Global Water Futures 2021 Operations Team Meeting – Project Reporting Template

Project Name:	Lake Futures

Our major accomplishments to date are:

- Developed a machine learning model for all watersheds across the Great Lakes Basin that can predict seasonal concentrations and loads of nitrate, total nitrogen, soluble reactive phosphorus and total phosphorus (dataset, including daily concentration and load data published in the CUAHSI archive, and paper in review at Earth's Future)

- Quantified the role of various landscape drivers (land use, reservoirs and point sources) on seasonality of nutrient concentrations across the GLB (Van Meter et al. 2019). Significant conceptual insights on how reservoirs alter bioavailable P and what that implies for algal blooms in the lake

- Developed a process-based model ELEMeNT that predicts N and P concentrations and loads as a function of current land use and climate and past nutrient legacies. ELEMeNT is the first ever process-based model that can describe legacy accumulation and time lags to water quality improvement. We have developed ELEMeNT-N and ELEMeNT-P models for the Grand River Basin (Liu et al. 2021, Van Meter et al. 2021).

- Developed a detailed mass balance for P inputs and outputs across Ontario and potential water quality risks from legacy P (Van Staden et al 2021)

- Wrote a review paper on how to manage water quality, given nitrogen legacies (Basu et al., in press Nature Geosciences). The paper provides major insight on nutrient legacies as watershed managers and policy makers are grappling with this question

- Developed a new hydro-economic model for the GLB which analyzes the direct and indirect impacts of possible future water use restrictions due to climate change on economic activities

- Developed an integrated cross sectoral modelling framework to assess the cost effectiveness of water quality improvement policy measures in rural agriculture and urban wastewater treatment

- Developed a methodology for conducting regionalized mass balance modelling in large lakes, and quantified water and P exchange rates between the different regions of Lake Erie (near shore-off shore, interbasin, along-shore fluxes), focusing on the eastern basin (Manuscript in prep, Zahra et al. 2021)

- Quantified internal loadings in Lake Erie and Ontario (Manuscript in prep, Bocaniov et al. 2021) using a numerical model

- Developed a machine learning model to predict chlorophyll-a concentrations in large lakes (Kheyrollapour et al. 2021, in prep). Corresponding dataset published in Adam et al (2021, in review)

- Analyzed streamflow data across North America to show how human interventions are amplifying and dampening seasonal streamflow patterns (Singh and Basu, 2021)

- Compared freshwater monitoring approaches with and developed a comprehensive monitoring framework with diverse stakeholders and collaborators using the principles of Community-based Participatory Action Research to improve water quality monitoring activities in the Grand River-Lake Erie interface (Ho et al. 2020)

- Developed a watershed lake routing tool for streamflow routing across basins

- KM Accomplishments
    - Launch of Lake Futures Webinar Series in Fall 2020, featuring 6 webinars that summarized some of the research findings from the project; attracted over 450 participants, and were a catalyst for community conversation about the application of research
    - Organization of a 2-day workshop in December 2020, in collaboration with The Gordon Foundation, on "Data Needs in the Great Lakes"
    - Lake Futures PhD student, Elaine Ho developed *Grand Expressions*, a virtual art exhibit composed of works by youth from Six Nations of the Grand River. Youth from Music for the Spirit & Indigenous Visual Arts created artworks and wrote associated stories for the exhibit

Our current activities are:

- Organizing another webinar series for winter 2022 to highlight new research findings from the project
- Developing a reservoir model to describe P speciation in reservoirs for Belwood and Conestogo reservoirs. The reservoir model will be integrated with the watershed model
- Developing a Nitrogen model for all watersheds in the Lake Erie Basin
- Developing a Phosphorus model for all watersheds in the Lake Erie basin
- Completing an economic analysis, including conducting cost-benefit analysis of the implementation of policy measures in the Great Lakes to improve water quality
- Developing relationships between lake ice and chlorophyll-a for the Northern lakes
- Developing P movement and internal loading models for Lake Ontario
- Connecting watershed nutrient models with lake models

The main accomplishments expected by the end of the project are:

- A new operational version of the Water Quality Valuation Model for the Great Lakes
- Process-based and machine learning nutrient (N and P) models for watersheds draining into Lake Erie
- Within lake nutrient models capturing littoral zone processes and internal loading for lakes Erie and Ontario
- Coupled watershed-lake model for Lake Erie
- Machine learning models to describe chlorophyll-a and lake ice for northern lakes
- Roadmap to identify cost-effective and socially acceptable framework for nutrient reduction strategies for the GL
- Policy brief summarizing the economic analysis
- Conversation Canada article highlighting nutrient legacies and water quality

Here is a key visual from the project (figure, photo, table, graph, etc.)

Phosphorus legacies and future water quality trajectories in the Grand River Watershed, Ontario, Canada