the information included above is not intended to be a complete list of design challenges as new information may present challenges that are not apparent from conducting a desktop study such as this. Further studies are needed to further evaluate the proposed corridors, identify borrow sources, and define the geotechnical engineering parameters for each corridor.

8.0 CLOSURE AND LIMITATIONS

This report was prepared for the exclusive use of our client and their representatives for evaluating the site as it relates to the geotechnical aspects discussed herein. The conclusions contained in this report are based on information provided from the observed site conditions and other conditions described herein. The analyses and conclusions contained in this report are based on site conditions as they presently exist.

The evaluations and conclusions in this report are based on literature research. As such, the information contained in this report should be considered preliminary and not used for final design of the access corridors. A significant degree of additional explorations and engineering analyses is required to develop design-level engineering recommendations for this project. The information included in this report is intended to be used only for preliminary route evaluation purposes.

Unanticipated soil conditions are commonly encountered and cannot fully be determined by merely taking soil samples or advancing borings. Such unexpected conditions frequently require that additional expenditures be made to attain a properly constructed project. Therefore, some contingency fund is recommended to accommodate such potential extra costs. Shannon & Wilson has prepared the attachments in Appendix A *Important Information About Your Geotechnical/Environmental Report* to assist you and others in understanding the use and limitations of the reports.

Copies of documents that may be relied upon by our client are limited to the printed copies (also known as hard copies) that are signed or sealed by Shannon & Wilson with a wet, blue ink signature. Files provided in electronic media format are furnished solely for the convenience of the client. Any conclusion or information obtained or derived from such electronic files shall be at the user's sole risk. If there is a discrepancy between the electronic files and the hard copies, or you question the authenticity of the report please contact the undersigned.

We appreciate this opportunity to be of service. Please contact the undersigned at (907) 561-2120 with questions or comments concerning the contents of this report.

SHANNON & WILSON, INC.

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Senior Geologist

Reviewed By:

Kyle Brennan, P.E.
Senior Associate

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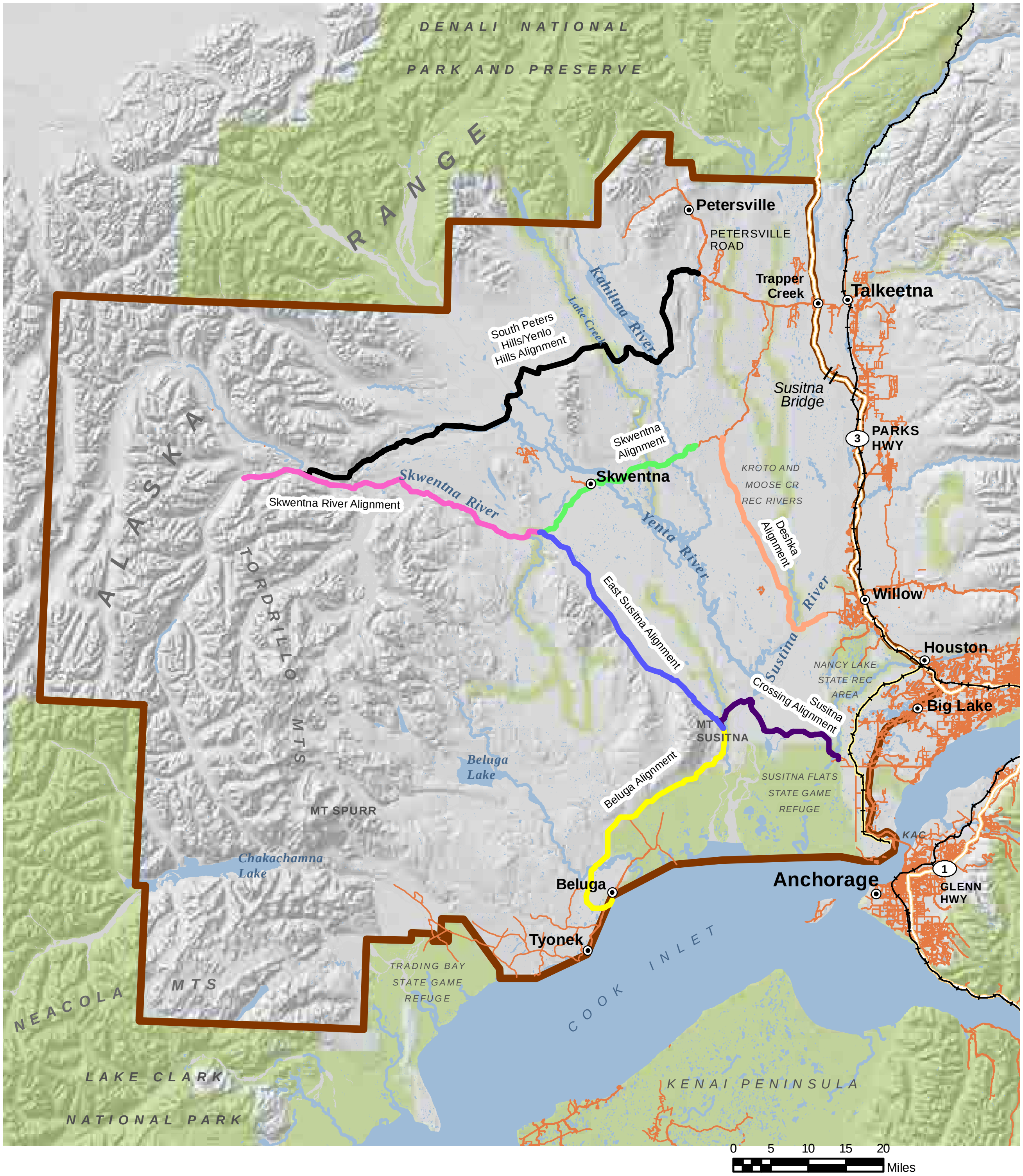

LEGEND

Alignment

- Beluga Alignment
- Deshka Alignment
- East Susitna Alignment
- Skwentna Alignment
- Skwentna River Alignment
- South Peters Hills/Yenlo Hills Alignment
- Susitna Crossing Alignment
- Study Area
- Park or Refuge

N

West Susitna Access
Mat-Su Borough, Alaska

VICINITY MAP

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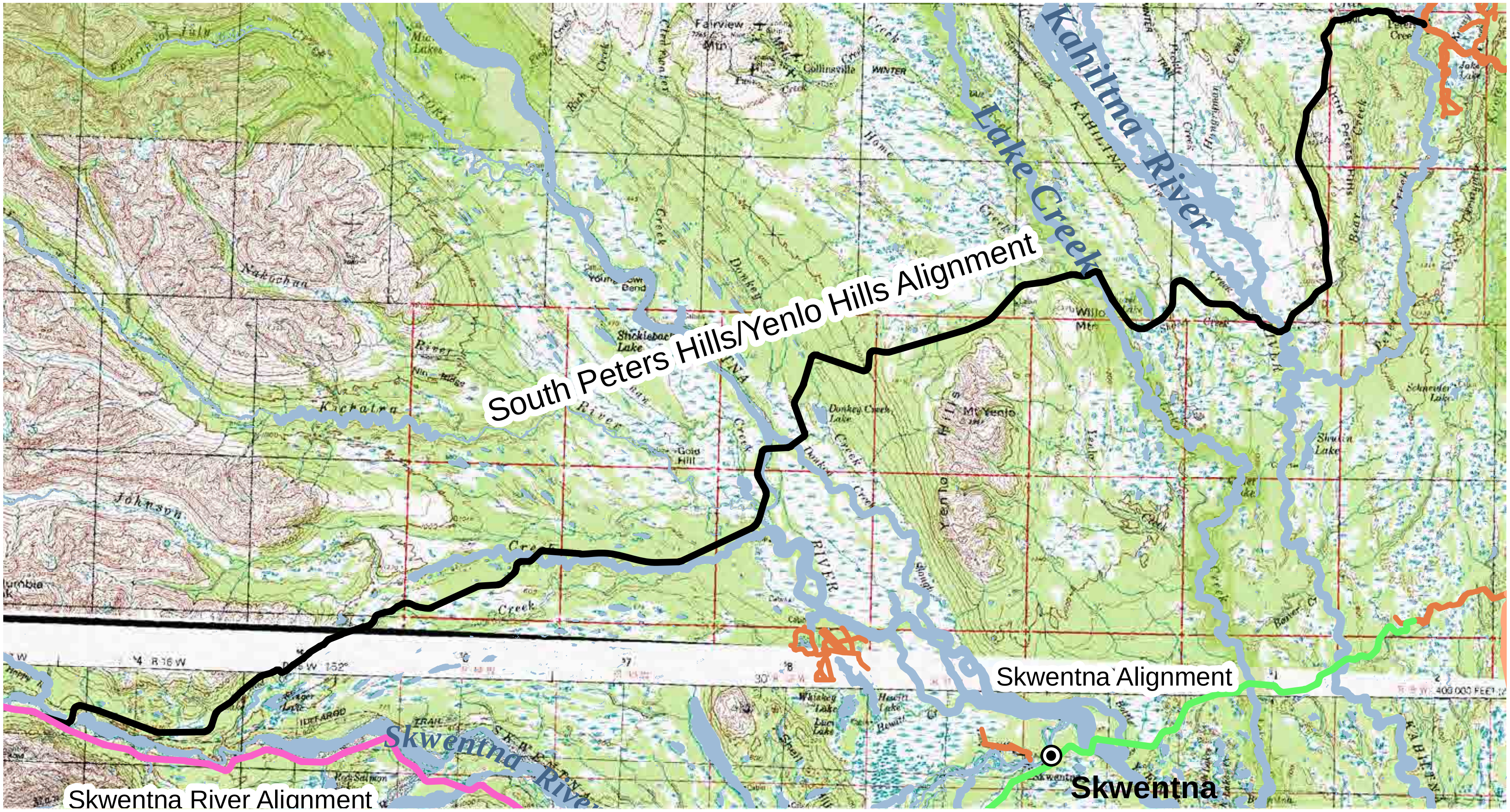
FIG. 1



LEGEND

Alignment

- South Peters Hills/Yenlo Hills Alignment
- Skwentna River Alignment
- Skwentna Alignment
- Secondary Road

West Susitna Access
Mat-Su Borough, Alaska

SOUTH PETERS HILLS/YENLO HILLS ALIGNMENT TOPOGRAPHY

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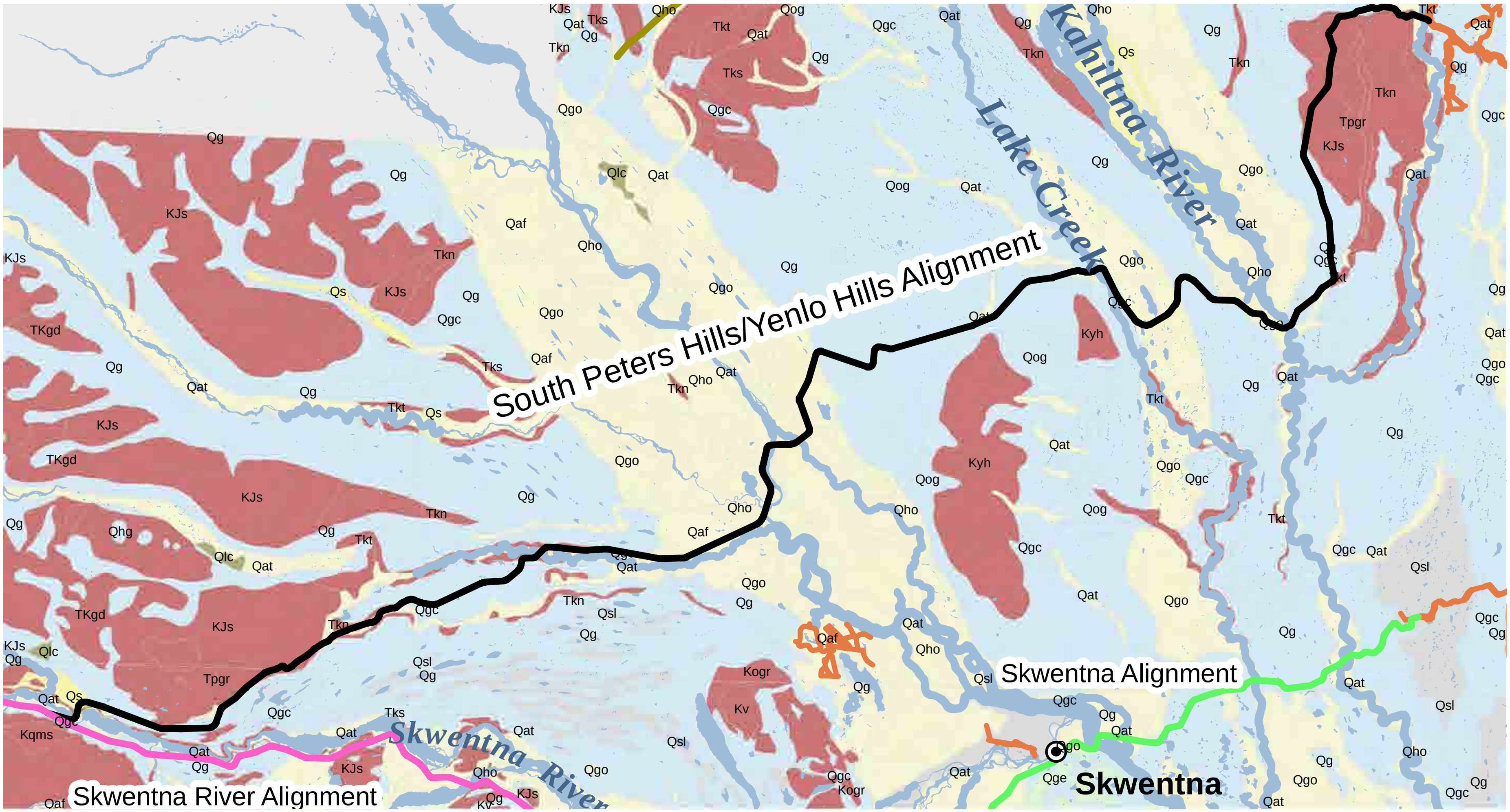
FIG. 2a



Note: See Figure 9 for geologic unit descriptions

LEGEND

Alignment

- South Peters Hills/Yenlo Hills Alignment
- Skwentna River Alignment
- Skwentna Alignment
- Secondary Road

West Susitna Access
Mat-Su Borough, Alaska

SOUTH PETERS HILLS/YENLO HILLS ALIGNMENT GEOLOGY

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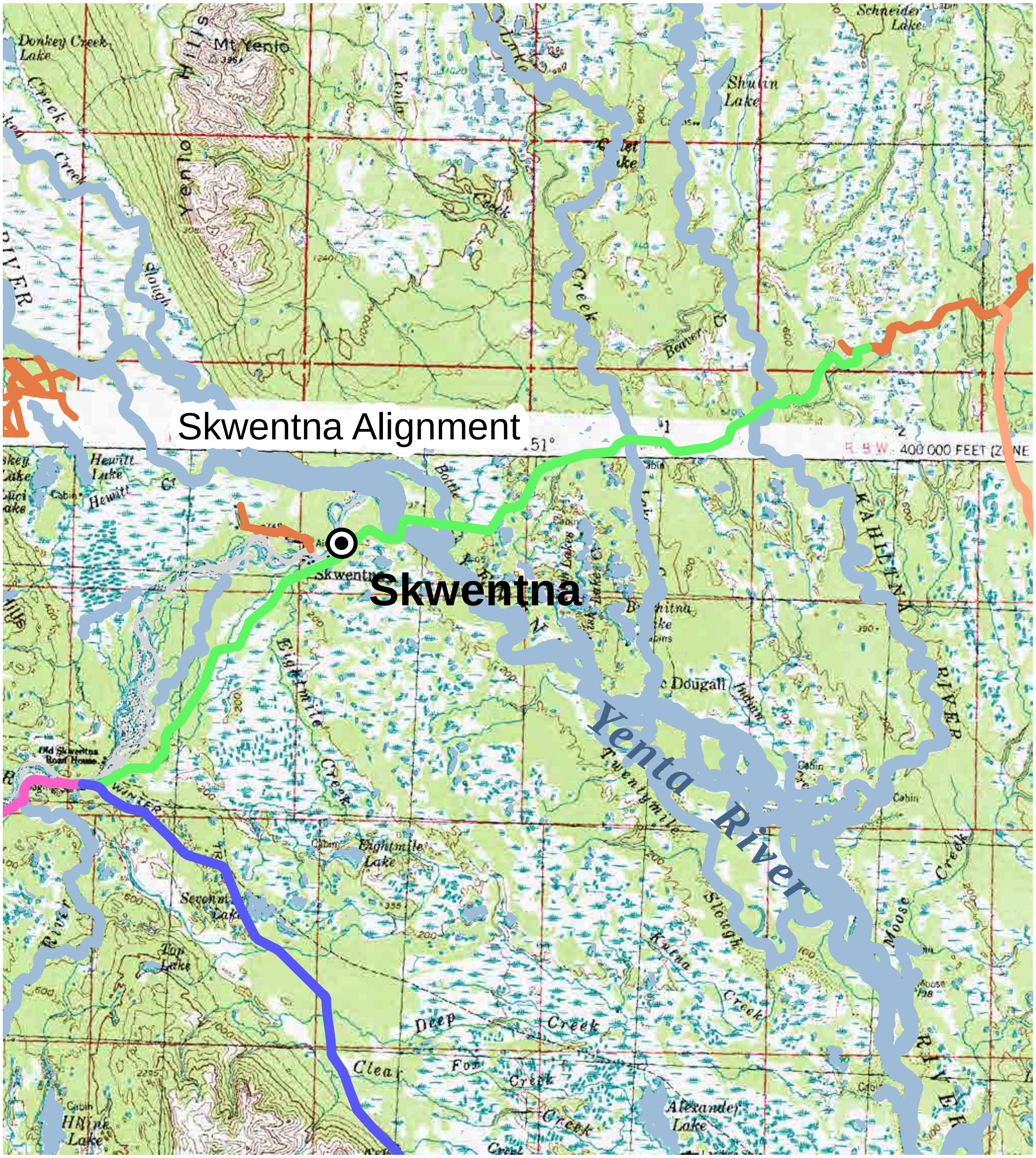
FIG. 2b



LEGEND

Alignment

- Skwentna Alignment
- East Susitna Alignment
- Skwentna River Alignment
- Deshka Alignment
- Secondary Road

West Susitna Access
Mat-Su Borough, Alaska

SKWENTNA ALIGNMENT TOPOGRAPHY

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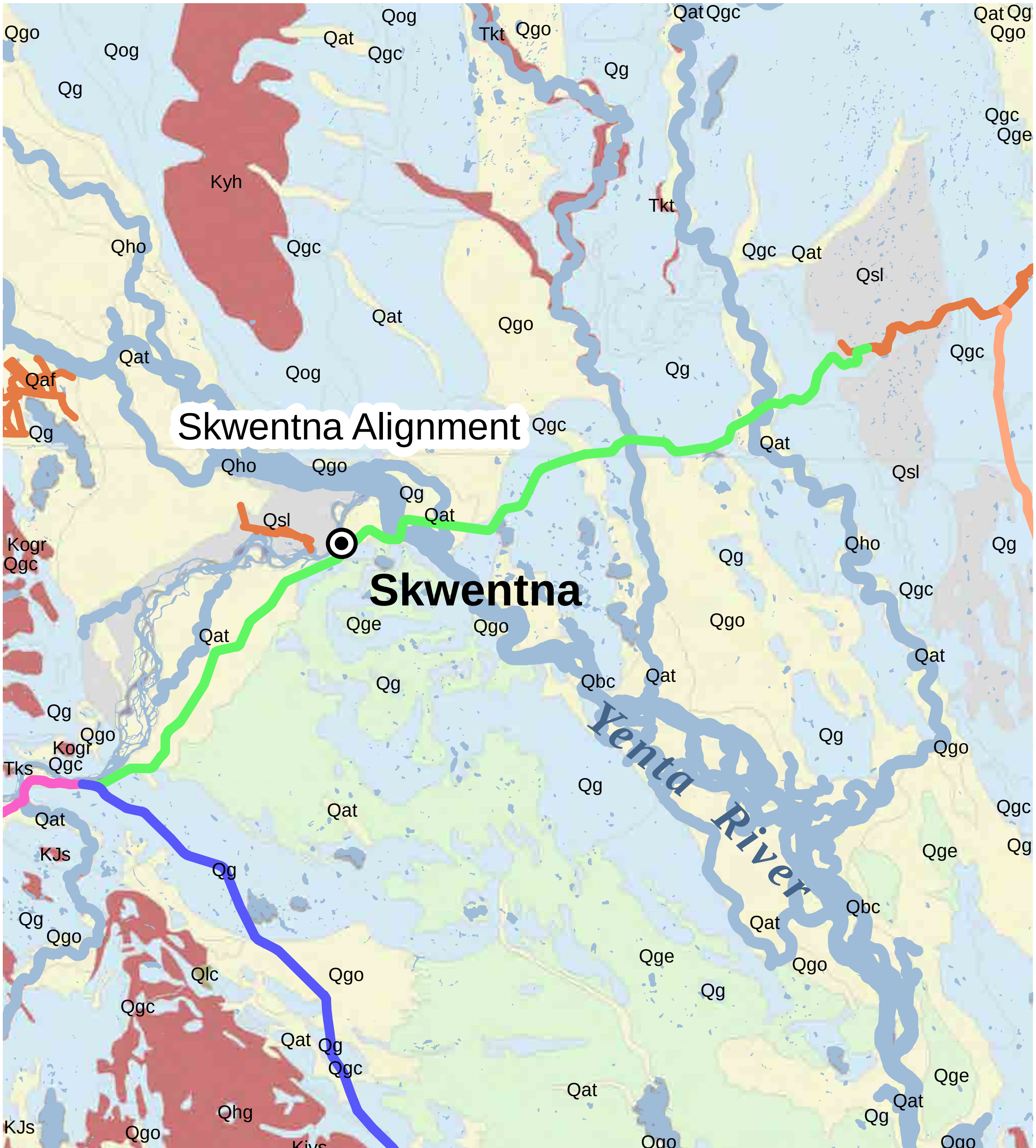
FIG. 3a



Note: See Figure 9 for geologic unit descriptions

0 1 2 3 4 Miles

LEGEND

Alignment

- Skwentna Alignment
- East Susitna Alignment
- Skwentna River Alignment
- Deshka Alignment
- Secondary Road

N

West Susitna Access
Mat-Su Borough, Alaska

SKWENTNA ALIGNMENT GEOLOGY

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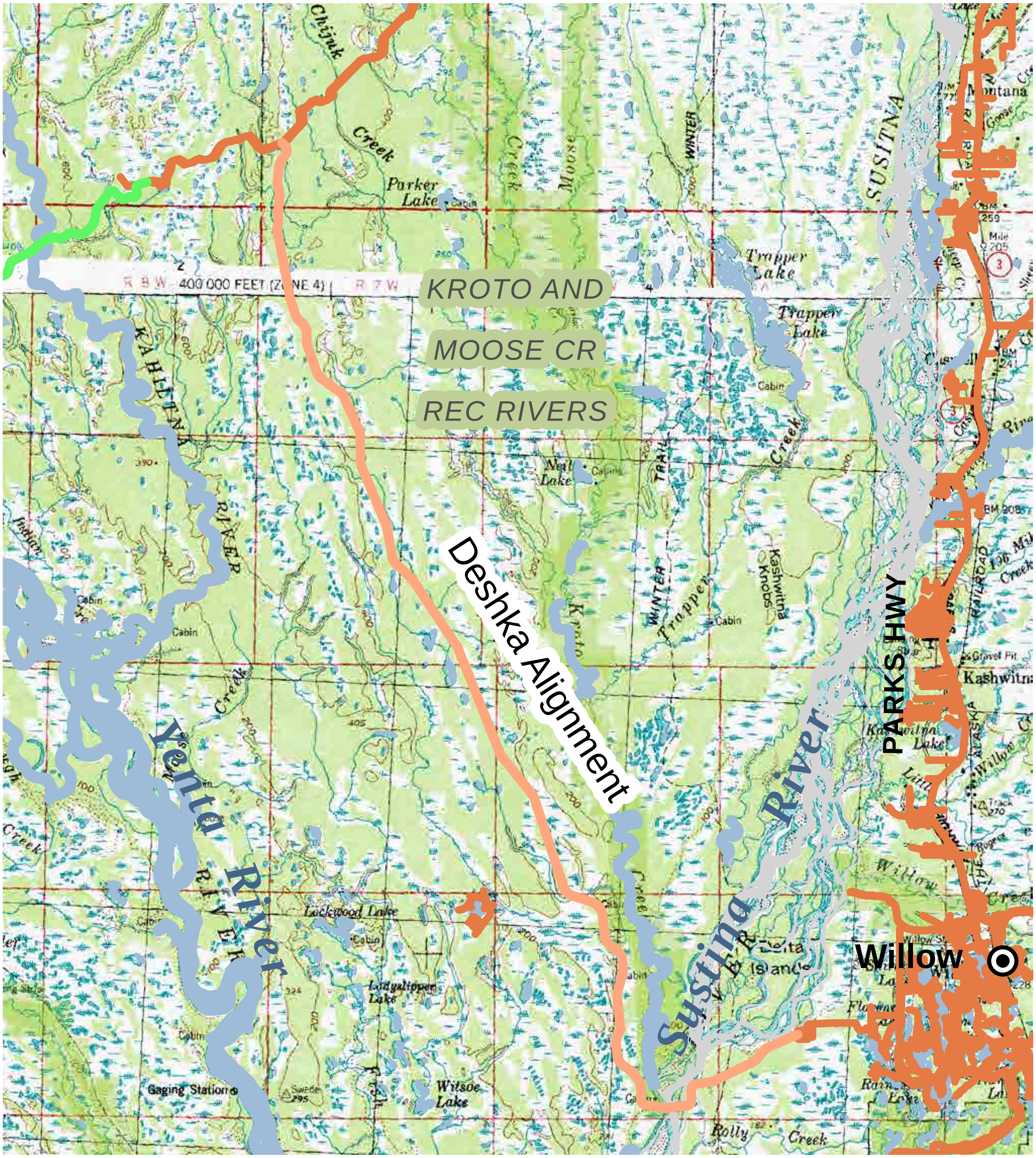
FIG. 3b



0 1 2 3 4 Miles

N

LEGEND

Alignment

- Deshka Alignment
- Skwentna Alignment
- Secondary Road

West Susitna Access
Mat-Su Borough, Alaska

DESHKA ALIGNMENT TOPOGRAPHY

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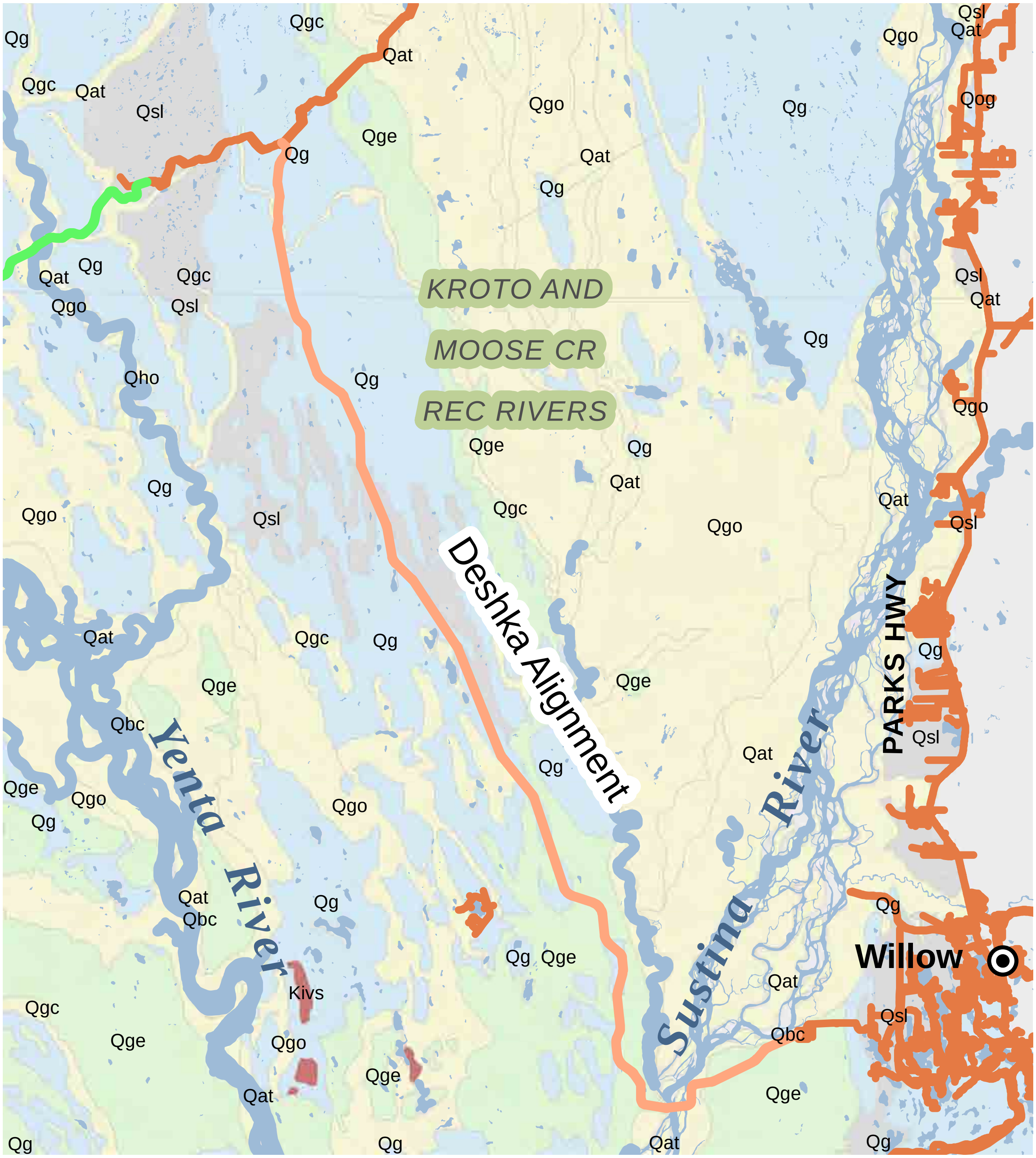
FIG. 4a



Note: See Figure 9 for geologic unit descriptions

LEGEND

Alignment

- Deshka Alignment
- Skwentna Alignment
- Secondary Road

N

West Susitna Access
Mat-Su Borough, Alaska

DESHKA ALIGNMENT GEOLOGY

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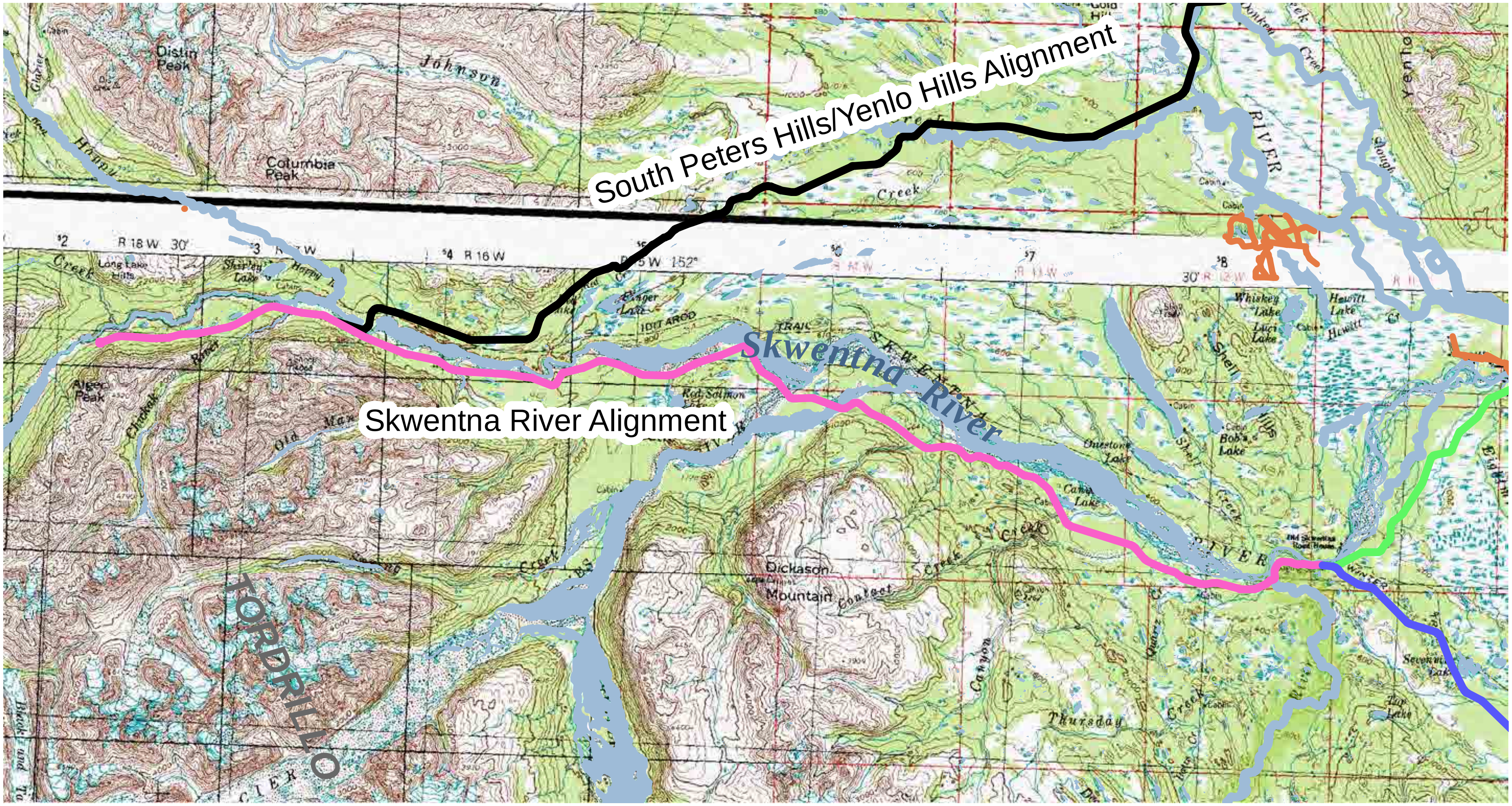
FIG. 4b



0 1 2 3 4
Miles

N

LEGEND

Alignment

- South Peters Hills/Yenlo Hills Alignment
- Skwentna River Alignment
- Skwentna Alignment
- Secondary Road
- East Susitna Alignment

West Susitna Access
Mat-Su Borough, Alaska

SKWENTNA RIVER ALIGNMENT TOPOGRAPHY

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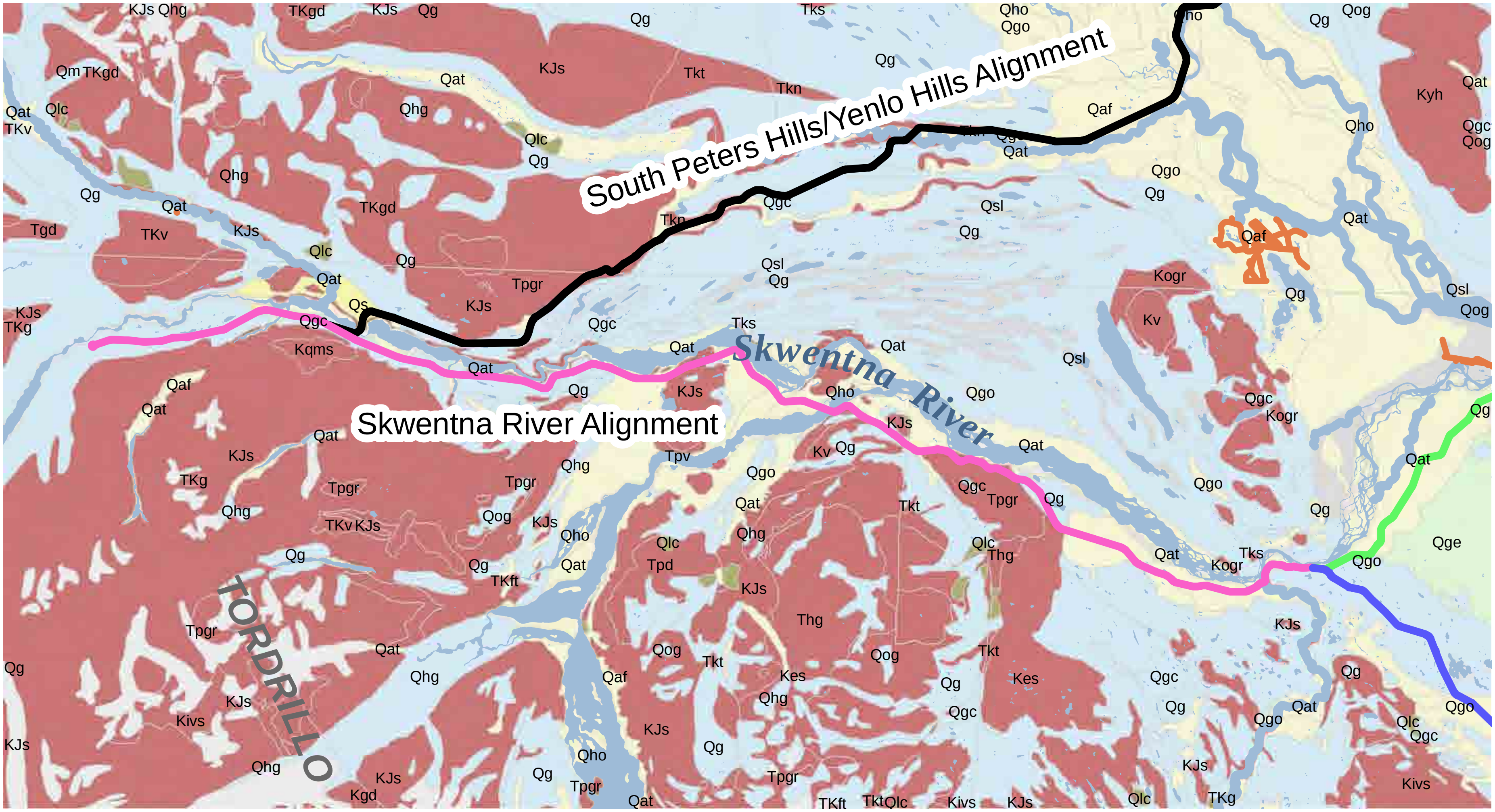
FIG. 5a



Note: See Figure 9 for geologic unit descriptions

LEGEND

Alignment

- South Peters Hills/Yenlo Hills Alignment
- Skwentna River Alignment
- Skwentna Alignment
- Secondary Road
- East Susitna Alignment

N

0 1 2 3 4 Miles

West Susitna Access
Mat-Su Borough, Alaska

SKWENTNA RIVER ALIGNMENT GEOLOGY

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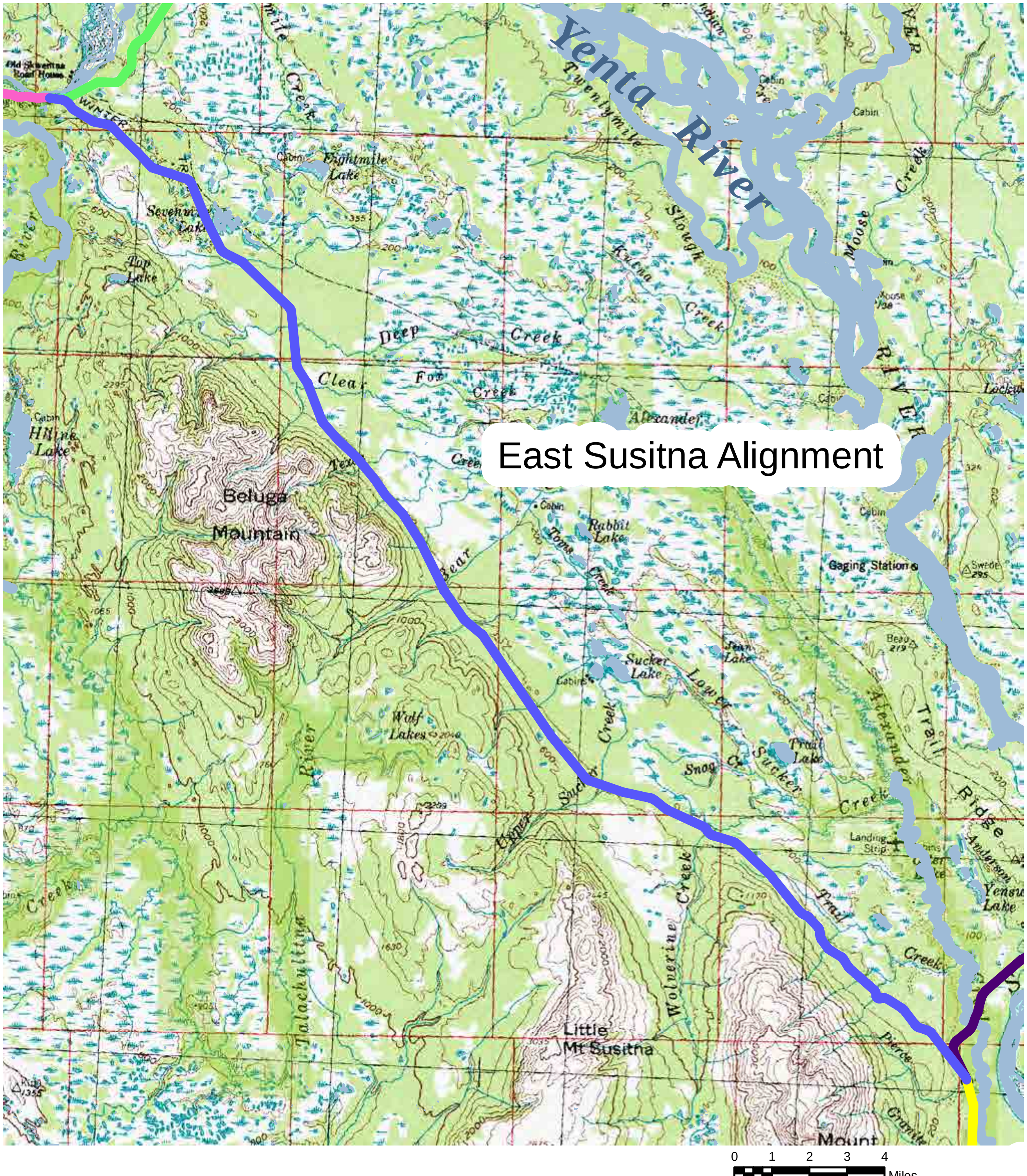
FIG. 5b



LEGEND

Alignment

- Beluga Alignment
- East Susitna Alignment
- Skwentna Alignment
- Skwentna River Alignment
- Susitna Crossing Alignment

N

West Susitna Access
Mat-Su Borough, Alaska

EAST SUSITNA CROSSING ALIGNMENT TOPOGRAPHY

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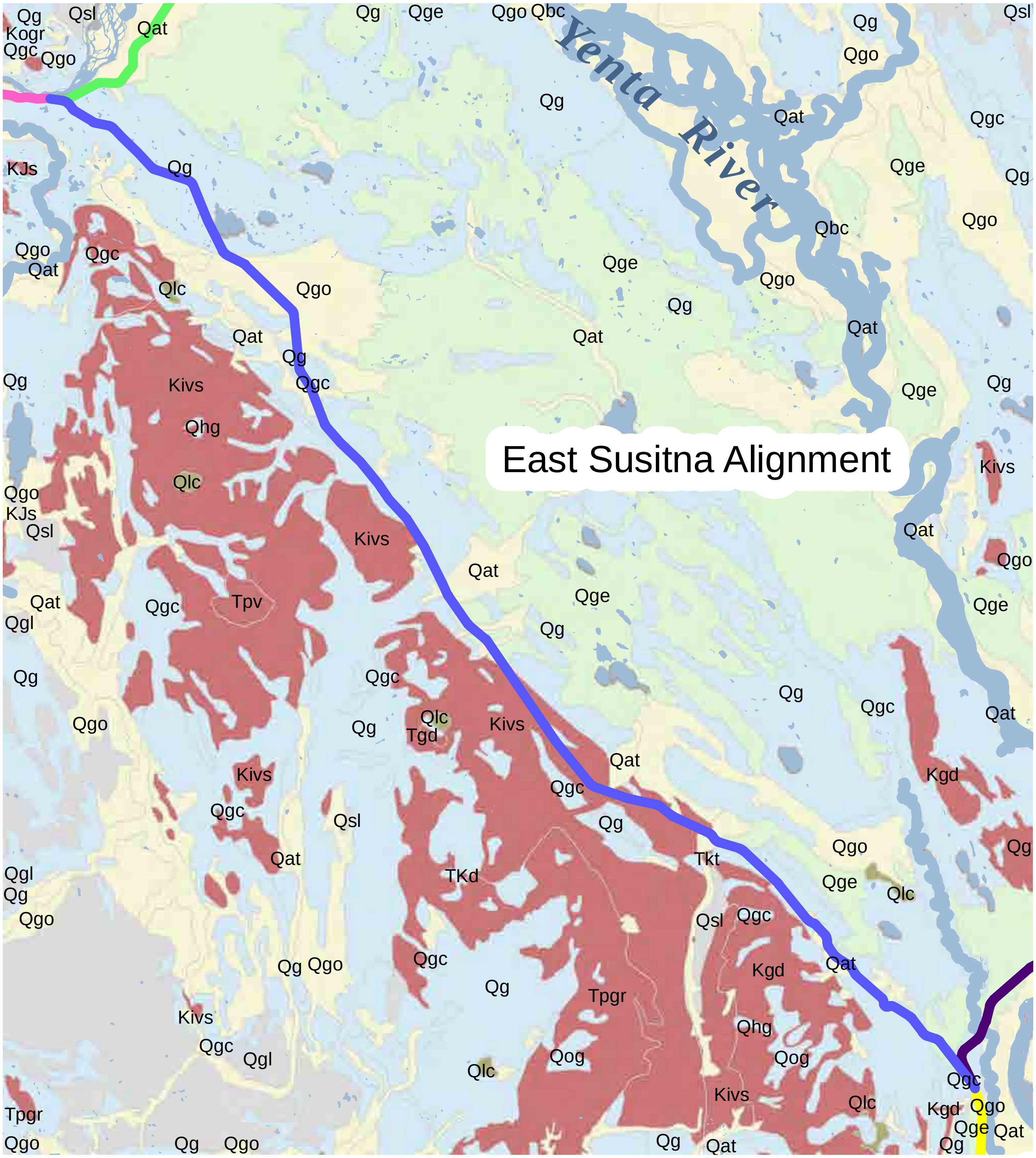
FIG. 6a



Note: See Figure 9 for geologic unit descriptions

0 1 2 3 4 Miles

LEGEND

Alignment

- Beluga Alignment
- East Susitna Alignment
- Skwentna Alignment
- Skwentna River Alignment
- Susitna Crossing Alignment

N

West Susitna Access
Mat-Su Borough, Alaska

EAST SUSITNA CROSSING ALIGNMENT GEOLOGY

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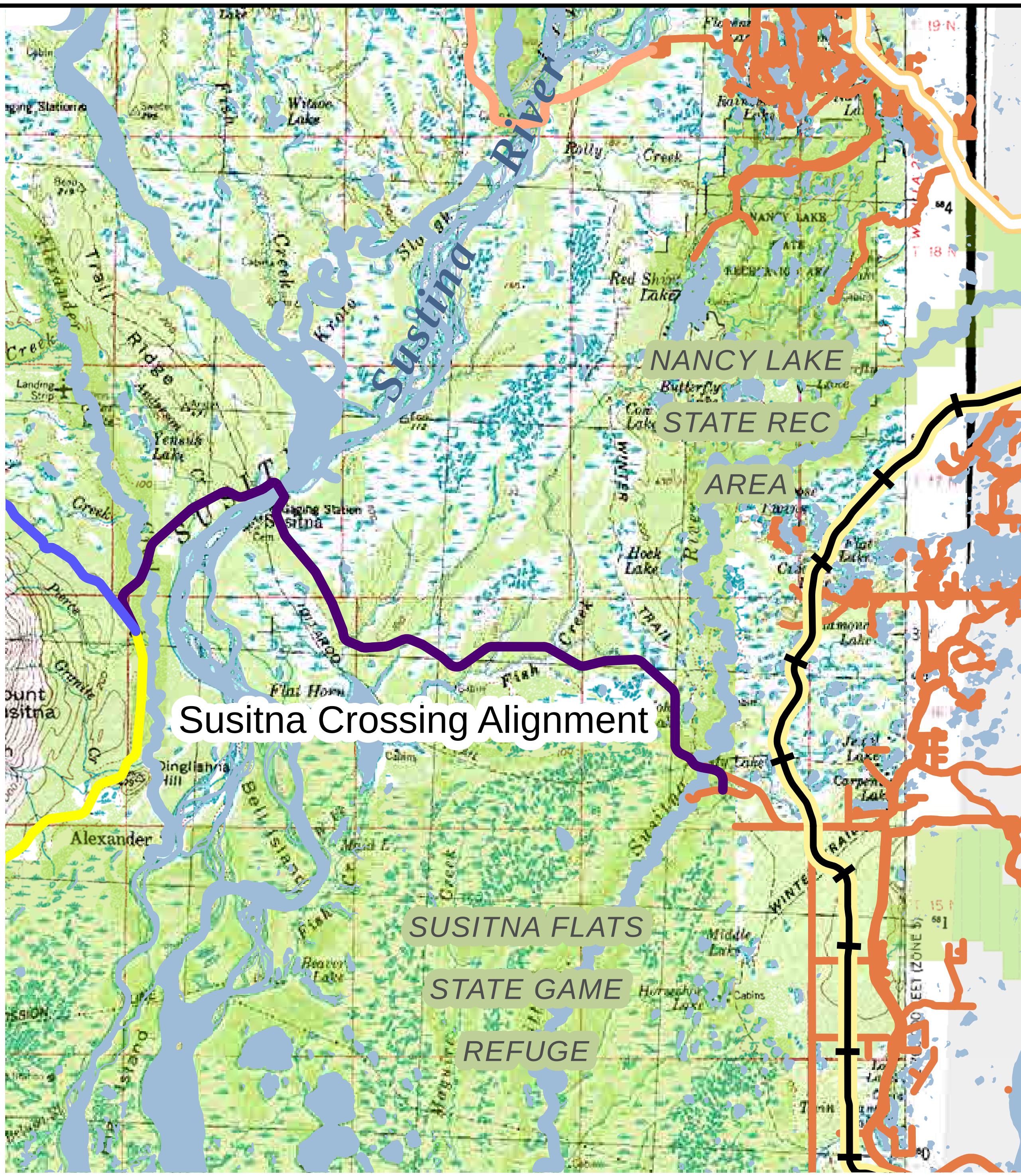
FIG. 6b



LEGEND

Alignment

- Beluga Alignment
- East Susitna Alignment
- Susitna Crossing Alignment
- Secondary Road
- Port MacKenzie Rail Extension
- Highway

N

West Susitna Access
Mat-Su Borough, Alaska

SUSITNA CROSSING ALIGNMENT TOPOGRAPHY

December 2013

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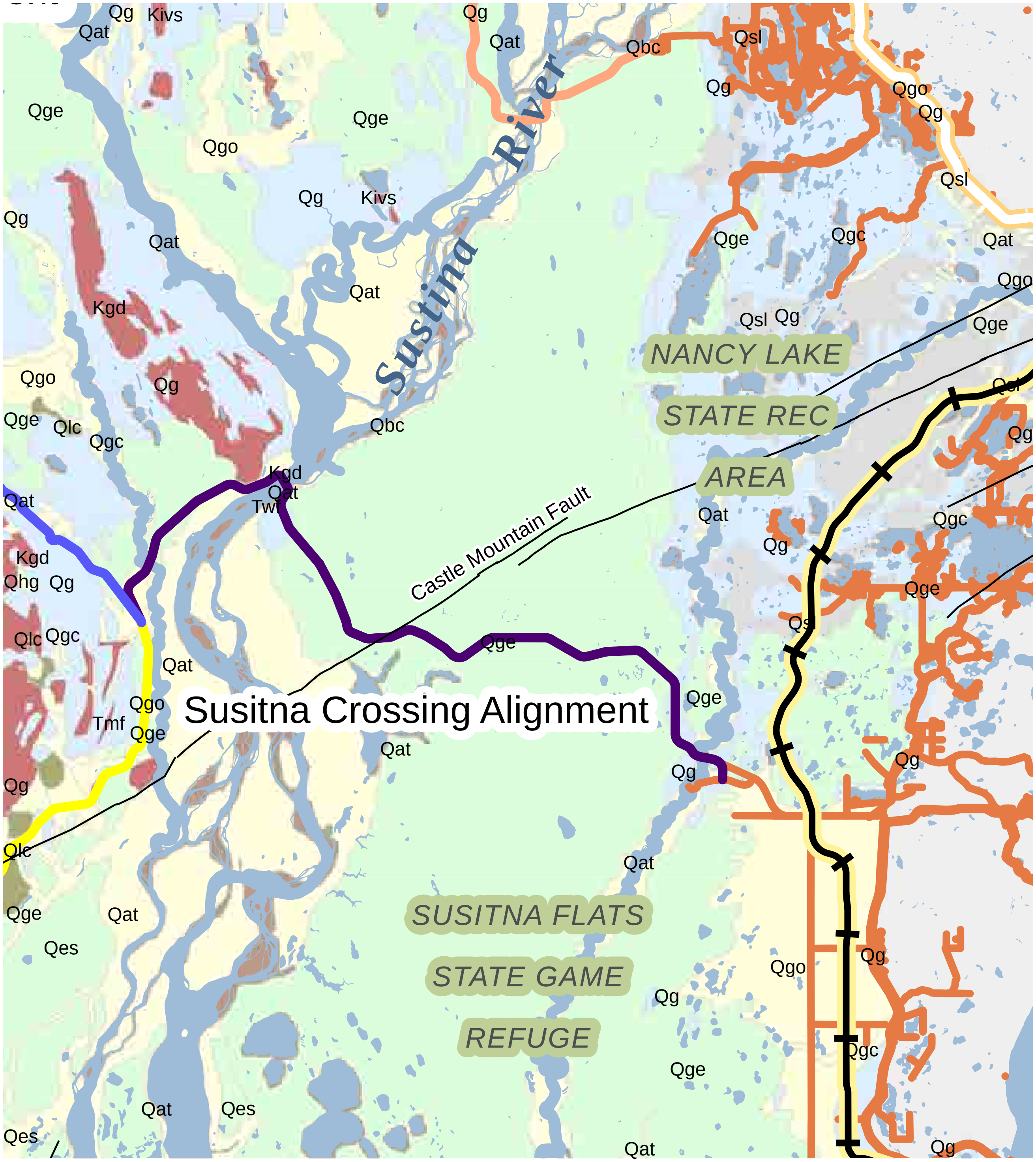
FIG. 7a



Note: See Figure 9 for geologic unit descriptions

LEGEND

Alignment

- Beluga Alignment
- East Susitna Alignment
- Susitna Crossing Alignment
- Secondary Road
- Port MacKenzie Rail Extension
- Highway
- Quaternary Faults

N

West Susitna Access
Mat-Su Borough, Alaska

SUSITNA CROSSING ALIGNMENT GEOLOGY

December 2013

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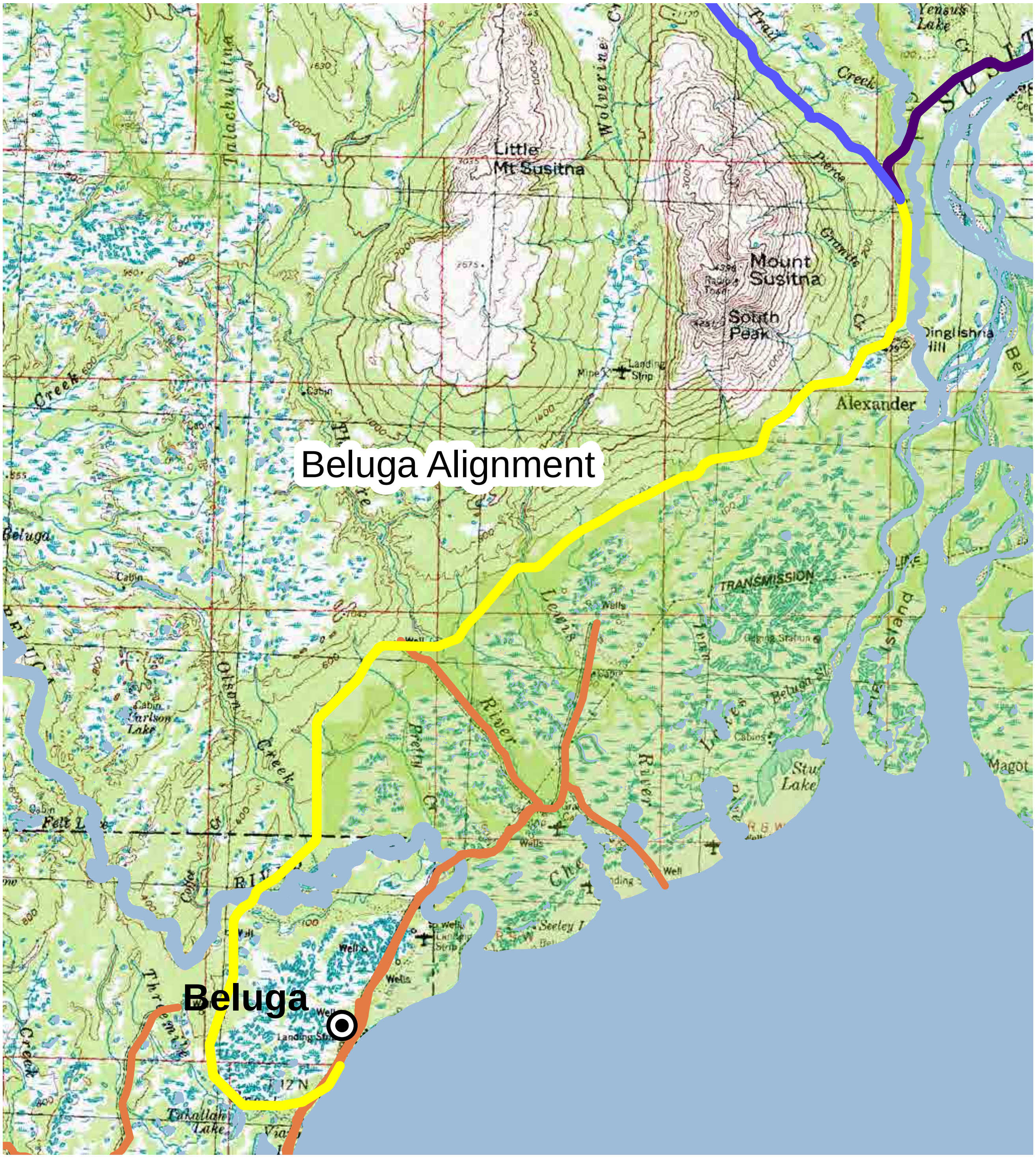
FIG. 7b



0 1 2 3 4
Miles

LEGEND

Alignment

- Beluga Alignment
- East Susitna Alignment
- Susitna Crossing Alignment
- Secondary Road

N

West Susitna Access
Mat-Su Borough, Alaska

BELUGA ALIGNMENT TOPOGRAPHY

December 2013 | 32-1-02301

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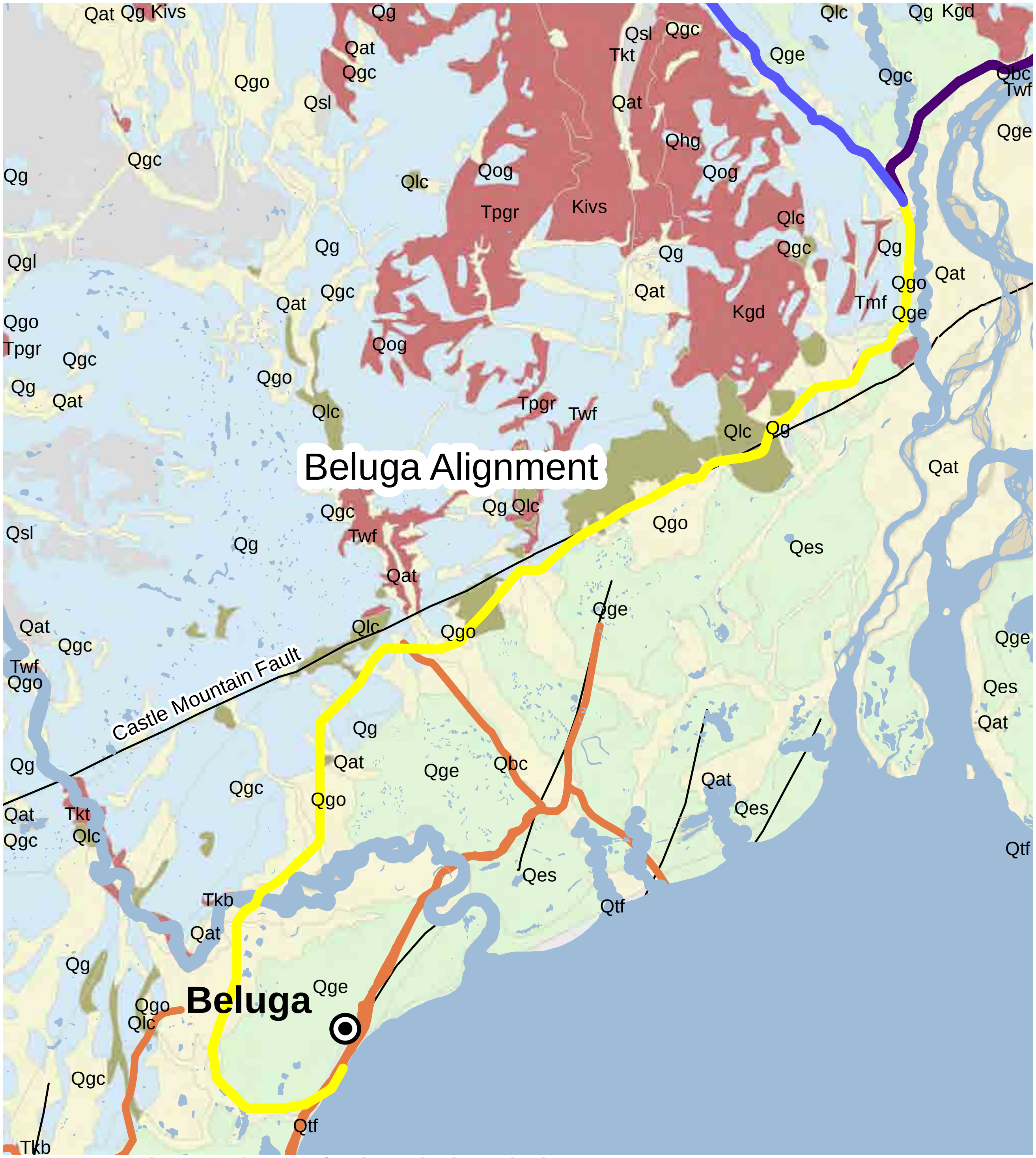
FIG. 8a



Note: See Figure 9 for geologic unit descriptions

0 1 2 3 4 Miles

N

LEGEND

Alignment

- Beluga Alignment
- East Susitna Alignment
- Susitna Crossing Alignment
- Secondary Road
- Quaternary Faults

West Susitna Access
Mat-Su Borough, Alaska

BELUGA ALIGNMENT GEOLOGY

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FIG. 8b

Legend

All Rock Units

Jqd, KJq, Kivs, Kogr, Kqms, KJs, Kes, Kyh, Ksf, Kgd, Kqd, TKg, TKgb, TKgd, Tgd, Tpd, Kv, Tkb, Tkn, Tks, Tkt, Tvs, TKft, TKv, Tgn, Thg, Tmf, Tpgr, Tpv, Twf, TFd, Qhv, Qv

Alluvial Deposits (including glaciofluvial)

Qaf, Qdl, Qat, Qho, Qgc, Qgo

Estuarine and Marine Deposits

Qge, Qes, Qtf, Qbc

Lacustrine and Silt Deposits

Qsl, Qgl

Flow, Slide, and Colluvial Deposits

Qdf, Qlc

Glacial Deposits (excluding glaciofluvial)

Qhg, Qm, Qg, Qog

Surficial Deposits

Qs

Note:

The geologic units included in this report have been grouped for presentation purposes. Due to the variability of the various subtypes in each unit delineated in this report, please refer to the the source publication for more detailed descriptions of individual units.

Legend based on Preliminary Geologic Map of the Cook Inlet Region, Alaska: United States Geological Survey, Open-File Report 2009-1108, Version 1.0, Sheet 1 of 2, Scale 1:250,000 by Wilson, F.H., Hults, C.P., Schmoll, H.R., Haeussler, P.J., Schmidt, J.M., Yehle, L.A., Labay, K.A., 2009.

West Susitna Access Mat-Su Borough, Alaska	
GEOLOGY LEGEND	
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SHANNON & WILSON, INC. GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS	**FIG. 9**

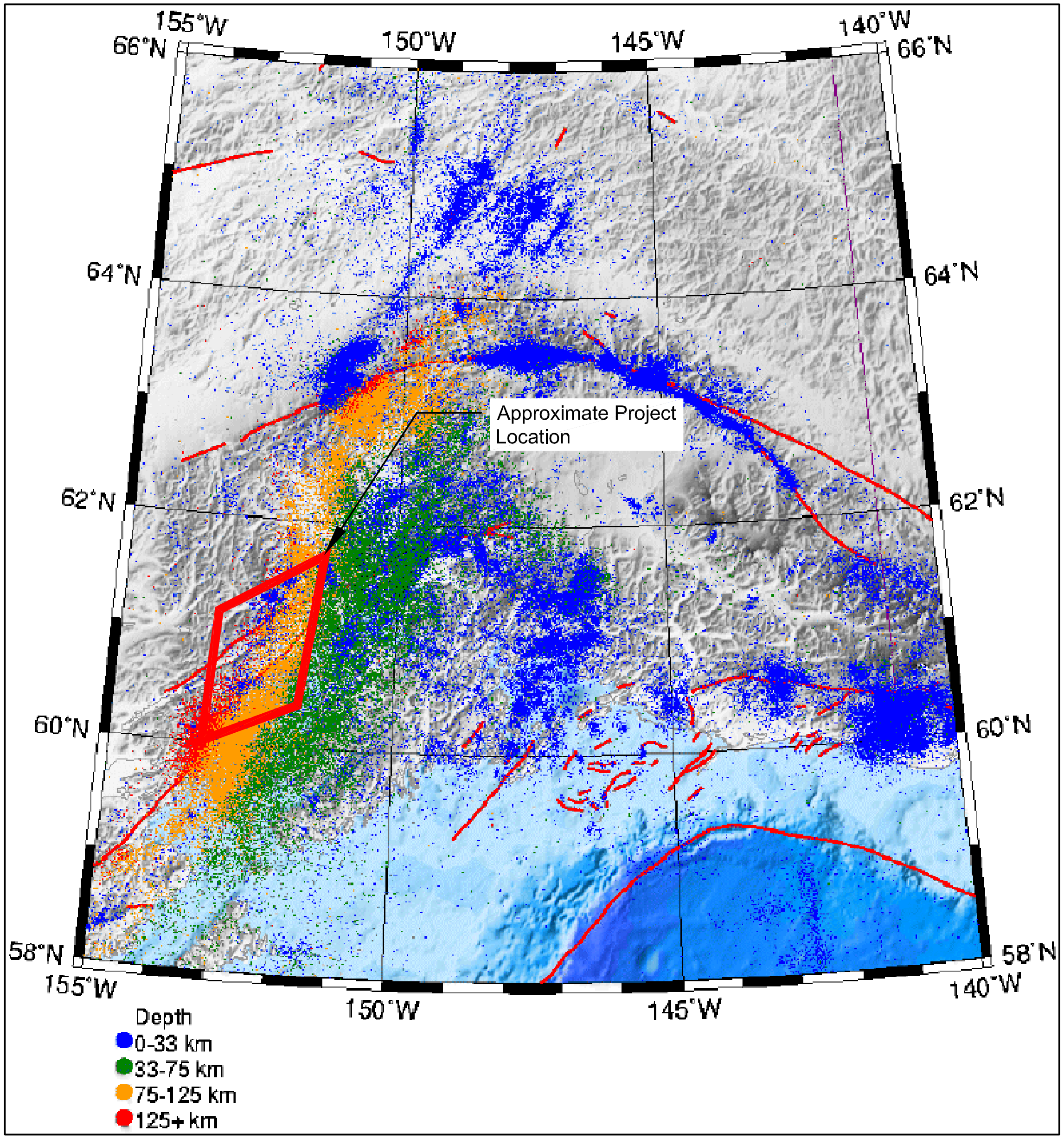

Image provided by Alaska Earthquake Information Center. www.aeic.alaska.edu

West Susitna Access
Mat-Su Borough, Alaska

REGIONAL SEISMICITY

December 2013

32-1-02301

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FIG. 10

APPENDIX A

IMPORTANT INFORMATION ABOUT YOUR GEOTECHNICAL/ENVIRONMENTAL REPORT

Attachment to 32-1-02301

Date:	December 2013
To:	HDR Alaska, Inc.
Re:	West Susitna Access, Mat-Su Borough, Alaska

Important Information About Your Geotechnical/Environmental Report

CONSULTING SERVICES ARE PERFORMED FOR SPECIFIC PURPOSES AND FOR SPECIFIC CLIENTS.

Consultants prepare reports to meet the specific needs of specific individuals. A report prepared for a civil engineer may not be adequate for a construction contractor or even another civil engineer. Unless indicated otherwise, your consultant prepared your report expressly for you and expressly for the purposes you indicated. No one other than you should apply this report for its intended purpose without first conferring with the consultant. No party should apply this report for any purpose other than that originally contemplated without first conferring with the consultant.

THE CONSULTANT'S REPORT IS BASED ON PROJECT-SPECIFIC FACTORS.

A geotechnical/environmental report is based on a subsurface exploration plan designed to consider a unique set of project-specific factors. Depending on the project, these may include: the general nature of the structure and property involved; its size and configuration; its historical use and practice; the location of the structure on the site and its orientation; other improvements such as access roads, parking lots, and underground utilities; and the additional risk created by scope-of-service limitations imposed by the client. To help avoid costly problems, ask the consultant to evaluate how any factors that change subsequent to the date of the report may affect the recommendations. Unless your consultant indicates otherwise, your report should not be used: (1) when the nature of the proposed project is changed (for example, if an office building will be erected instead of a parking garage, or if a refrigerated warehouse will be built instead of an unrefrigerated one, or chemicals are discovered on or near the site); (2) when the size, elevation, or configuration of the proposed project is altered; (3) when the location or orientation of the proposed project is modified; (4) when there is a change of ownership; or (5) for application to an adjacent site. Consultants cannot accept responsibility for problems that may occur if they are not consulted after factors, which were considered in the development of the report, have changed.

SUBSURFACE CONDITIONS CAN CHANGE.

Subsurface conditions may be affected as a result of natural processes or human activity. Because a geotechnical/environmental report is based on conditions that existed at the time of subsurface exploration, construction decisions should not be based on a report whose adequacy may have been affected by time. Ask the consultant to advise if additional tests are desirable before construction starts; for example, groundwater conditions commonly vary seasonally.

Construction operations at or adjacent to the site and natural events such as floods, earthquakes, or groundwater fluctuations may also affect subsurface conditions and, thus, the continuing adequacy of a geotechnical/environmental report. The consultant should be kept apprised of any such events, and should be consulted to determine if additional tests are necessary.

MOST RECOMMENDATIONS ARE PROFESSIONAL JUDGMENTS.

Site exploration and testing identifies actual surface and subsurface conditions only at those points where samples are taken. The data were extrapolated by your consultant, who then applied judgment to render an opinion about overall subsurface conditions. The actual interface between materials may be far more gradual or abrupt than your report indicates. Actual conditions in areas not sampled may differ from those predicted in your report. While nothing can be done to prevent such situations, you and your consultant can work together to help reduce their impacts. Retaining your consultant to observe subsurface construction operations can be particularly beneficial in this respect.

A REPORT'S CONCLUSIONS ARE PRELIMINARY.

The conclusions contained in your consultant's report are preliminary because they must be based on the assumption that conditions revealed through selective exploratory sampling are indicative of actual conditions throughout a site. Actual subsurface conditions can be discerned only during earthwork; therefore, you should retain your consultant to observe actual conditions and to provide conclusions. Only the consultant who prepared the report is fully familiar with the background information needed to determine whether or not the report's recommendations based on those conclusions are valid and whether or not the contractor is abiding by applicable recommendations. The consultant who developed your report cannot assume responsibility or liability for the adequacy of the report's recommendations if another party is retained to observe construction.

THE CONSULTANT'S REPORT IS SUBJECT TO MISINTERPRETATION.

Costly problems can occur when other design professionals develop their plans based on misinterpretation of a geotechnical/environmental report. To help avoid these problems, the consultant should be retained to work with other project design professionals to explain relevant geotechnical, geological, hydrogeological, and environmental findings, and to review the adequacy of their plans and specifications relative to these issues.

BORING LOGS AND/OR MONITORING WELL DATA SHOULD NOT BE SEPARATED FROM THE REPORT.

Final boring logs developed by the consultant are based upon interpretation of field logs (assembled by site personnel), field test results, and laboratory and/or office evaluation of field samples and data. Only final boring logs and data are customarily included in geotechnical/environmental reports. These final logs should not, under any circumstances, be redrawn for inclusion in architectural or other design drawings, because drafters may commit errors or omissions in the transfer process.

To reduce the likelihood of boring log or monitoring well misinterpretation, contractors should be given ready access to the complete geotechnical engineering/environmental report prepared or authorized for their use. If access is provided only to the report prepared for you, you should advise contractors of the report's limitations, assuming that a contractor was not one of the specific persons for whom the report was prepared, and that developing construction cost estimates was not one of the specific purposes for which it was prepared. While a contractor may gain important knowledge from a report prepared for another party, the contractor should discuss the report with your consultant and perform the additional or alternative work believed necessary to obtain the data specifically appropriate for construction cost estimating purposes. Some clients hold the mistaken impression that simply disclaiming responsibility for the accuracy of subsurface information always insulates them from attendant liability. Providing the best available information to contractors helps prevent costly construction problems and the adversarial attitudes that aggravate them to a disproportionate scale.

READ RESPONSIBILITY CLAUSES CLOSELY.

Because geotechnical/environmental engineering is based extensively on judgment and opinion, it is far less exact than other design disciplines. This situation has resulted in wholly unwarranted claims being lodged against consultants. To help prevent this problem, consultants have developed a number of clauses for use in their contracts, reports and other documents. These responsibility clauses are not exculpatory clauses designed to transfer the consultant's liabilities to other parties; rather, they are definitive clauses that identify where the consultant's responsibilities begin and end. Their use helps all parties involved recognize their individual responsibilities and take appropriate action. Some of these definitive clauses are likely to appear in your report, and you are encouraged to read them closely. Your consultant will be pleased to give full and frank answers to your questions.

The preceding paragraphs are based on information provided by the
ASFE/Association of Engineering Firms Practicing in the Geosciences, Silver Spring, Maryland