Post-Wildfire Water Quality in the Kenai Lowlands: Six Years After the 2019 Swan Lake Fire

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NORTHERN HYDROCLIMATE LAB

Introduction & Background:

- The Kenai Peninsula is warming and drying, causing wetland drying, spruce beetle tree mortality, and shrub growth, fueling more frequent and intense wildfires.
- The 2019 Swan Lake Fire (SLF) exemplifies this trend, burning 164,803 acres predominantly in the Kenai Lowlands, which contain over 80% of the Peninsula's peatlands
- Despite holding one thirds of Earth's carbon stocks, carbon quantification of peatlands has relied largely on surficial assessments, rarely accounting subsurface carbon vulnerable to aerobic decay or combustion.
- Peat combustion concentrates heavy metals (Fe, Cu, Cd, As, Bi, Th, etc.) in the near-surface under anoxic conditions, where reducin conditions can mobilize them into the hydrosphere.
- Here, we investigate the lasting impacts of the 2019 SLF on water quality in the East Fork Moose River Subwatershed (26, 902 acres; 73% burned; feeding a major Kenai River tributary) including near-surface heavy metal remobilization (As, Fe) potentially triggered following the SLF, alongside progress on peat carbon quantification in the region.

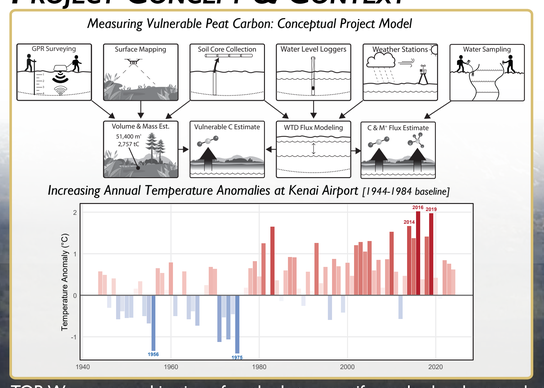
Methods:

- Water, environmental, and soil carbon data were collected across 36 sites (wetlands, lakes, and streams) during three field campaigns in June, August, and November 2025.
- Near-surface (<0.10 m) water quality parameters (pH, ORP, DO, temperature, conductivity) were recorded at each sampling location using a calibrated YSI ProQuatro.
- DOC samples were filtered (0.45 µm), stored in trace carbon-cleaned HDPE containers, frozen within 72 hours, and analyzed in replicate (>2) on a Shimadzu TOC-L at the UAA ASET Laboratory.
- Major and trace metal samples were collected in trace metal-cleaned HDPE containers, acid-fixed to 1% HNO_3, and analyzed in quintuplicate by ICP-MS (Agilent 7850) at the UAA ASET Laboratory.
- Peat carbon mass was estimated by combining Kriging-interpolated GPR measurements of the basal mineral contact, DEM-derived surface elevations, and soil carbon densities from LOI analysis of peat cores at 1 cm resolution.

Discussion & Next Steps:

- Elevated Fe and As in Egumen Wetland reflect millennia-scale accumulation and post-fire concentration under reducing conditions; however, downgradient sites show metals below detection limits, suggesting poor hydraulic connectivity and/or sufficient dilution.
- Low DOC across eastern catchment sites reflects sparse wetland coverage and poor wetland-stream connectivity. Elevated DOC in Lily Lake indicates strong exchange with adjacent wetlands.
- Forthcoming stable water isotope analyses will further clarify residence times and hydraulic connectivity among sites.
- Whether burned wetlands pose a downstream heavy metal threat particularly during high watertable stand events remains unresolved, underscoring the need for continued investigation as wildfires like the 2019 SLF become increasingly common on the peninsula.

Project Concept & Context



TOP: We use a combination of methods to quantify peatland carbon, track water table levels as vulnerablity predictors, and quantify dissolved carbon and metals mobilization. These efforts enable estimation of total carbon mass and near-surface material exposed to aerobic decomposition and fire.
BOTTOM: Mean annual temperatures in the region are increasing, with the anticipated long-term trend of hotter, drier summers.

Peat Carbon Storage

"Vulnerable" Peat Carbon Mass by Site

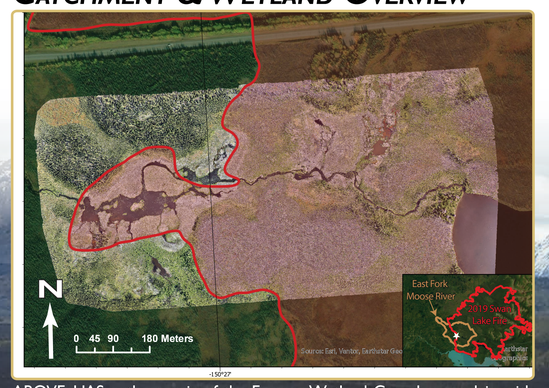
Site	Surface Area (m²)	Mean WL Depth (cm)	Mean Carbon %	Mean Bulk Density	Peat Volume (m³)	"Vulnerable" Mass (tC)
Lily Lake	65,973	4.5	45.8	0.0948	2,969	129
Mystery Creek	90,077	8.4	36.7	0.1063	7,566	295
Nest	21,222	7.1	44.3	0.0477	1,507	32
Skilak Turnoff	67,036	9.8	45.3	0.0375	6,570	112

Total Peat Carbon Mass by Site

Site	Surface Area (m²)	Mean Carbon %	Mean Bulk Density	Peat Volume (m³)	Total Mass (tC)	tC per Hectare
Lily Lake	65,973	41.5	0.153	117,846	7,483	1134
Mystery Creek	90,077	40.0	0.194	81,012	6,287	698
Nest	21,222	41.4	0.152	84,187	5,298	2,496
Skilak Turnoff	67,036	42.8	0.137	81,457	4,776	712

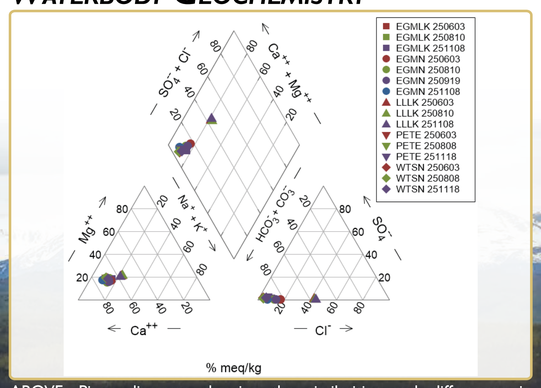
ABOVE: "Vulnerable" peat carbon is contained in the wetland soil materials and vegetation in the near-surface, where the water table fluctuates. This thin slice is generally <5% of the total volume and carbon mass of the peatland. Different wetland types have varying concentrations of peat and carbon determined by their vegetation, hydrology, and topography.

Catchment & Wetland Overview



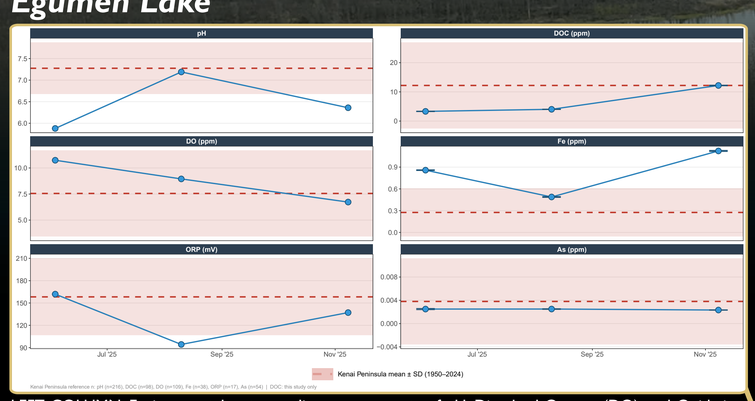
ABOVE: UAS orthomosaic of the Egumen Wetland Complex overlain with the burn perimeter of the 2019 Swan Lake Fire (SLF) in red with burned area in red transparency and a local map (inset) showing the East Fork Moose River Subwatershed boundary (tan) and SLF burn perimeter (red). Note the reddish-tan ponds within the wetlands north of the East Fork, this is the location of Egumen Wetland water sampling.

Waterbody Geochemistry



ABOVE: Piper diagrams showing the similarities and differences in waterbody geochemistry over the 2025 season with Peterson Lake (PETE), Egumen Lake (EGMLK), Egumen Wetland (EGMN), and Watson Lake (WTSN) showing a calcium carbonate-dominated composition, while Lily Lake (LLLK) shows elevated chloride content likely indicating its isolation from the eastern portion of the subwatershed.

Egumen Lake

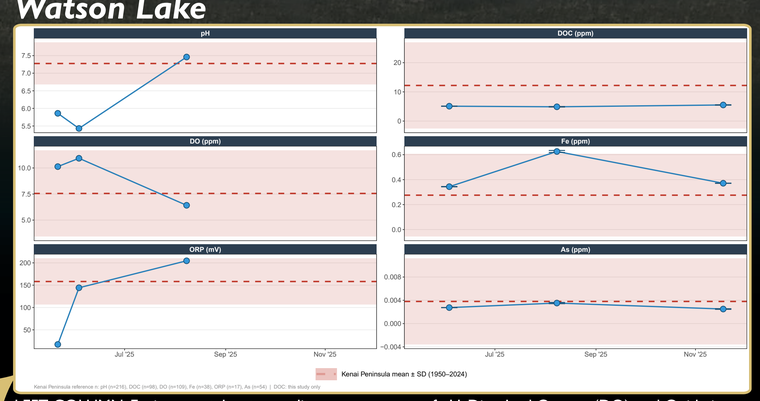


LEFT COLUMN: Environmental water quality measurements of pH, Dissolved Oxygen (DO), and Oxidative-Reductive Potential (ORP) over the 2025 season for Egumen Lake, largely consistent with Kenai Baseline.
RIGHT COLUMN: Dissolved Organic Carbon (DOC), extractable iron (Fe) and extractable arsenic (As) over the 2025 field season for Egumen Lake showing levels consistent with the 1950-2024 Kenai Peninsula baseline.

Egumen Wetland

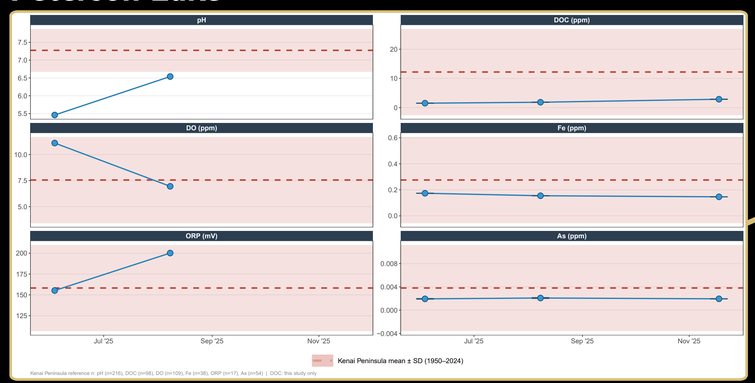
LEFT COLUMN: Environmental water quality measurements of pH, Dissolved Oxygen (DO), and Oxidative-Reductive Potential (ORP) over the 2025 season for Egumen Wetland all below 1950-2024 Kenai baseline.
RIGHT COLUMN: Dissolved Organic Carbon (DOC), extractable iron (Fe) and extractable arsenic (As) over the 2025 field season showing Fe and As levels well above the 1950-2024 Kenai Peninsula baseline.

Watson Lake



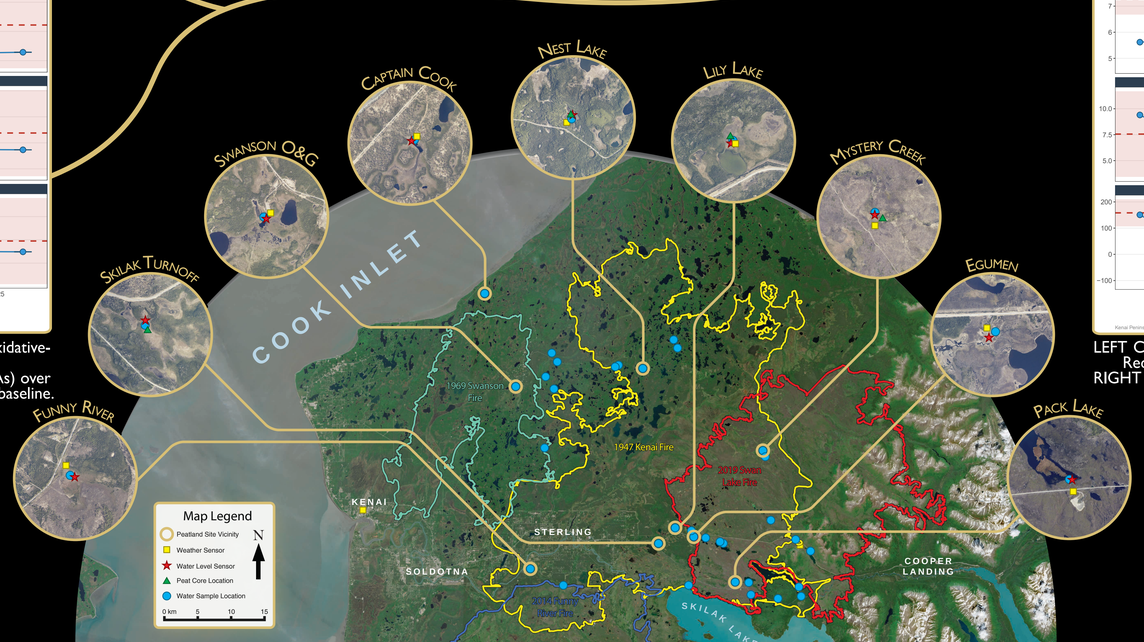
LEFT COLUMN: Environmental water quality measurements of pH, Dissolved Oxygen (DO), and Oxidative-Reductive Potential (ORP) over the 2025 season for Watson Lake with pH and ORP below the Kenai baseline.
RIGHT COLUMN: Dissolved Organic Carbon (DOC), extractable iron (Fe) and extractable arsenic (As) over the 2025 season for Watson Lake showing levels consistent with the 1950-2024 Kenai Peninsula baseline.

Peterson Lake

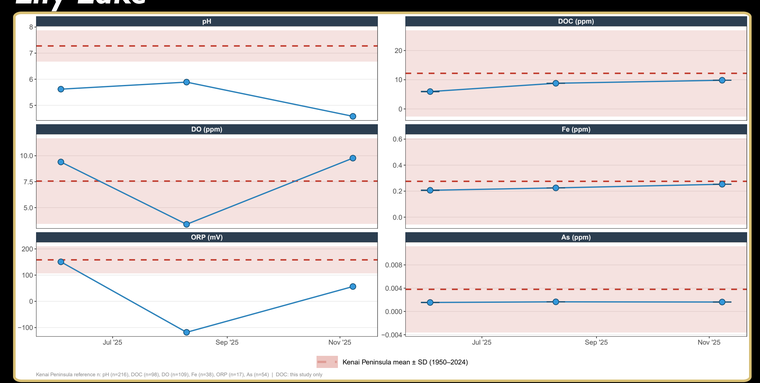


LEFT COLUMN: Environmental water quality measurements of pH, Dissolved Oxygen (DO), and Oxidative-Reductive Potential (ORP) over the 2025 season for Peterson Lake with pH below Kenai Baseline.
RIGHT COLUMN: Dissolved Organic Carbon (DOC), extractable iron (Fe) and extractable arsenic (As) over the 2025 field season for Peterson Lake showing levels consistent with the 1950-2024 Kenai Peninsula baseline.

East Fork Moose River



Lily Lake



LEFT COLUMN: Environmental water quality measurements of pH, Dissolved Oxygen (DO), and Oxidative-Reductive Potential (ORP) over the 2025 season for Lily Lake with pH and ORP below the Kenai baseline.
RIGHT COLUMN: Dissolved Organic Carbon (DOC), extractable iron (Fe) and extractable arsenic (As) over the 2025 season for Lily Lake showing levels consistent with the 1950-2024 Kenai Peninsula baseline.

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USGS science for a changing world

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