# PEBBLE PROJECT
# ENVIRONMENTAL BASELINE DOCUMENT
# 2004 through 2008

## CHAPTER 4.
## PHYSIOGRAPHY
## Bristol Bay Drainages

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# PHOTOGRAPHS

# ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| API | aerial photograph interpretation |
| F | Fahrenheit |
| GIS | geographical information system |

# 4. PHYSIOGRAPHY

## 4.1 Introduction

This chapter discusses the physiography of the study area in the Bristol Bay drainages, including topography, landforms, and stream drainage patterns. This discussion is based on a review of published information, information gathered from field reconnaissance studies during 2004 to 2008, and topographical information obtained from Eagle Mapping Ltd. for the mine study area and from Resource Data Inc., for the transportation corridor study area. The physiography of the study area has been strongly influenced by bedrock geology and by the erosion, transport, and deposition of surficial materials by Pleistocene glaciers and glacial meltwater. The bedrock geology, surficial geology, and glacial history of the study area are presented in Chapter 3. The detailed physiographies of individual stream valleys within the mine study area are described in Chapter 7.

## 4.2 Study Objectives

The objective of the physiography study is to describe the physiographic characteristics of the mine study area and the transportation corridor study area within the drainage basin of Bristol Bay.

## 4.3 Study Area

The physiography study area runs generally eastward from the north fork Koktuli River area along the north side of Iliamna Lake to the drainage boundary of Bristol Bay and Cook Inlet as shown on Figure 4-1. The physiography study area for the Bristol Bay drainages, hereafter, the Bristol Bay study area, includes portions of the upper drainages of the north and south forks of the Koktuli River and northeastern Iliamna Lake including Upper Talarik Creek. The Bristol Bay study area is bounded to the east by the Bristol Bay/Cook Inlet drainage divide and to the north (as far west as Lake Clark) by the boundary of the Lake Clark National Park and Preserve. The Bristol Bay study area is indicated by diagonal hatching on Figure 4-1.

The Bristol Bay study area is divided into three physiographic divisions within the U.S. Geological Survey (USGS) Iliamna Quadrangle: Nushagak-Big River Hills, Nushagak-Bristol Bay Lowlands, and the southern part of the Alaska Range division (Detterman and Reed, 1973). The portions of these physiographic divisions contained within the Bristol Bay study area are shown on Figure 4-1 and described below.

- The Nushagak-Big River Hills division encompasses the mine study area and the transportation corridor study area west of Roadhouse Mountain.
- The Alaska Range division encompasses the transportation corridor study area east of Roadhouse Mountain, along the north shore of Iliamna Lake, and through the mountain pass to Cook Inlet. This division includes a strip of relatively flat terrain along the shore of Iliamna Lake as well as the rugged mountains to the north and east of the lake.

- The Nushagak-Bristol Bay Lowlands division encompasses the lowland areas at the western end of Iliamna Lake and south of the Nushagak-Big River Hills division, including the village of Iliamna. Technically, this division does not encompass any of the mine study area or the transportation corridor study area. However, the eastward extension of the same terrain type along the north shore of Iliamna Lake forms part of the transportation corridor study area within the Alaska Range division.

This chapter focuses on the physiography of the mine study area located within the Nushagak-Big River Hills physiographic division and the transportation corridor study area within the Nushagak-Big River Hills and Alaska Range physiographic divisions.

## 4.4 Scope of Work

The physiographic baseline information presented in this chapter is based on a review of published information, information gathered during site investigations, and surficial geological and topographical information obtained from various consultants working on the Pebble study area. Work was conducted by Knight Piésold Ltd.

## 4.5 Methods

The following published information, desktop studies, and field reconnaissance programs are used as reference material for this chapter:

- *Surficial Geologic Map of parts of the Iliamna D-6 and D-7 quadrangles, Pebble project area, southwestern Alaska: Alaska Division of Geological & Geophysical Surveys Report of Investigation 2009-4* (Hamilton and Klieforth, 2010).
- *Surficial Geology of the Iliamna Quadrangle, Alaska* (Detterman and Reed, 1973).
- *Permafrost Map of Alaska* (Ferrians, 1965).
- *Pebble Project – Geotechnical Site Investigation Data Report* (Knight Piésold Ltd, 2005).
- Regional topographic information obtained from the USGS.
- Local topographical information for the mine study area obtained from Eagle Mapping Ltd. (50-foot contour intervals).
- A slope angle map has been generated for the mine study area using 50-foot topographic data provided by Eagle Mapping Ltd. and the geographical information system (GIS) software ArcView, with the three-dimensional analyst extension. The slope angle map is shown on Figure 4-2.
- Local topographical information for the possible transportation corridor obtained from Resource Data Inc., in Anchorage (50-foot contour intervals), which is presented in Chapter 3.
- Selected oblique aerial photographs taken by Knight Piésold Ltd. personnel during field reconnaissance trips between 2004 and 2008 are presented in this chapter to illustrate key physiographic features. The approximate location of the camera and the direction of the photo view for each photograph are shown on Figure 4-3.

# 4.6 Results and Discussion

## 4.6.1 Mine Study Area

The mine study area straddles the divide between the Nushagak River and Kvichak River watersheds, both of which drain into Bristol Bay. More specifically, the Pebble Deposit area is located at the headwaters of the South Fork Koktuli River and Upper Talarik Creek, as shown on Figure 4-1. The headwaters of the North Fork Koktuli River are immediately north of the deposit. The south and north forks of the Koktuli River flow southwest and west, respectively, and join downstream (west) of the mine study area where they form the Koktuli River, which drains into the Nushagak River. The Upper Talarik Creek flows generally southward into Iliamna Lake, which is drained by the Kvichak River.

The mine study area lies within the Nushagak-Big River Hills physiographic division, which is an area of low, rolling hills separated by wide, shallow valleys (Detterman and Reed, 1973). The main streams occupy valley bottoms that are 0.5 to 2 miles wide and lie at elevations of approximately 800 to 1,000 feet above sea level. The pass between the headwaters of the South Fork Koktuli River and the Upper Talarik Creek is slightly higher than 1,000 feet in elevation. The hills and ridges between the valleys rise to elevations of 2,000 to 2,700 feet. Tributaries to the main streams are incised into the hilly terrain and typically occupy narrow valleys with bottom widths of only 0.1 to 0.2 miles.

Hamilton and Klieforth (2010) applied the existing names of individual peaks to the blocks of elevated terrain between the main stream valleys. The Koktuli Mountain block lies between the Upper Talarik Creek and the South Fork Koktuli River valleys, southeast of the deposit area. The Kaskanak Mountain block lies between the valleys of the north and south forks of the Koktuli River, southwest of the deposit area. The Groundhog and Cone mountain blocks lie northeast and northwest of the deposit area, respectively, and are located outside of the mine study area along the watershed divides of the Upper Talarik Creek and the North Fork Koktuli River, respectively. Sharp Mountain is an isolated peak situated within the South Fork Koktuli River watershed near the southern boundary of the mine study area. The elevation in the vicinity surrounding the mine study area ranges from approximately 580 feet at the confluence of the north and south forks of the Koktuli River to 3,074 feet on Groundhog Mountain. The elevation within the mine study area ranges from approximately 775 feet near the southwestern end of the South Fork Koktuli valley to 2,760 feet on Kaskanak Mountain.

Glacial and fluvial sediment of varying thickness covers most of the study area at elevations below approximately 1,400 feet, whereas the ridges and hills above 1,400 feet generally exhibit exposed bedrock or have thin veneers of surficial material. The hills tend to be moderately sloped with rounded tops. The valley bottoms are generally flat, with some topographic anomalies that are explained by the glacial history of the surficial materials, as follows:

- The three main stream channels in the mine study area are highly sinuous and flow within floodplains containing wetlands and oxbow lakes.
- Glaciofluvial terraces of outwash sediments occupy parts of the main valleys and take the form of flat to gently sloping benches or terraces situated at slightly higher elevations than the adjacent floodplains. The terraces are typically well-drained and characterized by distinctly different vegetation than the wetter floodplains. The boundaries between terraces and floodplains are marked by distinct erosional scarps in which the gravelly to sandy outwash material is exposed.

- Glaciolacustrine deposits occupy the upper parts of the three main valleys and are represented by flat, poorly drained terrain. Frying Pan Lake is a shallow residual waterbody in the glaciolacustrine basin in the upper part of the South Fork Koktuli River valley. It is the largest lake in the mine study area and measures approximately 1 mile long by 0.5 miles wide. Frying Pan Lake has been waded as part of various data collection programs. It has a relatively uniform depth of approximately 3 feet.
- Extensive areas of glacial drift deposits occur along lower hillslopes and near the headwaters of the main stream valleys and are characterized by undulating terrain and numerous kettle lakes.

A slope angle map for the mine study area is presented on Figure 4-2. Slopes are generally five percent or less in the valleys. The glaciofluvial terrace scarps in the valley bottoms typically have heights of less than 50 feet and are not resolved by the 50-foot contour interval. The main valleys have side slopes that generally range from 6 to 26 percent. Some tributary valleys have side slopes ranging from 27 to 49 percent. The hillslopes in the mine study area generally have convex profiles.

Photos 4-1 through 4-7 are oblique areal images of the mine study area. These photographs illustrate the key physiographic features described above.

### 4.6.2 Transportation Corridor Study Area

The transportation corridor study area follows an east-southeasterly course from the deposit area, across the Newhalen River, around the southern flank of Roadhouse Mountain, along the north shore of Iliamna Lake, and through a mountain pass to Cook Inlet. The boundary between the Nushagak-Big River Hills and Alaska Range physiographic divisions occurs immediately west of Roadhouse Mountain. Aerial photographs of the transportation corridor study area are shown on Figures 4-4a through 4-4f.

The transportation corridor study area follows flat to moderately undulating terrain across the Upper Talarik Creek valley (Figure 4-4a) and continues through a low pass into the Newhalen River valley (Figure 4-4b) in the Nushagak-Big River Hills division. The Newhalen River occupies a broad trough measuring 7 miles in width. The river channel is approximately 500 feet wide, is entrenched within glaciofluvial deposits (Detterman and Reed, 1973), and does not actively meander across the bottom of the trough. The Newhalen River is shown in Photos 4-8 and 4-9. The eastern boundary of the trough is defined by Roadhouse Mountain, which is the westernmost limit of the Alaska Range.

The study area skirts around the southern flank of Roadhouse Mountain in the Alaska Range division, approximately 4 miles northeast of the village of Iliamna as seen on Figure 4-4c. The study area then follows the flat to gently sloping terrain north of Iliamna Lake from Roadhouse Mountain to Canyon Creek, which constitutes an eastward extension of elevated beach deposits and glacial drift deposits typical of the Nushagak-Bristol Bay Lowlands division. The lowlands are flat or gently sloping toward the lake, and contain numerous wetlands and ponds. Iliamna Lake lies at 46 feet above sea level. Photo 4-10 provides a view looking westward along the north shore of Iliamna Lake toward Roadhouse Mountain. East of Canyon Creek, the north shore of Iliamna Lake is directly encroached upon by steep mountain slopes and colluvial deposits with moderate to steep slopes. Examples of this terrain are shown in Photos 4-11 through 4-13.

The study area crosses Chekok Creek and Canyon Creek within half a mile of one another at the eastern end of the lowland area as shown on Figure 4-4d. Canyon Creek has an active braided channel, as shown in Photo 4-14, whereas Chekok Creek appears to be more stable. The study area then crosses two other streams with alluvial valley bottoms and active, braided channels: Knutson Creek (Figure 4-4e) and Pile River (Figure 4-4f) between Canyon Creek and the eastern end of Iliamna Lake. These two streams are shown in Photos 4-15 through 4-17.

East of Iliamna Lake, the study area crosses the wide alluvial valley and actively meandering channel of the Iliamna River, which is shown in Photo 4-18. The study area then follows the narrow valley of Chinkelyes Creek, a tributary to the Iliamna River as shown on Figure 4-4f. The Chinkelyes Creek valley is steep-sided and contains a narrow, gently sloped alluvial valley fill, as shown in Photos 4-19 and 4-20. The study area then approximately follows an existing road that runs up the Chinkelyes Creek valley as far as Summit Lake, where it crosses the divide into the Cook Inlet drainage, as shown in Photo 4-21. The existing crossing of Chinkelyes Creek is located below Summit Lake and appears to be relatively stable as is typical of lake outlet channels.

### 4.6.3 Permafrost Conditions

A review of the Permafrost Map of Alaska (Ferrians, 1965) indicates that the Bristol Bay study area lies within a zone of sporadic permafrost, although it is very close to the southern limit of this zone. The zone of sporadic permafrost is defined as 0 to 50 percent of the area underneath the landscape consisting of permafrost. The distribution of permafrost in the sporadic zone is patchy and complex, and permafrost-free terrain is common in this zone. Any permafrost in the study area is most likely relict permafrost from previous periods of glaciation because the current climatic conditions do not support the aggradation of permafrost. Relict permafrost is more likely to be found in the following sites:

- Areas where the surficial organic content is high (i.e., sphagnum mosses, sedge, cottongrass, or peat may suggest the presence of frozen ground because these types of vegetation typically grow in poorly drained soils.).
- Areas where fine-grained sediments are present near the surface.
- North facing slopes and shaded areas.
- Zones of deeper accumulations of coarse-grained soils.

API and regional mapping of the study area (Hamilton and Klieforth, 2010) identified some regional geomorphic features that suggest permafrost was present at one time in the vicinity of the mine study area including: patterned ground, large hummocks, water filled depressions (thermokarst), and solifluction lobes. Hamilton and Klieforth’s surficial geology report states: “Apparent thaw ponds in some poorly drained lowlands suggest that permafrost may be present locally or may recently have thawed as a result of warming climate” (Hamilton and Klieforth, 2010). Hamilton indicated that these apparent thaw ponds are located in the Wiggly Lake Basin (Hamilton, 2007, personal communication with Rod Smith) to the north of the mine study area. The presence of tundra vegetation is not necessarily an indicator of permafrost as tundra environments typically have active layer thicknesses of approximately 1 to 10 feet. The actual depth of ground freezing varies seasonally and depends on the local ground conditions, snow cover, and drainage.

Permafrost has not been encountered in previous site investigation and exploration programs within the mine study area. Frozen ground has been encountered at shallow depths (up to 10 feet) in test pits excavations in the winter and spring months. A few test pits excavated in July 2005 and 2008 encountered frozen soil at or near the surface but these test pits were located in areas with a greater amount of vegetation overlying the soils and were therefore insulated for longer from thawing. Frozen ground was also encountered by auger test holes in June 2007 at very shallow depths (~1 foot) in some lowlands, but the active layer could not be distinguished from relict permafrost that early in the summer without mechanical excavation (Hamilton and Klieforth, 2010). Thermistor strings (temperature sensors) were installed in 1991 in six boreholes throughout the mine study area and initial readings after installation indicate that ground temperatures ranged from 34.5 degrees Fahrenheit (F) to 47.1 degrees F, with a mean of 39.1 degrees F in the mine study area (Knight Piésold Ltd., 2005). Groundwater temperatures have been measured in the deposit area and indicate that the temperature of the groundwater is well above freezing throughout the year.

## 4.7 Summary

The physiography study area in the Bristol Bay drainages falls into three physiographic divisions: Nushagak-Big River Hills, Nushagak-Bristol Bay Lowlands, and the southern part of the Alaska Range (Detterman and Reed, 1973).

The mine study area is located within the Nushagak-Big River Hills division, which consists of low, rolling hills separated by wide, shallow valleys with sinuous drainage channels. The elevation in the vicinity of the mine study area varies from approximately 580 feet at the confluence of the south and north forks of the Koktuli River to 3,074 feet on Groundhog Mountain. The pass between the South Fork Koktuli River and Upper Talarik Creek, where the deposit area is located, lies at approximately 1,000 feet elevation.

South of the mine study area, the Nushagak-Bristol Bay Lowlands comprises relatively flat-lying topography with abundant wetlands and ponds along the north shore of Iliamna Lake. The village of Iliamna lies within this division.

The transportation corridor study area traverses the following sequence of terrain types:

- Mostly flat to gently sloping valley bottom terrain within the Nushagak-Big River Hills division from the deposit area to Roadhouse Mountain.
- Lowland terrain along the north shore of Iliamna Lake from Roadhouse Mountain to Canyon Creek.
- Mountain slopes and colluvial terrain along the north shore of Iliamna Lake from Canyon Creek to Pile River.
- Narrow valley bottom and mountain slope terrain within Chinkelyes Creek valley.

The major possible stream crossings within the transportation corridor study area are the Newhalen River, which flows within a relatively stable, entrenched channel; Chekok Creek, which is relatively small and stable; Canyon Creek, Knutson Creek, the Pile River, and the Iliamna River, which have braided or meandering channels within actively eroding floodplains; and Chinkelyes Creek, which has a relatively stable, lake outlet channel.

The study area lies within a zone of sporadic permafrost; however, to date no perennially frozen ground has been encountered in the mine study area during site investigations and exploration programs.

## 4.8 References

Detterman, R.L., and B.L. Reed. 1973. Surficial Geology of the Iliamna Quadrangle, Alaska. U.S. Department of the Interior. Geological Survey Bulletin # 1368-A.

Ferrians, O.J. 1965. Permafrost Map of Alaska. U.S. Geological Survey.

Hamilton, T.D., and R.F. Klieforth. 2010. Surficial geologic map of parts of the Iliamna D-6 and D-7 quadrangles, Pebble Project area, southwestern Alaska: Alaska Division of Geological & Geophysical Surveys Report of Investigation 2009-4, 19 p., 1 sheet, scale 1:50,000. (reproduced with permission from David Szumigala, Apr. 21, 2010).

Knight Piésold Ltd (KP). 2005. Pebble Project — Geotechnical Site Investigation Data Report. Ref. No. VA101-176/8-3, Rev. 0. March.

## 4.9 Glossary

Active layer—seasonally thawed surface layer between a few centimeters and about 10 feet thick.

Aggradation—the general accumulation of frozen material forming permafrost.

Alluvial deposits—sediment and detritus transported by a stream or river and deposited as the river floodplain.

Colluvial deposits—material transported by gravity, typically deposited and accumulated on lower slopes and/or at the base of slopes.

Fluvial deposits—material transported by moving water, typically deposited in a stream channel, along a stream bank, or on a floodplain.

Glacial drift—any sediment laid down by, or in association with, glacial ice activity.

Glaciofluvial deposits—material transported by glaciers and subsequently sorted and deposited by streams flowing from the melting ice.

Glaciolacustrine deposits—material transported by glaciers and deposited by or settled out of lake waters and exposed by the lowering of water levels or the elevation of land.

Kettle lake—a shallow, sediment-filled body of water formed by retreating glaciers or draining floodwaters.

Outwash—stratified sands and gravels deposited at or near ice margins.

Oxbow lake—a crescent-shaped body of water formed when a wide meander from the main stem of a river is cut off to create a lake. This landform is called an oxbow lake for the distinctive curved shape that results from this process.

Pleistocene—from 1.64 million years ago to about 10,000 years ago, the first of two epochs of the Quaternary sub-era.

Physiography—the study of the physical features of the earth's surface.

Quadrangle—a U.S. Geological Survey (USGS) 7.5-minute quadrangle map.

Relict permafrost—perennially frozen ground that has persisted since the last period of glaciation.

Scarp—a cliff or steep slope found at the margin of a flat or gently sloping area.

Solifluction—the slow creeping of fragmented material down a slope as a result of the alternate freezing and thawing of the water contained in the material

Thaw pond—a pond or lake in a permafrost area formed by the thawing of ground ice.

Thermistor—a semiconductor whose electrical resistance decreases markedly with increasing temperature, and which is used as a sensitive device for measuring temperature.

Thermokarst—a periglacial landform assemblage characterized by enclosed depressions (some with standing water) caused by the selective thaw of ground ice associated with thermal erosion by stream and lake water.

# FIGURES

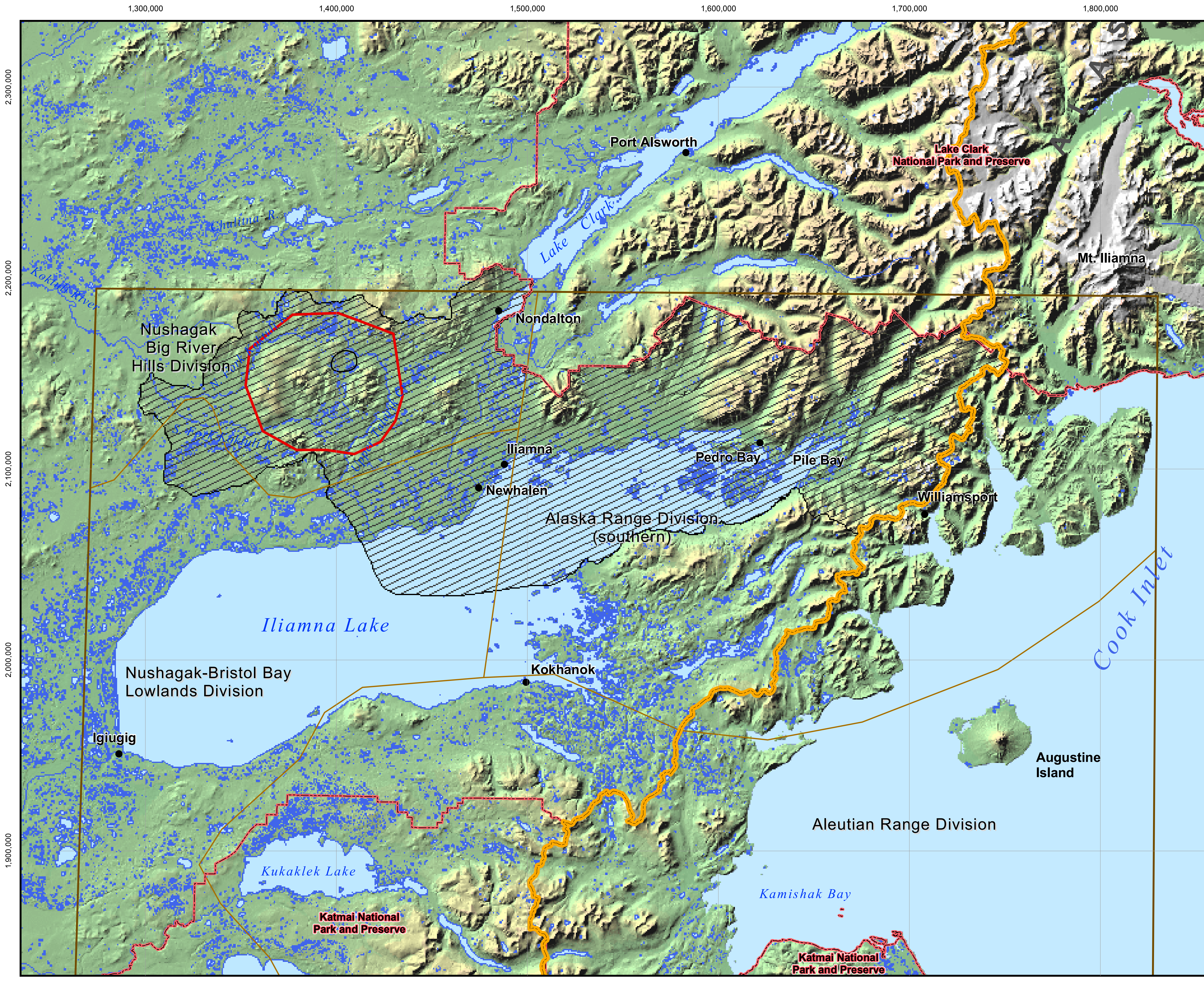


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Figure 4-1
Physiography Study Area
Bristol Bay Drainages

## Legend

- USGS Iliamna Quadrangle
- Physiographic Divisions
- General Deposit Location
- Bristol Bay Study Area
- Mine Study Area
- Population Centers
- National Park and Preserve Boundary
- BB / CI Drainages Boundary
- Existing Roads

## Notes

1. Physiographic Divisions are approximated from Figure 2 in Detterman and Reed, 1973.
2. BB/CI refers to Bristol Bay/Cook Inlet drainages.


Miles: 5 0 5 10 15 20

Kilometers: 5 0 5 10 15 20 25

N

Scale 1:600,000

**Alaska State Plane Zone 5 (units feet)**
**1983 North American Datum**

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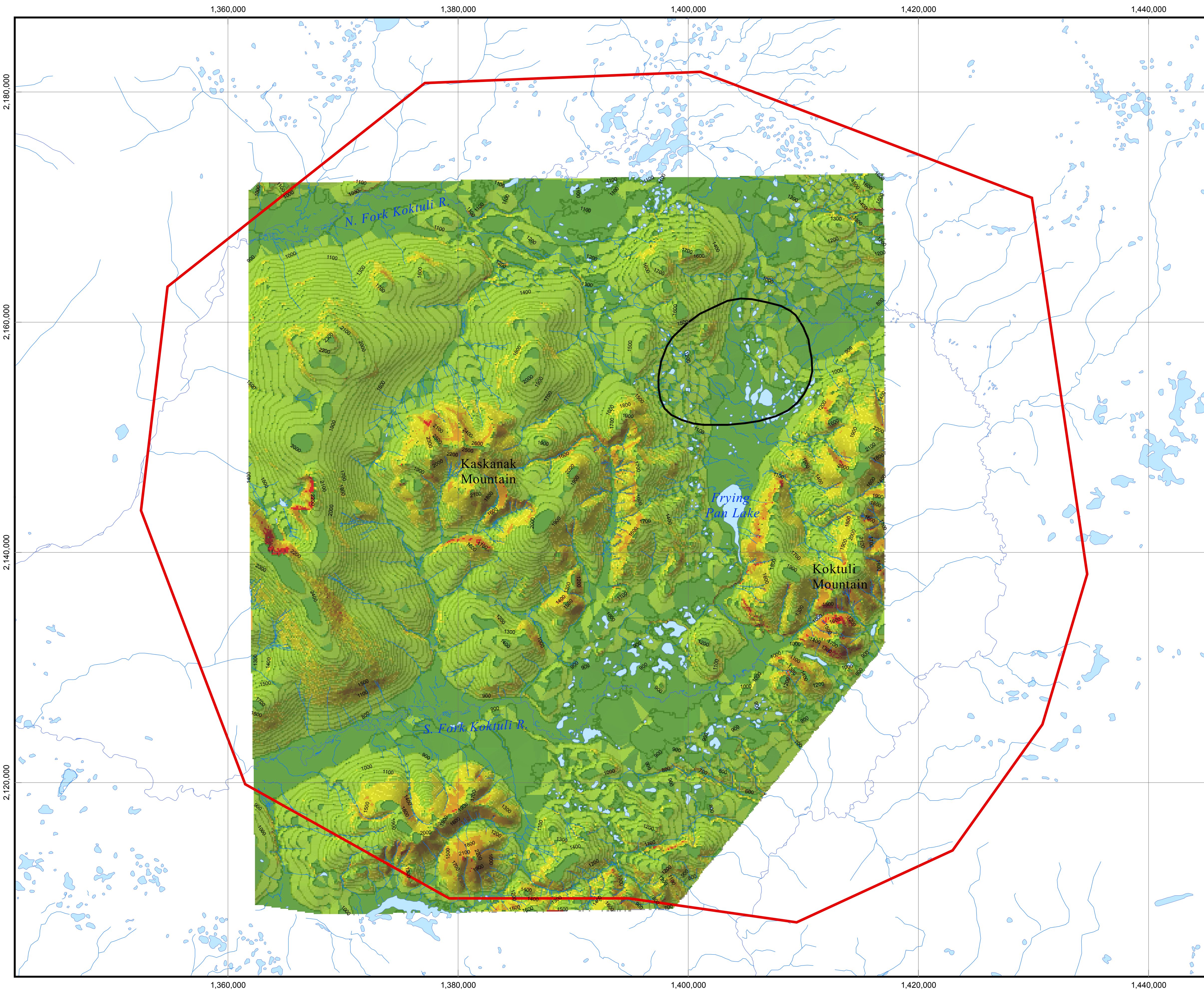


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## Figure 4-2
## Physiography Study
## Slope Angle Map
## Mine Study Area

### Legend

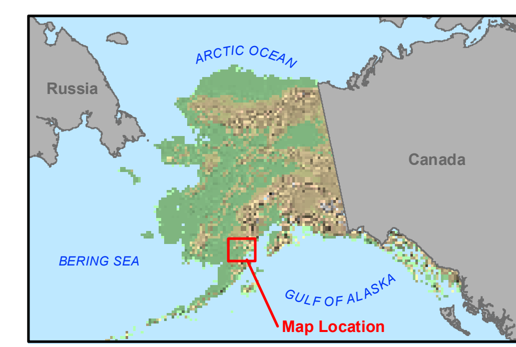
- General Deposit Location
- Mine Study Area
- Streams

**Slope Angle (%)**

- 0 - 5 Plain
- 6 - 26 Gentle
- 27 - 49 Moderate
- 50 - 70 Moderately steep
- > 70 Steep

### Notes

1. Contour Interval is 50 ft.

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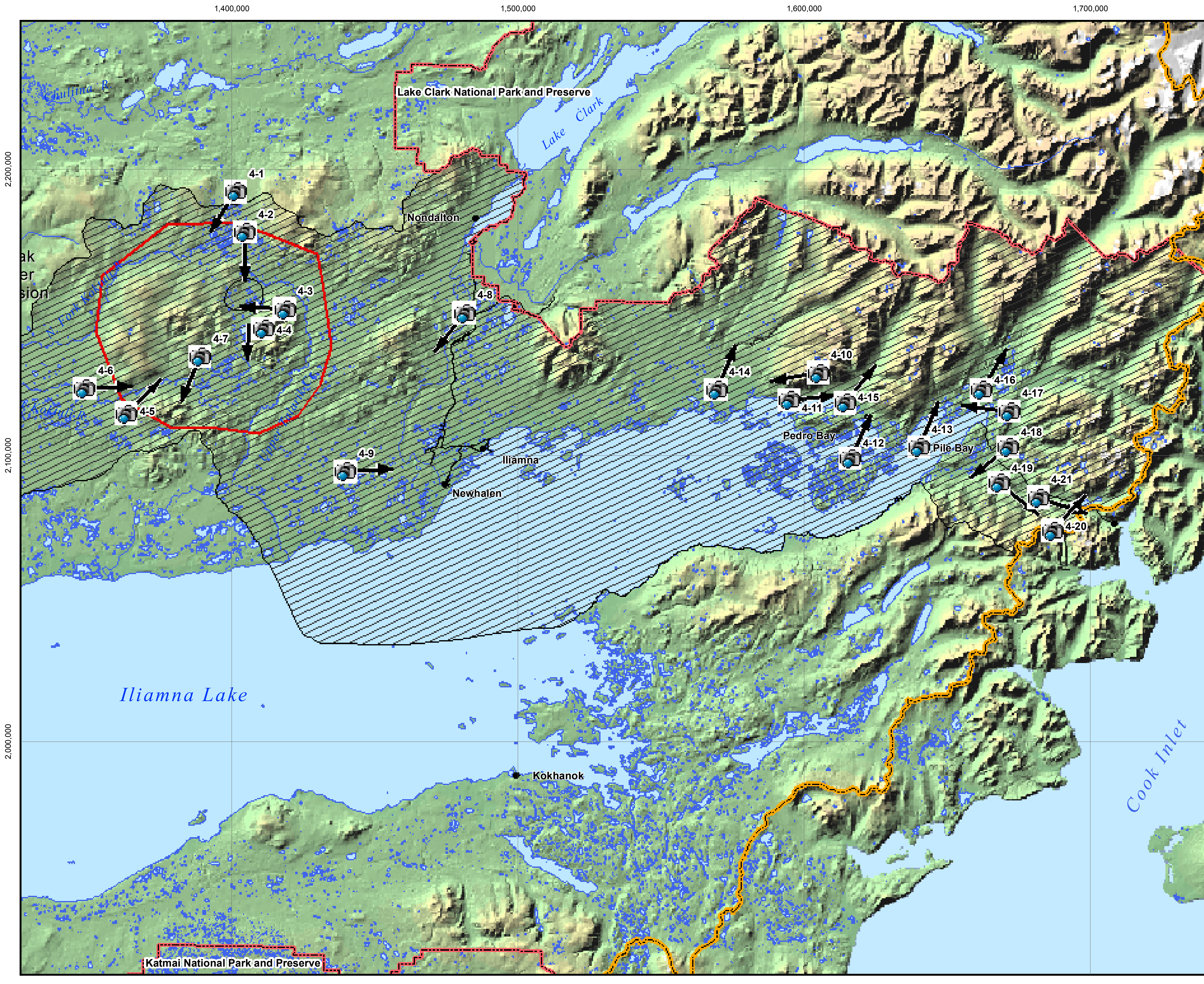


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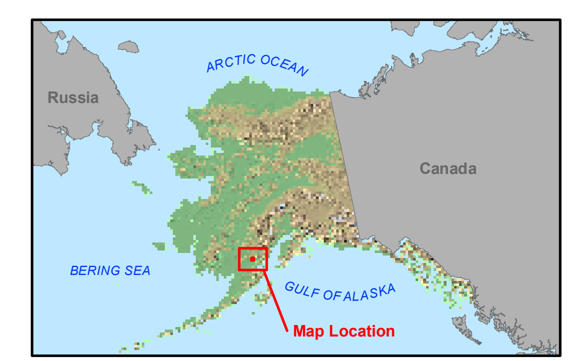
Figure 4-3
Physiography Study Area
Photograph Locations,
Bristol Bay Drainages

**Legend**

- Camera Location
- Photo Direction
- General Deposit Location
- Bristol Bay Study Area
- Mine Study Area
- Population Centers
- National Park and Preserve Boundary
- BB / CI Drainages Boundary
- Existing Roads

**Notes**

1. BB/CI refers to Bristol Bay/Cook Inlet drainages.

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Scale 1:400,000

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**1983 North American Datum**

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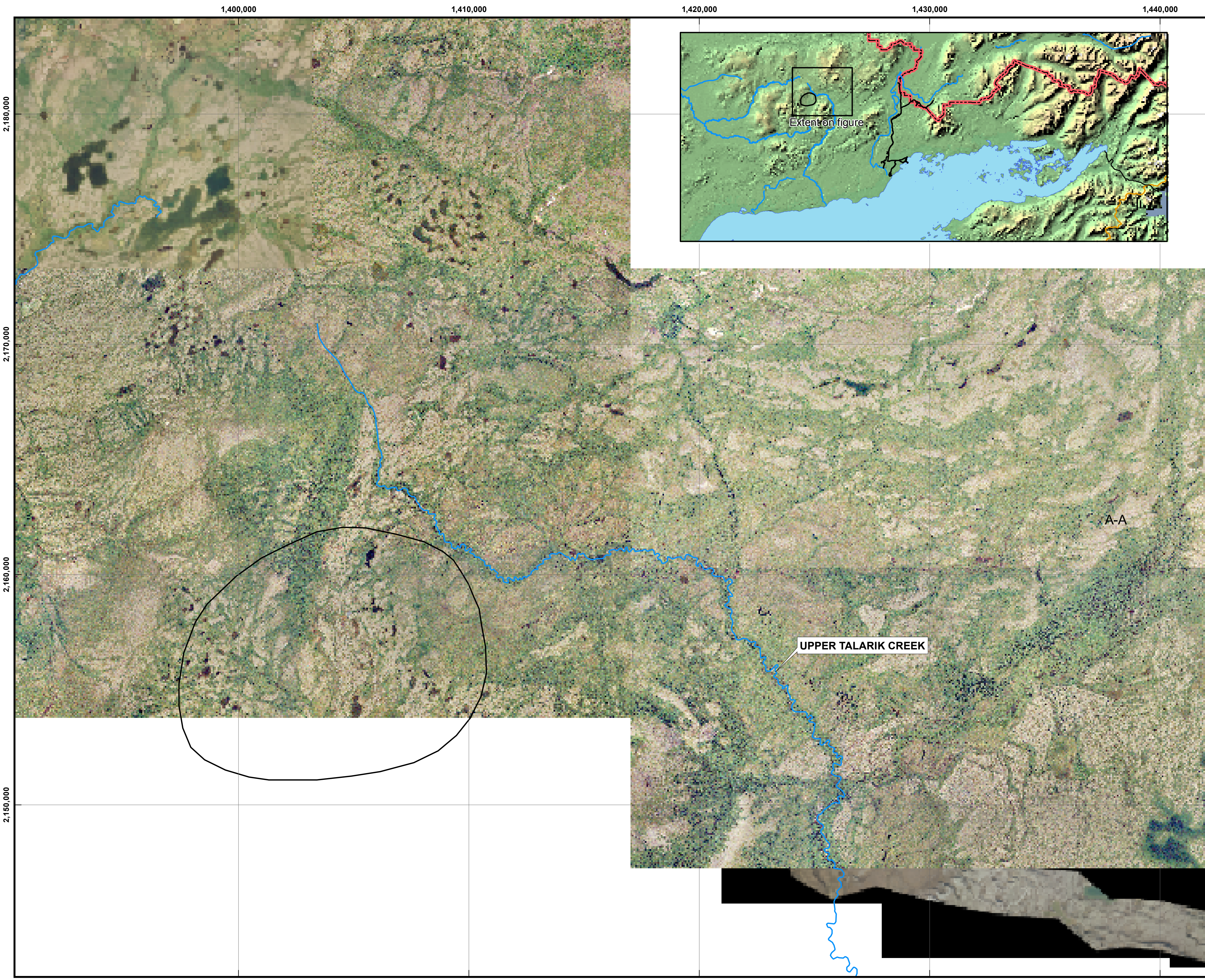


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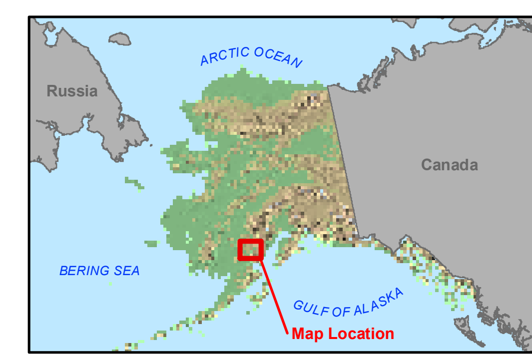
# Figure 4-4a
# Physiography Study, Aerial Photograph Transportation Corridor Bristol Bay Study Area

## Legend

- General Deposit Location
- National Park and Preserve Boundary
- BB / CI Drainages Boundary
- Existing Roads

## Notes

1. BB/CI refers to Bristol Bay/Cook Inlet drainages.
2. Inset scale is 1:1,000,000.

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Kilometers: 1 0 1 2

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Scale 1:50,000

**Alaska State Plane Zone 5 (units feet)**
**1983 North American Datum**

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| Version: 2008-2 | Author: Knight Piésold Ltd. |

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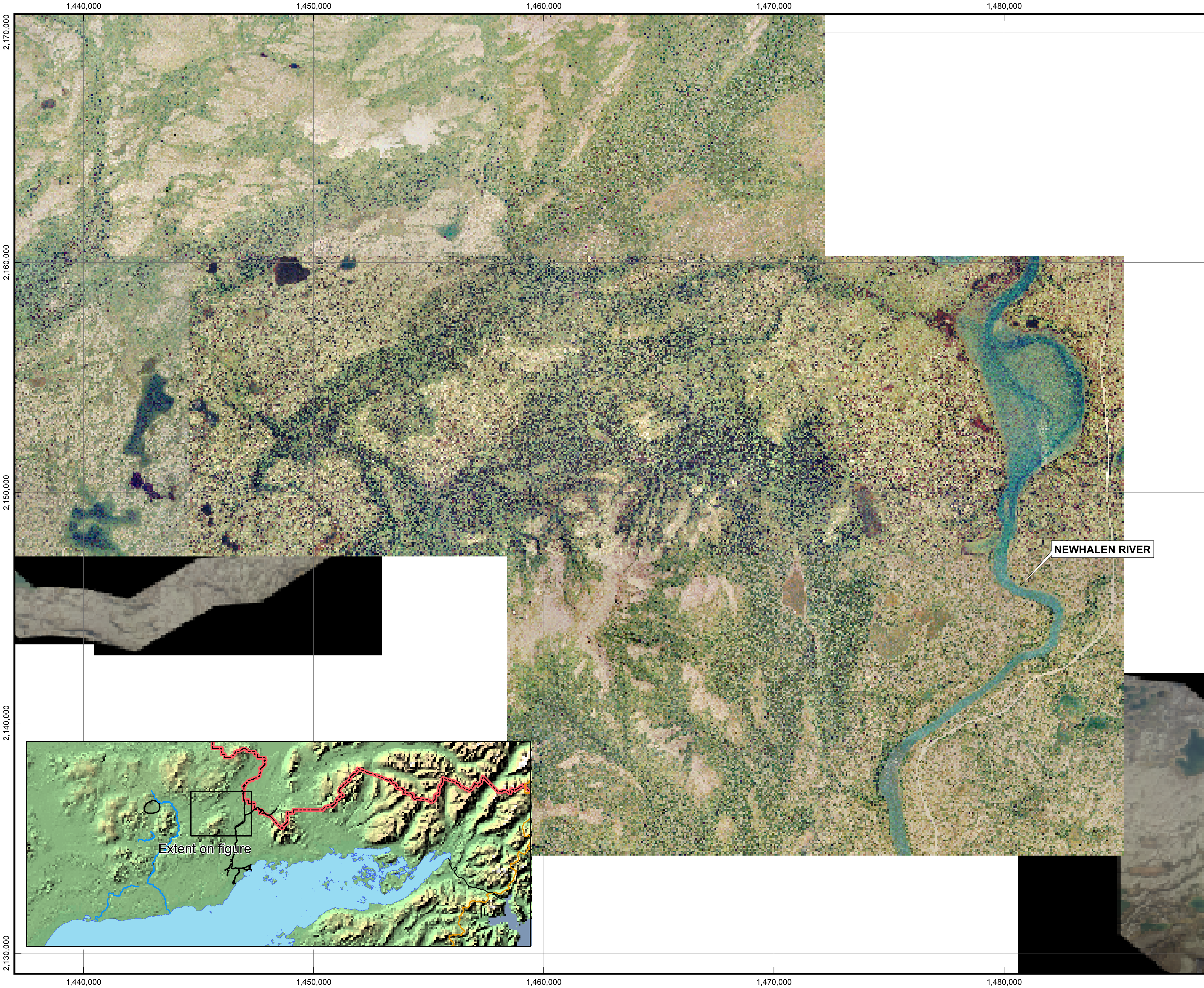


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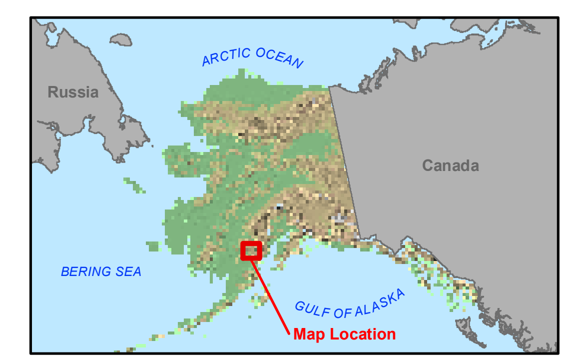
Figure 4-4b
Physiography Study,
Aerial Photograph
Transportation Corridor
Bristol Bay Study Area

## Legend

- General Deposit Location
- National Park and Preserve Boundary
- BB / CI Drainages Boundary
- Existing Roads

## Notes

1. BB/CI refers to Bristol Bay/Cook Inlet drainages
2. Inset scale is 1:1,000,000




Miles 0.5 0 0.5 1 1.5

Kilometers 0.5 0 0.5 1 1.5 2

N

Scale 1:50,000

**Alaska State Plane Zone 5 (units feet)**
**1983 North American Datum**

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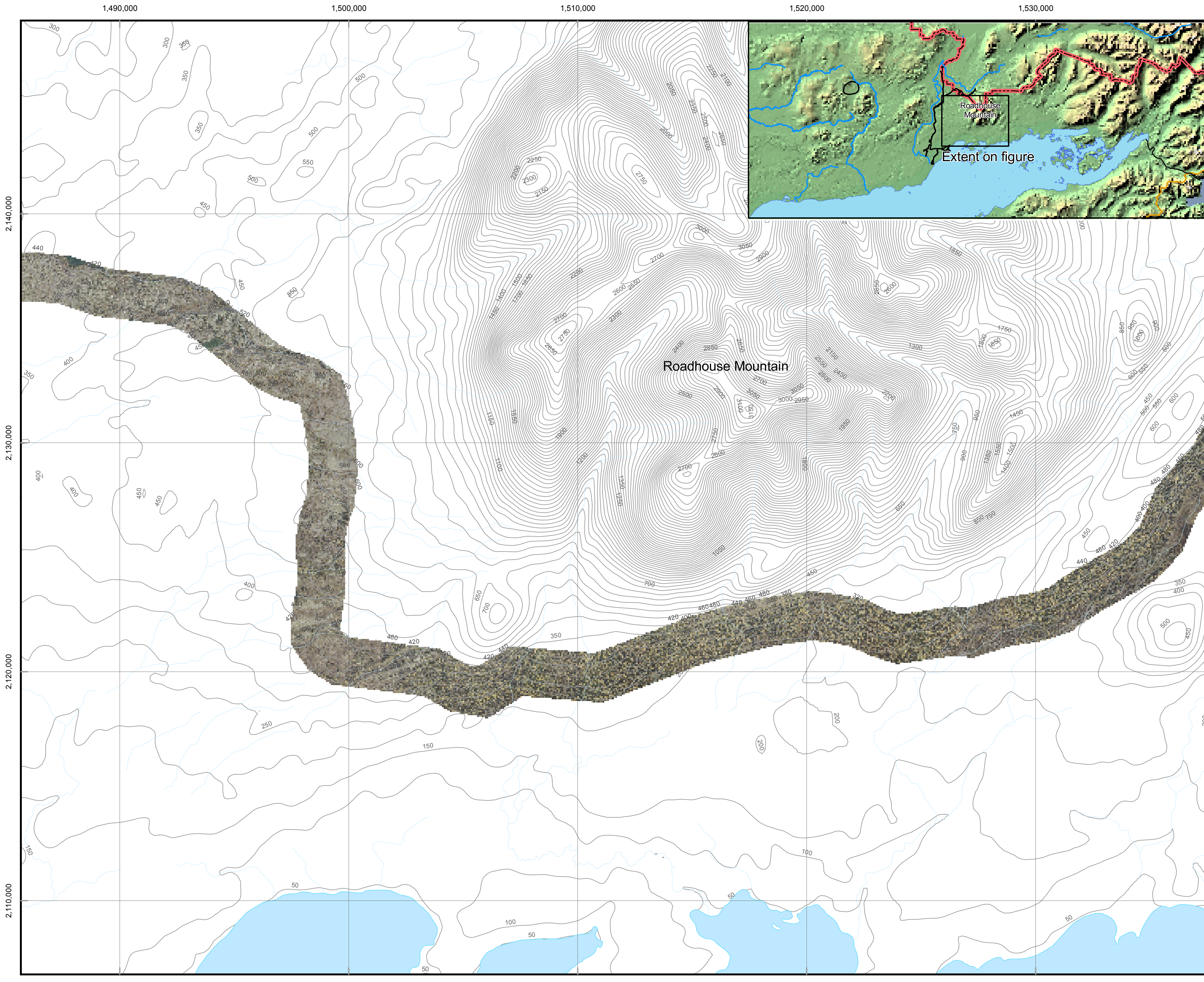



THE pebble PARTNERSHIP

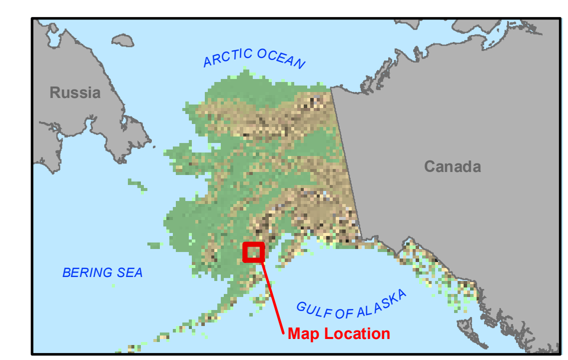
# Figure 4-4c
# Physiography Study, Aerial Photograph Transportation Corridor Bristol Bay Study Area

## Legend

- General Deposit Location
- National Park and Preserve Boundary
- BB / CI Drainages Boundary
- Existing Roads

## Notes

1. BB/CI refers to Bristol Bay/Cook Inlet drainages.
2. Contour interval is 50 ft.
3. Inset scale is 1:1,000,000.




Miles: 0.5 0 0.5 1 1.5

Kilometers: 0.5 0 0.5 1 1.5 2

N

Scale 1:50,000

**Alaska State Plane Zone 5 (units feet)**
**1983 North American Datum**

| | |
|---|---|
| File: B04_r0.mxd | Date: June 10, 2010 |
| Version: 2008-2 | Author: Knight Piésold Ltd. |

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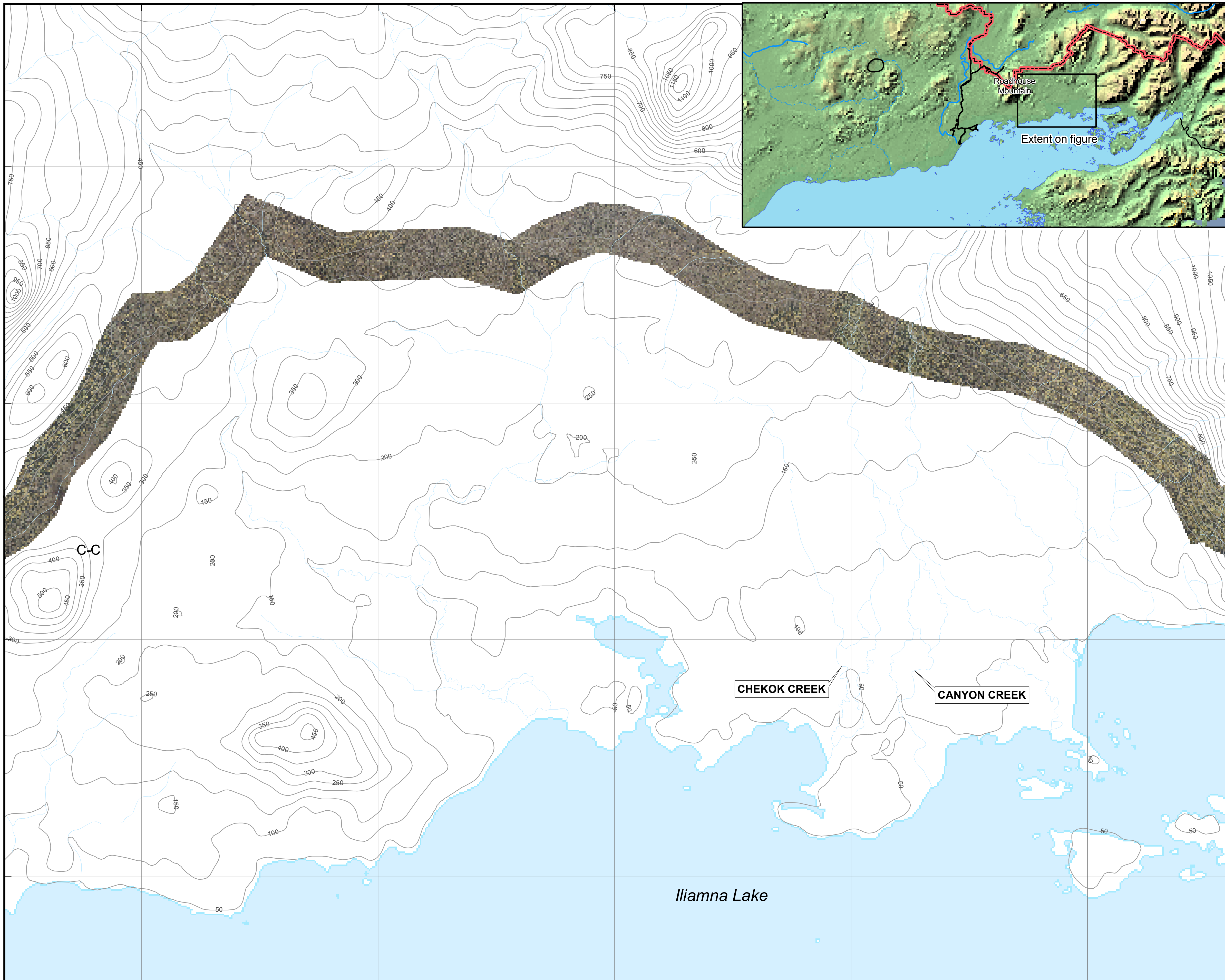



THE pebble PARTNERSHIP

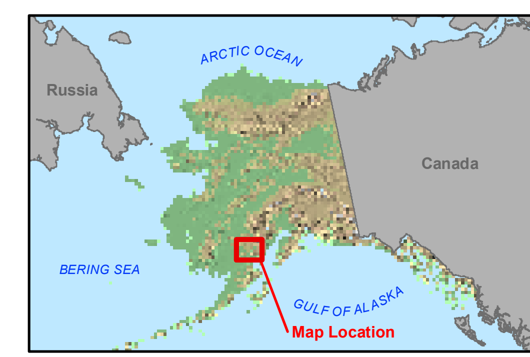
# Figure 4-4d
# Physiography Study, Aerial Photograph Transportation Corridor Bristol Bay Study Area

## Legend

- General Deposit Location
- National Park and Preserve Boundary
- BB / CI Drainages Boundary
- Existing Roads

## Notes

1. BB/CI refers to Bristol Bay/Cook Inlet drainages
2. Contour interval is 50 ft.
3. Inset scale is 1:1,000,000




0.5 0 0.5 1 1.5 Miles

0.5 0 0.5 1 1.5 2 Kilometers

N

Scale 1:50,000

**Alaska State Plane Zone 5 (units feet)**
**1983 North American Datum**

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|---|---|
| File: B05_r0.mxd | Date: June 10, 2010 |
| Version: 2008-2 | Author: Knight Piésold Ltd. |

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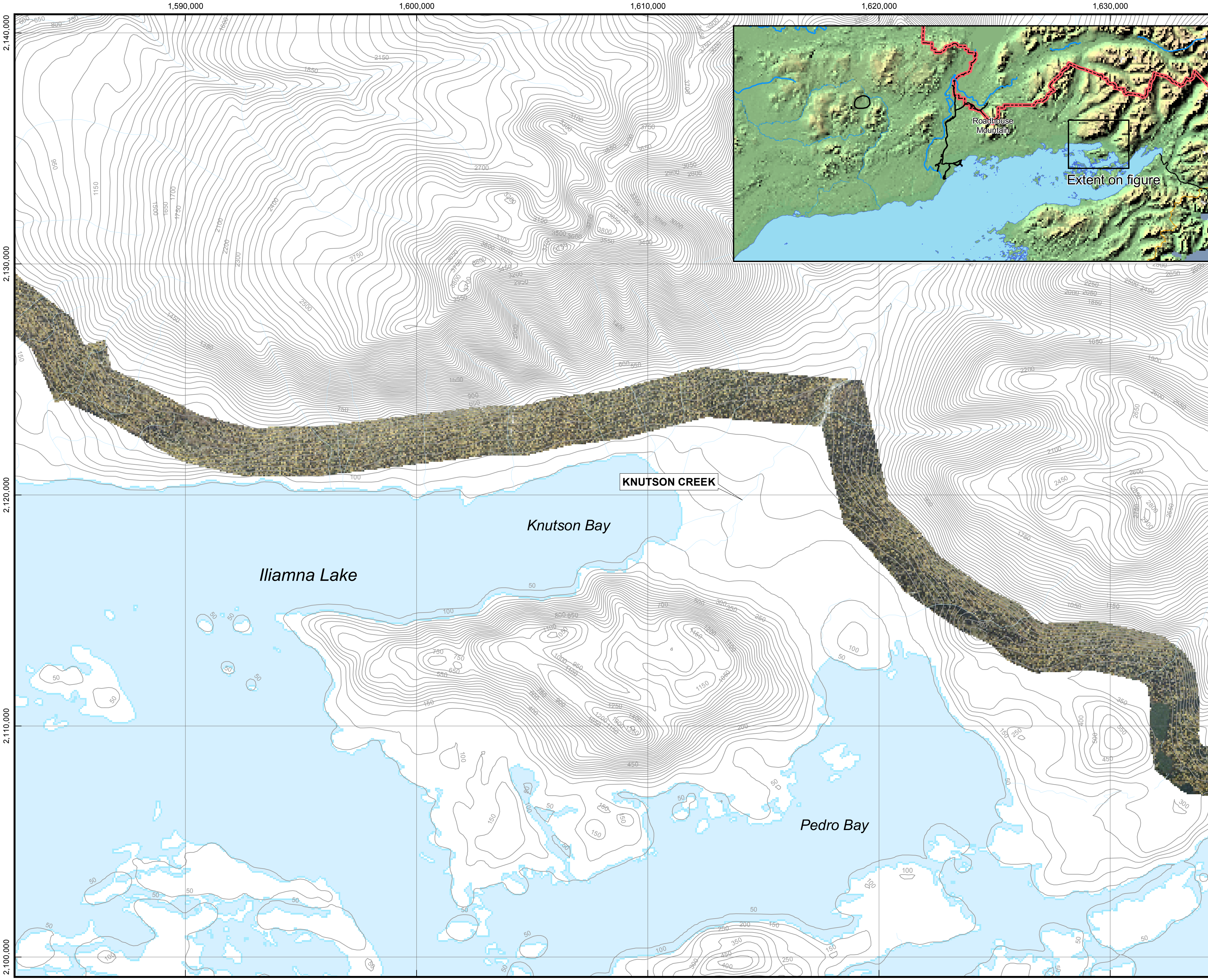



THE pebble PARTNERSHIP

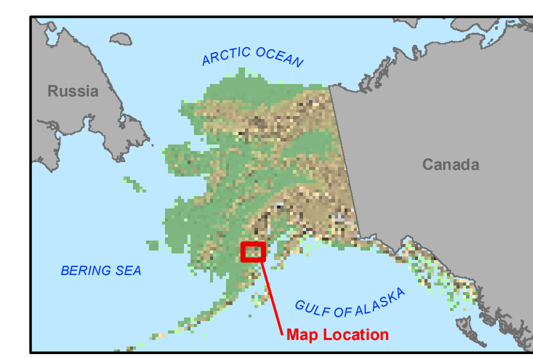
Figure 4-4e
Physiography Study,
Aerial Photograph
Transportation Corridor
Bristol Bay Study Area

## Legend

- General Deposit Location
- National Park and Preserve Boundary
- BB / CI Drainages Boundary
- Existing Roads

## Notes

1. BB/CI refers to Bristol Bay/Cook Inlet drainages
2. Contour interval is 50 ft.
3. Inset scale is 1:1,000,000




Miles: 0.5 0 0.5 1 1.5
Kilometers: 0.5 0 0.5 1 1.5 2

N

Scale 1:50,000

**Alaska State Plane Zone 5 (units feet)**
**1983 North American Datum**

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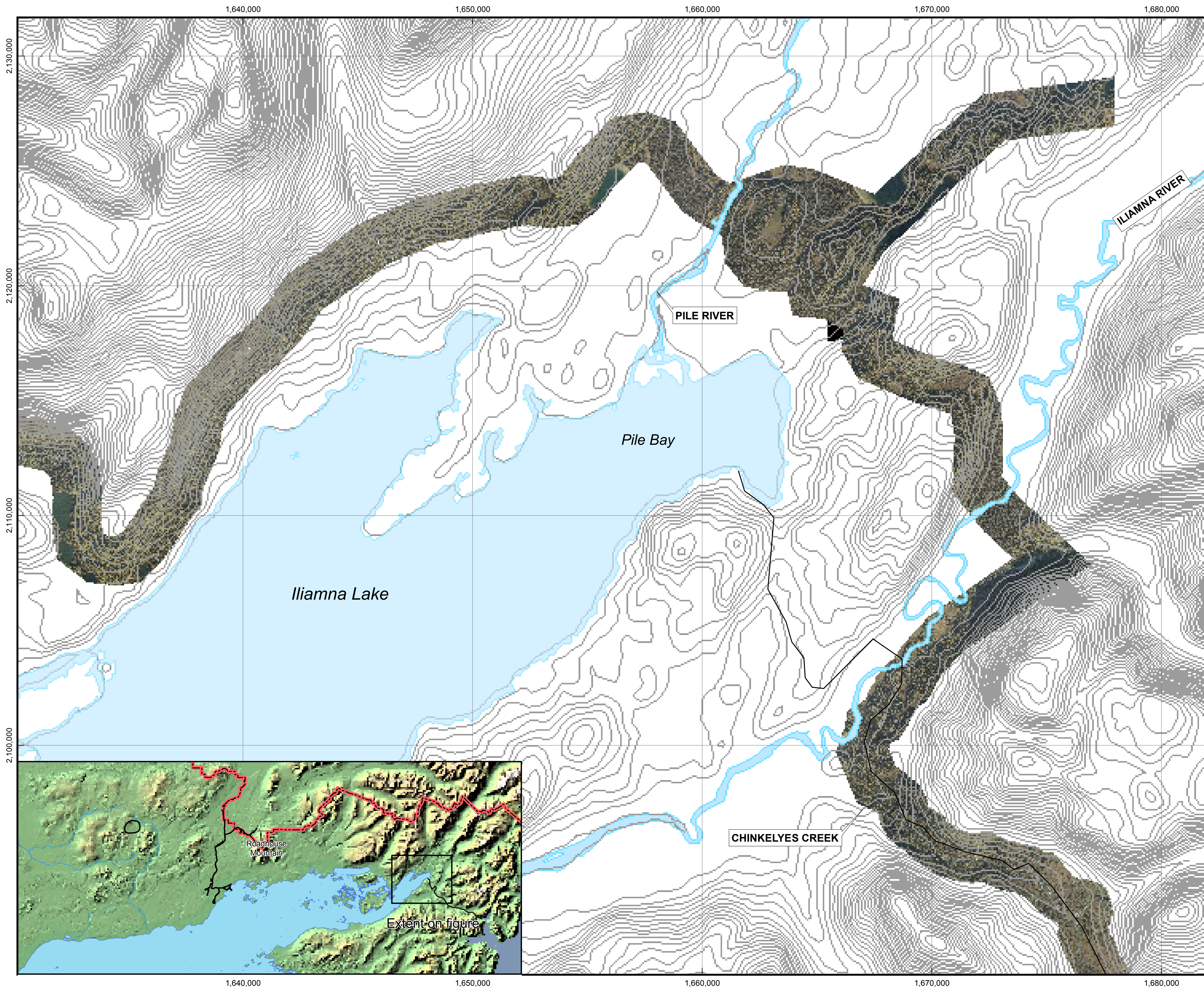
|---|---|
| File: B06_r0.mxd | Date: June 10, 2010 |
| Version: 2008-2 | Author: Knight Piésold Ltd. |



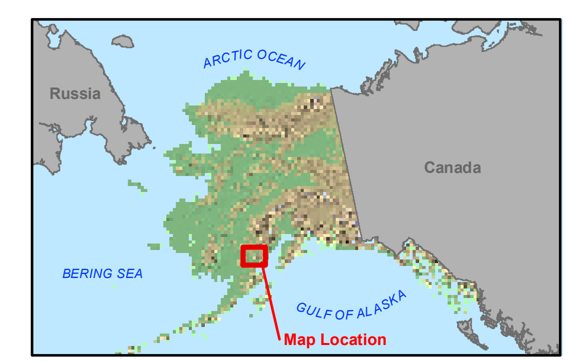

# Figure 4-4f
# Physiography Study, Aerial Photograph Transportation Corridor Bristol Bay Study Area

## Legend

- General Deposit Location
- National Park and Preserve Boundary
- BB / CI Drainages Boundary
- Existing Roads

## Notes

1. BB/CI refers to Bristol Bay/Cook Inlet drainages
2. Contour interval is 50 ft.
3. Inset scale is 1:1,000,000




Miles: 0.5 0 0.5 1 1.5

Kilometers: 0.5 0 0.5 1 1.5 2

N

Scale 1:50,000

**Alaska State Plane Zone 5 (units feet)**
**1983 North American Datum**

| | |
|---|---|
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| Version: 2008-2 | Author: Knight Piésold Ltd. |

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# PHOTOGRAPHS

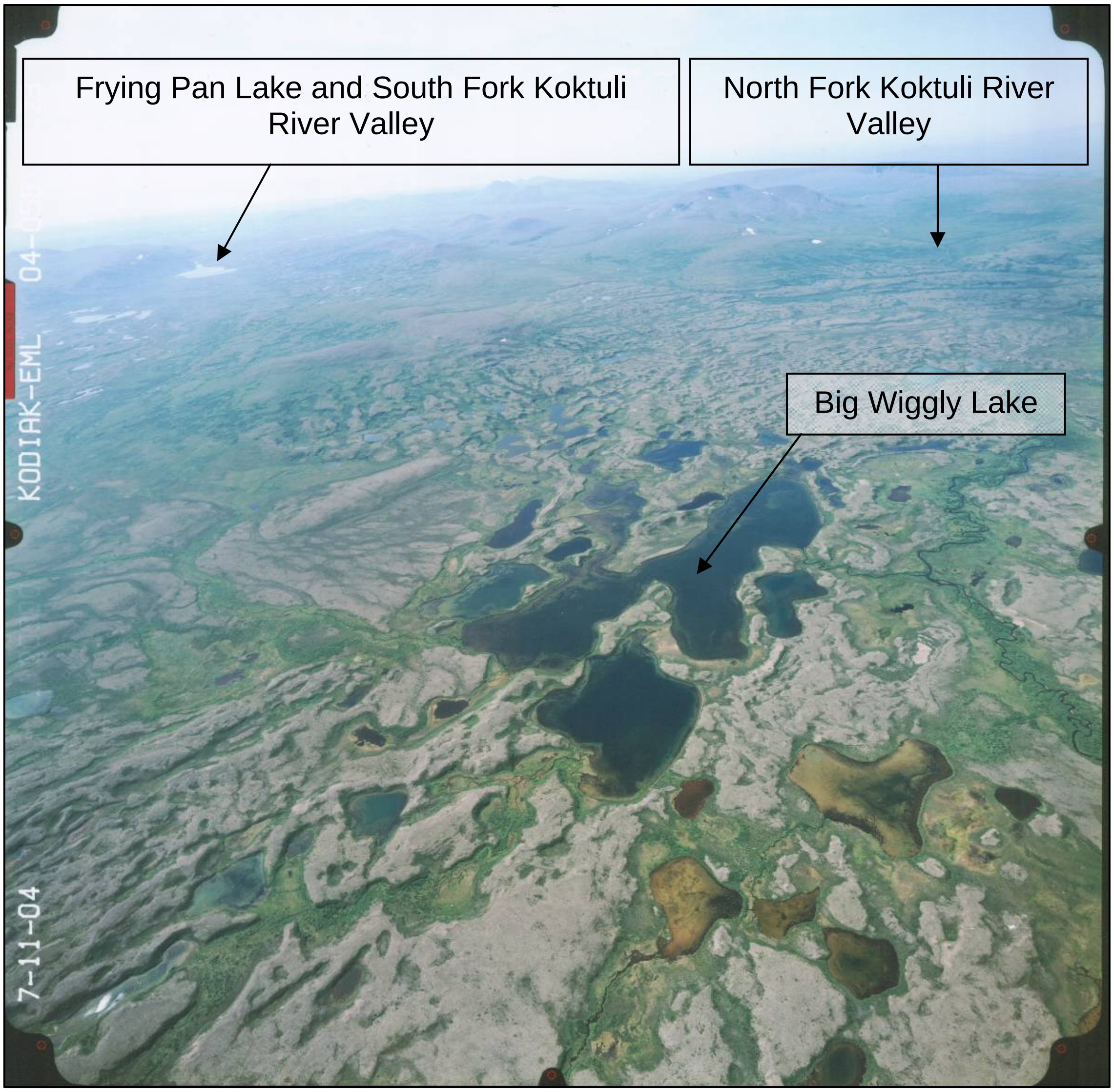


PHOTO 4-1: Mine study area, view to the southwest from Big Wiggly Lake toward the upper parts of the valleys of the north and south forks of the Koktuli River, July 2004.

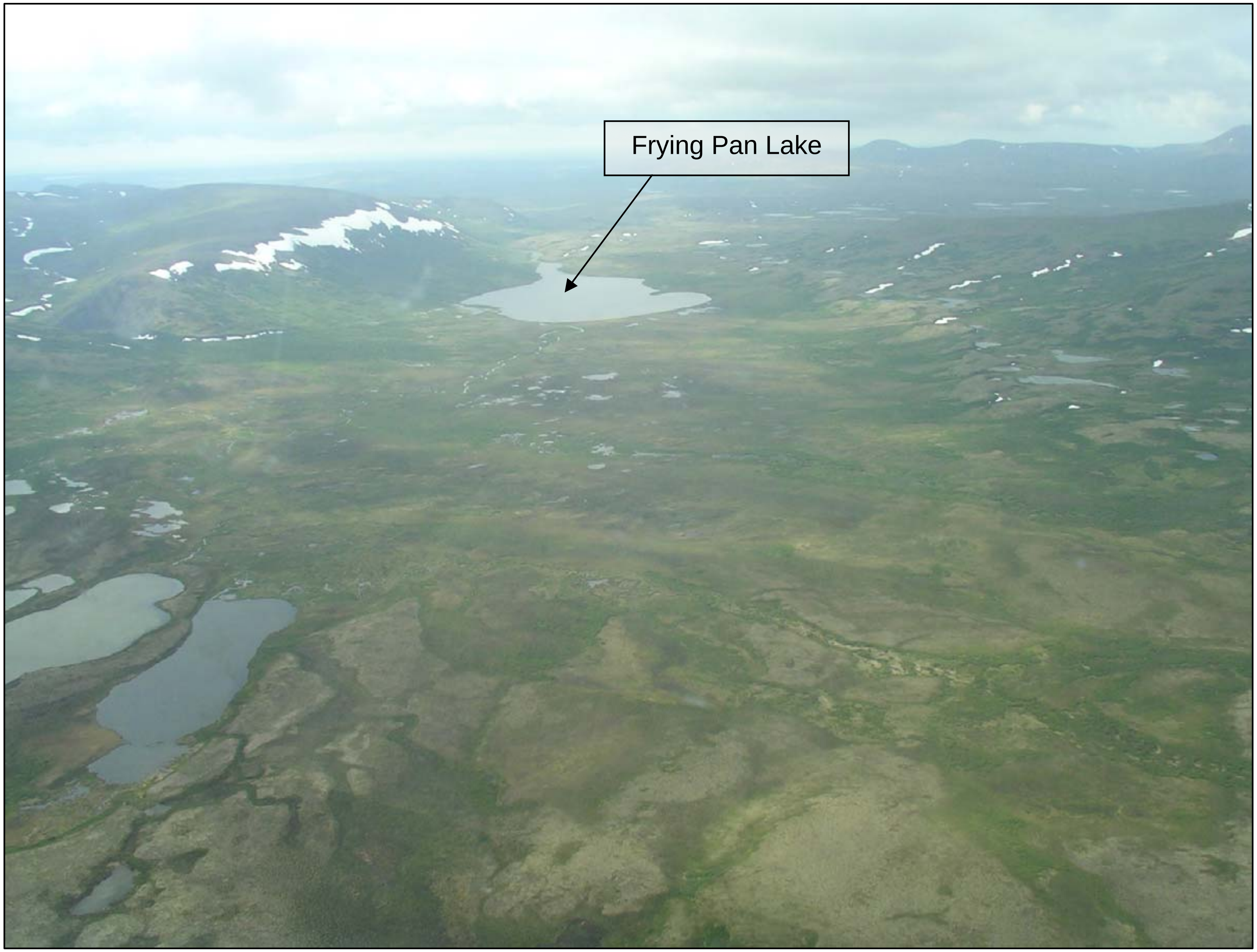


PHOTO 4-2: Mine study area, view to the south toward Frying Pan Lake, July 2004.

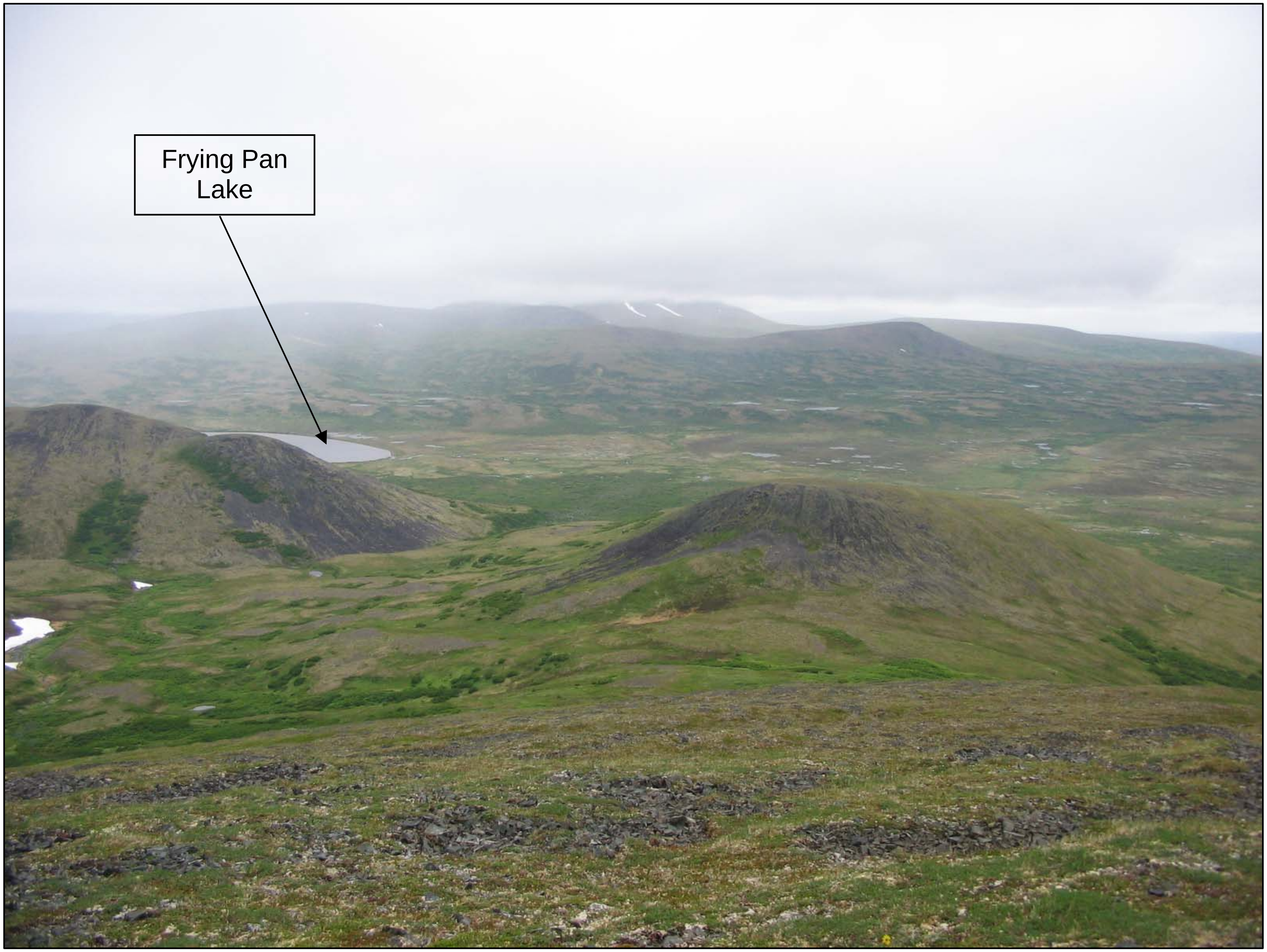


PHOTO 4-3: Mine study area, view to the west across the South Fork Koktuli River valley upstream of Frying Pan Lake, July 2004.

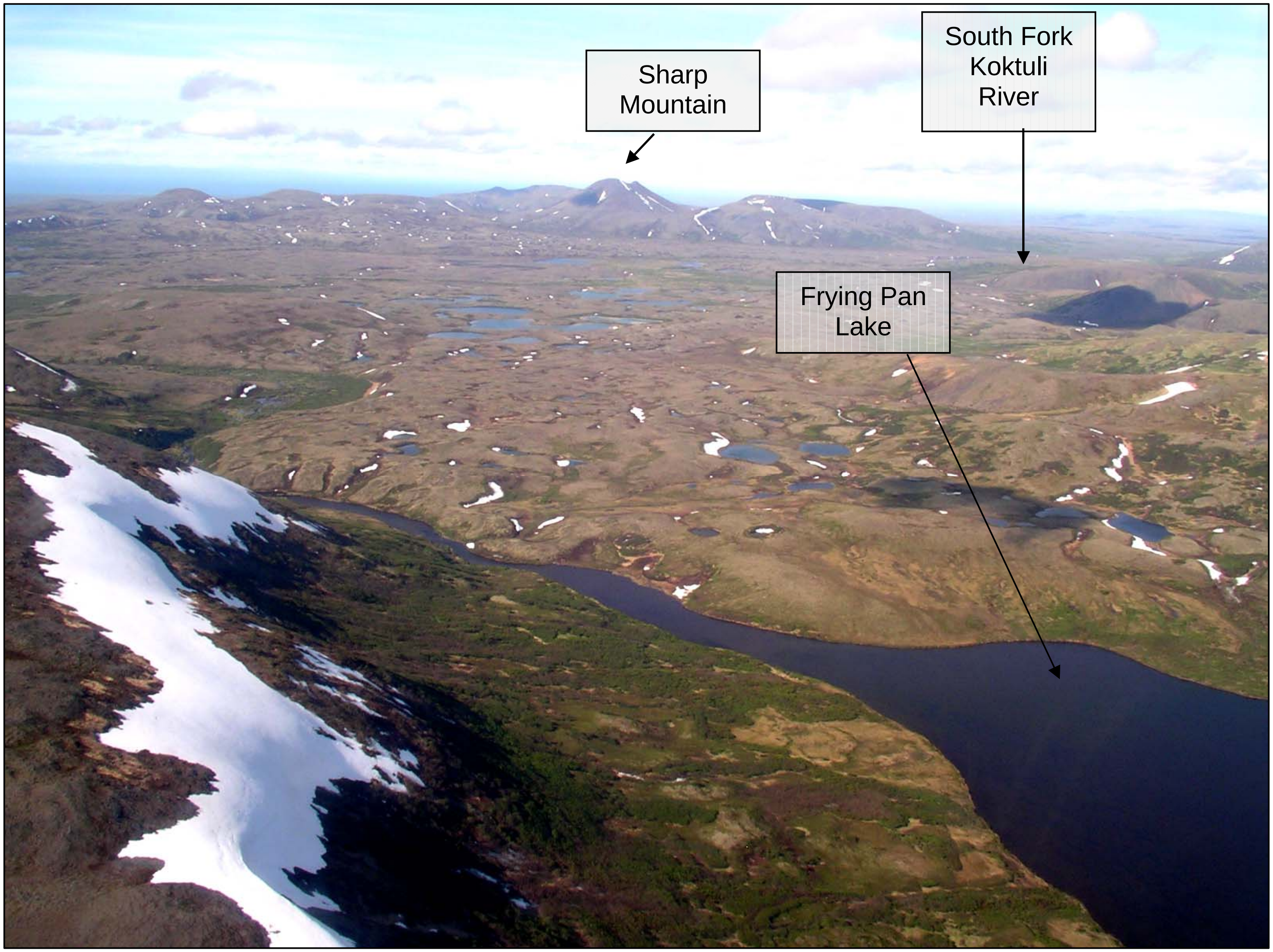


PHOTO 4-4: Mine study area, view to the southwest down the South Fork Koktuli River valley downstream of Frying Pan Lake, July 2004.

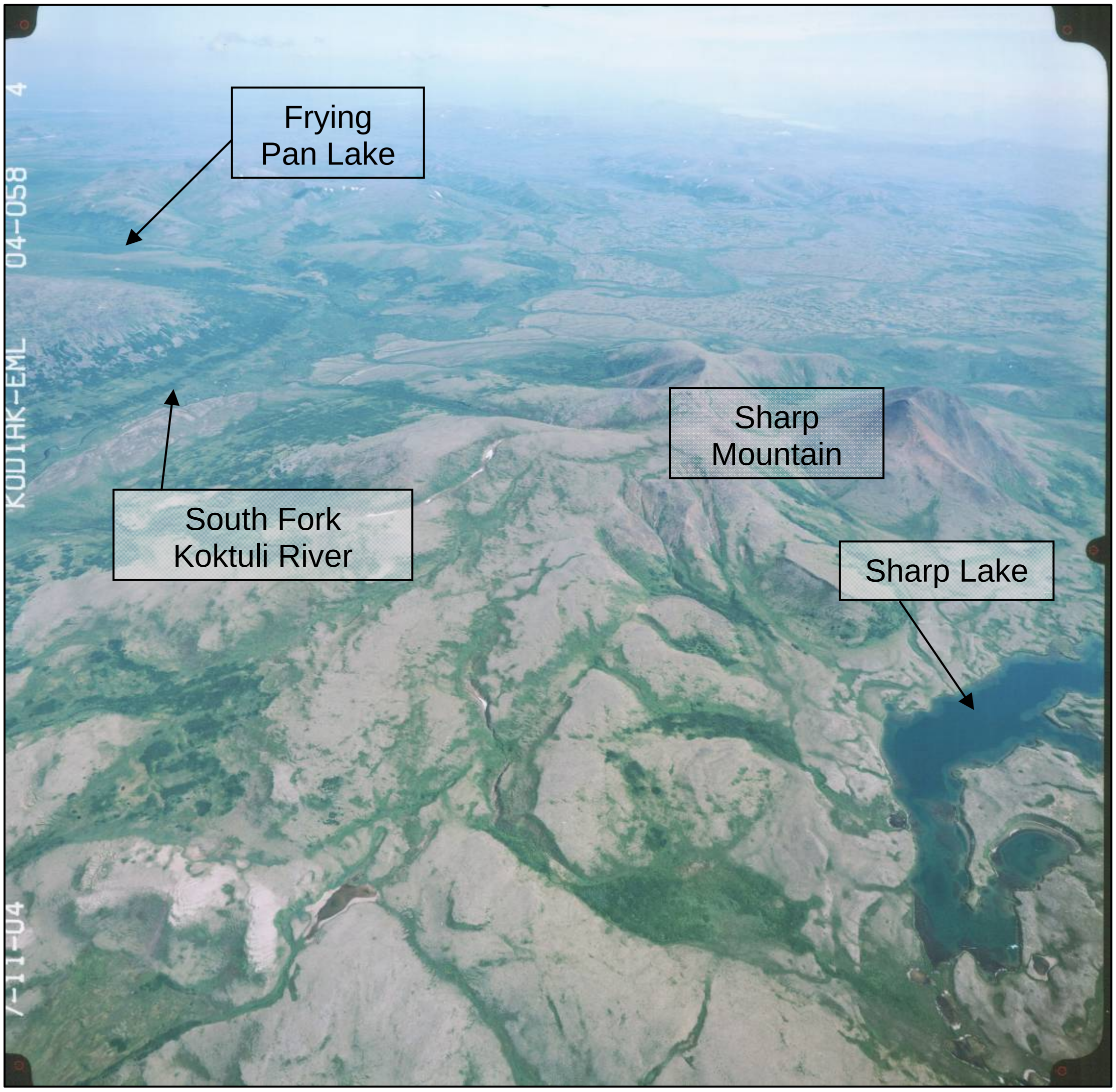


PHOTO 4-5: Mine study area, view to the northeast up the South Fork Koktuli River valley toward Frying Pan Lake, July 2004.

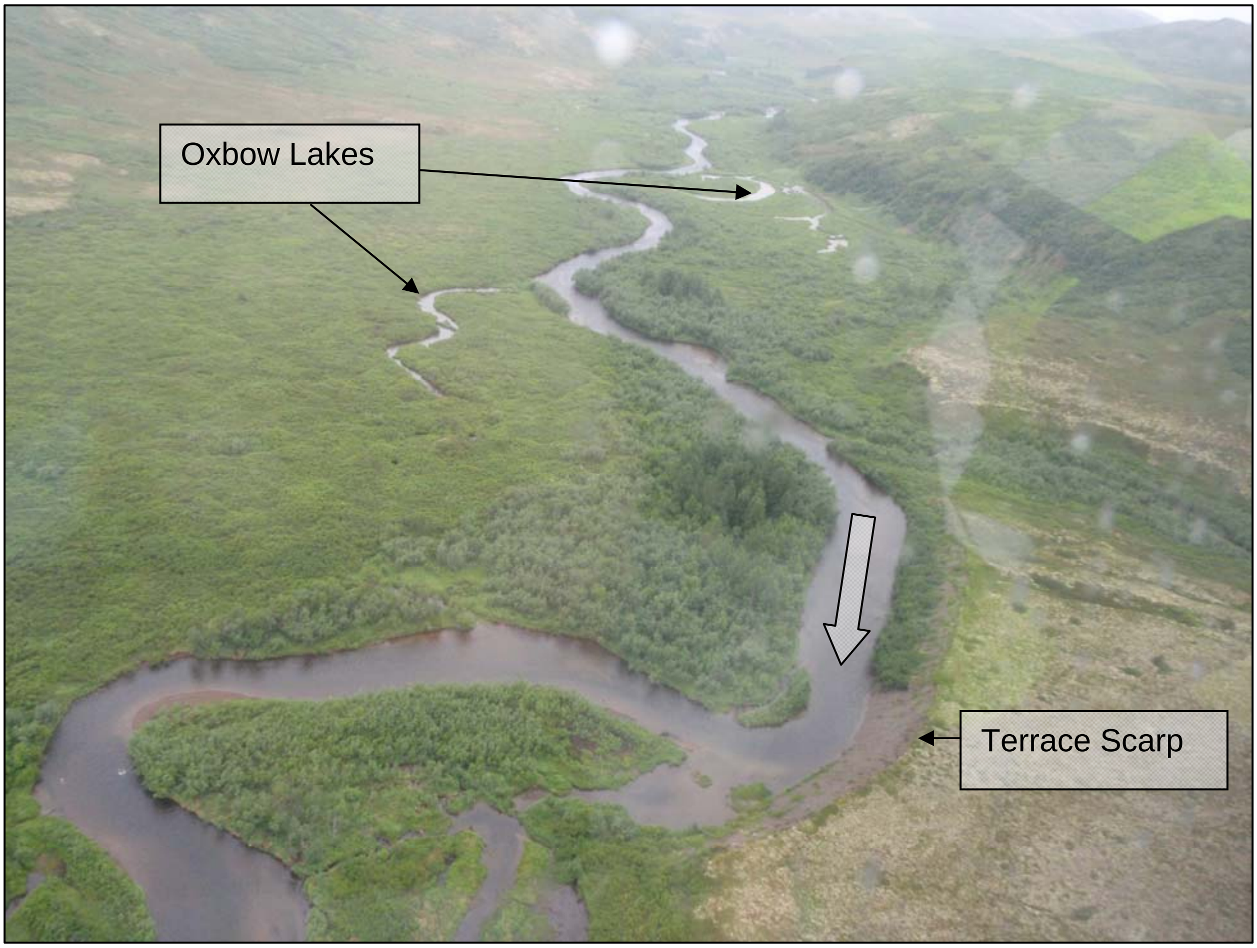


PHOTO 4-6: Mine study area, typical view upstream along the South Fork Koktuli River valley showing meandering channel and glaciofluvial terrace scarp, July 2008.

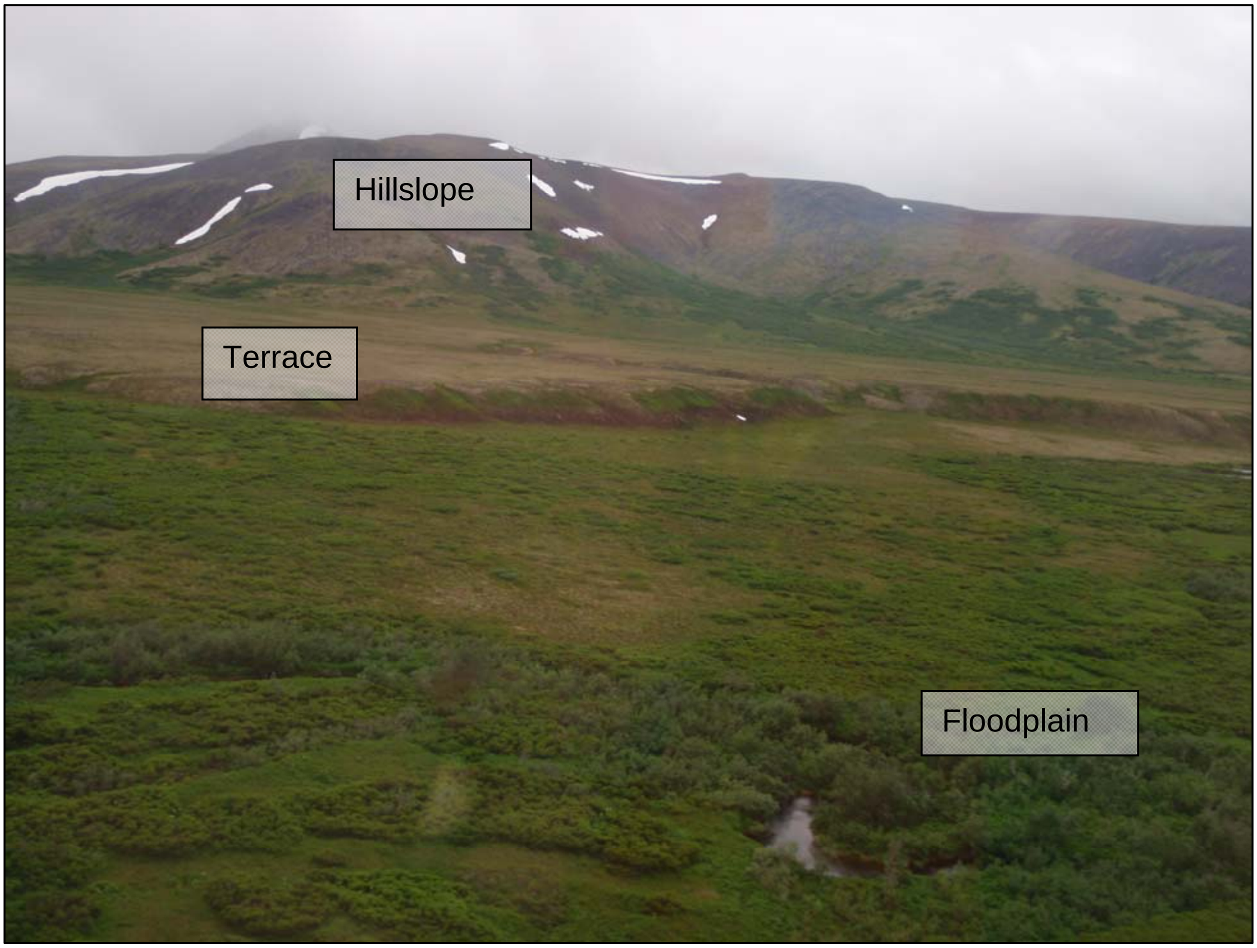


PHOTO 4-7: Mine study area, typical view across the South Fork Koktuli River valley showing floodplain, glaciofluvial terrace and hillslope terrain, July 2008.

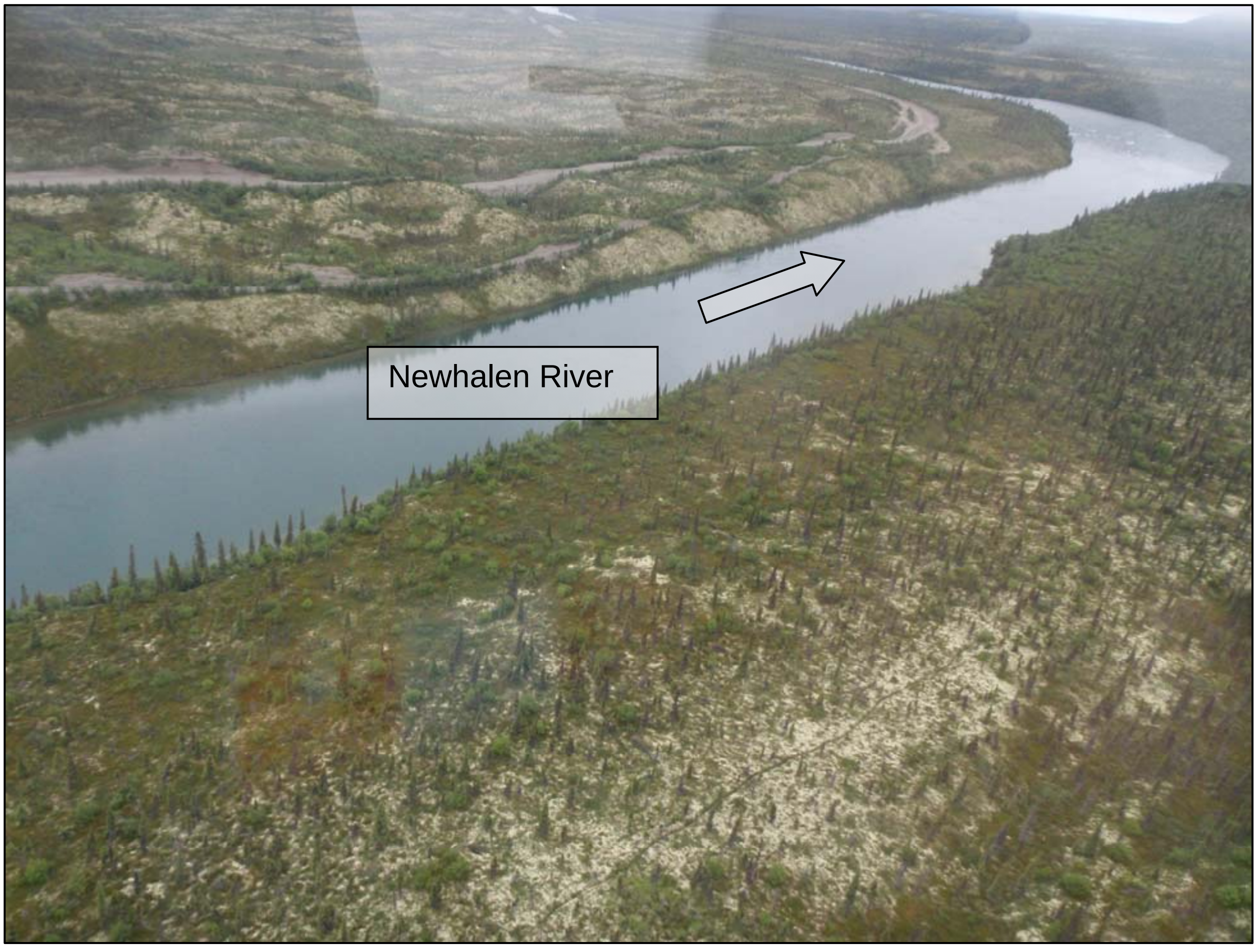


PHOTO 4-8: Transportation corridor study area, view downstream along the Newhalen River, July 2008.

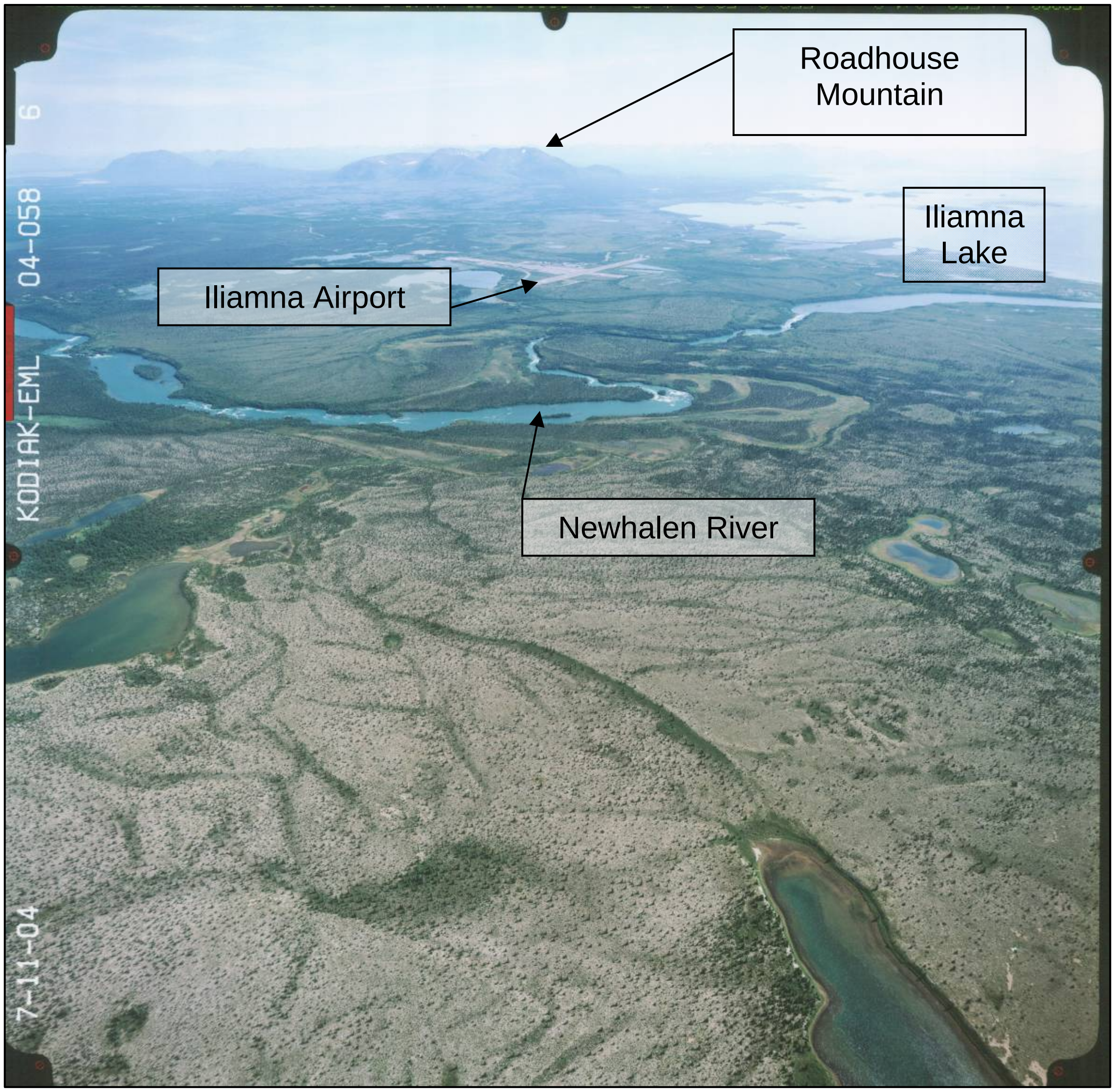


PHOTO 4-9: Transportation corridor study area, view to the east toward Roadhouse Mountain showing typical terrain in the Nushagak-Bristol Bay Lowlands physiographic division, July 2004.

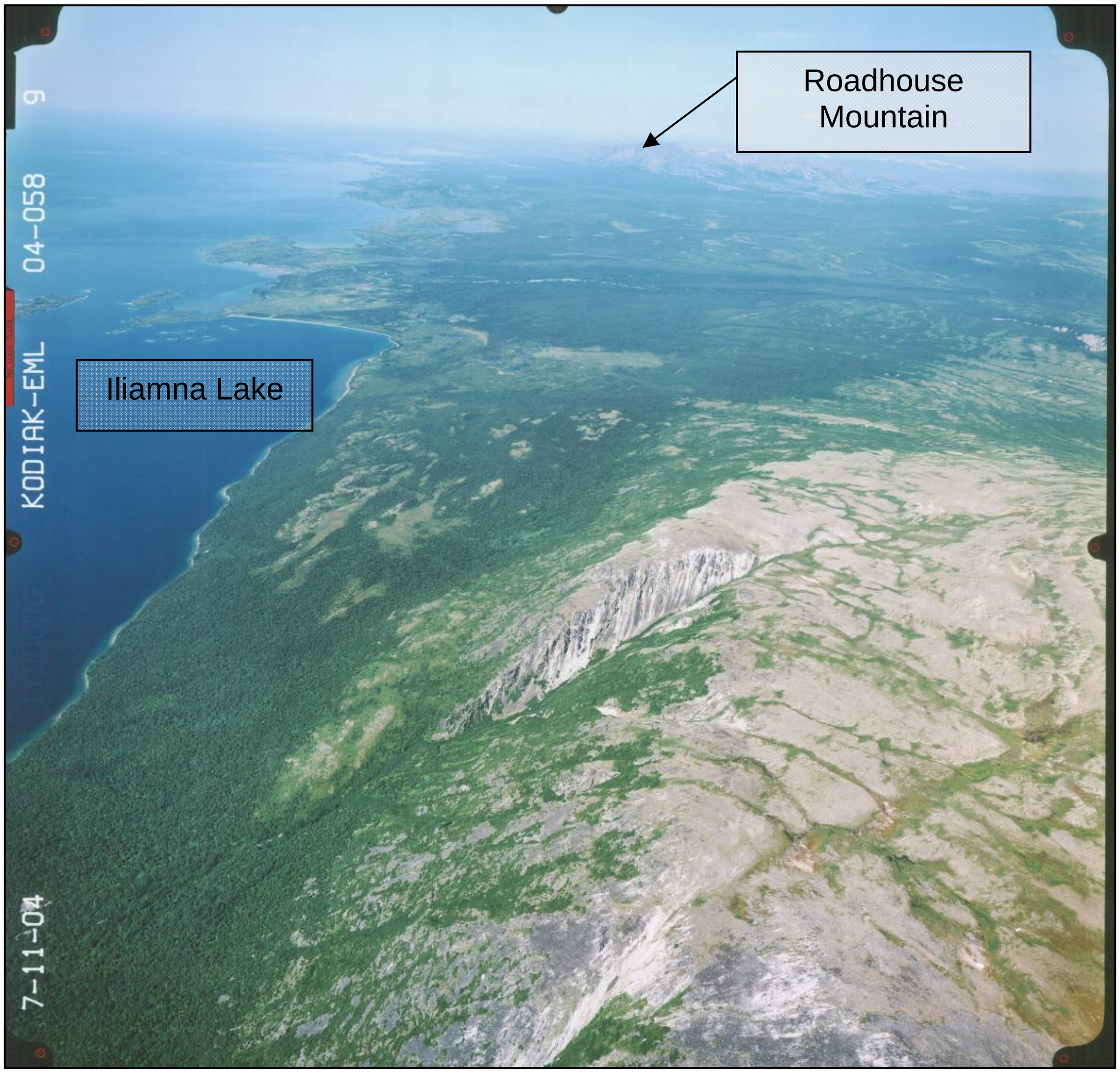


PHOTO 4-10: Transportation corridor study area, view to the west toward Roadhouse Mountain, July 2004.

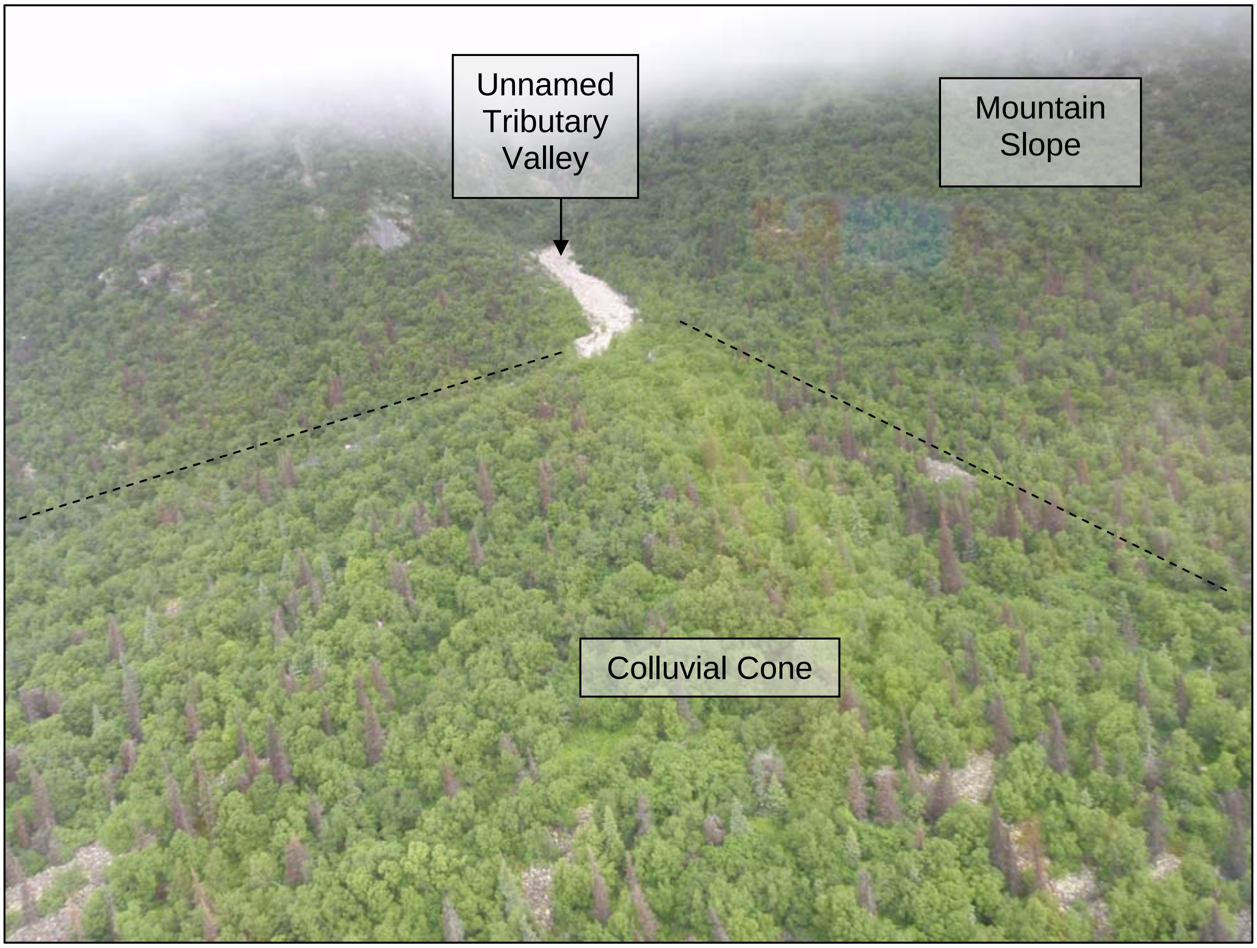


PHOTO 4-11: Transportation corridor study area, typical mountain slope and colluvial cone along the north shore of Iliamna Lake between Canyon Creek and Knutson Creek, July 2008.

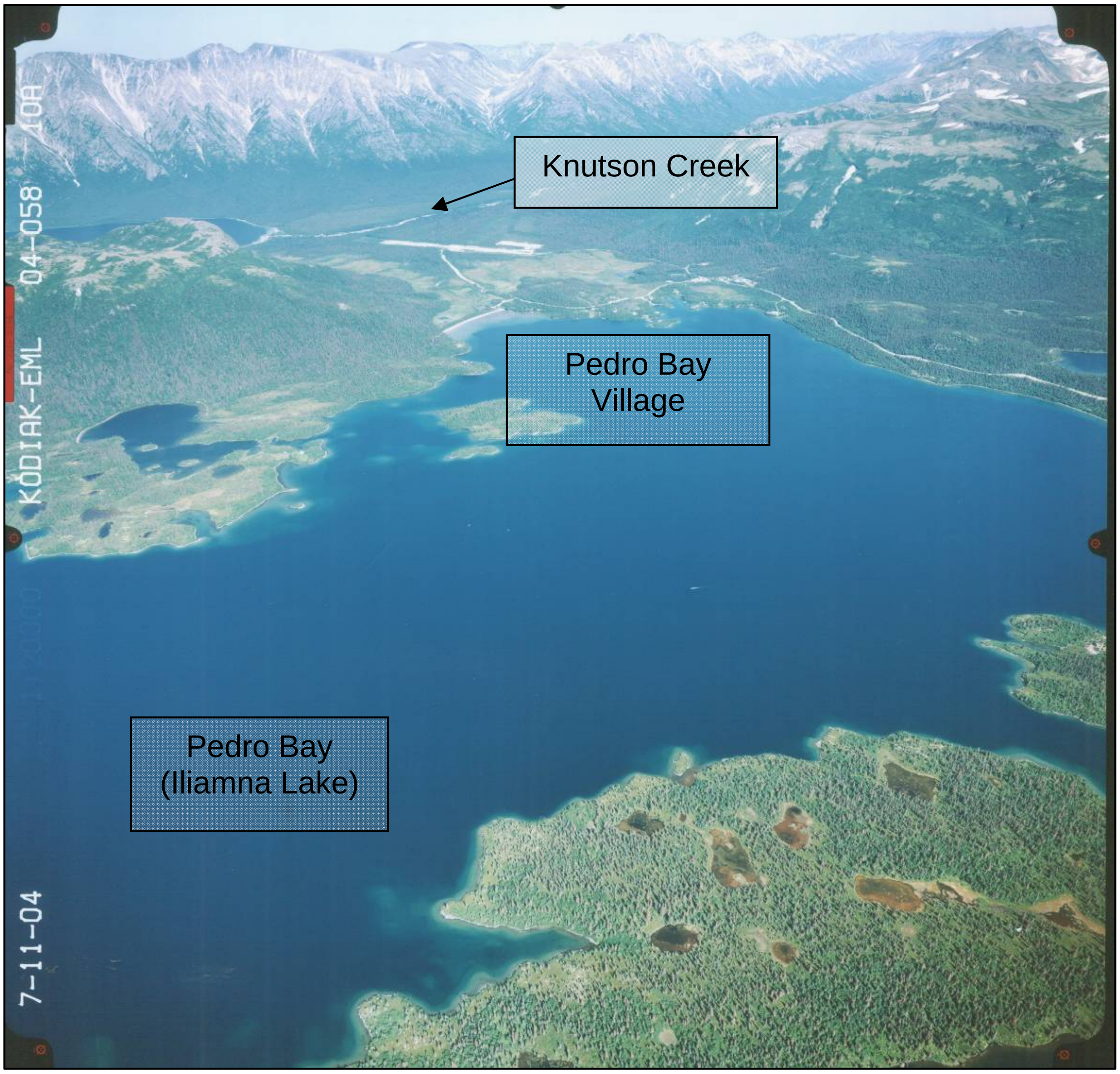


PHOTO 4-12: Transportation corridor study area, view to the northeast across Pedro Bay toward the village of Pedro Bay, with Knutson Creek in the background, July 2004.

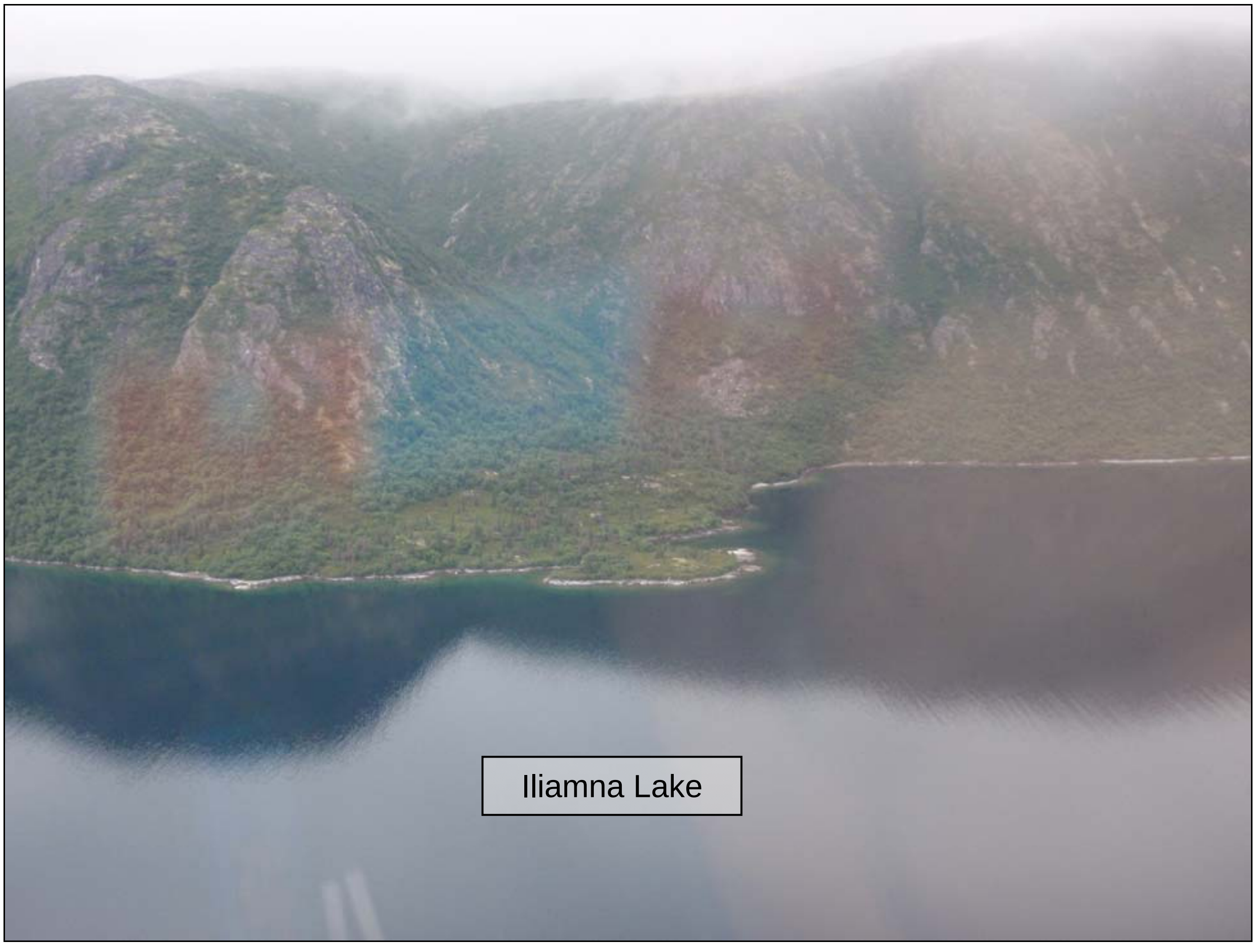


PHOTO 4-13: Transportation corridor study area, typical mountain slope along the north shore of Iliamna Lake between Knutson Creek and Pile River, July 2008.


PHOTO 4-14: Transportation corridor study area, upstream view along Canyon Creek, July 2008.


PHOTO 4-15: Transportation corridor study area, upstream view of Knutson Creek, July 2008.

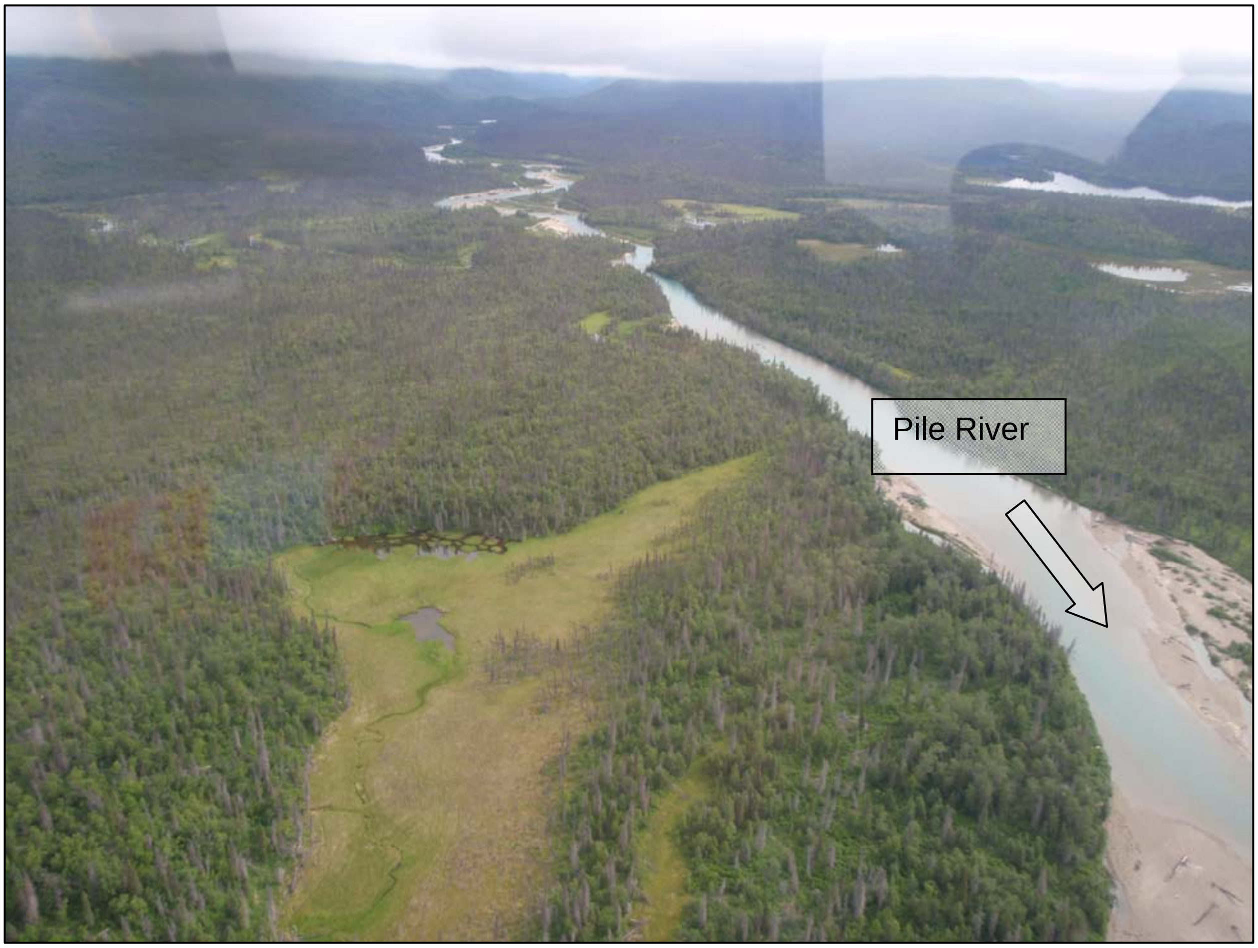


PHOTO 4-16: Transportation corridor study area, upstream view along the Pile River, July 2008.

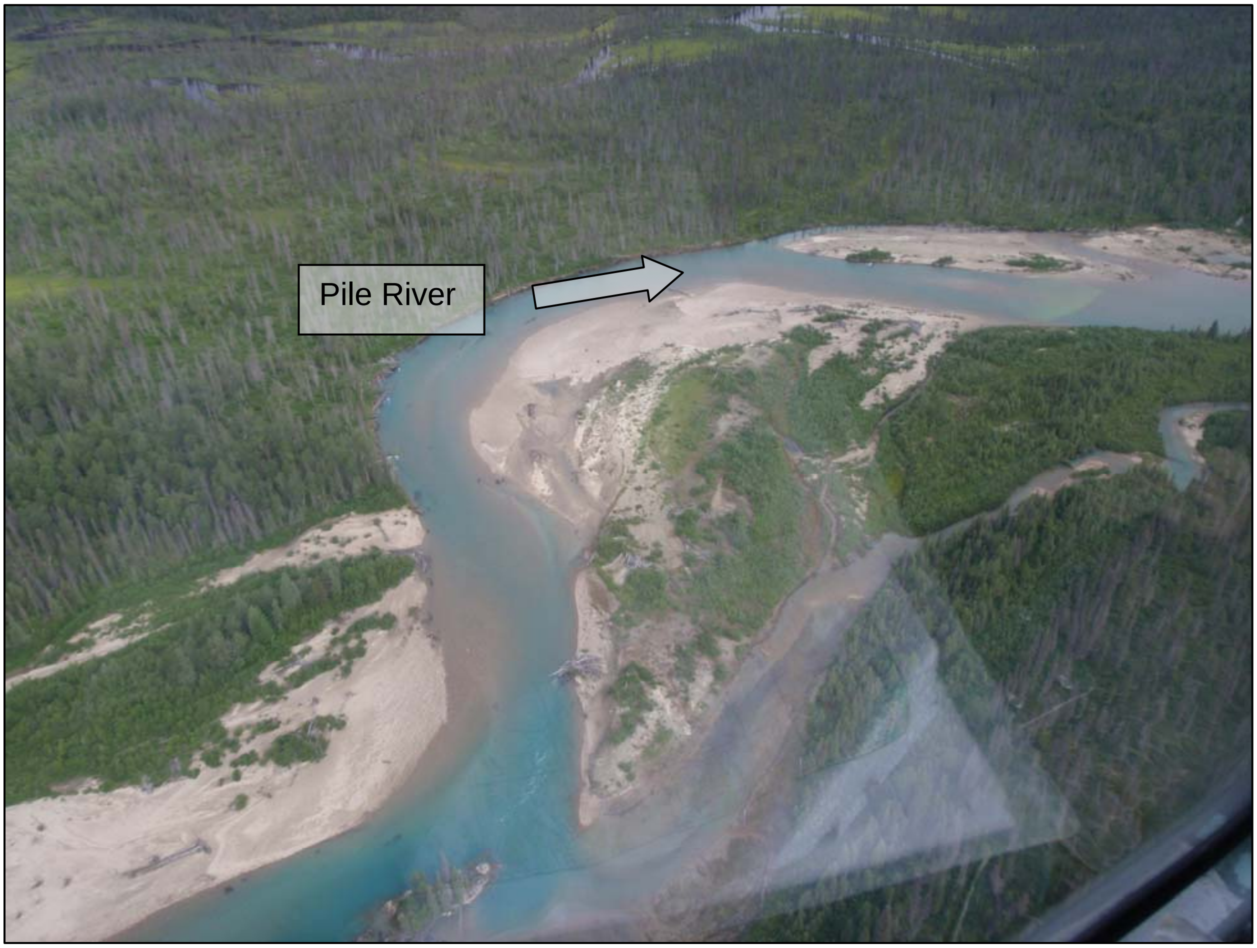


PHOTO 4-17: Transportation corridor study area, typical braided channel pattern in the Pile River near the mouth, July 2008.


PHOTO 4-18: Transportation corridor study area, typical meandering channel pattern in the Iliamna River near the Chinkelyes Creek confluence, July 2008.


PHOTO 4-19: Transportation corridor study area, upstream view along Chinkelyes Creek valley near the mouth, July 2008.

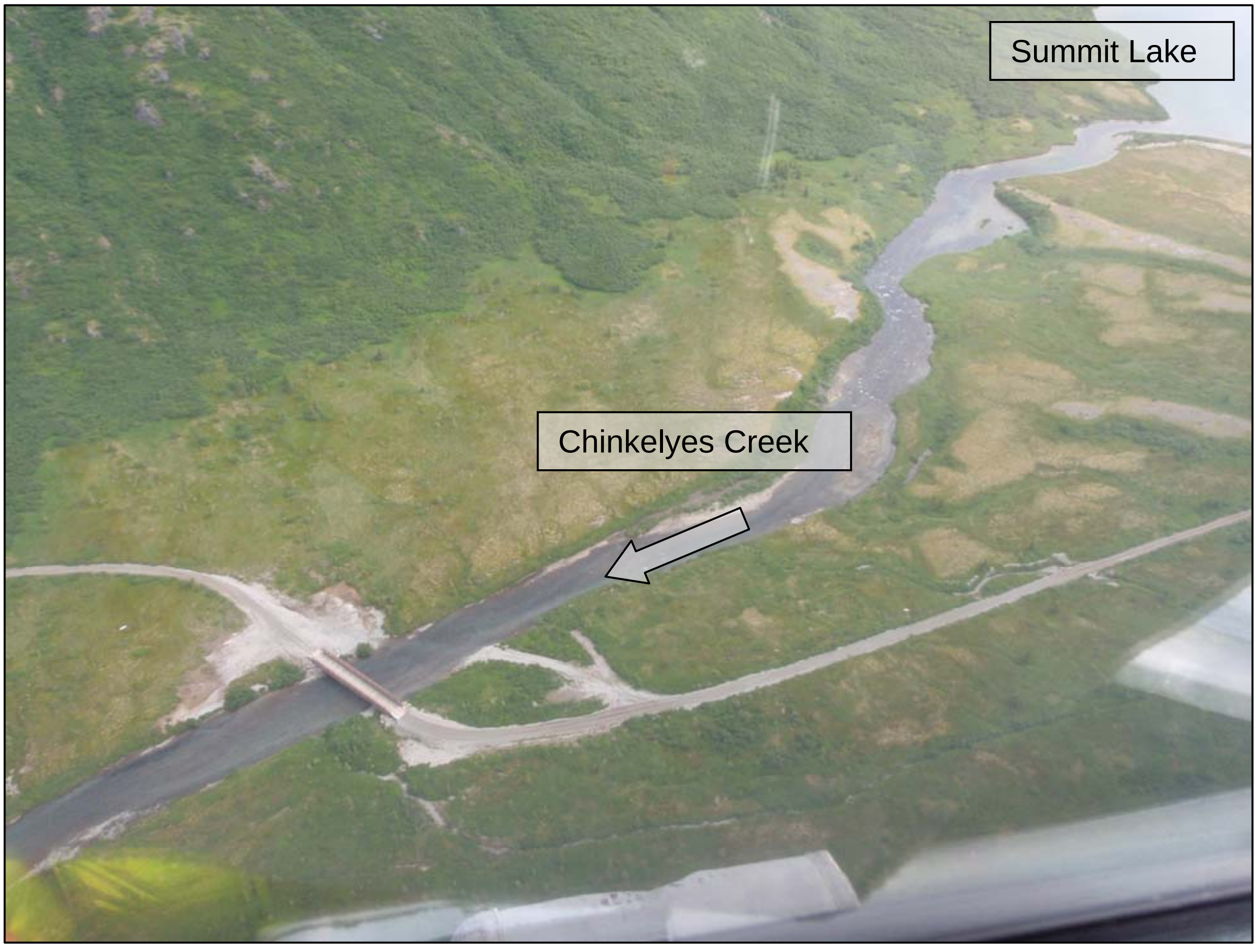


PHOTO 4-20: Transportation corridor study area, existing crossing on Chinkelyes Creek below Summit Lake, July 2008.

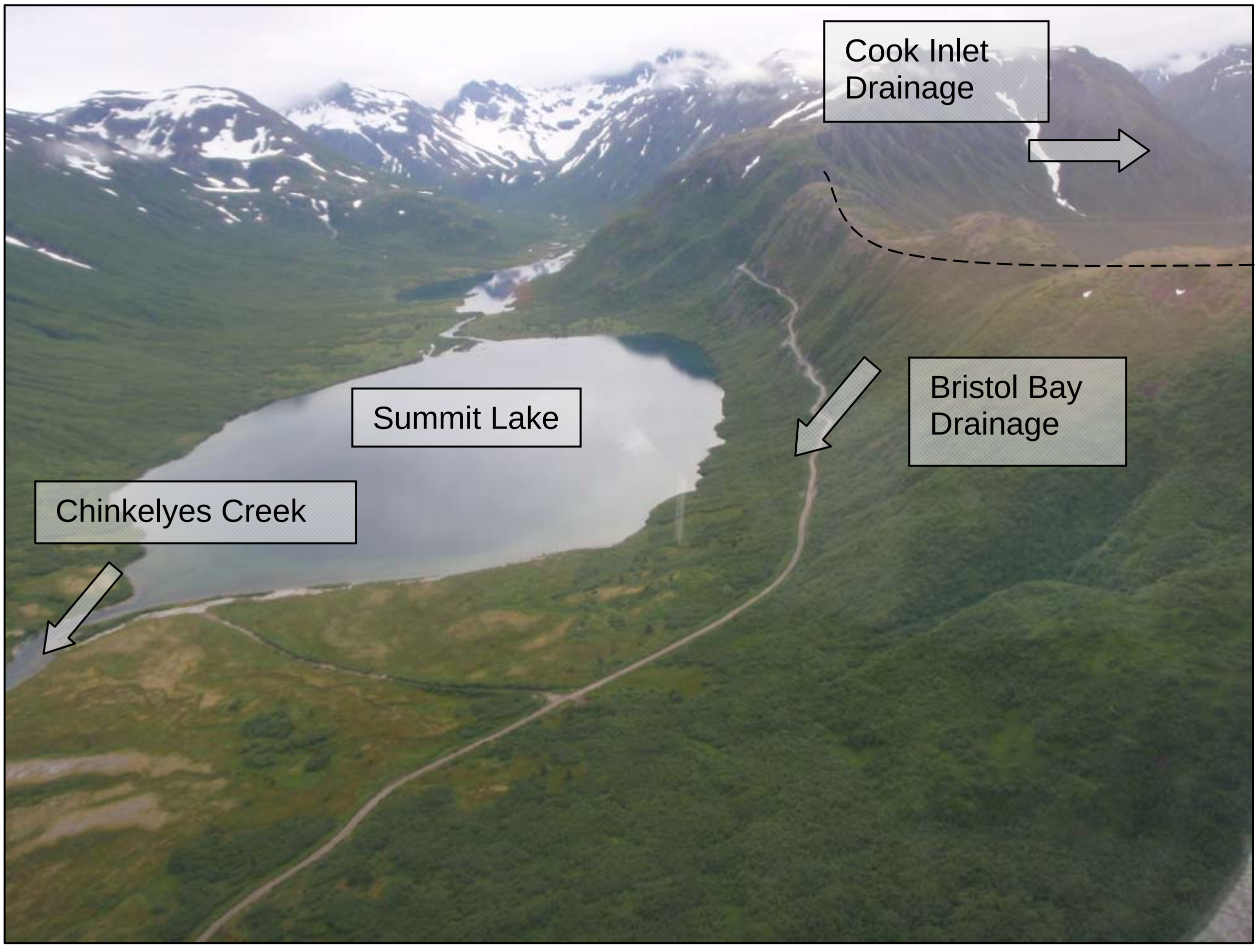


PHOTO 4-21: Transportation corridor study area, upstream view along Chinkelyes Creek valley near the Bristol Bay-Cook Inlet drainage divide, July 2008.