Flooding and Environmental History in the Upper Tanana Region near Manh Choh

Virtual Alaska Weather Symposium Talk

Dr. Jessica Cherry, Regional Climate Services Director for Alaska

National Centers for Environmental Information (NCEI)

January 24, 2024

Outline

- Why is this currently an area of special interest for Interior Alaska?
- Why am I speaking to you about this region?
- The 2017 Flood on the Upper Tanana and its impacts
- The history of the road to Tetlin
- Environmental context and potential risk

Why is this currently an area of special interest for Interior Alaska?

Transport route

Image of similar highway truck used every day along Alaskan highways

https://manhchoh.com/

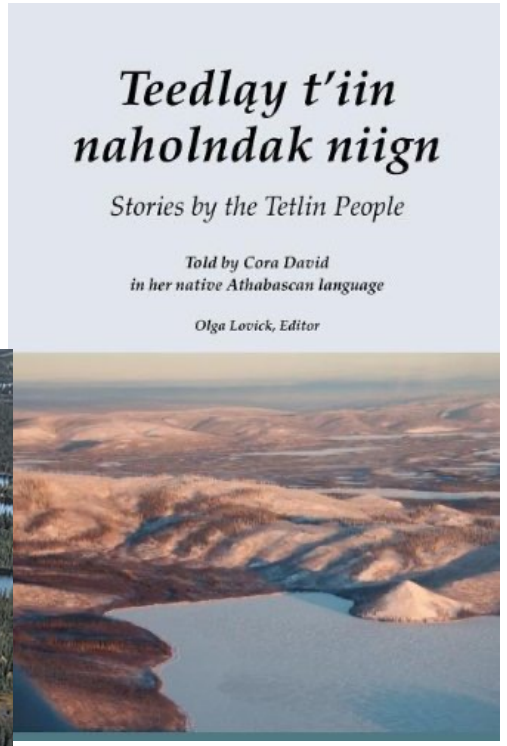
KINROSS Manh Choh A JV with Contango ORE KINROSS Fort Knox

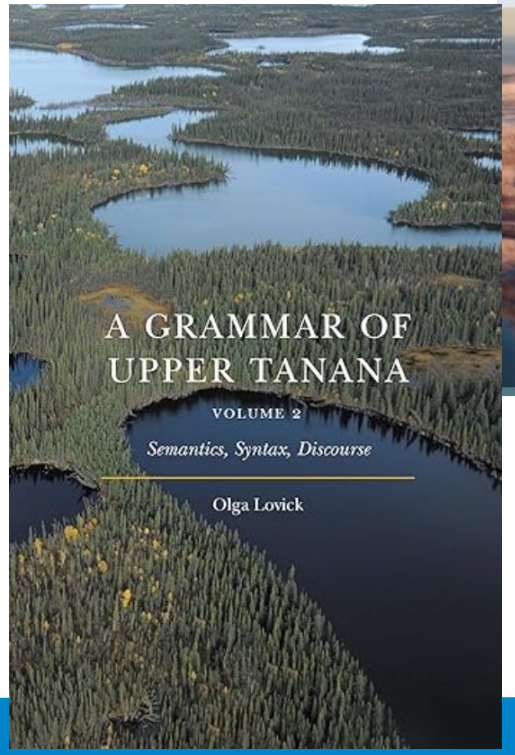
Native Village of Tetlin

- Tetlin Indian Reserve existed from 1930-1971 (see book J. Ferguson, *Parallel Destinies;* UAF Project Jukebox)
- In 1971, the Tribe opted for surface and subsurface rights to the former reserve instead of joining the corporate structure of the Alaska Native Claims Settlement Act
- The Tetlin Tribe does not benefit from the revenue sharing aspect of ANCSA
- The proposed mine could be an economic boost for this area

Why am I speaking to you about this region?

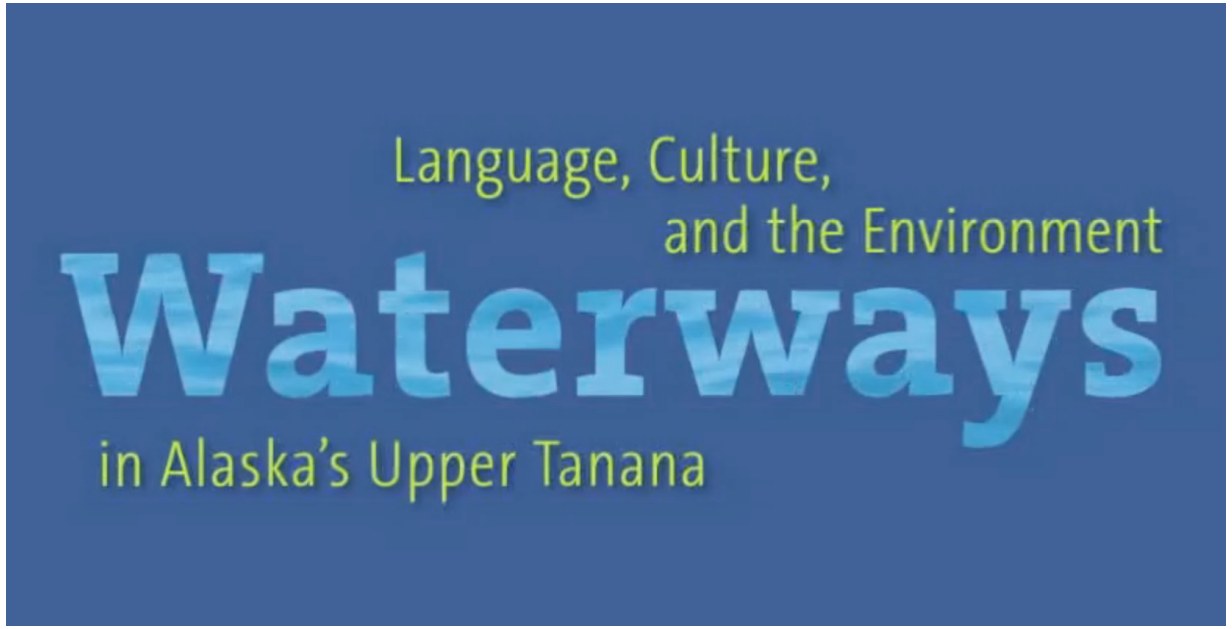
- I had the opportunity to fly and map the area around the proposed mine
- I took oblique aerial photographs of the Tetlin area for a couple of books edited by linguist Olga Lovick: Stories by the Tetlin People told by Cora David and the cover of a grammar of the Upper Tanana
- I worked the 2017 flood event on the Tetlin Road while at the NWS Alaska-Pacific River Forecast Center





Why am I speaking to you about this region?

I had the honor of working with Cora David as a producer of a short film about her water-related stories and had the opportunity to visit Tetlin (by plane and car) and Last Tetlin fish camp by boat. Besides Cora, Olga Lovick and multi-media artist Pat Harman were my collaborators. Siri Tuttle, former director of the Alaska Native Language Center narrated between Cora's stories.



https://vimeo.com/905844691

Tetlin Road Flooding 2017

Photo credit: Paul Kelley (area resident)

The road between the Village of Tetlin and the Alaska Highway was underwater for 0.75 miles for nearly a month during the summer of 2017.

Photo credit: Paul and Nancy Kelley

We want to know:

- What happened?
- Factors contributing to impacts
- When will it happen again?
- What is the source of our information?
- What can NOAA do to help monitor flood water?

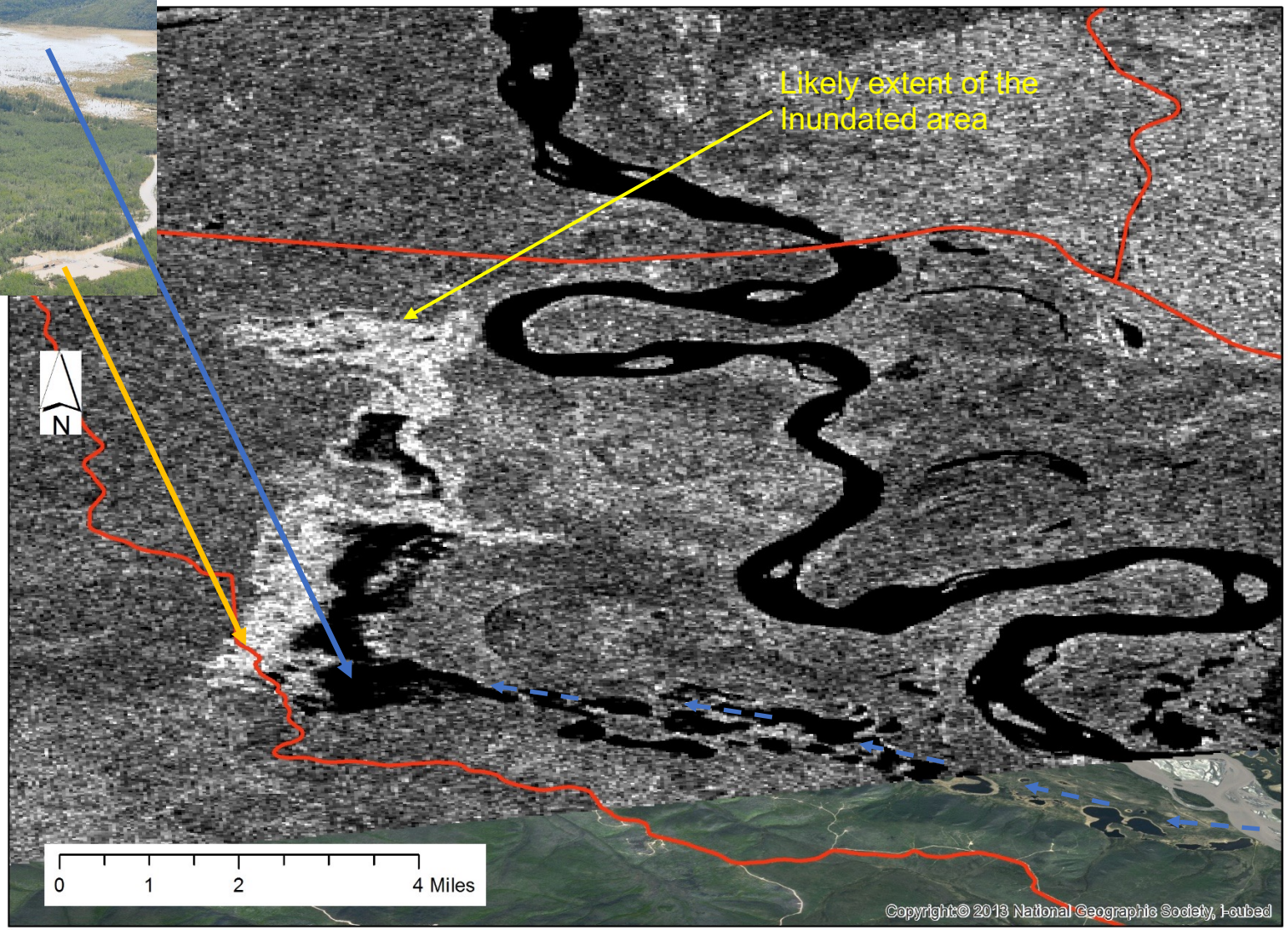
What Happened?

Civil Air Patrol Flight, August 5th Looking Southeast at the Flooded Portion of the Road

Civil Air Patrol Flight, August 5th Looking Southeast at the Flooded Portion of the Road

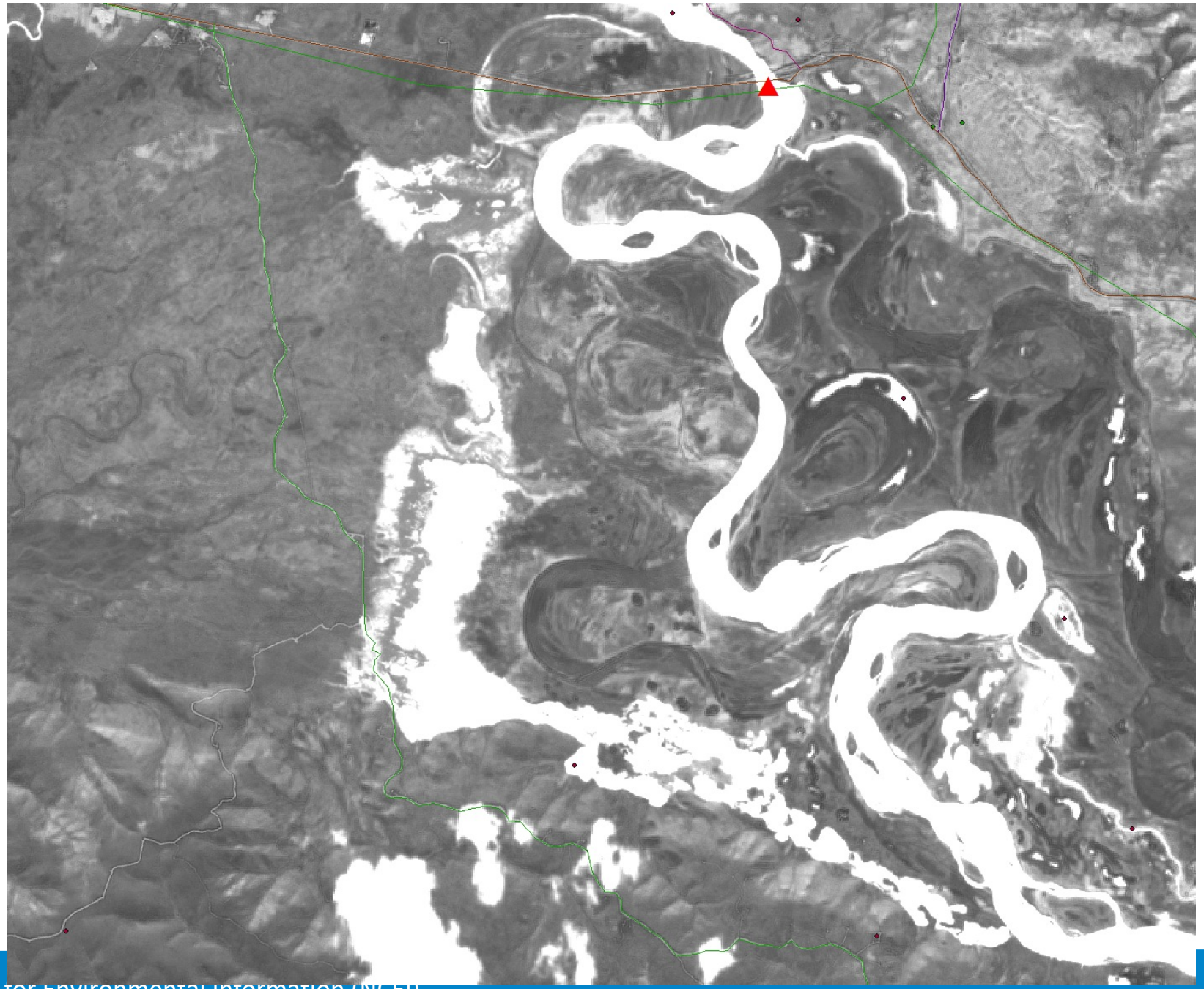
Civil Air Patrol Flight, August 5th looking south at the flooded portion of the road

Aug 5th SAR Imagery



Satellite imagery between Aug 3rd and Aug 5th shows similar flooding extents near the Tetlin Road with the area expanding to the North towards the Tanana River.

Peak flooding on Aug 7, 2017 SAR imagery, Processed by Lori Schultz, NASA SPoRT



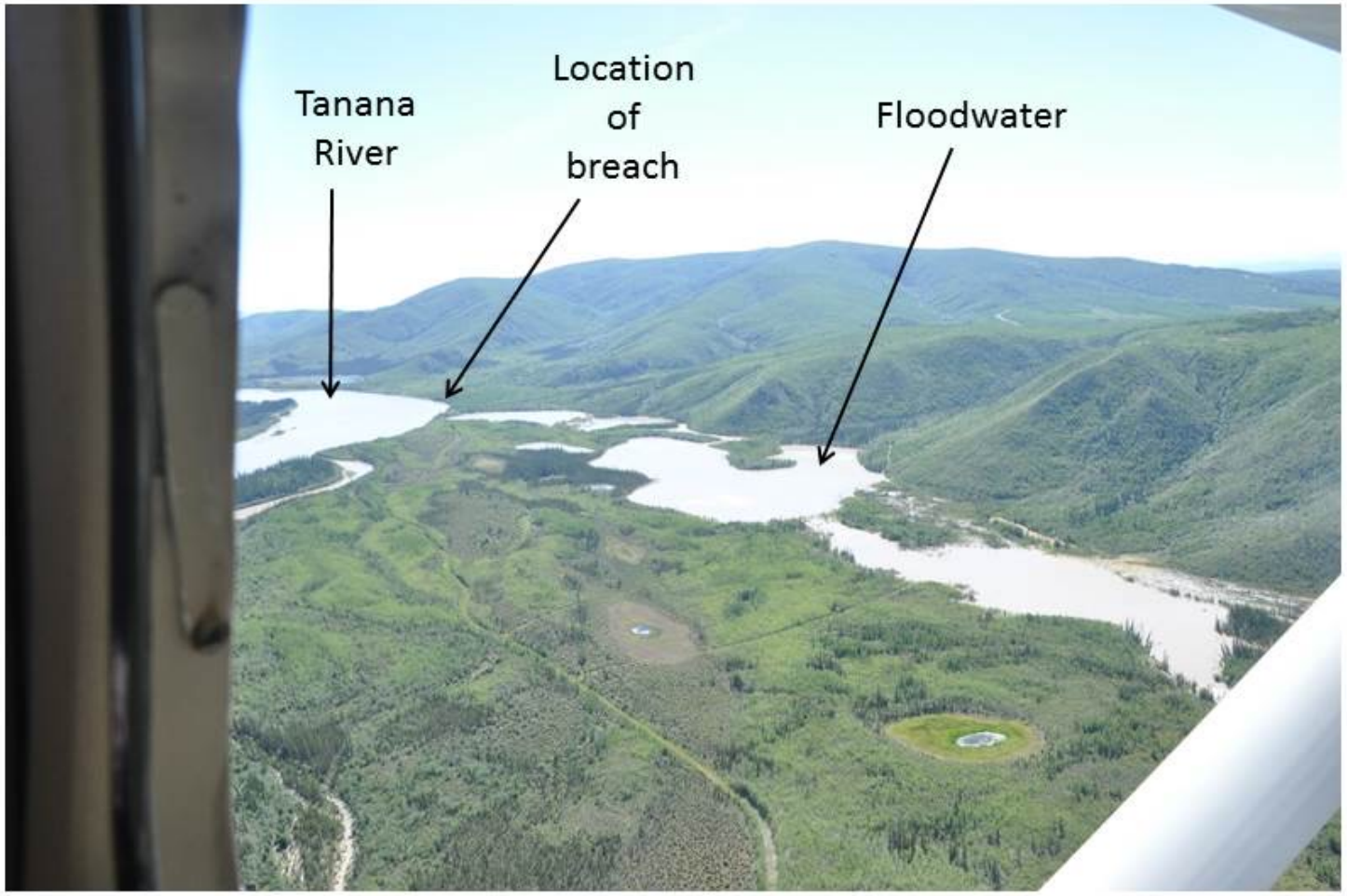
Peak flooding on Aug 7, 2017 SAR imagery, Processed by Lori Schultz, NASA SPoRT

Peak flooding on Aug 7, 2017 SAR imagery, Processed by Lori Schultz, NASA SPoRT


Road Inundation
DigitalGlobe/Google


DigitalGlobe/Google


DigitalGlobe/Google



CAP photo from 8/5/17 shows location where the Tanana overflowed its banks and created overland flooding. This confirms the water is hydrologically connected to the Tanana.

Photo credit: CAP

Photo credit: CAP

Photo credit:
Joe Young

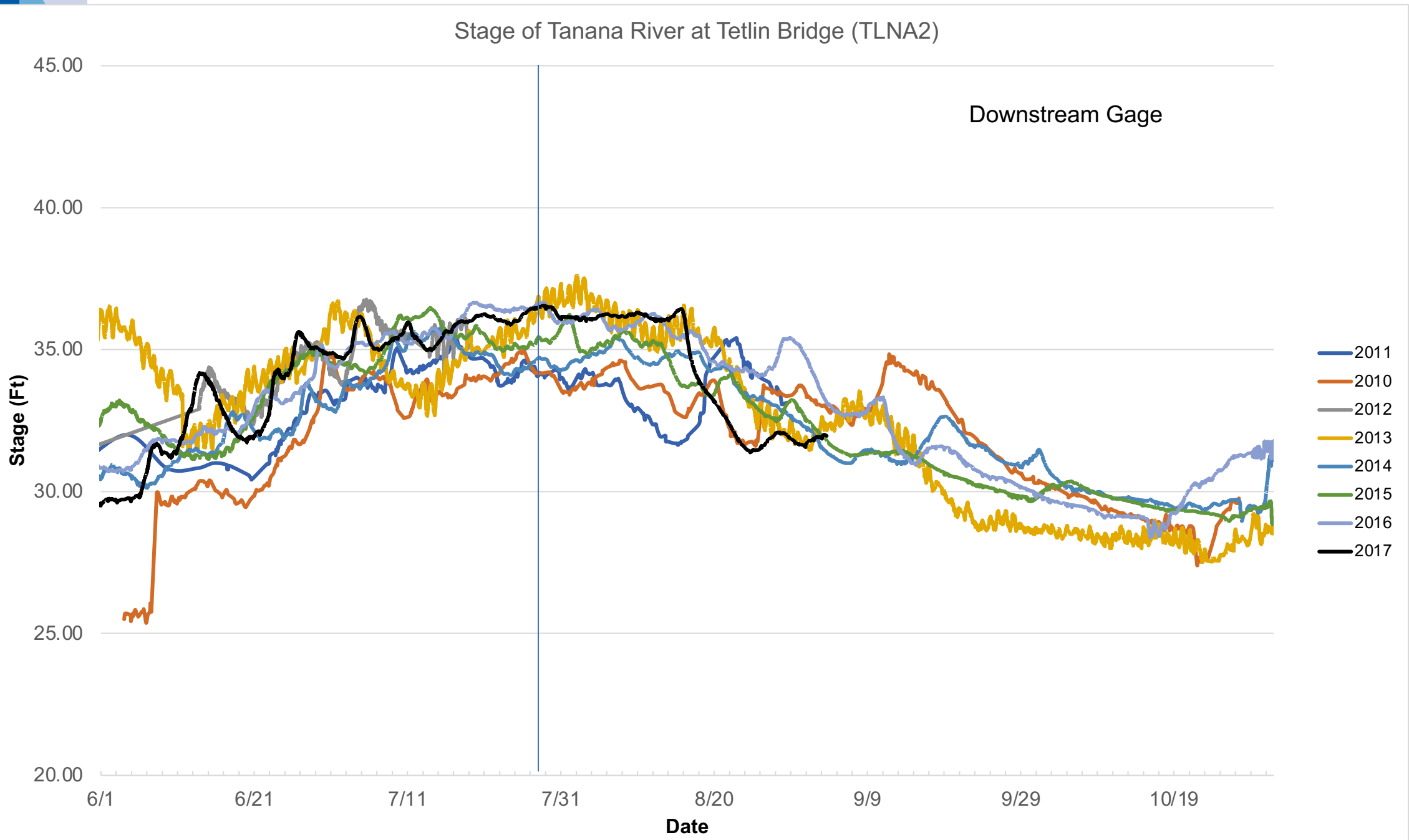
Timeline of events

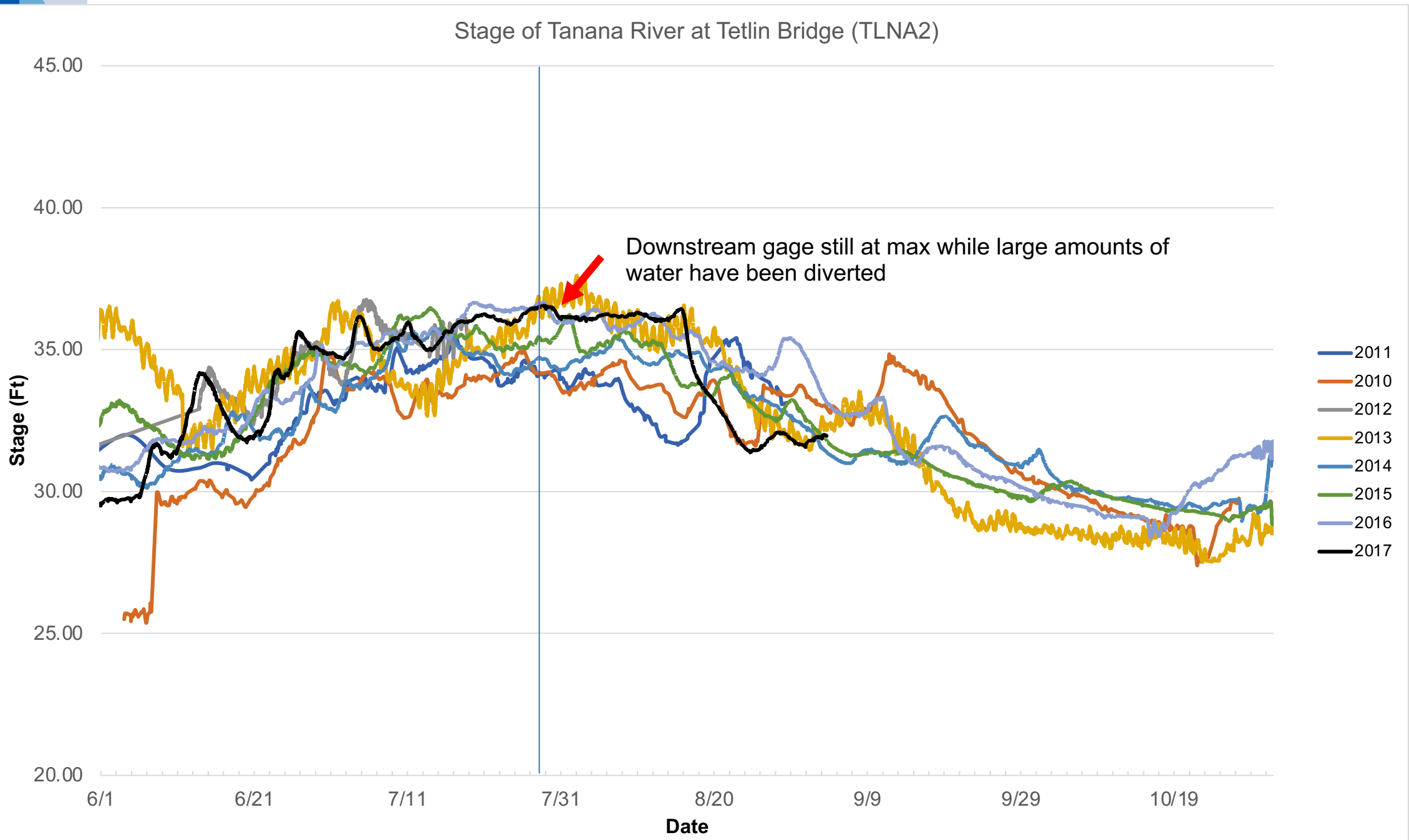
- July 12, 2017 Report from FNSB EM that Tanana River was high at Tanacross. Staff confirmed from photo that not yet bankfull, but culvert was full
- July 15, 2017 Beginning of ~a month of temps 5-10 deg F above normal at Northway and Port Alcan
- July 21, 2017 Upstream gauge water levels on Chisana (CRNA2) start dropping
- July 25, 2017 A period of heavy rain begins, lasting 4 days at Tok and 6 days at Port Alcan
- July 28, 2017 Upstream gauge water levels on Nabesna (NABA2) start dropping
- July 28, 2017 Area resident reports that the Tetlin road is flooded at ~ mile 5.3
- July 29, 2017 Tetlin road now closed now impassable
- July 31, 2017 Gauge downstream of Tanana breach (TLNA2) drops slightly but remains anomalously high until August 15
- August 1, 2017 First crest in water level according to observers at road
- August 4, 2017 Report that water level is up again
- August 8, 2017 Water at Tetlin Road continues to rise
- August 10, 2017 Water pooling along Alcan Hwy reported
- August 11-14, 2017 Local rain reported by observer
- August 14, 2017 Reports of water backed up along Northway Rd
- August 15, 2017 Air temperatures cool below normal and both upstream and downstream river gauges show sharp drop off in discharge
- August 15-18, 2017 Locals report water is starting to drop at Tetlin Road
- August 26, 2017 Observer reports original road still flooded but a bypass has been constructed
- August 28, 2017 Reports that water has significantly receded from roads

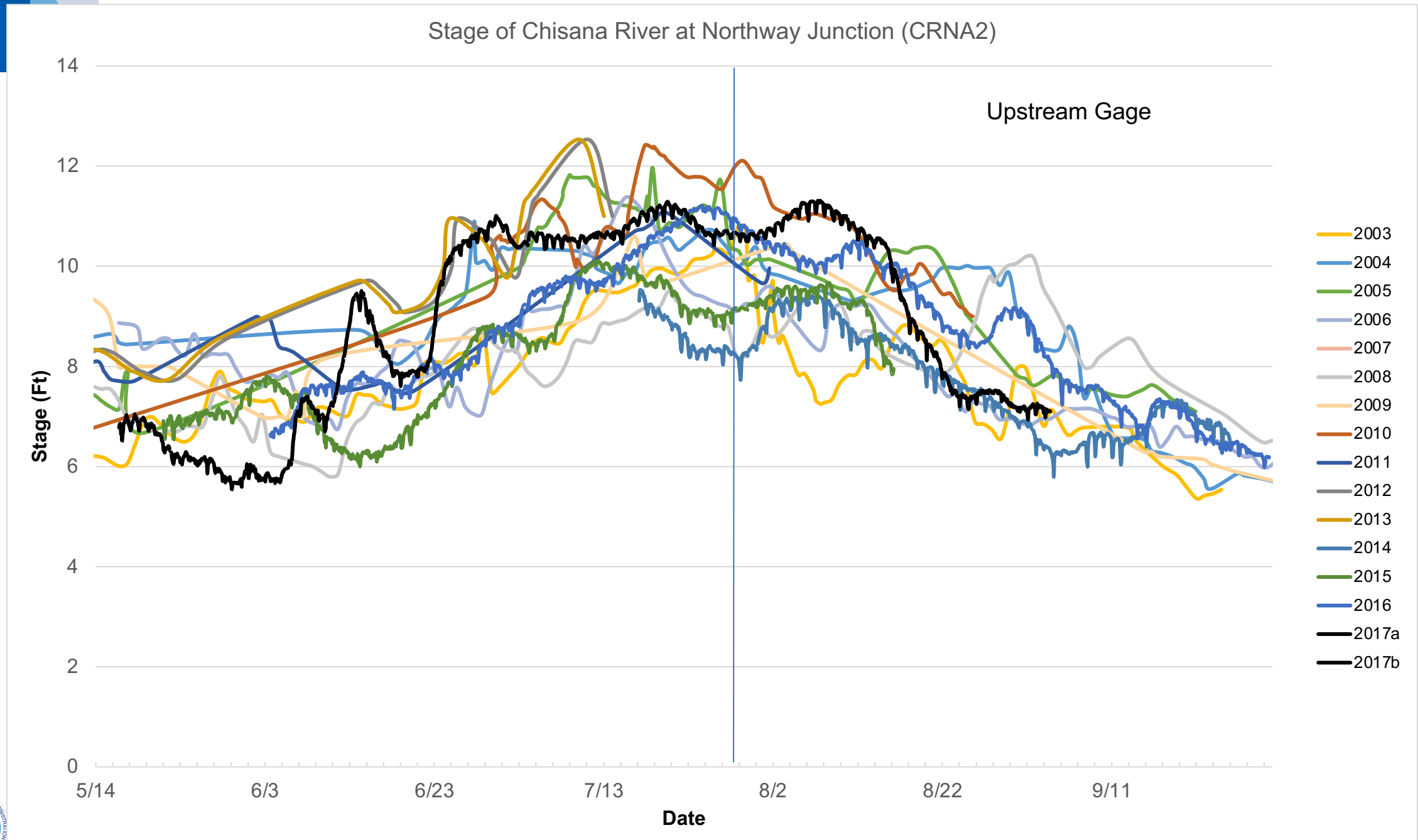
Gage Data

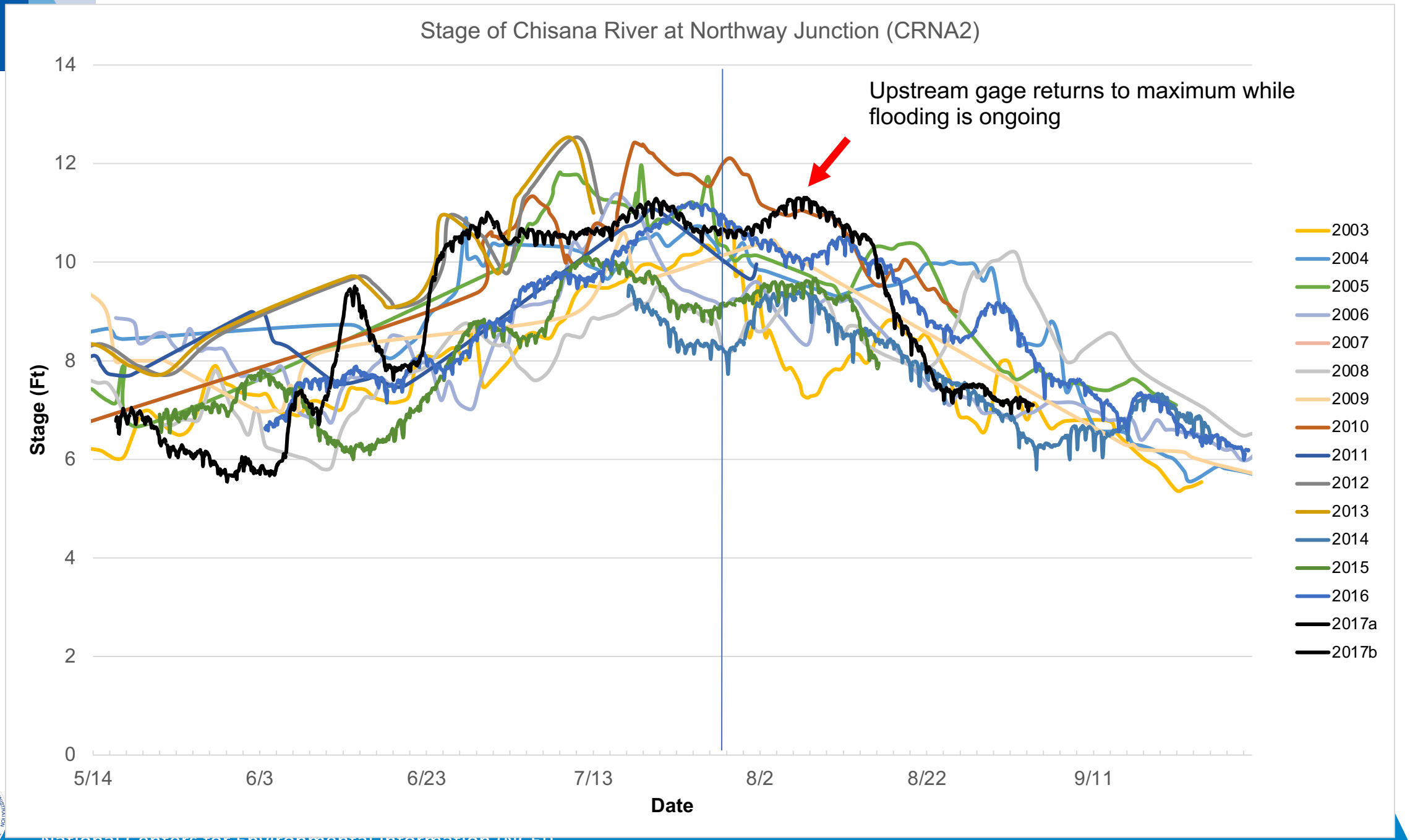
Imagery only: DigitalGlobe/Google

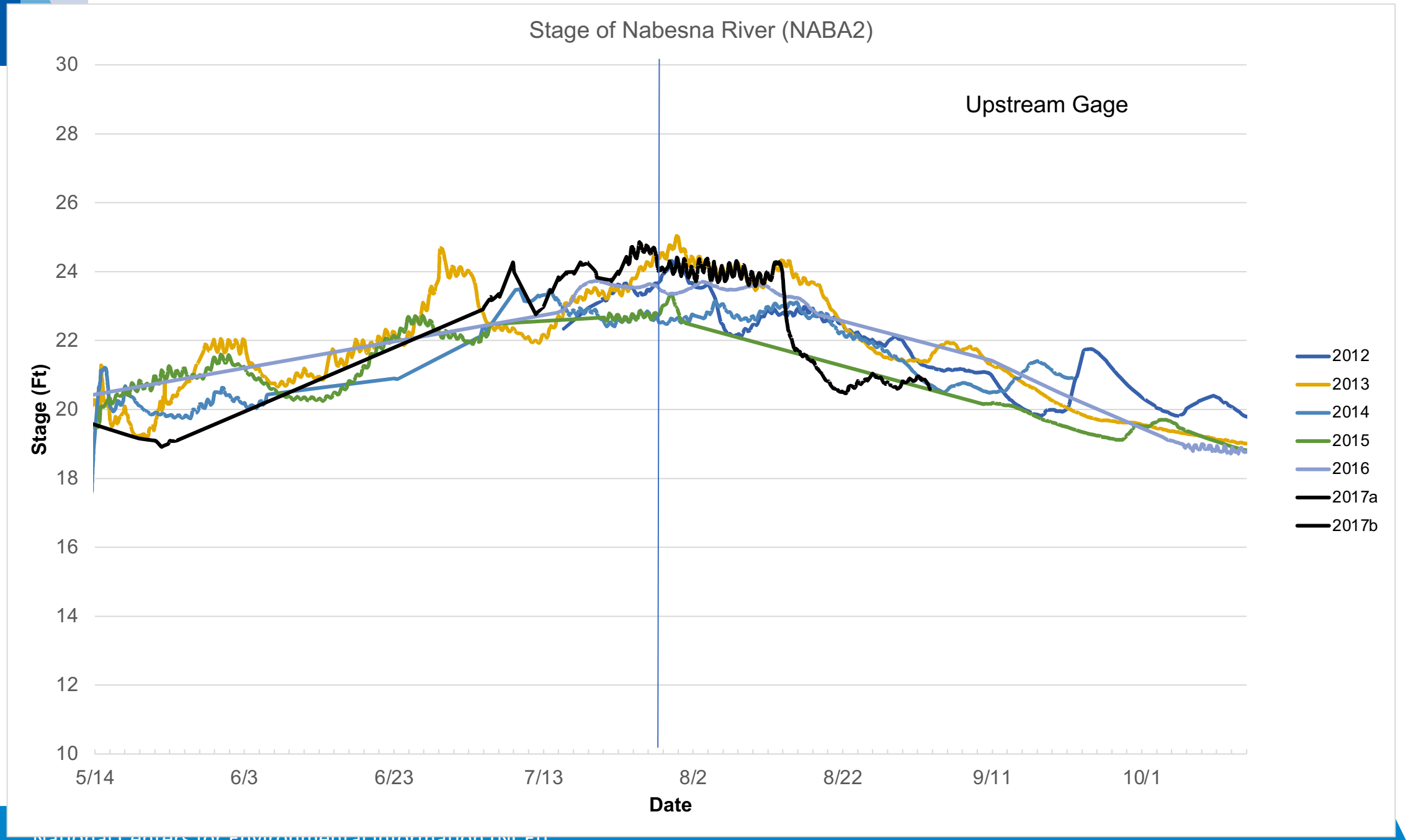
National Centers fo

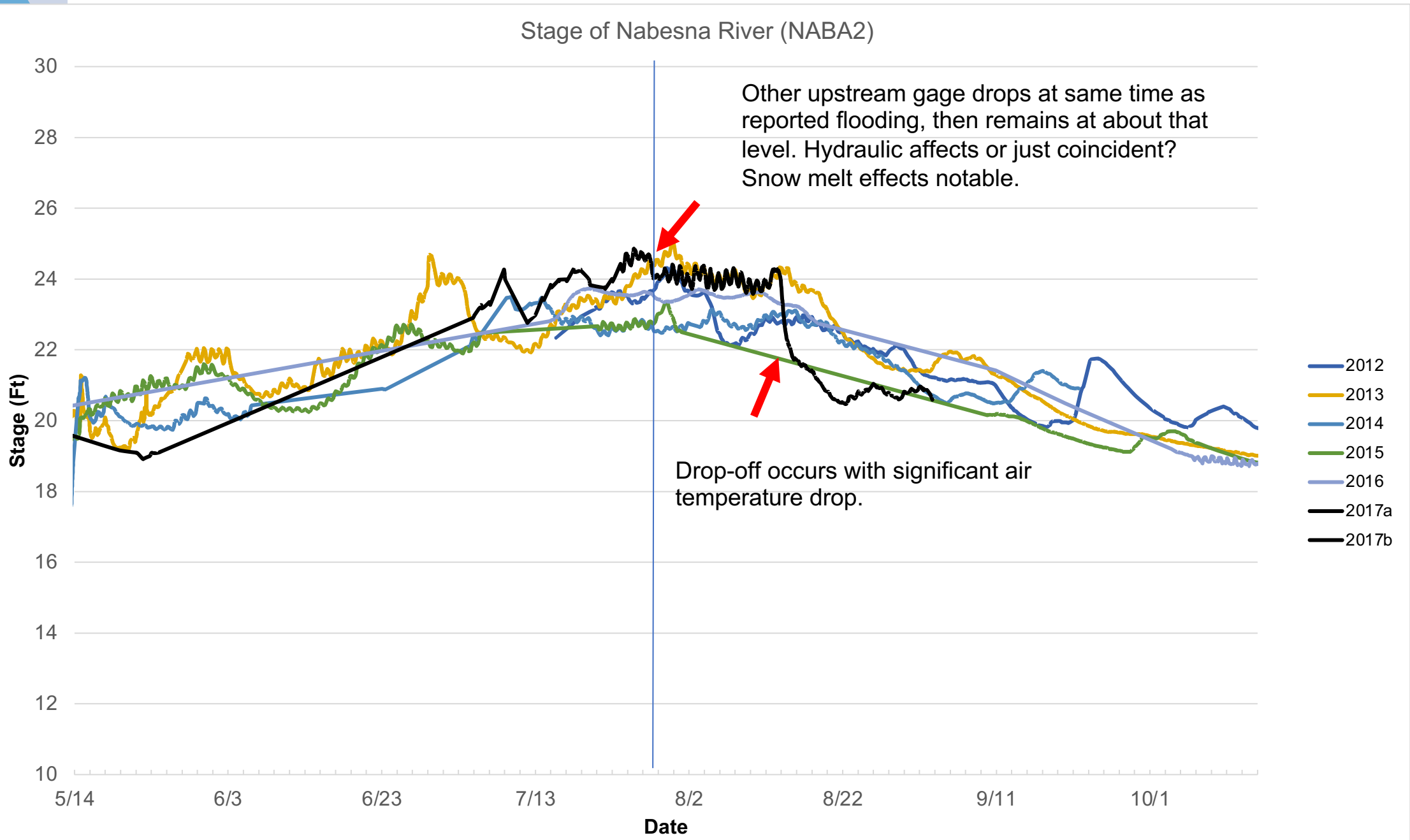

Stage of Tanana River at Tetlin Bridge (TLNA2)
Downstream Gage
45.00
40.00
35.00
30.00
25.00
20.00
Stage (Ft)
6/1
6/21
7/11
7/31
8/20
9/9
9/29
10/19
Date
2011
2010
2012
2013
2014
2015
2016
2017

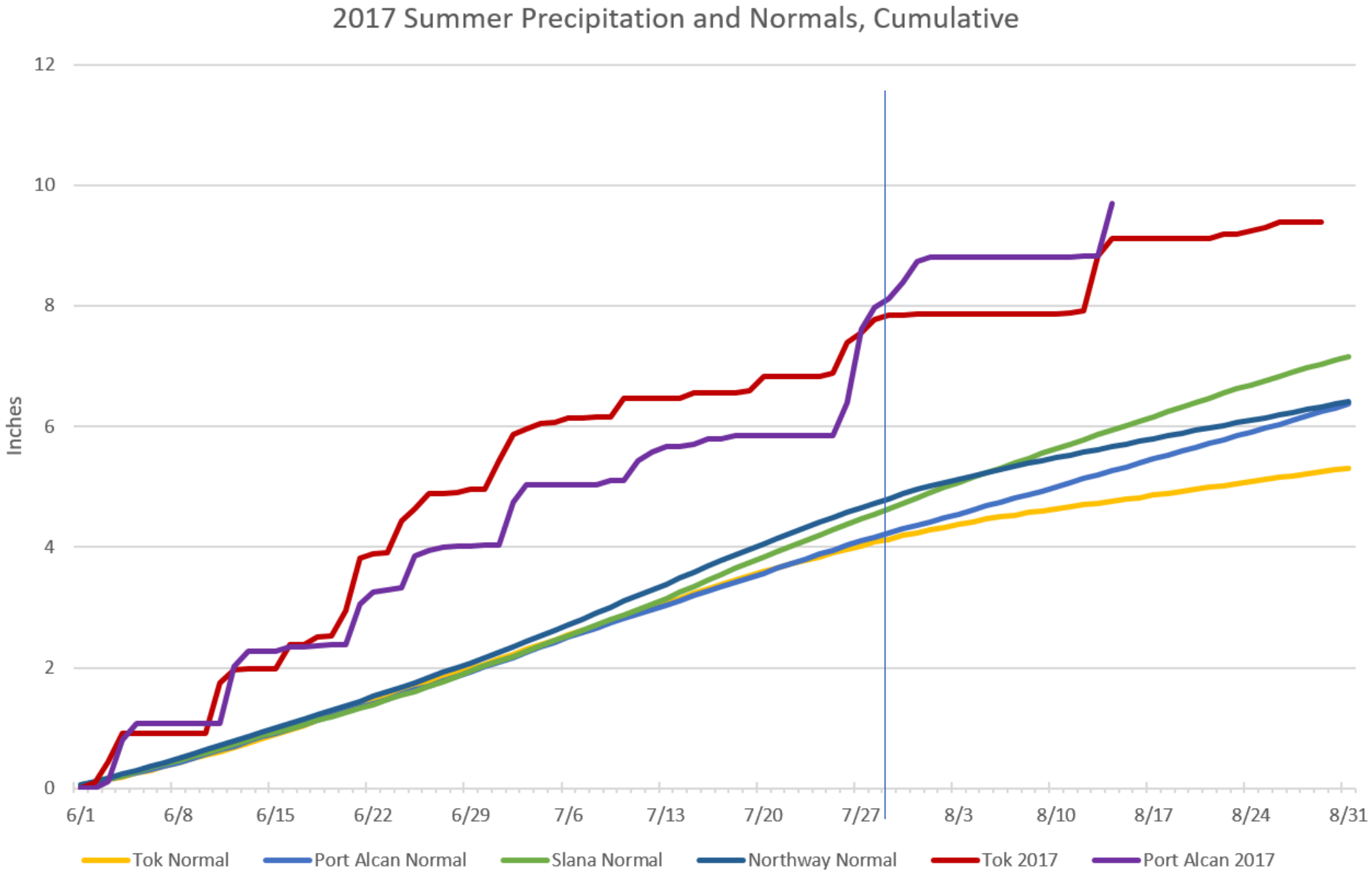

Stage of Tanana River at Tetlin Bridge (TLNA2)
45.00
40.00
35.00
30.00
25.00
20.00
Stage (Ft)
6/1
6/21
7/11
7/31
8/20
9/9
9/29
10/19
Date
Downstream gage still at max while large amounts of water have been diverted
2011
2010
2012
2013
2014
2015
2016
2017

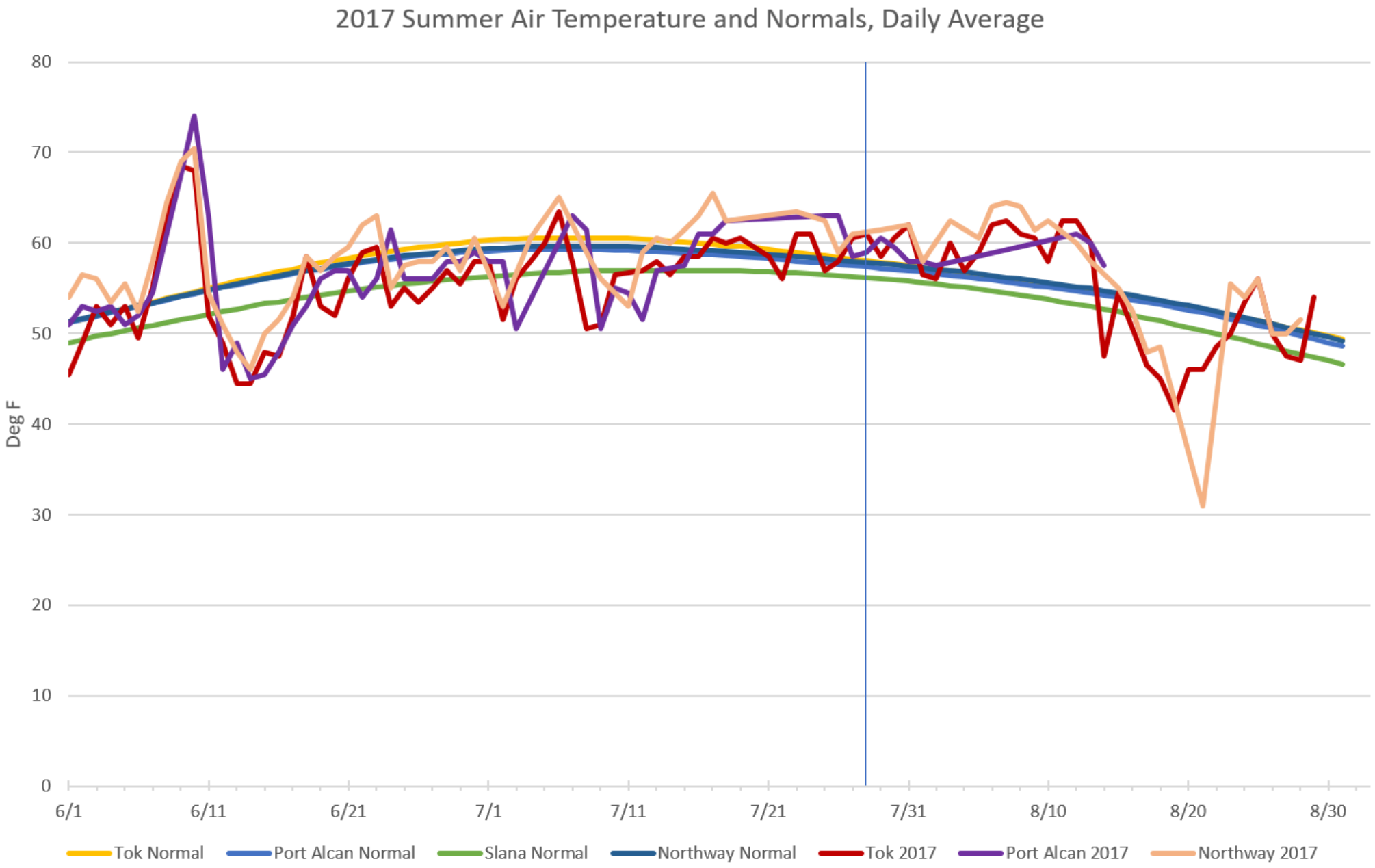

Stage of Chisana River at Northway Junction (CRNA2)
Upstream Gage
Stage (Ft)
14
12
10
8
6
4
2
0
5/14
6/3
6/23
7/13
8/2
8/22
9/11
Date
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017a
2017b


Stage of Chisana River at Northway Junction (CRNA2)
Upstream gage returns to maximum while flooding is ongoing
Stage (Ft)
14
12
10
8
6
4
2
0
5/14
6/3
6/23
7/13
8/2
8/22
9/11
Date
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017a
2017b


Stage of Nabesna River (NABA2)
Upstream Gage
Stage (Ft)
30
28
26
24
22
20
18
16
14
12
10
5/14
6/3
6/23
7/13
8/2
8/22
9/11
10/1
Date
2012
2013
2014
2015
2016
2017a
2017b


Stage of Nabesna River (NABA2)
Other upstream gage drops at same time as reported flooding, then remains at about that level. Hydraulic affects or just coincident? Snow melt effects notable.
Drop-off occurs with significant air temperature drop.
Stage (Ft)
30
28
26
24
22
20
18
16
14
12
10
5/14
6/3
6/23
7/13
8/2
8/22
9/11
10/1
Date
2012
2013
2014
2015
2016
2017a
2017b

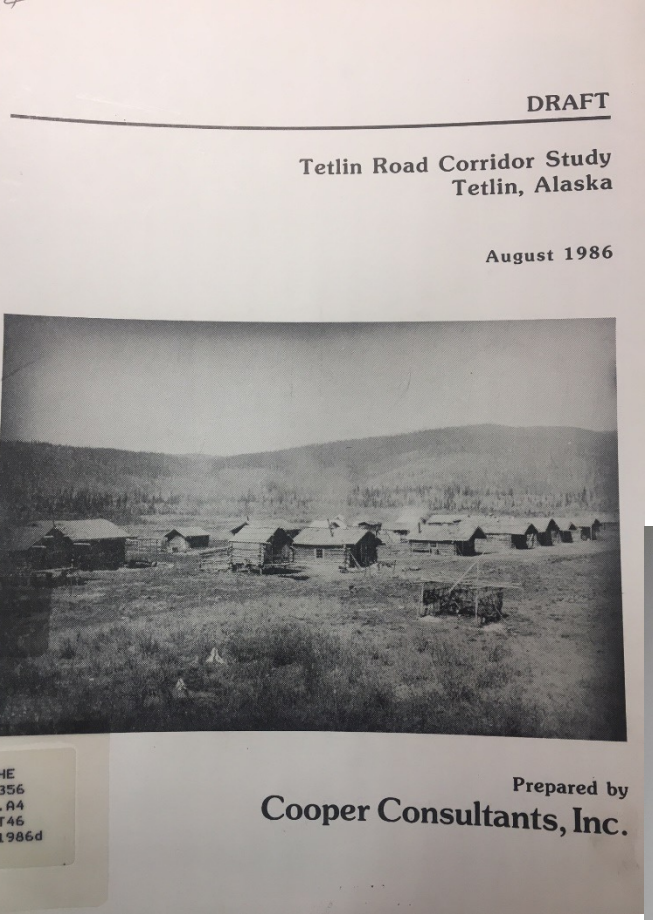

2017 Summer Precipitation and Normals, Cumulative
Inches
12
10
8
6
4
2
0
6/1
6/8
6/15
6/22
6/29
7/6
7/13
7/20
7/27
8/3
8/10
8/17
8/24
8/31
Tok Normal
Port Alcan Normal
Slana Normal
Northway Normal
Tok 2017
Port Alcan 2017


2017 Summer Air Temperature and Normals, Daily Average
Deg F
80
70
60
50
40
30
20
10
0
6/1
6/11
6/21
7/1
7/11
7/21
7/31
8/10
8/20
8/30
Tok Normal
Port Alcan Normal
Slana Normal
Northway Normal
Tok 2017
Port Alcan 2017
Northway 2017

Factors Contributing to Impacts

- The year-round road was built on top of a previous winter trail, not the route studied in the engineering design completed in 1986
- The winter trail was built with heavy machinery sometime between 1955 and 1974, based on photo analysis.
- The sections where the new road deviates from the old winter trail are near the area that flooded. The section that flooded is essentially along the 'engineered route' but the waters this year blew through the section indicated as wetland on the USGS map used at that time
- The landscape is (at best) a low-lying wetland with continuous and discontinuous permafrost and (at worst) an active flood plain
- There are many relic roads and trails in the area which may channel and convey water. There may be new roads since the mine was developed recently.
- Changing permafrost distributions and subsurface water connectivity and storage may also be a factor. Large-scale subsidence is likely.
- Road is not maintained by the AKDOT&PF

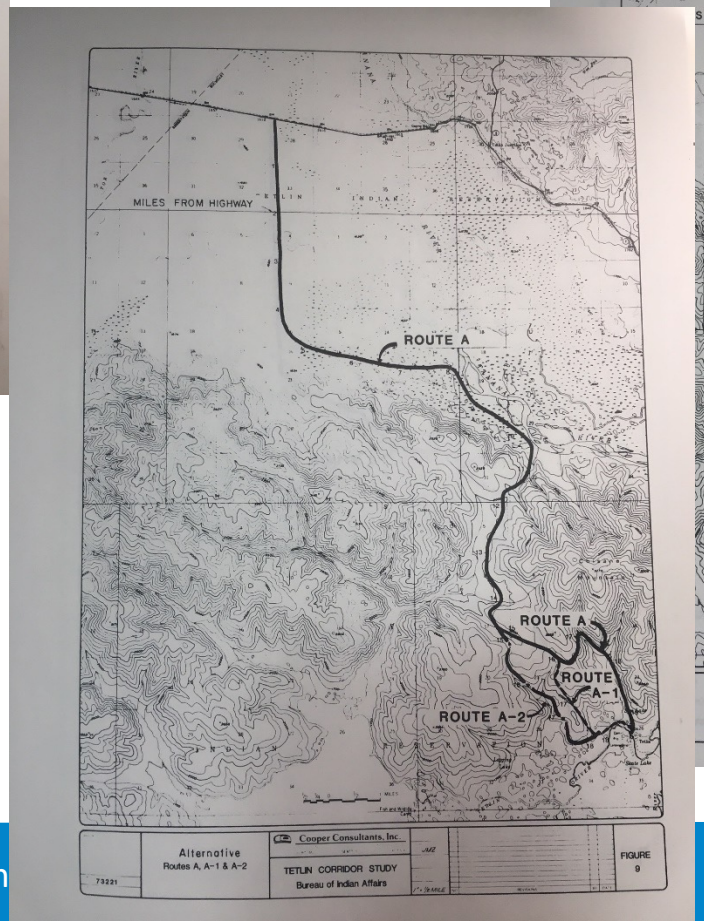
1986 Road Engineering Study

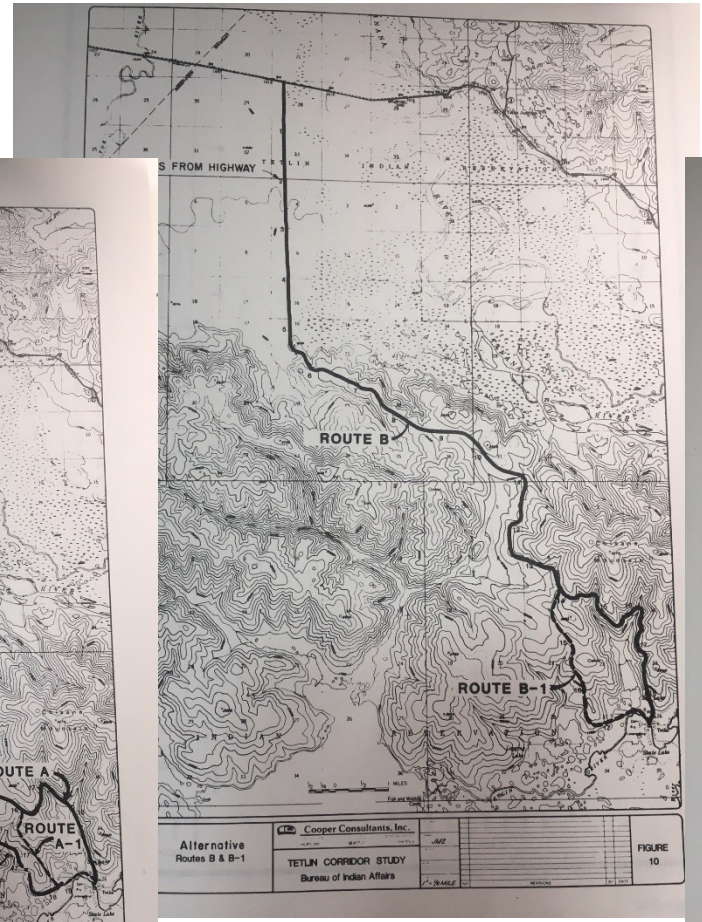

DRAFT

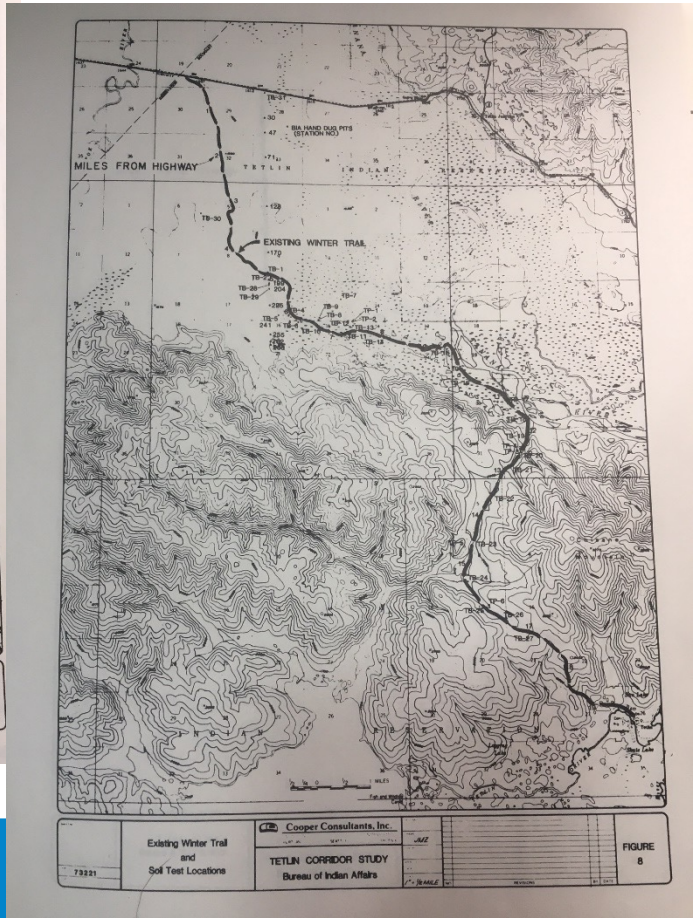
Tetlin Road Corridor Study
Tetlin, Alaska

August 1986

Prepared by
Cooper Consultants, Inc.



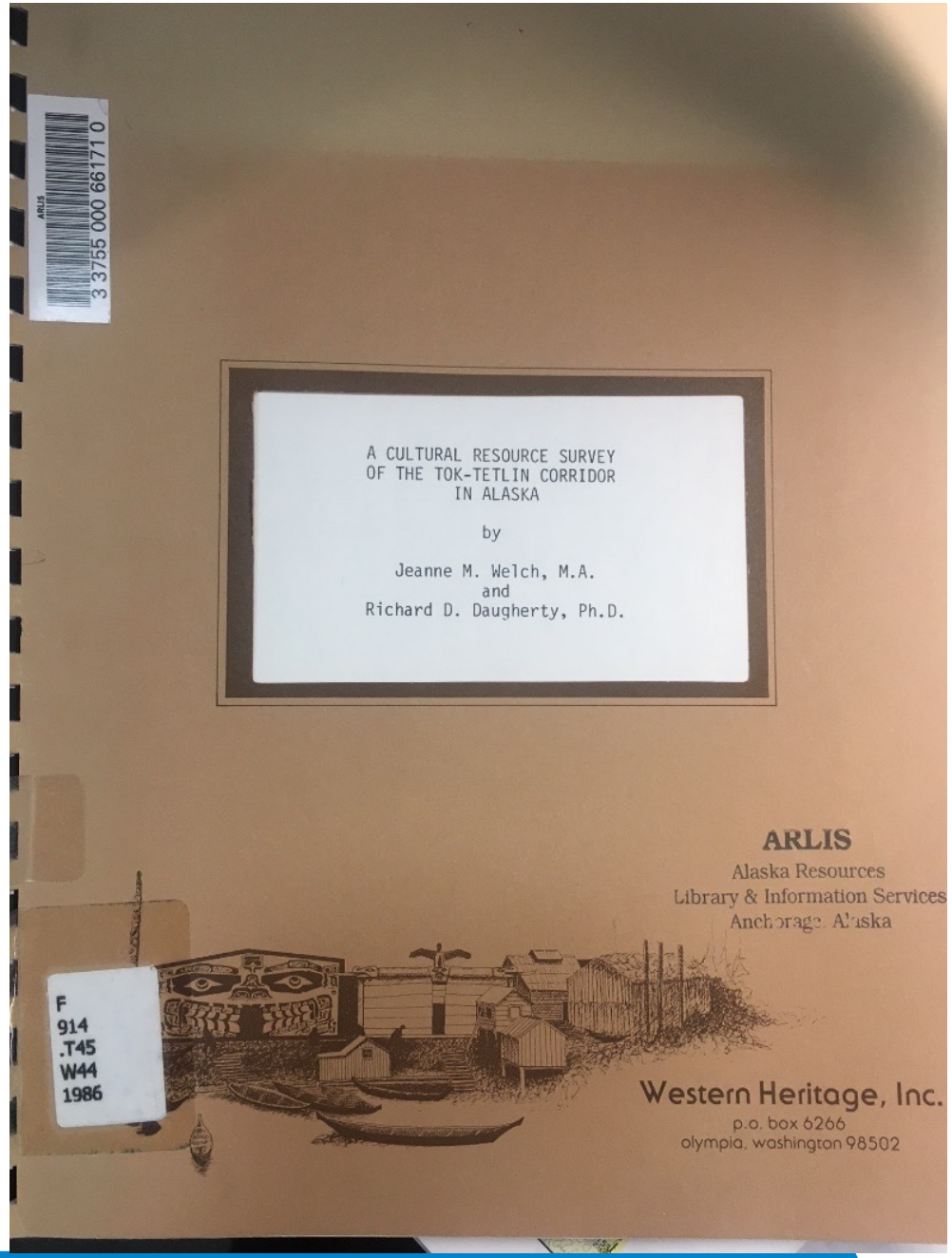


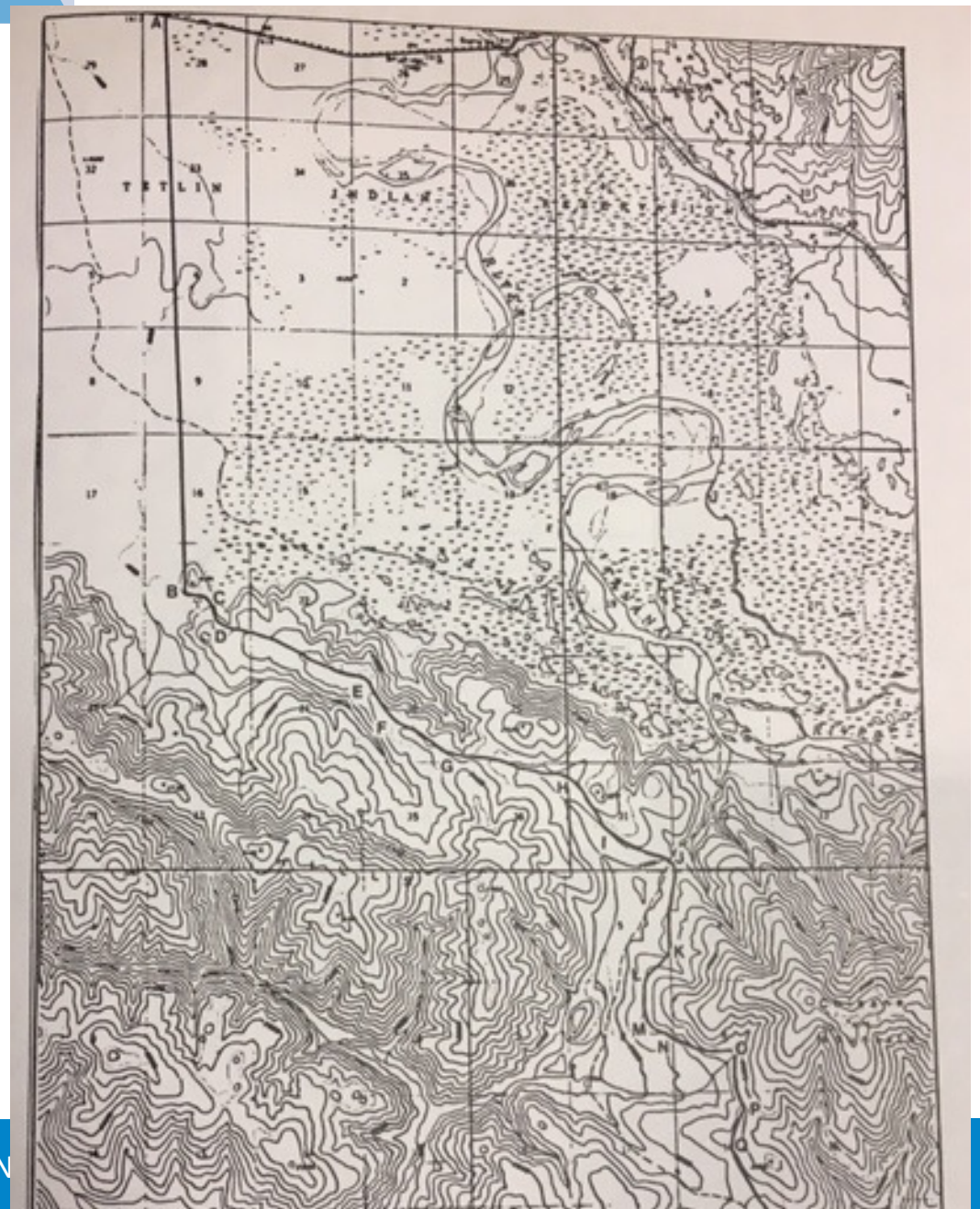


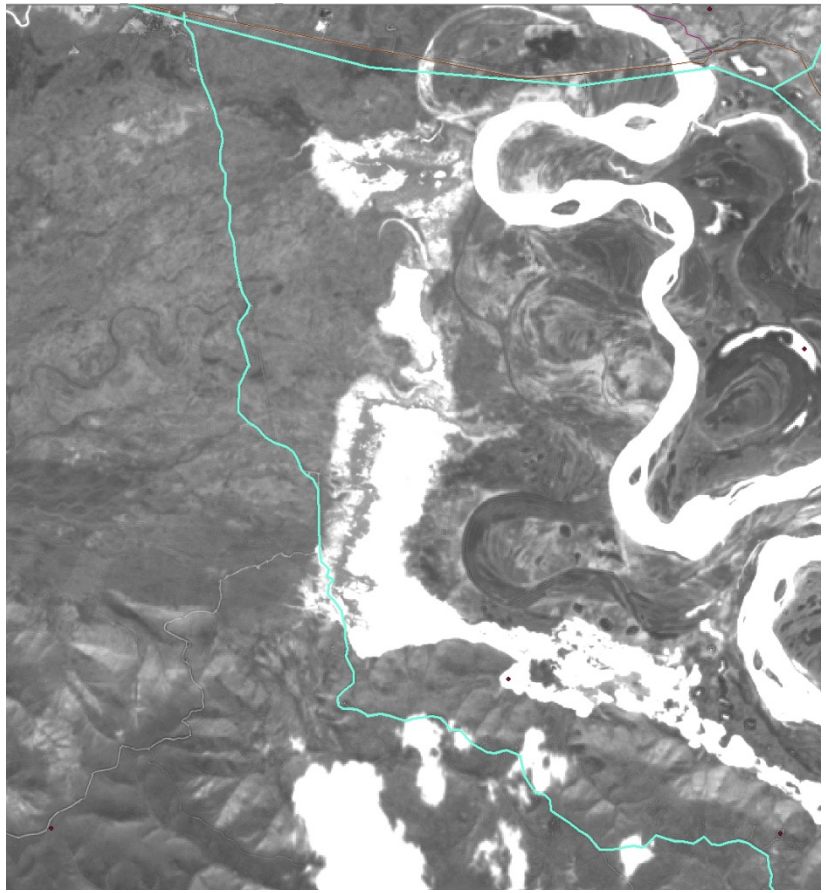
1986 Road Archaeology Study

Used USGS maps from 1950s

May have had less data on surficial geology/land cover

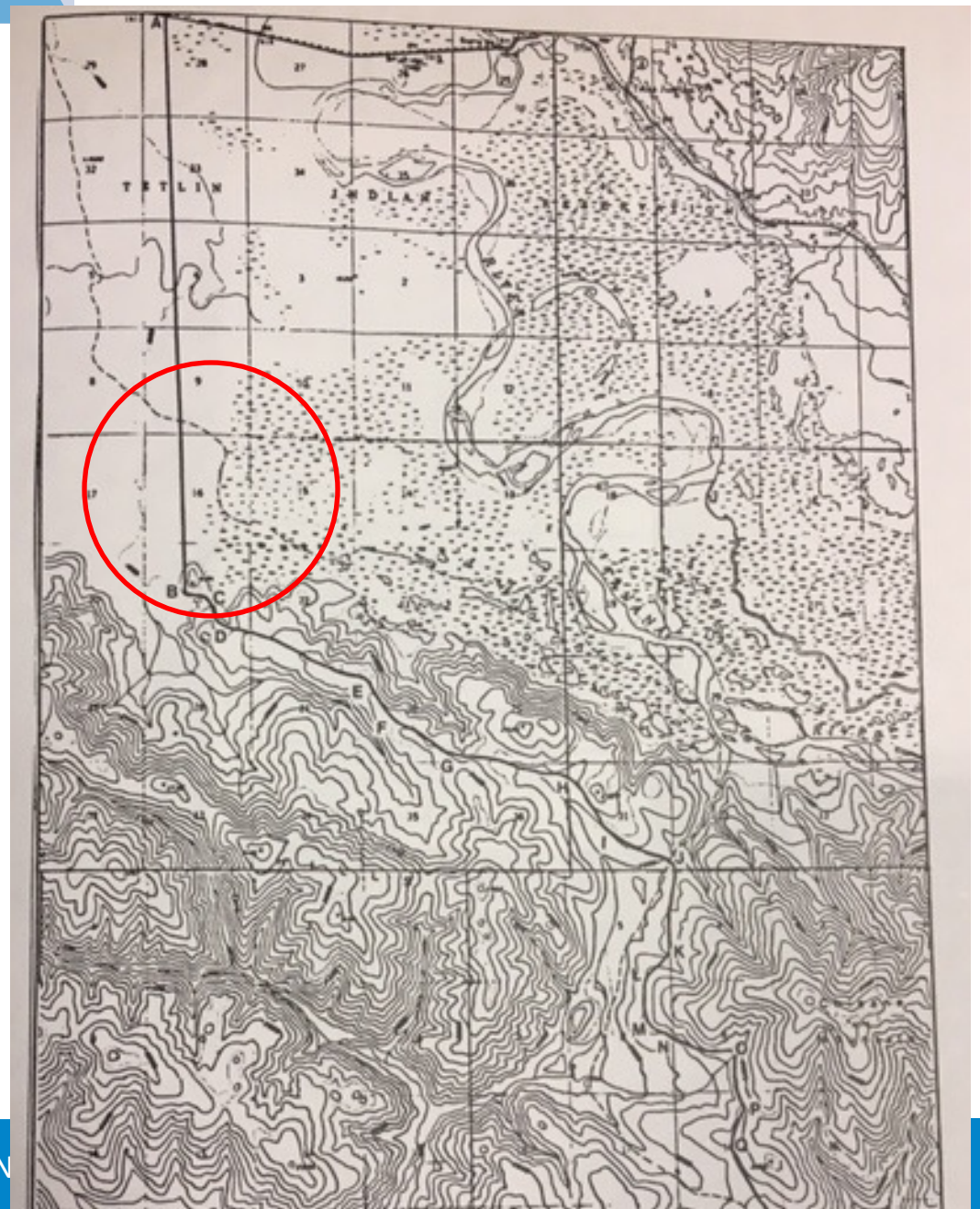


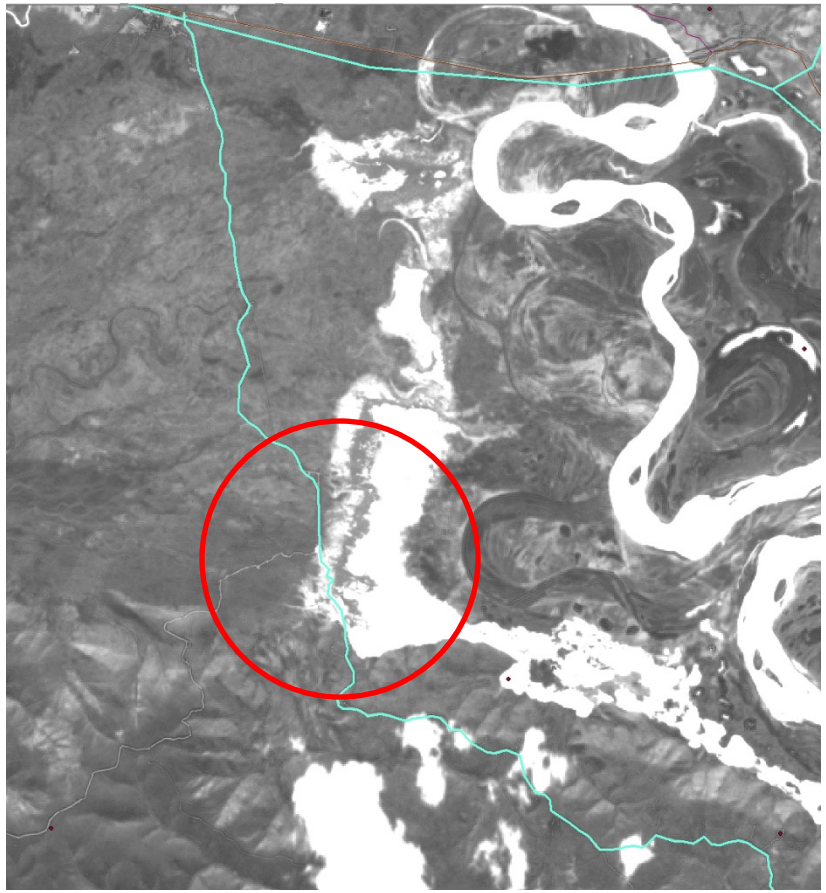




SAR

Welch and Daugherty, 1986





SAR

Welch and Daugherty, 1986

When will it happen again?

When will it happen again?

Probably Frequently now that River Bank Eroded and channel is migrating

Comments from observer from Tetlin area residents when we asked how often this happens

- Billy and Anita Sam: this happened 2 years ago
- Lydia David: Been over 5 years also didn't get this high. This is the highest it's ever been
- Paul Kelley: I talked to a fellow who is older and he estimated about once every ten years...he thought that maybe Tok would also flood like we did a few years ago...
- Katy Turk: The Tetlin Road really hasn't been there very long, maybe around 10 years or less. It's been mostly a winter-only trail until recently, with improvements to it every year. It has always been a problematic area, very low boggy permafrost ground. But yes, I think this is the first time I remember that it has actually flooded from the Tanana River.

  The road was only closed for a very short time by the State Troopers, the residents of Tetlin objected strongly to that, as it is their only way in and out, and the road belongs to the Tetlin Village, it's a private road. It remains open, with only a few risking the drive. I believe one man on the 'outside' is getting his daughter in the village to tie a small boat on the Tetlin side, so anyone who needs to get out can use the boat to get to the other side, where there are a few vehicles parked. That's where I was when I took the photos.

Possible Historic Events

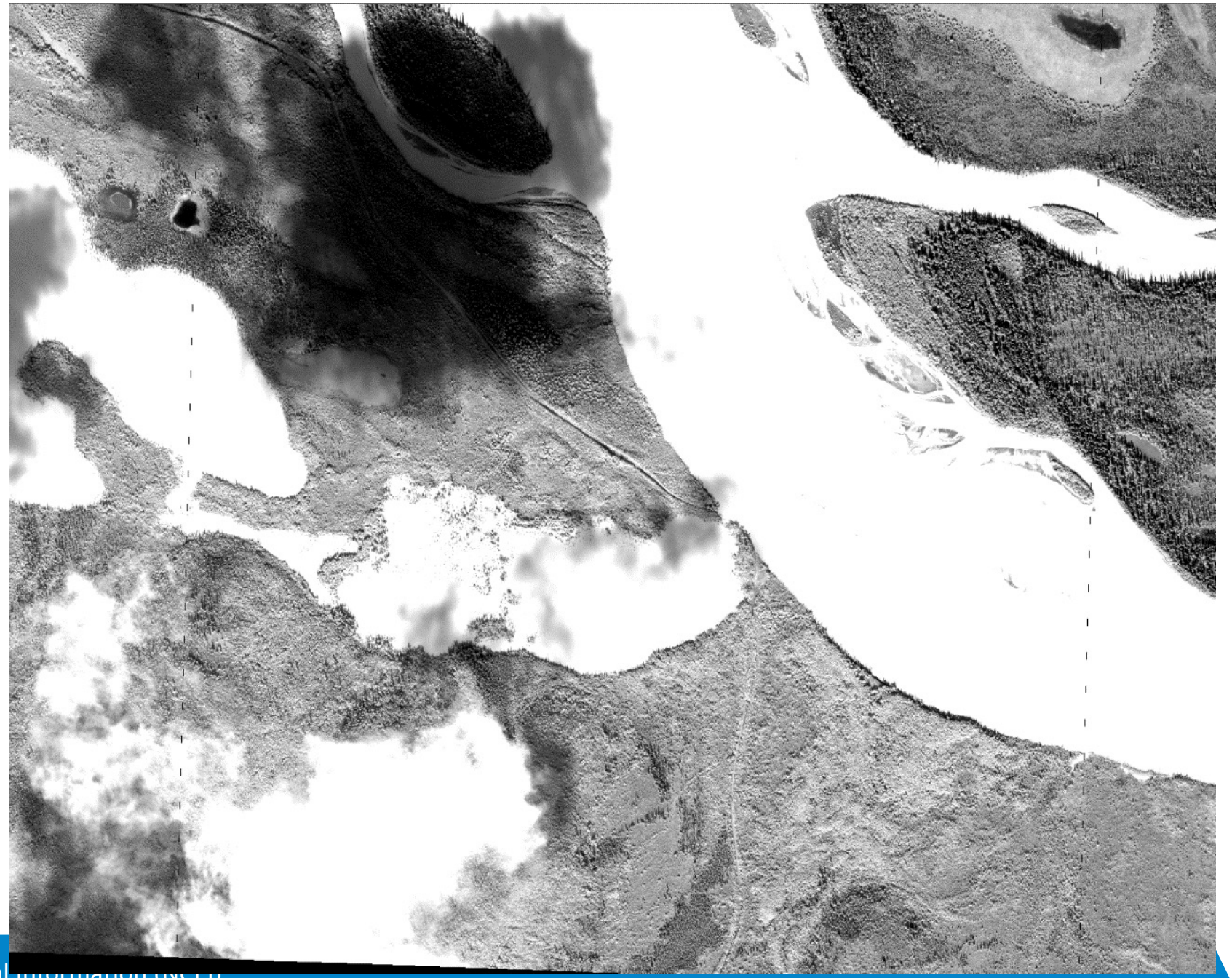
- Though some current residents remember this happening relatively frequently, there was initial confusion in 2017 over the source of the water, suggesting that flood waters of the recent past may not have come from the Tanana River via this particular mechanism. The Tok river more routinely floods nearby; it caused impacts in Tok in early June, 2013.
- Oral history from Cora David's mother Lucy Adams indicates a very large flood in the vicinity of Last Tetlin sometime between about 1902 and 1910 around Christmas. The location and likely cause of this flood are different from 2017. If memories are accurate, water probably came from the Nabesna or Tetlin rivers and the mechanism may have been rain on snow, a Jökulhlaup, melting from a volcanic eruption, or ice jam. Mt. Wrangell erupted throughout 2011.
- Northway was moved across the Nabesna River and renamed in about 1942 and one of the reasons cited by some elders was flooding at the old site around 1940.

Historic Aerial Imagery Available for the Area

- **Sept 14, 1948**
- **June 18, 1955**
- **June 15, 1974**
- **July 9, 1978**
- **Aug 28, 1978**

Tanana Breach in 2017

Worldview 3 Imagery, Aug 12



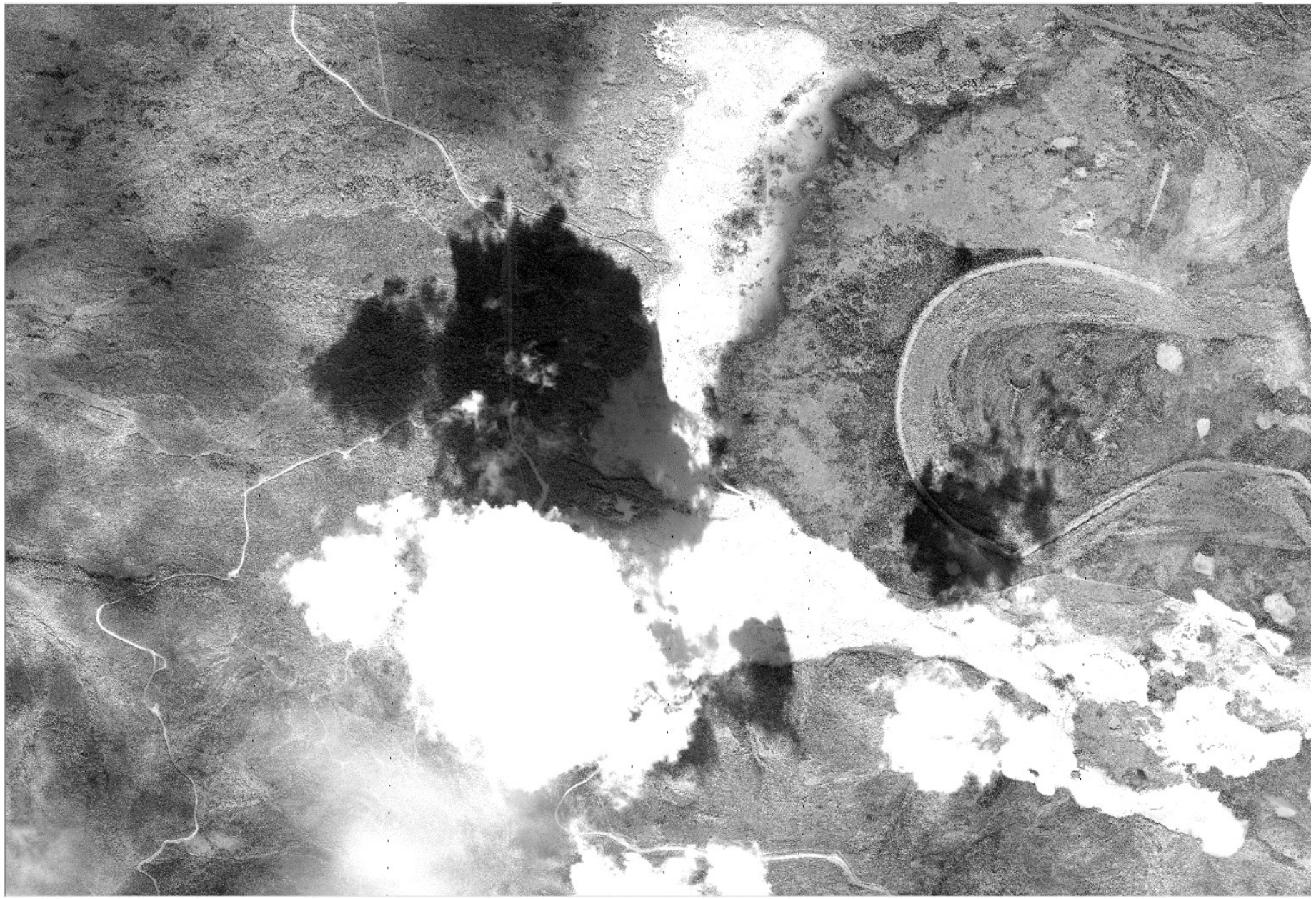
Imagery provided by Digital Globe to the USGS and governmental partners to help in disaster response. Commercial usage prohibited.

Tanana Breach in 1948

DOD Aerial Imagery, Sept 14

Flood Plain in 2017

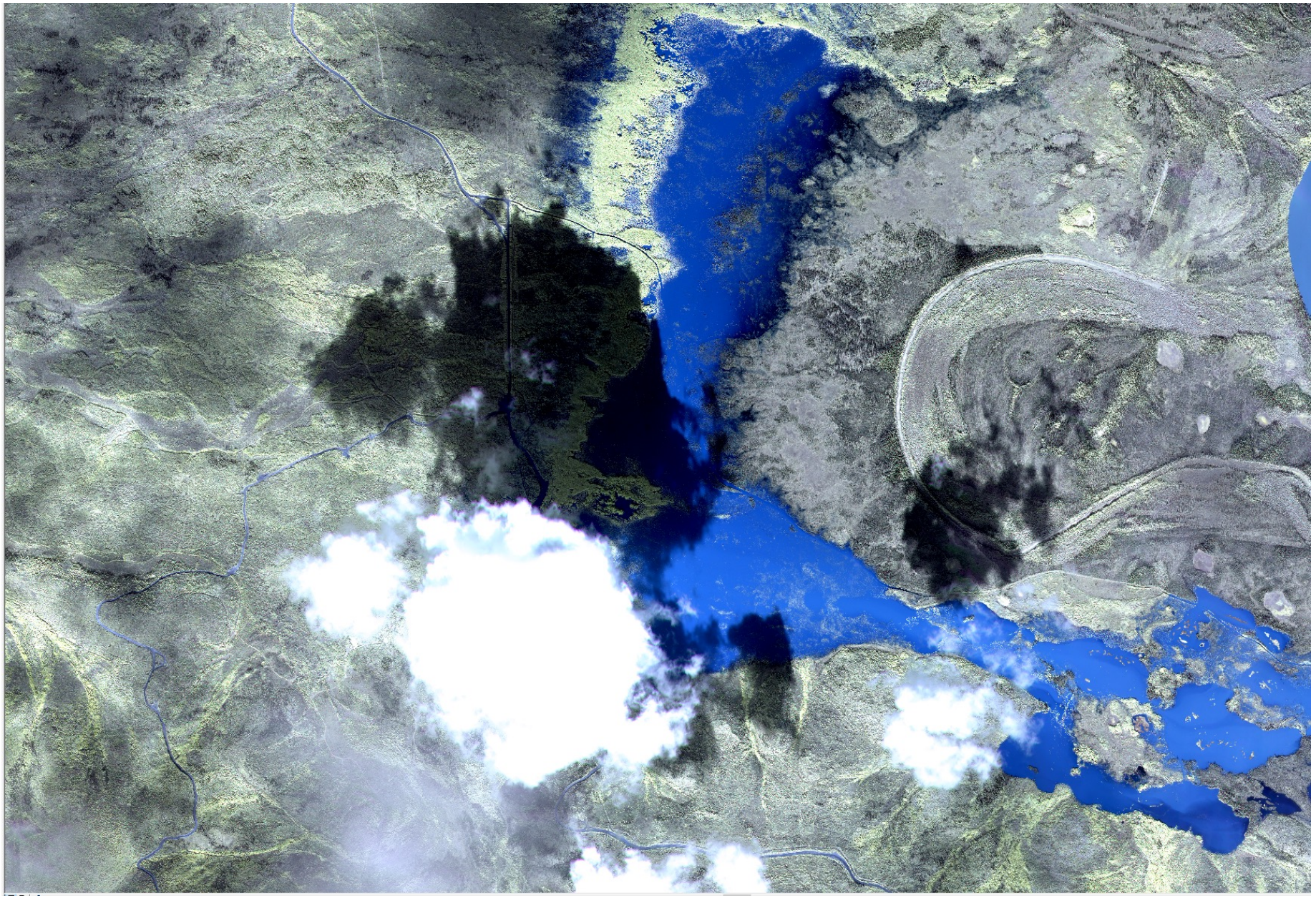
Worldview 3 Imagery, Aug 12



Imagery provided by Digital Globe to the USGS and governmental partners to help in disaster response. Commercial usage prohibited.

Flood Plain in 2017

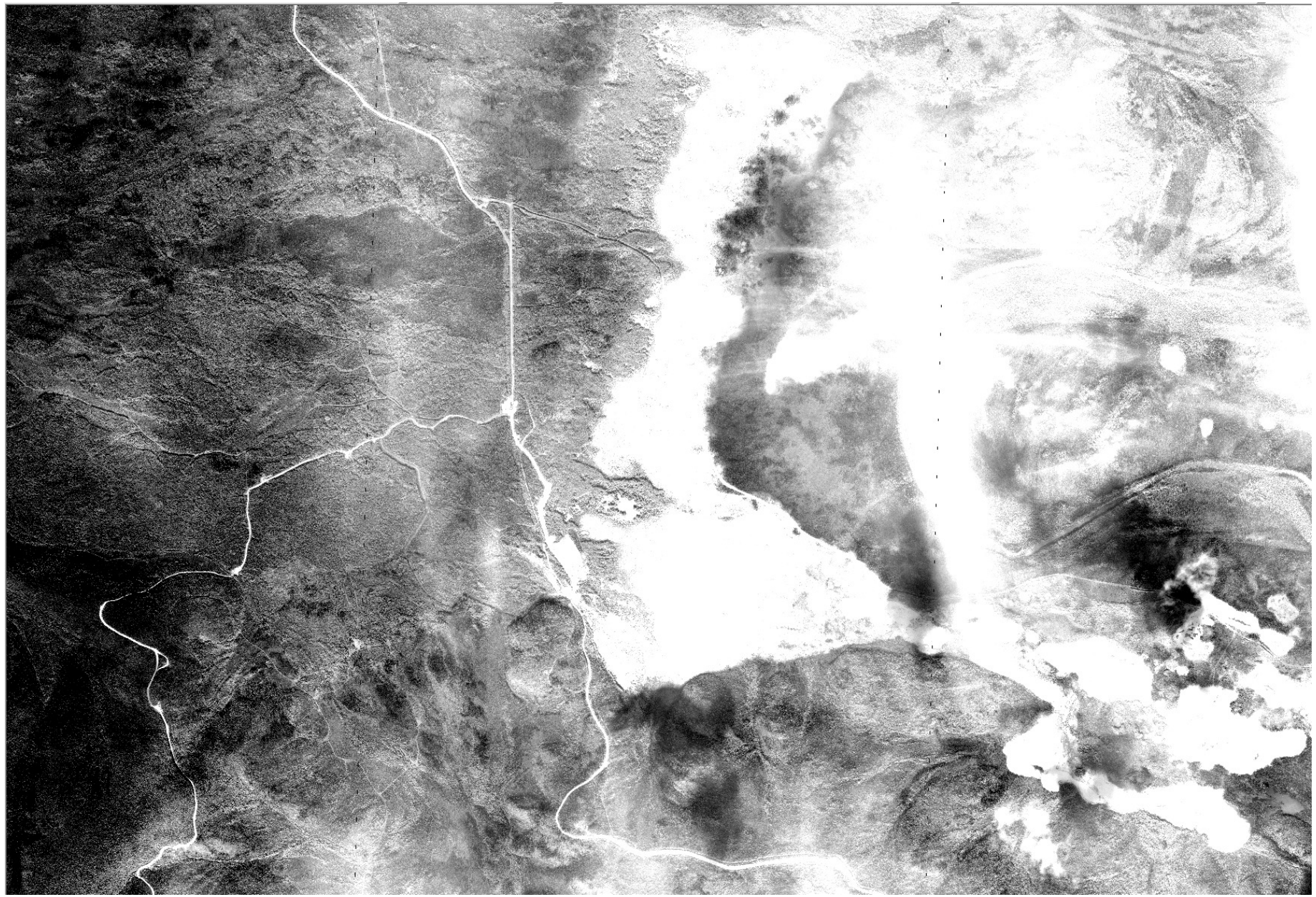
Worldview 3 Imagery, Aug 12



Imagery provided by Digital Globe to the USGS and governmental partners to help in disaster response. Commercial usage prohibited.

Flood Plain in 2017

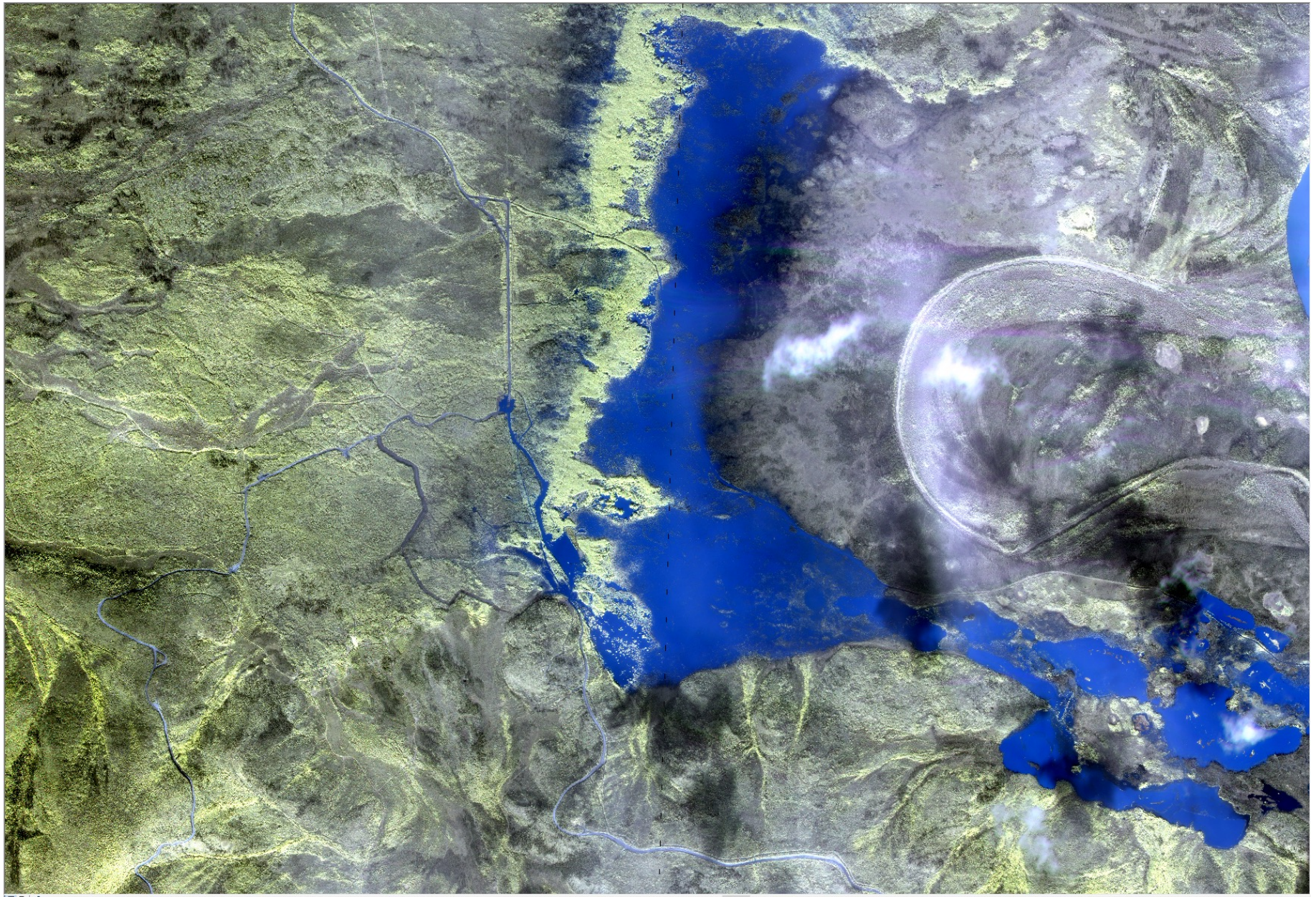
Worldview 3 Imagery, Aug 18



Imagery provided by Digital Globe to the USGS and governmental partners to help in disaster response. Commercial usage prohibited.

Flood Plain in 2017

Worldview 3 Imagery, Aug 18



Imagery provided by Digital Globe to the USGS and governmental partners to help in disaster response. Commercial usage prohibited.

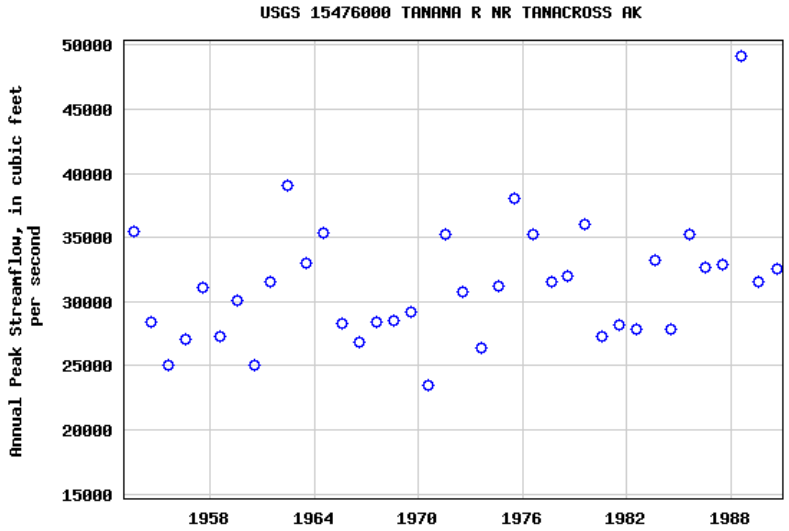
Flood Plain in 1978

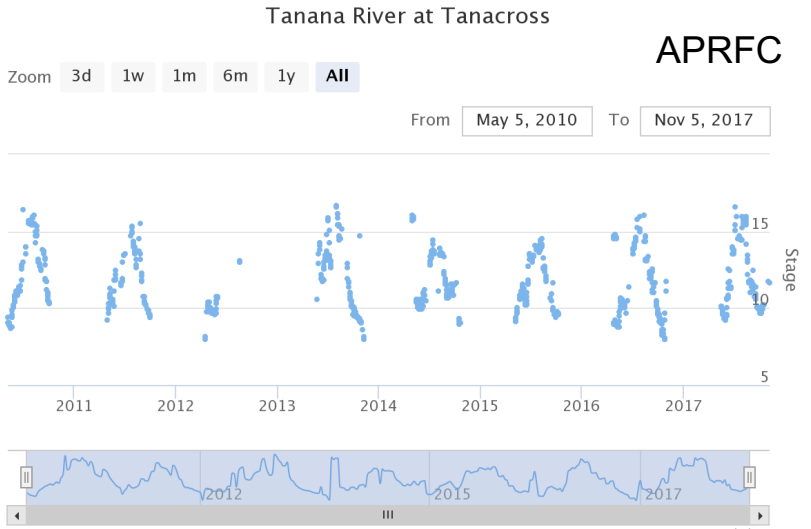
AHAP Imagery, Aug 28

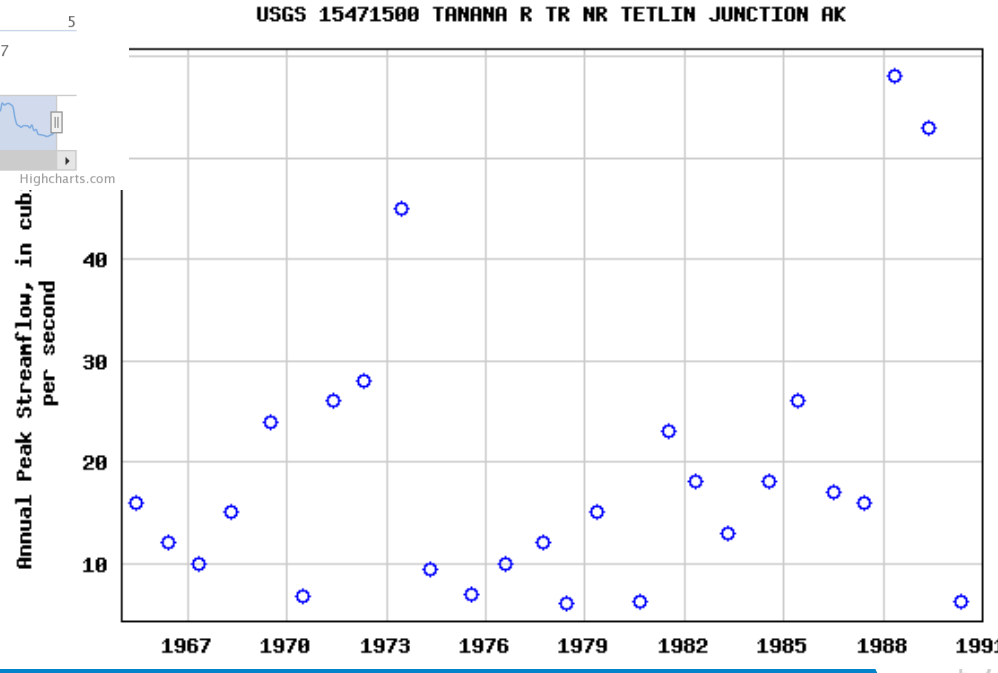
Flood Plain in 1955

DOD Imagery, Jun 18

Limited Gage Data Overlap w/Imagery:
1955 (dry), 1974 (dry to avg), 1978 (dry to avg), 2017 (avg to wet)







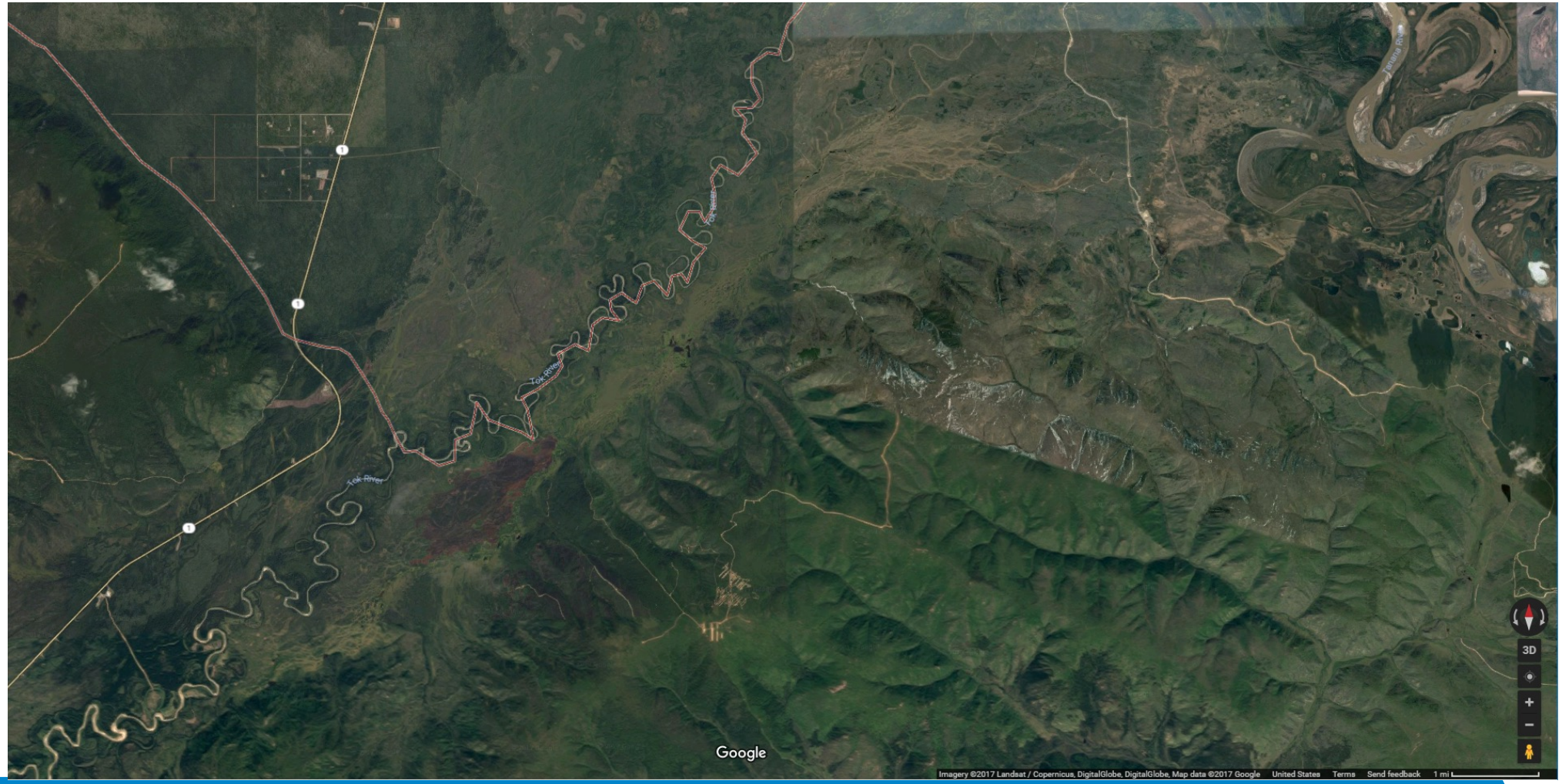
Historic to Geologic Timelines

- Vegetation imagery alone suggests there's an ample supply of water at the western edge of the flood plain near the Tetlin/Avalon Road junction. But the 2017 flood blew past this line of vegetation. Causes for ample water along this line could be: a topographic low point with pooling of rainwater, remnant surface water from past flooding, groundwater surfacing and/or a change in soils.


DigitalGlobe/Google

Other Agents of Change on Historic to Geologic Time

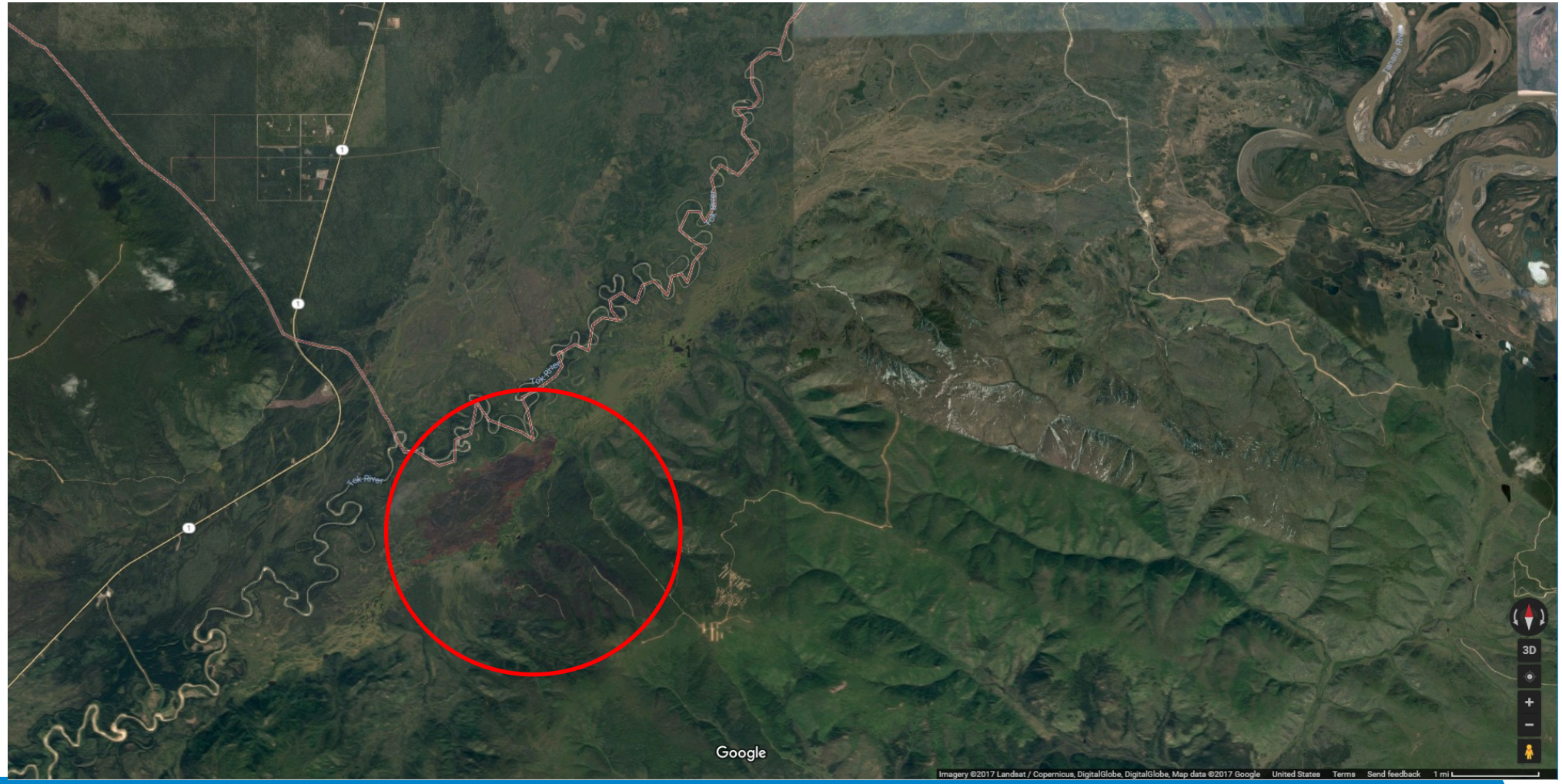
- Fire



DigitalGlobe/Google

Other Agents of Change on Historic to Geologic Time

- Fire



DigitalGlobe/Google

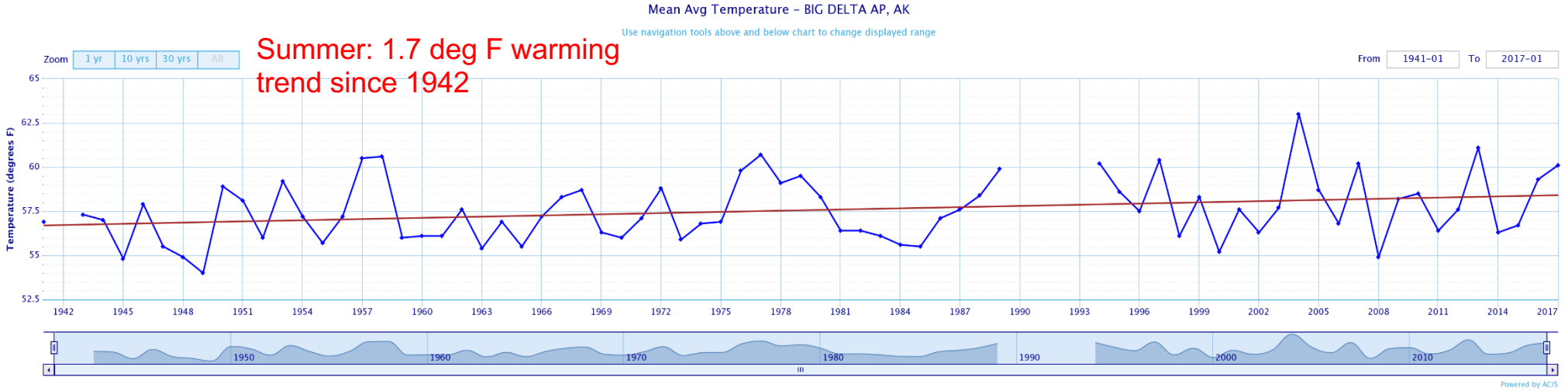
Other Agents of Change on Historic to Geologic Time

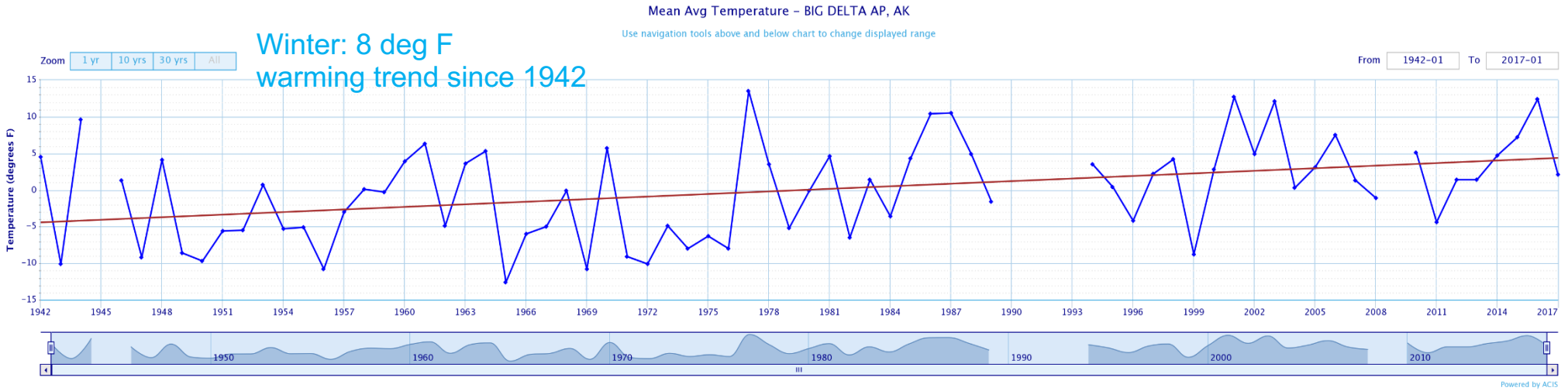
- Humans: road-building, mining, and deforestation

DigitalGlobe/Google

Other Agents of Change on Historic to Geologic Time

Warming causing permafrost thaw and potentially subsidence

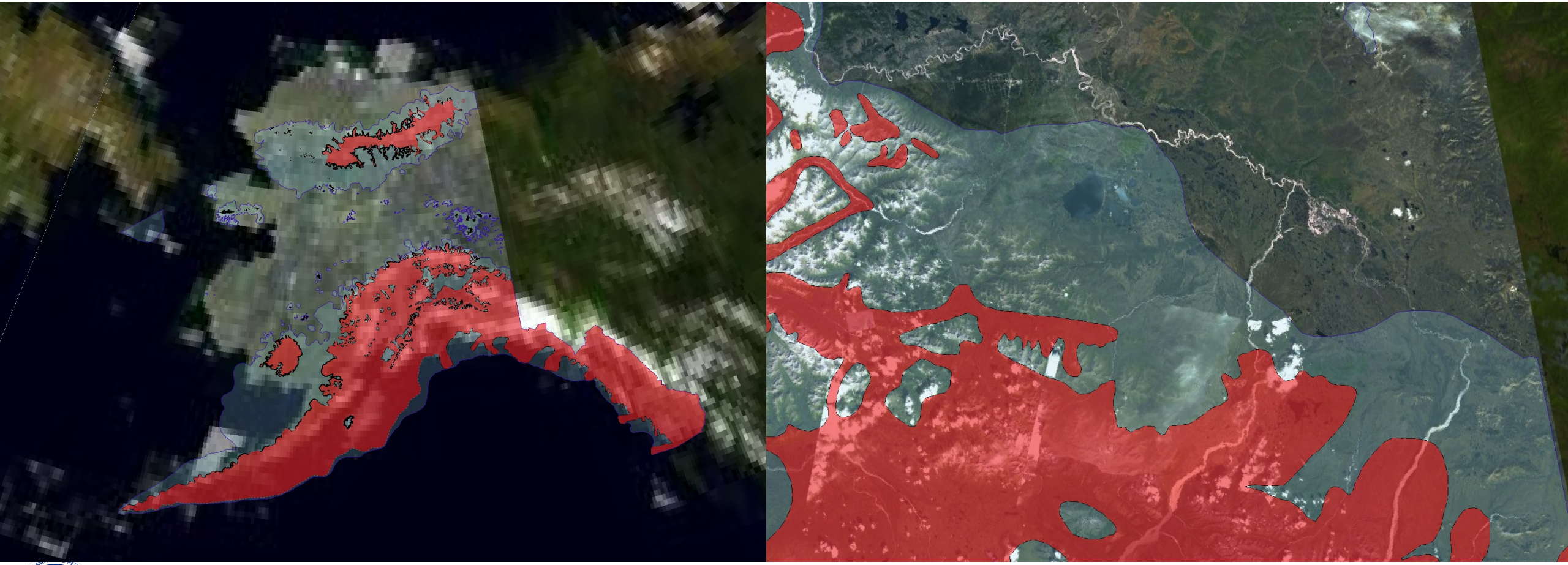




xmACIS2

Other Agents of Change on Historic to Geologic Time

- Maximum and Last Glacial Extent

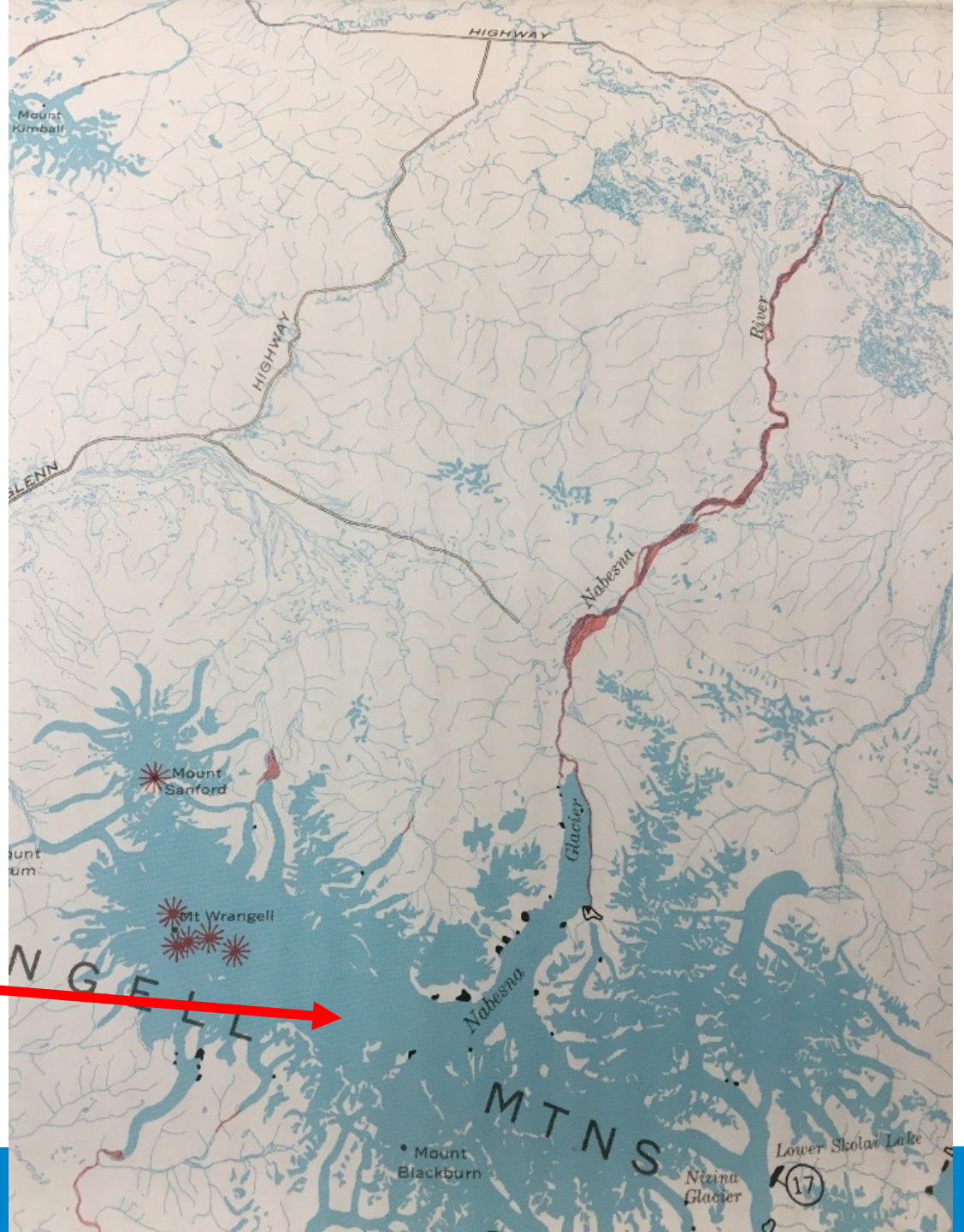


William Manley, INSTAAR, University of Colorado, William.Manley@colorado.edu
Darrell Kaufman, Geology Dept., N. Arizona University, Darrell.Kaufman@nau.edu
With contributions from: T.A. Ager, Y. Axford, N. Balascio, J.E. Beget, J.P. Briner, P. Carrara, T.D. Hamilton, D.J. Lubinski, R.D. Reger, H.R. Schmoll, R.M. Thorson, C.F. Waythomas, F.R. Weber, A. Werner, and F.H. Wilson.

Post and Mayo (1971) show a large number of glacial dammed lakes on the Nabesna Glacier and they describe the Nabesna River as vulnerable to outburst flooding. Reger et al. (2012) suggest they didn't see evidence of recent outburst floods, in their limited reconnaissance.

The Nabesna Glacier is one of the longest land glaciers in the world and there is virtually no research on it.

Li et al. (2008) used SAR to track short term movement of the Nabesna Glacier only.



Post and Mayo, 1971

Li et al. (2008) show no information on GDLs

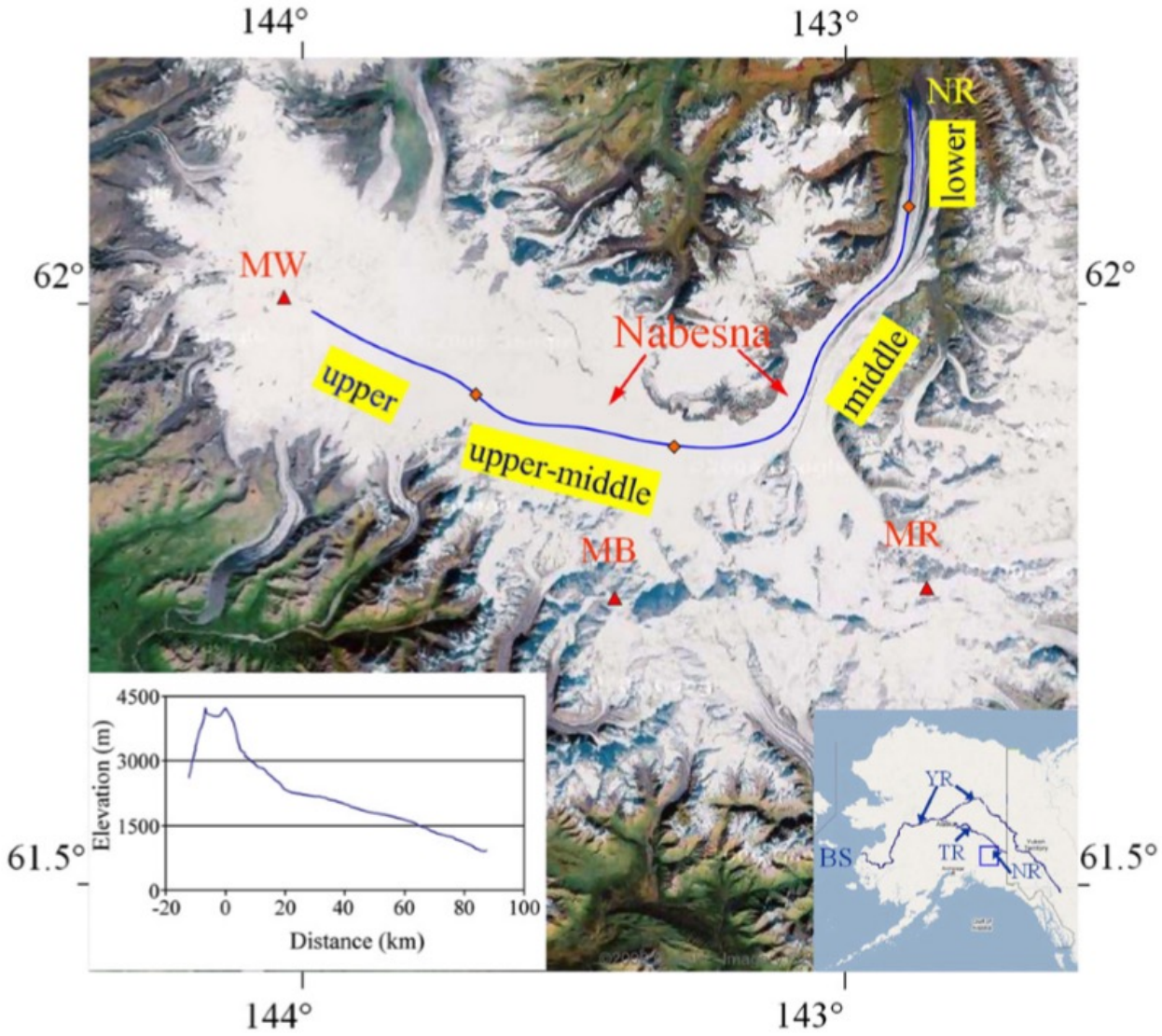


Fig. 1. Location map (Based on Google web image in Mercator projection) and elevation profile of Nabesna Glacier. The blue curve depicts the 87 km course of Nabesna Glacier. Four sections along the glacier: upper, upper-middle, middle and lower, are delineated. The symbols MW, MB, MR, and NR denote Mt. Wrangell, Mt. Blackburn, Mt. Regal, and the Nabesna River, respectively. The location of the study area within Alaska is outlined in a small blue box in the right inset. The symbols TR, YR, and BS in the inset represent the Tanana River and the Yukon River, and the Bering Sea, respectively. In the left inset, the starting point of the elevation profile of Nabesna Glacier is defined at the 4200 m top of Mt. Wrangell's Summit Caldera.

Impacts of Glaciers on Region over Geologic Time

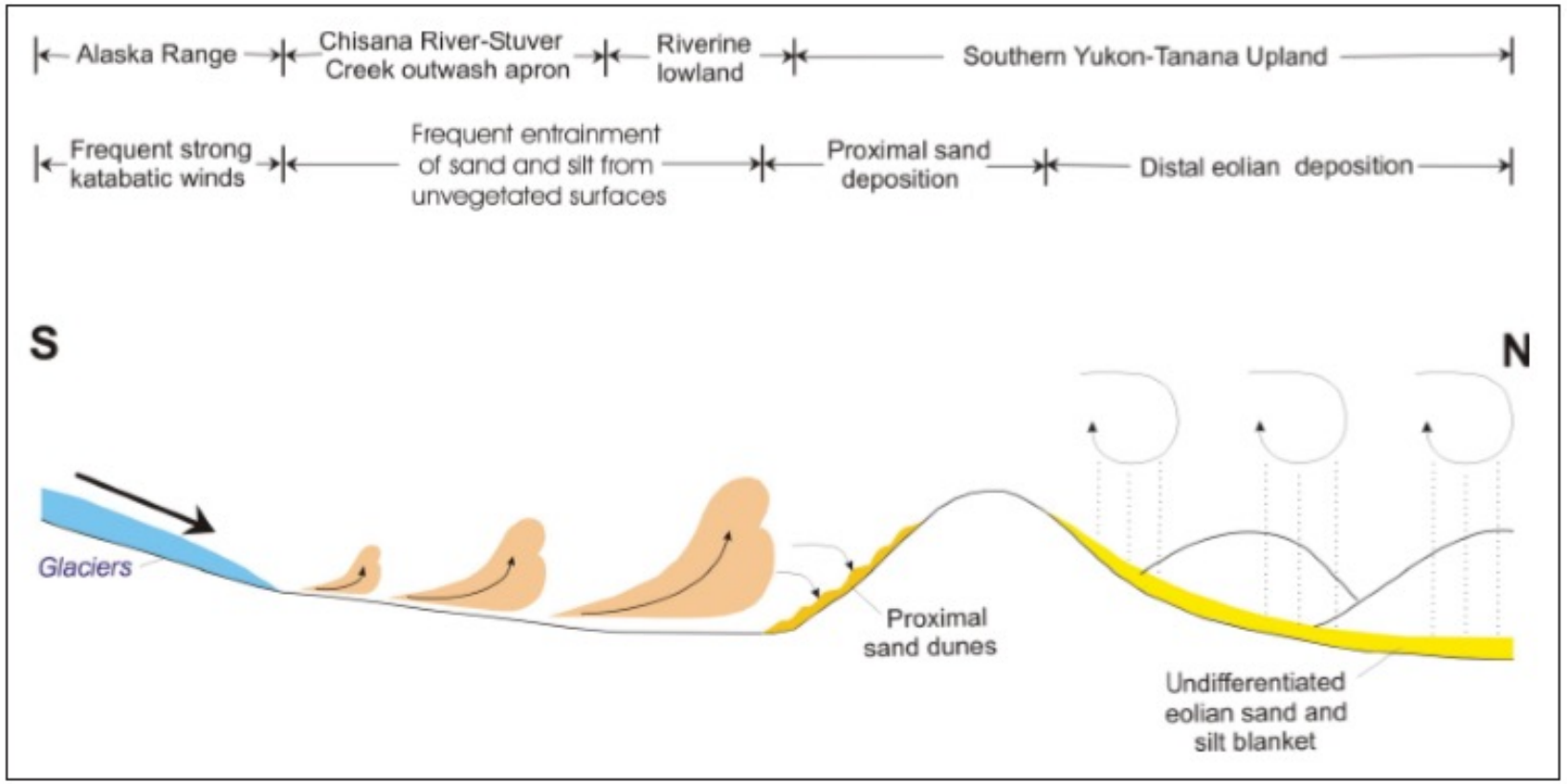
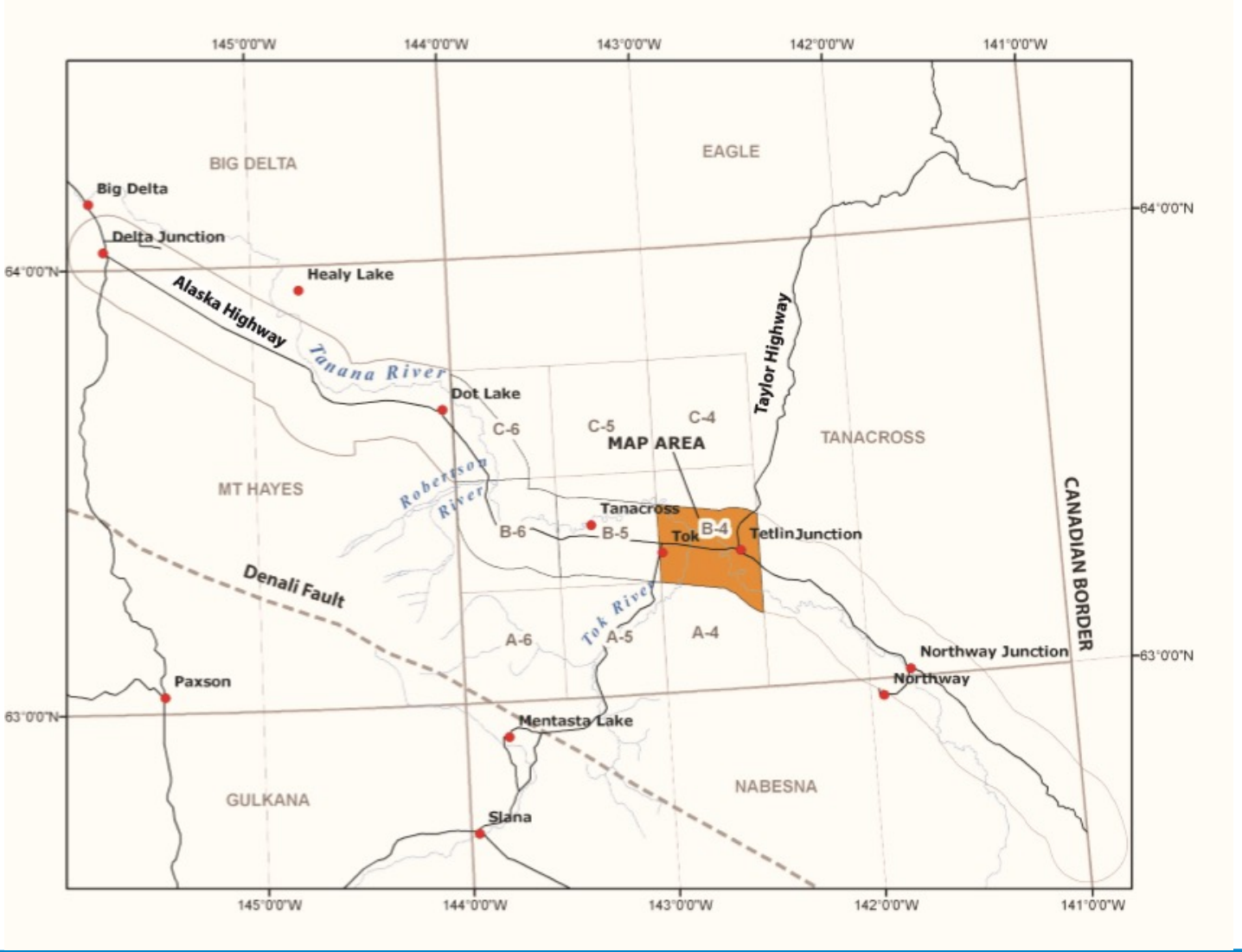


Figure 8. Model of eolian processes and deposits during penultimate and last major glaciations in southeastern Northway–Tanacross Lowland, Nabesna Quadrangle.

Reger et al., 2012

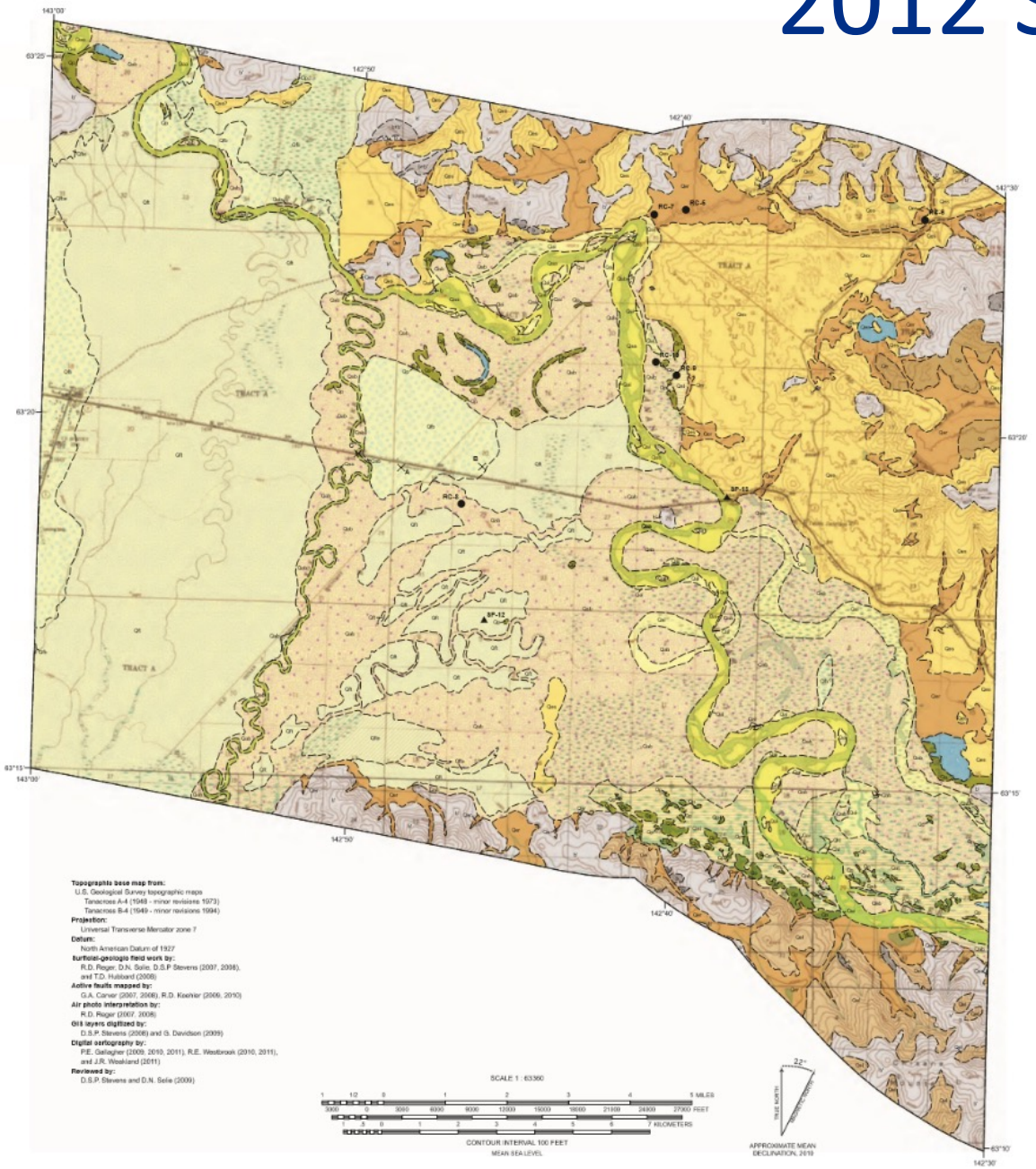
New Mapping Associated with Gas Line Proposal



Reger et al., 2012

2012 Surficial Geology

ALASKA DIVISION OF GEOLOGICAL & GEOPHYSICAL SURVEYS



Qaa — ACTIVE-FLOODPLAIN ALLUVIUM—Chiefly well sorted and well stratified layers and lenses of polymictic pebble gravel, sand, and silt with rare to scattered cobbles comprising river bars subject to recurrent inundation by streams every 5 yrs or less (Chapin and others, 2006); mapped extent is a function of river level (stage) and reflects the transitory extent of exposed river bars at the time the photographs were taken; in braided and anastomosing reaches, active channels typically shift positions from year to year and present channel locations may differ from locations in the photography on which the deposits were mapped; active alluvium underlies upper stream bank and active stream channels and includes point-bar and meander-scroll deposits (Brakenridge, 1988); composed dominantly of gravel and sand where stream is braided and anastomosing and sand and silt bars and cover deposits where meandering; prone to liquefaction where fine grained and unfrozen (Harp and others, 2003); where braided, subject to formation of extensive, thick seasonal-stream icings (aufeis); generally unfrozen, except seasonally frozen to depth of frost penetration; shallow water table

Qab — ABANDONED-FLOODPLAIN ALLUVIUM—Chiefly 10 to 20 ft (3 to 6 m) of overbank sandy silt and silty sand overlying sandy, polymictic riverbed gravel beneath surfaces with widespread cover of lowland loess and local sand dunes and subject to stream flooding about once every 500 to 1,000 yrs (Mann and others, 1995); may include several surfaces at different levels; overbank sequences include flood-related features, like natural levees, crevasse splays, and expansion fans near channels and fine-grained, peaty back-levee swale deposits farther from channels (Brakenridge, 1988; Mann and others, 1995); may contain organic-silt channel fills 7 to 20 ft (2.1 to 6 m) thick; surface peat generally discontinuous to widespread in backwater areas away from channels; floodplain lakes are larger than lakes on younger floodplain surfaces and typically have rounded to scalloped shorelines formed by thermokarst erosion; generally frozen with low to moderate ice content

Qat — STREAM-TERRACE ALLUVIUM—Chiefly 4 to >20 ft (0.6 to >6 m) of organic sandy silt and silty sand overlying well sorted, polymictic sand and gravel beneath stream terrace treads no longer subject to inundations by the stream that deposited the alluvium (Kreig and Reger, 1982); may include several levels and flood-related features such as natural levees, crevasse-splays, and expansion fans near channels; may incorporate outwash alluvium of Donnelly age in highest terraces; locally covered by ≤15 ft (≤4.5 m) of lowland loess and eolian-sand blanket and dune complexes, especially close to active sediment sources; thaw lakes with rounded to scalloped shorelines formed by thermokarst erosion are typically present (Weber and Péwé, 1961, 1970; Péwé, 1970; Reger and Hubbard, 2009); locally subject to seasonal stream icings where buildup of aufeis in stream channels diverts subsequent drainage and spreads aufeis and meltwater across terrace treads that would not otherwise be flooded (Springer and others, 1976; Sloan and others, 1976); continuously to discontinuously frozen with low to moderate ice content

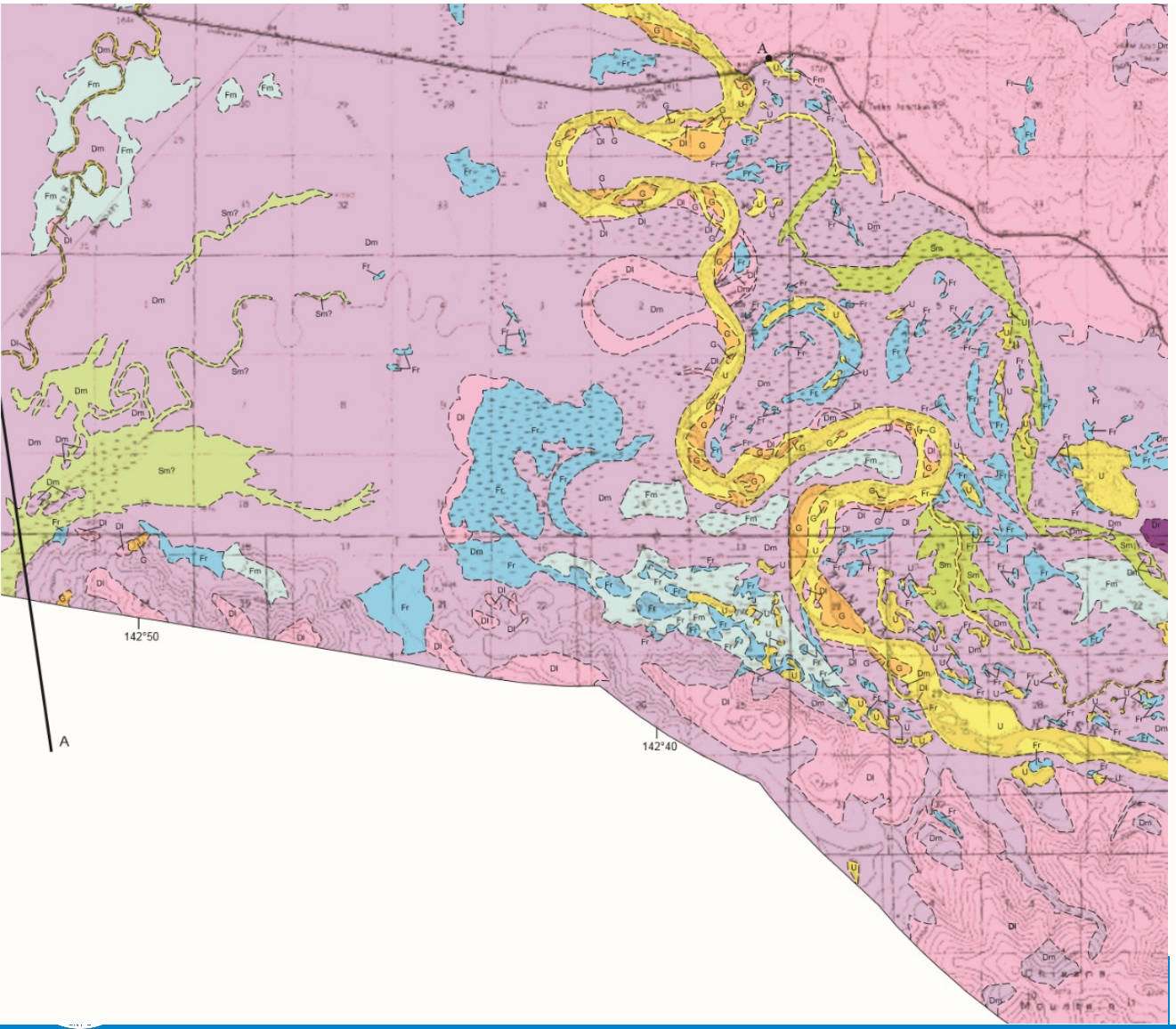
Qes — EOLIAN SAND—Chiefly blankets and dunes of fine to medium, massive to cross-bedded eolian sand with trace to some silt (Kreig and Reger, 1982, pl. 9); dunes stand 5 to 15 ft (1.5 to 4.5 m) in relief and ridges may extend for up to 3 mi (4.8 km) in the direction of dominant summer winds; mapped extents, based on the presence of dunes, should be considered minimum; cliffhead dunes locally crown steep slopes that are the sand sources; discontinuous with thicknesses up to ~25 ft (~7.6 m); unweathered color grayish brown (2.5Y5/2); generally covered by 1 to 3 ft (0.3 to 0.9 m) of loess (Lindholm and others, 1959); locally being deposited along the margins of braided floodplains; average moisture content ~8 percent (Kreig and Reger, 1982); discontinuously frozen with low to moderate ice content

PALUDAL DEPOSITS

Qp — SWAMP DEPOSITS—Primarily fibrous and locally woody, autochthonous peat with organic silt and sand deposited in lowland sites (Kreig and Reger, 1982); ≤8 ft (≤2.4 m) thick; discontinuously to continuously frozen with moderate to high ice content

Reger et al., 2012

2012 Permafrost Map

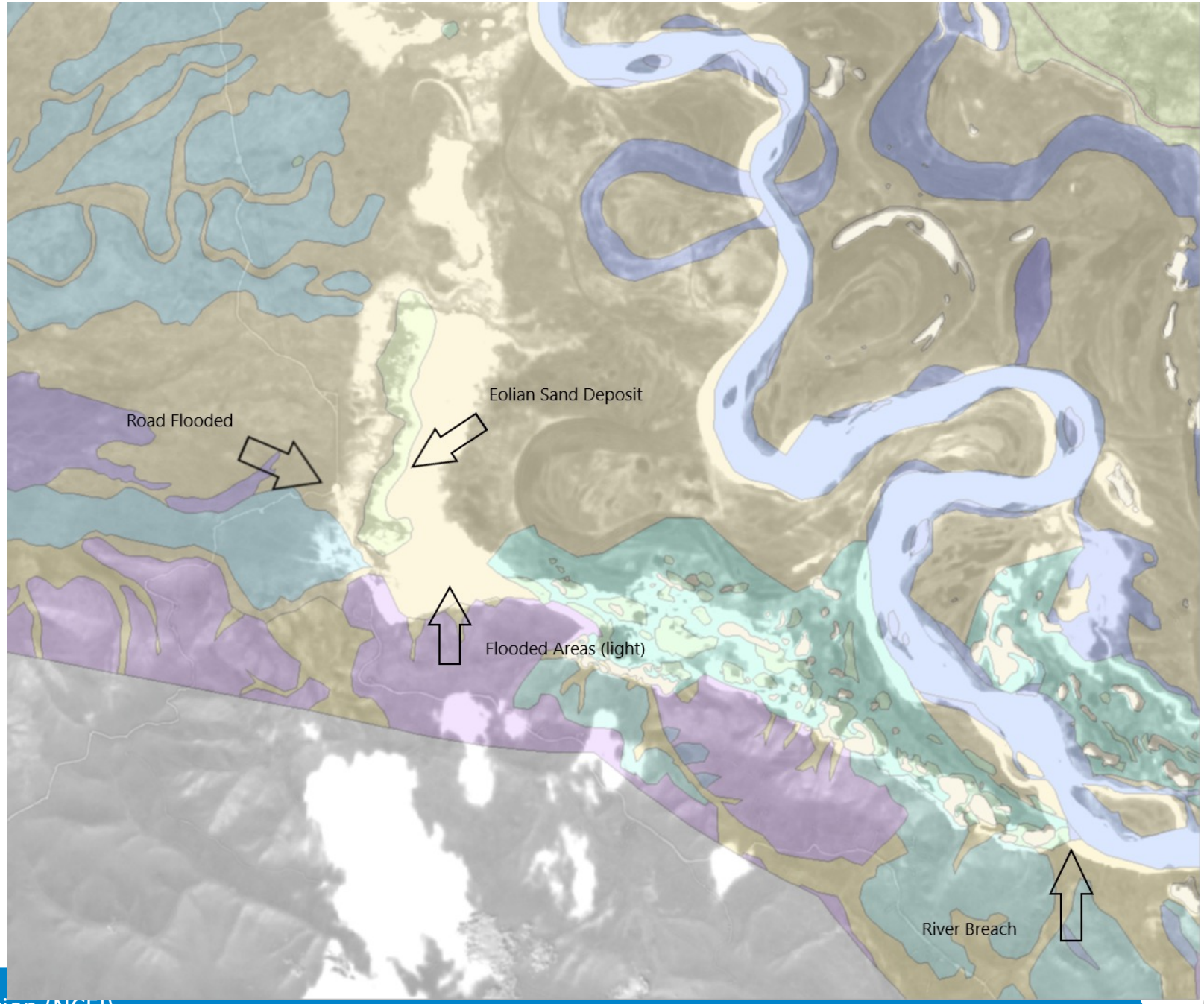


EXPLANATION OF MAP UNITS
(All map units may not appear on this sheet)

Fr	Fr?	CONTINUOUSLY FROZEN, MODERATE TO HIGH ICE CONTENT
Fm	Fm?	CONTINUOUSLY FROZEN, LOW TO MODERATE ICE CONTENT
	Dr	DISCONTINUOUSLY FROZEN, MODERATE TO HIGH ICE CONTENT
Dm	Dm?	DISCONTINUOUSLY FROZEN, LOW TO MODERATE ICE CONTENT
Dl	Dl?	DISCONTINUOUSLY FROZEN, LOW ICE CONTENT
Sm	Sm?	SPORADICALLY FROZEN, LOW TO MODERATE ICE CONTENT
Sl	Sl?	SPORADICALLY FROZEN, LOW ICE CONTENT
G	G?	GENERALLY UNFROZEN (ISOLATED PERMAFROST MASSES)
	U	NO PERMAFROST

Reger et al., 2012

Combined Surficial Geology Map and SAR imagery



Other Unique Soils in the Region

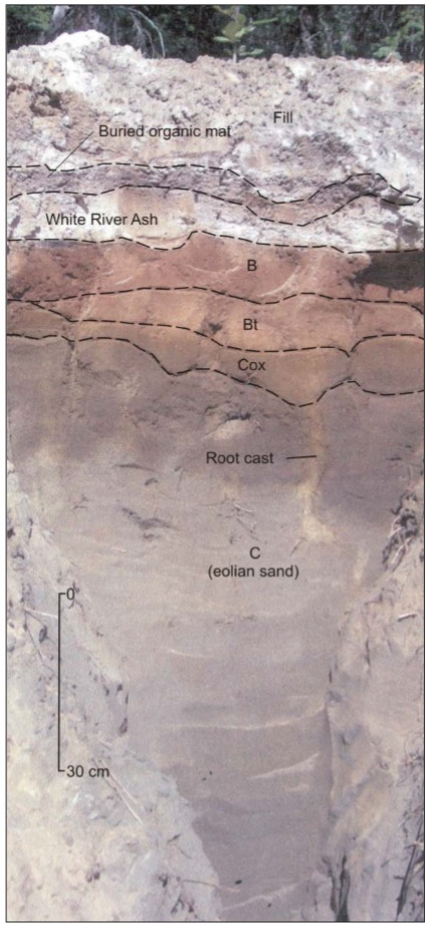
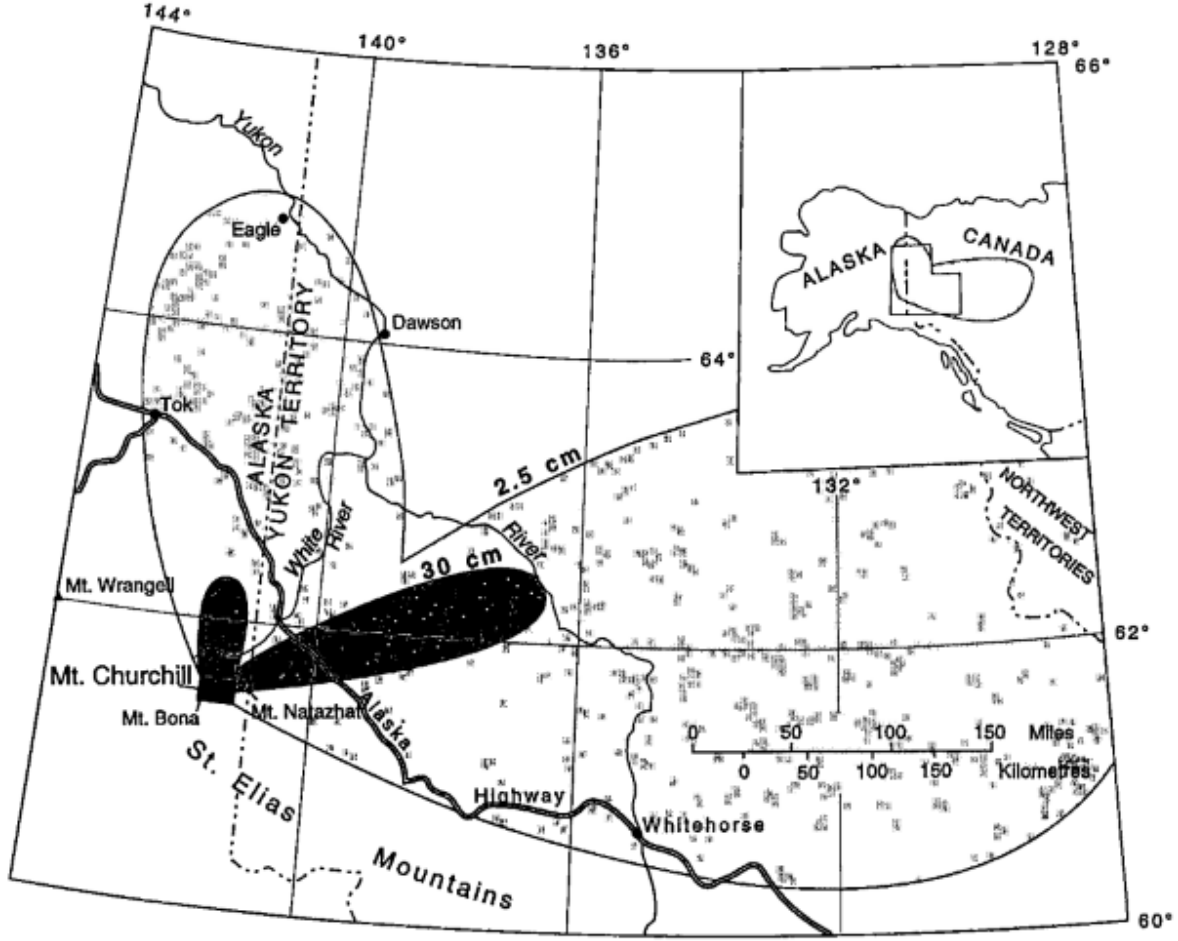


Figure 7. Soil profile (SP-14) in eolian sand blanket exposed in Material Site 62-1-020-5 on ridge crest north of Alaska Highway milepost 1276.9 in northeastern Tanacross A-3 Quadrangle (sheet 1). Removal of 0.9- to 1.8-m-thick sand blanket overlying frost-rived schist bedrock exposed scattered quartz ventifacts at and near base of eolian sand. Moderately indurated Bt horizon indicates profile could be of penultimate glacial age.

Fig. 1. Map of parts of the Yukon Territory and Alaska showing the 30 cm (1 ft) and 2.5 cm (1 in.) isopachs of the White River Ash (after Lerbekmo et al. 1975). Small rectangle indicates area shown in Fig. 3. Inset index map shows approximate outer limit of detectable ash.



Reger et al. 2012

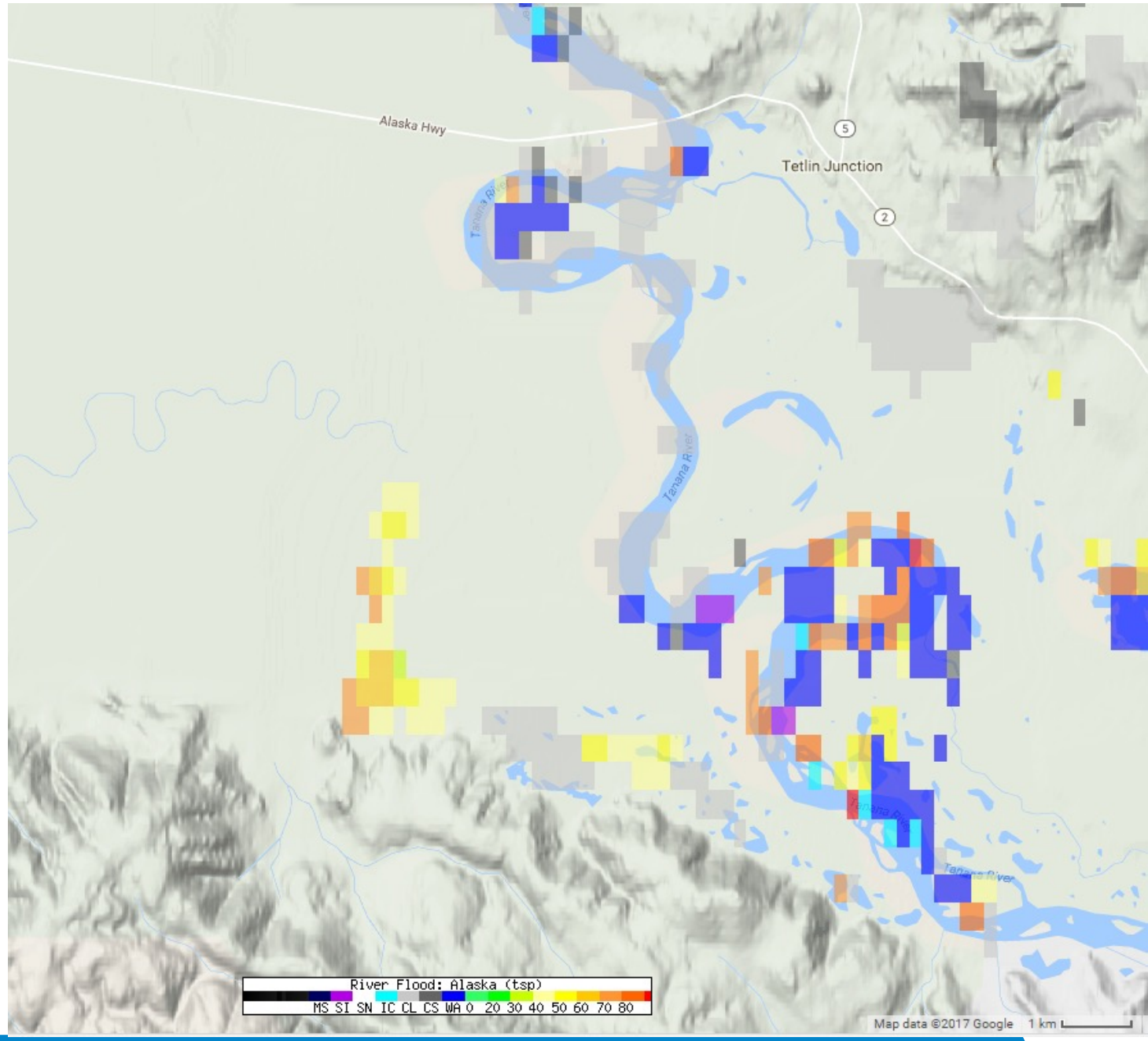
Richter et al. 1995. Can. J. Earth Sci.

What can NOAA (NWS and NESDIS) do to Help Detect and Monitor Flood Waters?

Best ‘Alert’ for a possible future event:

VIIRS Flood Product 7/29/17

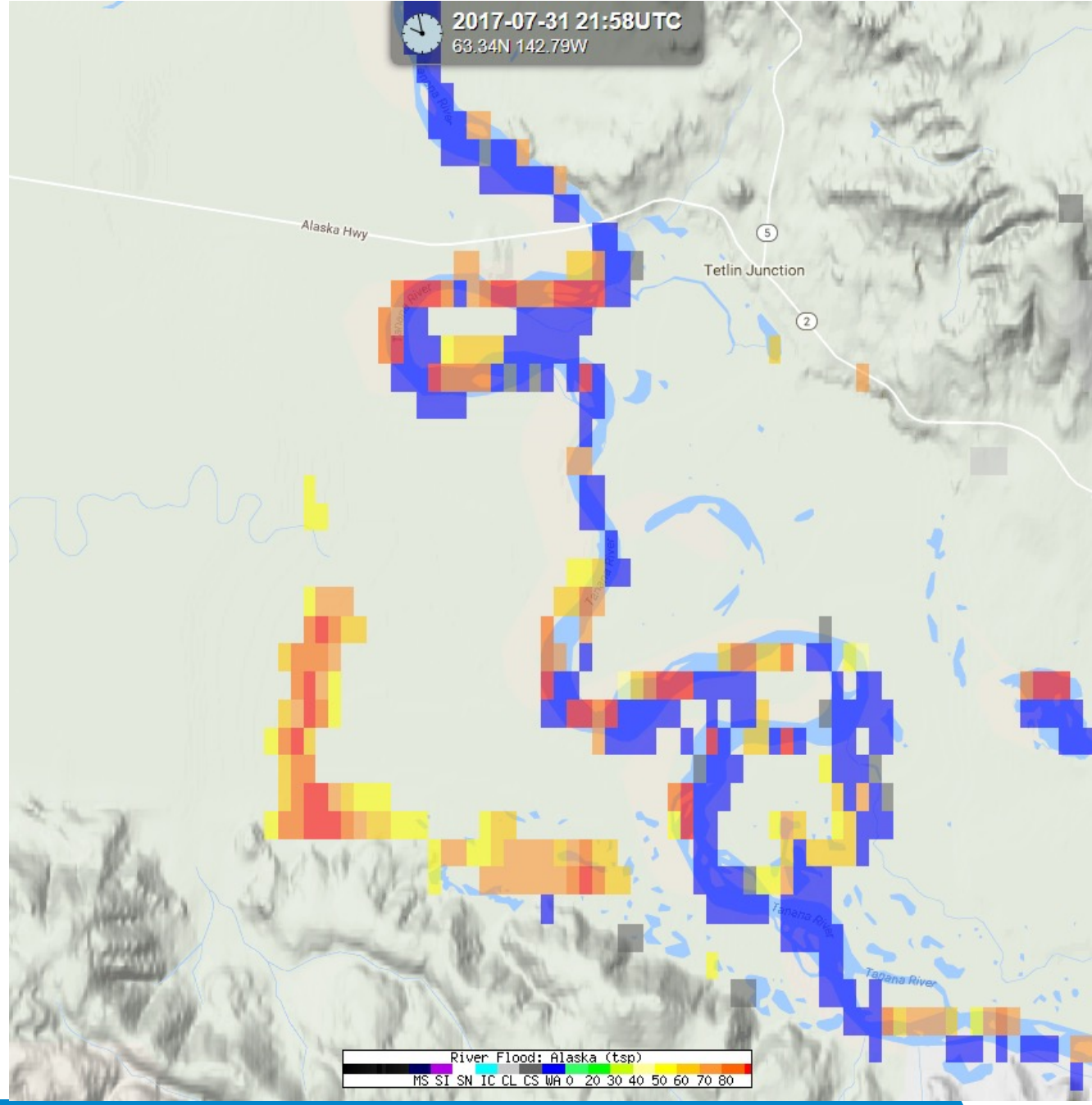
Has become the APRFC daily workhorse product during cloud-free conditions



Best ‘Alert’ for a possible future event:

VIIRS Flood Product 7/31/17

Has become the APRFC daily workhorse product during cloud-free conditions



Questions, Comments, Discussion?

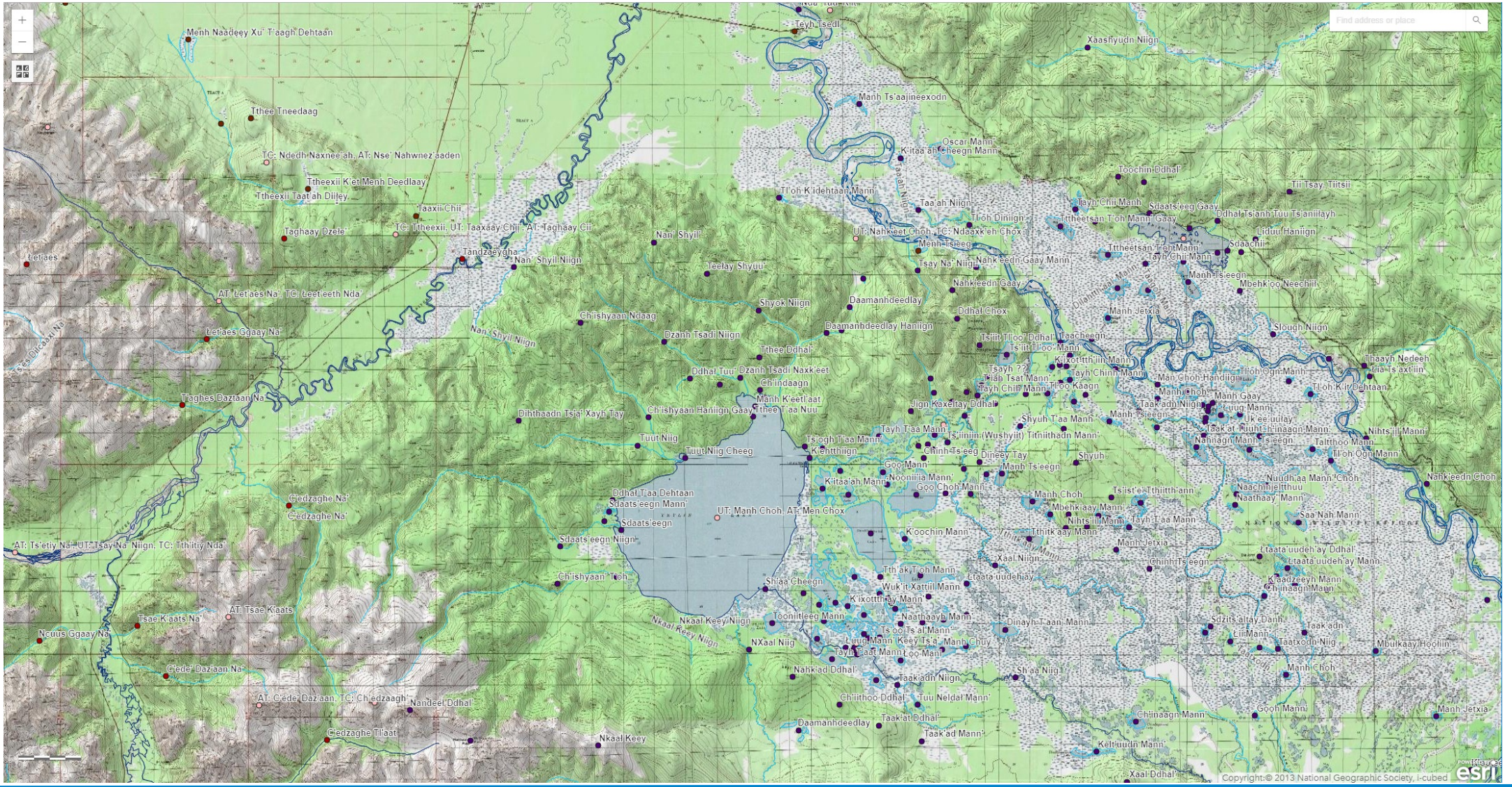
contact: Jessica.Cherry@noaa.gov

Photo credit: Katy Turk

Information Sources

- Satellite Imagery: SAR, VIIRS Flood Product, Worldview, Landsat
- Aerial Reconnaissance: Civil Air Patrol
- Gage data
- Resident’s reports, pictures, video
- NWS Observers
- APRFC Staff visit
- Publications by DGGS and others

Native Placenames Could Reveal Hydrologic Clues



James Kari, Gerad Smith and collaborators

Other Complexity: hydrologic piracy

Could have impacted Upper Tanana people on historic timescales. Scottie Creek is an important waterway in the lives of UT cultural groups in/around Northway and across Canadian border. Reger (pers. Comm.) says he has no idea when this rerouting occurred. Our awareness of this phenomena increased after a major piracy occurred in the Yukon Territory in 2016, impacting our Alsek River forecast point.

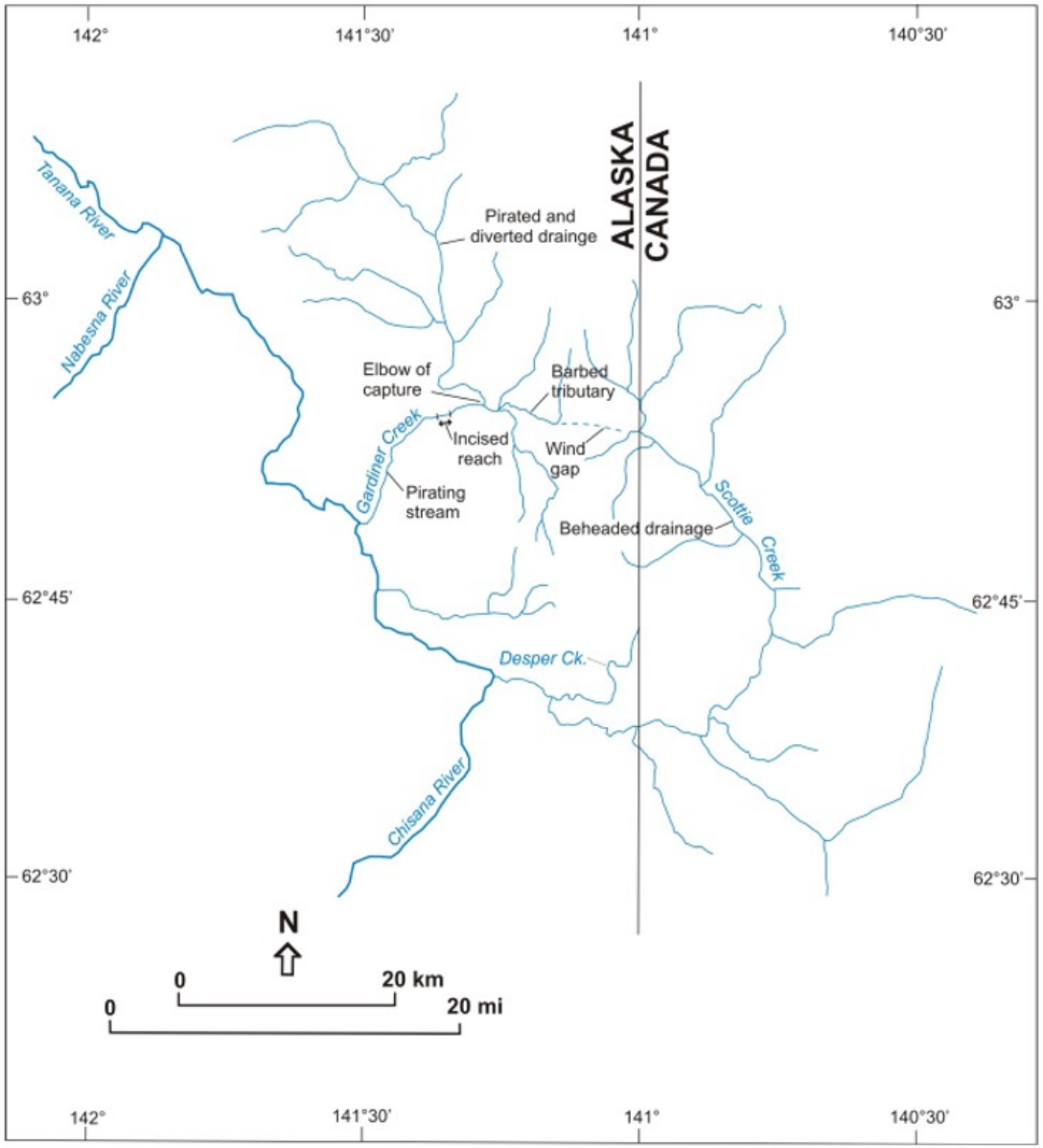


Figure 2. Features demonstrating piracy by Gardiner Creek of headwaters of much longer former course of Scottie Creek.

Reger et al., 2012

Where else could it happen?

Northway, AK


Tetlin
Tetlin Lake
Northway Junction
Northway Village
Northway
DigitalGlobe/Google

Northway, AK

Photo credit: CAP

DigitalGlobe/Google

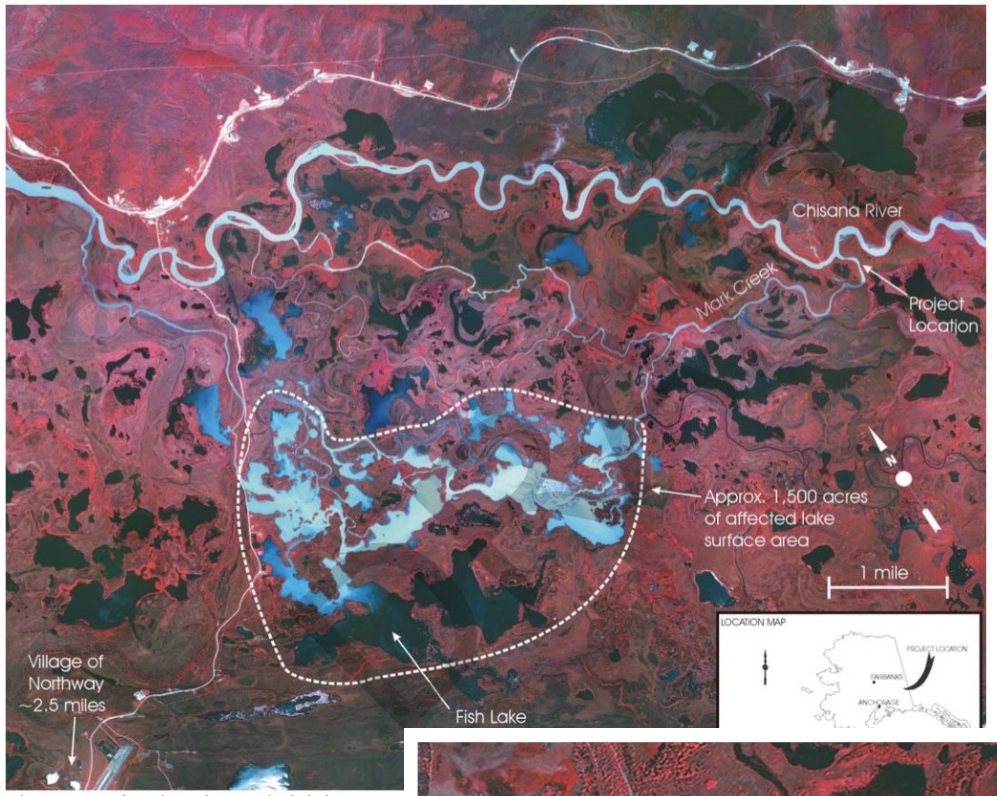


Figure1. Project location and vicinity map.

USACE

Chisana near Northway rerouted in late 1960s

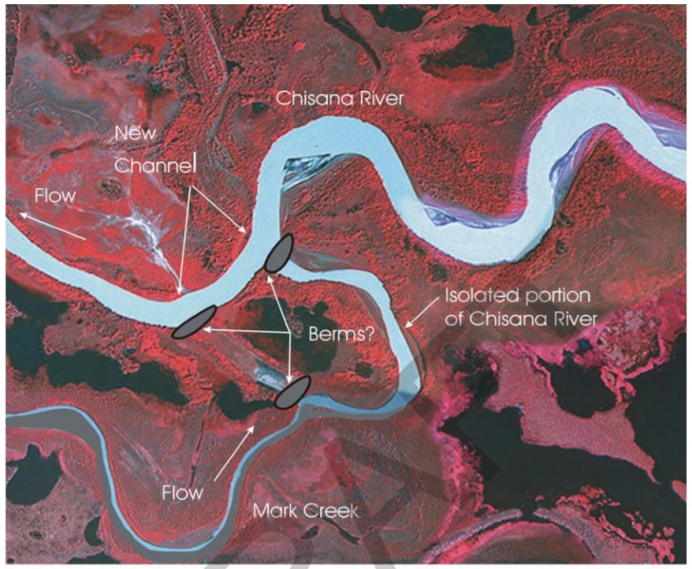
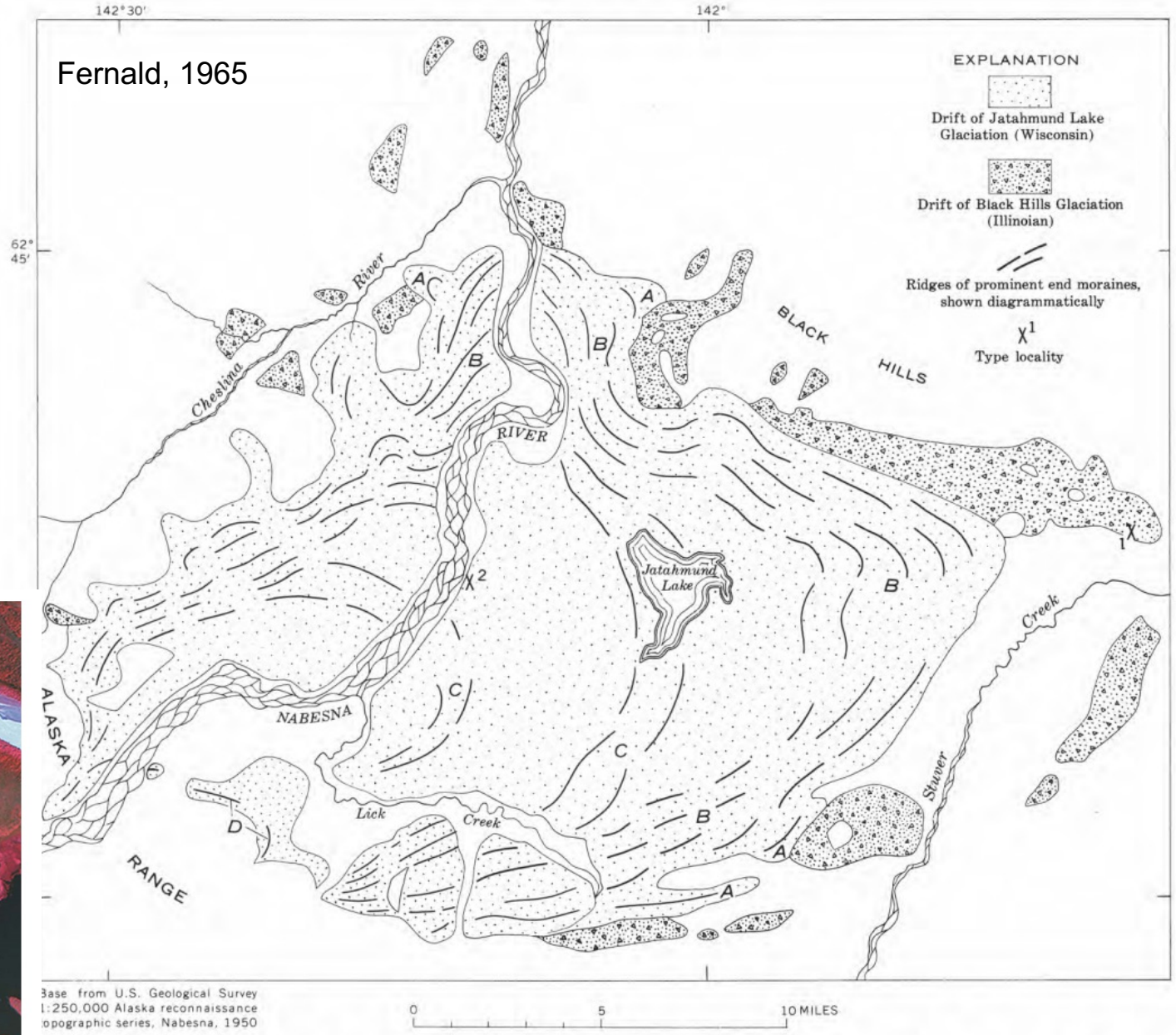


Figure 5. Conditions after the new channel was created. To prevent the Chisana River from entering the old channel, berms were most likely put in place.

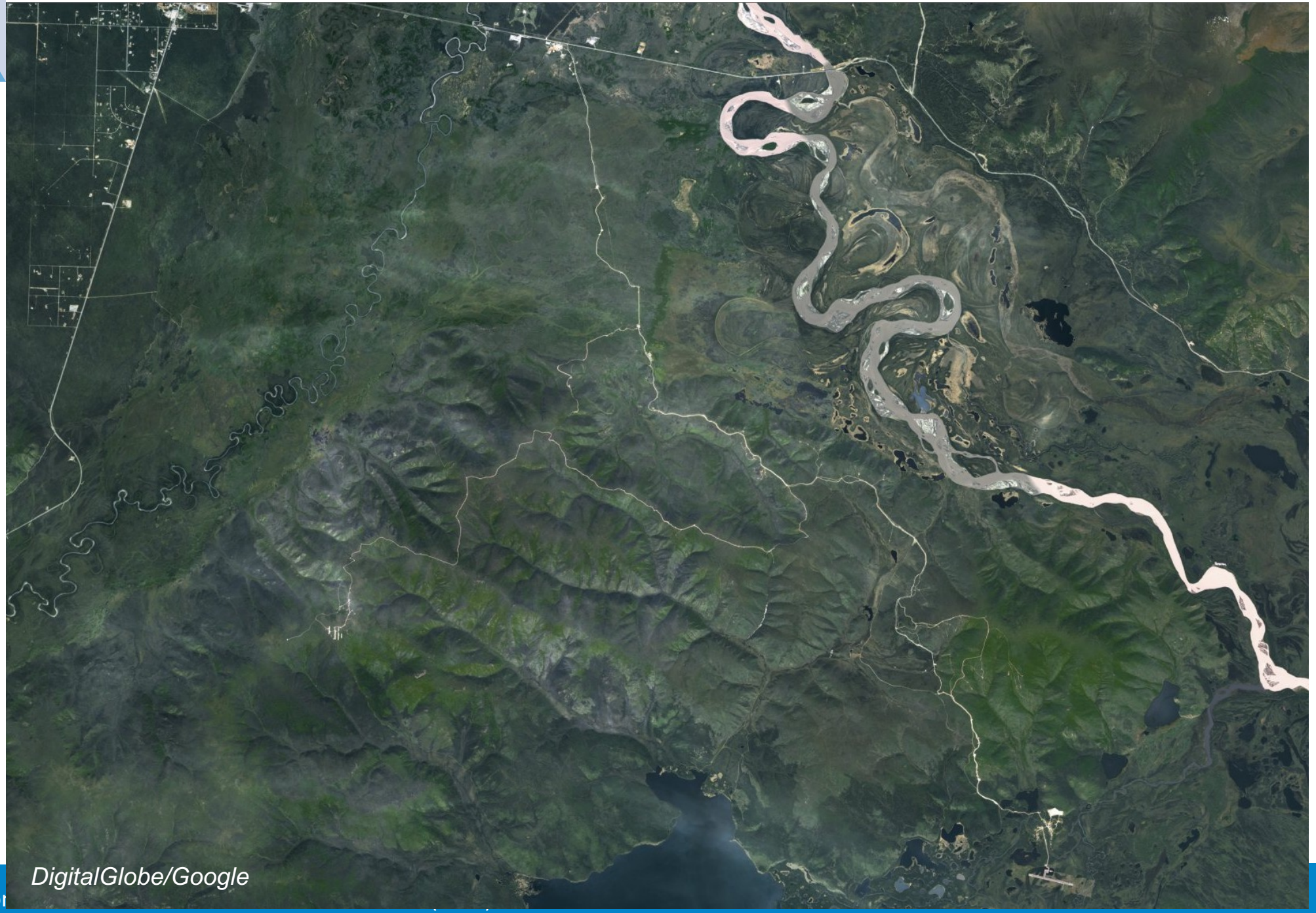
Fernald, 1965



GURE 2.—Distribution of drift of the Nabesna glacier on the north side of the Alaska Range. *A*, Stuver moraine; *B*, Takomahto Lake moraines; *C*, Lick Creek moraines; *D*, Pickerel Lakes moraines.

Mission of the National Weather Service

- The **National Weather Service** (**NWS**) provides weather, water, and climate data, forecasts and warnings for the protection of life and property and enhancement of the national economy
- NWS is moving toward increased local and regional partnerships to provide **Impact-Based Decision Support Services (IDSS)**
- IDSS are forecast advice and interpretative services the NWS provides to help core partners, such as emergency personnel and public safety officials, make decisions when weather, water and climate impacts the lives and livelihoods of the American people


DigitalGlobe/Google