Where Does Sediment Come From?

Sediment Storage Dynamics in the Lower Sauk River Watershed

Scott Anderson, U.S. Geological Survey
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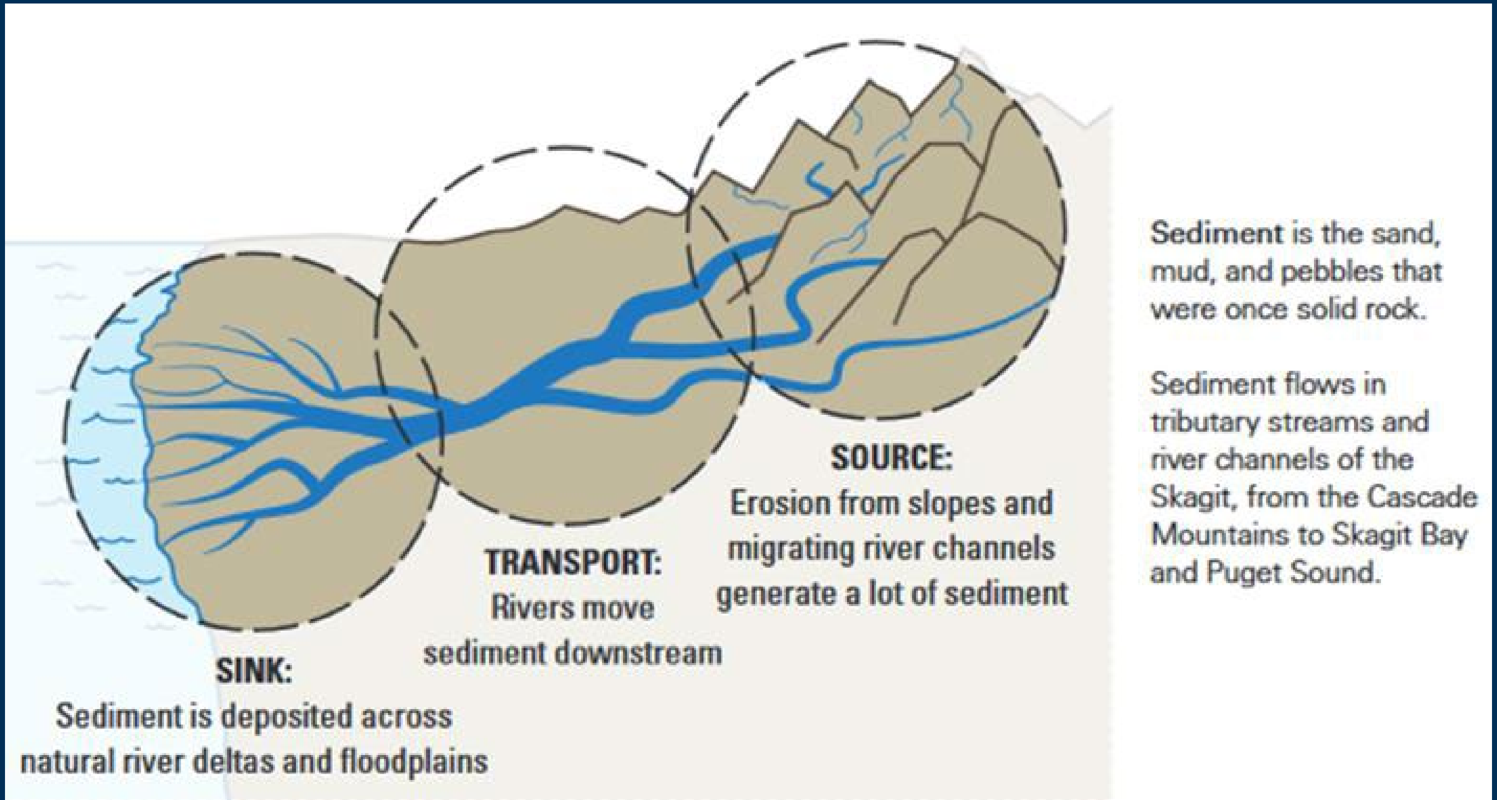
Background



http://www.skagitclimatescience.org/skagit-impacts/sediment/

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Background

- **Transient sediment storage in ‘transport’ zones can decouple upland sediment production from lowland transport over ‘short’ (geologic) timescales**

- **Recent studies have reiterated contemporary importance of sediment storage dynamics in western WA rivers**

Differentiating the effects of logging, river engineering, and hydropower dams on flooding in the Skokomish River, Washington, USA

Brian D. Collins [a,*], Susan E. Dickerson-Lange [b,1], Sarah Schanz [a,2], Shawn Harrington [a,3]

[a] Department of Earth and Space Sciences, University of Washington, Seattle, WA, United States of America
[b] Department of Civil and Environmental Engineering, University of Washington, Seattle, WA, United States of America

Collins et al., 2019

Western Washington University
Western CEDAR

WWU Graduate School Collection | WWU Graduate and Undergraduate Scholarship

Fall 2017

Sediment Budget of the Middle Reach Skagit River, Washington 1937-2015 Reveals Decadal Variations in Sediment Export and Storage

Amelia Deuell Rothleutner
Western Washington University, amelia.deuell@gmail.com

Rothleutner, 2017

Morphodynamics and sediment tracers in 1-D (MAST-1D): 1-D sediment transport that includes exchange with an off-channel sediment reservoir

J. Wesley Lauer [a,*], Enrica Viparelli [b], Hervé Piégay [c]

[a] Department of Civil and Environmental Engineering, Seattle University, 901 12th Avenue, Seattle, WA 98122-1090, USA
[b] Department of Civil and Environmental Engineering, University of South Carolina, 300 Main St., Columbia, SC 29208, USA
[c] Ecole Normale Supérieure de Lyon, 15 Parvis René Descartes, Bureau R. 241 - Bat. Recherche BP 7000, 69342 Lyon cedex 07, France

Lauer et al., 2016

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Coarse sediment dynamics in a large glaciated river system: Holocene history and storage dynamics dictate contemporary climate sensitivity

Scott W. Anderson[†] and Kristin L. Jaeger
U.S. Geological Survey, Washington Water Science Center, Tacoma, Washington 98402, USA

Anderson and Jaeger, 2020

Water Resources Research

RESEARCH ARTICLE
10.1029/2020WR028389

Frequent Mass Movements From Glacial and Lahar Terraces, Controlled by Both Hillslope Characteristics and Fluvial Erosion, are an Important Sediment Source to Puget Sound Rivers

Daniel N. Scott[1] and Brian D. Collins[1]

[1] Department of Earth and Space Sciences, University of Washington, Seattle, WA, USA

Key Points:
- Glacial and lahar terraces deliver sediment to Puget Sound Rivers primarily via frequent, small mass movements
- Terrace sediment has a substantial coarse-grained fraction, is likely resistant to attrition, and is delivered low in river networks

Scott and Collins, 2021

RESEARCH ARTICLE — ESPL WILEY

Spatial and temporal controls on proglacial erosion rates: A comparison of four basins on Mount Rainier, 1960 to 2017

Scott W. Anderson[1] | David Shean[2]

Anderson and Shean, 2021

USGS

Motivation

- **Need reasonable understanding of present-day sediment and channel dynamics before we can forecast potential climate impacts**
- **Need contemporary understanding and potential future changes for effective river and floodplain management**

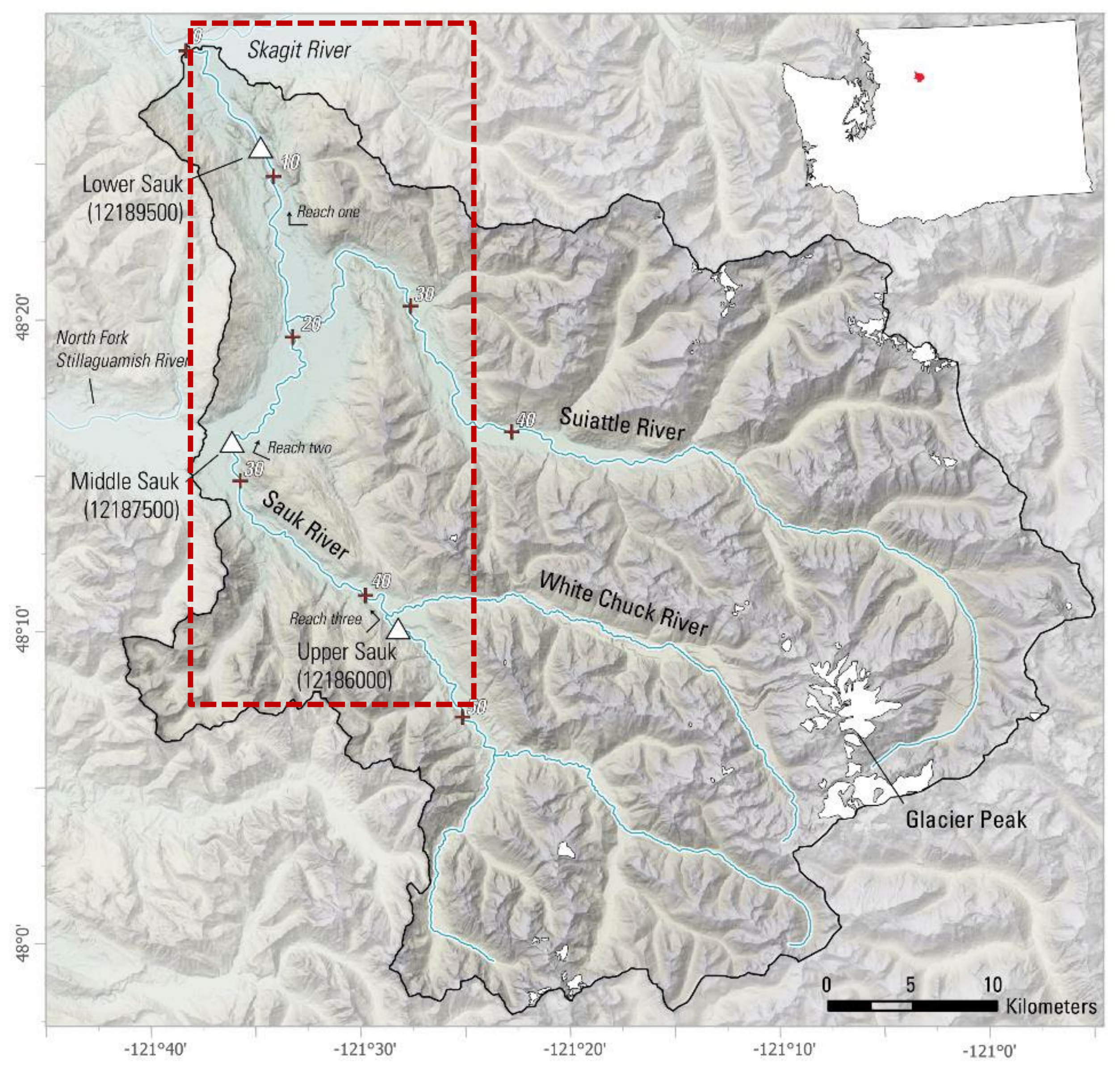
Photo: Whatcom County

https://www.skagitwatershed.org/
Photo: John R. McMillan NOAA/NWFSC

https://www.pugetsoundinstitute.org/ Photo: Kitsap Public Health District

Sauk River Watershed

- **Major unregulated tributary of the Skagit**
- **Watershed includes all of Glacier Peak**
- **Supplies ~30-50% of lower Skagit River sediment load**
  (Curran et al., 2016; Jaeger et al., 2017)



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Overview

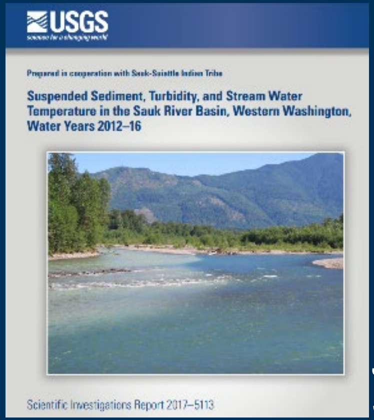
- Sediment transport monitoring
- Repeat topography

(Sediment transport monitoring and Repeat topography → Lower river sediment budget)

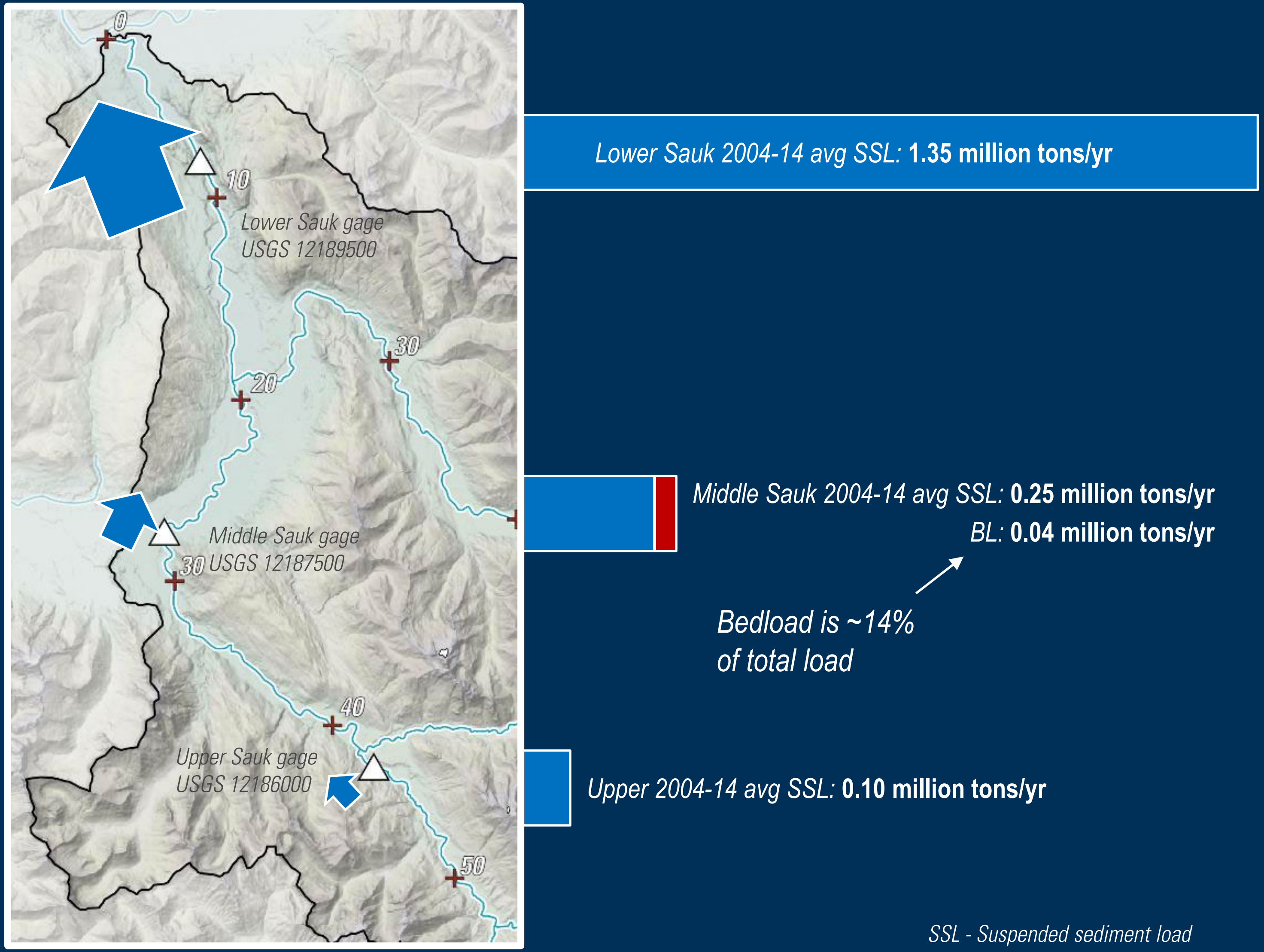
- Gravel lithology
- Knit all together

Sediment Flux Monitoring

- Suspended sediment monitoring at three locations along Sauk River
  - Using mass-balance to estimate inputs from Suiattle, White Chuck
- Bedload measurements at Middle Sauk gage (USGS 12187500) near Darrington



Jaeger et al., 2017
Supported by Sauk-Suiattle Indian Tribe

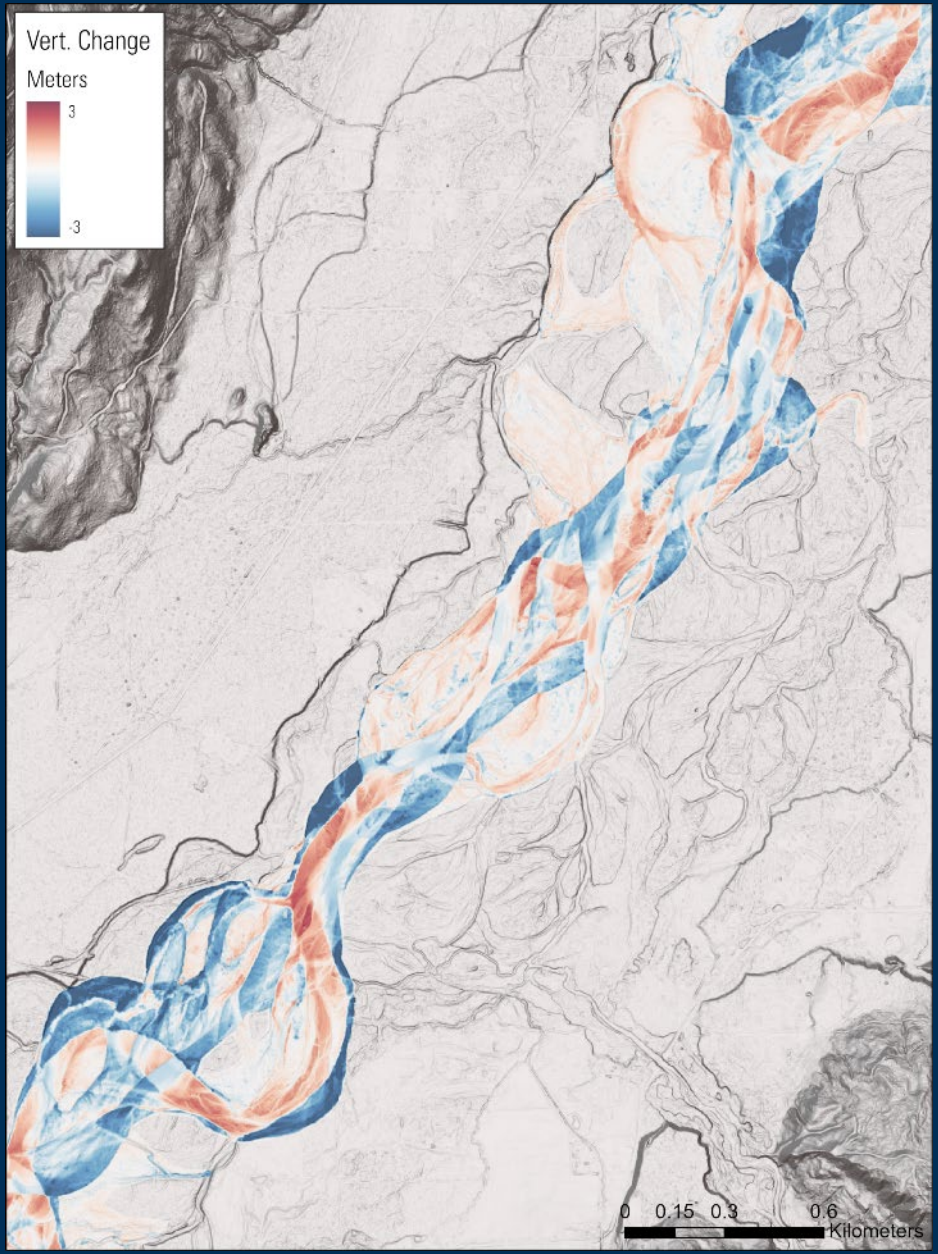


SSL - Suspended sediment load
BL - Bedload

Repeat Topography

- Using repeat aerial lidar surveys to quantify sediment storage gains/losses

- Relatively complete surveys in ~2004 and 2014/16



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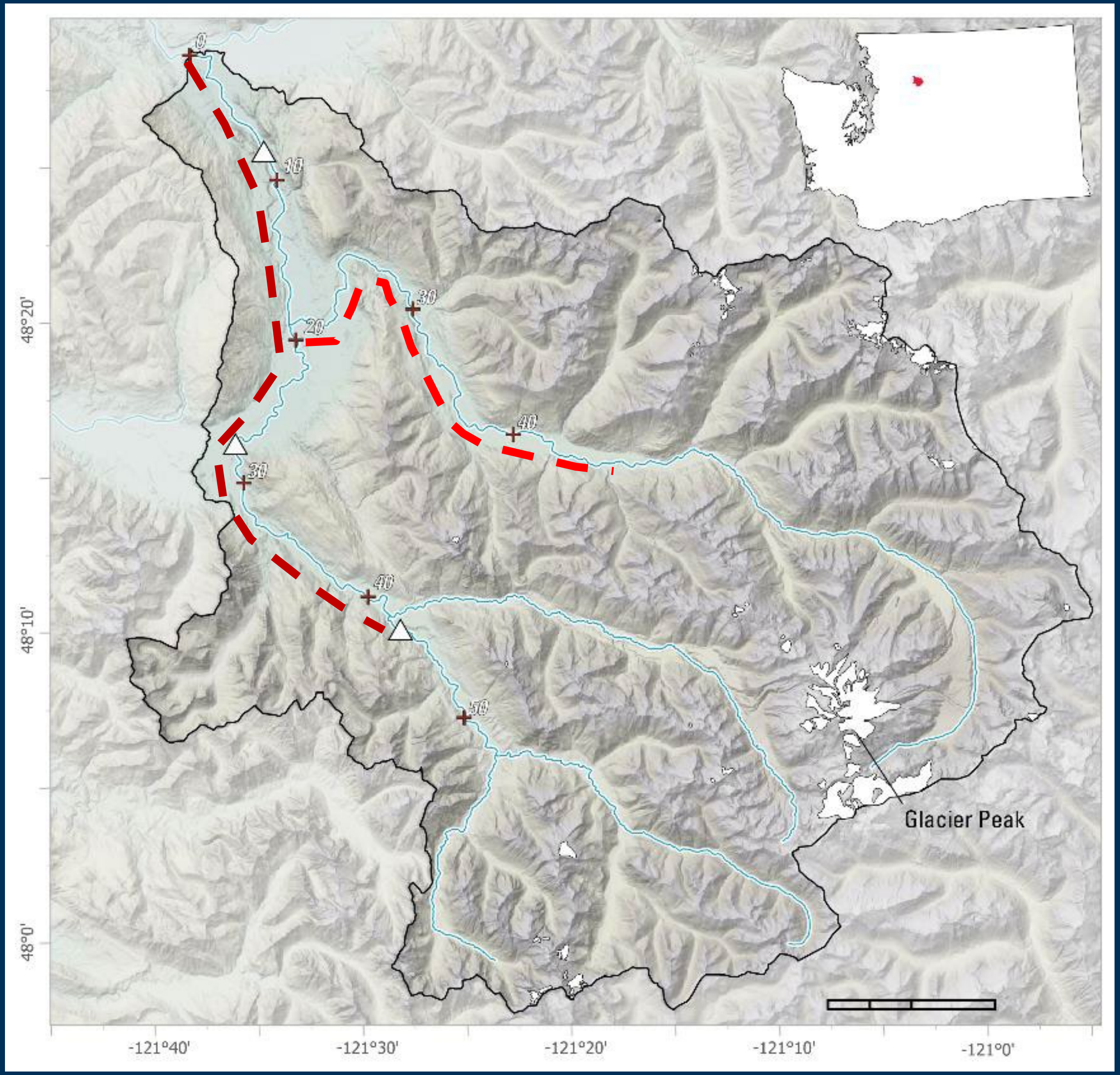

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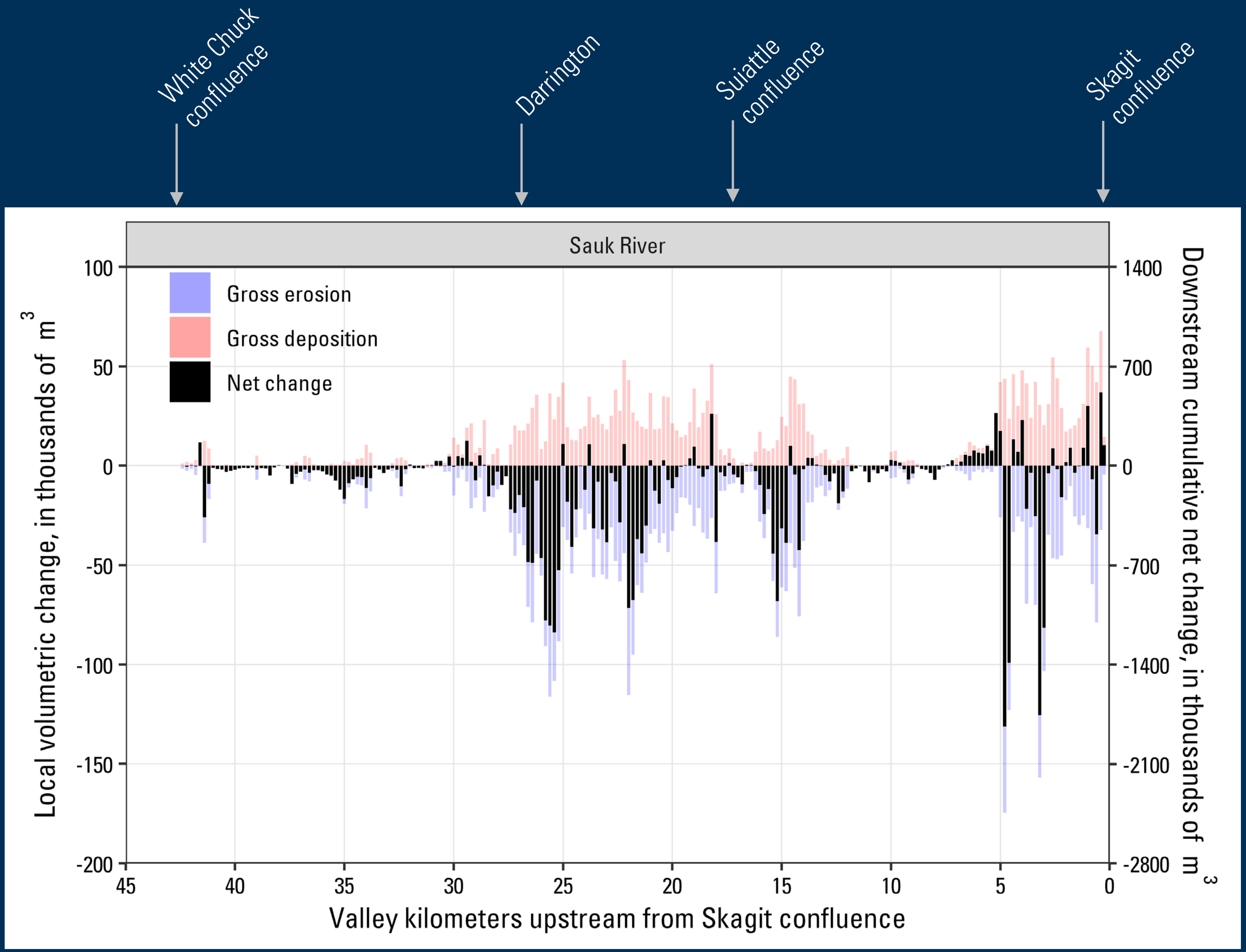
Repeat Topography

From 2004 to 2014 (ish):

- Negative storage trend throughout the Sauk



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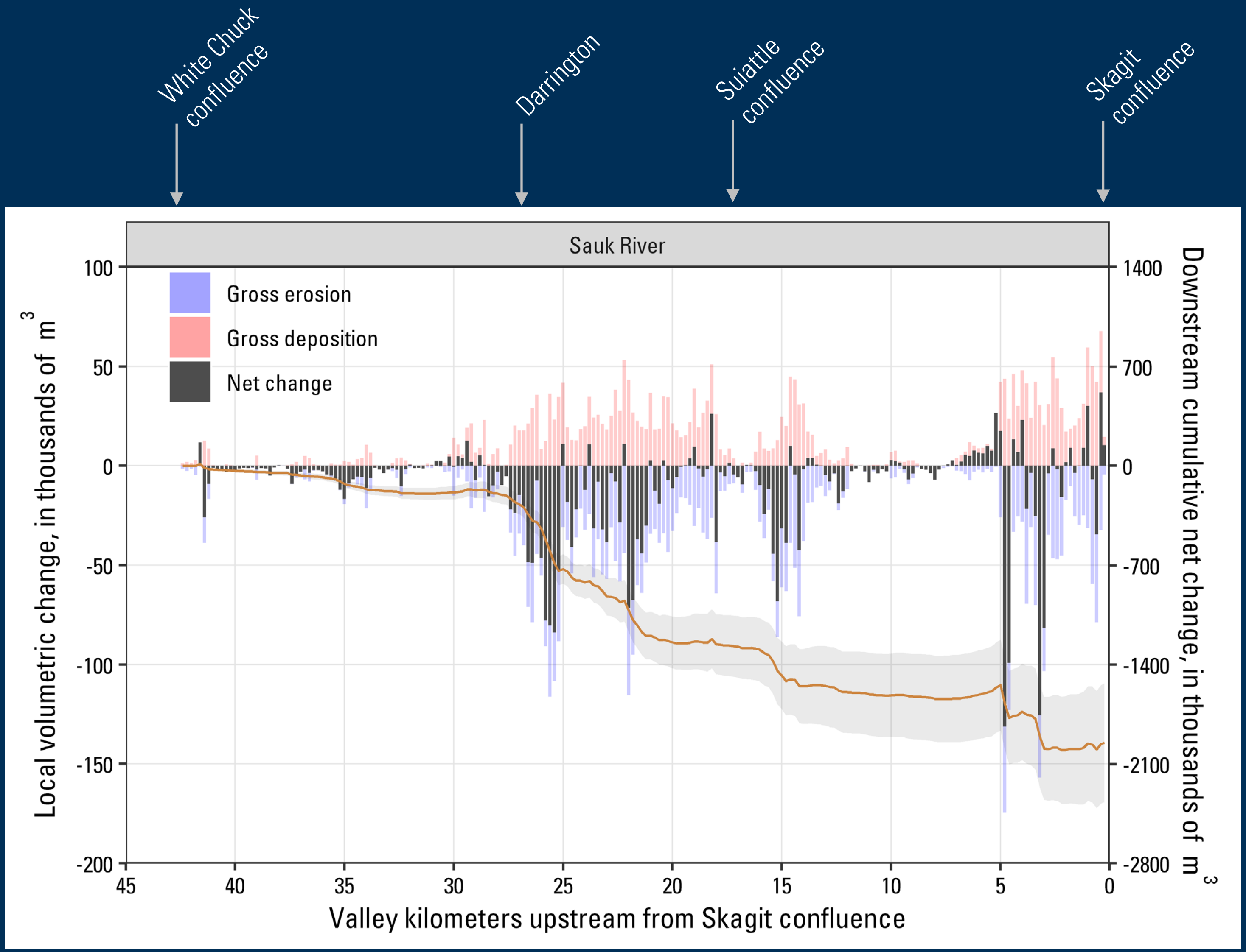
Results preliminary and subject to change

Repeat Topography

From 2004 to 2014 (ish):

- **Negative storage trend throughout the Sauk**
- **Total: ~2.0 million m^3**
- **~0.36 million tons/yr**
  - ***Assume 2 tons/m^3***



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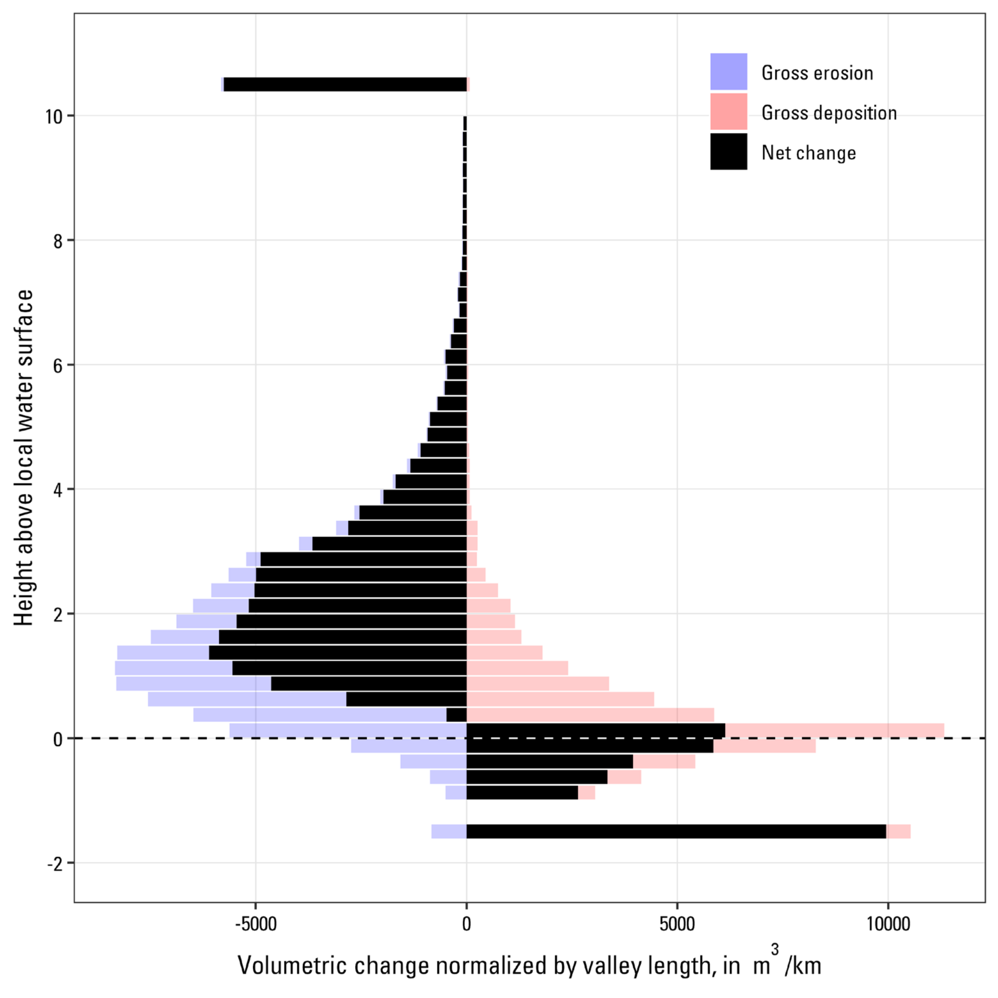

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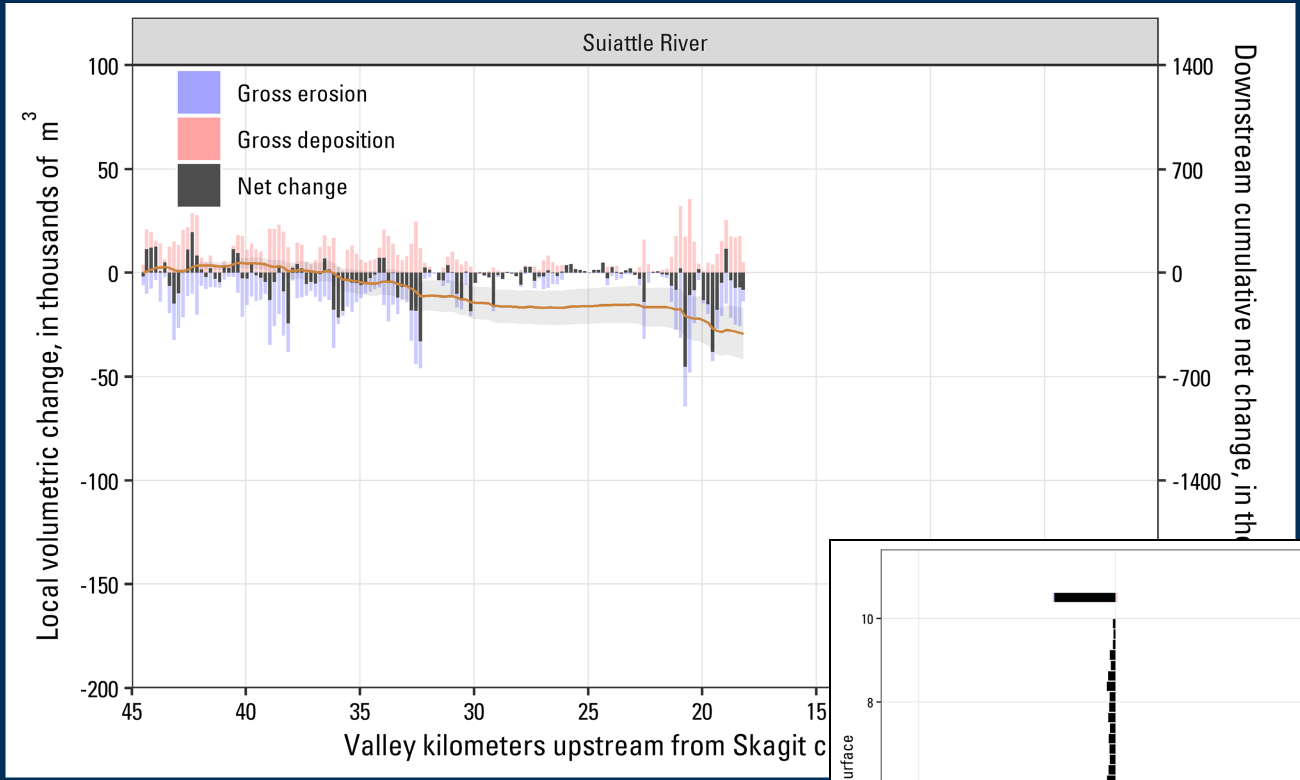
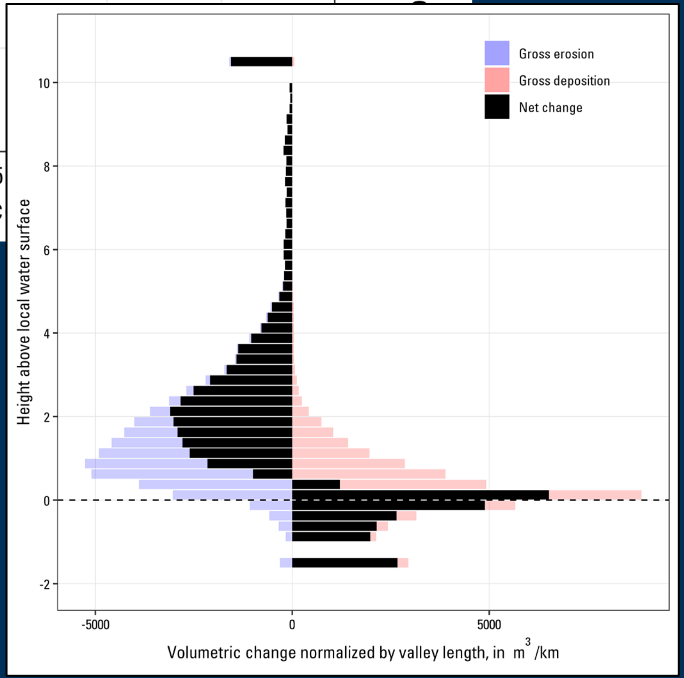
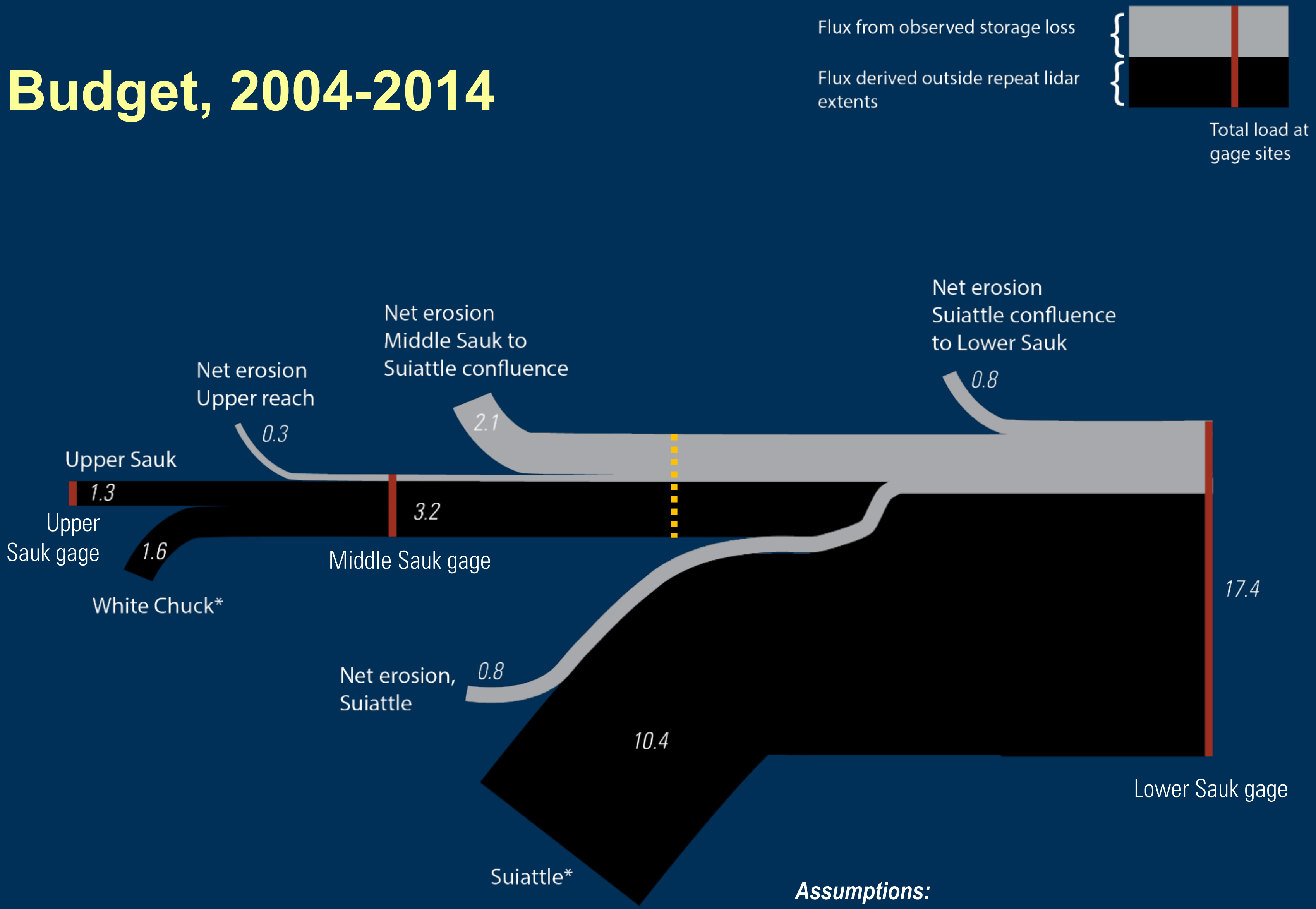




Results preliminary and subject to change

Integrated Sediment Budget, 2004-2014

- **Valley floor erosion within available data limits accounted for ~25% of total sediment flux past the lower Sauk gage**
- **Seems reasonable that relative contribution of bed material would be higher**



Line width, numbers indicate estimated total sediment flux from 2004-14 in millions of tons

Assumptions:

-Uniform bulk density of 2.0 tons/m^3

-Bedload is 14% of total load at gage sites

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Results preliminary and subject to change

Gravel Lithology

- Following in Allison's footsteps
- Sieved gravels to 32-64 mm fraction; sorted out and weighed vesicular Glacier Peak Dacite
  - Lahars, pyroclastic debris
- Attempt to characterize relative importance of Glacier Peak gravel input, including secondary re-working of valley deposits

JGR Earth Surface

RESEARCH ARTICLE
10.1029/2021JF006455

Key Points:

- We present a new method for rapidly quantifying baseline abrasion rate in the field via Schmidt Hammer Rock Strength
- Abrasion is extremely effective at this site due to vesicular volcanic rocks, yet easy to underestimate using simplistic sampling approaches

Survival of the Strong and Dense: Field Evidence for Rapid, Transport-Dependent Bed Material Abrasion of Heterogeneous Source Lithology

Allison M. Pfeiffer[1], Susannah Morey[2], Hannah M. Karlsson[2], Edward M. Fordham[1], and David R. Montgomery[2]

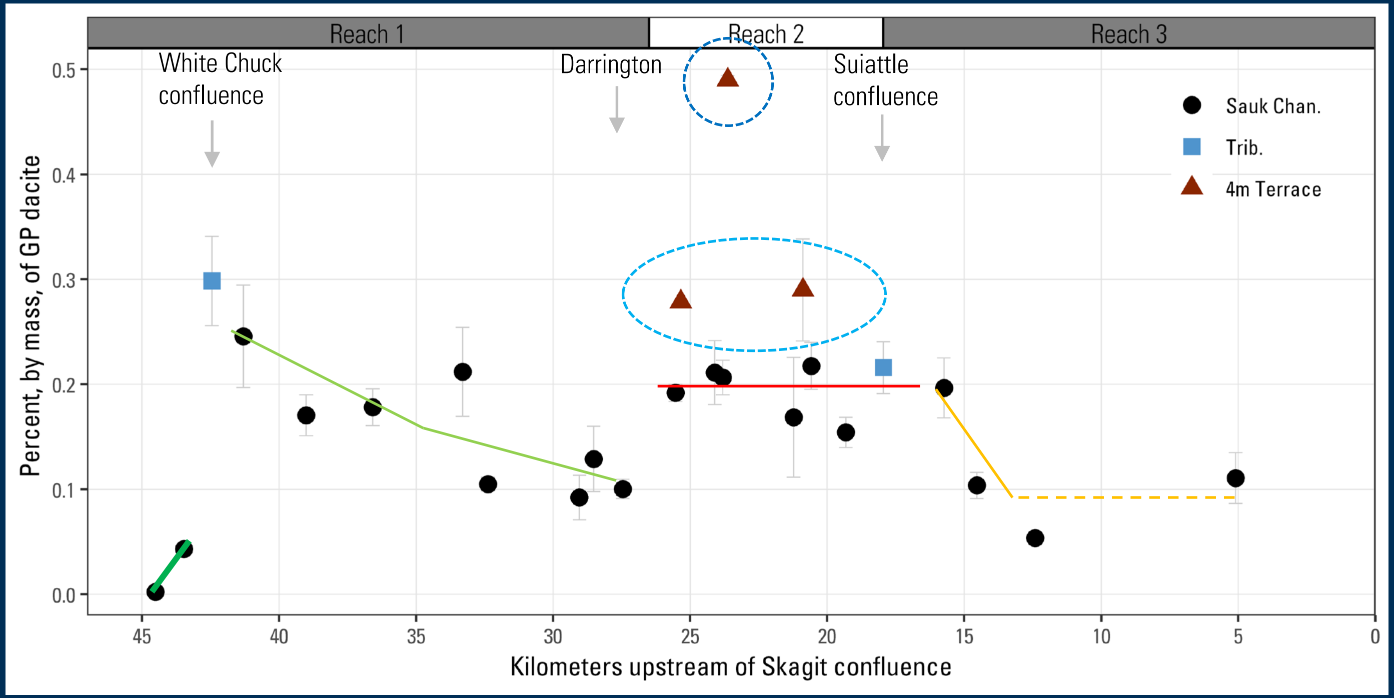
[1]Geology Department, Western Washington University, Bellingham, WA, USA, [2]Department of Earth and Space Sciences, University of Washington, Seattle, WA, USA

Glacier Peak dacite

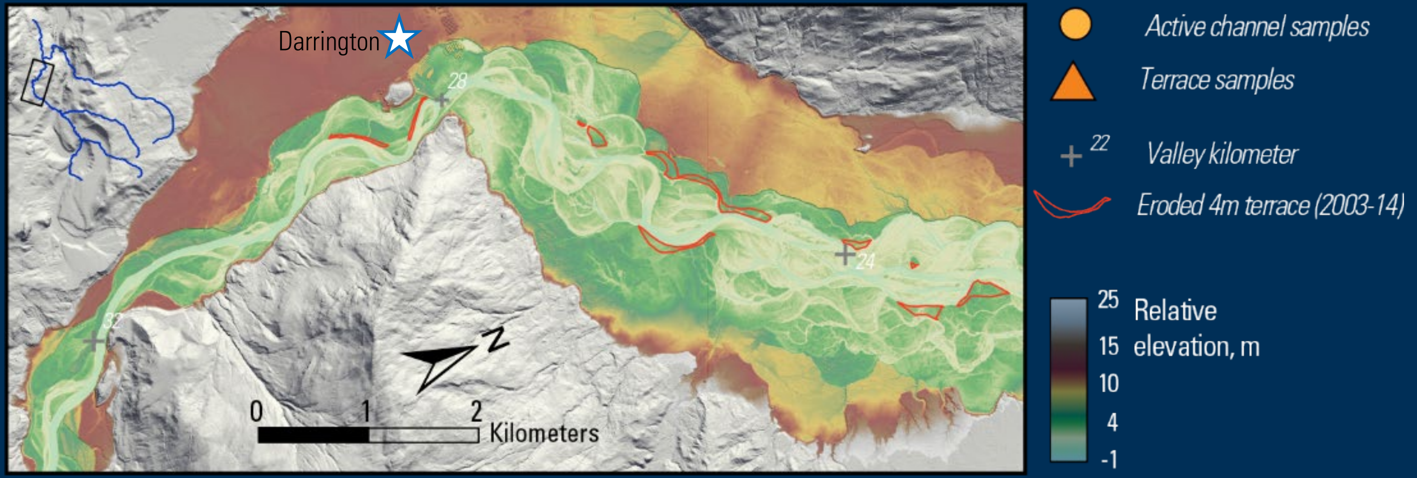
Gravel Lithology

- Spatial trends in vesicular Glacier Peak dacite independently imply gravel exchange/input from distinct valley floor sources

- Gravel samples from 4-m terrace have higher dacite fractions
  - Modern channel: ~15-20%
  - Terrace fluvial gravels: ~25-30%
  - Likely lahar deposit: ~50%



Anderson, S.W., 2021, Lithologic classifications of river gravels in the Sauk River watershed: U.S. Geological Survey data release, https://doi.org/10.5066/P9YFI793.



Presence of 4-m terrace originally called out by:
Natural System Designs, 2014, Flood and Erosion Hazard Assessment for the Sauk-Suiattle Indian Tribe Phase 1 Report for the Sauk River Climate Impacts Study. Available at https://nwifc.org/w/wp-content/uploads/2014/11/NSD_Sauk_River_Final_Report_062614.pdf

USGS

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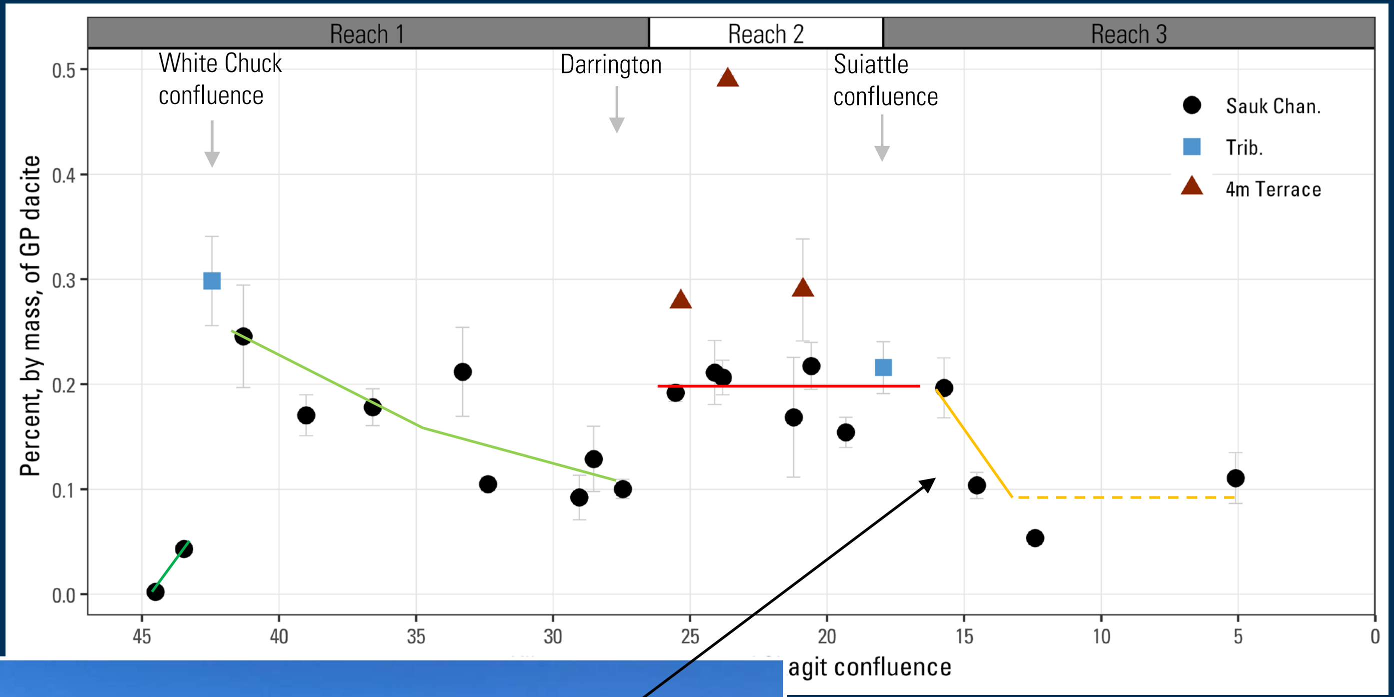
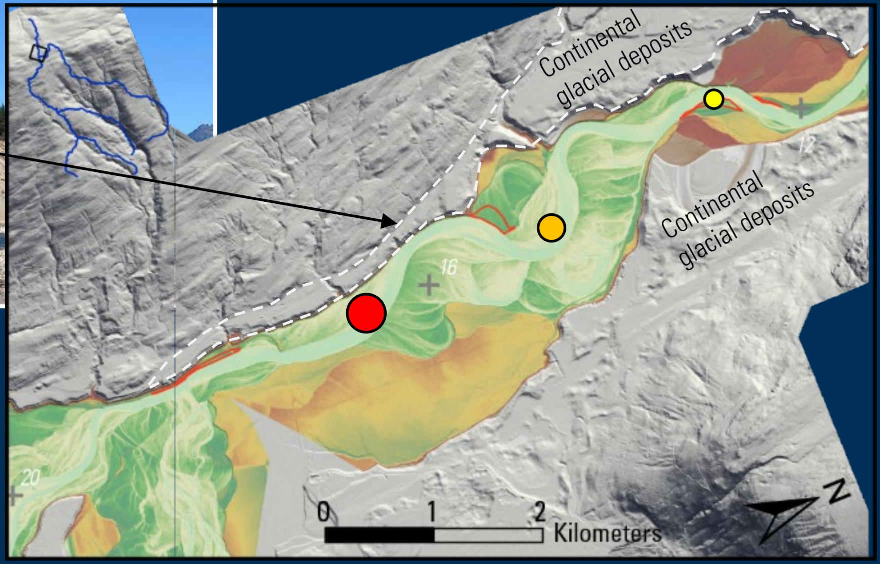


uk River watershed: U.S. Geological Survey data release,



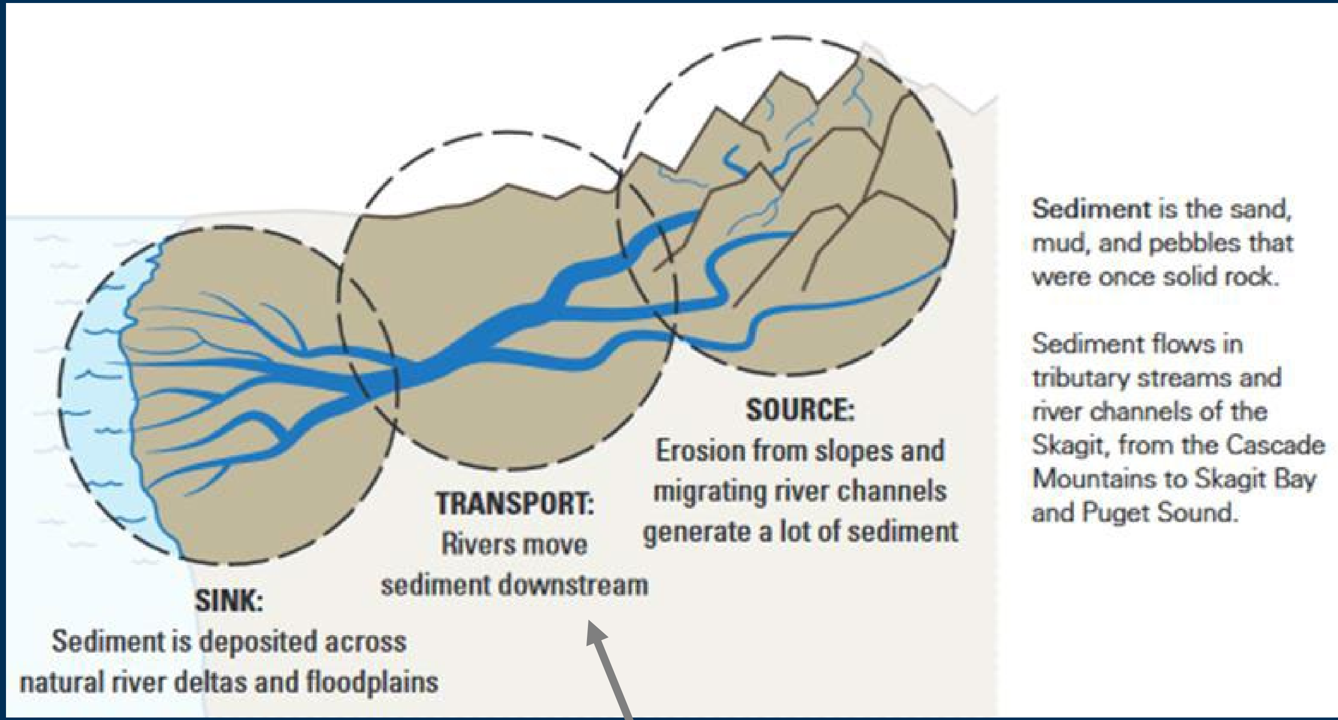
Summary

- Valley floor erosion in the lower watershed has recently been a non-trivial component of the total Sauk River sediment load
- Predominately erosion of ‘low’ (<5 m) surfaces, lateral regrading of valley floor
- Eroded material includes a mix of modern fluvial, relict fluvial, lahar, and glacial deposits
- Persistence and cause of recent erosion remain open questions

What does it all mean?

- Channel dynamics reflect an ***interplay between contemporary climate + hydrology + disturbance and landscape history,*** *as encoded in storage*

- Downstream sediment + channel dynamics are not simply lagged/muted responses to contemporary changes in upland sediment delivery



http://www.skagitclimatescience.org/skagit-impacts/sediment/

This part is complicated

USGS

Acknowledgements

- **Work funded by the Sauk-Suiattle Indian Tribe**
  - **Personal thanks to Scott Morris!**

- **Chris Curran, Kris Jaeger at USGS**

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