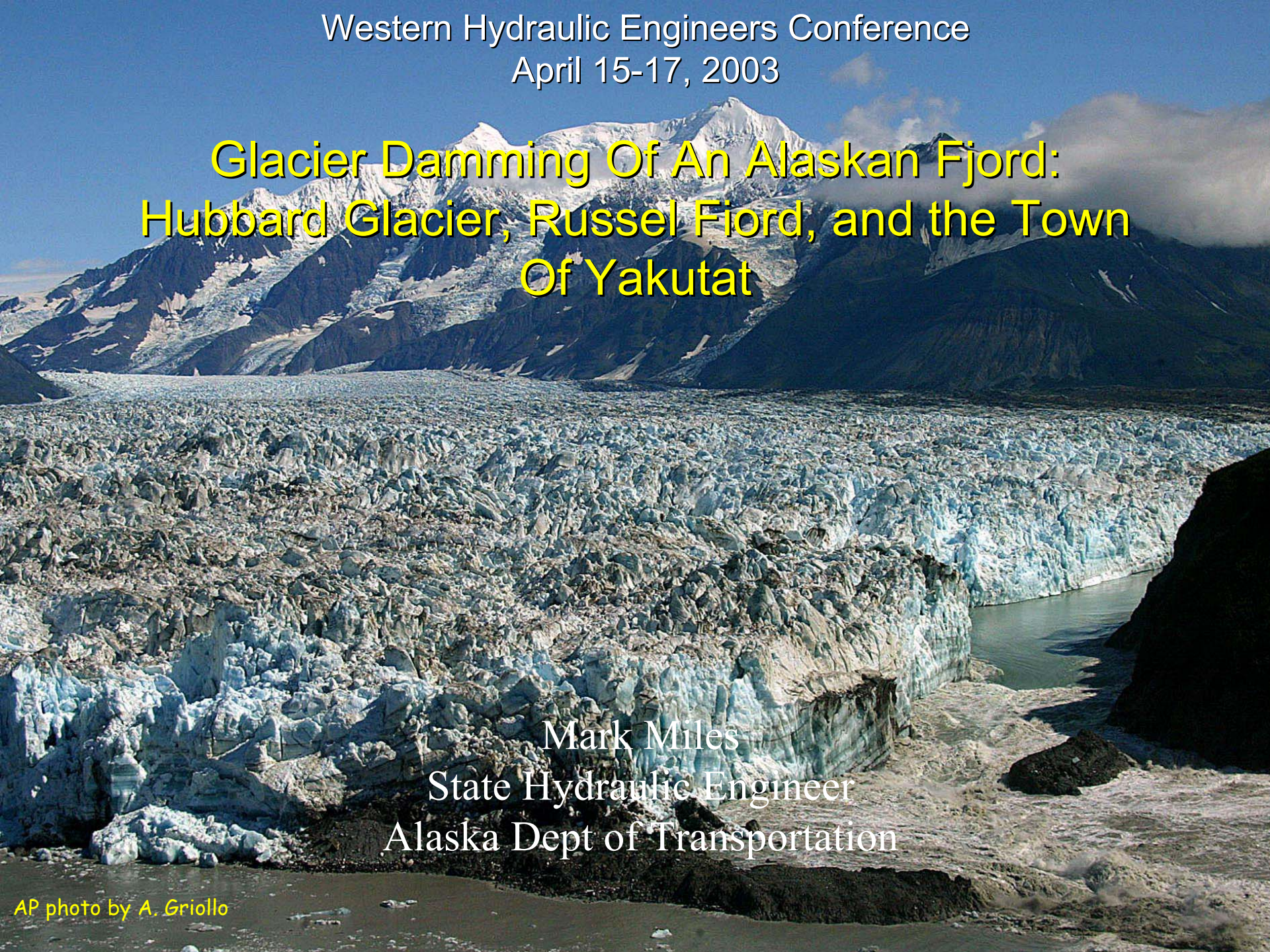
Western Hydraulic Engineers Conference
April 15-17, 2003

Glacier Damming Of An Alaskan Fjord: Hubbard Glacier, Russel Fiord, and the Town Of Yakutat



Mark Miles
State Hydraulic Engineer
Alaska Dept of Transportation

AP photo by A. Griollo

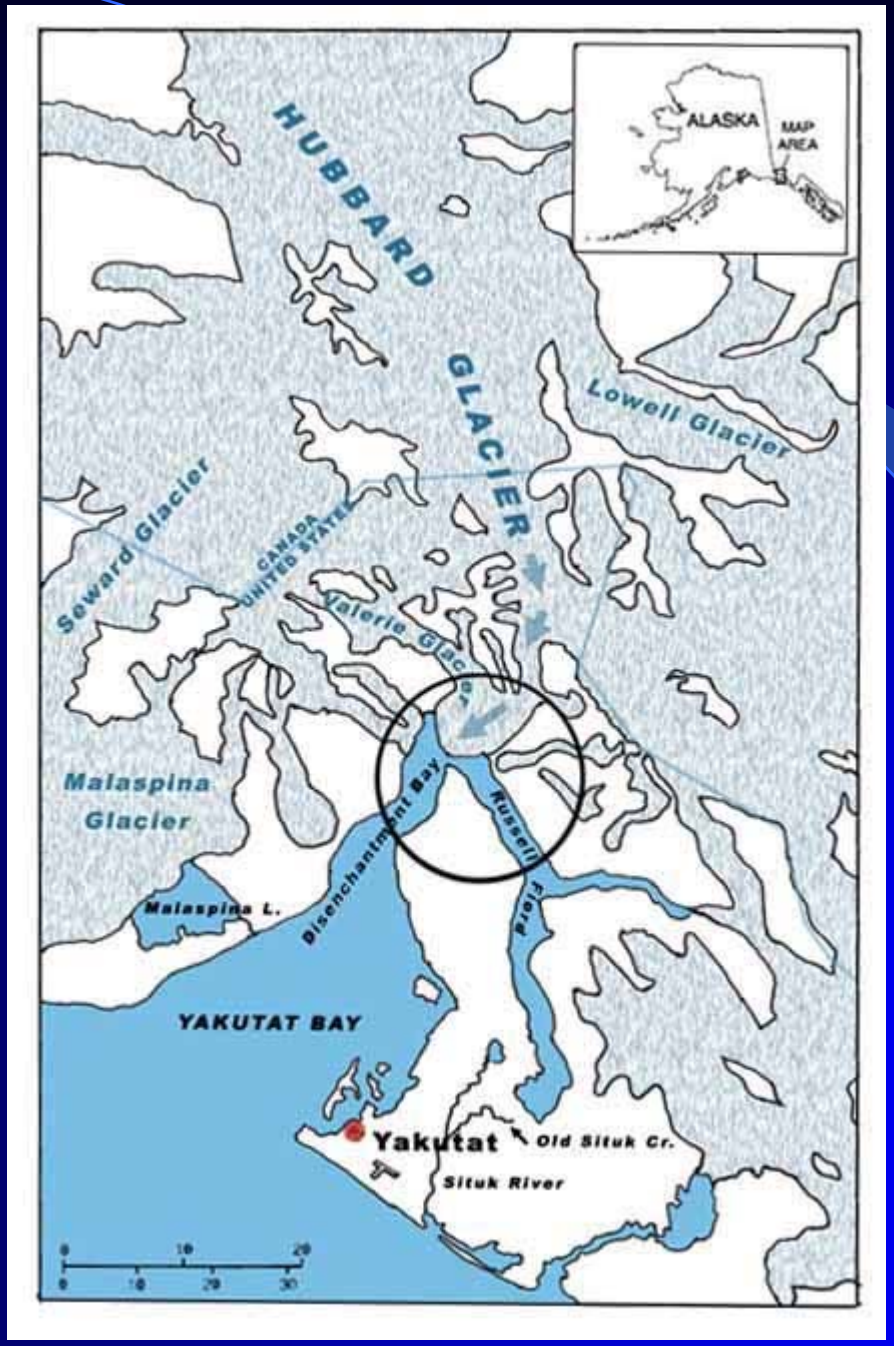
Acknowledgements

- Dennis Trabant, Glaciologist
  - USGS, Alaska Division
- Bob Gubernick, Engineering Geologist
  - USFS, Tongass National Forest

Introduction

- Location
- Event History
- Impacts of “Spillover”
- Ongoing Studies
- Future Studies

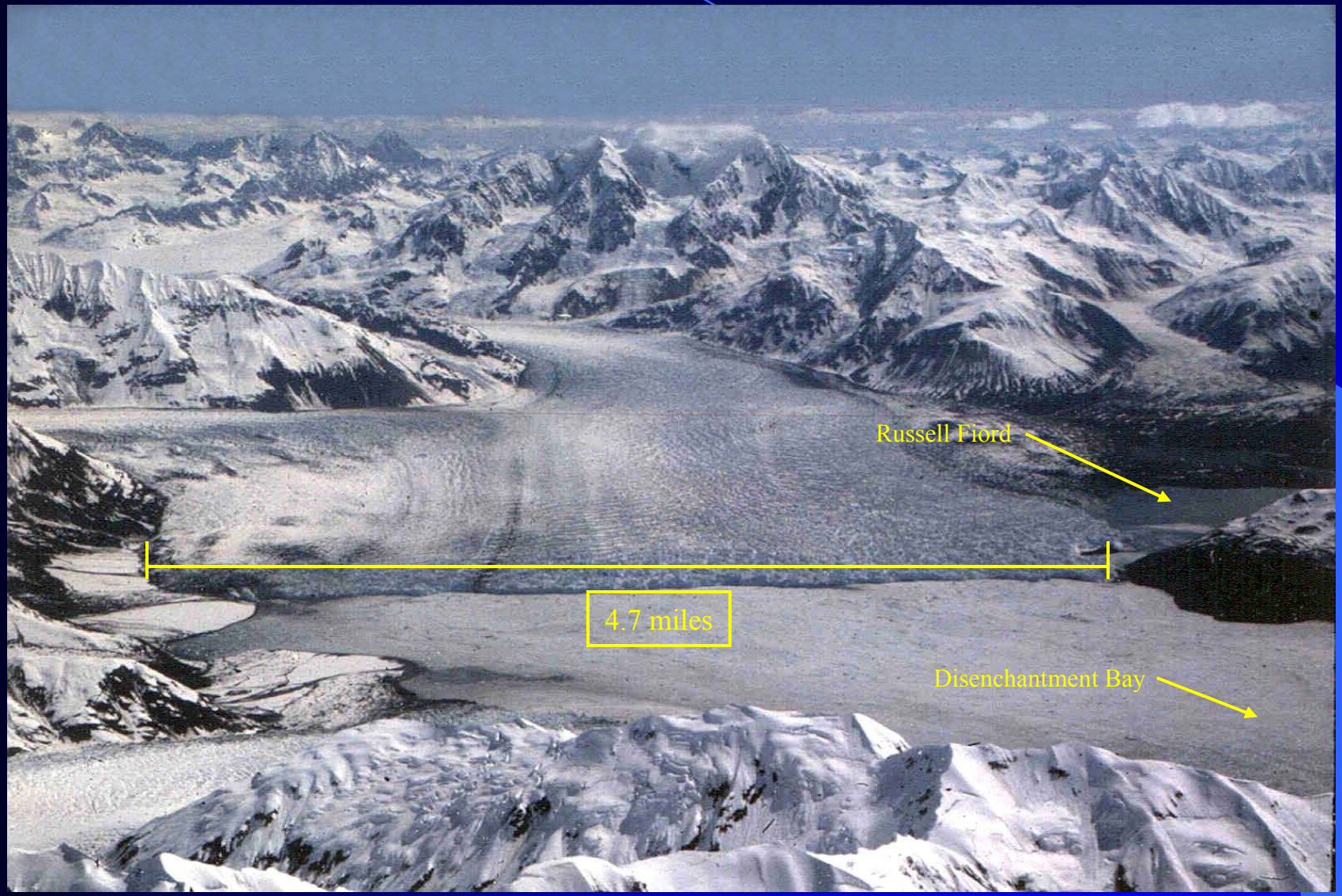

ARCTIC OCEAN
U.S.S.R.
NORTON SOUND
BERING SEA
Fairbanks
CANADA
Anchorage
Yakutat
Juneau
GULF OF ALASKA
PACIFIC OCEAN
ALASKA
0 50 100 200 400 MI


HUBBARD GLACIER
ALASKA
MAP AREA
Lowell Glacier
Seward Glacier
CANADA
UNITED STATES
Valerie Glacier
Malaspina Glacier
Disenchantment Bay
Russell Fiord
Malaspina L.
YAKUTAT BAY
Yakutat
Old Situk Cr.
Situk River

Hubbard Glacier

- Largest (and longest - 76 mi) tidewater glacier on N. American continent
- Has been advancing since first mapped in 1895, lately about 80 ft/year
- “Headwaters” on Mt. Logan (#2, 19,550 ft) and Mt. St. Elias (#3, 18,008 ft)
- 95 percent of it’s area is above the accumulation zone - not likely to retreat
- Volume increased 12 km^3, last 40 years
- Likely to close-off Russell Fiord permanently
- 300 feet high (above MSL) at tidewater face

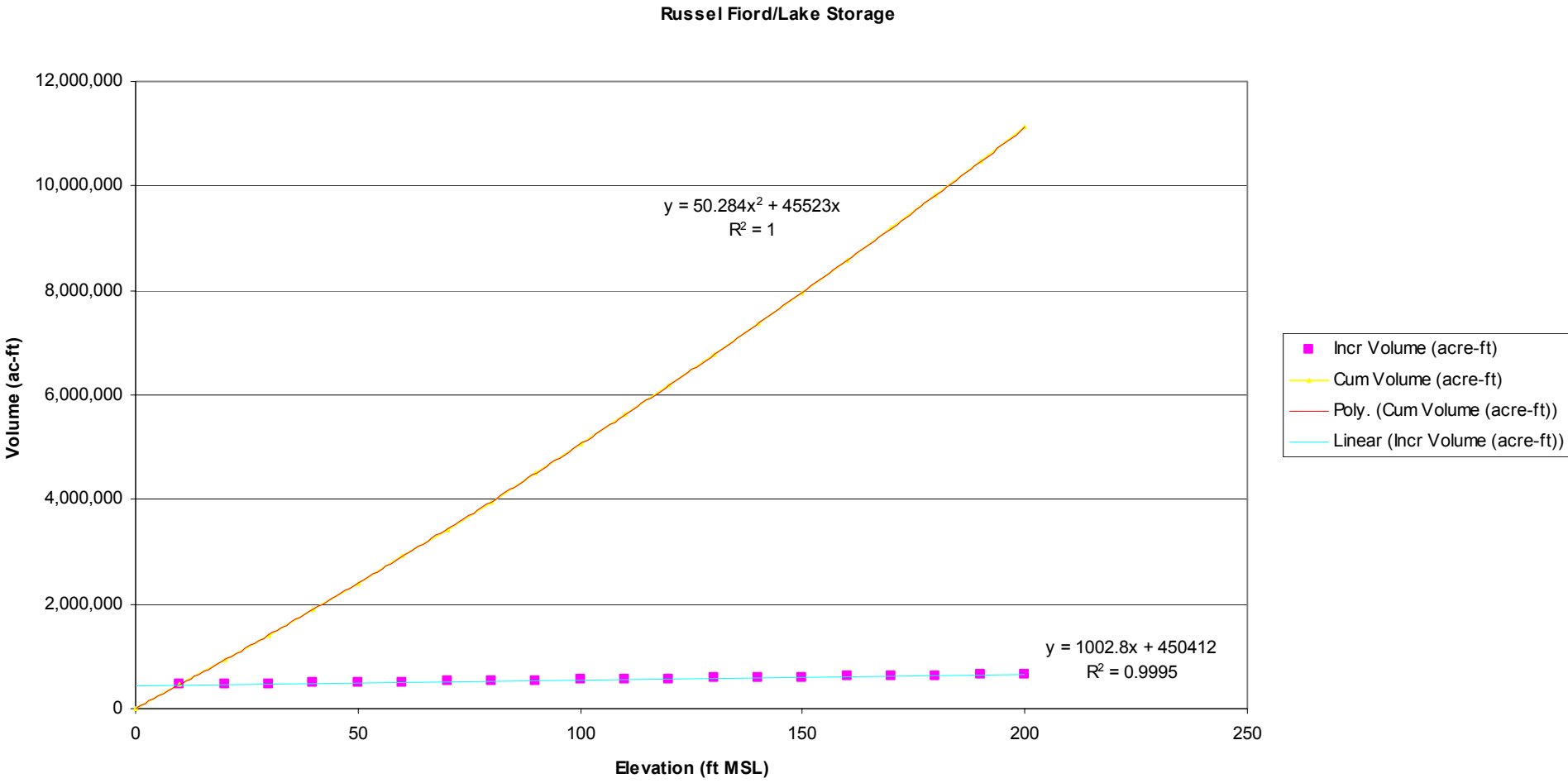
Hubbard Glacier



Russell Fiord/Lake

- 34 miles long and 1 -2 miles wide
- 75 sq mi surface area (at msl)
- Drainage area = 700 sq mi
  - mostly glaciated
  - how much inflow ??????
- Average depth = 1500 ft (at msl)
- Significant Storage
  - in excess of 8,000,000 ac-ft

Russel Lake Storage



Event History

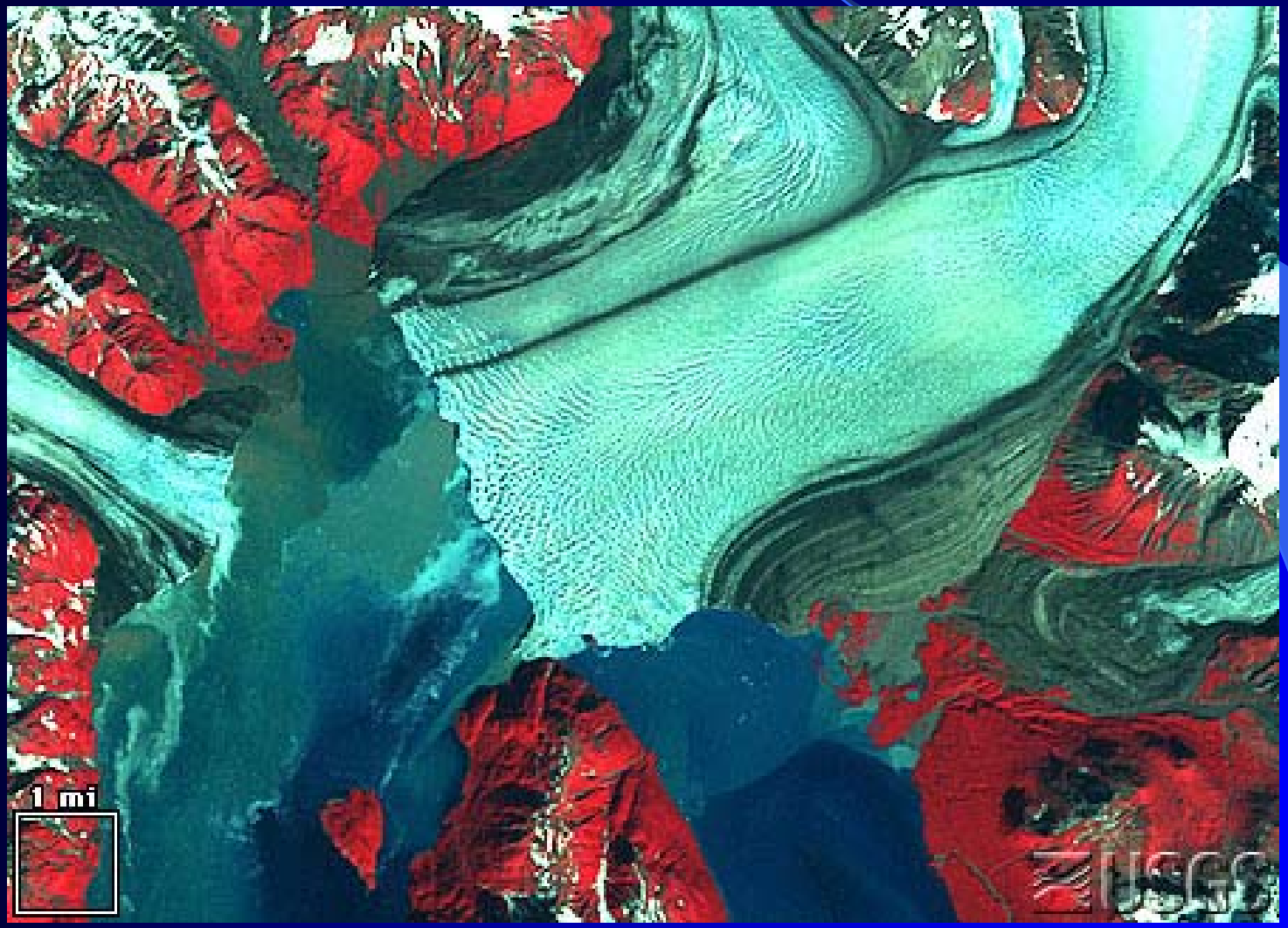
- Unwritten History - Native Lore
- Recent Temporary Closures / Outburst
  - 1986
  - 2002

1986 Closure and Outburst

Outburst Event (10/08/1986)

- Max Stage before outburst = 83 feet msl
- Completely drained “lake” in 23 hours
- Max Discharge = 3.7 million cfs
  - 1.7 trillion gpm
  - 2.5 times higher than Misssissippi @ Baton Rouge
- Volume Loss = 4.3 million ac-ft
  - 1.4 trillion gals.
- Largest outburst flood worldwide

June 2002



Push Moraine - June 2002

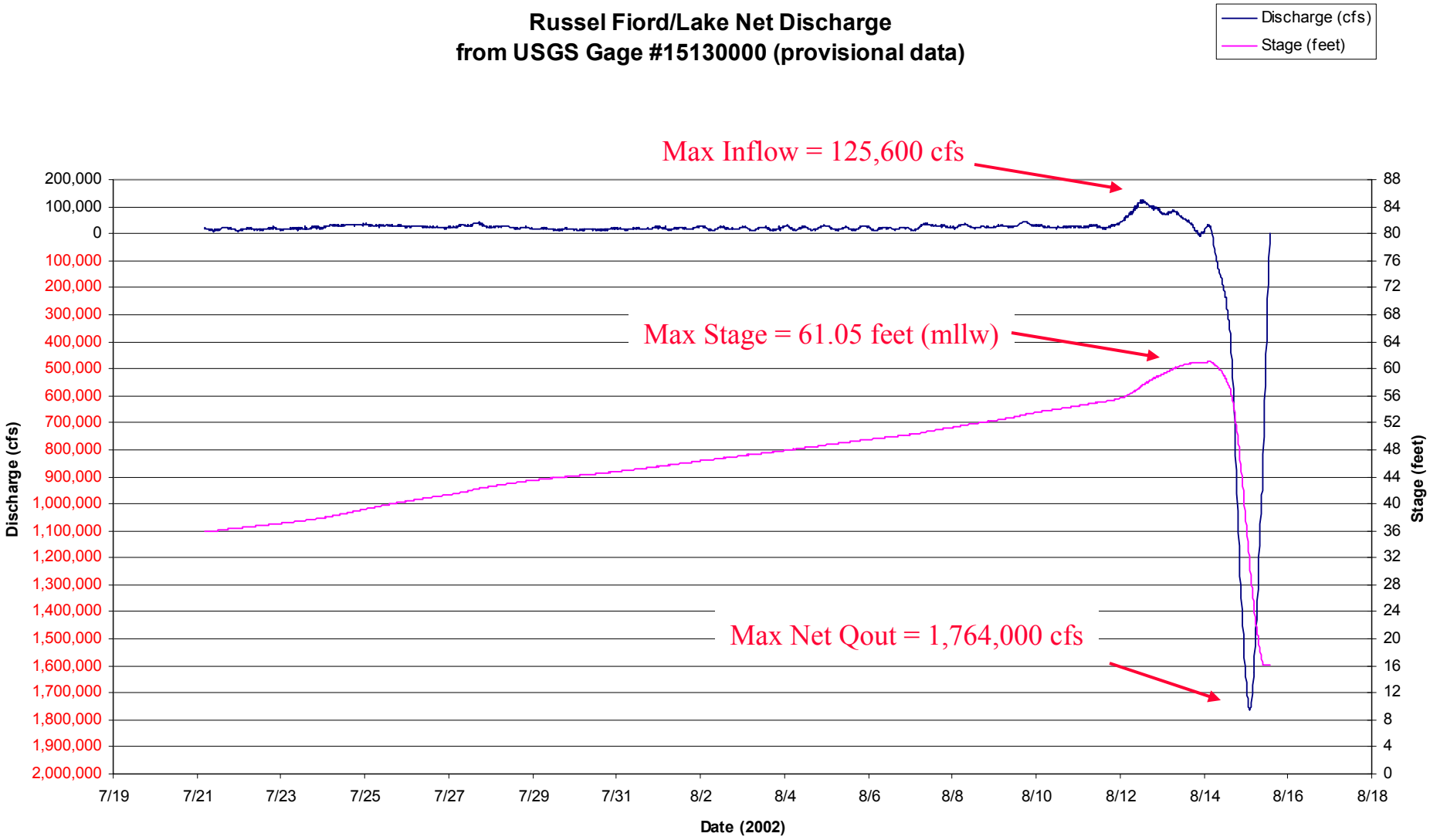
July 2002

August 2002

Outburst Event (8/14/02)

- Max Stage = 49 ft msl (61’ MLLW)
- Completely drained “lake” in 29 hours
- Max discharge = 1.8 million cfs
  - 790 billion gpm
  - 20percent higher than Mississippi R @ Baton Rouge
- Volume loss = 2,220,000 ac-ft
  - 722 billion gal.
- 2nd largest outburst flood worldwide

2002 Glacier Dam Failure




AP photo by A. Griollo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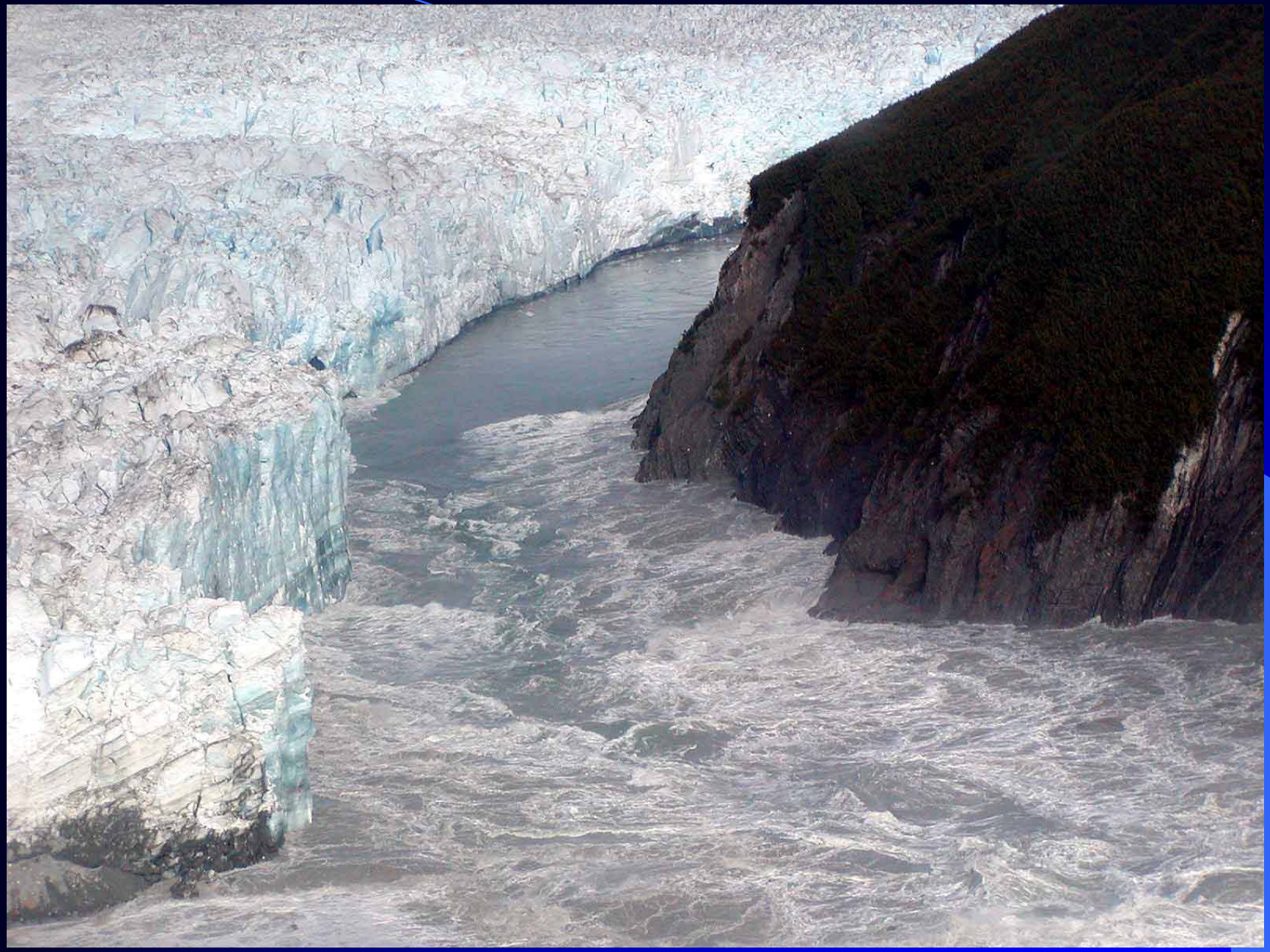
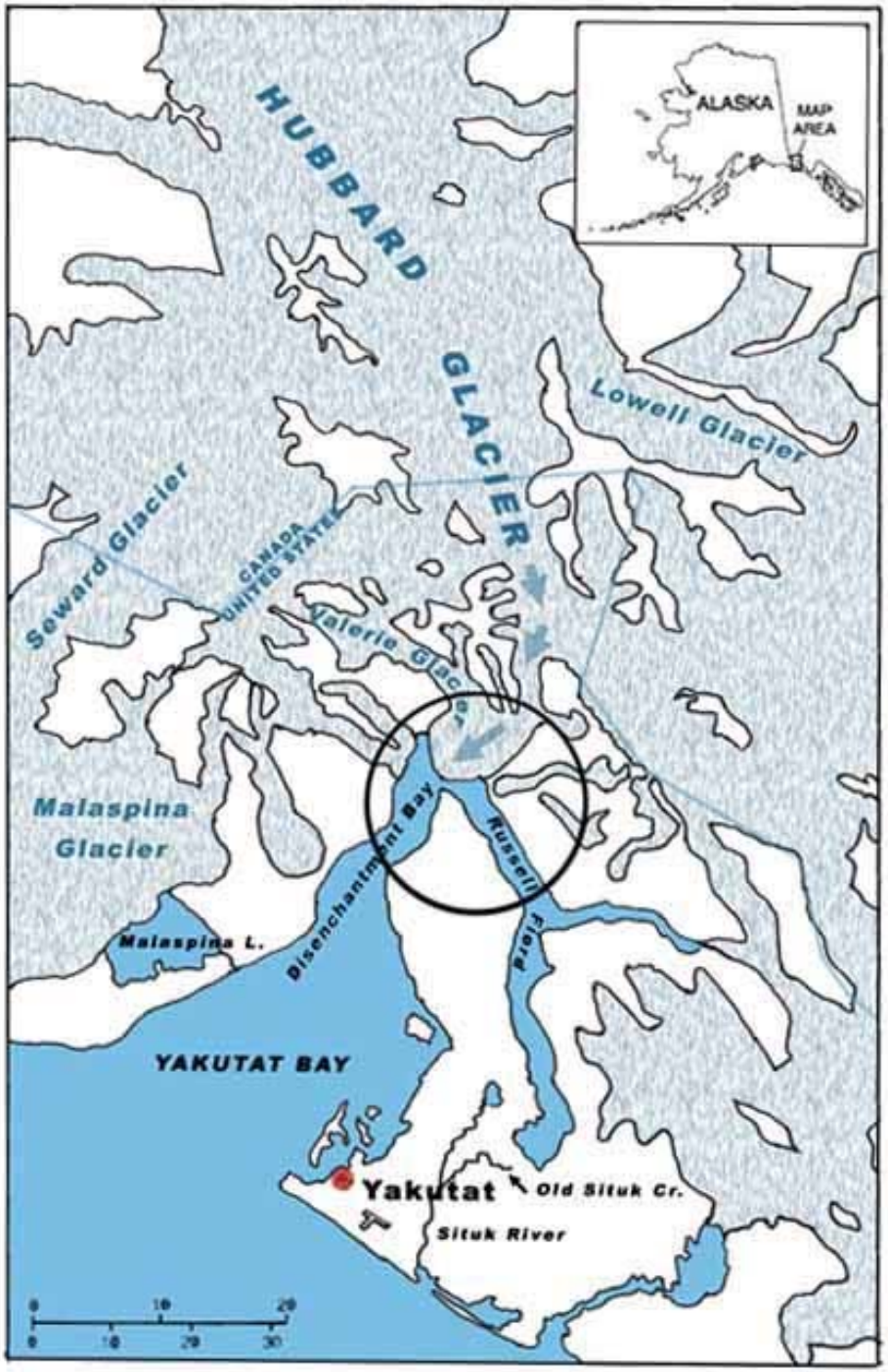
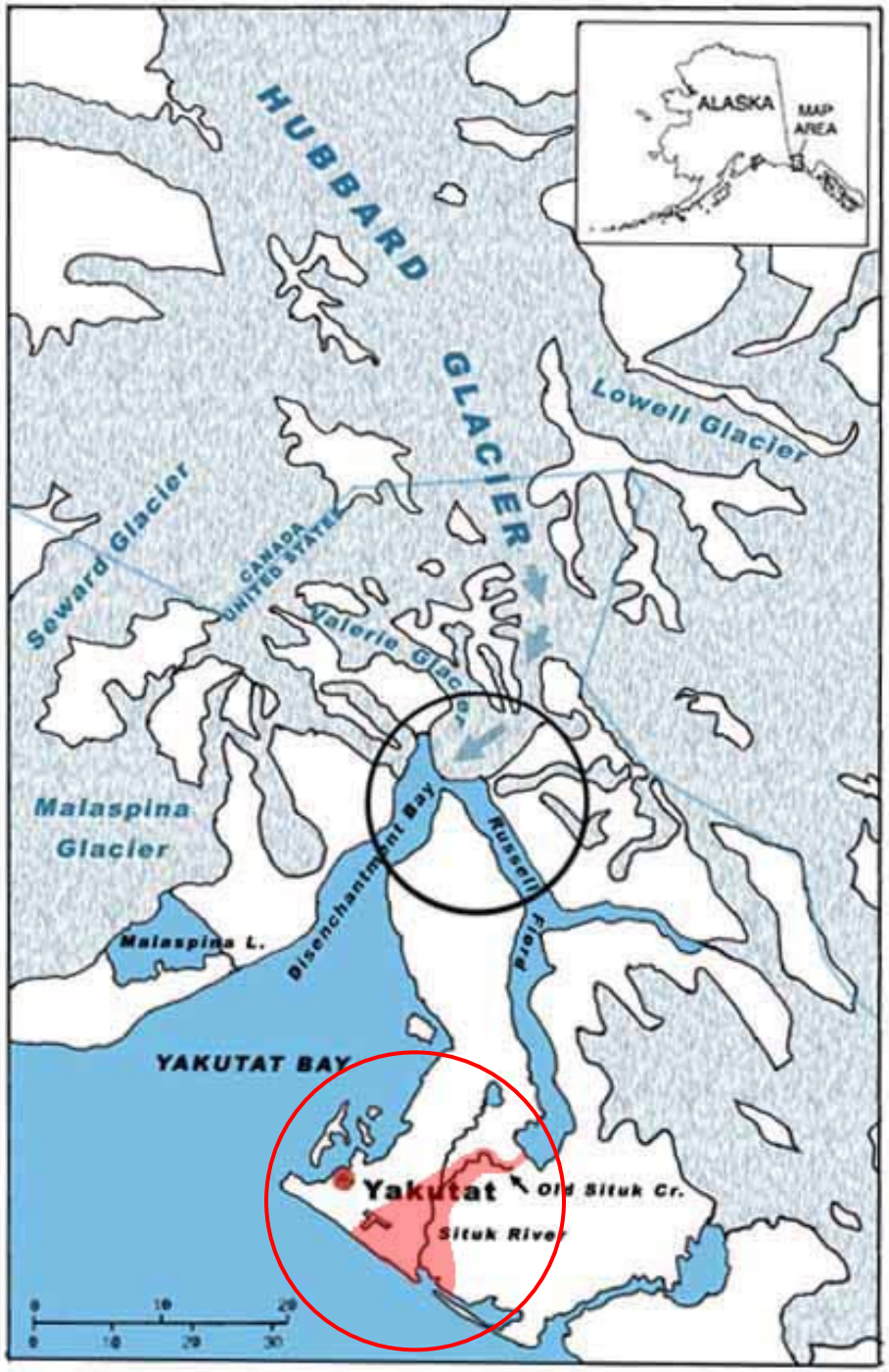


Consequences of a permanent glacier dam



Consequences of a permanent glacier dam

- Airport
- Situk River fisheries
  - Mean Annual 360 cfs
  - Peak 3840 cfs

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Situk River

- World Class
  - Steelhead
  - Salmon
- Primary economic basis for Yakutat
- Multi-million dollar industry

Ongoing and Future Studies

- Economic
- Topographic
  - Define spill-over points
  - Define outwash area
- Hydrology
  - Define expected inflow / frequency
- Geotechnical
  - "Spillway" stability
    - Some "armoring" evident at Old Situk Notch
      - Last flowed mid to late 1800's
    - Drilling program in a Wilderness Area?

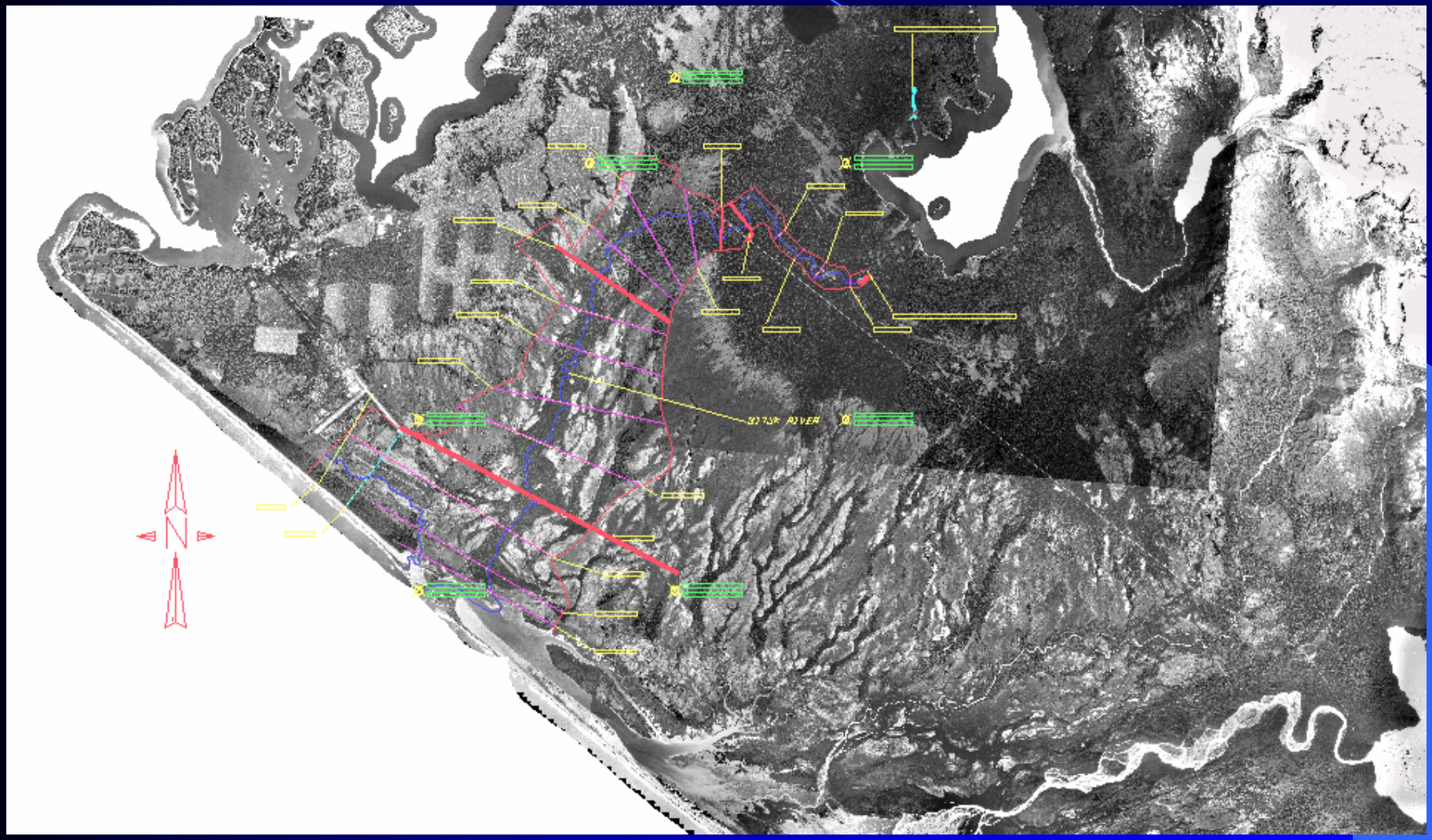
Ongoing and Future Studies

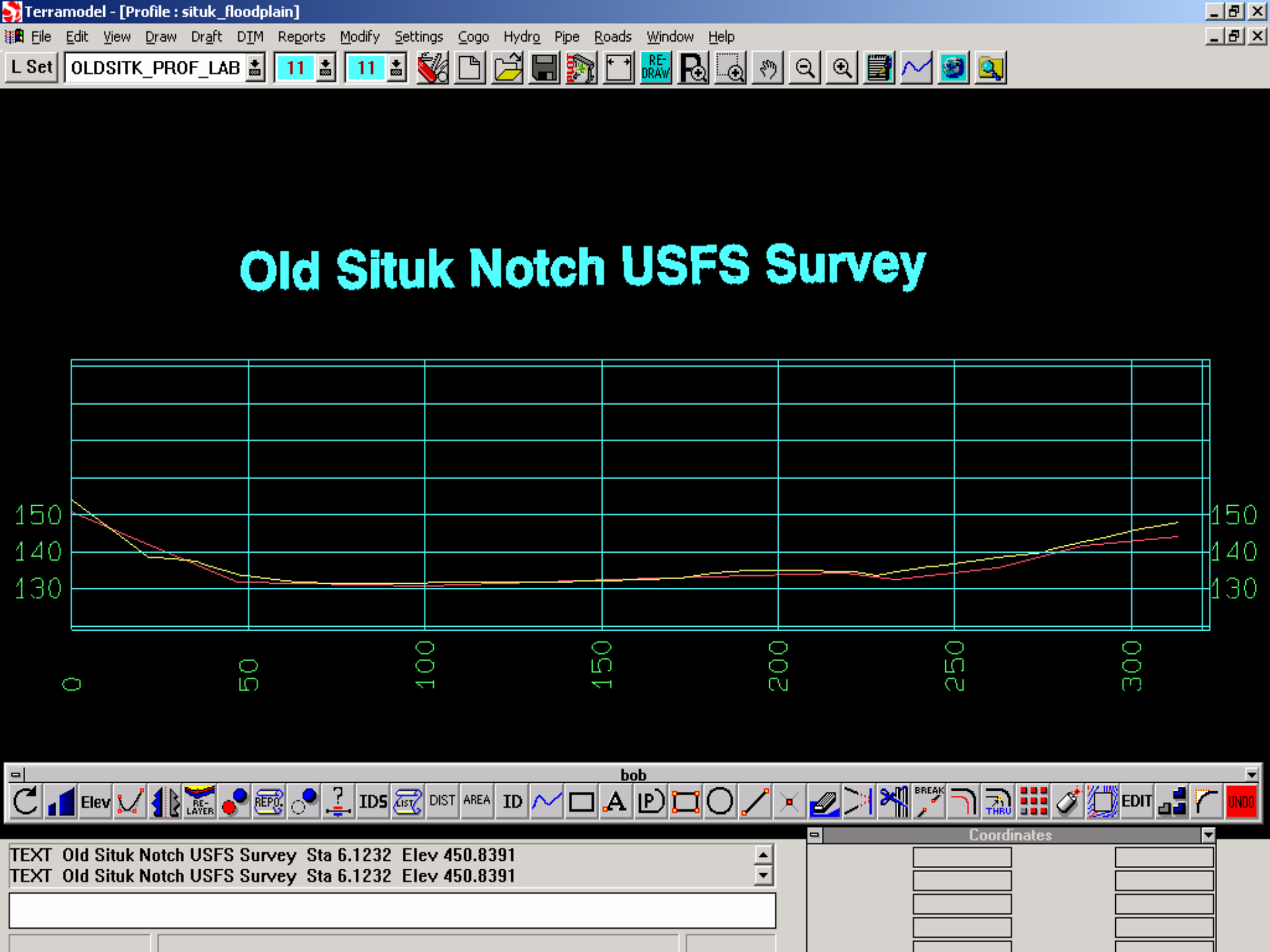
- Hydraulic
  - Define expected flows at spill-over points
    - One-dimensional rigid boundary - ongoning
    - One-dimensional sediment transport
    - Two-dimensional?
  - Define inundation downstream of spill-over
    - will need complete LIDAR survey
      - flat outwash plain
    - Channel formation processes?
      - will probably be braided
      - major component will be “debris islands” that divert/split flow
    - Hydraulic study
      - possible inundation width
      - impacts at Airport

Topographic Studies

- USFS 2002 Study
  - 48.2 sq-mi total area
  - LIDAR - $89,000 ($1850/sqmi)
  - Ground Truth Study - $275,000
    - GPS Control Network
    - Control Profiles

2002 LIDAR Survey

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File Edit View Draw Draft DTM Reports Modify Settings Cogo Hydro Pipe Roads Window Help
L Set
OLDSITK_PROF_LAB
11
11
RE-DRAW
Old Situk Notch USFS Survey
150
140
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0
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100
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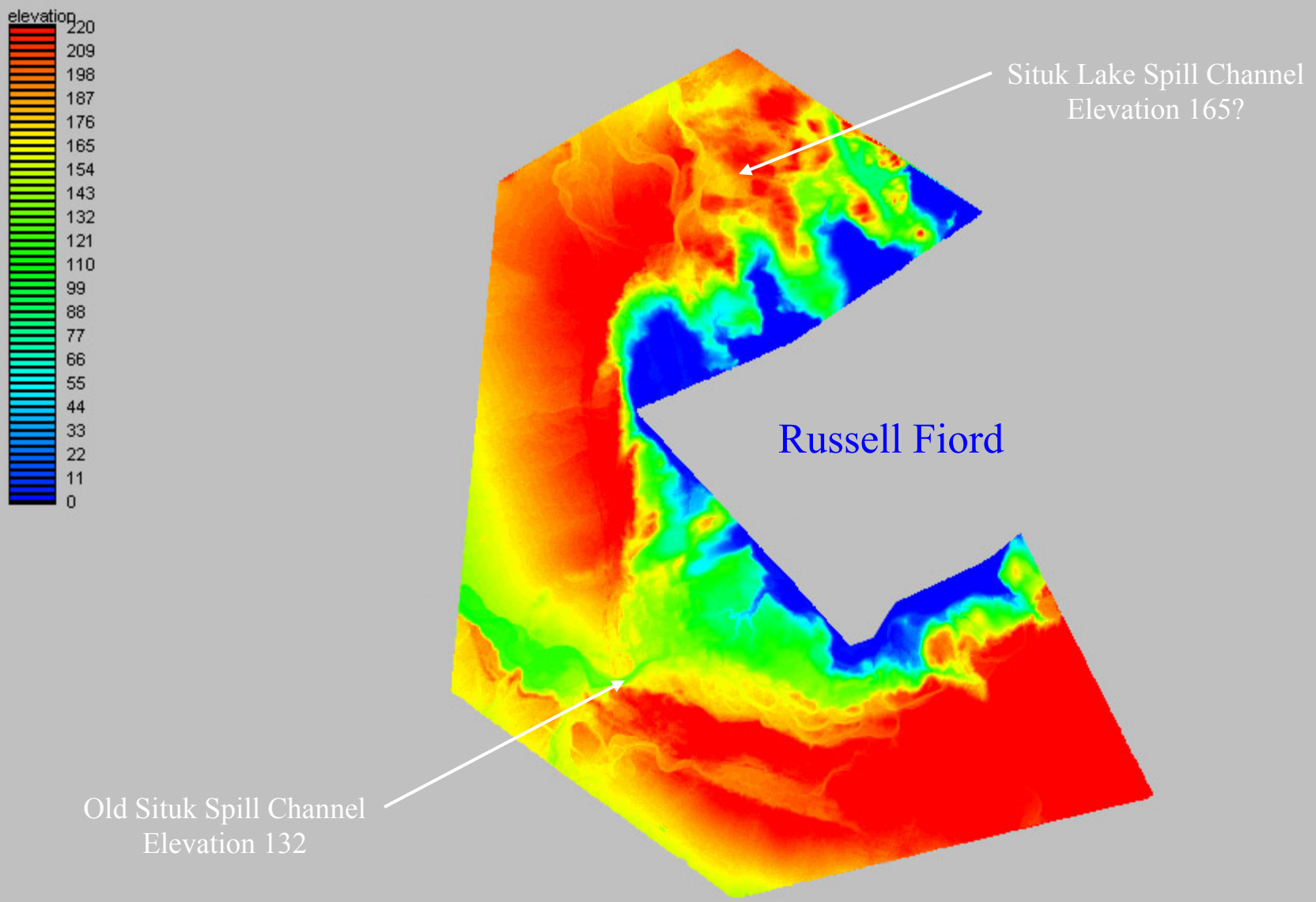
300
bob
Elev
RE-LAYER
REPO
IDS
LIST
DIST
AREA
ID
BREAK
THRU
EDIT
UNDO
Coordinates
TEXT Old Situk Notch USFS Survey Sta 6.1232 Elev 450.8391
TEXT Old Situk Notch USFS Survey Sta 6.1232 Elev 450.8391

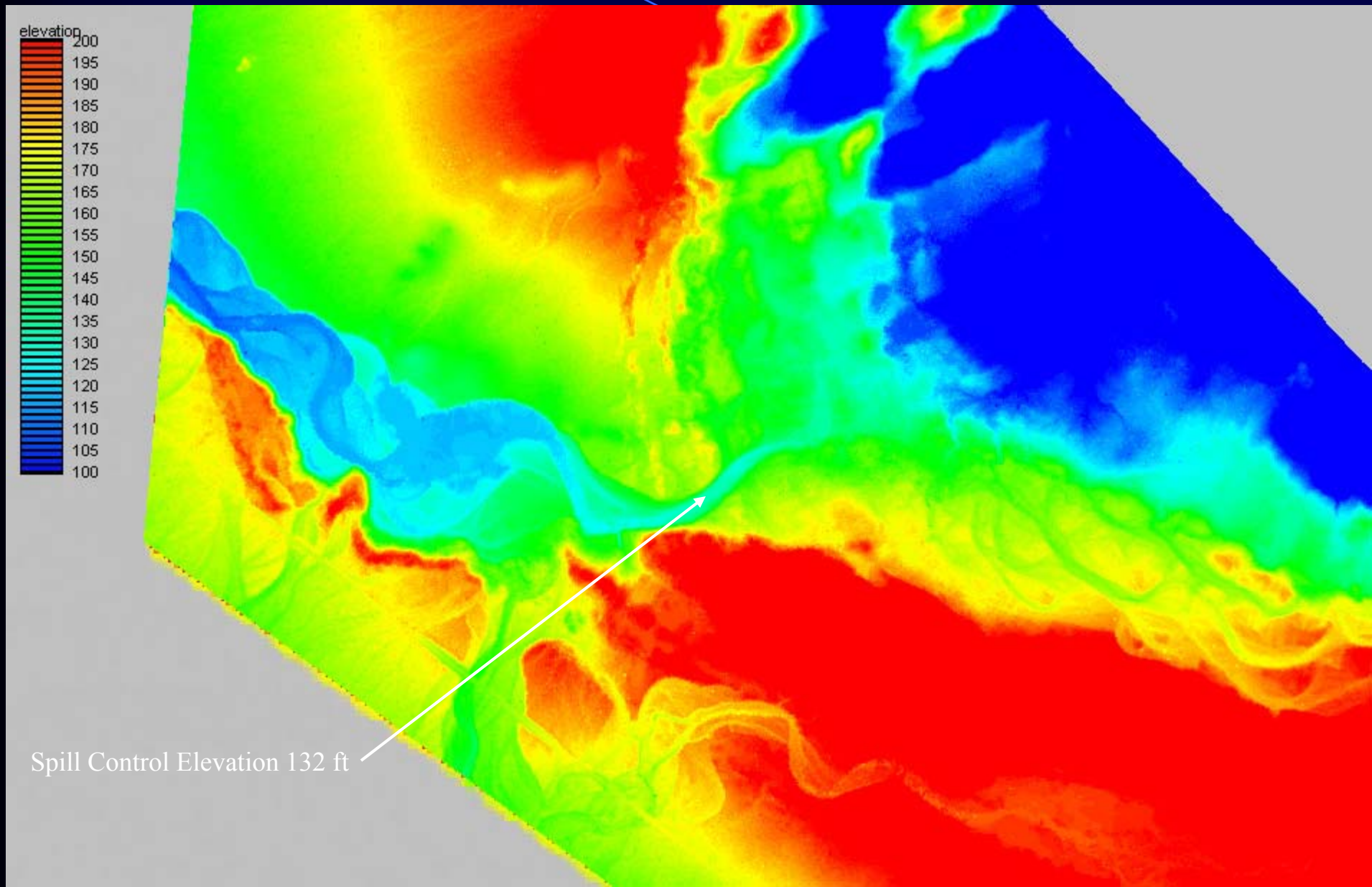
PRELIMINARY TERRAIN ANALYSIS RESULTS

- LIDAR survey appears to be very good, so far there is good agreement with all ground surveys
- LIDAR data penetrated vegetation well, even thought survey occurred during full leaf on conditions
- Hand removal of minor vegetation effects will be necessary to develop floodplain cross sections
- Data collected in the spring should be even better because of leaf off condition

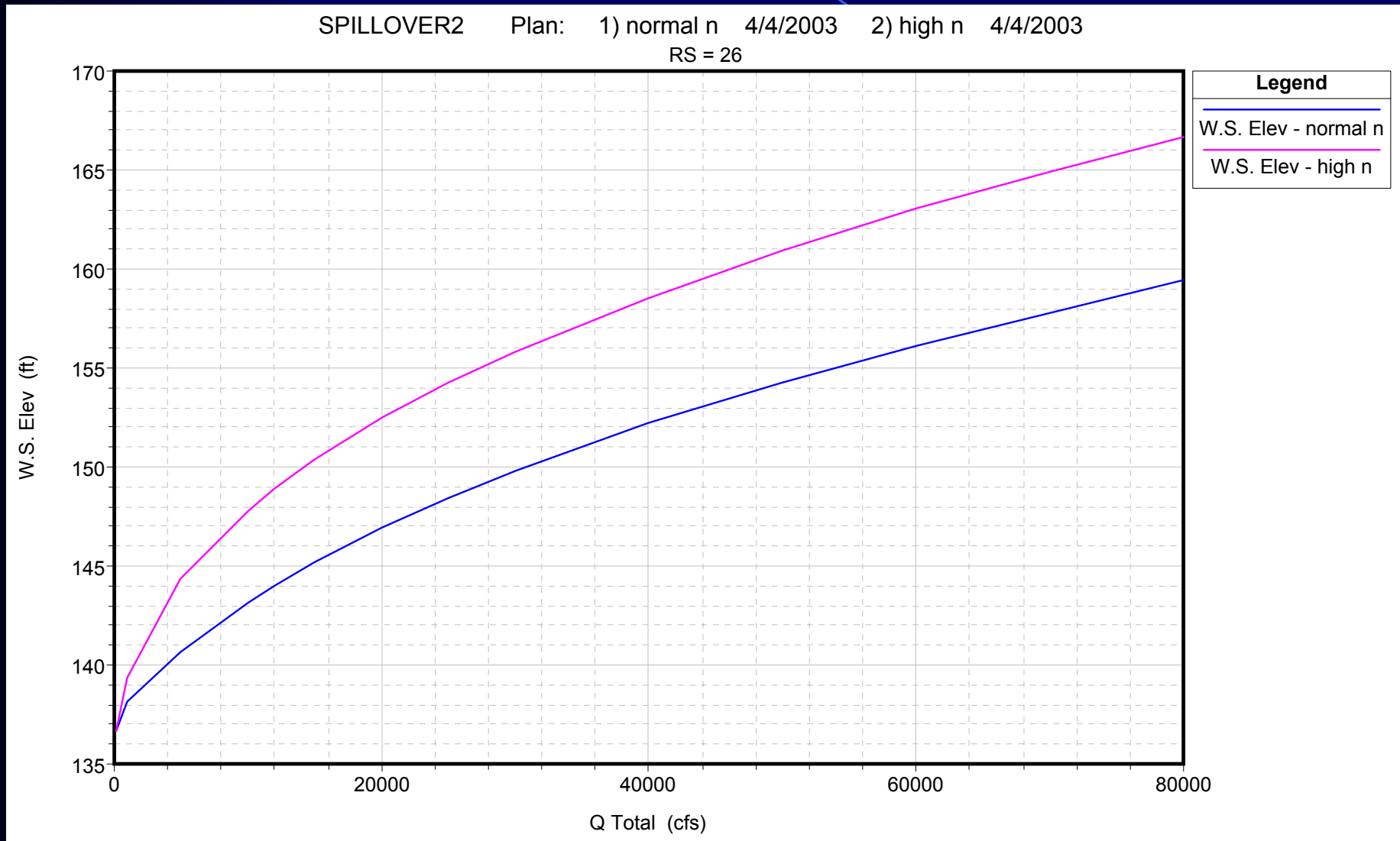
Moraine (from LIDAR)



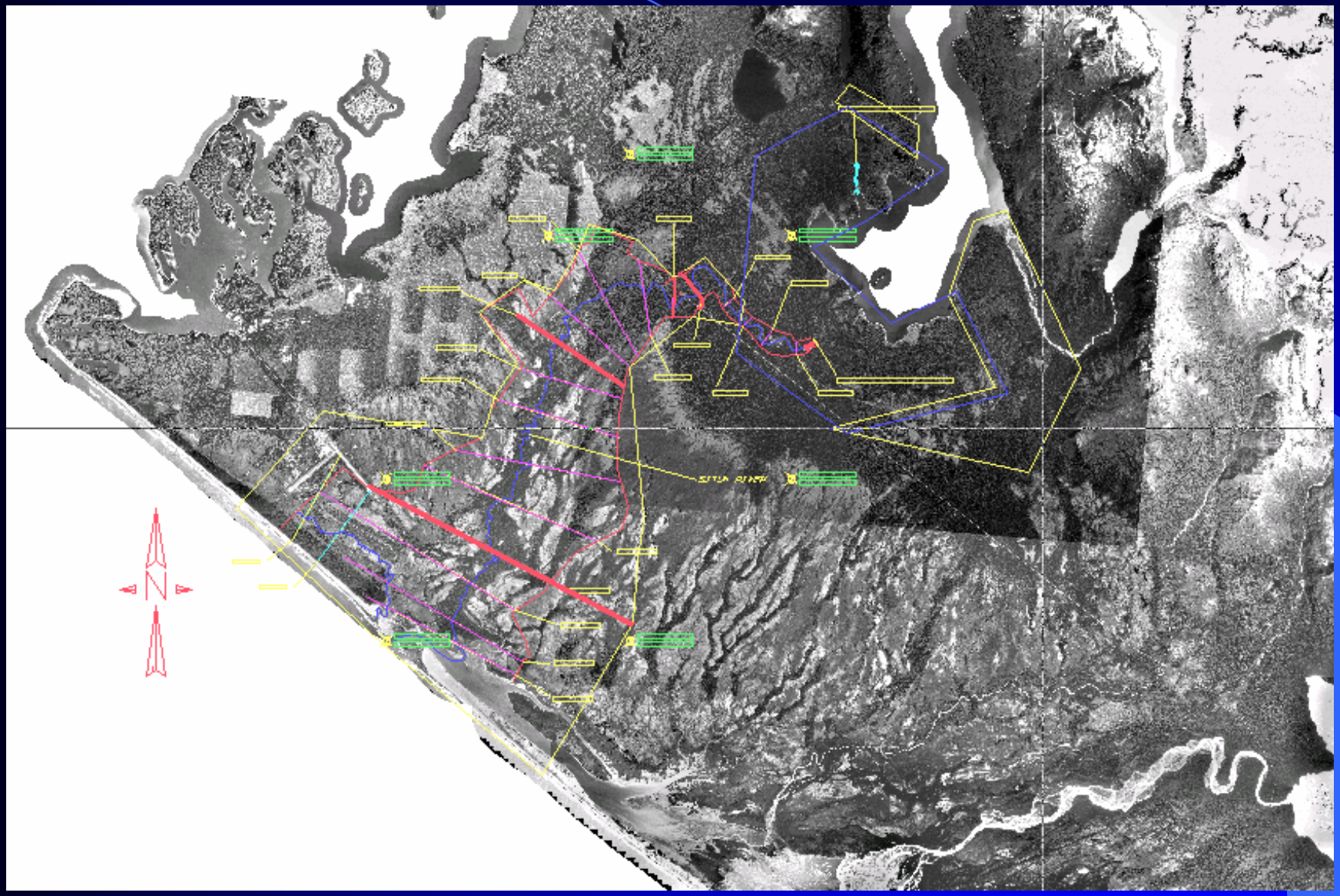
Old Situk Spill Channel



Old Situk Rating (HEC-RAS rigid boundary)



Proposed 2003 LIDAR



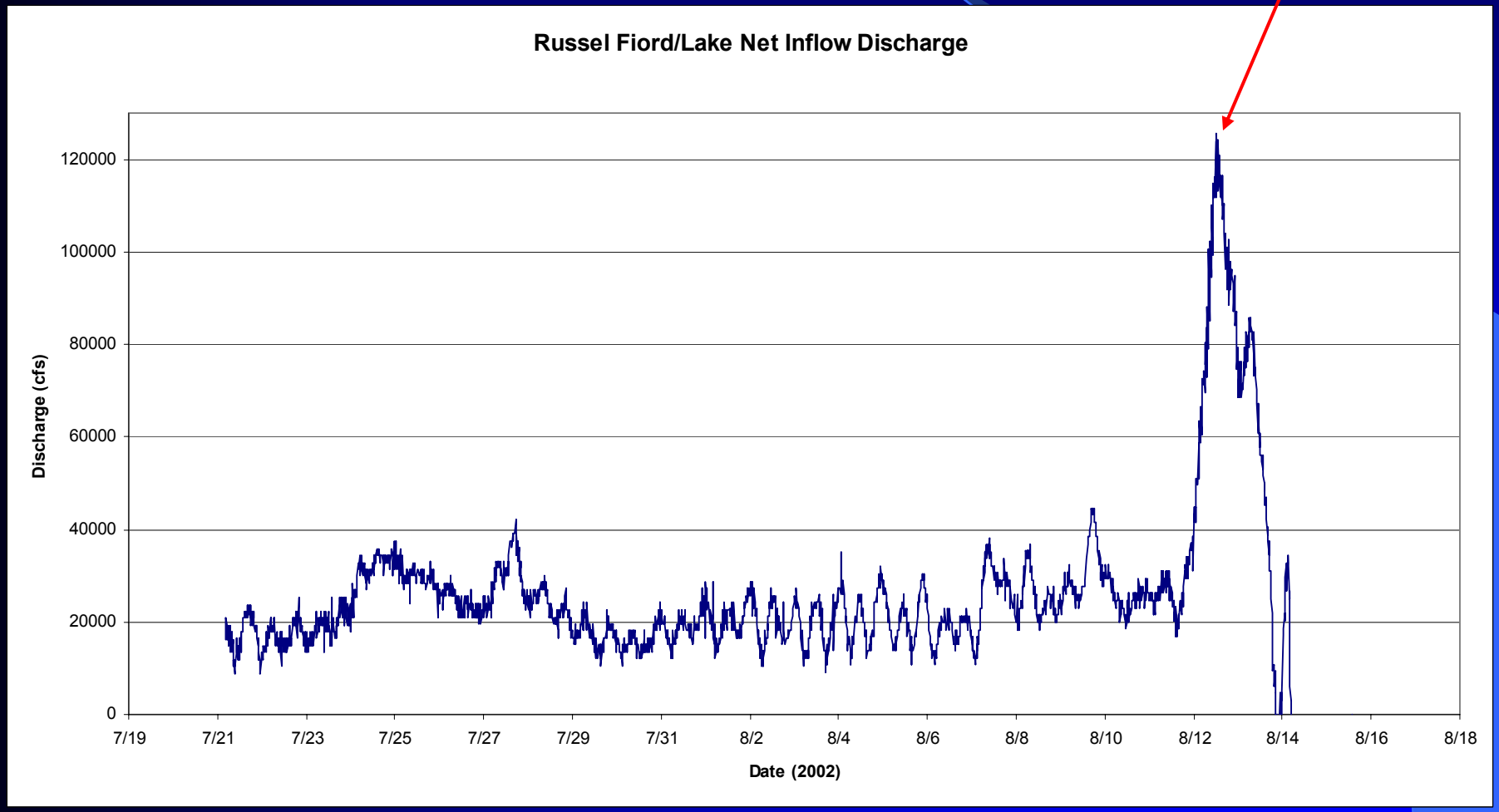
Hydrologic Studies

- Russel Lake Stage-Storage
- Inflow Discharge / Frequency
  - Problematic
    - large proportion of watersheds are glaciated
    - elevation ranges from sea level to 17,000+ ft.
    - what proportion of PPT is runoff vs permanent snow/ice?

2002 Inflow Rates

- USGS Stage Gage at Russell Lake
  - Extremely short record
  - Rate of rise during 2002 dam event can be converted to inflow discharge
    - minimum - 8900 cfs
    - mean - 22,700 cfs (pre-storm)
    - max - 44,600 (pre-storm)
    - max - 125,600 cfs
      - this peak flow resulted from rainfall that was less than the 1-yr 24-hr rainfall for Yakutat.
      - 19 percent exceedence for month of August
      - 3-day rainfall was 6.15”, max record (54 years) is 15.36”
      - fall rains usually greater

Inflow Discharge



Russell Lake Filling (2002)

- Discharge
  - Max = 44,600 cfs (before storm leading to failure)
  - Average = 22,700 cfs
- Rate of Rise
  - Min = 0.6 feet per day
  - Max = 1.3 feet per day
  - Average = 0.9 feet per day

Prediction of Long-term Inflow Rates

- Difficult to predict with existing data
- Maximum Inflow will be significant
  - 125,600 cfs resulted from a common rainfall
    - 6.15 inches vs max of 15.36 inches (3-day)
  - Heaviest rainfall in late fall and early winter
  - What is a reasonable estimate
    - Q50 (net) = 300,000 cfs?
- Qin = Qout ? Spillway Characteristics?


New “Situk River” will be
LARGE and braided

Hydraulic Studies, 2003+

- Outwash plain inundation
  - estimate width of inundation
    - probably greater than 1 mile
  - identify possible geomorphic processes
  - debris islands
  - identify possible new breach locations in barrier beach
- Airport inundation study
  - impacts to facilities / runways
  - identify possible mitigation scenarios

Questions?