2015

KOTLIK

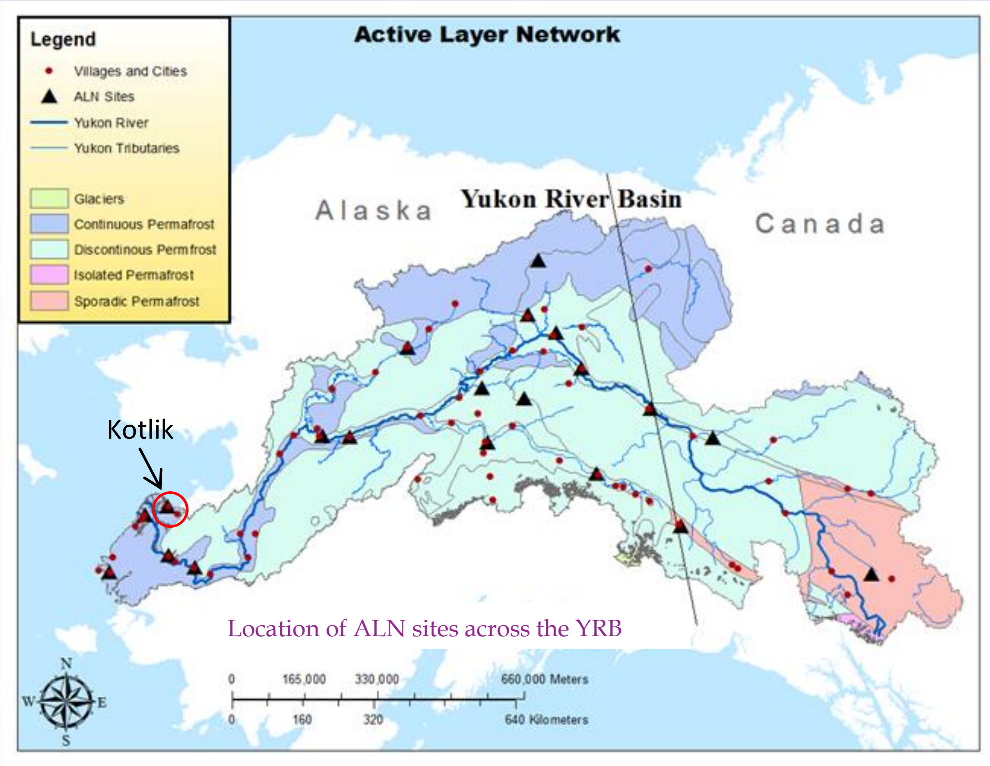
THE ACTIVE LAYER NETWORK: A COLLABORATIVE PROJECT BETWEEN THE US GEOLOGICAL SURVEY, YUKON RIVER INTER-TRIBAL WATERSHED COUNCIL, AND YUKON RIVER BASIN COMMUNITIES. A FIVE YEAR SUMMARY REPORT FOR KOTLIK

USGS science for a changing world

ONE PEOPLE-ONE RIVER
Yukon River Inter-Tribal Watershed Council
www.yritwc.org

Introduction

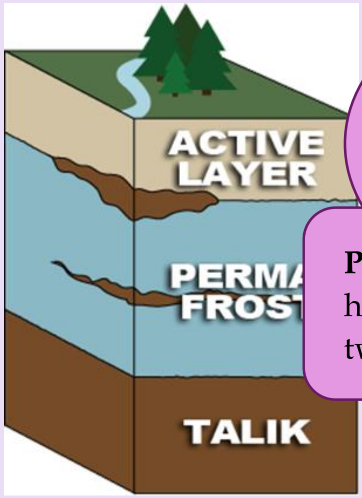
The Active Layer Network (ALN) was launched in 2009 as a cooperative project between the United States Geological Survey (USGS), the Yukon River Inter-Tribal Watershed Council (YRITWC) and Yukon River Basin (YRB) communities. The active layer is the soil above the permanently frozen ground that thaws during the summer months and freezes again in the autumn. By measuring the depth of the active layer in late summer, at the time of maximum thaw over several years, we are able to better understand the effects of a warming climate on permafrost. Over the 2009 and 2010 field seasons twenty ALN sites were installed across the YRB.



Location of ALN sites across the YRB

Problem and Need

Numerous studies indicate that permafrost is thawing and the active layer is deepening. Permafrost thaw will likely lead to changes in groundwater flows and the quantity and quality of the rivers, streams, and lakes in the YRB. Additionally, changes in the thickness of the active layer may have profound effects on human infrastructure such as houses, sewage lagoons, and water systems.



Active Layer: layer of soil above the permafrost that freezes and thaws ...s.

Permafrost: soil that has been frozen for two or more years.

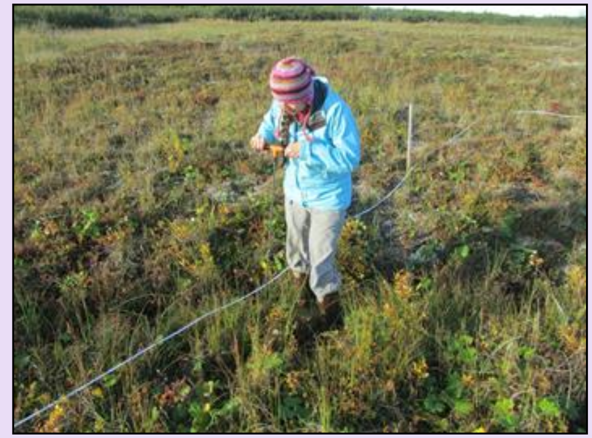
Talik: year round unfrozen ground in permafrost areas.

"Drunken Houses" that are falling over due to permafrost thaw

Faculty at the University of Alaska – Fairbanks (UAF) pioneered permafrost and active layer network studies in Alaska through the development of the global Circumpolar Active Layer Monitoring Program (CALM). The primary goal of CALM is to observe the response of the active layer and near surface permafrost to climate change of long (multi-decadal) time scales. The data collected as part of the ALN is submitted to the CALM program and available online at http://www.gwu.edu/~calm/.

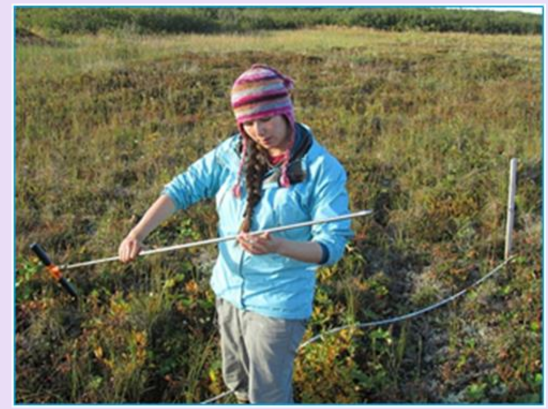
Methods

Site Locations

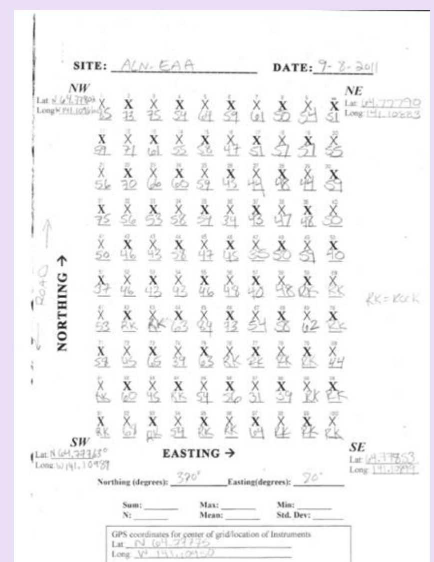


The location of ALN site was based on several factors. First, locations were chosen based on the presence of generally continuous permafrost at a depth that can be measured manually with a calibrated rod. Second, distribution of sites within the YRB must represent the wide range of regions and land cover such us upland, lowland, un-forested, and forested areas. Third, the site must be available for community involvement. The specific location of each site within the chosen regions was selected through community participation using community member's location knowledge of permafrost distribution and depth.

Design



The general project design for the ALN follows the design of other CALM projects. All sites consist of 50 meter by 50 meter grids. The depth of the active layer is measured each year at these grid locations. Measurements are taken every 5 meters for a total of 100 measurements. Measurements are made with a calibrated 1.1 meter steel metal rod with a blunt tip and a T-handle grip. The rod is pushed into the active layer until it makes contact with the permafrost. The depth is then measured and recorded on a field sheet. The results of these measurements from your community are provided on the following pages. In addition to manual active layer measurements soil temperature, soil moisture, and air temperature data are all recorded at the ALN site in the center of the grid. Each site is equipped with two soil temperature and two soil moisture sensors. One soil temperature sensor and one soil moisture sensor is placed just above the permafrost and the others are placed just below the soil surface. The sensors collect data every 30 minutes. The air temperature sensor is placed on a tree or a wooden stake and also collects data every 30 minutes. Each year this data is downloaded onto a laptop computer from the data logger box which is also placed at the ALN grid.



Air Temperature Sensor

Data Logger

Soil Temperature & Moisture Sensors

Results from manual measurements. The colors in each square represent how far from the surface the permafrost is, which is also the depth of the active layer. The darker the color the deeper the active layer.

KEY

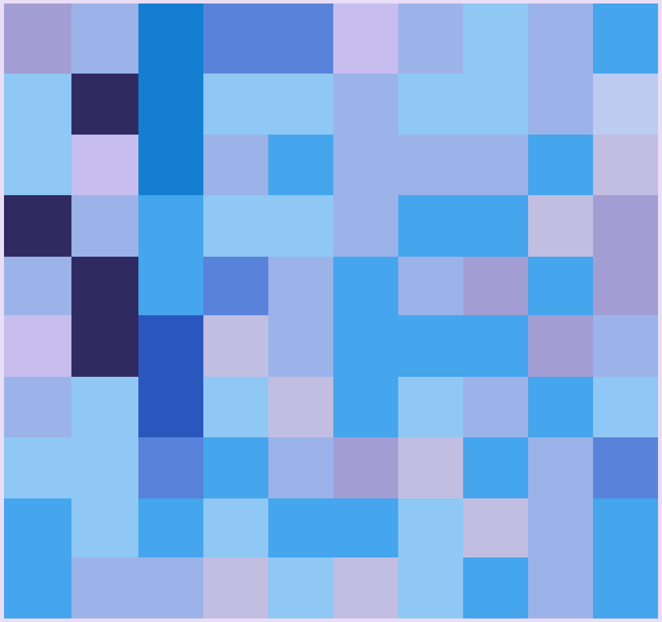
15 cm or less	16-20 cm	21-25 cm	26-30 cm	31-35 cm
36-40 cm	41-45 cm	46-50 cm	51-55 cm	56-60 cm
61-65 cm	66-70 cm	71-75 cm	76-80 cm	81-85 cm
86-90 cm	91-95 cm	96 cm -1 m		

2009

Average depth: 51.4 cm

Minimum depth: 34 cm

Maximum depth: 1 meter

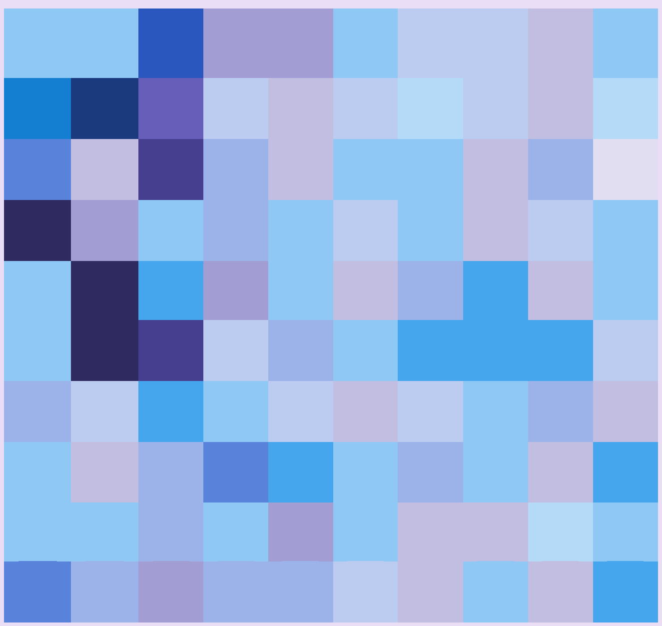


2010

Average depth: 47.3 cm

Minimum depth: 27 cm

Maximum depth: 1 meter

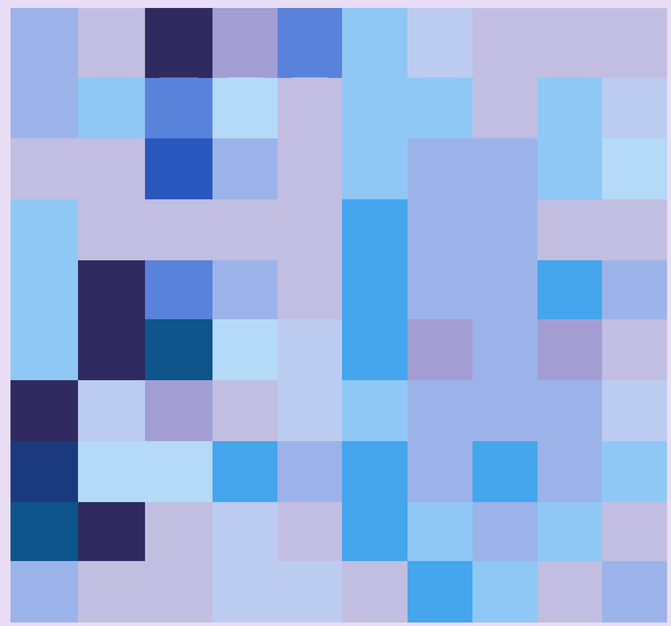


2011

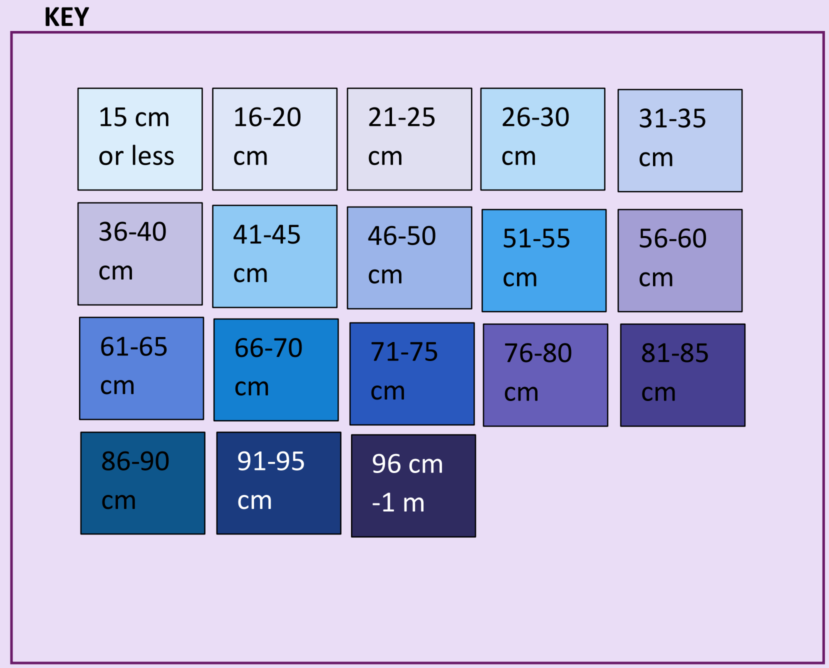
Average depth: 47.9 cm

Minimum depth: 27 cm

Maximum depth: 1 meter



Results from manual measurements. The colors in each square represent how far from the surface the permafrost is, which is also the depth of the active layer. The darker the color the deeper the active layer.

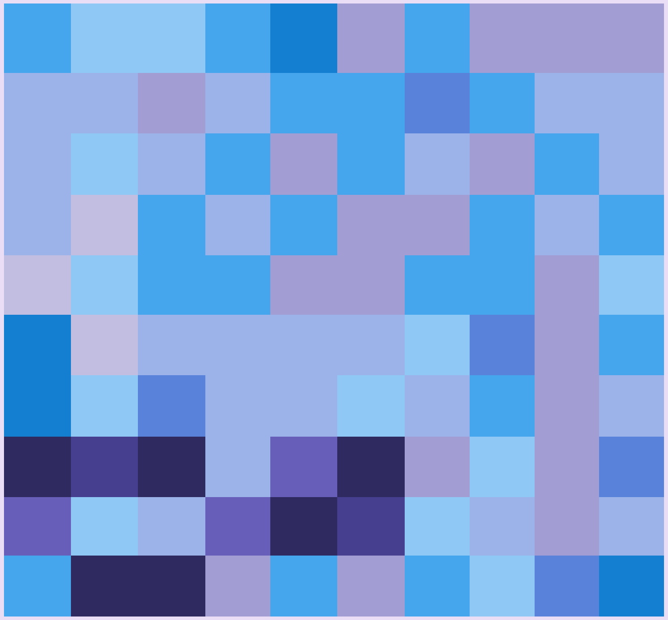


2012

Average depth: 56.4 cm

Minimum depth: 39 cm

Maximum depth: 1 meter

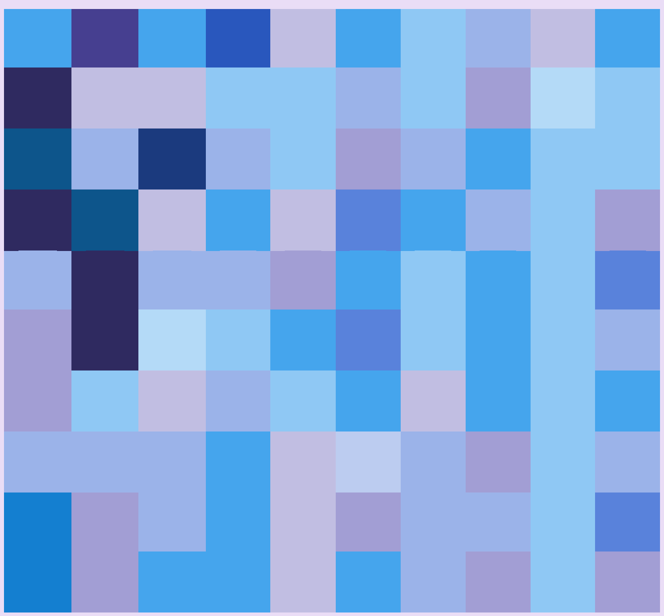


2013

Average depth: 52.5 cm

Minimum depth: 28 cm

Maximum depth: 1 meter

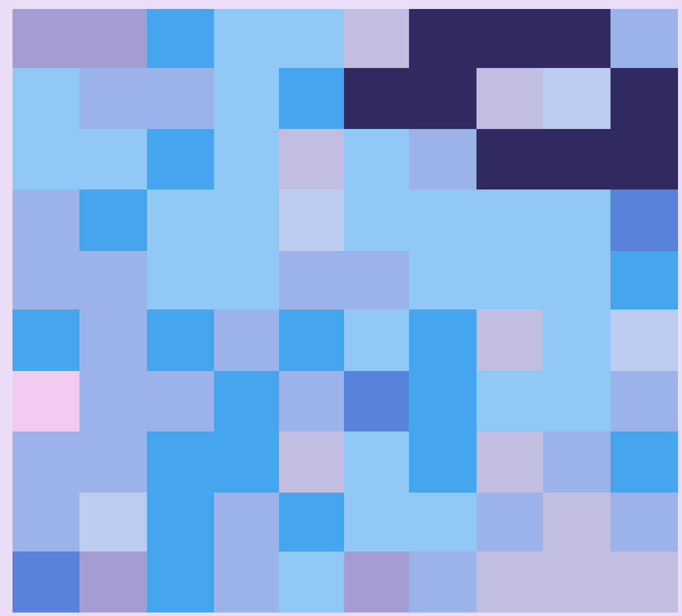


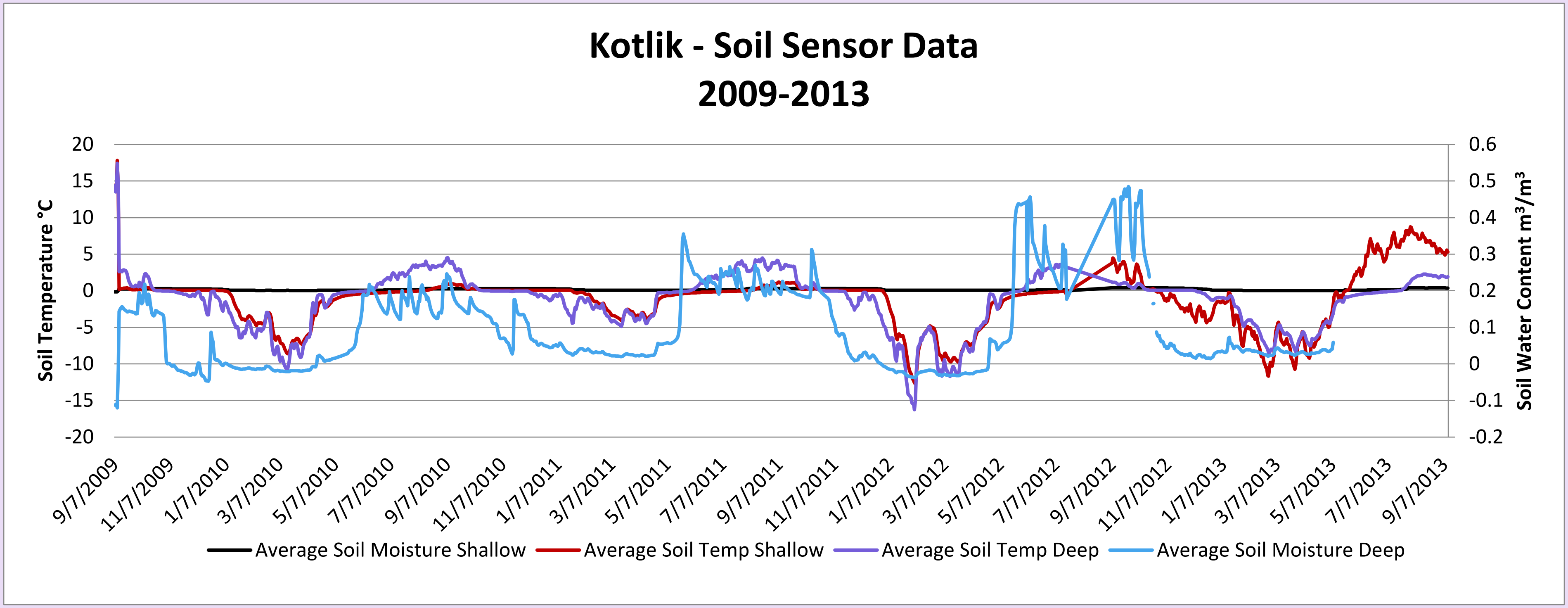
2014

Average depth: 51.8

Minimum depth: 33 cm

Maximum depth: 1 meter





Annual soil moisture and temperature °C Averages 2009-2010

Soil measurements	September	October	November	December	January	February	March	April	May	June	July	August
shallow soil moisture	0.180	0.264	Frozen	Frozen	Frozen	Frozen	Frozen	Frozen	Frozen	0.077	0.089	0.231
deep soil moisture	0.096	0.158	Frozen	Frozen	Frozen	Frozen	Frozen	Frozen	Frozen	0.170	0.165	0.159
Shallow soil temperature	3.231	0.184	0.051	0.050	-1.770	-4.040	-7.171	-3.826	-0.881	-0.343	-0.159	0.140
Deep soil temperature	4.457	0.734	-0.310	-0.008	-4.043	-5.130	-8.767	-3.436	-0.392	0.260	2.164	3.392

Freeze Back	Frozen Ground	Thawing	Thaw peak

Annual soil moisture and temperature °C Averages 2010-2011

Soil measurements	September	October	November	December	January	February	March	April	May	June	July	August
shallow soil moisture	0.291	0.287	Frozen	Frozen	Frozen	Frozen	Frozen	Frozen	Frozen	0.087	0.107	0.310
deep soil moisture	0.181	0.140	Frozen	Frozen	Frozen	Frozen	Frozen	Frozen	Frozen	0.235	0.233	0.211
Shallow soil temperature	0.715	0.135	0.053	0.051	-0.033	-1.103	-3.184	-2.969	-0.552	-0.228	-0.088	0.392
Deep soil temperature	2.948	0.229	-0.046	-0.594	-1.865	-1.871	-3.749	-3.059	-0.181	1.057	2.650	3.473

Freeze Back	Frozen Ground	Thawing	Thaw peak

Annual soil moisture and temperature °C Averages 2011-2012

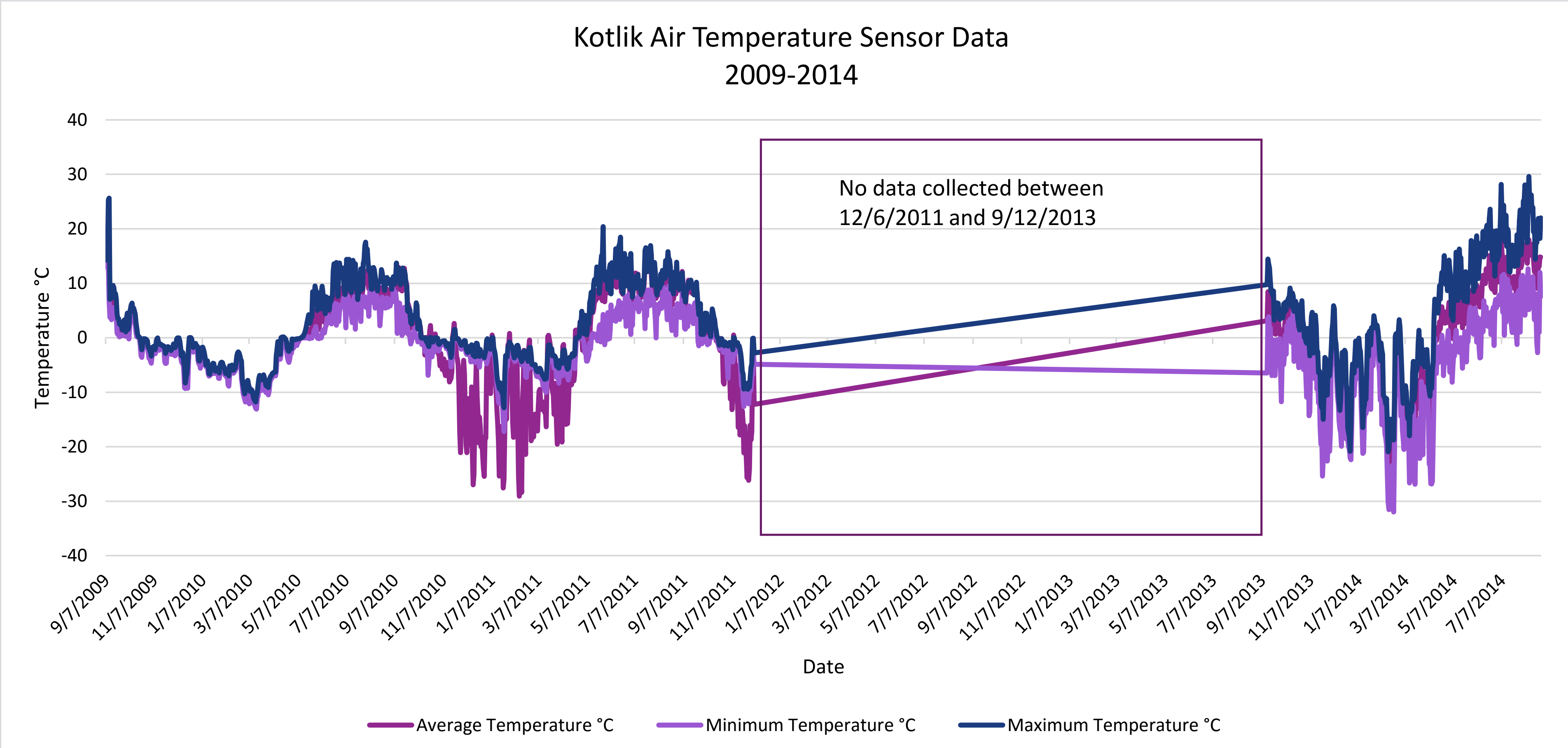
Soil measurements	September	October	November	December	January	February	March	April	May	June	July	August
shallow soil moisture	0.308	0.306	Frozen	Frozen	Frozen	Frozen	Frozen	Frozen	Frozen	0.077	0.091	No data
deep soil moisture	0.201	0.208	Frozen	Frozen	Frozen	Frozen	Frozen	Frozen	Frozen	0.341	0.248	No data
Shallow soil temperature	0.946	0.174	0.051	0.039	-5.690	-7.256	-8.908	-5.062	-1.186	-0.328	-0.157	No data
Deep soil temperature	3.056	0.309	-0.608	-1.635	-8.915	-8.061	-10.22	-4.735	-0.644	1.877	3.318	No data

Freeze Back	Frozen Ground	Thawing	Thaw peak

Annual soil moisture and temperature °C Averages 2012-2013

Soil measurements	September	October	November	December	January	February	March	April	May	June	July	August
shallow soil moisture	0.386	0.380	Frozen	Frozen	Frozen	Frozen	Frozen	Frozen	Frozen	0.082	0.147	0.376
deep soil moisture	0.408	0.277	Frozen	Frozen	Frozen	Frozen	Frozen	Frozen	Frozen	no data	no data	no data
Shallow soil temperature	2.893	0.876	-1.565	-3.119	-3.048	-7.683	-7.717	-6.672	-1.041	4.470	6.411	7.048
Deep soil temperature	0.903	0.311	0.051	-0.499	-1.884	-5.742	-6.551	-6.112	-1.929	-0.384	0.113	1.980

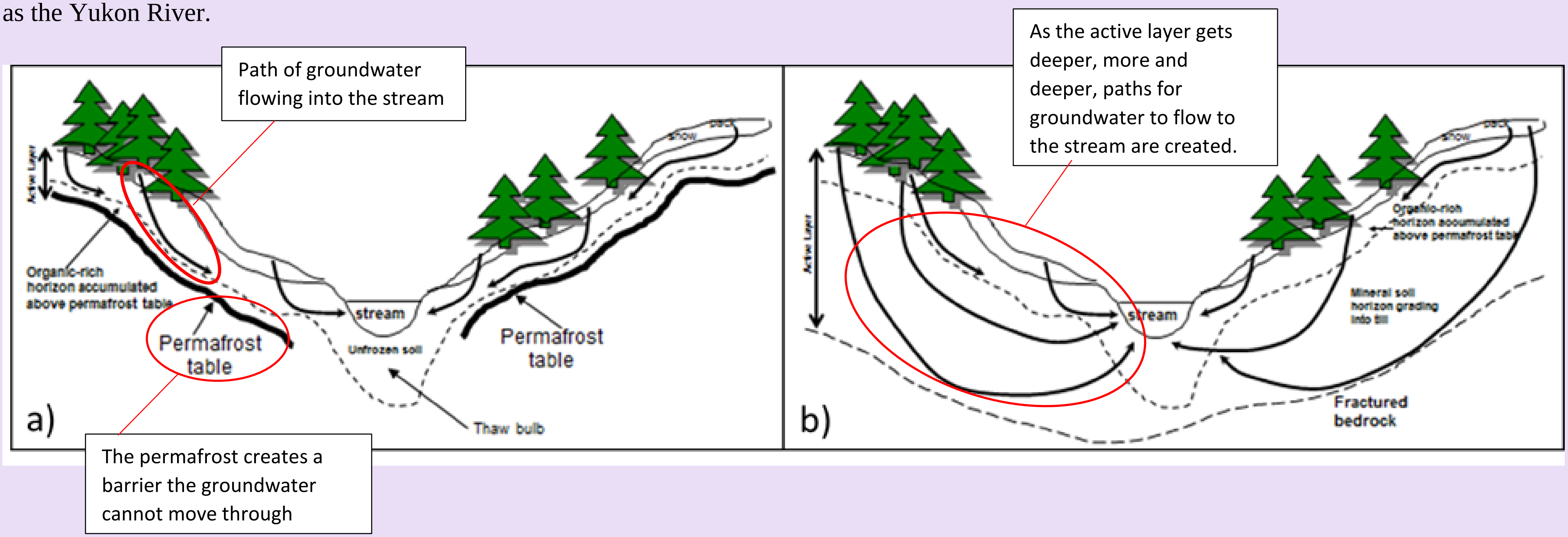
Freeze Back	Frozen Ground	Thawing	Thaw peak



Annual Averages	September	October	November	December	January	February	March	April	May	June	July	August
2009-2010	6.18	0.95	-2.21	-2.68	-5.04	-5.82	-9.64	-3.49	0.97	5.29	8.40	8.69
2010-2011	8.15	0.25	-5.51	-16.05	-10.58	-13.67	-10.99	-7.16	4.12	10.94	10.55	9.69
2011-2012	7.68	-0.33	-13.12	no data	no data	no data	no data	no data	no data	no data	no data	no data
2012-2013	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data
2013-2014	3.12	2.24	-6.45	-9.00	-4.99	-12.02	-12.53	-3.05	4.33	9.66	12.19	14.60
Average Temperature 5 years	6.28	0.78	-6.82	-9.24	-6.87	-10.51	-11.05	-4.57	3.14	8.63	10.38	10.99

Next Steps

The ALN project is designed to continue for decades as it can take years to see a definitive change in the depth to the active layer and permafrost degradation. However, early analysis of the ALN and water-quality data suggests that we are seeing a relationship between a thawing active layer and ground water. As the diagram below shows as the active layer deepens new paths for groundwater to flow through are created. This means that more elements in the soil may be dissolved by the water traveling through new paths and these elements may be carried into the nearby streams such as the Yukon River.



As the figure above shows in figure a) the permafrost creates a barrier that groundwater cannot move through, this forces the groundwater to move through shallow paths into the stream; in figure b) the active layer is deeper, which means the permafrost is further down and the groundwater can move through more paths and deeper paths than before. New and deeper paths of groundwater flow can change the chemical composition of the stream this groundwater is flowing into. The results of preliminary analysis at key ALN locations across the YRB suggest that we are seeing a seasonal change in the chemical composition of the river due to seasonal changes in the depth of the active layer. In order to confirm these findings the ALN and Water-quality monitoring must continue in the future at key locations so that we can collect more data to see if this trend continues into the future.