



Integrated Watershed Research in the Nechako River Basin, Phase 2 **Final report**

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Committee

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Table of Contents

1. Overview 3

2. Outreach and extension 3

3. Contributions to collective efforts in the Nechako Watershed 3

 Nechako Watershed Roundtable 3

 Rio Tinto Water Engagement Initiative..... 4

4. Training of Highly Qualified Personnel (HQP) 4

5. Theme Summaries 4

 Theme 1: Water security and climate change (Déry and students) 5

 Theme 2: Fine-grained sediment sources and dynamics (Owens, Petticrew and students) 5

 Theme 3: Tools for integration in watershed management and governance (Parkes and students) .. 7

6. Emerging principals to guide future IWRG research 8

 Meaningful relationships with indigenous partners in the Nechako 8

 Strengthening capacity for the next generation of collaborative research in the Nechako..... 9

Appendix 1: Outreach, knowledge exchange and extension..... 10

 Publications 10

 Outreach, knowledge exchange and extension. 11

 IWRG Group Presentations 11

 Presentations: conference/meetings/others (by year 2018-2022)..... 11

Appendix 2. List of HQP engaged in Phase 2 18

Appendix 3. 2022 Finances..... 20

Appendix 4. Phase 2 Finance summary 22

1. Overview

In December 2017, the Integrated Watershed Research Group (IWRG) at the University of Northern British Columbia was awarded a \$499,950 contract from the Nechako Environmental Enhancement Fund Society (NEEFS) to initiate Phase 2 of the IWRG research project in the Nechako River Basin (NRB). This contract allowed for the seamless continuation of Phase 1 of the NEEF funded research that ended on December 31, 2017. We begin our summary with a focus on one of the key benefits and outcomes in relation to IWRG outreach and extension activities, our contribution to collective efforts/initiatives, and an overview of the capacity-strengthening achieved through training of team members throughout this work. We then provide a more detailed summary of the work completed by the IWRG team with reference to the goals and objectives that were proposed within each of the three IWRG research themes. To conclude, our summary reflects on some overarching principals that have emerged through Phase 2 research to guide the future work of the team. We also present an accounting of expenditures over the course of this phase of research.

2. Outreach and extension

One of our main overarching goals was to extend our research into the general as well as the academic community. To highlight this aspect of our work, we have attached a list of the 12 journal articles that have been published by team members and the two that are in preparation/under review during the course of Phase 2. In addition, we have listed the extensive range of academic and community presentations that our team has delivered over the term of this Phase of research. Of the total of 56 presentations, approximately 55% were to academic and scholarly communities, and 45% were to community audiences within the Nechako or related groups (Appendix 1). Other aspects of our community outreach are summarised in Section 3 in relation to our contributions to collective efforts in the Nechako Watershed.

3. Contributions to collective efforts in the Nechako Watershed

Nechako Watershed Roundtable

During Phase 1 and continuing through to Phase 2, team members including their staff and students have made significant contributions to the support of, and participation in, the efforts of the Nechako Watershed Roundtable (NWR).

- Margot Parkes served as a core committee member of the NWR with Stephen Déry and Barry Booth (IWRG Research Manager) serving as her alternates (2018-2021);
- Margot has chaired several NWR meetings including the Technical Advisory Committee meeting in 2019, and the NWR Annual meeting also in 2019;
- Barry Booth was a member of the Technical Advisory Committee with the Nechako watershed strategy that is being developed by the Fraser Basin Council in conjunction with the NWR (2018-2019);
- Numerous staff and students have attended NWR annual meetings and Technical Advisory Committee meetings where they provided program updates to the Roundtable and Advisory Committees;

- Several IWRG Team members contributed to the background survey information that led to the development of the NWR Strategic Plan: NWR (2021). Nechako Watershed Roundtable Strategic Plan 2022-2026. November 2021;
- Several staff and students including Ella Parker, Tavia McKinnon, Jordan Cranmer and Barry Booth have expended considerable effort in developing a youth engagement component of the NWR;
- IWRG staff member Ella Parker (IWRG/MITACS intern) worked with Kim Menounos from the Fraser Basin Council, and Marieka Sax from UNBC's Cumulative Impacts Research Consortium in 2018 to staff the NWR Secretariat, including taking on the following tasks:
 - Attending bi-weekly NWR Secretariat meetings to plan meetings and communications (starting in September 2018);
 - Updating the NWR contact list;
 - Assisting with the planning of the NWR Annual Meetings;
 - Attending, taking notes and handling remote participation at the NWR Annual Meetings
 - Writing the initial draft of Annual Meeting Summary Reports;
 - Compiling content and designing the NWR Newsletters;
 - Assisting with the development of a Communications Plan for the Core Committee.

Rio Tinto Water Engagement Initiative

Stephen Déry has attended Rio Tinto's Water Engagement Initiative (WEI) meetings and has participated in the monthly Technical Working Group meetings beginning in 2020 and continuing through to this date. During this time, he has given three presentations to the WEI Main Table. Aside from all this, Stephen meets periodically with an ad hoc group to discuss climate change research in the Nechako.

4. Training of Highly Qualified Personnel (HQP)

An important component of the IWRG team's approach and philosophy is to actively engage in the training of highly qualified personnel in ways that develop the knowledge, skills and capacity of all members of our team, as well as helping to train the next generation of researchers. Over the course of the last five years, over 30 people worked with us in a range of different capacities, ranging from research assistants and associates, through the graduate students and post-doctoral fellows. Appendix 2 at the end of this report provides a detailed list of all research staff and students who contributed to the IWRG's Phase 2 activities between 2018 to 2022.

5. Theme Summaries

During Phase 2, the IWRG sought to fill gaps in knowledge about the NRB, and to contribute to the integration of information, knowledge and perspectives to better understand and respond to interrelated issues at the watershed scale. We sought to achieve this through three interrelated themes each with their respective goals and objectives. A summary of progress in each theme is provided here.

Theme 1: Water security and climate change (Déry and students)

The overarching goal of this research theme was to create a comprehensive research framework using hydrological modeling supplemented by observations to identify the relative impacts of climate change and flow regulation on water availability, flow timing and water temperatures in NRB rivers and streams.

This was to be achieved by:

1. Developing and testing a diagnostic water temperature model for the NRB, which included the deployment of water temperature data loggers throughout the NRB. A key component of this work was also to build meaningful collaborative working relationships with local First Nations communities;
2. Applying the Variable Infiltration Capacity model (VIC) to the NRB to better understand the impact of climate change and flow regulation on hydrological processes.

This Phase of work has allowed us to detect a general 0.7°C warming trend in water temperatures across the Nechako Watershed from 1950 to 2015 based on Air2Stream model simulations (Islam et al. 2019a). As well, a successful pilot project initiated in 2019 to monitor water temperatures eventually led to a network of 30 stream temperature loggers in the main stem Nechako River and many other tributaries across the Nechako Watershed (Gilbert et al. 2022). Water temperature data are quality controlled after being collected in the field and deposited into publicly accessible data archives such as Zenodo (e.g., <https://zenodo.org/record/6426024>).

Building on the work of Islam et al. (2019b), the Variable Infiltration Capacity (VIC) hydrological model was also applied to reconstruct historical (naturalized) daily flows of the Nechako River from 1950-2019 with additional time series of simulated daily flows for its principal unregulated tributaries (e.g., Stuart, Nautley, and Chilako rivers). Future projections of climate conditions from 17 climate models are presently being downscaled to allow simulations of daily hydrological and water temperature conditions up to 2100 across the Nechako Watershed. When considered together with our initial phase of work, we have revealed a significant warming trend across the Nechako Watershed that has altered regional hydrology and stream temperatures including the timing and volumes of spring freshets and peak summer water temperatures; these trends are anticipated to amplify under future climate warming in the 21st century. One of our key accomplishments was the relationships that we have established with Cheslatta Carrier, Stellat'en, Nak'azdli Whut'en and Tl'azt'en First Nations. The cultivation of these relationships has facilitated deployment of water temperature loggers in otherwise unmonitored areas, while enabling knowledge exchanges between UNBC researchers and members of each Nation. This work improves the scientific basis for managing the NRB's ecosystems and enhances understanding of the water supply by identifying challenges in the resiliency of existing water infrastructure and management systems under the increasing risks of future water shortages and floods.

Theme 2: Fine-grained sediment sources and dynamics (Owens, Petticrew and students)

The overarching goal of Theme 2 was to develop a framework for the use of the sediment fingerprinting technique, supplemented by other approaches such as land use and river channel mapping and sediment quality assessment, to identify the role of key watersheds dominated by specific land uses (i.e., agriculture and forestry) and disturbances (e.g., wildfires) in supplying fine-grained sediment to the Nechako main stem.

There were four objectives:

1. Using compound-specific stable isotopes (CSSIs) as sediment fingerprints to investigate the contribution of sediment from different land cover types (e.g., forest vs agricultural crops vs pasture) to the sediment load delivered to the Nechako main stem;
2. Using persistent organic pollutants (POPs; e.g., PAHs, PCBs, legacy pesticides) to identify the contribution of specific agricultural practices and areas impacted by forest disturbance (i.e., wildfire) to the sediment load delivered to the Nechako main stem;
3. To further assess (i.e., extend the results of Phase 1 project) the quality of the sediment delivered to the Nechako mainstem in terms of POPs and heavy metals;
4. To provide guidance on the likely roles of projected changes in land use, watershed management and climate change on sediment sources in the NRB.

In this Phase of work, we refined the sediment fingerprinting approach developed in Phase 1 with a particular emphasis on the use of compound-specific stable isotopes (CSSIs; [Objective 1](#)) and polycyclic aromatic hydrocarbons (PAHs, [Objective 2](#)) as fingerprints. For [Objective 1](#), the use CSSIs of very long chain fatty acids (VLCFA) was undertaken in order to determine the sources of sediment to Murray Creek, an agriculturally dominated watershed. Initial results have shown that while VLCFA are easily able to discriminate between riparian zones, banks, forested and agricultural uses, and thus the proportions of sediment from these sources, they are not as good at discriminating between specific types of agricultural land use (i.e., natural pasture, oats, hay). For [Objective 2](#), we focused specifically on the use of PAHs to investigate the role of extreme wildfires in delivering fine sediment to river channels. In part, this was because of the 2018 Shovel Lake wildfire near Fraser Lake which provided a unique opportunity to both investigate the response to wildfires and also to test novel tracers. We also investigated how far downstream the wildfire-signal could be detected. We found that the Shovel Lake wildfire was a significant source of sediment and PAHs in tributary streams, but less so in the Nechako River at Vanderhoof where industry and vehicular traffic were the dominant sources of PAHs and where sediment was derived from stream banks and other local tributaries, such as Murray Creek.

For [Objective 3](#), we investigated the quality of the sediment in terms of PAHs and metals, which can be detrimental to aquatic ecosystems. This built upon work undertaken in Phase 1 (e.g., Owens et al., 2019) but investigated in more detail the role of wildfires in supplying PAHs to rivers. We found that PAHs in areas affected by the Shovel Lake wildfire were elevated in topsoils, which persisted for several years. These PAHs were also detectable in tributary streams with concentrations for individual PAH congeners being above sediment quality guidelines for the protection of aquatic organisms. Specific metals were also elevated in places reflecting local urban and industrial sources. The work described above has enabled us to provide guidance on the effects of forecasted changes in climate, river management and land use on sediment sources and sediment dynamics (i.e., [Objective 4](#)). The work has shown that extreme climate events like high rainfall (e.g., atmospheric rivers) and wildfires are likely to increase soil erosion and the delivery of sediment and associated contaminants to aquatic systems. Watershed changes, such as forest harvesting and increased river flows, will also cause changes in sediment sources (e.g., bank erosion) and increase sediment delivery to channels. Overall, this work has provided the scientific basis for an improved understanding of sediment sources and transfers in the Nechako Watershed, thereby helping to protect sensitive aquatic habitats and ecosystems from sediment and its associated contaminants.

Theme 3: Tools for integration in watershed management and governance (Parkes and students)

The overarching goal of Theme 3 was to explore how integrative tools and processes can be optimized to increase understanding of the cumulative impacts of environment, community, and health changes within the NRB, and inform and support intersectoral action and watershed governance.

We accomplished this by:

1. Further developing and enhancing the Nechako watershed portal through an expanded “Portal User Research Group” of current collaborators and new research partners;
2. Coupling community-based monitoring with youth engagement and research in the NRB, leveraging overlaps between the areas of School District 91 and the NRB;
3. Examining and applying frameworks for integrative watershed reporting, that reflect combined environmental, community and health issues within the NRB, with a particular orientation to understanding the cumulative impacts of resource development;
4. Evaluating the contributions of the web-portal development, youth engagement on community-based monitoring and integrative watershed reporting as tools and processes that inform and support intersectoral action and watershed governance.

In our Phase 2 efforts, we collaboratively developed and refined an open-source web-based geospatial tool (henceforth referred to as the portal) as a platform on which to integrate and share new and existing information about interacting environment, community, and health issues in the Nechako. A key aspect of the portal developments was the identification of several portal user groups (Cheslatta Carrier Nation; Nechako Environment and Water Stewardship Society (NEWSS); School District 91 (SD91); and a user group within the IWRG (focused on sharing and exchanging information across IWRG themes and other groups)) that were instrumental in our development of the portal, especially in guiding refinements and identifying priorities for future research. Our main focus in Phase 2 was further development, trialing and refinement of the portal whereby we are enhancing it as a platform to share and profile resources among different knowledge users in the Nechako, and also as a testing-ground where functioning portals can be developed for other user groups in the watershed and then turned over for long-term maintenance and development by the respective user-groups, once sufficient capacity is achieved. The collaborations, developments, and refinements during Phase 2, provided the opportunity for the IWRG Portal to be expanded and combined with other emerging portal initiatives, to create the ‘Nechako Watershed Portal’ (<http://iwrp.gis.unbc.ca/>).

Of critical importance in the development of governance and decision-making in the first phase of work was the fostering of initiatives that promote integrative collaborations. This included the establishment and continual support of the Nechako Watershed Roundtable (NWR) in 2015. The portal and associated collaborations have informed and influenced the NWR as a well-functioning, cross-sectoral body that convenes, connects and fosters collaborative efforts to protect and improve the health of the Nechako Watershed for future generations. Ongoing collaborations with the NWR has increased opportunities for the portal to enhance knowledge sharing and exchange for community-based monitoring through the support of the emerging Lakes Monitoring initiative as part of the NWR Strategic Plan, as well as increased opportunities for the NWR youth engagement working group to profile their activities in conjunction with other youth-led initiatives in the area, including in partnership with SD 91. During

Phase 2 there was also active collaboration with other related projects seeking to develop, trial and connect tools for integration, especially in rural, remote and northern contexts, with a particular focus on youth. This included active collaboration with a five-year UNBC-led project, launched in 2017 (co-led by Parkes) titled the “Environment, Community, Health Observatory (ECHO) Network”, which has connected collaborative efforts across watersheds in northern BC, as well as with youth and other community partners across Canada and internationally. At the close of Phase 2, an emerging area of interest is using the portal as a knowledge exchange platform across different youth, education and community initiatives within and across watersheds.

Overall, work in Phase 2 has resulted in a range of approaches to moving knowledge to action, with an ongoing focus on the ‘Nechako Watershed Portal’ that is building a ‘made-in-the-Nechako’ archive of existing resources, with new and expanding functions to enable users to collate, curate and display this information to serve their own needs. This includes other members of the IWRG team, community partners such as SD91 and NWR, with new opportunities for cross-referencing and sharing information across groups and growing interest in amplifying co-benefits across the Nechako.

6. Emerging principals to guide future IWRG research

During the course of meeting our Phase 2 objectives, several shared principals were strengthened within our IWRG team, with a focus on long-term sustainability of capacity of integrated watershed research and engagement with our community partners.

Meaningful relationships with indigenous partners in the Nechako

One of the IWRG accomplishments during Phase 2 was the relationships that we have established and developed with a number of First Nations in the NRB, most notably with Cheslatta Carrier, Stellat’en, Nak’azdli Whut’en, and T’azt’en First Nations. IWRG engagements with First Nations have also complemented the other efforts to prioritise reconciliation and enhance work in partnership with First Nations, including work being developed by NWR and members of the Carrier Sekani Tribal Council, and other collaborations with Lheidli T’enneh First Nation focused on Land, Health and Healing (led by Parkes), that have ongoing relevance for community engagement all the way to the confluence of the Nechako and the Fraser Rivers.

Our growing and ongoing attention to fostering meaningful relations with First Nations has led to a clear set of processes, especially for research that will be conducted on First Nations territories. Examples of these processes include a commitment that, prior to the selection of experimental sites and equipment deployment while building on our past community engagement, we consult with the appropriate First Nations who have a vested interest in their traditional territories. Where and when possible, we will invite members of their Nations to join our field teams during site visits and share data as requested. Academic researchers will benefit from the astute traditional knowledge of First Nations on their changing environment and engage in a mutually beneficial knowledge exchange, co-learning and training experiences. Once sufficient data are collected and analyses are performed, we will undertake outreach events at select First Nations to share our experiences and results.

Strengthening capacity for the next generation of collaborative research in the Nechako

During the course of Phase 2 our team has also identified the need for our team to be planning proactively to engage with the next-generation of researchers in the Nechako. This includes a commitment to ongoing community engagement including, where possible across the educational spectrum from school students living within the Nechako, through to undergraduate and graduate students, as well as early career researchers (post-doctoral fellows and new colleagues at UNBC).

This commitment has led us to look at strategic additions to our team as we look ahead to future phases of work. Leveraging from our past experience and expertise, we are looking forward to developing an expanded network of colleagues and early career collaborators who will increase our team capacity to address the ongoing and emerging issues in the Nechako Watershed. Our research and community engagement to date has identified the expanding and continued demand for sustained watershed research in the context of a changing climate.

Looking ahead, upcoming IWRG team efforts will focus on the climate crisis as a cross-cutting driver of watershed change, and the need to strengthen preparedness for integrative responses to climate, water and community connections in the Nechako Watershed.

Appendix 1: Outreach, knowledge exchange and extension

Outreach, knowledge exchange and extension can be divided up into the following categories: publications and presentations/outreach activities. In Phase 2 the team published a total of 12 peer-reviewed papers that were associated with work carried out in Phase 2. Two further papers are in different stages of development and will be published in the near future.

Presentations and outreach activities can include presentations, posters presented at events, interviews and guest lectures given by team members. These can be divided into activities that were directed towards an academic audience such as conferences and professional meetings, and those intended for a lay audience. In Phase 2 the team did 66 presentations, of these 55% were delivered at academic conferences and meetings and 45% were intended for the public.

Publications

1. Gislason, M. K., Morgan, V. S., Mitchell-Foster, K., & Parkes, M. W. (2018). Voices from the landscape: Storytelling as emergent counter-narratives and collective action from northern BC watersheds. *Health & Place*, 54, 191–199. <https://doi.org/10.1016/j.healthplace.2018.08.024>
2. Hernández-Henríquez, M. A., Sharma, A. R., Taylor, M., Thompson, H. D. and Déry, S. J. (2018). The Cariboo Alpine Mesonet: Sub-hourly hydrometeorological observations of British Columbia's Cariboo Mountains and surrounding area since 2006. *Earth System Science Data*, 10, 1655-1672, <https://doi.org/10.5194/essd-10-1655-2018>
3. Gateuille, D., Owens, P.N., Petticrew, E.L., Booth, B.P, French, T.D., and Déry, S.J. (2019). Determining contemporary and historical sediment sources in a large drainage basin impacted by cumulative effects: the regulated Nechako River, British Columbia, Canada. *Journal of Soils and Sediments*, 19, 3357-3373. <https://doi.org/10.1007/s11368-019-02299-2>*
4. Gilbert, D. E., Morris, J. E., Kaveney, A. R., Déry, S. J. (2022). Sub-hourly water temperature data collected across the Nechako Watershed, 2019-2021, *Data in Brief*, **43**, 108425, <https://doi.org/10.1016/j.dib.2022.108425>
5. Horwitz P. and Parkes M. W. (2019). Intertwined strands for ecology in planetary health. *Challenges*. 10(1), 20, <https://doi.org/10.3390/challe10010020>
6. Islam, S. U., Curry, C. L., Déry, S. J. and Zwiers, F. W. (2019). Quantifying projected changes in runoff variability and flow regimes of the Fraser River Basin, British Columbia, *Hydrology and Earth System Sciences*, 23, 811-828, <https://doi.org/10.5194/hess-23-811-2019>
7. Islam, S. U., Hay, R. W., Déry S. J. and Booth, B. P. (2019). Modeling the impacts of climate change on riverine thermal regimes in western Canada's largest Pacific watershed, *Scientific Reports* 9, 11398. <https://www.nature.com/articles/s41598-019-47804-2>
8. Kieta, K.A., Owens, P.N., Petticrew, E.L., French, T.D., Koiter, A.J., Rutherford, P.M. (accepted). Polycyclic aromatic hydrocarbons in the aquatic environment following wildfire: a review. *Environmental Reviews*.
9. Kieta, K.A., Owens, P.N., Petticrew, E.L. (submitted). Post-wildfire contamination of soils and sediments by polycyclic aromatic hydrocarbons in north-central British Columbia.

* This paper is related to work conducted during Phase 1 of the research, but published during Phase 2, and thus did involve effort after the conclusion of Phase 1 officially ended.

10. Owens, P. N., Gateuille, D. J., Petticrew, E. L., Booth, B. P. and French, T. D. (2019). Sediment-associated organopollutants, metals and nutrients in the Nechako River, British Columbia: a current study with a synthesis of historical data. *Canadian Water Resources Journal / Revue canadienne des ressources hydriques*, 44(1), 42-64, <https://doi.org/10.1080/07011784.2018.1531063> *
11. Parkes, M.W., Allison, S., Harder, H.G., Hoogeveen, D., Kutzner, D., Aalhus, M. et al. (2019). Addressing the environmental, community and health impacts of resource development: Challenges across scales, sectors and sites. *Challenges*. 10(1), 22, <https://doi.org/10.3390/challe10010022>
12. Parkes, M.W. (2022). River conversations: A confluence of lessons and emergence from the Taieri River and the Nechako River. *River Research and Applications*. 38(3), 443-452, Special Issue Paper. <https://doi.org/10.1002/rra.3907>
13. Picketts, I. M., Matthews, C. A., Parkes, M. W., Déry, S. J. and Sharma, A. R. (2019). Scenarios of climate change and natural resource development: complexity and uncertainty in the Nechako Watershed, *Canadian Geographer*. 64(3), 475-488. <https://doi.org/10.1111/cag.12609>
14. Vore, M. E., Déry, S. J., Hou, Y., and Wei, A. (2020). Climatic influences on forest fire and mountain pine beetle outbreaks and resulting runoff effects in large watersheds in British Columbia, Canada, *Hydrological Processes*, 34(24), 4560-4575, doi: <https://doi.org/10.1002/hyp.13908>.

Outreach, knowledge exchange and extension.

IWRG Group Presentations

2019: The IWRG researchers presented aspects of their research at the [NRESi colloquium series](#).

2021: On February 23, 2021 the IWRG Research Team presented a '[virtual](#)' update of their research as 'An evening in the Nechako'. This evening included a formal presentation by the principal investigators summarizing their work, as well as 'breakout sessions' that allowed attendees to interact directly with researchers including graduate students, research associates and the principal investigators.

While the IWRG Team intended to host in person presentations in the Fall, the realities, and challenges of convening during COVID-19 meant that alternative approaches needed to be pursued. This included the "Evening in the Nechako" in February 2021, and contributions to other online events.

Presentations: conference/meetings/others (by year 2018-2022)

2018 Conference presentations/meetings

Déry, S. J., Guay, C., Hay, R., Islam, S. U., Koenig, K., MacDonald, M., Sharma, A. and Stadnyk, T. (2018). Disentangling the impacts of climate change and human interventions on the hydrology of key Canadian watersheds, Pacific Climate Impacts Consortium, 27 June 2018.

Déry, S. J., Guay, C., Hay, R., Islam, S. U., Koenig, K., MacDonald, M., Sharma, A., and Stadnyk, T. (2018). Disentangling the impacts of climate change and human interventions on the hydrology of key Canadian watersheds, Canadian Water Resources Association (Manitoba Branch) luncheon, 6 November 2018 (invited talk).

Déry, S. J., Guay, C., Hay, R., Islam, S. U., Koenig, K., MacDonald, M., and Stadnyk, T. (2018). Disentangling the impacts of climate change and human interventions on the hydrology of the

Hudson Bay, Nechako and Fraser River Basins, Centre for Earth Observation Science, University of Manitoba, 14 November 2018.

Déry, S. J., Islam, S. U. and Sharma, A. (2018). Quantifying the impacts of flow regulation and climate change on streamflow trends in British Columbia's Nechako River Basin, 8th GEWEX Open Science Conference: Extremes and Water on the Edge, 6-11 May 2018, Canmore, Alberta, Canada.

Owens, P. N., Gateuille, D., Petticrew, E. L., Booth, B. P. and French, T. D. (2018). Determining changes in the sources of fine-grained sediment in a large regulated watershed in British Columbia using the sediment fingerprinting technique. European Geosciences Union annual conference, Vienna, Austria, April 2018;

Owens, P.N., Gateuille, D., Petticrew, E.L., Booth, B.P. and French, T. D. (2018). Determining contemporary and historical sources of fine-grained sediment in a large regulated watershed in British Columbia using the sediment fingerprinting technique. American Geophysical Union annual conference, Washington-DC, USA, December 2018.

Parkes, M. W. (2018). Equity, ecology and well-being in watersheds: Lessons from integrative approaches to knowledge and governance at the land, water, health nexus. Nicola Symposium: Collaboration in a Sensitive Watershed, February 1, 2018.

Parkes, M. W. (2018). Integrative approaches to health, ecosystems & society: New tools and processes to address the cumulative determinants of health impact, and the land-water-health nexus. SESYNC SYMPOSIUM, Boundary Spanning Advances in Socio-Environmental Systems Research. June 12, 2018, Annapolis, Maryland, USA.

Parkes, M. W., Emmons, S., Gothreau, J. and Booth, B. (2018). Integrative approaches to the land-water-health nexus in islands: Developing next generation geospatial tools within an Environment, Community, Health Observatory (ECHO) Network. 7th International Conference on Environmental Future: Humans and Island Environments, 16 – 20 April 2018, Honolulu, Hawai'i.

Sharma, A. R. and Déry, S. J. (2018). Rivers in the sky: Climatology of landfalling atmospheric rivers in BC. Climate Science Informal Seminar 2018 Winter session at UNBC.

Sharma, A. S. and Déry, S. J. (2018). Contribution of atmospheric rivers to extreme snowfall across British Columbia, Canada, 8th GEWEX Open Science Conference: Extremes and Water on the Edge, 6-11 May 2018, Canmore, Alberta, Canada.

2018 Other presentations/outreach activities

The IWRG Team and UNBC Office of Research held a public event celebrating the launch of Phase 2 of the NEEF funding agreement on March 27, 2018. Two Presentations by IWRG team members were delivered at this event:

Stephen Déry provided an overview of IWRG research on behalf of the research team;

Joseph Gothreau briefly described how his Master's degree research project had been influenced by involvement and engagement across all three IWRG Themes.

Two posters were presented at this event relating to work conducted by the IWRG team.

Hay, R.W. and Déry; S.J. Preliminary results from the sub-grid parameterization of snow in the CLASS model.

Islam, S.U. and Déry, S.J. Hydrological modeling of Nechako River Basin's flows.

Stephen Déry gave a presentation entitled: 'The 2017/2018 winter snowpack in Prince George and surrounding area' at Winston's Thursday Breakfast Club, 8 March 2018 (invited talk).

Ben Pelto, UNBC graduate student spoke about Glacier Change and Climate Change in BC at the Caledonia Nordic Ski Club February 24, 2018

2019 Conference presentations/meetings

Islam, S. U. (2019). Modelling the impacts of climate change on riverine thermal regimes in western Canada's largest Pacific watershed. 27th IUGG General Assembly, Montréal, Québec, Canada, July 8-18, 2019.

Owens, P. N. (2019). Sources of fine-grained sediment in a large regulated watershed in BC using the sediment fingerprinting technique. European Geosciences Union annual meeting, Vienna, Austria, 7-12 April 2019.

Owens, P. N. (2019). Sources of fine-grained sediment in a large regulated watershed in BC using the sediment fingerprinting technique. Western Division of the Canadian Association of Geographers, Victoria, Canada, 8-9 March 2019.

Kieta, K. A. (2019). Determining sources of sediment in the Nechako River Basin in British Columbia: present and future work using sediment fingerprinting. International Union of Geodesy and Geophysics Conference – Montreal, QC (July 2019).

Kieta, K.A. (2019). Determining sources of sediment in response to landscape changes in the Nechako River basin using the sediment fingerprinting approach. Presentation to the Nechako White Sturgeon Working Group at the Ministry of Forests, Lands, Natural Resource Operations and Rural Development, Prince George, BC – (November 2019).

Parkes MW. (2019). *Visualization and analytic tools for community engagement on social-ecological health impacts of resource extraction*. IUHPE 23rd World Conference on Health Promotion. Rotorua, Aotearoa/NZ. April 7-11, 2019.

Parkes MW (2019) *Better Together for Health, Ecosystems & Society: Insights from a decade of collaborative, intersectoral engagements in Canada and Oceania*. Public Health Seminar Series, Department of Preventive and Social Medicine, University of Otago, NZ. April 18, 2019.

Parkes MW (2019). Communities, justice and living systems: connections for a healthy and thriving future. Invited convenor and presenter, Breakout sub-plenary session: Planetary Health Annual Meeting. Co-hosted by Planetary Health Alliance, Harvard University and Stanford University. Palo Alto, Sept 4-6, 2019.

2019 Other presentations/outreach activities

Kristen Kieta spoke about her PhD research to EBus grade 10 science students as part of the UNBC Research Ambassadors program on February 27, 2019;

Kristen Kieta, Barry Booth, and Phil Owens set up an interactive display about sediment transport and storage in the Nechako River Basin at the White Sturgeon Release Event in Vanderhoof on May 3rd.

Kristen Kieta attended and spoke to the members of the Fraser Basin Council about her ongoing work in the NRB during their field day to visit the sturgeon hatchery on June 12th, 2019.

Phil Owens and Ellen Petticrew were invited to Environment and Climate Change Canada (ECCC) in Vancouver on 19th June to discuss work on contaminants in the Nechako watershed. This ECCC team are assembling information on contaminants in the Fraser basin and BC coast in order to protect the southern resident killer whale population, including their main food source, salmon.

Scott Emmons attended the ECHO Network Annual Meeting in New Brunswick on behalf of the Theme 3 research team, making connections with other watershed partners (especially Cocagne and Battle River watersheds) for sharing the watershed portal to foster youth and student engagement in watersheds.

Leona Prince (SD 91), Margot Parkes, Céline Surette and Annika Chiasson (members of the ECHO Network's New Brunswick Environmental Network Regional Case) all participated in an Indigenous led environment, community, health workshop: 'Ma Uta Ki Tai' ("From the Oceans to the Sea") which was held in Auckland, NZ, April 4-5, 2019.

2020 Conference/meeting presentations

Kieta, K. (2020). Determining sources of sediment in response to land cover change in the Nechako River Basin. Western Division of the Canadian Association of Geographers, 14th March 2020, Prince George, BC.

Parkes, M, Emmons, S., Parker, E., (2020). The Nechako Watershed Portal: An integrative, geospatial tool to bridge governance, knowledge exchange, and information-sharing needs, and foster co-benefits for health, ecosystems and equity. Research Week Conference on 6th March 2020 at UNBC in Prince George.

2020 Other presentations/outreach activities

Stephen Déry gave a presentation at the True North Business Forum on January 28th

Stephen Déry was interviewed on CBC Radio's Daybreak North Radio on February 13th about the heavy snowpacks in the Stuart and Upper Fraser and the potential implications to the spring freshet in northern BC and by the Omineca Express (May 1st) on a similar topic as the above interview.

Stephen Déry gave a presentation to the Kitimat Public Advisory Committee on September 8th to provide the group a progress update on research being undertaken.

Stephen Déry's team demonstrated various aspects of climate data collection and the overall research project to students from the SD 91 Koh-Learning program on October 23rd.

Stephen Déry's team and Kristen Kieta presented to students from the SD 91 Koh-Learning program on October 23rd about their respective research projects in the NRB;

Kristen Kieta gave a guest lecture on work completed by Dr. Gateuille and her on-going work in the NRB to UNBC's Environmental Science 111 class.

Margot Parkes, Barry Booth, and staff and students from SD 91 were part of the plenary session of the [C2C Conference](#) on October 23rd, 2020 where they discussed the IWRG partnership, and tools such as the UNBC portal as enhancing a supportive, collaborative basis from which to develop the Koh-Learning in our Watersheds program.

2021 Conference/meeting presentations

Kieta, K.A. (2021). Tracing the 2018 Shovel Lake wildfire using polycyclic aromatic hydrocarbons, presented at the Canadian Institute of Forestry's Master's Night (online), 16 April 2021;

Kieta, K.A., Owens, P.N., and Petticrew, E.L. (2021). Using polycyclic aromatic hydrocarbons to determine post-wildfire contamination and sediment sources in a large watershed in central British Columbia, Canada. European Geophysical Union General Assembly 2021, online, 19–30 Apr 2021, EGU21-10491, <https://doi.org/10.5194/egusphere-egu21-10491>, 2021;

Kieta, K.A., Owens, P.N., and Petticrew, E.L. (2021). Post-wildfire sediment and contaminant transport in the Nechako River Basin. Canadian Association of Geographers Annual Conference, Prince George, BC, 11 June 2021;

Kieta, K.A., Owens, P.N., and Petticrew, E.L. (2021). Utilizing polycyclic aromatic hydrocarbons as an indicator of post-wildfire contamination and as a tracer for source apportionment in a large watershed in central British Columbia, Canada, American Geophysical Union Fall Meeting (online), 14 December 2021.

Margot Parkes, Lars Hallstrom, Aita Bezzola, Christiana Onabola, Stacy Jupiter, Aaron Jenkins (speakers). (2021) Health in Watersheds Exploring Connections and Data Complexities. ECHO Pulse Day 3. <https://www.echonetwork-reseaecho.ca/echo-pulseresources#Watersheds>. 23 November, 2021.

2021 Other presentations/outreach activities

Stephen Déry delivered a talk titled "Climate change and water security research at UNBC" to the Main Table of the Water Engagement Initiative on February 10

Stephen Déry provided an update on IRC research at the Nechako Watershed Roundtable's Spring Technical Meeting. May 26.

Stephen Déry presented to the Terrace City Council about his research on Atmospheric Rivers (AR). April 12.

Stephen Déry presented on TRARE to the Water Engagement Initiatives main table, November 24.

Jeremy Morris and Stephen Déry presented the river temperature research to Binche Whut'en Chief and Council on 6 July 2021;

Jeremy Morris delivered a "Lunch and Learn" presentation to Environmental Dynamics (EDI) in Prince George outlining Nechako Hydrology research and an overview of Atmospheric Rivers, November 17.

Margot Parkes presented to the Health Research Institute Seminar Series on "Healthy Confluences and River Conversations: Lessons from Eco-social Approaches to Public Health from Oceana to Canada" on December 12, 2021. Online at:

<https://www.youtube.com/watch?v=9zY4WEfZMe8&t=1s>

IWRG Team members delivered several portal demonstrations including:

During the IWRG's Evening on the Nechako Virtual Event, February 23rd, 2021;

"Into the Portal of Experiential Education" at the Koh-learning Winter Festival. February 25th, 2021 as part of the NWR's Spring Technical Meeting, May 26th, 2021.

2022 Conference/Meeting presentations

Kirsten Kieta, on behalf of co-authors Phil Owens and Ellen Petticrew, delivered a talk titled "Determining post-wildfire contamination and sediment sources using polycyclic aromatic hydrocarbons" at the International Association for Sediment Water Science, Piran, Slovenia, July 2022.

Kirsten Kieta, again on behalf of co-authors Phil Owens and Ellen Petticrew, presented a talk at the International Association of Geomorphology conference in Portugal, September 2022. The talk was titled "Tracing sediment sources after wildfire using polycyclic aromatic hydrocarbons".

On June 1st, Stephen Déry presented at the Joint CMOS/CGU/ESC congress. His presentation was entitled: "The Tahtsa Ranges Atmospheric River Experiment (TRARE)"

Margot Parkes, Aita Bezzola and Tavia McKinnon. Presented on "Just what we needed (!?): Lessons from working together with a user-driven, open-source, geospatial tool for archiving and sharing data across diverse contexts." as part of the BC Love Data Week, through a UBC-UNBC collaboration, presenting on. February 16, 2022. <https://researchcommons.library.ubc.ca/2022/01/19/love-data-week-feb-14-18-2022/>

2022 Other presentations/outreach activities

On April 25th, Stephen Déry presented a talk titled "Rivers in the sky: Unraveling the atmospheric river phenomenon" for the Exploration Place's Virtual Adult Speaker Series, Prince George, Canada

On May 24th, members of Theme 3 contributed to a Portals workshop in partnership with the ECHO Network and the Battle River Watershed Alliance, titled: “Using riparian & watershed portals data to connect and share data & information: an interactive workshop”. Opportunities for collaborations were discussed across different portal tools, including the Riparian Web Portal: <https://riparian.info/#/riparian>, the Nechako Watershed Portal: <http://iwrg.gis.unbc.ca/> and the ECHO Network Portal: <http://echo-portal.gis.unbc.ca/>

On May 25th, Stephen Déry, Rajtantra Lihare, and Jingwen Wu presented an update on climate change research in the Nechako Watershed to the Main Table of the Water Engagement Initiative

On June 8th, Stephen Déry presented a talk entitled “Atmospheric Rivers and their role on floods in BC” to the Real Estate Foundation of BC and the Northern BC Real Estate Board.

Between April and June 2022, Aita Bezzola and Margot Parkes participated in planning presentations and discussions with members of the Nechako Watershed Roundtable Secretariat to inform the use of the Nechako Watershed Portal as a tool for profiling and sharing information relating to the NWR Lakes Monitoring and Youth Engagement Working Groups.

On June 29, members of Theme 3 team contributed to a Session focused on geospatial tools, as part of the ECHO Network Annual meeting, exploring potential future collaborations and learning among geospatial tools, such as the BC EnviroScreen and Nechako Watershed Portal. <https://www.echonetwork-reseaecho.ca/geospatial-tools>.

Appendix 2. List of HQP engaged in Phase 2

Name of Team Member	Position	Theme	2018	2019	2020	2021	2022
Aita Bezzola	Research Associate	3				x	x
Alex Lane	Research Assistant	3				x	
Alexis Seely	Research Assistant	3				x	x
Anna Kaveney	Research Assistant	1				x	
Aseem Sharma	Graduate student	1	x	x	x		
Barry Booth	Research Manager & Research Associate	4	x	x	x	x	x
Bruno Sobral	Graduate student	1				x	
David Gateuille	Post-doctoral fellow	2	x	x			
Derek Gilbert	Research Assistant	1				x	
Diana Kutzner	Research Associate	3				x	
Ella Parker	Research Associate	3	x	x	x	x	
Emma Burak	Post-doctoral fellow	2		x			
Grace Wilson	Research Assistant	1					x
Jade Reynolds	Research Assistant	1					x
Jamie Reschney	Research Associate	3					x
Jeremy Morris	Research Associate	1	x	x	x	x	
Jingwen Wu	Research Associate	1				x	x
Jordan Cranmer	Research Assistant	3				x	x
Jorja Cranmer	Research Assistant	3				x	
Joseph Gothreau	Research Assistant & Graduate Student	1 & 3	x	x	x		
Justin Kokoszka	Graduate student	1			x	x	
Katie Cornish	Research Associate	3				x	
Kelly Hurley	Research Associate	1			x	x	x
Kierstin Vohar	Research Assistant						x
Kristen Kieta	Graduate student	2	x	x	x	x	x
Kristy Rasmus	Research Associate	2			x	x	
Lisa Rickard	Research Assistant	3					x
Makayla Skrlac	Research Associate	3				x	x
Margot Vore	Research Associate	1		x	x		
Meghan Hunter-Gauthier	Research Assistant	1					x
Melissa Bates	Research Assistant						x
Michael Allchin	Research Associate	1			x		
Natalie Maslowski	Research Assistant	3					x
Rachel Hay	Research Assistant	1	x				

Appendix 2. List of HQP engaged in Phase 2, continued

Name of Team Member	Position	Theme	2018	2019	2020	2021	2022
Rajtantra Lihare	Research Associate & Graduate student	1			x	x	
Siraj ul Uslam	Post-doctoral fellow	1	x	x			
Spencer Woyke	Research Assistant	1				x	x
Tamar Richards-Thomas	Research Associate	1				x	
Tavia McKinnon	Research Associate	3				x	x
Todd French	Research Associate	2	x	x	x	x	x

Appendix 3. 2022 Finances

Our financial summary from UNBC Finance is attached below. In 2022 we spent a total of \$46,689 whereas our 2022 budget was ~\$100,000. This amount is below the annual allotment of ~\$100,000 and is in line with our commitment of remaining within the overall budget of \$499,950 as per the funding agreement between NEEFs and UNBC. As in previous years, we have matched NEEFs spending with contributions from other sources. In 2022 matching funds totaled ~\$163,000.

3333 University Way
Prince George, BC V2N 4Z9
UNBC Finance Department
Tel:(250) 960-5616 Fax: (250) 960-5794

Funding Agency:

Nechako Environmental Enhancement Fund
BOX 101
Prince George, BC V2L 4R9

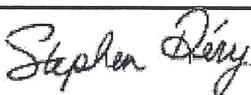
UNBC Fund # 28532
UNBC Contract # RC17-3439

Project Title: "Integrated Watershed Research in the Nechako River Basin: Phase 2"

Statement of Cash Receipts and Expenditures
For the period from January 1, 2022 to September 19, 2022

Opening Fund Balance		(\$108,260.73)
Funds received in the reporting period		\$0
Amount of matching funds in the reporting period	Salaries	\$146,305.61
	Expenses	\$16,974.45
Funds Available		\$55,019.33

LABOUR		
Research Associates	\$95,752.98	
Research Assistants	\$44,599.01	
Graduate Students	\$35,966.69	
Part-time Project Manager	\$7,507.76	
TRAVEL		
Travel (Conferences)	\$ 305.38	
Travel (Field work)	\$6,937.47	
Travel (Workshops and Outreach)	\$876.99	
EQUIPMENT, ANALYSIS and SUPPLIES		
Computers	\$6,312.35	
Equipment	\$1,251.63	
Laboratory Analysis and Supplies	\$0	
Materials and Supplies	\$3,333.80	
PROMOTIONAL MATERIAL		
Publication and Poster Costs	\$0	
UNBC O/H	\$2,125.00	
Total expenses	\$204,969.06	\$204,969.06
Fund Balance at September 19, 2022		(\$149,949.73)



Stephen Dery Professor
22 September 2022

Date



Colleen Smith Associate VP, Financial Services
Sept 20/22

Date

Appendix 4. Phase 2 Finance summary

Our project financial summary is provided below. Over the course of the project, we spent a total of \$1,402,868. This included the budgeted \$499,950 from NEEF and a match from UNBC and other sources of \$902,918. The majority of the match funding has come from projects that have contributed to our overall efforts of integrated research in the Nechako River Valley¹.

	Year					Five-year total
	2018	2019	2020	2021	2022	
Annual budget	\$100,000	\$100,000	\$100,000	\$100,000	\$99,950	\$499,950
Total annual expenditures	\$260,673	\$306,132	\$304,980	\$326,114	\$204,969	\$1,402,868
Total NEEF expenditures	\$101,502	\$152,359	\$116,526	\$87,874	\$41,689	\$499,950
NEEF salaries	\$73,058	\$85,825	\$70,922	\$48,272	\$37,521	\$315,597
NEEF expenses (includes overhead)	\$28,444	\$66,533	\$45,605	\$39,602	\$4,168	\$184,352
Match salaries	\$130,978	\$118,019	\$149,816	\$221,292	\$146,306	\$766,411
Match expenses (includes overhead)	\$28,192	\$35,754	\$38,638	\$16,948	\$16,974	\$136,507
Total Match (includes overhead)	\$159,171	\$153,773	\$188,453	\$238,240	\$163,280	\$902,918
Total expenses	\$1,402,868					
Total NEEF expenditures	\$499,950					
Total Match	\$902,918					
Match balance	\$402,968					

¹ in 2019, we used ~ \$56,000 in salaries of the five Principal investigators as match