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Final Report

Identification

Program Name: Collaborative Research and Development Grant
Due Date: 2018-12-31

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Project Title: Consortium for Permafrost Ecosystem in Transition (CPET)

File Number: CRDPJ 469053 - 2014
Co-Applicant: Aaron A. Berg, Geography, Guelph
Co-Applicant: Jennifer JL. Baltzer, Biology, Wilfrid Laurier
Co-Applicant: James JR. Craig, Civil & Environmental Engineering, Waterloo
Collaborator: Elizabeth Grace EG. Johnson, Head Office, BC Ministry of Forests, Lands and Natural Resource Operations and Rura
Collaborator: Oliver O. Sonnentag, Géographie, Montréal
Collaborator: Masaki M. Hayashi, Geoscience, Calgary
Supporting Organization: Nexen Canada Ltd
Petroleum Technology Alliance Canada
Government of Northwest Territories
Geoscience BC

Final Report

Final Report (2009-W)

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Version française disponible

Identification

Canada

Public Summary of Outcomes and Benefits to Canada

Northwestern Canada is one of the most rapidly warming regions on Earth. This has led to unprecedented rates of permafrost thaw and resulting land-cover changes. This part of Canada is also the heart of the nation's oil and gas development, and as such has also experienced extensive human disturbance on the land. CPET has developed and tested new practical tools to predict the rate and pattern of permafrost thaw induced land cover change, and how these changes affect runoff and storage in drainage basins. These are essential tools for effective planning and management of resources and resource development, and contribute to the knowledge economy by increasing the capacity for science-based decision making. CPET has also fostered new collaborations among researchers, students, Indigenous organisations, local communities, government agencies and industry through cooperation on research and training initiative focused on permafrost and water resources.

Progress Towards Objectives/Milestones

To what extent were the objectives of the grant achieved? Rate your answer on a scale from 1 to 7.

Not at all			Somewhat		To a great extent	
○ 1	○ 2	○ 3	○ 4	○ 5	● 6	○ 7

Northeastern British Columbia and the adjacent southern Northwest Territories are among the most rapidly warming regions on Earth, and are experiencing unprecedented industrial expansion. Climate warming and human disturbance in the NEBC-NWT border region has led to widespread permafrost thaw and landcover change that has disrupted the hydrological cycle and the ecosystems and human activities that depend on it. The Consortium for Permafrost Ecosystems in Transition (CPET) was developed in response to the need for improved understanding of and ability to predict permafrost thaw impacts. CPET investigated hydrological and ecological changes resulting from permafrost thaw in the border region, developed and mobilised new knowledge of these changes, developed predictive modelling tools, and provided interactive training on these tools to our partners in industry, government and communities, including First Nations.

Hydrological field and modelling studies focussed on improving the understanding of permafrost thaw rates, patterns and processes and their implications on water flow and storage processes. This work was conducted at the two Primary sites at the northern (Scotty Creek, NWT) and southern (Suhm Creek, BC) ends of the 200 km north-to-south transect. Secondary sites at the northern (Jean-Marie R.) and southern (Calendar Creek) were established so that the CPET modelling tools could be tested. Our research demonstrated the wide-spread occurrence of perennially unfrozen ground (talik) between the active layer which freezes and thaws annually, and the underlying permafrost. Progress was also made on the development and testing of algorithms that numerically describe the seasonal freezing and thaw of the ground and thaw of permafrost, development of perennially-unfrozen layers (i.e. Talik). These advancements were used to develop numerical descriptions of the same for incorporation into the Raven hydrological modelling platform. This was needed to evaluate the impact of permafrost thaw on the water balance of drainage basins. Field studies combined with analysis of archived data demonstrated a simultaneous rise in basin discharge and dewatering of wetlands at Scotty Creek (see Haynes et al., 2018). This led to new insights on the trajectory of permafrost thaw-induced landcover change over the southern margin of thawing, discontinuouis permafrost between Scotty Creek and Suhm Creek, 200 km to the south (see Carpino et al., 2018).

The progress of CPET is described below for five areas of scientific advancement. For each specific area, the research projects (RPs) completed and the HQP associated with each are reported. A summary of the overall scientific significance for each area is also provided.

1. Map the changing spatial distribution of permafrost, wetland and forest coverage over the past 60 years from aerial and satellite remote sensing and couple this with structural and functional ecosystem changes across the region.

Summary: CPET demonstrated the rate and pattern of permafrost thaw induced land-cover change. It also demonstrated methods of detecting permafrost from remote sensing, and defined the limits of such methods. This work made a significant contribution to understanding the trajectories of land-cover change and ecosystem succession in the southern margin of thawing discontinuous permafrost based on the rates and patterns of permafrost thaw in this region. This work was essential to predicting hydrological futures in this region.

RP1: *Image analyses of permafrost thaw-induced land cover and ecosystem change was conducted using archived aerial imagery, repeated LiDAR surveys and optical satellite imagery. Ground-based measurements captured the functional and structural changes of ecosystems with thaw.*

- This RP was completed at both Scotty Creek (NWT) and Suhm Creek (BC). This involved image analyses of permafrost thaw-induced land cover change at the 12 intervening areas of interest AOIs located along the 200 km north-to-south transect between the Scotty Creek and Suhm Creek end-members. This work was led by O. Carpino (MSc) and J. Adams (PDF).
- Remote sensing analyses were complemented by surveys of ground vegetation community composition. This included plant functional trait measurements at Scotty Creek and Suhm Creek, and community-weighted trait estimates across resource gradients at both sites by K. Standen (NSERC-funded PhD student).
- Results from the first paper focused on functional trait variation boreal plants in preparation from this work was presented at the Arctic Change meeting in Ottawa in December: Standen, K and Baltzer J (2018).
- Multiple Airborne Lidar was flown over Scotty Creek between 2010 and 2018 for fine-scale measurement of the rate and pattern of permafrost thaw.
- Collaboration with NASA/ABoVE produced additional imagery from NASA flights over Scotty, Suhm and each of the intervening AOIs along the 200 km transect. This was often done in combination with simultaneous ground-based measurements for the purpose of improving the remote detection of permafrost conditions.

RP2: *Field verification and quantification of permafrost was conducted for different degrees of permafrost thaw for comparison to satellite imagery*.

- O. Carpino transitioned into a PhD programme in Sept., 2018. Since then she has produced several iterations of a permafrost probability map for the study region. Ground verification of this map took place in September and October, 2018. New collaboration with S. Kokelj (GNWT) expanded the capabilities for improving this map product by making available to *CPET* additional data resources, and instrumentation for field verification.

RP3: *Dendrochronological analyses was used to assess historic patterns of ecosystem response to climate change and permafrost thaw to gain insights into rates, patterns and trajectories of ecosystem change. To support this, archived hydro-climatic records were analysed to detect changes in air temperature, precipitation, and stream flow for the areas of reconstructed permafrost loss in* RP1*.*

- N. Perron and C. Pappas (NSERC/SNSF-funded CPET postdoc) documented dendrochronolocal records for Scotty Creek and Suhm Creek and used this to identify age characteristics of forest stands in permafrost and permafrost-free locations, and sensitivity of annual growth rates to variations in meteorological conditions. This work complemented that of K. Haynes (PDF) and R. Connon (PhD) who evaluated changes to basin runoff as a result of forest loss and changes to the distribution of permafrost.

2. Field studies were conducted to improve the understanding of the volume and timing of runoff from peat plateau-bog complexes and channel fens, and to investigate potential impacts of seismic lines on basin water storage and flux processes.

Summary: These studies provided the specific process understanding needed to inform hydrological model development and evaluation. A rapidly thawing permafrost landscape is a relatively new phenomenon of study. As such, the results of these field studies, which identify specific water redistribution processes and pathways, make an important contribute of new knowledge and provide a

new level of understanding needed to predict the hydrological changes to this landscape over the next several decades.

RP4: *Key runoff processes were examined at selected plateau-bog complexes, referred to as Study Complexes* (SCs).

- Devoie (PhD student) and Connon (PhD student) defined the major water flux and storage process, and the major runoff pathways connecting to stream channels. They also extended this work to include examinations of talik formation and subsurface water conductance, and numerical descriptions of these processes are being developed for incorporation into Raven. The occurrence of talik is far more widespread than previously believed, and was shown to provide an important flowpath for water throughout the year.

RP5: *Evapotranspiration*.

- M. Helbig (PhD student) defined rates and patterns of evapotranspiration from plateau bog complexes and from channel fens by evaluating eddy covariance measurements for different wind directions within a landscape "foot print" in the vicinity of a 20 m eddy covariance tower. This work formed the basis of a publication that evaluated the impact of permafrost thaw induced land cover change (i.e. increasing wetland coverage and decreasing permafrost plateau coverage) on the ET flux from the landscape.
- Pappas (PDF student) and Perron (PhD student) linked forest structure and sap flux measurements to derive forest-scale estimates of evapotranspiration (ET) which compared closely with ecosystem-scale ET obtained with eddy covariance.

RP6: *Local groundwater exchanges were measured and characterised, including groundwater connections among bogs, and between bogs and channel fens*.

- Directions, rates and patterns of groundwater flow below and over permafrost bodies was quantified and incorporated with rates of overland flow and near-surface flow to define the dominant flowpaths throughout the year.
- E. Devoie (PhD) defined sub-permafrost groundwater flow rates between land-cover types. This increases the understanding of the overall groundwater flux including supra-permafrost flow through talik and active layer.

RP7: The flux and storage of water within and from plateau bog complexes was characterised.

- Elise Devoie (PhD) developed and applied a water level-dependent hydraulic transfer algorithm for bog cascades and open bogs, and this will be augmented by numerical descriptions of subsurface flow through taliks. This was incorporated into the Raven modelling platform.
- Field studies and image analyses by B. Disher (M.Sc.) demonstrated the widespread occurrence of a "tree-bogs", a permafrost-free terrain which indicates a landcover trajectory from the more common transition from treed permafrost plateaus to treeless bogs.

RP8: *Key basin-scale drainage processes were examined at Scotty Creek to improve conceptual and numerical models*.

- Studies by M. Braverman at Scotty on Seismic lines were extended to other sites in both the NWT and BC sites. This began with an assessment of seismic grid densities throughout the study region (based on NWT and BC government archives). Our hydrological studies have shown that these and other linear disturbances soon develop linear taliks that conducts subsurface drainage

throughout the year. As such, these features can influence water flux and storage processes at basin scales.

- An examination of archived water level records since 1999, clearly indicate that the wetlands at Scotty Creek are dewatering. The amount of water released over this period contributed to the rise in discharge from Scotty Creek that commenced in 1995, and lasted until approximately 2012. This increased runoff was driven by transient (wetland dewatering) and permanent (increased hydrological connectivity) changes, both driven by permafrost thaw.

3. The major water flux and storage processes controlling runoff from plateau-bog complexes and routing along natural drainage ways (i.e. channel fens) and seismic lines was simulated using complementary Raven informed by new process understanding from O2.

Summary: CPET represents a uniquely close collaboration between field researchers and numerical modellers. This has allowed for rapid advancement in predictive capacity as new knowledge on processes arising from RPs 4-8 is numerically described and tested with a minimum of delay. In this way, not only did the field studies inform model development, but model development also directed field studies by identifying areas where improved process understanding was needed.

RP9: The *CRHM model was used to compute snowmelt, active layer thaw, and subsurface water fluxes from measurements in the Main and Replicate SCs (see RP4) at both Primary basins*.

- Devoie (PhD) developed a conceptual box-model of permafrost thaw and it has been incorporated into Raven. She has successfully bench-marked it against a fully coupled soil-moisture freeze thaw model that she developed from scratch. All work with CRHM is now complete. Our focus is now on incorporating simulations into Raven.
- A Raven model was developed of the Scotty Creek basin in support of RP9 with adequate match to observed streamflows; Development and application of models for active layer evolution is ongoing.
- G. Brown (M.Sc.) assembled and synthesized historical observation data on water and energy balance (characterizing data uncertainty and variability) in support of long-term modelling efforts.

RP10: *Using the algorithms developed and tested in CRHM* (*RP7, RP8) and existing algorithms* (*RP9*)*, Raven was used to build a new model (Raven-SC) for application to plateau-bog complexes* (**PhD3**).

- All CRHM modelling is complete. We continue to make progress in building a model in Raven for application to plateau-bog complexes, apply it to the Main and Replicate SCs, force it with meteorological data, and evaluate its hydrological response.
- Slight delays in this modelling objective are anticipated as we await the availability of data being gathered over the winter of 2018-19.

4. A new method to simulate the thaw of discontinuous permafrost and the resulting land cover changes was developed.

Summary: CPET used lessons learned from the modelling of the specific land-covers at the field sites to develop more generalised relationships for a wide range of possible peatland cover assemblages arising from on-going permafrost thaw and resulting land-cover changes. This component of CPET research is significant scientifically because it increases the portability and applicability of CPET results.

RP11: *Permafrost thickness and surface topography was mapped using electrical resistivity imaging (ERI)*.

- ERT measurements confirmed the absence of permafrost below treed bogs indicating that these features evolved from bogs rather than from plateaus. ERT transect measurements from 2010 were repeated in 2018 to evaluate changes in permafrost thickness and horizontal extent from which permafrost thaw rates were derived and the differences in these rates was determined from different locations over the 200 km transect.

RP12: *The RP11 measurements were used to inform simulations of thaw-induced changes to the spatial pattern of permafrost (plateau) and permafrost-free (bog and fen) terrains* (**PhD3**).

- New algorithms for soil thaw and refreeze were developed and tested, and incorporated into Raven in the previous reporting period, were improved upon. We also completed the development of a 2D permafrost evolution model using the finite element method. It was benchmarked by E. Amiri (Ph.D.) to quantify impact of horizontal and vertical energy fluxes to permafrost.
- Progress continues with the development of lateral thaw algorithms to support permafrost modelling and mapping by HQP E. Amiri (PhD); full 3D permafrost evolution algorithm tested on individual peatlands for extrapolation to mesoscale models.

RP13: *Plateau, bog and fen surfaces were modelled separately by three land cover specific models, forced by archived climate data and run simultaneously to include lateral heat transfers among them* (**PhD3**).

- New algorithms for quantifying the total primary and secondary contributing area, bog area distribution, and bog contributing area distribution for current, historical, and projected land use maps were developed and rigorously tested and improved. These were used to map the land cover projections needed to simulate future land cover arising from continued permafrost thaw.

5. Information from the hydrological (O3) and permafrost (O4) simulators was used to estimate future quantities of runoff from wetland-dominated basins with discontinuous permafrost under possible scenarios of climate warming and human disturbance.

Summary: This component of CPET is not yet completed, but significant progress has been made. This research relates future land-covers based on rates and patterns of permafrost thaw in 4 to their associated hydrographs. Preliminary results indicate increased runoff from land covers due to permafrost thaw as a result of 1) drainage of areas previously impounded by permafrost, and 2) expansion of the runoff source area of basins. The former represents a transient increase in drainage which is expected to last for years to a few decades, while the latter is a results in a permanent increase in basin discharge. The impact of year-round flows through taliks and the impact of seismic grids on drainage are currently being incorporated into hydrograph predictions.

RP14: *Raven-Bas was run with the land-cover distributions generated by NEST-Mod in RP13 to approximate the change in stream flow as the land-covers of the basins change due to permafrost thaw* (**PhD3**).

- A Raven model of the Scotty Creek study complex was developed by PhD student É. Devoie. The model explicitly represents the cascading bog phenomenon. This bypasses the CRHM work and is a primary deliverable. Testing of this new model on the replicate SCs is progressing well.

RP15: *Raven was run for the basin scale will be on all four basins (i.e. both primary and both secondary basins) to assess the trajectory of hydrological and ecological change resulting from permafrost thaw* (**PhD3**).

- The Raven model has been extended to support generalized lateral transfer of water between Hydrological response units, wetland overflow, and seepage from wetlands. The model now can support the HEW (hydrologic equivalent wetland) modelling approach or the GIW (geographically isolated wetland) modelling approach, both of which will be applied. Basin scale runoff simulations are on-going (Devoie, PhD student).

Problems Encountered

Identify the problems encountered during the research project. (Select all that apply.)

- [ ] Technical or scientific problems
- [ ] Problems with direction of research or findings
- [ ] Equipment and facilities
- [ ] Staffing issues (e.g., availability of students, staff leaving project)
- [ ] Funding problems
- [ ] Partners withdrew from project
- [ ] Partners interaction issues
- [ ] No problems were encountered
- [x] Other (specify)

The economic down-turn in the resources sector reduced Nexen's capacity to participate.

Problems Encountered

If problems were identified, briefly describe them and the steps taken to resolve each one.

Approximately half-way through the project, the economic down-turn had caused Nexen to re-assess its spending priorities. This meant that the individuals at Nexen that we had collaborated with until that point had left the company. Because by this time all of our field instrumentation was a already installed, the project continued with a minimum of delay.

Research Team

Entry 1 of 37

Consent obtained: ● Yes ○ No

Name: Aaron Berg

Role: Co-Applicant

If role is "Other", specify:

Contribution

Lead researcher for studies on remote sensing studies. Supervision of graduate students.

Entry 2 of 37

Consent obtained: ● Yes ○ No

Name: James Craig

Role: Co-Applicant

If role is "Other", specify:

Contribution

Lead researcher for numerical modelling studies. Co-supervision of graduate students.

Entry 3 of 37

Consent obtained: ● Yes ○ No

Name: Jenn Baltzer

Role: Co-Applicant

If role is "Other", specify:

Contribution

Lead research for ecological studies. Supervision of graduate students. Field studies at Scotty Creek and Suhm Creek.

Research Team

Entry 4 of 37

Consent obtained: ● Yes ○ No
Name: Jessica Smart
Role: Undergraduate Student
If role is "Other", specify:

Contribution

Research assistant / undergraduate thesis.

Entry 5 of 37

Consent obtained: ● Yes ○ No
Name: Izabela Jasiak
Role: Undergraduate Student
If role is "Other", specify:

Contribution

Research assistant.

Entry 6 of 37

Consent obtained: ● Yes ○ No
Name: Nia Perron
Role: Graduate Student
If role is "Other", specify:

Contribution

Changes to plant functional groups with permafrost thaw induced land cover change.

Research Team

Entry 7 of 37

Consent obtained: ● Yes ○ No

Name: Elise Devoie

Role: Graduate Student

If role is "Other", specify:

Contribution

Field studies on thermal and hydrological processes. Development of new code for Raven model.

Entry 8 of 37

Consent obtained: ● Yes ○ No

Name: Olivia Carpino

Role: Graduate Student

If role is "Other", specify:

Contribution

Analysis of historical and contemporary images to quantify rates and patterns of permafrost thaw over the last half century in the southern margin of discontinuous permafrost between northeastern BC and the southern NWT.

Entry 9 of 37

Consent obtained: ● Yes ○ No

Name: Elzbieta Mastej

Role: Graduate Student

If role is "Other", specify:

Contribution

development of innovative ground freezing systems.

Research Team

Entry 10 of 37

Consent obtained: ● Yes ○ No
Name: Angela Elgie
Role: Graduate Student
If role is "Other", specify:

Contribution

Impact of seismic lines on water balance of wetlands.

Entry 11 of 37

Consent obtained: ● Yes ○ No
Name: Lindsay Stone
Role: Graduate Student
If role is "Other", specify:

Contribution

Model simulation of water flow through channel fens.

Entry 12 of 37

Consent obtained: ● Yes ○ No
Name: Rebecca Warren
Role: Graduate Student
If role is "Other", specify:

Contribution

Impact of permafrost land cover change on basin evaporation regimes.

Research Team

Entry 13 of 37

Consent obtained: ● Yes ○ No
Name: Katherine Standen
Role: Graduate Student
If role is "Other", specify:

Contribution

Field studies on functions for permafrost, transitional, and permafrost free ecosystems.

Entry 14 of 37

Consent obtained: ● Yes ○ No
Name: Erfan Amiri
Role: Graduate Student
If role is "Other", specify:

Contribution

Numerical modelling / code development and testing.

Entry 15 of 37

Consent obtained: ● Yes ○ No
Name: Ana Sniderhan
Role: Graduate Student
If role is "Other", specify:

Contribution

Field assistant.

Research Team

Entry 16 of 37

Consent obtained: ● Yes ○ No
Name: Mason Dominico
Role: Graduate Student
If role is "Other", specify:

Contribution

Energy balance of a permafrost body.

Entry 17 of 37

Consent obtained: ● Yes ○ No
Name: Emily Haughton
Role: Graduate Student
If role is "Other", specify:

Contribution

Evaluation of impact of permafrost thaw induced land cover change on snow melt runoff contributions to stream hydrographs.

Entry 18 of 37

Consent obtained: ● Yes ○ No
Name: Meagan Warkentin
Role: Graduate Student
If role is "Other", specify:

Contribution

Impact of seismic lines on water balance of wetlands

Research Team

Entry 19 of 37

Consent obtained: ● Yes ○ No

Name: Caren Ackley

Role: Graduate Student

If role is "Other", specify:

Contribution

Evaluation of impact of landcover changes resulting from wildfires on thermal and hydrological processes. Although fire is not directly studied by CPET, this examination identified important site characteristics controlling thermal and hydrological processes.

Entry 20 of 37

Consent obtained: ● Yes ○ No

Name: Brenden Disher

Role: Graduate Student

If role is "Other", specify:

Contribution

development of conceptual models of permafrost thaw induced land cover change.

Entry 21 of 37

Consent obtained: ● Yes ○ No

Name: Bhaleka Persaud

Role: Graduate Student

If role is "Other", specify:

Contribution

Development of improved methods of applying re-analysis climate data in the data poor CPET region.

Research Team

Entry 22 of 37

Consent obtained: ● Yes ○ No
Name: Elyse Mathieu
Role: Graduate Student
If role is "Other", specify:

Contribution

Evaluating the impacts of wildfire on permafrost thaw runoff processes.

Entry 23 of 37

Consent obtained: ● Yes ○ No
Name: Julianne Mai
Role: Postdoctoral Fellow
If role is "Other", specify:

Contribution

probability modelling of permafrost thaw-induced land cover change.

Entry 24 of 37

Consent obtained: ● Yes ○ No
Name: Chris Pappas
Role: Postdoctoral Fellow
If role is "Other", specify:

Contribution

Sap flux rates and patterns from black spruce canopies.

Research Team

Entry 25 of 37

Consent obtained: ● Yes ○ No
Name: Kristine Haynes
Role: Postdoctoral Fellow
If role is "Other", specify:

Contribution

Evaluation of the impact of permafrost thaw induced land cover change on water storage in basins.

Entry 26 of 37

Consent obtained: ● Yes ○ No
Name: Justin Adams
Role: Postdoctoral Fellow
If role is "Other", specify:

Contribution

Acquire all historical satellite and aerial imagery for the study region. Develop Areas of Interest (AOIs) for analysis of land cover change over time.

Entry 27 of 37

Consent obtained: ● Yes ○ No
Name: Eva Needlay
Role: Technician
If role is "Other", specify:

Contribution

Research Technician.

Research Team

Entry 28 of 37

Consent obtained: ● Yes ○ No

Name: Dirk Friesen

Role: Technician

If role is "Other", specify:

Contribution

Development and testing of new instruments to directly detect below ground frost formation.

Entry 29 of 37

Consent obtained: ● Yes ○ No

Name: Tom Lakusta

Role: Government Research Partner

If role is "Other", specify:

Contribution

Provided expert guidance, logistical support and equipment for the development of permafrost probability maps.

Entry 30 of 37

Consent obtained: ● Yes ○ No

Name: Elizabeth Johnson

Role: Government Research Partner

If role is "Other", specify:

Contribution

Logistical support for field studies in BC. Liaison with government groups and industry.

Research Team

Entry 31 of 37

Consent obtained: ● Yes ○ No

Name: Ryan Connon

Role: Government Research Partner

If role is "Other", specify:

Contribution

Field studies at Scotty Creek and Suhm Creek. Collaboration with Co-I James Craig on incorporation of Raven model into GNWT resources management and decision making.

Entry 32 of 37

Consent obtained: ● Yes ○ No

Name: Steve Kokelj

Role: Government Research Partner

If role is "Other", specify:

Contribution

Provided expert guidance, logistical support and equipment for the development of permafrost probability maps.

Entry 33 of 37

Consent obtained: ● Yes ○ No

Name: Michael Braverman

Role: Industry Research Partner

If role is "Other", specify:

Contribution

Development and testing of new ground freezing systems to reduce or reverse permafrost thaw.

Research Team

Entry 34 of 37

Consent obtained: ● Yes ○ No

Name: Dieter Cazon

Role: Collaborator

If role is "Other", specify:

Contribution

As Resources Director for the Liidlii Kue First Nation, Dieter coordinates collaborative research and training initiatives at Scotty Creek.

Entry 35 of 37

Consent obtained: ● Yes ○ No

Name: Dahti Tsetso

Role: Collaborator

If role is "Other", specify:

Contribution

As the Resource Director for the Dehcho region, Dahti coordinates collaborative research and training initiatives with local communities.

Entry 36 of 37

Consent obtained: ● Yes ○ No

Name: Oliver Sonnentag

Role: Collaborator

If role is "Other", specify:

Contribution

Lead researcher for studies on evapotranspiration (ET). Co-supervision of graduate students. Field studies at Scotty Creek and Suhm Creek.

Research Team

Entry 37 of 37

Consent obtained: ● Yes ○ No

Name: Sorina Ciururita

Role: Other

If role is "Other", specify: Project Manager

Contribution

Reconciling of budgets and accounts, event planning and organisation.

Training of Highly Qualified Personnel (HQP)

What types of interactions did the HQP have with the partners during the project? (Select all that apply.)

- [x] HQP presented research results to the partners
- [x] HQP discussed the project directly with partners to obtain input
- [x] Partners jointly supervised thesis projects of HQP
- [ ] HQP worked regularly in the partner's facilities
- [ ] HQP did not interact with the partners
- [ ] Other (specify)

Entry 1 of 28

Name:	Izabela Jasiak
Type:	Undergraduate Student
If type is "Other", specify:	
Start Date yyyy/mm:	2017/09
End Date yyyy/mm:	2018/04
Percentage (%) of time this individual spent on this project:	10
Percentage (%) of salary from this grant (NSERC and industry contribution):	100
Total person-months:	1
To the best of your knowledge trainee is:	Continuing Academic Training
If "Employed by Other", specify:	

Entry 2 of 28

Name:	Jessica Smart
Type:	Undergraduate Student
If type is "Other", specify:	
Start Date yyyy/mm:	2018/05
End Date yyyy/mm:	2019/04
Percentage (%) of time this individual spent on this project:	50
Percentage (%) of salary from this grant (NSERC and industry contribution):	50
Total person-months:	6
To the best of your knowledge trainee is:	Continuing Academic Training
If "Employed by Other", specify:	

Training of Highly Qualified Personnel (HQP)

Entry 3 of 28

Name:	Meagan Warkentin
Type:	Master's Student
If type is "Other", specify:	
Start Date yyyy/mm:	2016/05
End Date yyyy/mm:	2016/09
Percentage (%) of time this individual spent on this project:	33
Percentage (%) of salary from this grant (NSERC and industry contribution):	33
Total person-months:	1
To the best of your knowledge trainee is:	Continuing Academic Training
If "Employed by Other", specify:	

Entry 4 of 28

Name:	Emily Haughton
Type:	Master's Student
If type is "Other", specify:	
Start Date yyyy/mm:	2014/09
End Date yyyy/mm:	2017/09
Percentage (%) of time this individual spent on this project:	100
Percentage (%) of salary from this grant (NSERC and industry contribution):	50
Total person-months:	36
To the best of your knowledge trainee is:	Employed in Industry
If "Employed by Other", specify:	

Entry 5 of 28

Name:	Lindsay Stone
Type:	Master's Student
If type is "Other", specify:	
Start Date yyyy/mm:	2015/09
End Date yyyy/mm:	2018/01
Percentage (%) of time this individual spent on this project:	100
Percentage (%) of salary from this grant (NSERC and industry contribution):	50
Total person-months:	28
To the best of your knowledge trainee is:	Employed in Industry
If "Employed by Other", specify:	

Training of Highly Qualified Personnel (HQP)

Entry 6 of 28

Name:	Caren Ackley
Type:	Master's Student
If type is "Other", specify:	
Start Date yyyy/mm:	2015/09
End Date yyyy/mm:	2019/02
Percentage (%) of time this individual spent on this project:	100
Percentage (%) of salary from this grant (NSERC and industry contribution):	25
Total person-months:	41
To the best of your knowledge trainee is:	Employed in Industry
If "Employed by Other", specify:	

Entry 7 of 28

Name:	Elyse Mathieu
Type:	Master's Student
If type is "Other", specify:	
Start Date yyyy/mm:	2015/09
End Date yyyy/mm:	2018/05
Percentage (%) of time this individual spent on this project:	100
Percentage (%) of salary from this grant (NSERC and industry contribution):	50
Total person-months:	32
To the best of your knowledge trainee is:	Employed in Industry
If "Employed by Other", specify:	

Entry 8 of 28

Name:	Angela Elgie
Type:	Master's Student
If type is "Other", specify:	
Start Date yyyy/mm:	2017/09
End Date yyyy/mm:	2019/09
Percentage (%) of time this individual spent on this project:	100
Percentage (%) of salary from this grant (NSERC and industry contribution):	50
Total person-months:	24
To the best of your knowledge trainee is:	Continuing Academic Training
If "Employed by Other", specify:	

Training of Highly Qualified Personnel (HQP)

Entry 9 of 28

Name:	Brenden Disher
Type:	Master's Student
If type is "Other", specify:	
Start Date yyyy/mm:	2017/09
End Date yyyy/mm:	2019/09
Percentage (%) of time this individual spent on this project:	100
Percentage (%) of salary from this grant (NSERC and industry contribution):	50
Total person-months:	24
To the best of your knowledge trainee is:	Continuing Academic Training
If "Employed by Other", specify:	

Entry 10 of 28

Name:	Elzbieta Mastej
Type:	Master's Student
If type is "Other", specify:	
Start Date yyyy/mm:	2017/09
End Date yyyy/mm:	2019/09
Percentage (%) of time this individual spent on this project:	100
Percentage (%) of salary from this grant (NSERC and industry contribution):	50
Total person-months:	24
To the best of your knowledge trainee is:	Continuing Academic Training
If "Employed by Other", specify:	

Entry 11 of 28

Name:	Olivia Carpino
Type:	Master's Student
If type is "Other", specify:	
Start Date yyyy/mm:	2015/09
End Date yyyy/mm:	2017/09
Percentage (%) of time this individual spent on this project:	100
Percentage (%) of salary from this grant (NSERC and industry contribution):	100
Total person-months:	24
To the best of your knowledge trainee is:	Continuing Academic Training
If "Employed by Other", specify:	

Training of Highly Qualified Personnel (HQP)

Entry 12 of 28

Name:	Michael Braverman
Type:	Master's Student
If type is "Other", specify:	
Start Date yyyy/mm:	2012/09
End Date yyyy/mm:	2016/09
Percentage (%) of time this individual spent on this project:	100
Percentage (%) of salary from this grant (NSERC and industry contribution):	20
Total person-months:	48
To the best of your knowledge trainee is:	Employed in Industry
If "Employed by Other", specify:	

Entry 13 of 28

Name:	Élise Devoie
Type:	Doctoral Student
If type is "Other", specify:	
Start Date yyyy/mm:	2016/01
End Date yyyy/mm:	2020/01
Percentage (%) of time this individual spent on this project:	100
Percentage (%) of salary from this grant (NSERC and industry contribution):	100
Total person-months:	48
To the best of your knowledge trainee is:	Continuing Academic Training
If "Employed by Other", specify:	

Entry 14 of 28

Name:	Erfan Amiri
Type:	Doctoral Student
If type is "Other", specify:	
Start Date yyyy/mm:	2016/09
End Date yyyy/mm:	2020/09
Percentage (%) of time this individual spent on this project:	25
Percentage (%) of salary from this grant (NSERC and industry contribution):	0
Total person-months:	12
To the best of your knowledge trainee is:	Continuing Academic Training
If "Employed by Other", specify:	

Training of Highly Qualified Personnel (HQP)

Entry 15 of 28

Name:	Katherine Standen
Type:	Doctoral Student
If type is "Other", specify:	
Start Date yyyy/mm:	2016/05
End Date yyyy/mm:	2020/05
Percentage (%) of time this individual spent on this project:	100
Percentage (%) of salary from this grant (NSERC and industry contribution):	33
Total person-months:	48
To the best of your knowledge trainee is:	Continuing Academic Training
If "Employed by Other", specify:	

Entry 16 of 28

Name:	Ana Sniderhan
Type:	Doctoral Student
If type is "Other", specify:	
Start Date yyyy/mm:	2012/09
End Date yyyy/mm:	2017/11
Percentage (%) of time this individual spent on this project:	20
Percentage (%) of salary from this grant (NSERC and industry contribution):	0
Total person-months:	12
To the best of your knowledge trainee is:	Employed in Academia / Non-Faculty
If "Employed by Other", specify:	

Entry 17 of 28

Name:	Ryan Connon
Type:	Doctoral Student
If type is "Other", specify:	
Start Date yyyy/mm:	2014/09
End Date yyyy/mm:	2017/09
Percentage (%) of time this individual spent on this project:	100
Percentage (%) of salary from this grant (NSERC and industry contribution):	50
Total person-months:	36
To the best of your knowledge trainee is:	Employed by Partners
If "Employed by Other", specify:	

Training of Highly Qualified Personnel (HQP)

Entry 18 of 28

Name:	Bhaleka Persaud
Type:	Doctoral Student
If type is "Other", specify:	
Start Date yyyy/mm:	2014/09
End Date yyyy/mm:	2020/09
Percentage (%) of time this individual spent on this project:	100
Percentage (%) of salary from this grant (NSERC and industry contribution):	50
Total person-months:	72
To the best of your knowledge trainee is:	Continuing Academic Training
If "Employed by Other", specify:	

Entry 19 of 28

Name:	Nia Perron
Type:	Doctoral Student
If type is "Other", specify:	
Start Date yyyy/mm:	2017/09
End Date yyyy/mm:	2020/09
Percentage (%) of time this individual spent on this project:	25
Percentage (%) of salary from this grant (NSERC and industry contribution):	20
Total person-months:	9
To the best of your knowledge trainee is:	Continuing Academic Training
If "Employed by Other", specify:	

Entry 20 of 28

Name:	Juliane Mai
Type:	Postdoctoral Fellows
If type is "Other", specify:	
Start Date yyyy/mm:	2017/09
End Date yyyy/mm:	2017/12
Percentage (%) of time this individual spent on this project:	100
Percentage (%) of salary from this grant (NSERC and industry contribution):	100
Total person-months:	3
To the best of your knowledge trainee is:	Employed in Academia / Non-Faculty
If "Employed by Other", specify:	

Training of Highly Qualified Personnel (HQP)

Entry 21 of 28

Name:	Christoforos Pappas
Type:	Postdoctoral Fellows
If type is "Other", specify:	
Start Date yyyy/mm:	2015/03
End Date yyyy/mm:	2020/03
Percentage (%) of time this individual spent on this project:	20
Percentage (%) of salary from this grant (NSERC and industry contribution):	0
Total person-months:	12
To the best of your knowledge trainee is:	Employed in Academia / Non-Faculty
If "Employed by Other", specify:	

Entry 22 of 28

Name:	Justin Adams
Type:	Postdoctoral Fellows
If type is "Other", specify:	
Start Date yyyy/mm:	2016/09
End Date yyyy/mm:	2017/12
Percentage (%) of time this individual spent on this project:	100
Percentage (%) of salary from this grant (NSERC and industry contribution):	60
Total person-months:	15
To the best of your knowledge trainee is:	Employed by Partners
If "Employed by Other", specify:	

Entry 23 of 28

Name:	Kristine Haynes
Type:	Postdoctoral Fellows
If type is "Other", specify:	
Start Date yyyy/mm:	2018/01
End Date yyyy/mm:	2019/07
Percentage (%) of time this individual spent on this project:	100
Percentage (%) of salary from this grant (NSERC and industry contribution):	50
Total person-months:	18
To the best of your knowledge trainee is:	Continuing Academic Training
If "Employed by Other", specify:	

Training of Highly Qualified Personnel (HQP)

Entry 24 of 28

Name:	Rebecca Warren
Type:	Research Associate
If type is "Other", specify:	
Start Date yyyy/mm:	2016/09
End Date yyyy/mm:	2017/03
Percentage (%) of time this individual spent on this project:	100
Percentage (%) of salary from this grant (NSERC and industry contribution):	25
Total person-months:	6
To the best of your knowledge trainee is:	Employed in Industry
If "Employed by Other", specify:	

Entry 25 of 28

Name:	Dirk Friesen
Type:	Technician
If type is "Other", specify:	
Start Date yyyy/mm:	2017/05
End Date yyyy/mm:	2017/09
Percentage (%) of time this individual spent on this project:	100
Percentage (%) of salary from this grant (NSERC and industry contribution):	20
Total person-months:	4
To the best of your knowledge trainee is:	Continuing Academic Training
If "Employed by Other", specify:	

Entry 26 of 28

Name:	Mason Dominico
Type:	Technician
If type is "Other", specify:	
Start Date yyyy/mm:	2018/05
End Date yyyy/mm:	2018/09
Percentage (%) of time this individual spent on this project:	100
Percentage (%) of salary from this grant (NSERC and industry contribution):	50
Total person-months:	4
To the best of your knowledge trainee is:	Continuing Academic Training
If "Employed by Other", specify:	

Training of Highly Qualified Personnel (HQP)

Entry 27 of 28

Name:	Eva Needlay
Type:	Technician
If type is "Other", specify:	
Start Date yyyy/mm:	2015/03
End Date yyyy/mm:	2016/06
Percentage (%) of time this individual spent on this project:	5
Percentage (%) of salary from this grant (NSERC and industry contribution):	100
Total person-months:	1
To the best of your knowledge trainee is:	Employed by Partners
If "Employed by Other", specify:	

Entry 28 of 28

Name:	Sorina Ciucurita
Type:	Other
If type is "Other", specify:	Project Manager
Start Date yyyy/mm:	2015/09
End Date yyyy/mm:	2019/01
Percentage (%) of time this individual spent on this project:	20
Percentage (%) of salary from this grant (NSERC and industry contribution):	10
Total person-months:	8
To the best of your knowledge trainee is:	Employed in Academia / Non-Faculty
If "Employed by Other", specify:	

Dissemination of Research Results

Refereed Journal Articles Submitted :	7
Refereed Journal Articles Accepted or Published:	32
Conference Presentations/ Posters:	219
Other (Technical Reports, Non-Refereed Articles, etc.):	20
How many of the publications, conference presentations, etc. identified above were co-authored with a non-academic partner?	72

1. Refereed Journal Articles, Submitted (7):

Amiri, E.*, J.R. Craig, and M. Hirmand, *A fully nonlinear scheme for numerical modelling of non-isothemal phase-change*, submitted to Computers and Geosciences, Oct 2018

McCarter, C.P.R., F. Rezanezhad, W.L. Quinton, B. Gharedaghloo, B. Lennartz, J. Price, R. Connon, P. Van Cappellen. In Review. Untangling the pore network controls on the hydro (bio) geochemical processes in peat and peatlands, *Environmental Reviews.*

Persaud, B., P. Whitfield, L. Stone, W. Quinton, In Review. Evaluating the suitability of three gridded datasets for small scale hydrological applications at Scotty Creek in the southern Northwest Territories, Canada. *Hydrological Process*.

Natali, S.M. *et al*., 2018. In Review. Substantial winter CO2 losses shift the Arctic to a carbon source under current and future climates, *Nature*.

Devoie É.G., J.R. Craig, W.L. Quinton, R.F. Connon. In Review. Taliks : A tipping point in discontinuous permafrost degradation in peatlands, *Water Resources Research*.

Langford, J.E., R.A. Schincariol, R.M. Nagare, W.L. Quinton, A.A. Mohammed, In Review. Transient and transition factors in modeling permafrost thaw and groundwater flow. *Groundwater*.

Sniderhan, AE, Mamet, SD, Baltzer, JL. From treeline to treeline: non-uniform growth dynamics of a dominant boreal tree species in the face of rapid climate change. Environmental Research Letters, in review.

2. Refereed Journal Articles, Accepted or Published (32):

Quinton, W.L. A. Berg, M. Braverman, O. Carpino, L. Chasmer, R.F. Connon, J. Craig, É. Devoie, M. Hayashi, K. Haynes, D. Olefeldt, A. Pietroniro, F. Rezanezhad, R. Schincariol, O. Sonnentag, 2018. A Synthesis of Three Decades of Eco-Hydrological Research at Scotty Creek, NWT, Canada. *Hydrology and Earth System Sciences (HESS)*.

Amiri, E. A.*, J.R. Craig, and B. Kurylyk, A theoretical extension of the soil freezing curve paradigm, Advances in Water Resources, 111, p319-328, 2018

Tank S., D. Olefeldt, W. Quinton W, C. Spence, N. Dion, C. Ackley, K. Burd, R. Hutchins, S. Mengistu, 2018. Fire in the Arctic: The effect of wildfire across diverse aquatic ecosystems of the Northwest Territories. *Polar Knowledge: Aqhaliat* (peer-reviewed, online journal produced by Polar Canada).

Haynes, KM, RF. Connon, WL Quinton. Hydrometric measurements in peatland-dominated, discontinuous permafrost at Scotty Creek, Northwest Territories, Canada. Changing Cold Regions Network (CCRN) Special Observation and Analysis Period (SOAP), Earth System Science Data, Manuscript #: essd-2018-68.

Carpino, O., A. Berg and W. Quinton, 2018. Climate change and permafrost thaw-induced boreal forest loss in northwestern Canada. *Environ. Res. Lett*., 13, 084018.

Haynes, KM, RF. Connon, WL Quinton, 2018. Permafrost thaw induced drying of wetlands at Scotty Creek, NWT, Canada. *Environ. Res. Lett*., 13, 114001.

Stone, L., W.L. Quinton, X. Fang, W. Pomeroy, O. Sonnentag, In Review. Modelling the effects of permafrost loss on discharge from wetland dominated basins in the discontinuous permafrost zone. *Hydrological Proc*.

Burd, K., S. Tank, N. Dione, W. Quinton, C. Spence, D. Olefeldt, 2018. Seasonal shifts in export of DOC and nutrients from burned and unburned peatland-rich catchments, Northwest Territories, Canada. *Hydrology Earth System Science*, 22, 4455–4472.

Sniderhan, AE, Baltzer, JL (2016) Growth dynamics of black spruce (Picea mariana) in a rapidly-thawing discontinuous permafrost peatland. Journal Geophysical Research Biogeosciences, 121: 2988-3000.

Gibson, CM, Chasmer, LE, Thompson, DK, Quinton, WL, Flannigan, MD, Olefeldt, D., 2018. Wildfire as a major driver of recent permafrost thaw in boreal peatlands. *Nature Communications*, volume 9, Article number: 3041, DOI: 10.1038/s41467-018-05457-1.

Warren, R.K, P. Christoforos, M. Helbig, L. Chasmer, R. Patankar, A. Berg, J. Baltzer, W.L. Quinton, and O. Sonnentag, In Press. Minor contribution of black spruce transpiration to evapotranspiration in boreal permafrost peatlands, *Ecohydrology*. doi.org/10.1002/eco.1975. https://rdcu.be/LCby.

Gharedaghloo, B., J. Price, F. Rezanezhad, W.L. Quinton, 2018. Evaluating the hydraulic and transport properties of peat soil using pore network modeling and X-Ray micro computed tomography. *Journal of Hydrology*, 561, 494–508. doi.org/10.1016/j.jhydrol.2018.04.007.

Connon, R.F., É Devoie, W.L. Quinton, T. Veness, M. Hayashi, 2018. The influence of shallow taliks on permafrost thaw and active layer dynamics in subarctic Canada. *Journal of Geophysical Research*. DOI: 10.1002/2017JF004469.

Helbig, M., W. Quinton and O. Sonnentag, 2017. Warmer spring increases annual methane emissions from a boreal peat landscape with sporadic permafrost. *Environmental Research Letters*, 12 (11), DOI: 10.1088/1748-9326/aa8c85.

Helbig M., Chasmer L., Desai, A., Kljun N., Quinton W., Sonnentag O., 2017. Direct and indirect climate change effects on carbon dioxide fluxes in a thawing boreal forest-wetland landscape. *Global Change Biology*, 23: 3231–3248. DOI: 10.1111/gcb.13638.

Helbig, M., L. Chasmer, N. Kljun, W. Quinton, C Treat, O. Sonnentag, 2016. The positive net radiative greenhouse gas forcing of increasing methane emissions from a thawing boreal forest-wetland landscape. *Global Change Biology*.10.1111/gcb.13520.

Merchant, M.A., Adams, J.R., Berg, A.A., Baltzer, J.L., Quinton, W.L., Chasmer, L.E., 2016. The contributions of C-band SAR multipolarization data and polarimetric decompositions to subarctic boreal peatland mapping. *IEEE Journal of Selected Topics in Applied Earth Observation and Remote Sensing*, 10(4):1467-1482. DOI: 10.1109/JSTARS.2016.2621043.

Pelletier, N., J. Talbot, D. Olefeldt, M. Turetsky, C. Blodau, O.Sonnentag and W.L. Quinton, 2017. Influence of Holocene permafrost aggradation and thaw on the paleoecology and carbon storage of a peatland complex in northwestern Canada. The *Holocene*, 27(9) 1391-1405. DOI: 10.1177/0959683617693899.

Helbig M, Wischnewski K, Kljun N, Chasmer L, Quinton W, Detto M, Sonnentag, O., 2016. Regional atmospheric cooling and wetting effect of permafrost thaw-induced boreal forest loss. *Global Change Biology*, 22, 4048-4066. doi:10.1111/gcb.13348.

Kurylyk, B.L., M. Hayashi, W.L. Quinton, J.M. McKenzie and C.I. Voss, 2016. Influence of vertical and lateral heat transfer on permafrost thaw, peatland landscape transition, and groundwater flow, *Water Resources Research*, 52, doi:10.1002/2015WR018057.

Mohammed, A., R.A. Schincariol, W.L. Quinton, R.M. Nagare, and Flerchinger, G.N., 2017. On the use of mulching to mitigate permafrost thaw due to linear disturbances in sub-arctic peatlands. *Ecological Engineering*, 102, 207–223.

Helbig, M., K. Wischnewski, G. Gosselin, S. Biraud, I. Bogoev, W. Chan, E. Euskirchen, A. Glenn, P. Marsh, W. Quinton, O. Sonnentag, 2016. Addressing a systematic bias in carbon dioxide flux measurements with the EC150 and the IRGASON open-path gas analyzers. *Agricultural and Forest Meteorology*, 228, 349–359.

Gordon, J., W. Quinton, B. Branfireun, D. Olefeltd, 2016. Mercury and methylmercury biogeochemistry in a thawing permafrost wetland complex, Northwest Territories, Canada. *Hydrological Processes*, DOI: 10.1002/hyp.10911.

Williams, T.J., J. W. Pomeroy, J. R. Janowicz, S. Carey, K. Rasouli, & W.L. Quinton, 2015. A radiative–conductive–convective approach to calculate thaw season ground surface temperatures for modelling frost table dynamics. *Hydrological Processes*, 29, 3954–3965. DOI: 10.1002/hyp.10573

Connon, R., W. Quinton, J. Craig, J. Hanisch, O. Sonnentag, 2015. The hydrology of interconnected bog complexes in discontinuous permafrost terrains. *Hydrological Processes*, DOI: 10.1002/hyp.10604.

Braverman, M. & W. Quinton, 2015. Hydrological impacts of seismic lines in the wetland-dominated zone of thawing, discontinuous permafrost, Northwest Territories, Canada. *Hydrological Processes*, DOI: 10.1002/hyp.10695.

DeBeer, C., H. Wheater, W. Quinton, S. Carey, R. Stewart, M. MacKay, P. Marsh, 2014. The Changing Cold Regions Network: Observation, Diagnosis, and Prediction of Environmental Change in the Saskatchewan and Mackenzie River Basins, Canada. Science China: *Earth Sciences*. Special Issue: Watershed science: bridge the new advancements in hydrological science with good management of river basins. X. Li, G. Zhang, C. He, T. Yue (eds.). Vol. 57, No. 1, p. 1-16.

Patankar, R., W. Quinton, M. Hayashi, J. Baltzer, 2015. Sap flow responses to seasonal thaw and permafrost degradation in a subarctic boreal peatland. *Trees - Structure and Function*: Volume 29, Issue 1, 129-142. DOI 10.1007/s00468-014-1097-8.

Mohammed, A., R. Schincariol, R. Nagare and W. Quinton, 2014. Reproducing Field-Scale Active Layer Thaw in the Lab. *Vadose Zone Journal*, 13 (8), doi:10.2136/vzj 20 14.01.0008

Rezanezhad, F., J. Price, W. Quinton, B. Lennartz, T. Milojevic, P. VanCappellen, 2016. Structure of peat soils and implications for water storage, flow and solute transport: A review update for geochemists. *Chemical Geology*, 429, 75-84. http://www.sciencedirect.com/science/article/pii/S0009254116301243.

Connon, R., W. Quinton, J. Craig and M. Hayashi, 2014. Changing hydrologic connectivity due to permafrost thaw in the lower Liard River valley, NWT, Canada. *Hydrological Processes*. pp. 4163-4178. DOI: 10.1002/hyp.10206.

Chasmer, L, C. Hopkinson, T. Veness, W. Quinton, and J. Baltzer, 2014. A decision-tree classification for low-lying complex land cover types within the zone of discontinuous permafrost. *Remote Sensing of Environment*, 143: 73-84.

3. Conferences Presentations and Posters (219).

a) Invited Talks (34):

Tank, S., S. Zolkos, S. Shakil, E. MacDonald, J. Li Yung Lung, R. Hutchins, B. Bonsal, R.M. Holmes, S. Kokelj, J.W. McClelland, D. Olefeldt, W. Quinton, C. Spence, R.G. Striegl, D. Yang. Landscape legacies and the biogeochemistry of surface waters in permafrost-affected terrains. Annual Meeting of the American Geophysical Union, Washington, DC, USA, 10 -14 Dec, 2018.

Quinton, W., C. Ackley, M. Braverman, A. Berg, O. Carpino, D. Cazon, L. Chasmer, R. Connon, J. Coughlin, J. Craig, E. Devoie, B. Disher, E. Haughton, M. Hayashi, K. Haynes, M. Helbig, J. Langford, J. Mai, E. Mathieu, B. Persaud, J. Pomeroy, W. Quinton, F. Rezanezhad, R. Schincariol, O. Sonnentag, L. Stone, S. Tank, D. Tsetso, P. Whitfield. Scotty Creek: Toward a Regional Research Park in the Dehcho. Laurier - Government of the NWT Partnership Annual General Meeting, 2-3 May, 2018, Waterloo, Canada.

Ackley, C., M. Braverman, A. Berg, O. Carpino, L. Chasmer, R. Connon, J. Craig, E. Devoie, B. Disher, E. Haughton, M. Hayashi, K. Haynes, M. Helbig, J. Langford, J. Mai, E. Mathieu, B. Persaud, J. Pomeroy, W. Quinton, F. Rezanezhad, R. Schincariol, O. Sonnentag, L. Stone, S. Tank, P. Whitfield. Summary of CCRN Hydrological Research at Scotty Creek. Changing Cold Regions Network (CCRN), Final Meeting and Workshop, Saskatoon, Canada, 5-6 March, 2018.

Ackley, C., W. Quinton, S. Tank. Impacts of wildfire on run-off flow paths on a peat plateau and implications for peat pore water chemistry Scotty Creek, NWT. Arctic Fire, Annual Meeting, Edmonton, Canada, 19 January, 2018.

Quinton, W.L. The Future of the Scotty Creek Research Station: Partners in Learning. Dehcho K'ehodi Regional Gethering, Fort Simpson, Canada, 17- 18 January, 2018.

Devoie, E., J. Craig, W.L. Quinton. Wetlands in transition: the impacts of permafrost degradation in peatland-dominated watersheds. World Wetlands Day 2018. University of Waterloo, 2 February, 2018.

Quinton, W., R. Connon, É. Devoie, M. Braverman. The influence of shallow taliks on permafrost thaw and active layer thickness in subarctic Canada. 21st International Northern Research Basins Symposium and Workshop, Yakutsk, Russia, 5-12 August, 2017.

Kershaw, G., W. Quinton, S. Mamet, P. Kershaw. Alpine permafrost loss in the Mackenzie and Selwyn Mountains, Canada: A remote assessment of thaw rates from 1944-2013. 21st International Northern Research Basins Symposium and Workshop, Yakutsk, Russia, 5-12 August, 2017.

Sonnentag, O. and W. Quinton. The Consortium, for Permafrost Ecosystems in Transition, *CPET*. NASA/ABoVE Airborne Science Planning and Science Team Meeting, Boulder, CO, USA, 17 – 20 January, 2017.

Turetsky, M. and W. Quinton. The Scotty Creek Research Station. NASA/ABoVE Airborne Science Planning and Science Team Meeting, Boulder, CO, USA, 17 – 20 January, 2017.

C. Ackley, J. Adams, M. Braverman, A. Berg, O. Carpino, R. Connon, J. Craig, E. Devoie, E. Haughton, M. Hayashi, M. Helbig, G. Kershaw, J. Langford, J. Mai, E. Mathieu, B. Persaud, W. Quinton, F. Rezanezhad, O. Sonnentag, L. Stone, S. Tank, S. VanOpstal, P. Whitfield. Update of peatland Hydrological Studies, Scotty Creek, NWT, Canada. Changing Cold Regions Network, 4th Annual General Meeting, University of Guelph, 2 - 4 November, 2016.

Baltzer, J, Quinton, W., Patankar, R, Day, N, White, A, Carriere, S, Sniderhan, A and McNickle, G (2016) Landcover changes in high latitude ecosystems. School of Environmental Science Sciences Seminar Series, University of Guelph. https://www.uoguelph.ca/ses/events/jennifer-baltzer-guest-ses-seminar-series

Baltzer, J, Quinton, W., Patankar, R, Day, N, White, A, Carriere, S, Sniderhan, A and McNickle, G (2016) Landcover changes in high latitude ecosystems. Department of Geography and Environmental Studies Seminar Series, Wilfrid Laurier University.

Baltzer, J, Quinton, W, Patankar, R, Chasmer, L, Hayashi, M, Berg, A, Sonnentag, O, Sniderhan, A, Veness, T and Warren, R (2016) Forests on uncertain ground: impacts of permafrost thaw on water use and productivity in black spruce. Ecohydrology Seminar Series, University of Waterloo. https://uwaterloo.ca/ecohydrology/events/seminar-baltzer

Hayashi, M. and W. Quinton, 2016. Water-Energy Feedback on Permafrost Thawing and Water Resources in the Mackenzie Valley. Canol Shale Play – Groundwater/ permafrost research needs. Calgary, 5 April, 2016.

Quinton, W. The Scotty Creek Research Station: Overview of past and present activities, and plans for the future. Dehcho Results Workshop. Cumulative Impact Monotoring Programme (CIMP). Regional Monitoring Workshop, Fort Simpson, Canada, 19-20 Jan., 2016.

Quinton W. Opening Remarks for Climate Warming and Aboriginal Communities in Northern Canada: Uncertain Futures. Panel Discussion, Cold Regions Research Centre & Office of Aboriginal Initiatives, Wilfrid Laurier University, 19 Nov., 2015.

Quinton, W., J. Craig and J. Adams. Consortium for Permafrost Ecosystems in Transition. Invited Research Seminar. Nexen Energy, Calgary, Canada, 11 Nov., 2015.

Quinton, W., C. Ackley, J. Adams, M. Braverman, A. Berg, R. Connon, J. Craig, E. Devoie, C. Frayne, J. Hanisch, E. Haughton, M. Hayashi, M. Helbig, B. Kurlyuk, E. Mathieu, V. Pedinotti, B. Persaud, O. Sonnentag, L. Stone, S. Tank, S. VanOpstal, P. Whitfield, 2015. Update on Peatland Hydrology Studies. Changing Cold Regions Network, 3rd Annual General Meeting, University of Saskatchewan, 2 – 4 November, 2015.

Kurylyk, B., M. Hayashi, W. Quinton, 2015. Recent advances in modelling the thermal regime of frozen ground. CCRN Modelling Workshop (Modelling Change in Cold Regions), National Hydrology Research Centre, Saskatoon, Canada, September 28-30, 2015.

Quinton, W. Engaging the public with Science. Invited Panelist. Early Career Hydrology Network. Hosted by the American Geophysical Union. CGU-AGU Joint Assembly, Montreal , Canada, 3-7 May, 2015.

Quinton, W., J. Baltzer, A. Berg, M. Braverman, L. Chasmer, R. Connon, J. Craig, A. McManus, O. Sonnentag, 2015. Multi-scale hydrological studies in thawing permafrost terrain: some insights for modelling Hydrological modelling across scales: on the issue of scale dependency. CGU-AGU Joint Assembly, Montreal , Canada, 3-7 May.

English, M., J. Baltzer, A. Blay-Palmer, R. Hall, A. Lister, P. Marsh, D. MacLatchy, J. McGeer, W. Quinton, S. Schiff, S. Smith, A. Spring, K. Stevens, M. Wilkie, B. Wolfe. Research Contribution of Wilfrid Laurier University researchers to understanding issues relevant to the NWT Water Strategy 2012-2014. Government of the NWT Water Strategy Meeting, Yellowknife, 4 February, 2015.

Quinton, W. Rates, patterns and trends of landcover change in the southern Taiga Plains. CCRN Theme A Meeting on Conceptual Models of Change, McMaster University, Hamilton, 22 January 2015.

Marsh, P., W. Quinton, J. Baltzer. Understanding the challenges confronting the Arctic: Water-Northern Ecosystems-Economy-Communities. Centre for International Governance Innovation (CIGI), Future of the Arctic, CIGI Campus, Waterloo, February 3, 2015.

English, M., W. Quinton, J. Baltzer, D. MacLatchy, M. Wilkie, P. Marsh, J. McGeer. The State of Water in the NWT. 2nd NWT Environmental Monitoring Results Workshop, 2015, Explorer Hotel, 4825-49th Avenue, Yellowknife, NT.

Quinton, W.L. Conceptual model development for warming-induced ecosystem change in the southern Taiga Plains Ecoregion. CCRN Theme A Workshop, McMaster University, Hamilton, Canada, 22 January, 2015.

Quinton, W.L. A glimpse of the future: insights into water resources in a warmer NWT. Legislature Talks: The Knowledge Series. Invited public presentation at the Legislature Building, Yellowknife, 14 January, 2015.

Quinton, William, Jennifer L Baltzer, Oliver Sonnentag, Aaron A Berg and Laura Chasmer. Multiscale studies of Permafrost Thaw Impacts on EcoHydrology in the Southern Fringe of Permafrost, Northwestern Canada. AGU-GAC-MAC-CGU Joint Assembly, Montreal, 3-7 May, 2015.

Baltzer, J. W. Quinton, O. Sonnentag, 2014. Boreal forests in permafrost landscapes: changing structure and function in response to climate warming. American Geophysical Union Annual Meeting, 15-19 Dec., San Fransisco, USA.

Quinton, W., M. Braverman, J. Baltzer, A. Berg, R. Connon, J. Craig, L. Freeman, J. Gordon, E. Haugton, M. Hayashi, M. Helbig, A. McManus, A. Mohammed, B. Persaud, R. Schincariol, O. Sonnentag, L. Stone, S. VanOpstal, P. Rahimzadeh, T. Veness, A. Verma. Update on Hydrology Research at Scotty Creek, NWT. Changing Cold Regions Network, 2nd Annual General Meeting. Wilfrid Laurier University, Waterloo, Canada, 20-22 October, 2014.

Helbig, M., Detto, M., Wischnewski, K., Chasmer, L., Quinton, W., Kljun, N., Payette, F. & Sonnentag, O, 2014. On the challenges of measuring greenhouse gas and energy fluxes over heterogeneous boreal landscapes. Institute of Soil Science at the University of Hamburg, 19 Sept., 2014.

Baltzer, JL Quinton, W, Berg, A, and Marsh, P., 2014. Assessing landscape change in high latitude ecosystems. Interdisciplinary Workshop on Geospatial Computing, Kitchener, ON.

Baltzer, J., and W. Quinton, 2014. Building on the Laurier-GNWT Partnership. Invited presentation to the Deputy Minister, Environment and Natural Resources, Government of the Northwest Territories, Yellowknife, 23 July, 2014.

b) Volunteered Presentations (185):

(**Note**: Only the most recent 50 presentation are listed below).

Amiri, E., and J.R. Craig, and É. Devoie, Controlling factors on lateral permafrost thaw in the Northwest Territories: a numerical study, Canadian Geophysical Union Joint Meeting, Niagara Falls, Jun 10-14, 2018

Devoie, É., R.F. Connon, J.R. Craig, and W.L. Quinton, Modelling controls on local talik formation in discontinuous permafrost, Canadian Geophysical Union Joint Meeting, Niagara Falls, Jun 10-14, 2018

Devoie, É., J.R. Craig, W.L. Quinton, and R.F. Connon, Quantifying thaw mechanisms in discontinuous permafrost: Is talik formation a tipping point? 45th Annual Yellowknife Geoscience Forum, Yellowknife, NT, Nov 14-16, 2017

Connon, R., É. Devoie, J.R. Craig, M. Hayashi, O. Sonnentag, T. Veness, W. Quinton, Changing runoff patterns due to permafrost thaw in discontinuous permafrost terrains, XI International Conference on Permafrost, Potsdam, Germany, June 20-24, 2016

Standen, KE and Baltzer JL (2018) Plant functional traits across a boreal peatland productivity gradient. Arctic Change 2018, Ottawa, ON.

Sonnentag, O, Pappas, C, Perron, N, Standen, K, Rakowski, S, Baltzer, J, Detto, M (2018) Functional and hydraulic traits plasticity of boreal tree species along a latitudinal climate and permafrost gradient in Northwestern North America. Amercian Geophysical Union Meeting, Washington.

Sniderhan, A, Mamet, S, Baltzer, J (2017) Black spruce growth dynamics in northwestern Canada: contrasting trends and climatic drivers from tree-line to tree-line. Ecological Society of America Annual Meeting, Portland, OR

Sniderhan, A, Mamet, S, Baltzer, J (2017) Treeline to treeline: latitudinal variability in black spruce growth dynamics in northwestern Canada. Arctic Change 2017, Quebec City, QC.

Ackley, C., S. Tank, W. Quinton, F. Rezanezhad, C. McCarter. Low-severity wildfire on a tree covered peat plateau: interactive effects of changes in runoff flowpath, pore water chemistry and ground thaw dynamics. Annual Meeting of the American Geophysical Union, Washington, DC, USA, 10 -14 Dec, 2018.

Natali, S., et al. Respiration from frozen soils across the Arctic. Annual Meeting of the American Geophysical Union, Washington, DC, USA, 10 -14 Dec, 2018.

Devoie, É, JR Craig., RF Connon, WL Quinton. Talik formation as a tipping point in permafrost degradation in discontinuous permafrost peatlands, Association of Canadian Universities for Northern Studies (ACUNS), Student Conference, November 1-3, 2018, Edmonton, Canada.

Disher, B., Connon, R. and Quinton, W. (2018). Examining the subsurface and thermal properties of treed bogs, Association of Canadian Universities for Northern Studies (ACUNS), Student Conference, November 1-3, 2018, Edmonton, Canada.

Ackley, C, S. Tank, W. Quinton, F. Rezanezhad, C. McCarter. Low-severity wildfire on a tree covered peat plateau: interactive effects of runoff flowpath and ground thaw dynamics on pore water chemistry. Association of Canadian Universities for Northern Studies (ACUNS), Student Conference, November 1-3, 2018, Edmonton, Canada.

Kershaw, GL, WL Quinton, M English. Using stable isotopes to assess seasonal variations in runoff response from an alpine valley basin in the Mackenzie Mountains, NWT, Association of Canadian Universities for Northern Studies (ACUNS), Student Conference, November 1-3, 2018, Edmonton, Canada.

Elgie, A., M. Braverman and W.L. Quinton. The impacts of seismic lines on the hydrology of adjacent wetlands. Association of Canadian Universities for Northern Studies (ACUNS), Student Conference, November 1-3, 2018, Edmonton, Canada.

Hopkinson, C., L. Chasmer, W. Quinton. A Decade of Airborne Lidar Ecosystem Change Monitoring in NWT Permafrost Landscapes. Canadian Permafrost Association, First Annual Conference and Business Meeting, October 10-12th, 2018, Whitehorse, Canada.

Schincariol, R.A., J.E. Langford, R.M. Nagare, W.L. Quinton, A.A. Mohammed. Modelling permafrost aggradation and thaw in a peat plateau wetland complex. Nordic Water 2018, 13-15 August, Bergen, Norway.

Connon, R.F., A.E. Coles, S.A. Kokelj and W.L. Quinton. New insights into snowfall and snow accumulation trends and patterns across the Northwest Territories. 5th European Conference on Permafrost, Chamonix-Mont Blanc, France, 23th June - 1st July, 2018.

Quinton, W.L., M. Braverman, R. Connon1, J. Craig, É. Devoie, K. Haynes. Hydrological change trajectories in the southern Taiga Plains, Canada. 5th European Conference on Permafrost, Chamonix-Mont Blanc, France, 23th June - 1st July, 2018.

Amiri, E.A., J.R. Craig, Devoie, É., and W.L. Quinton, Numerical simulation of lateral permafrost thaw in the Northwest Territories, 5th European Conference on Permafrost (EUCOP5), Chamonix Mont-Blanc, France, Jun 23-Jul 1, 2018

Braverman, M. and W.L. Quinton. An experimental study of permafrost restoration under the seismic line in the wetland-dominated zone of discontinuous permafrost, Northwest Territories, Canada. 5th European Conference on Permafrost, Chamonix-Mont Blanc, France, 23th June - 1st July, 2018.

Fouché, J., O. Sonnentag, M. Helbig, K. Lillie, G. Gosselin, W. Quinton, T. Moore. Dissolved organic carbon export and its contribution to the carbon budget in a boreal peat landscape undergoing rapid permafrost thaw. 5th European Conference on Permafrost, Chamonix-Mont Blanc, France, 23th June - 1st July, 2018.

Devoie, É, J.R. Craig, W.L. Quinton, R.F. Connon, E.A. Amiri. Taliks, a tipping point in permafrost degradation. 5th European Conference on Permafrost, Chamonix-Mont Blanc, France, 23th June - 1st July, 2018.

Chasmer, L., C. Mahoney, A. Paluck, R. Connon, W. Quinton, C. Hopkinson. Spatial Drivers of Permafrost Thaw using an Integrated Machine Learning Approach and in situ Methods. 39th Canadian Symposium on Remoste Sensing. Saskatoon, Canada, 19-21 June, 2018.

Flade, L. Chasmer, L., C. Hopkinson, W. Quinton. Quantifying spatial variability of permafrost condition using thermal as well as multi-temporal and multi-spectral LiDAR. 39th Canadian Symposium on Remote Sensing. Saskatoon, Canada, 19-21 June, 2018.

Ackley, C., W.L. Quinton, S. Tank, F. Rezanezhad, C. McCarter. Influence of a low-severity wildfire on runoff flowpaths and porewater chemistry of a peat plateau
Scotty Creek, NWT. Joint Annual Meeting for the Canadian Geophysical Union, Canadian Soil Science Society, Computational Infrastructure in Geodynamics, Eastern Section of the Seismological Society of America, and the Canadian Society for Agricultural and Forest Meteorology, Niagara Falls Canada, 10-14 June, 2018.

Haynes, K., R.F. Connon, W.L. Quinton. Permafrost thaw induced drying of wetlands at Scotty Creek, NWT, Canada. Joint Annual Meeting for the Canadian Geophysical Union, Canadian Soil Science Society, Computational Infrastructure in Geodynamics, Eastern Section of the Seismological Society of America, and the Canadian Society for Agricultural and Forest Meteorology, Niagara Falls Canada, 10-14 June, 2018.

Devoie, É., R.F. Connon, J.R. Craig, W.L. Quinton. Modelling controls on local talik formation in discontinuous permafrost. Joint Annual Meeting for the Canadian Geophysical Union, Canadian Soil Science Society, Computational Infrastructure in Geodynamics, Eastern Section of the Seismological Society of America, and the Canadian Society for Agricultural and Forest Meteorology, Niagara Falls Canada, 10-14 June, 2018.

Langford, J.L. R.A. Schincariol, R.M. Nagare, W.L. Quinton, A.A. Mohammed. Modelling thermal transport during permafrost aggradation and thaw in peatlands. Joint Annual Meeting for the Canadian Geophysical Union, Canadian Soil Science Society, Computational Infrastructure in Geodynamics, Eastern Section of the Seismological Society of America, and the Canadian Society for Agricultural and Forest Meteorology, Niagara Falls Canada, 10-14 June, 2018.

Carpino, O., W.L. Quinton, R.F. Connon. A permafrost probability map for northwestern Canada's sporadic discontinuous permafrost zone. Joint Annual Meeting for the Canadian Geophysical Union, Canadian Soil Science Society, Computational Infrastructure in Geodynamics, Eastern Section of the Seismological Society of America, and the Canadian Society for Agricultural and Forest Meteorology, Niagara Falls Canada, 10-14 June, 2018.

Ackley, C., S. Tank and W. Quinton. Influence of a low severity wildfire on runoff flow path and pore water chemistry of a peat plateau, Scotty Creek, NWT. Summary of CCRN Hydrological Research at Scotty Creek. Changing Cold Regions Network (CCRN), Final Meeting and Workshop, Saskatoon, Canada, 5-6 March, 2018.

Persaud, B. and W. Quinton. Can gridded datasets adequately replace observations in the Canadian subarctic? Summary of CCRN Hydrological Research at Scotty Creek. Changing Cold Regions Network (CCRN), Final Meeting and Workshop, Saskatoon, Canada, 5-6 March, 2018.

Devoie, E., J. Craig, W. Quinton and R. Connon. Permafrost response to observed ground temperature regimes. Summary of CCRN Hydrological Research at Scotty Creek. Changing Cold Regions Network (CCRN), Final Meeting and Workshop, Saskatoon, Canada, 5-6 March, 2018.

Mathieu, E., R. Connon, W. Quinton and O. Sonnentag. The impact of a low-severity burn on the trajectory of permafrost thaw: Scotty Creek, Northwest Territories, Canada. Summary of CCRN Hydrological Research at Scotty Creek. Changing Cold Regions Network (CCRN), Final Meeting and Workshop, Saskatoon, Canada, 5-6 March, 2018.

Carpino, O., A. Berg and W. Quinton. Climate change and permafrost thaw-induced boreal forest loss in Canada's fringe permafrost zone. Summary of CCRN Hydrological Research at Scotty Creek. Changing Cold Regions Network (CCRN), Final Meeting and Workshop, Saskatoon, Canada, 5-6 March, 2018.

Haynes, K. and W. Quinton. Permafrost thaw leads to drying of wetlands, Scotty Creek, NWT, Canada. Summary of CCRN Hydrological Research at Scotty Creek. Changing Cold Regions Network (CCRN), Final Meeting and Workshop, Saskatoon, Canada, 5-6 March, 2018.

Stone, L. and W. Quinton. Modelling the effects of permafrost loss on discharge from wetland dominated basins in the discontinuous permafrost zone. Summary of CCRN Hydrological Research at Scotty Creek. Changing Cold Regions Network, Final Meeting and Workshop, Saskatoon, Canada, 5-6 Mar., 2018.

Carpino, O., A. Berg, W.L. Quinton, J. Adams. Climate change and permafrost thaw-induced boreal forest loss in Canada's fringe permafrost zone. Northeast Water Strategy Meeting, Government of British Columbia, Fort St. John, 13-14 March, 2018.

Turetsky, M., W. Quinton, O. Sonnentag, J. Blatzer. Collaborations between Global Water Futures & ABoVE: 2017 Updates & Ideas for Future Activities. 4th meeting of the NASA/ABoVE Science Team, Seattle Jan. 23-26, 2018.

Sonnentag, O., J. Fouché, M. Helbig, K. Lillie, G. Gosselin, W. Quinton, T. Moore. Dissolved organic carbon export and its contribution to the carbon budget in a boreal peat landscape undergoing rapid permafrost thaw. 4th meeting of the NASA/ABoVE Science Team, Seattle January 23-26, 2018

Schiferl, L. R. Commane, S. Conley, E. Euskirchen, M. Helbig, J. Henderson, E. Humphreys, M. Hurkuck, K. Luus, P. Marsh, K. McKain, W. Oechel, W. Quinton, O. Sonnentag, C. Sweeney, S. Wolter, D. Zona, S. Wofsy. Carbon dioxide and methane flux analysis over ABoVE domain during the 2017 ArctiCAP airborne measurement campaign: methods and early work. 4th meeting of the NASA/ABoVE Science Team, Seattle January 23-26, 2018

Connon, Ryan, Élise Devoie, Ashley Rudy, Caren Ackley, Olivia Carpino, Michael Braverman, William Quinton. Impacts of thawing permafrost at the Scotty Creek Research Station, NWT, Canada. 4th meeting of the NASA/ABoVE Science Team, Seattle January 23-26, 2018.

Carpino, Olivia, Aaron Berg, William Quinton, Justin Adams. Climate change and permafrost thaw-induced boreal forest loss in Canada's fringe permafrost zone. 4th meeting of the NASA/ABoVE Science Team, Seattle January 23-26, 2018.

Ackley, Caren, William Quinton, Suzanne Tank, Fereidoun Rezanezhad, Colin McCarter. Influence of wildfire on the hydrology and runoff chemistry of a peat plateau, Scotty Creek, NWT. 4th meeting of the NASA/ABoVE Science Team, Seattle January 23-26, 2018.

Hurkuck, M., O. Sonnentag, E. Humphreys, M. Helbig, G. Gosselin, P. Marsh, W. Quinton, P. Lafleur. A meso-network of eddy covariance towers across the Northwest Territories to assess high-latitude carbon and water budgets under increasing pressures. International Arctic Change Conference, 11-15 December, Québec City, Québec, Canada, 2017.

Devoie, É., Craig, J. R., Quinton, W.L., Connon, R.F. Quantifying thaw mechanisms in discontinuous prmafrost: Is talik formation a tipping point? Geoscience Forum, Yellowknife, Canada, 14-17 November 2017.

Braverman, M. and W. Quinton. Impact of seiemic lines of drainage processes. Geoscience Forum, Yellowknife, Canada, 14-17 November 2017.

Rudy, A. M. Braverman, R. Connon, E. Devoie, T. Emson, B. Walker, E. Wilcox, W. Quinton, P. Marsh. Implications of thawing permafrost on water in the NWT. Geoscience Forum, Yellowknife, Canada, 14-17 Nov., 2017.

Connon, R., M. Braverman, E. Devoie, J. Craig, W. Quinton. Over-winter flowpaths through talik networks in discontinuous permafrost terrains. Geoscience Forum, Yellowknife, Canada, 14-17 November, 2017.

Turetsky, M., O. Sonnentag, E. Kane, J. Blatzer, W. Quinton, E. Euskirchen, M. Waldrop, R. Neumann. Considering peatlands in frameworks of ecosystem and landscape resilience to disturbance in Alaska and northwestern Canada. Annual Meeting of the American Geophysical Union, New Orleans, USA, 11-15 Dec., 2017.

4. Other publications (20):

Haynes, K., O. Carpino, R.F. Connon, E. Devoie J.R. Craig, J.R., W.L. Quinton. Thaw-induced land-cover change in the southern margin of discontinuous permafrost
Geoscience BC Summary of Activities 2018, Geoscience BC, Report 2019-1, p. XX-XX.

Quinton, W.L. A. Berg, M. Braverman, O. Carpino, L. Chasmer, R.F. Connon, J. Craig, É. Devoie, M. Hayashi, K. Haynes, D. Olefeldt, A. Pietroniro, F. Rezanezhad, R. Schincariol, O. Sonnentag, 2018. A Synthesis of Three Decades of Eco-Hydrological Research at Scotty Creek, NWT, Canada. *HESS-Discussion*.

Amiri, E.A., J.R. Craig, Devoie, É., and W.L. Quinton, Numerical simulation of lateral permafrost thaw in the Northwest Territories, 5th European Conference on Permafrost (EUCOP5), Chamonix Mont-Blanc, France, Jun 23-Jul 1, 2018

Haynes, KM, RF. Connon, WL Quinton. Hydrometric measurements in peatland-dominated, discontinuous permafrost at Scotty Creek, Northwest Territories, Canada. Changing Cold Regions Network (CCRN) Special Observation and Analysis Period (SOAP), Earth System Science Data, Manuscript #: essd-2018-68.

Connon, R.F., A.E. Coles, S.A. Kokelj, W.L. Quinton. New insights into snowfall and snow accumulation trends and patterns across the Northwest Territories. 5th European Conference on Permafrost (EUCOP 2018), Chamonix-Mont Blanc, France, 23th June - 1st July 2018.

Quinton, W.L., M. Braverman, R. Connon1, J. Craig, É. Devoie, K. Haynes. Hydrological change trajectories in the southern Taiga Plains, Canada. 5th European Conference on Permafrost (EUCOP 2018), Chamonix-Mont Blanc, France, 23th June - 1st July 2018.

Braverman, M. and W.L. Quinton. An experimental study of permafrost restoration under the seismic line in the wetland-dominated zone of discontinuous permafrost, Northwest Territories, Canada. 5th European Conference on Permafrost (EUCOP 2018), Chamonix-Mont Blanc, France, 23th June - 1st July 2018.

Fouché, J., O. Sonnentag, M. Helbig, K. Lillie, G. Gosselin, W. Quinton, T. Moore. Dissolved organic carbon export and its contribution to the carbon budget in a boreal peat landscape undergoing rapid permafrost thaw. 5th European Conference on Permafrost (EUCOP 2018), Chamonix-Mont Blanc, France, 23th June - 1st July 2018.

Devoie, É, J.R. Craig, W.L. Quinton, R.F. Connon, E.A. Amiri. Taliks, a tipping point in permafrost degradation. 5th European Conference on Permafrost (EUCOP 2018), Chamonix-Mont Blanc, France, 23th June - 1st July 2018.

Quinton, W.L., Berg, A.A., O. Carpino, Connon, R.F., Craig, J.R., Devoie, E. Johnson. Toward Understanding the Trajectory of Hydrological Change in the Southern Taiga Plains, Northeastern British Columbia and Southwestern Northwest Territories. Geoscience BC Summary of Activities 2017, Geoscience BC, Report 2018-1, p. 77-86.

Hanna, B. and W.L. Quinton, 2017. Remote Sensing of the Scotty Creek Basin. NWT Environmental Research Bulletin, Vol. 2, 14, 2 pp.

Braverman, M., W.L. Quinton. An experimental study of permafrost restoration under seismic line in wetland-dominated zone of discontinuous permafrost, Northwest Territories, Canada. GEO Ottawa 2017. Ottawa, Canada, 1-4 October, 2017.

Kershaw, G., W. Quinton. A remote assessment of ice-rich permafrost loss across a ~500 m elevation gradient in the Mackenzie and Selwyn Mountains, Canada. 21st International Northern Research Basins Symposium and Workshop – Yakutsk, Russia, August 5-12, 2017.

Quinton, W., R. Connon. Toward understanding the trajectory of Hydrological Change in the southern Taiga Plains, NWT, Canada. 21st International Northern Research Basins Symposium and Workshop – Yakutsk, Russia, August 5-12, 2017.

Quinton, W.L., Adams, J.R., Baltzer, J.L., Berg, A.A., Craig, J.R. and Johnson, E. (2017): Permafrost ecosystems in transition: understanding and predicting hydrological and ecological change in the southern Taiga Plains, northeastern British Columbia and southwestern Northwest Territories. Geoscience BC Summary of Activities 2016, Geoscience BC, Report 2017-1, p. 79-86.

Quinton, WL and D. Peters, 2016. Preface, Special Issue of Hydrological Processes for Canadian Geophysical Union, Hydrology Section. Hydrol. Process;1-3. https://doi.org/10.1002/hyp.11081.

Quinton, W.L., Adams, J.R., Baltzer, J.L., Berg, A.A., Craig, J.R. and Johnson, E. (2016): Permafrost ecosystems in transition: understanding and predicting hydrological and ecological change in the southern Taiga Plains, northeastern British Columbia and southwestern Northwest Territories. Geoscience BC Summary of Activities 2015, Geoscience BC, Report 2016-1, p. 89–94.

English, M., J. Baltzer, A. Blay-Palmer, R. Hall, A. Lister, P. Marsh, D. MacLatchy, J. McGeer, W. Quinton, S. Schiff, S. Smith, K. Stevens, M. Wilkie, B. Wolfe. 2015. Research Contribution of Wilfrid Laurier University researchers to understanding issues relevant to the NWT Water Strategy 2012-2014. Government of the NWT Water Strategy Meeting, Yellowknife, NWT.

Quinton, WL and D. Peters, 2015. Preface, Special Issue of Hydrological Processes for Canadian Geophysical Union, Hydrology Section. Hydrol. Process. 29, 3829-3830 (2015) Published online in Wiley Online Library (wileyonlinelibrary.com). DOI: 10.1002/hyp.10632.

Carey, S. and W. Quinton, 2014. Preface, Special Issue of Hydrological Processes for Canadian Geophysical Union, Hydrology Section. Hydrol. Process. 28, 4161-4162 (2014) Published online in Wiley Online Library (wileyonlinelibrary.com) DOI: 10.1002/hyp.10262.

Intellectual Property Protection

Filing of patent applications:	Not applicable
Registration of copyright for computer software or databases:	Not applicable
Registration of copyright for educational materials:	Not applicable
Registration of industrial designs:	Not applicable
Filing for protection of trademarks:	Not applicable
Registration of integrated circuit topographies:	Not applicable
Filing of applications for plant breeders' rights:	Not applicable
Execution of non-disclosure or confidentiality agreements:	Not applicable
Other (specify):	Not applicable

Collaboration with the Partners

How was this research project initiated?

- [x] The university researcher approached the partners
- [ ] The partners approached the university researcher
- [ ] The government partner approached the university
- [ ] There was a previous collaboration with the partners
- [ ] This is a new collaboration
- [ ] Other (specify)

Did this project arise from a grant funded by the NSERC Strategic Workshops Program? ○ Yes ● No

Did this project arise from a grant funded by the Interaction and/or Engage Program? ○ Yes ● No

Collaboration with the Partners

Briefly describe the process.

This project arose from collaborations formed during the project entitled "Improved processes, Parameterisations and Predictions for Cold Regions" (IP3) funded by NSERC. As the IP3 lead for hydrological field studies in the central Mackenzie River basin, I was approached by Dr. Elizabeth Johnson of the BC Government to discuss the possibility of forming a collaboration among researchers, industry and the BC government focused on improving the understanding of and ability to predict how permafrost thaw affects water resources. This led to several group meetings involving researchers, industrial partners and government agencies. I expanded the collaboration by including First Nations communities within the NWT (Liidlii Kue First Nation, Deh Cho First Nations) and BC (Fort Nelson First Nation), in addition to NWT government agencies.

Collaboration with the Partners

To what extent were the partners involved in the project? Rate your answer on a scale from 1 to 7.

Not at all			Somewhat			To a great extent
○ 1	○ 2	○ 3	○ 4	○ 5	● 6	○ 7

In what way were the partners directly involved in the project? (Select all that apply.)

- [x] Partners were available for consultation
- [x] Partners provided facilities
- [ ] Partners provided training
- [x] Partners co-supervised students' theses
- [x] Partners received training from university personnel
- [x] Personnel from the partner organization received training from the university
- [x] Partners discussed the project regularly with the university team

  Average number of meetings per year: 6
- [x] Partners were involved in the research
- [ ] Other (specify)

Collaboration with the Partners

Describe the partners' involvement and comment on the collaboration.

The most active partnerships were between researchers and Indigenous communities. These partnerships focused on the development and implementation of field studies, training through field courses / on-the-land camps, and community engagement focused on interpretation of CPET results. Partnerships with government agencies (both BC and NWT) were focused on the development of products, such as permafrost probability maps, and tools for the prediction of rates and patterns of permafrost thaw and resulting land-cover changes. Collaborations with Industry had a similar focus to that described for government agencies, largely due to the requirement for industry to align their operations with government regulations and best practices legislation. Therefore, even though the involvement of industry in this project was reduced after the economic down-turn, the close alignment of industry with government in terms of their interest in CPET, ensured that CPET's deliverables remained highly relevant to all project partners.

Future Plans

What links are you maintaining with the partners? (Select all that apply.)

- [x] Collaborating with the partners on the same research
- [ ] Collaborating with the partners on other research
- [x] Collaborating with other partners on the same research
- [ ] Continuing the research without partners
- [ ] No contact with the partners currently and none planned
- [ ] No contact with the partners currently but future collaboration planned

Future Plans

Describe any follow-up or related work that will be undertaken as a result of this project, who will be involved in this work (including partners) and how it will be funded.

CPET demonstrated that climate warming and human disturbance in the Dehcho region of the NWT, has led to widespread permafrost thaw and land cover change that has disrupted the hydrological cycle and the ecosystems and human activities that depend on it. There is a growing awareness in the Dehcho that permafrost thaw is negatively affecting the region's economy, and the health, well-being and livelihoods of its residents. However, there is lack of information on permafrost distribution, evolution, and resultant landscape change trajectory in this region. As a result, the ability to manage and respond to this new and growing threat to the Dehcho is extremely limited. There is therefore an urgent need to develop and mobilise knowledge on permafrost thaw in the Dehcho and elsewhere in the subarctic, develop new, practical and customised predictive tools and strategies to adapt to permafrost thaw, and to provide interactive training to decision makers and other users. As a direct follow-on to CPET, the CPET researchers and the Dehcho First Nations (DFN), have co-proposed the Dehcho Collaborative on Permafrost (DCoP), a Dehcho-wide initiative whose overall objective is to generate a fusion of leading-edge scientific and Indigenous knowledge on permafrost, and to use it as a basis to co-develop new predictive decision support tools and innovative risk management strategies to inventory and manage permafrost and adapt to permafrost thaw. Close consultations with Indigenous communities throughout the Dehcho during CPET, identified the urgent need for sustained community engagement based on two-way knowledge exchange to guide specific needs for improved permafrost thaw monitoring, adaptation, process understanding, and prediction. These needs collectively form DCoP's "five themes", each with specific objectives. DCoP researchers and community members will co-develop a number of knowledge-based (i.e. founded upon scientific and/or Indigenous knowledge) resources for permafrost adaption, including novel and affordable devices for monitoring permafrost and inhibiting ground thaw, new probabilistic methods for determining permafrost presence and thaw susceptibility, knowledge-based evaluation of adaptation strategies, and new means of determining future permafrost conditions and resultant land cover and hydrological changes.

Future Plans

Describe any additional links that the partners will maintain with the university.

CPET introduced to the Laurier-GNWT Partnership Agreement (2010-2020) a new cohort of participants from industry, government and local communities. This has greatly strengthened the case for a renewed partnership agreement for the 10-year period commencing 2020. DCoP (see above) includes a rich complement of field courses and on-the-land camps as focal points for collaboration among the university, local Dehcho communities, and the NWT department responsible for education.

Knowledge and Technology Transfer

Research results transferred to the partners

- [x] Through informal discussions
- [x] Through reports provided to the partners
- [x] As a result of the partners participating in the research
- [x] Through formal publications
- [ ] Through patents
- [ ] Through licencing arrangements
- [ ] The research results have not been transferred to the partner
- [ ] Other (specify)

Research results being used and/or will be used by the partners

As a stimulus for future R&D:	Have been used
To enhance the skills and knowledge of personnel in the partner's organization:	Have been used
To improve an existing product:	Potential to be used
To improve an existing process:	Have been used
To improve an existing service:	Potential to be used
To develop a new product:	Have been used
To develop a new process:	Have been used
To develop a new service:	Potential to be used
To contribute to a policy, regulation or standard:	Have been used

Other (specify):

Knowledge and Technology Transfer

Briefly describe these outcomes

Development of best practices by CPET partners in the Forest Management Branch (ENR/GNWT) for seismic line installation. Use of CPET model runs by ENR/GNWT for scenario testing to determine impacts of different degrees of permafrost thaw-induced land cover change and how it might affect runoff stream flow. Development of probability maps for permafrost presence and susceptibility to thaw for use by government agencies and Indigenous governments for resource management decisions.

Knowledge and Technology Transfer

Describe any environmental or social benefit that resulted or could result in the future from this research

CPET increased the involvement of Indigenous communities in the planning and execution of research projects of importance to their communities. Involvement of Indigenous communities in CPET is empowering to them as it gives their communities a voice in the creation of new knowledge and leads to new collaborations and opportunities, such as the DCoP initiative described in detail above.

Impact on Researcher

Impact the project had on your teaching

- [x] Creation of new courses
- [x] New content for existing courses
- [x] Use of real world examples in courses
- [x] Guest lectures from partners
- [x] New equipment/material
- [ ] Project has had no impact on my teaching
- [ ] Other (specify)

Impact the project had on your research

- [x] Influenced the direction to more industrially relevant topics
- [x] Opened up new opportunities for research beyond the original objectives
- [x] The project has had no impact on my research
- [ ] Other (specify)

Contributions from Other Sources

Partners	Total Cash		Total In-Kind	
Company Name	**Committed**	**Received**	**Committed**	**Received**
PTAC (including HRBPG)	157,250	119,424	450,920	274,633
Have you had previous research collaborations with this partner? No				
Geoscience	65,000	110,000	0	0
Have you had previous research collaborations with this partner? No				
Nexen		50,450	0	9,600
Have you had previous research collaborations with this partner? No				
		0	0	0
Have you had previous research collaborations with this partner?				
		0	0	0
Have you had previous research collaborations with this partner?				
		0	0	0
Have you had previous research collaborations with this partner?				
		0	0	0
Have you had previous research collaborations with this partner?				

Contributions from Other Sources

Other Sources	Total Cash		Total In-Kind	
		Received		Received
				0
				0
				0
				0
				0
				0
				0
Total (partners and other sources)	**$222,250**	**$279,874**	**$450,920**	**$284,233**

Financial Information

Consolidated balance remaining at the end of the project: 6,000

Budget Items	Total Budget	Total Actual Expenditure	Percent Variation
1) Salaries and benefits			
PhD students	34,500	19,940	-42
Master's students	100,000	86,262	-14
Undergraduate students	33,000	18,722	-43
Postdoctoral fellows		104,684	
Technical/professional assistants	137,168	31,204	-77
Project Manager	9,700	35,693	268
2) Equipment or facility			
Purchase or rental	110,000	131,286	19
Operation and maintenance costs		0	-999
User fees		0	-999
		0	-999
3) Materials and supplies			
		0	-999
		0	-999
		0	-999
4) Travel			
Conferences		0	-999
Field work	80,610	137,666	71
Project related travel		0	-999
		0	-999
5) Dissemination			
Publication costs	2,000	2,896	45
		0	-999
6) Technology transfer activities			
Field trials		0	-999
Prototypes		0	-999
		0	-999
7) Others (specify)			
		0	-999
		0	-999
Total	506,978	568,353	12

Financial Information

Explanation for the variation of each budget item

PhD students: Underspending in this line resulted from a PhD candidate deciding to attend enrol in a PhD programme at another university, and from success of other CPET PhD students with scholarships which decreased the need to fund them through CPET.

Undergraduate students: Success of undergraduate students with NSERC USRA and other funding programmes decreased the need to fund them through CPET.

Postdoctoral fellows: The loss of the PhD student (see note on PhD students above) as well as under-spending for a Research Associate (RA) (see technical/professional budget line below), left an opportunity to hire a recent PhD graduate as a post doctoral fellow to take on tasks intended for completion by a PhD student and by an RA.

Technical/professional assistants: This line was originally intended for a Research Associate, which could have been filled by a graduate of a M.Sc. or PhD programme. However this was transformed to a post-doctoral fellow (PDF) position so that CPET could gain funding from Mitacs which matched funding from a CPET industry partner (NEXEN) to support a PDF. This budget line was mainly used for the hire of local technical experts to provide assistance to the CPET field research programmes.

Project Manager: CPET undersestimated the need for a Project Manager at the application stage. This single position performed multiple key functions including reconciliation of accounts, budgetting, event planning, etc.

Travel/Field work: The high cost of travel and accommodation combined with a growing CPET team led to overspending in this line.

Publication costs: The slight overspending ($896) was largely due to increases in page charges by journals.