



Modeling the Impacts of a Tailings Dam Failure at the Pebble Mine

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What is a Tailings Dam?



Highland Valley Copper Mine, Logan Lake, British Columbia, Canada

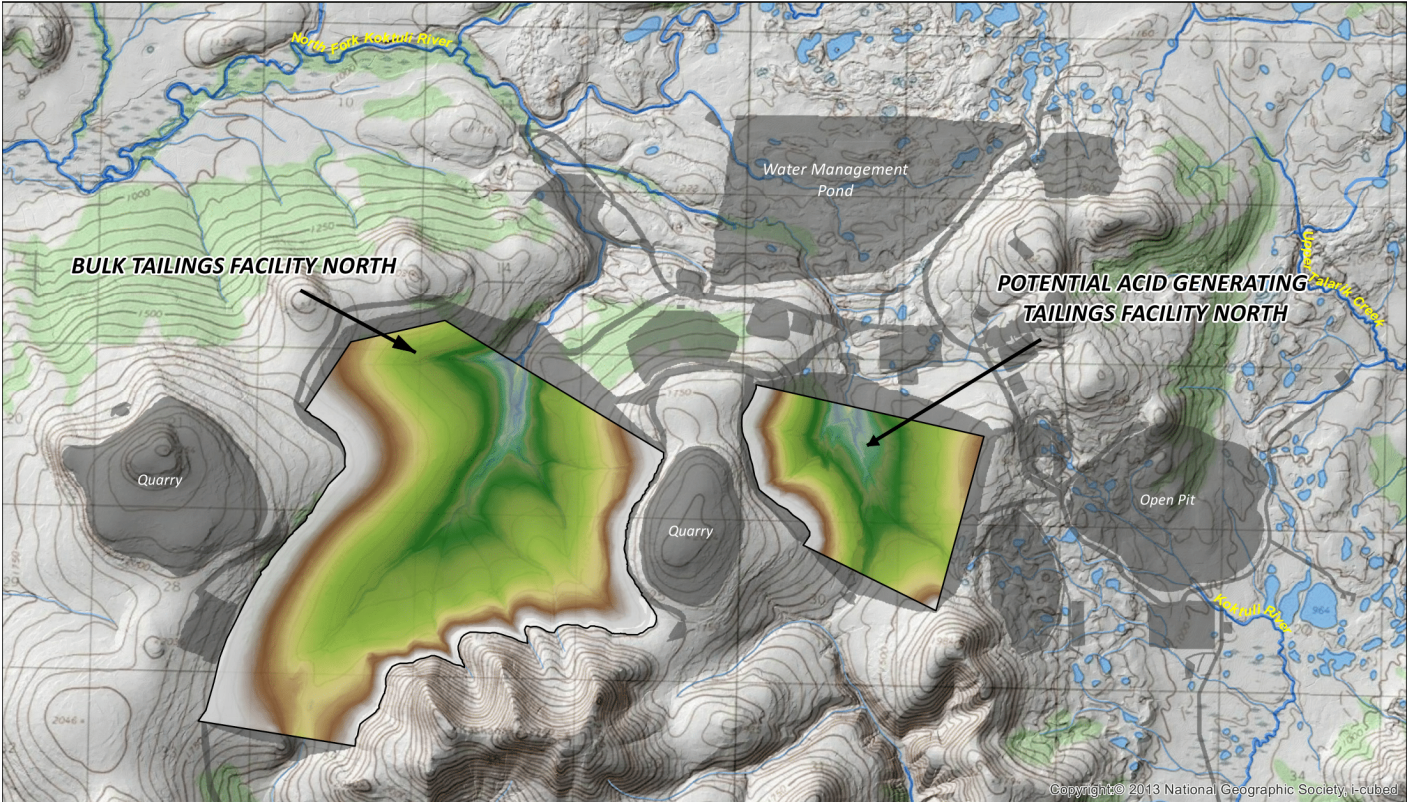
Image 1: Klohn Crippen Berger: <https://ambriefonline.com/tailings-dam-inspection-and-monitoring/>

Image 2: Mccosker Contracting Ltd: <http://www.mccoskers.com.au>



Pebble Tailings Storage Facilities (TSFs)

PROPOSED TAILINGS STORAGE FACILITIES FOR THE PEBBLE MINE - CURRENT PROPOSAL



TAILINGS STORAGE VOLUME AND AREA		V 2/25/2019	
<p>BULK TAILINGS FACILITY NORTH</p> <p>Elevation 1750 Ft/533.4 M Volume (Feet): 30,111,425,568 ft³ Volume (Meters): 852,660,618 m³ Area (SQ MI): 4.22sqmi Area (SQ KM): 10.93 sqkm</p>	<p>POTENTIAL ACID GENERATING FACILITY NORTH</p> <p>Elevation 1650 Ft/502.9 M Volume (Feet): 7,275,113,568 ft³ Volume (Meters): 206,008,275 m³ Area (SQ MI): 1.24 sqmi Area (SQ KM): 3.22 sqkm</p>	<ul style="list-style-type: none"> USGS STREAMS CATALOGED SALMON STREAMS PLP MINE SITE FEATURES (2018) TAILINGS STORAGE FACILITIES 	<p>1 inch = 1 miles</p> <p>0 0.25 0.5 1 1.5 2 Miles</p> <p>NORTH To The Future</p>



Recent Tailings Dam Failures



Brumadinho, Brazil, 2019



Samarco, Brazil, 2015



Mt. Polley, BC 2014 (Knight Piésold design)

<http://www.mining.com/tailings-breach-at-imperial-metals-mount-polley-mine-40156/>
<https://slate.com/news-and-politics/2015/12/brazil-mining-dam-disaster-toxic-sludge-and-irreversible-environmental-damage.html>
<https://www.theguardian.com/world/2019/jan/25/brazil-dam-collapse-news-latest-mining-disaster-brumadinho>



PLP's Proposed tailings dam uses inferior design

“Dams designed with downstream construction methods are less likely to fail than dams using centerline construction methods, especially under seismic shaking (ICOLD 2018).”

“The centerline construction method was selected for the bulk TSF north embankment to limit the footprint and volume of materials required for construction”

- Pebble Mine Draft EIS, p. 4.27-73



Draft EIS is Misleading about Failure Probability

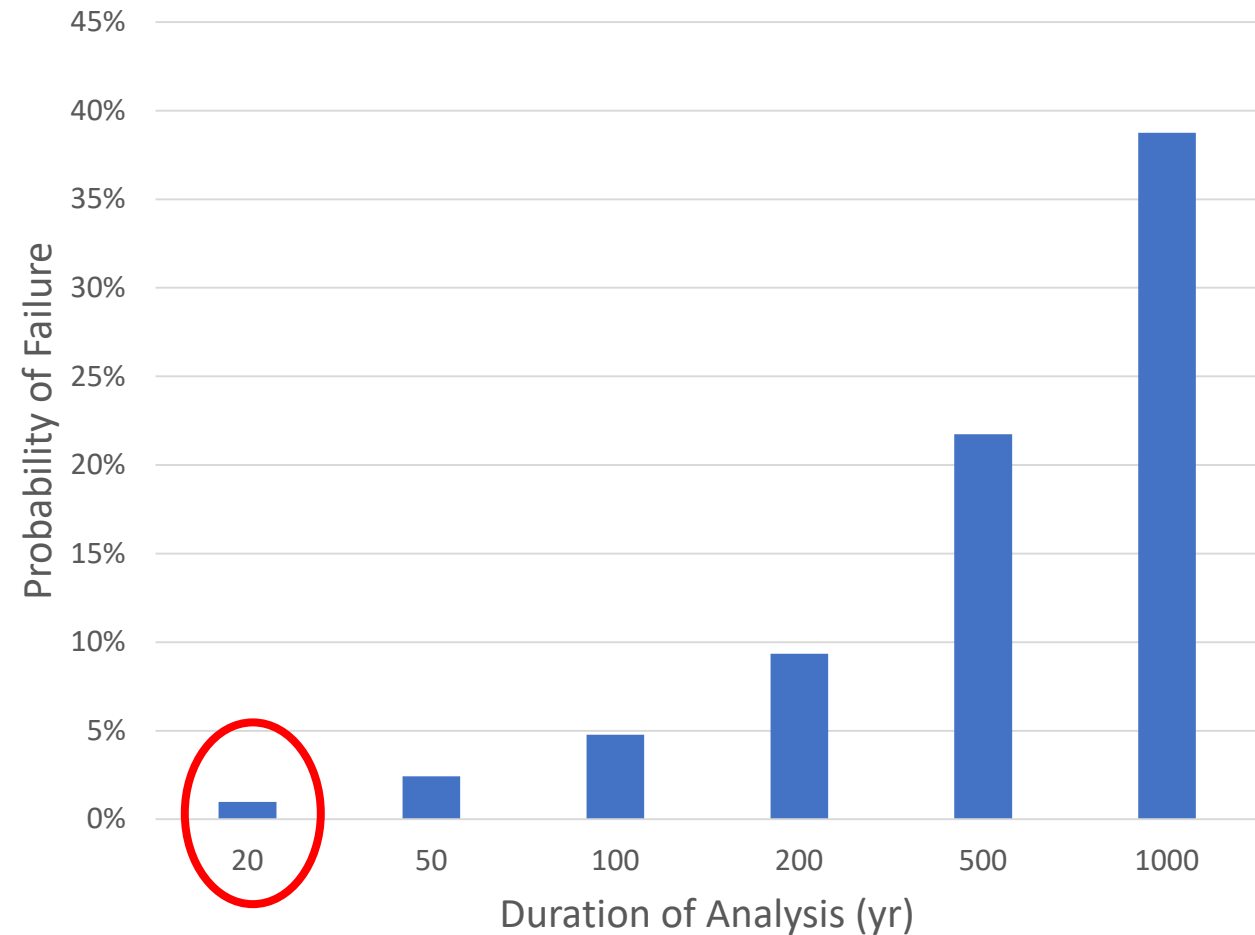
“The probability of a full breach of the bulk or pyritic TSF tailings embankments was assessed to be extremely low”

- DEIS p. 4.27-72

“[a full tailings breach was] ruled out as remote **during the 20-year operational life** due to likelihood of successful detection and intervention”

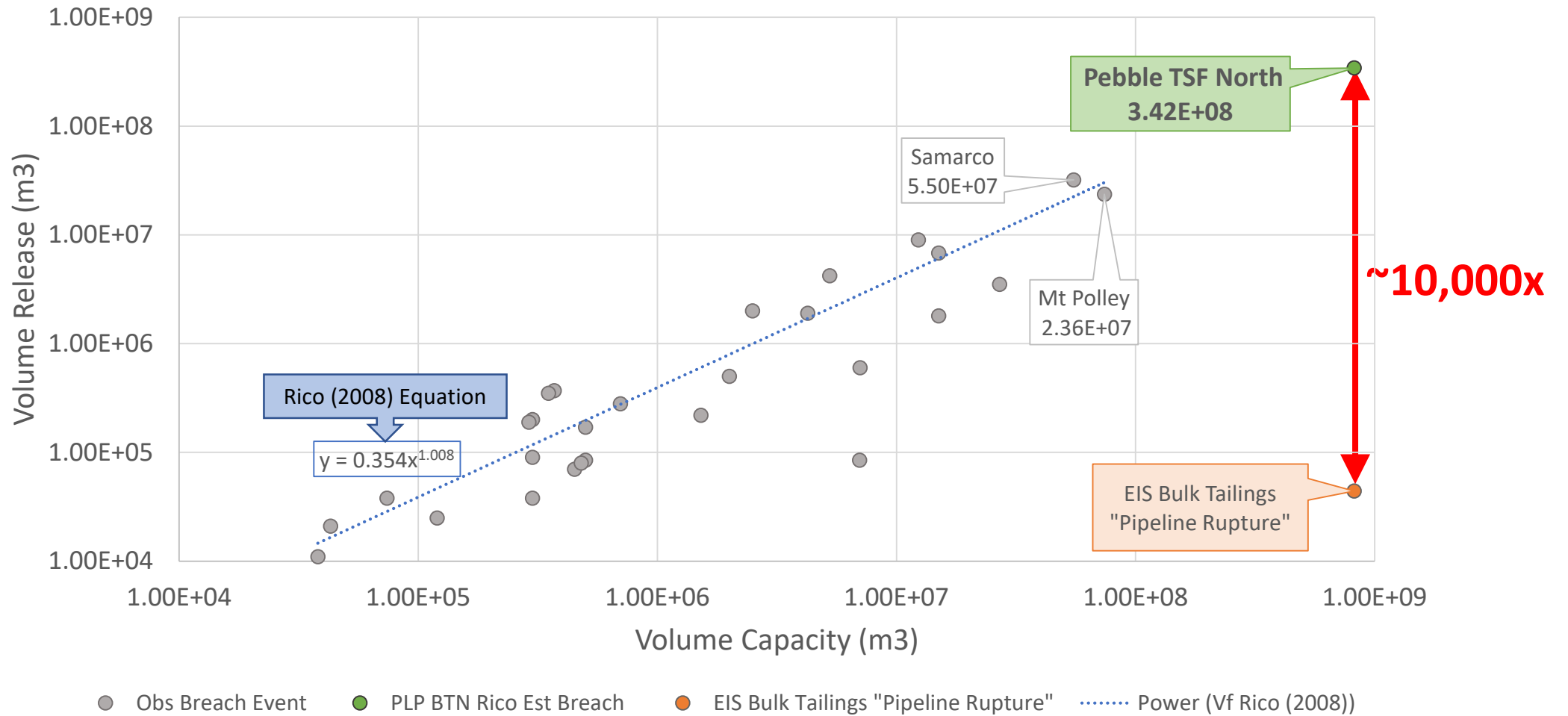
- FMEA, October 2018

Probability of "1 in 2000" Event vs Duration of Analysis



Draft EIS Did NOT consider a TSF failure

Breach Volume Released vs Tailings Storage Facility Capacity

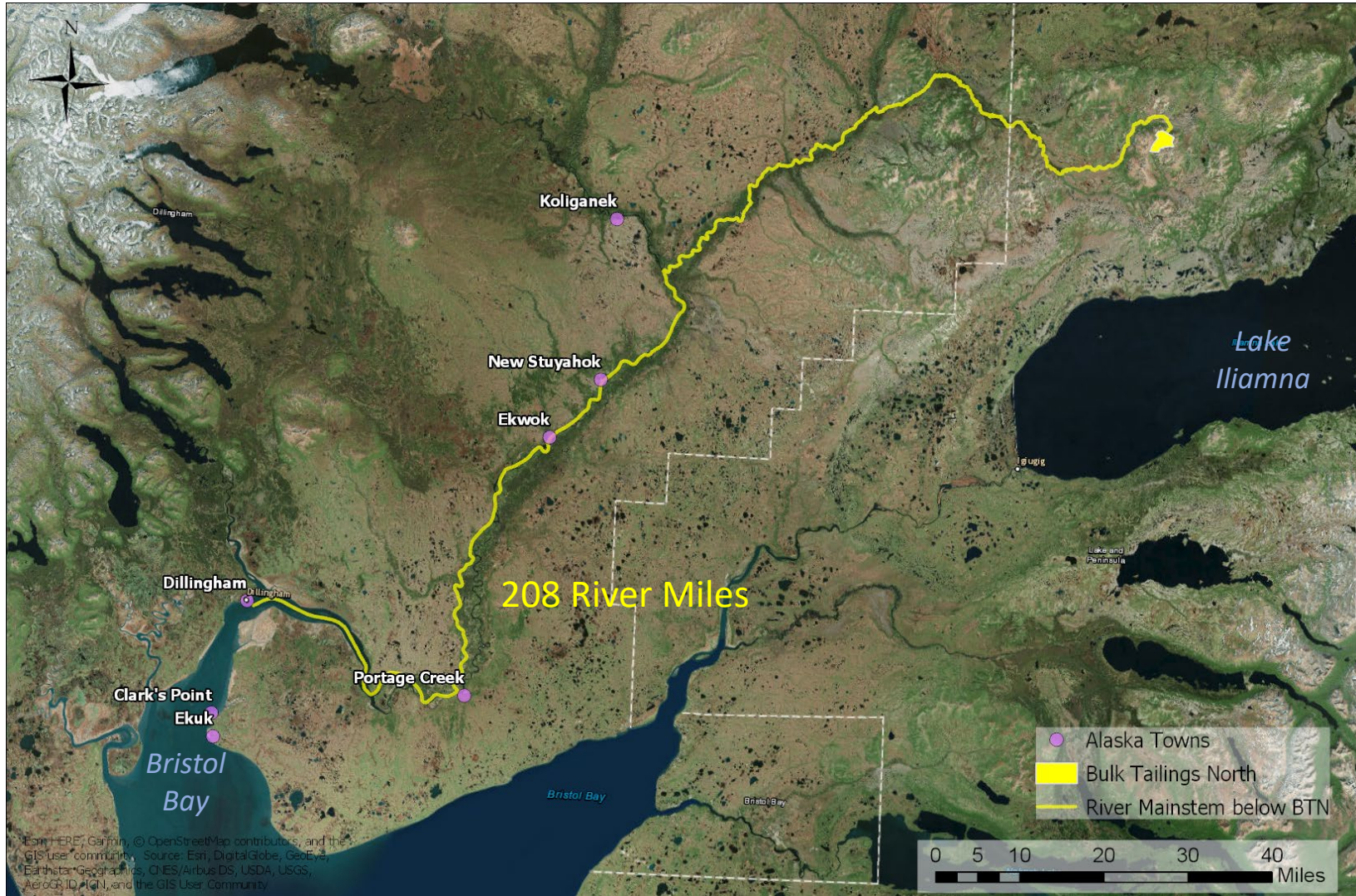


Our Goals and Approach

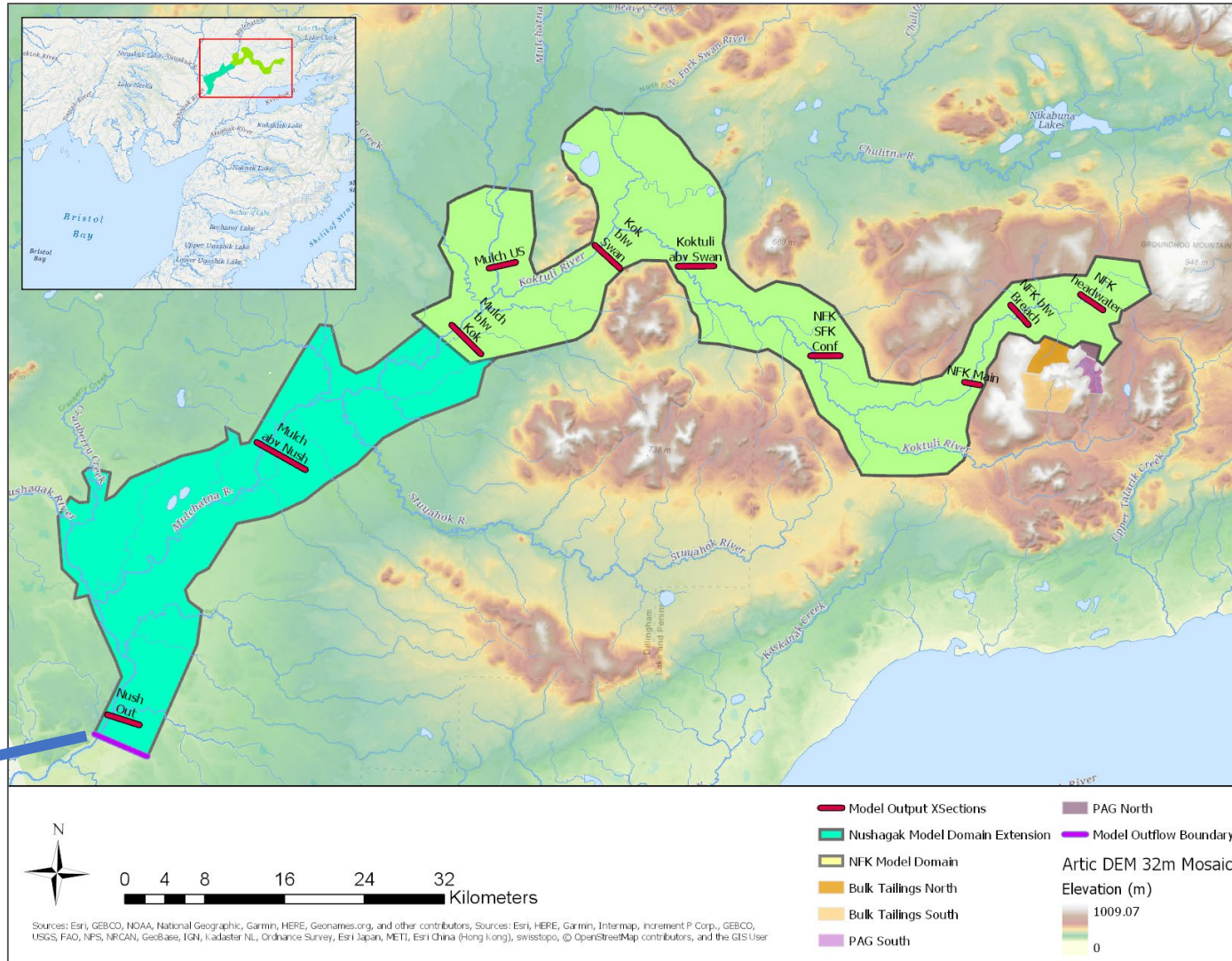
- Simulate the spatial extent of impacts in the event of a tailings dam failure at the Pebble Mine
- Develop scenarios based on historical TSF failures
- Use modeling framework consistent with prior industry practice (e.g., Knight Piesold, 2014; TetraTech, 2015)
- Explore sensitivity of outcomes to different physical and model parameters
 - Tailings sediment concentration
 - Tailings rheology (flow properties)
 - Duration of breach
 - Digital topographic dataset
 - Channel and valley “roughness”
- Examine results in the context of impacts to salmon habitat



Study Area – Regional View



Model Domain – Tailings runout



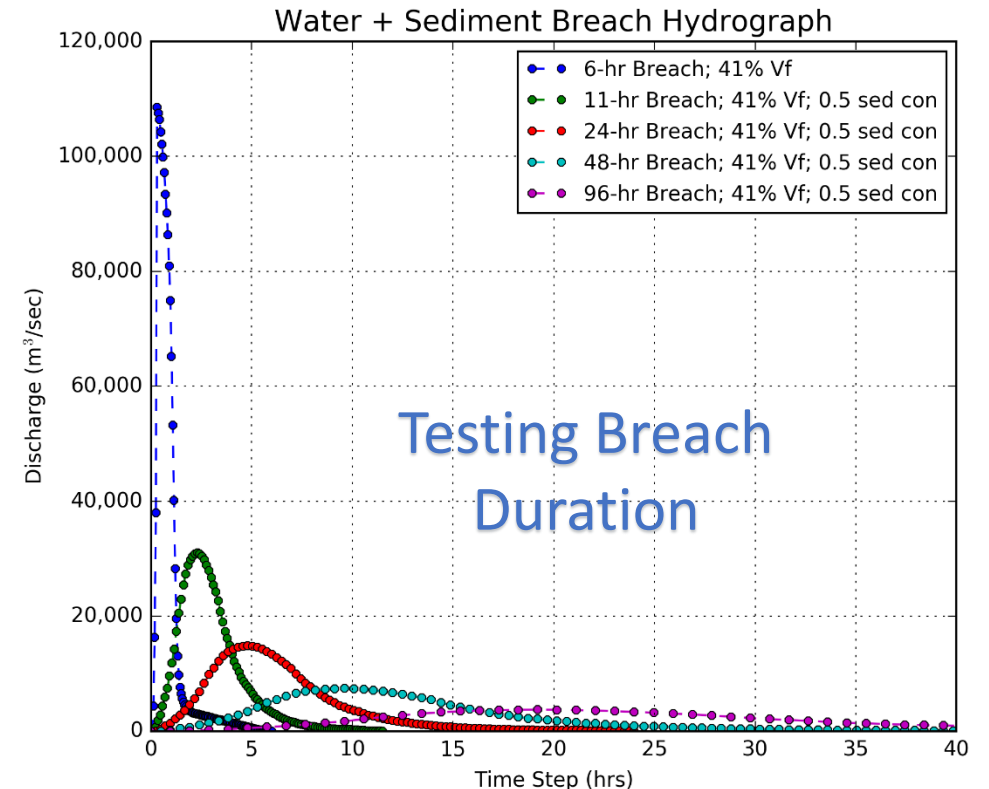
~125 miles to
Dillingham



Breach Scenario Simulations

Model runs explored a range of breach scenarios:

- Tailings volume released
 - Rico et al. (2008) → 41% release
 - Low estimate → 10% release
 - High estimate → 60% release
- Duration of breach event
 - Varied from 6hr to 96hr
 - Influences peak discharge rate
- Max sediment concentration
 - Varied from 35%-50%
 - Influences flow properties



Result: 24-hour Breach, 50 hr simulation



Sensitivity: Total volume released

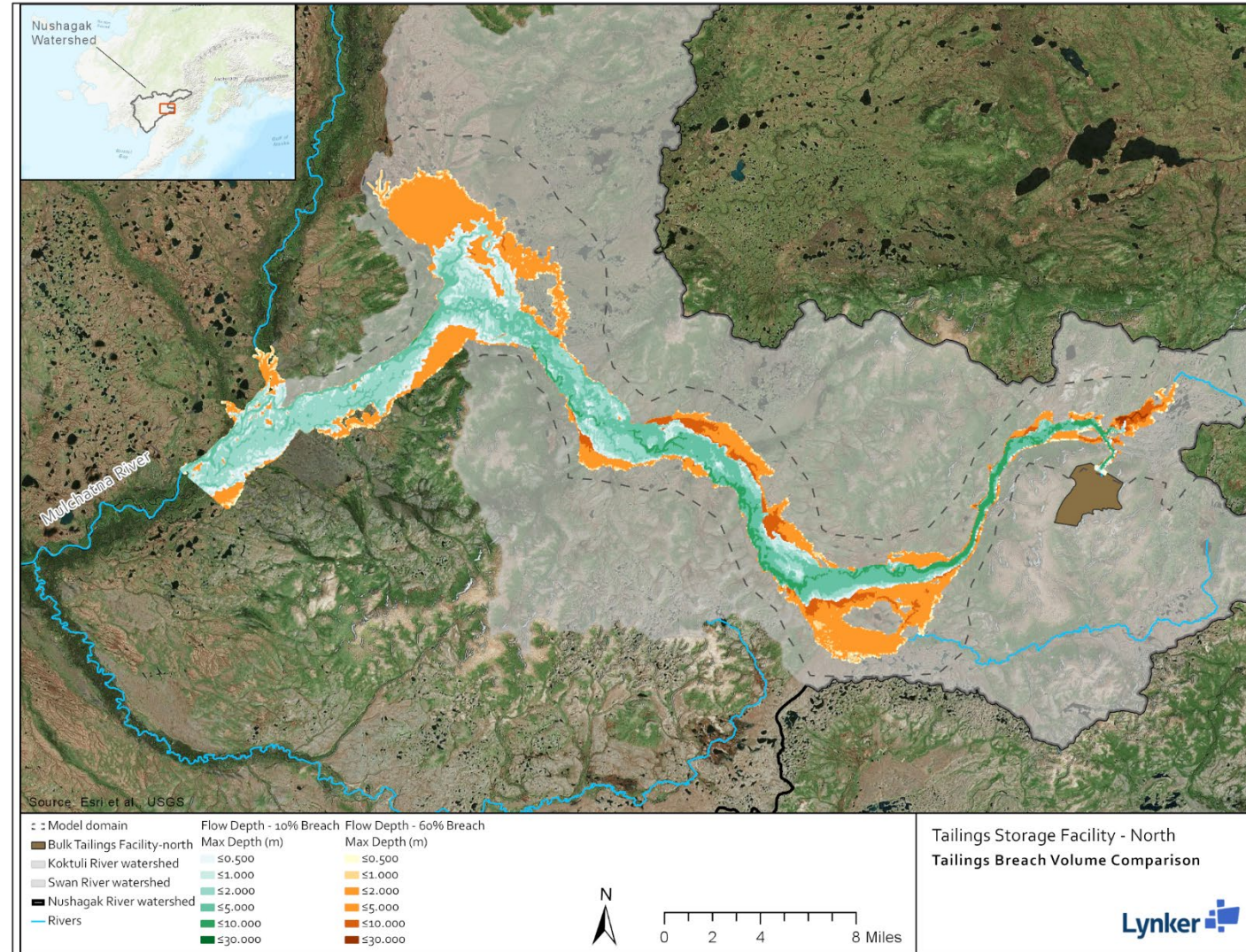
Breach Volume Comparison

10% breach volume (green)

- Inundated Area: 60.9 mi²

60% breach volume (orange)

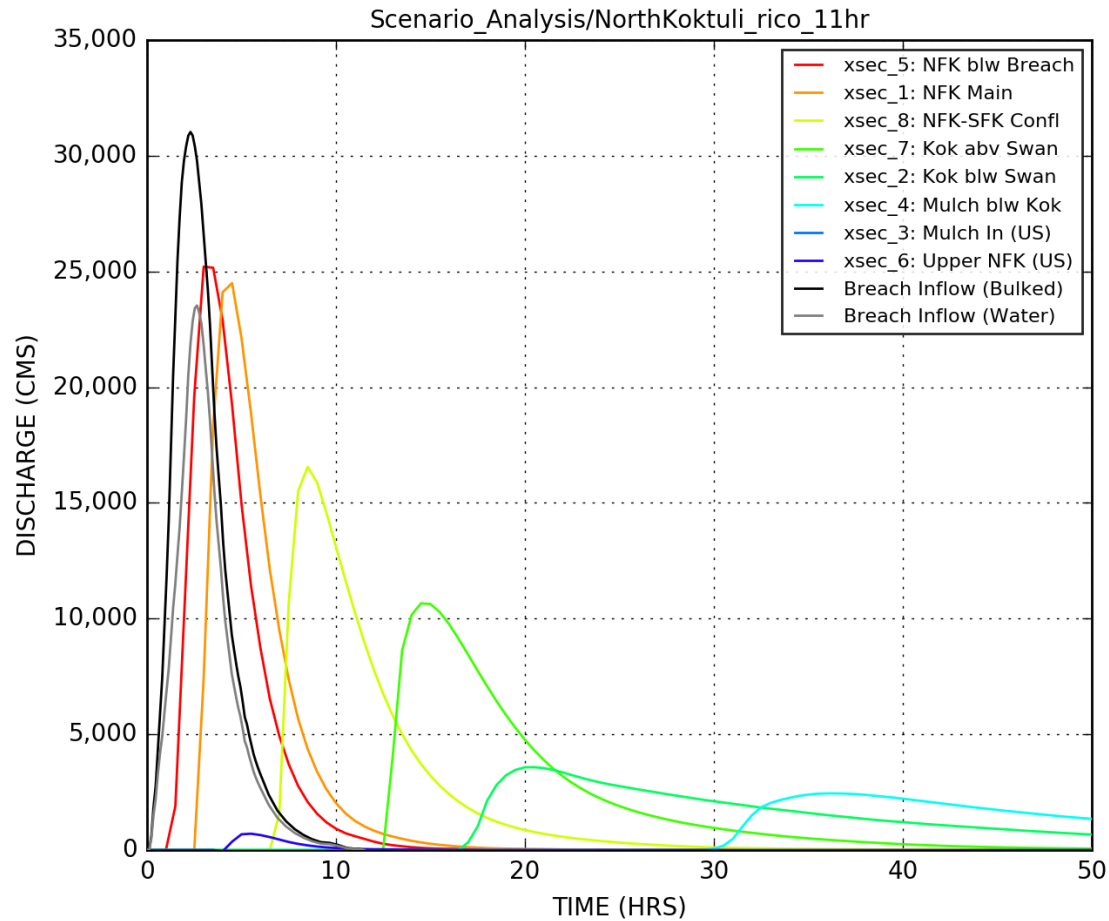
- Inundated Area: 110.3 mi²



Sensitivity: Duration of Breach

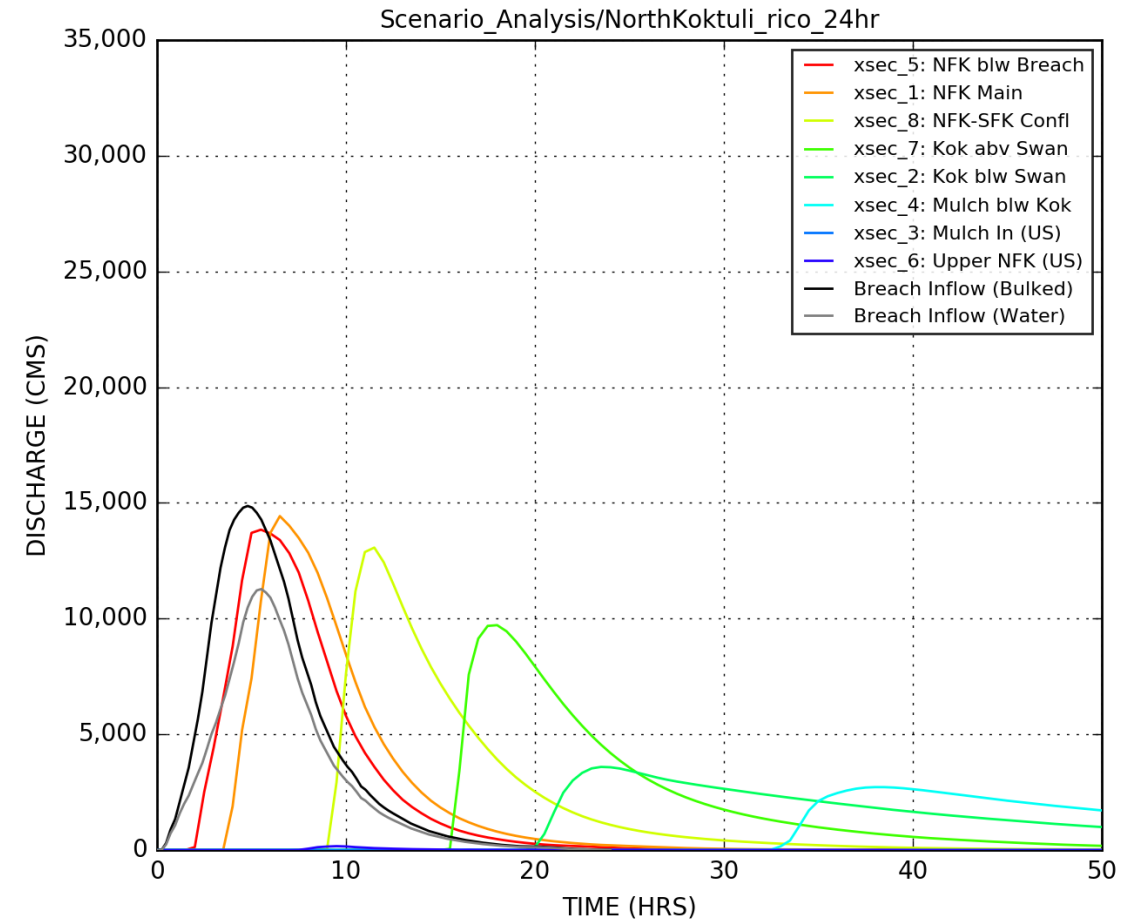
11-hour breach inflow

CROSS SECTION OUTPUT: DISCHARGE (CMS)

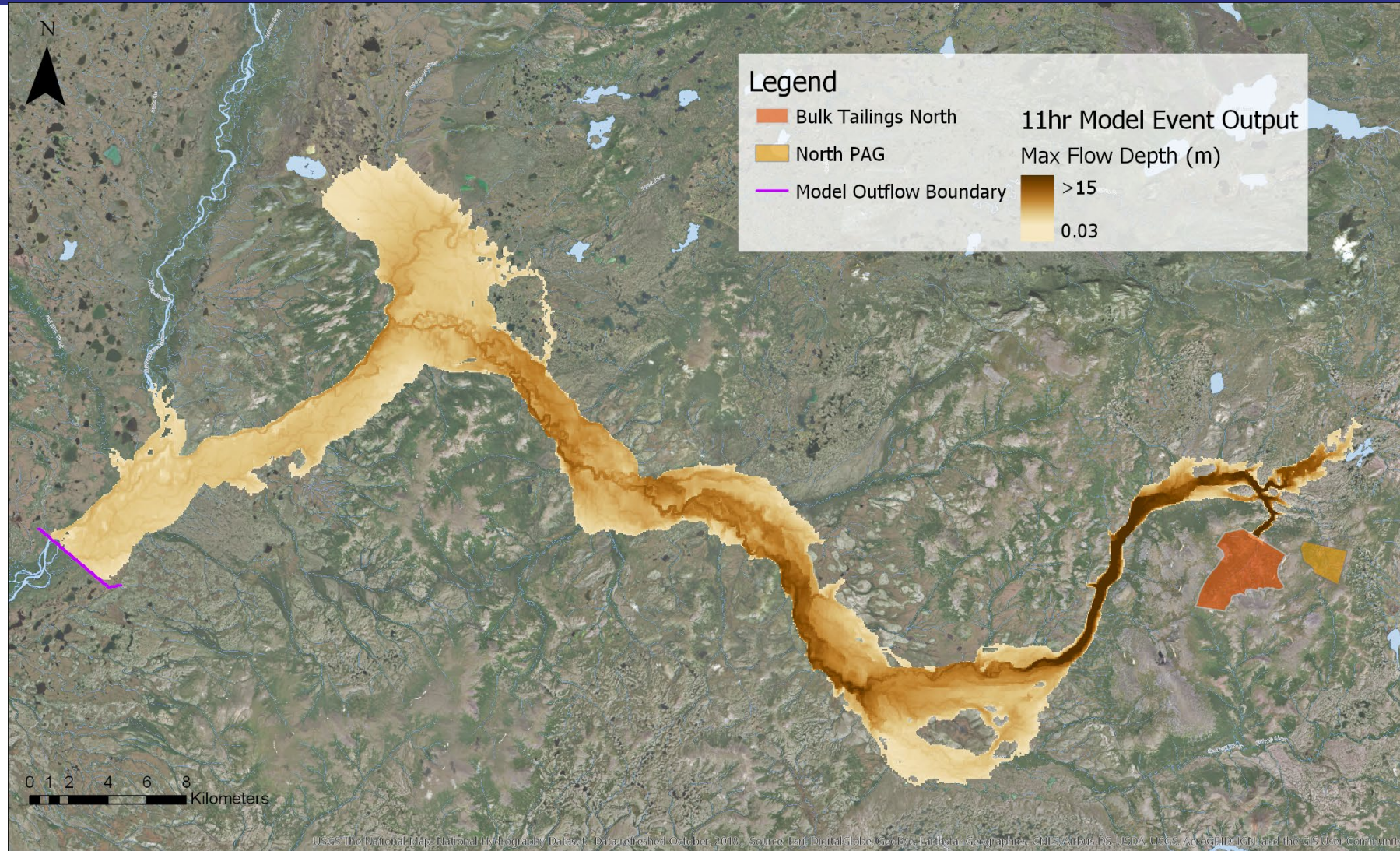


24-hour breach inflow

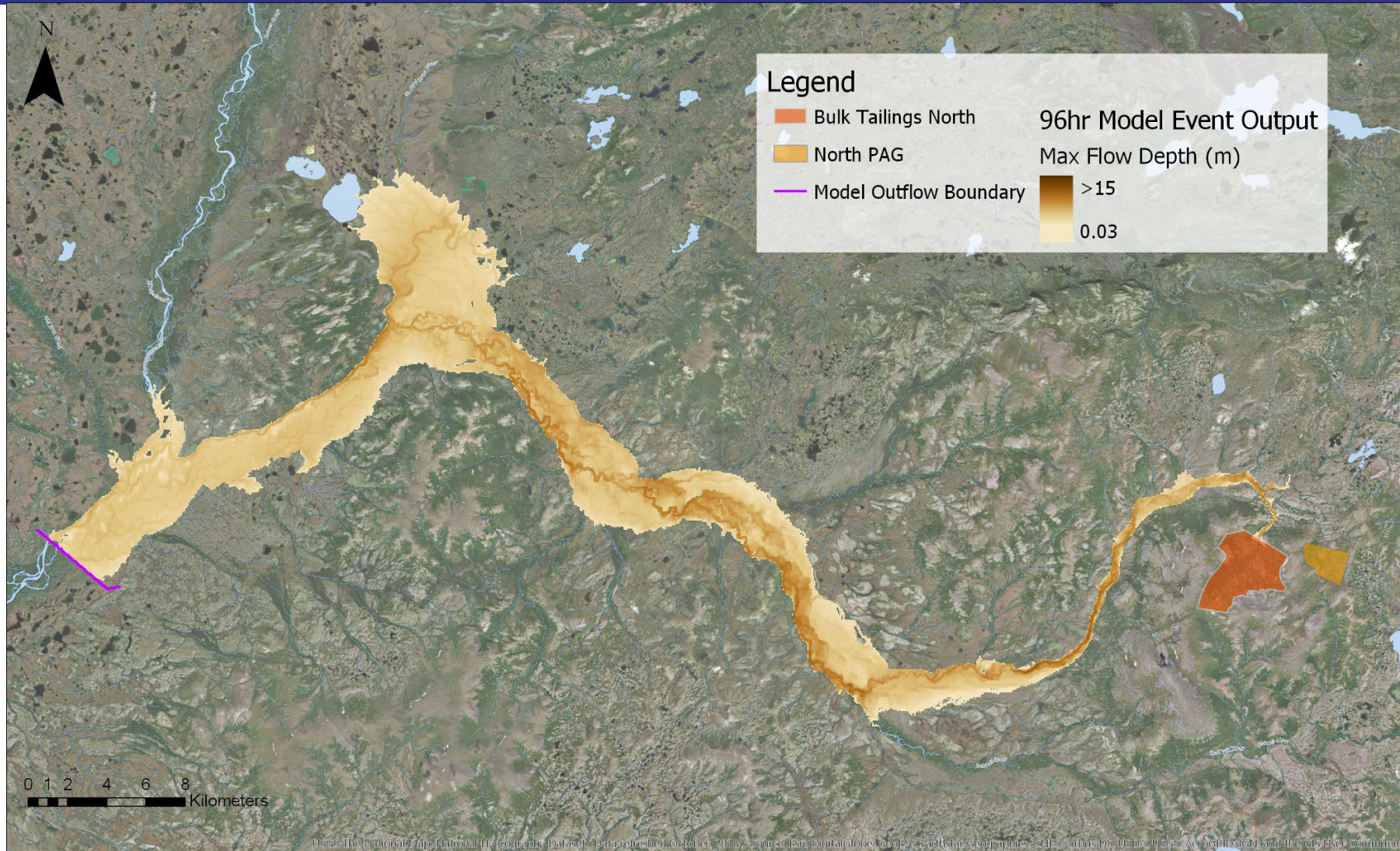
CROSS SECTION OUTPUT: DISCHARGE (CMS)



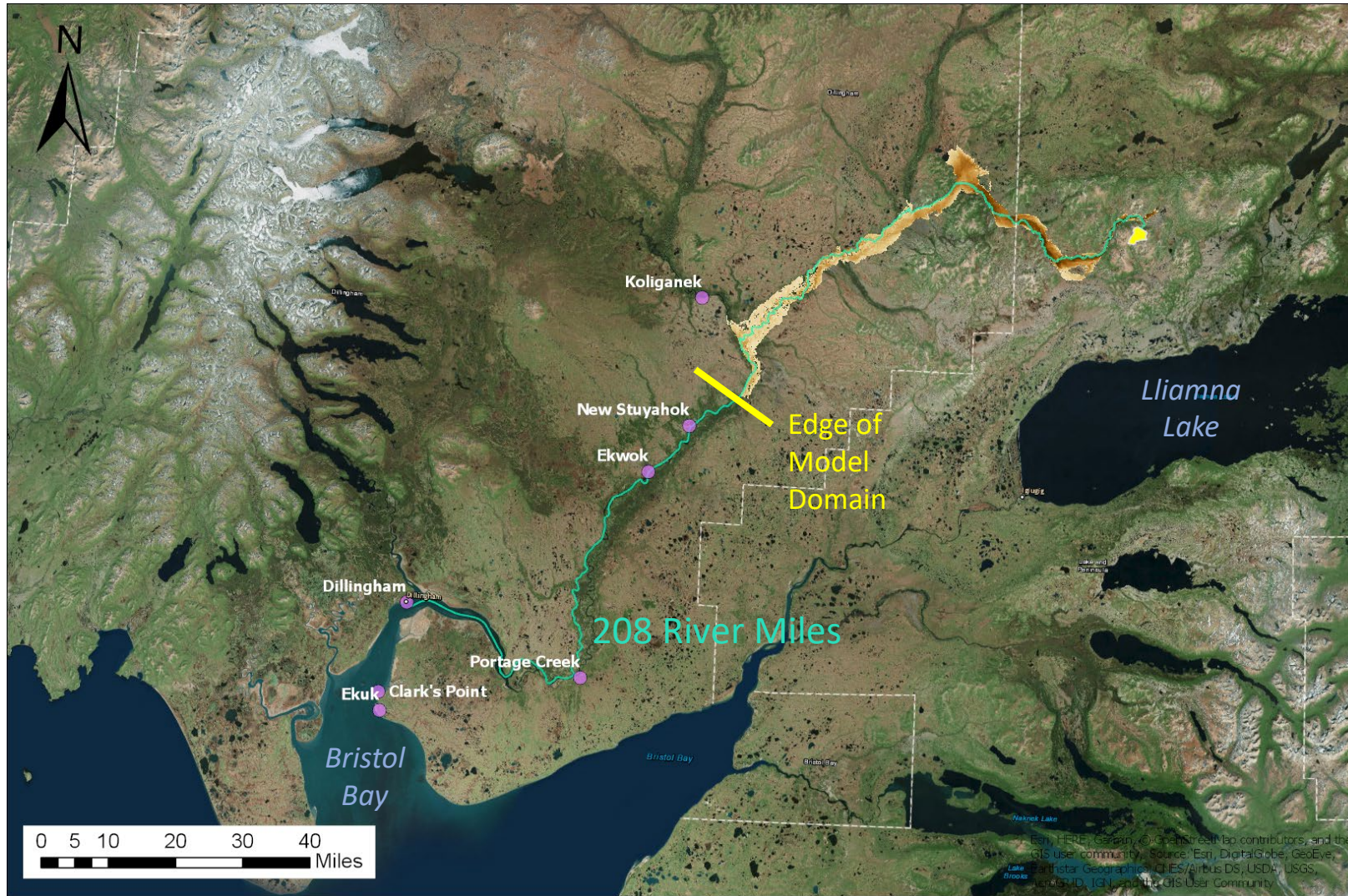
Sensitivity – Duration of Breach (11 hr)



Sensitivity – Duration of Breach (96 hr)



24-hour Breach: Larger Model Domain



Larger Model Domain: 24-hour Breach

Model extends from TSF to Nushagak-Mulchatna Confluence

- ~45% of tailings are deposited within the model floodplain
- ~55% of tailings flow past the model boundary



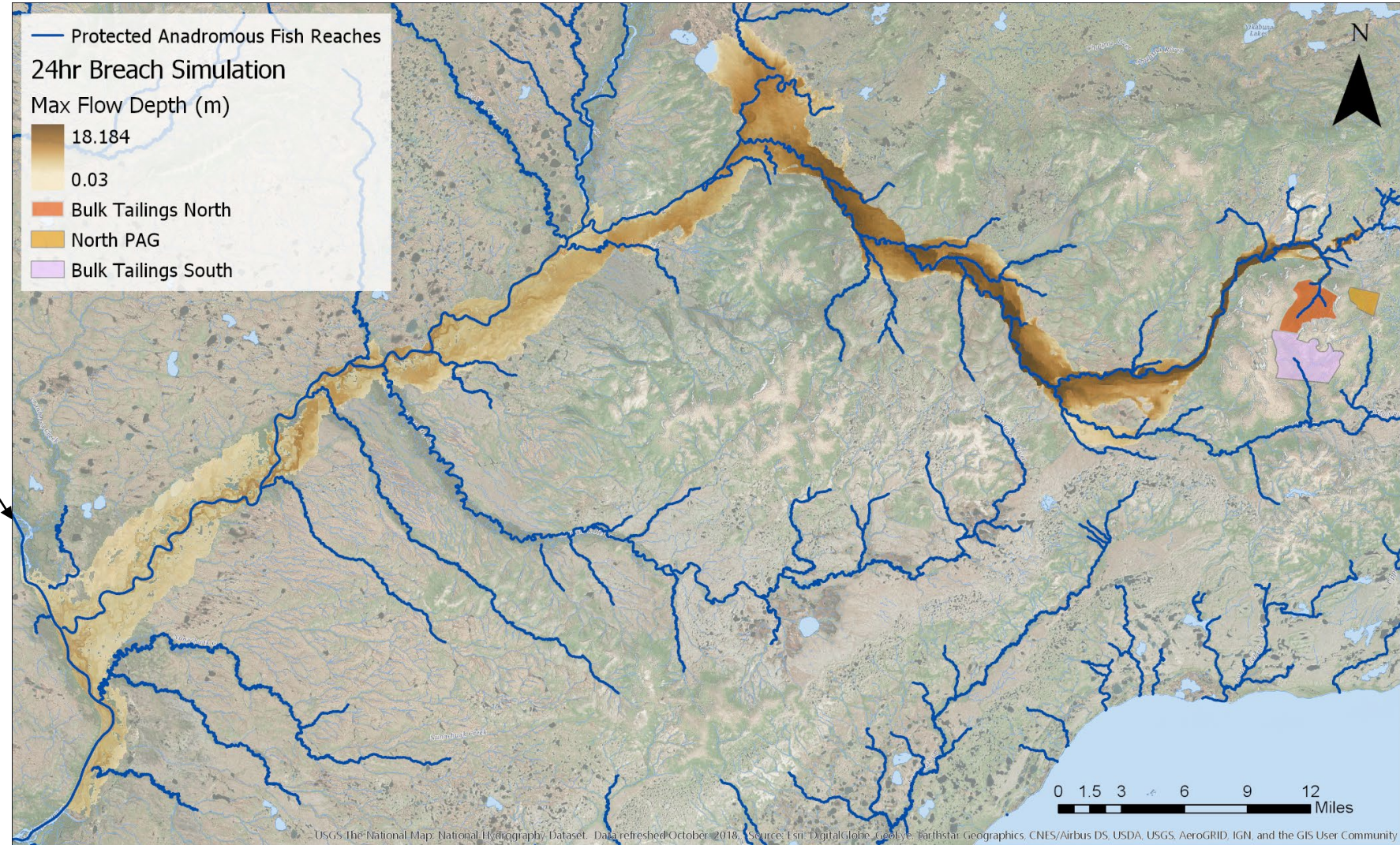
0 2 4 8 12 16 Miles

— Model Domain Centerline (mi)
■ Bulk Tailings North

24hr Breach Simulation
Max Flow Depth (m)
18.184
0.03



Anadromous Waters Affected – 24 Hour Event



- Tailings would directly impact >219 miles of anadromous waters



Potential impacts to the fishery

- Deposition of fine-grained tailings in spawning habitat could decrease emergence success (e.g., Chapman, 1988; Kondolf, 2000)
- Leaching of metals from tailings could create acute or chronic toxicity to salmonids

Chapman, D. W. (1988). Critical review of variables used to define effects of fines in redds of large salmonids. *Transactions of the American Fisheries Society*, 117(1), 1-21.

Kondolf, G. M. (2000). Assessing salmonid spawning gravel quality. *Transactions of the American fisheries Society*, 129(1), 262-281.



<https://www.salmonography.com/Salmonid-Topic/Covering-the-redd/>



Long-term impacts

“Unrecovered tailings that are exposed to oxygen could generate acid on a timescale of years to decades...acid and heavy metals that accumulate in streambed sediments, wetland soils, or isolated waterbodies could impact water quality on a timescale of decades.”

- Pebble DEIS, page 4.27-65

“Recovery of a massive release, especially one that reaches flowing water, would be extremely difficult.”

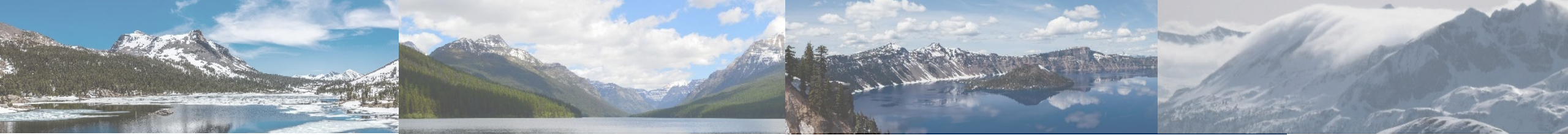
- Pebble DEIS, page 4.27-65



“The only common factor in all major TSF failures has been human error, including errors in design, construction, operations, maintenance, and regulatory oversight.”

- Pebble DEIS, p. 4.27-71





Questions

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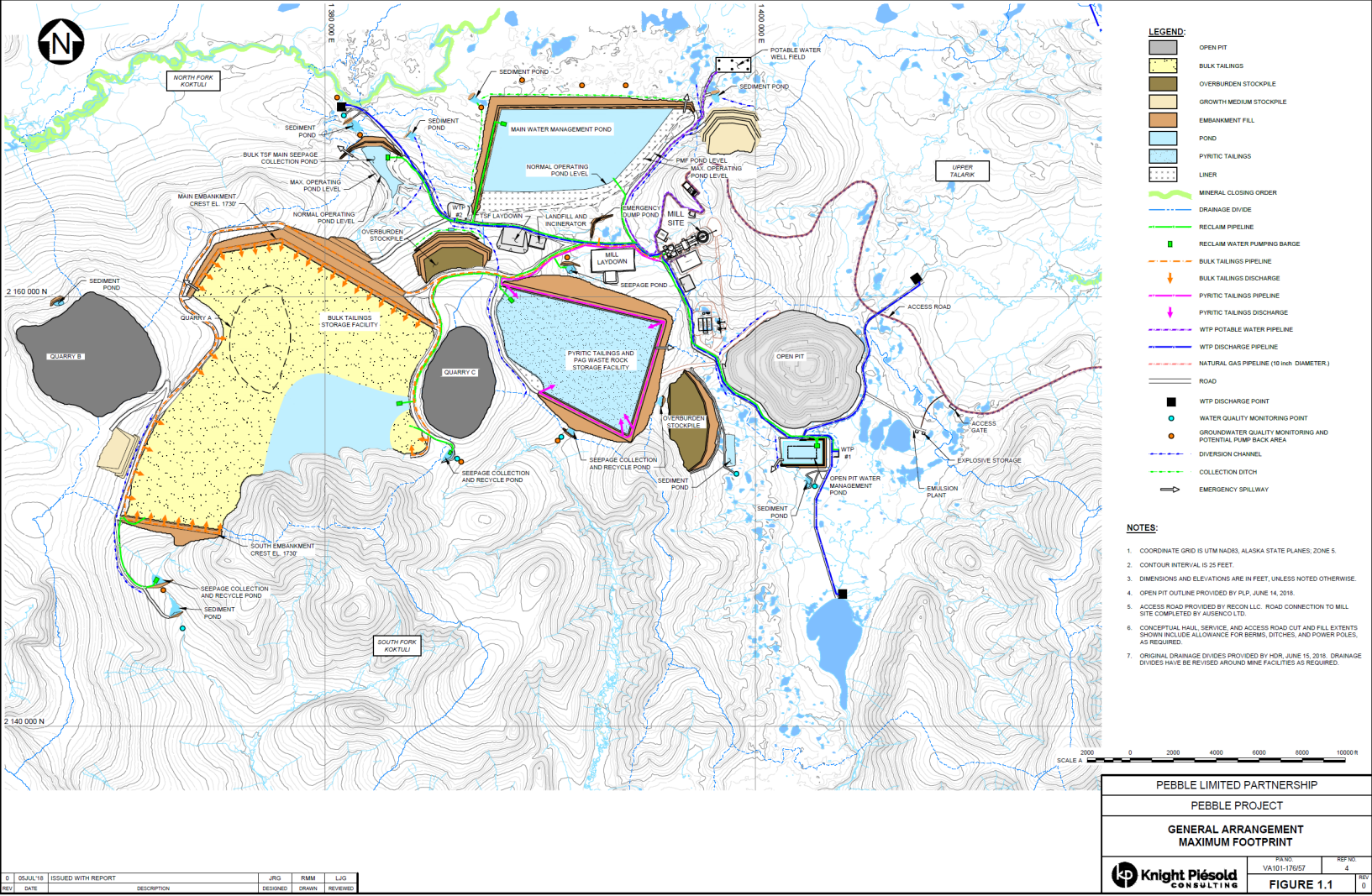
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Model Domain – Mine Layout



Our Project Goals

- Simulate the spatial extent of impacts in the event of a tailings dam failure at the Pebble Mine
- Overlay this distribution with information on essential fish habitat
- Rely to the maximum extent possible on physical information from PLP and from analysis of previous failures

“If tailings come out, it will kill fish for about 20 miles down the north fork of the Kuktuli. And that's it. And in 10 years, they'll come back naturally.”
- Tom Collier, Pebble CEO, 2018



Tailings Release Volumes

