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07 September 2021

Mr. Greg Bosse
Project Manager
Lake Diefenbaker Irrigation Projects
Impact Assessment Agency of Canada
Prairie and Northern Regional Office
Environment and Climate Change Canada
Edmonton, Alberta, Canada
Email: Greg.Bosse@canada.ca

Dear Mr. Bosse,

This letter details of my request that Phase 1, Phase 2, and Phase 3 of the *Lake Diefenbaker Irrigation Projects* (LDIP) each be designated as a "project" as defined in the 2019 *Impact Assessment Act* (IAA) of Canada and associated *Physical Activities Regulations* (SOR/2019-285).

My opinions are based on 28 years of freshwater research experience within Lake Diefenbaker, as well as over 100 aquatic ecosystems in southern Saskatchewan. My CV is available at https://www.uregina.ca/science/biology/people/faculty-research/leavitt-peter/index.html. Briefly, I am three-term Tier I Canada Research Chair in Environmental Change and Society, former President of the Society of Canadian Limnologists, past Director of the Canadian Institute of Ecology and Evolution, and Fellow of the Royal Society of Canada, our nation's National Academy. My specialty is Limnology, the study of inland waters.

Summary remarks

In my professional opinion, each phase of the proposed LDIP transfer has the potential to damage the environment as defined in the 2019 IAA as well as the *Saskatchewan Environmental Assessment Act* (SEAA). As detailed below, project designation can be justified because the potential for environmental damage is substantial in many permanent water bodies, including lakes, wetlands, streams, and other fresh and brackish water bodies, in each phase of the program. Specifically, I believe that there are no phases within the LDIP that can avoid impacting habitat for fish (protected under the 2019 modernization of the *Fisheries Act*), endangered species (including but not limited to Piping Plover, Forster's Tern, Whooping Crane, Northern Leopard Frogs; protected by *Species at Risk Act*), and migratory waterfowl (protected under *Migratory Bird Convention Act*). Many of same these issues were raised in a the 2017 judicial challenge at the Saskatchewan Court of Queen's Bench in which the Government of Saskatchewan was prevented from authorizing a much smaller water conveyance in southern Saskatchewan (the Kutawagan Creek Diversion Project).

Although this request is to designate each phase as a project, I also argue LDIP is in fact a single integrated project and should be evaluated as such within a cumulative impacts assessment framework. Specifically, I note that the Province of Saskatchewan describes the combined program as "...the largest infrastructure project in the province's history" (source Prov SK; https://diefenbakerirrigation.ca/author/laurissa/; accessed 04 Sept 2021). Water in this lake is the main domestic source for over one-half of the provinces inhabitants, yet is already supports electric power generation in Saskatchewan (Gardiner Dam, E.B. Campbell Station) and Manitoba (Grand Rapids generating station on Cedar Lake), solution potash mining (Mosaic and K+S mines on Buffalo Pound Lake; additional proposed mines), and maintenance of downstream ecosystems (South Saskatchewan River, Saskatchewan Delta, etc.). Given that there is only one source of water proposed for all three phases, that the Government of Saskatchewan has stated that it intends to develop all three phases, and that environmental damages may accrue both from all three individual phases (see below), I believe that this program should be evaluated as a single entity within an cumulative impacts assessment framework.

Finally, I note that project designation under the IAA of Canada may be justified because one of central goals of this legislation is to promote communication and cooperation with Indigenous Peoples with respect to treaty rights, sovereignty, and the role of traditional knowledge in protection of the environment. In particular, I note that many First Nations are potentially impacted by the three phases of the LDIP (e.g., Whitecap Dakota First Nation, James Smith Cree Nation, Cumberland House Cree Nation, Pasqua First Nations, Standing Buffalo Dakota First Nation, Cowessess First Nation, etc.) and that the Federation of Sovereign Indigenous Nations (FSIN) of Saskatchewan has already requested that the entire LDIP be designated a project under the IAA.

Scientific basis for project designation

The essence of the *Lake Diefenbaker Irrigation Projects* program is that it seeks to divert over 600 million m^3 of water from Lake Diefenbaker into a series of three subprojects, each presently designed mainly for agricultural irrigation: the Westside Irrigation Rehabilitation (aka Phase 1); the Westside Irrigation Expansion (Phase 2), and; Qu'Appelle Irrigation South Conveyance (Phase 3). Each phase of the program will consume far more than the 10 million m^3 threshold identified in the *Physical Activities Regulations* to designate each phase as a project under the IAA.

The Westside Irrigation Rehabilitation (Phase 1) will retrench over 40 km of existing water conveyance channels and add 100s of km of new side channels to irrigate over 300 km^2 of land within an area of over 700 km^2 identified by Government of Saskatchewan. The impacted region includes several major regional lakes (e.g, Stockwell Lake, Anerly Lakes, Coteau Lake) as well as numerous smaller water bodies. Given the regional topography, agricultural runoff will be expected to drain into these lakes as well as Lake Diefenbaker's Gardiner Arm, particularly under high runoff conditions such occurs during spring or following intense storm events. My multi-decadal monitoring shows that water quality in the east end of the lake is already degraded (Hall et al. 1999a; Tse et al. 2015) and that this process is continuing due to nutrient influx and reduced water inflow (Vogt et al. 2015), as well as depletion of dissolved oxygen (Carr et al. 2019; Jane et al. 2021).

The Westside Irrigation Expansion (Phase 2) will add 100s of km of new conveyance channels and associated infrastructure to irrigate a further 1000 km^2 within a proposed project area of over

3000 km^2. The proposed irrigation area includes several permanent lakes exist (e.g., Goose Lake, Rice Lake, Van Scoy Lake), as well as a pronounced creek system which drains the western side of Phase 2 north into the North Saskatchewan River, and a multitude of smaller wetlands systems. As detailed below, agricultural runoff may damage all these ecosystems though the process of eutrophication, as it has in lakes throughout the Canadian Prairies (Hall et al. 1999b; Bunting et al. 2016; Maheaux et al. 2016). These freshwater and brackish surface waters are critical reproductive areas for migratory water fowl, fish, and potentially endangered species.

Finally the Qu'Appelle Irrigation South Conveyance will require ~100 km of new channel to irrigate nearly 500 km^2 within an area of ~2000 km^2, and will directly release conveyance water and associated runoff into Buffalo Pound Lake, the drinking reservoir for the Cities of Regina and Moose Jaw. Due to management by the Saskatchewan Water Security Agency (WSA), Buffalo Pound Lake is now the source water for the Qu'Appelle River system. Published scientific research by my laboratory shows that nutrient influx (Swarbrick et al. 2019) and climate warming (Vogt et al. 2018) is worsening outbreaks of toxic cyanobacteria (Orihel et al. 2012; Hayes et al. 2020) that are being conveyed down the Qu'Apppelle River along with urban wastewater from Moose Jaw (via Moose Jaw Creek) and Regina (via Wascana Creek) (Bergbusch et al. 2021). This degraded water drains directly into other lakes of the Qu'Appelle river drainage basin (Pasqua, Echo, Mission, Katepwa, Crooked, Round lakes) where it can damage freshwater foodwebs, create toxic conditions, and limit traditional uses of the waterways by many First Nations (e.g., Pasqua First Nations, Standing Buffalo Dakota First Nation, Cowessess First Nation, etc.). Finally, waters of the Qu'Appelle River drain directly into the Assiniboine River within Manitoba, creating a situation where damages within the Qu'Appelle are passed into a neighbouring jurisdiction.

My concerns centre on four areas where potential environmental effects of LDIP may be expected: a) effects of construction of water conveyance channels and associated infrastructure on aquatic ecosystems; b) effects of water withdrawl on Lake Diefenbaker and downstream ecosystems; c) environmental degradation arising from agricultural runoff to surface waters, and; d) conveyance of pollutants from multiple sources into the Qu'Appelle River drainage basin. Below, I summarize the main issues in point form.

1. Effects of water conveyance construction

1A.. Construction of conveyance channels has a high probability of transecting existing streams and wetlands. If any of these sites are fish-bearing, such modifications should trigger an assessment under the *Fisheries Act*. Although the main north-south channel proposed in Phase 1 was constructed in the 1970s, this conveyance represents is only a fraction of the 400 km of channelization required to complete Phases 1 and 2 and has not conveyed any water to date. Consequently, this phase of the program cannot be considered 'substantially initiated'. Specifically, my preliminary analysis with current satellite images from the Sentinel 2 platform (https://www.sentinel-hub.com/) demonstrates that few of the side channels needed for water conveyance to the central and western sides of the Phase 1 area have been constructed. Given the abundance of surface waters in Phase 1 and 2 (see Figures 1 and 2 below), I believe it is highly probably that fish and migratory water fowl habitats will be impacted by channel construction.

Figure 1. Water bodies within the proposed Phase 1 of the Lake Diefenbaker Irrigation Projects. Thin circular white line represents approximate boundary of proposed Phase 1 based on Province of Saskatchewan presentations. Thin white line parallel to the S. Saskatchewan River represents pathway of the preliminary conveyance channel. No channels have been constructed to allow lateral (east-west) movement of water within the proposed Westside Phase 1 project.

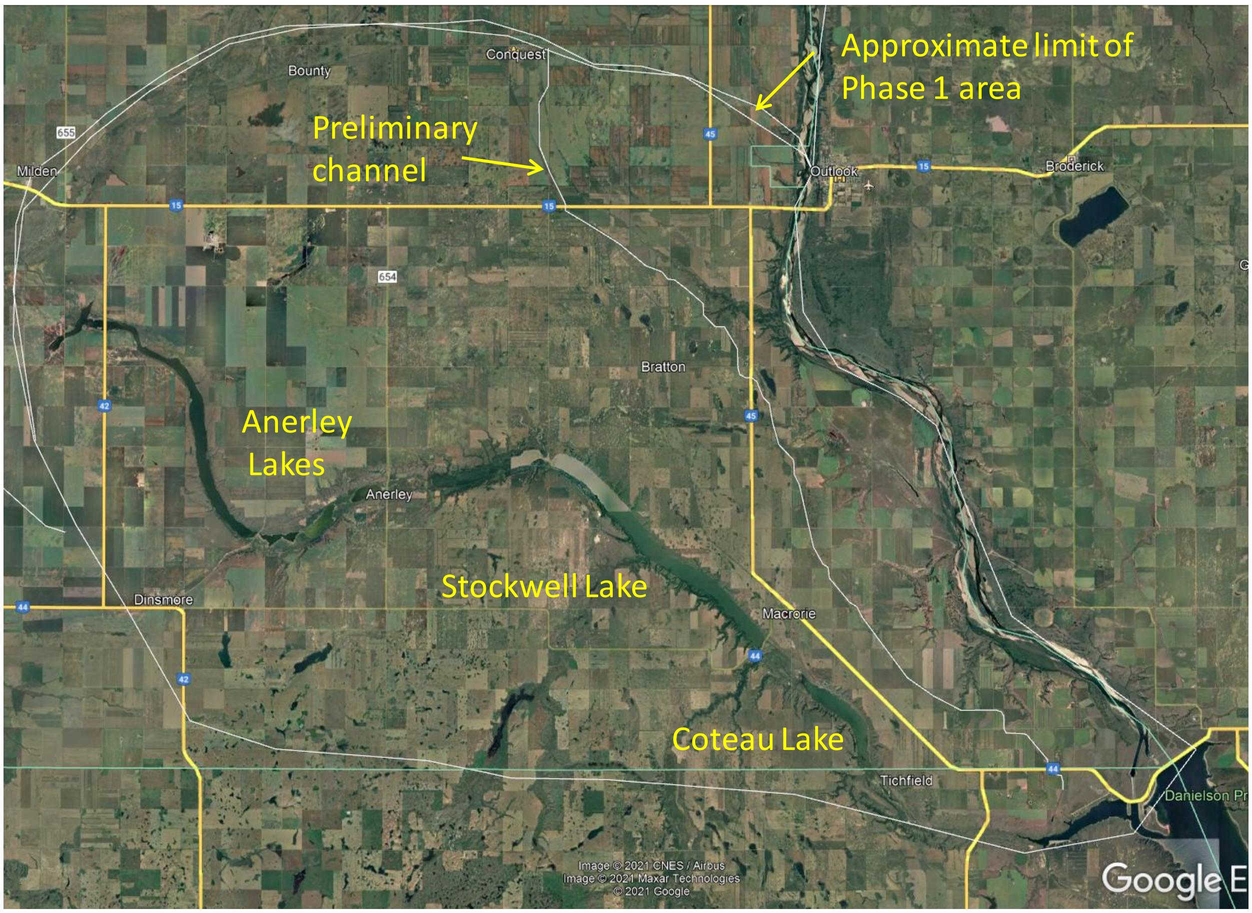
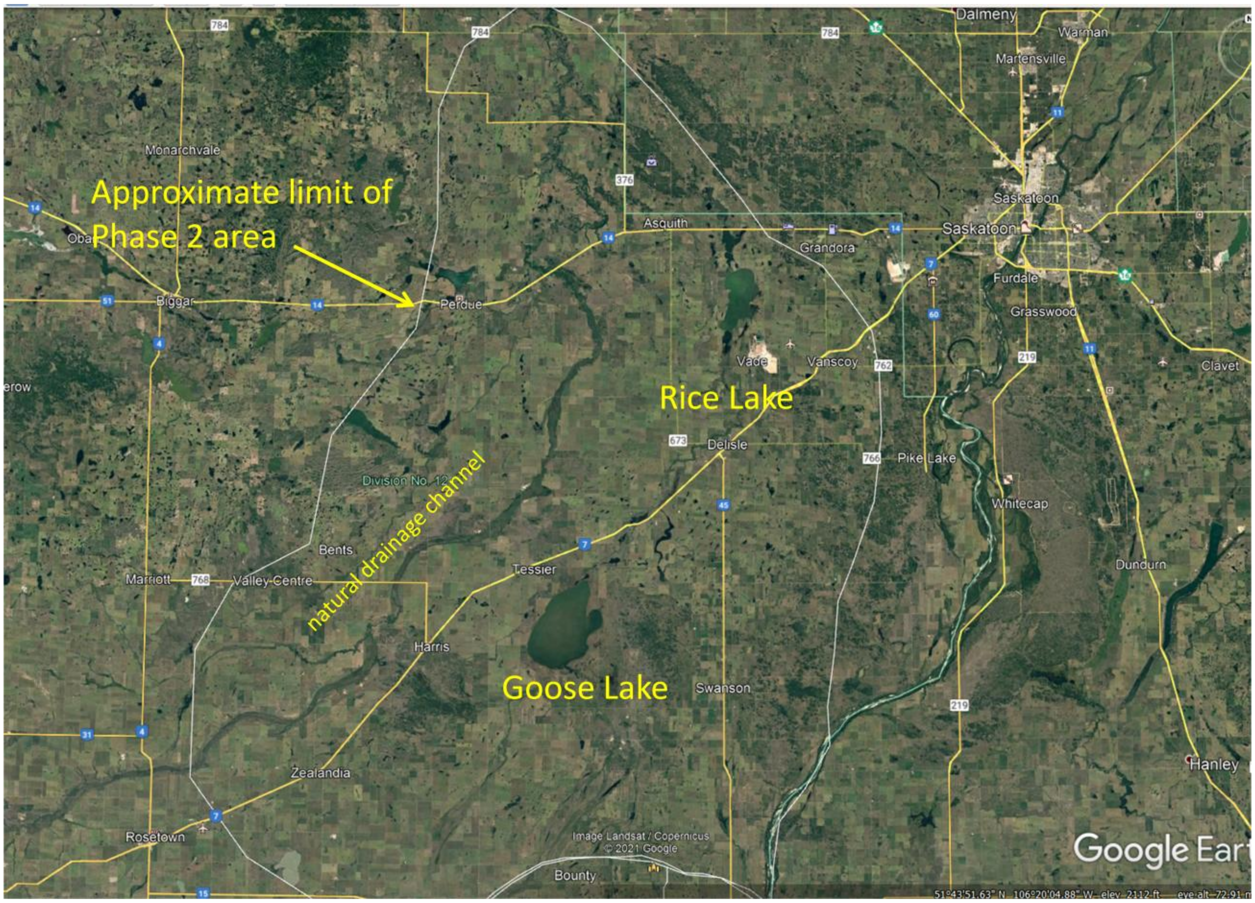


Figure 2. Major water bodies within proposed area of Phase 2 of the Lake Diefenbaker Irrigation Projects. Thin white line represents approximate boundary of proposed Phase 2. Note presence of a historical natural drainage channel which flows north to intersect with the North Saskatchewan River.



1B. Channelization can modify natural overland flow of surface water in the impacted regions. There are several large lakes whose existence depends on overland and groundwater flow (Figures 1, 2), therefore changes in runoff patterns may modify water supply to the lakes. At present, it is unclear whether such changes in water flow would lead to greatly elevated lake levels and associated flooding (which might be an issue when lakes are adjacent to villages; e.g., Vade, Perdue) or result in complete water loss and elimination of the aquatic habitats (e.g., Goose and Rice lakes). Loss of the lakes and smaller water bodies would be a particular concern for sites that are used as staging or breeding areas for migratory water fowl, have resident fish populations, or which are habitats for endangered species, such as the Piping Plover which used shoreline regions as critical habitats. Minimally, the biological status and water flow characteristics (hydrology) of permanent water bodies should be evaluated before the drainage is changed substantially by 100s of km of conveyance channels. Finally, the presence of a natural, north-flowing drainage in the centre of the proposed Phase 2 region (Figure 2) shows that changes in surface runoff could increase conveyance of agricultural chemicals into the North Saskatchewan River, particularly under high runoff conditions.

2. Effects of water withdrawal from Lake Diefenbaker

2A. According to preliminary information from the Saskatchewan Water Security Agency, the LDIP will extract over 600 million m^3 annually from Lake Diefenbaker, a value far in excess of the 10 million m^3 trigger point used to define a project within the 2019 IAA. Given the relative areas proposed to be irrigated (300 – 1000 km^2), each phase of the LDIP will consume more than 100 million m^3 per annum (range 100-333 million m^3)

Although Lake Diefenbaker is a man-made reservoir, its function is to restrain but not remove the natural flow of the South Saskatchewan River. Consequently, elimination of ~600 million m^3 of water from the South Saskatchewan River ecosystem will prevent the deposition of said water into the Saskatchewan River, at the confluence of the South and North Saskatchewan Rivers. In my opinion, this fact satisfies the definition of a *designated project* under the IAA because two natural water bodies are impacted by the singular action of a give water project. Similarly, the proposed transfer of water from the Lake Diefenbaker reservoir into Buffalo Pound Lake, itself a natural waterbody (Hall et al. 1999), satisfies the criterion for designation of Phase 3 as a physical project.

2B. Estimates of the quantity of water available for extraction do not account for natural climate variability, upstream extraction in Alberta, or effects of future climate change. As a result, the program and each individual phase may compromise the future integrity of the South Saskatchewan River, its navigability, the health of downstream ecosystems, and use by Indigenous Peoples of Saskatchewan.

Natural climate variability and future climate change may reduce water supply to Lake Diefenbaker and prevent current uses as well as proposed irrigation. In public presentations, WSA states that they "reviewed 88 years of flow data and found that with no significant change in operating, there is nearly 900,000 acre-feet/yr (1.11 billion m^3) of water available for irrigation". However, this calculation does not consider the effects of natural climate variation on the flow within the river. Research by Dr. David Sauchyn at University of Regina shows that natural climate variability has reduced flow in the South Saskatchewan below all levels seen during the 20th century on at least 25 occasions during the past 1000 years (Sauchyn and Ilich 2017 and Figure 3). These data show clearly, that the period of measurement used by the WSA is completely inadequate for defining the availability of water to be used for irrigation, as it does not include <u>*any*</u> major period of low flow periods seen commonly in previous centuries.

Research by Clarke et al. (2015) suggests that up to 70% of glacier water sources to the South Saskatchewan River will be lost over the next 80 years. Initially, this melting was expected to increase water supply to the river; however on-going research by Pradhananga and Pomeroy (2021) shows that ice loss is occurring far more rapidly than previously predicted, particularly as a result of recent heat domes and other phenomena associated with global warming. As the ice mass is lost, there is an initial increase in river flow, followed by long and permanent declines. However, even with increased supply of water from high elevations due to melting, there was insufficient water to completely replenish water levels in Lake Diefenbaker during the 2021 prairie drought (Figure 4). Together, these studies show suggest that both natural and human-induced changes in river flow have the capability of severely depleting water flow in the South

Saskatchewan River, and infer that industrial-scale extraction of water for the LDIP will not be sustainable in the future.

Figure 3. Paleo-climatic reconstructions of water-year flow in the South Saskatchewan River plotted as positive (blue) and negative (red) departures from the mean water-year flow (220 $m^3 s^{-1}$). Data from Sauchyn and Ilych (2017). Note: there are over 25 instances in which the flow of the South Saskatchewan River has been reduced by over 45% of average conditions during the past 900 years. These natural changes are independent of human withdrawls in Alberta, as well as effects of future climate change.

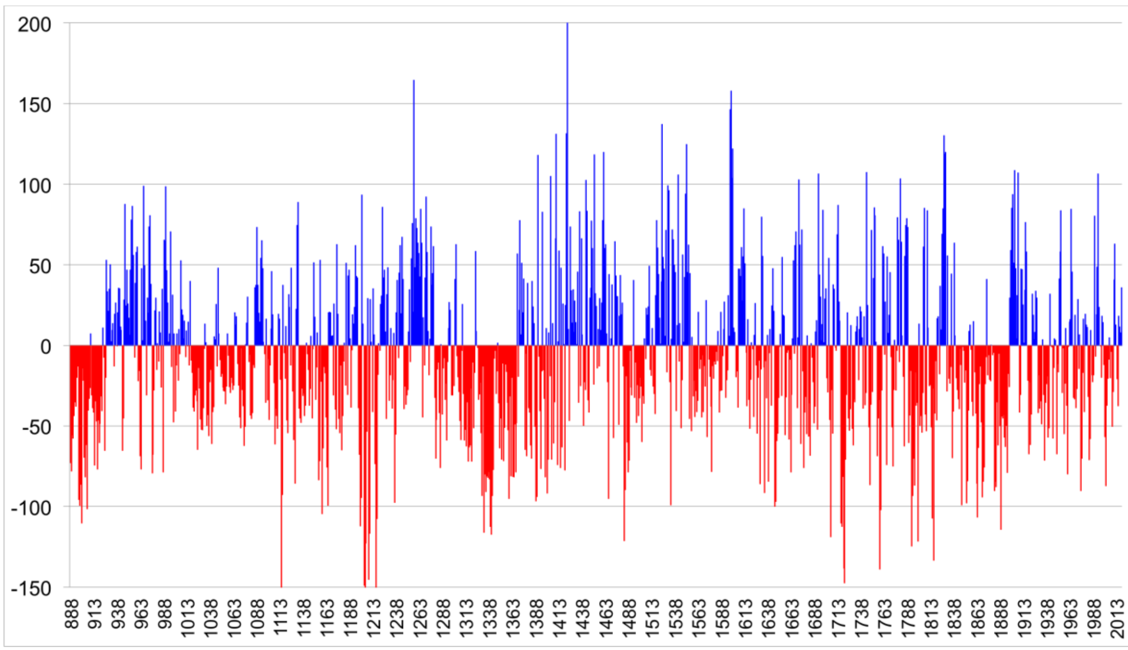


Figure 4. Depleted water levels in Lake Diefenbaker due to summer drought during 2021. Note extremely low water levels in the Qu'Appelle arm of Lake Diefenbaker. Image from 07 Aug 2021. Obtained from www.sentinel-hub.com.

Finally, the *Master Apportionment Agreement* of the Prairie Provinces Water Board guarantees that Alberta can take 50% of flow prior to its arrival in Saskatchewan. This value is evaluated on the basis of individual rivers which flow among provinces. To date, Alberta has not extracted their full quota from the South Saskatchewan River. However, on 09 October 2020, the Government of Alberta, along with the Canada Infrastructure Bank, announced $815 million in funding towards irrigation modernization in southern Alberta (https://www.alberta.ca/release.cfm?xID=744409082E7B3-B5F3-0F7A-8E5CF641A4308087 This project will likely affect water supply to the proposed LDIP and suggests that the Saskatchewan program should not be evaluated on the basis of historical water supply and should be evailated in the context of other prairie water project developments.

2C. Reduced flow out of Lake Diefenbaker due withdrawals for irrigation is likely to further impact the health and navigability of the South Saskatchewan River due to increased silt build up in the main river channel. Evaluation of the South Saskatchewan River using Google Earth shows that sand and silt build up is common only in the region downstream of the Gardiner Dam (to the City of Saskatoon) and not in other major regions, irrespective of river valley width (Figure 5). Similarly, such silt and sand bars are largely absent from the North Saskatchewan River. Under natural flow regimes, high flow events in spring and after major storms flush out sand and silts; however, elimination of these high flows due to the presence of large reservoirs can allow silt build up in downstream rivers. These changes can damage fish habitat and should be protected under the *Fisheries Act*. Furthermore, sandbars can form and influence use of the waterway by Indigenous people (e.g., White Cap Dakota First Nation) and others and should be considered in the context of the *Navigable Waters Act*. Additional reductions in peak flow due to extraction of up to 20% of the volume of Lake Diefenbaker for irrigation may further influence the health and navigability of the South Saskatchewan River.

Figure 5. Sand and silt build up in the South Saskatchewan River immediately downstream of the Gardiner Dam on Lake Diefenbaker and adjacent to the regional irrigation districts

2D. Reduced flow, and changes in timing of maximum river discharge rates, are of particular concern to the Indigenous Peoples of the Saskatchewan Delta. This massive wetlands complex was impacted by construction of the Tobin Lake reservoir on the Saskatchewan River, and several downstream bands (e.g., Cumberland House Cree Nation) are concerned about an additional upstream diversion of water and its impacts on their sovereignty (https://thestarphoenix.com/news/local-news/first-nation-declares-sovereignty-over-saskatchewan-river-delta). In particular, there are concerns about loss of high flow (flooding) events, loss wetlands due to lack of water replacement during high flow events, and reductions in availability of traditionally-harvested plants and animals. Loss of natural habitat has been identified by the United Nations as one of the main causes of biodiversity decline for plants and animals ([https://www.un.org/sustainabledevelopment/blog/2019/05/nature-decline-unprecedented-report/)](https://www.un.org/sustainabledevelopment/blog/2019/05/nature-decline-unprecedented-report/) and is capable of affecting traditional hunting, medicinal and sacred activities protected under Treaty rights.

2E. Further changes in lake level associated with increases water withdrawl for in the LDIP is likely to affect habitat for threatened and endangered species including but not limited to Piping Plover (*Charadrius melodus*), Whooping Crane (*Grus americana*), and Northern Leopard Frogs (*Lithobates pipiens*). Several of these taxa are protected by *Species at Risk Act*. In addition, Lake Diefenbaker and downstream waterbodies in the Qu'Appelle River drainage basin are critical habitat for Bigmouth Buffalo (*Ictiobus cyprinellus*), a fish considered at risk in Saskatchewan.

3. Environmental degradation arising from agricultural runoff

3A. All phases of the LDIP have the strong potential to pollute surface waters with excess fertilizer associated with intensive irrigation practises, particularly as a result of forecast increased in precipitation extremes (e.g., Li et al. 2018). Climate forecasts for southern Saskatchewan predict both warmer temperature and increased precipitation (Asong et al. 2016; Dibike et al. 2016), while the severity and frequency of extreme events is predicted to rise. These conditions have been shown to increase the magnitude of agricultural nutrient export from land to lakes, resulting in sudden and severe loss of water quality, such as seen in Lake Winnipeg since 1990 (McCullough et al. 2012; Bunting et al. 2016).

My 28-year research program on lakes in southern Saskatchewan shows that excess nutrients from agricultural runoff will have several interacting effects on prairie water quality. First, agricultural runoff increases lake production to unnatural levels (termed cultural eutrophication) and favours blooms of toxin-producing cyanobacteria (Hall et al. 1999b; Leavitt et al. 2006; Bunting et al. 2016). Our 2013 survey of 100 lakes in southern SK, including some basins potentially impacted by the proposed project, showed that more than 40% of all sites have toxin levels above drinking water limits (Hayes et al. 2020). Furthermore, many lakes exhibit toxin levels that exceeded recreational limits, while several lakes in farming regions pose acute health risks to humans due to poor water quality (Hayes et al. 2020). As part of this work, we have shown that these toxic blooms are becoming more intense and longer lasting due to climate warming interacting with excessive nutrients (Vogt et al. 2018; Hayes et al. 2020).

Our long-term monitoring program, as well as our analyses of the fossil record preserved in lake sediments, shows that water quality in the Gardiner and Qu'Appelle Arms of Lake Diefenbaker have been declining since reservoir completion due to combined effects of nutrient enrichment and declining water inflow (Hall et al. 1999a; Tse et al. 2015; Vogt et al. 2015, 2018). In particular, both total lake production and the presence of potentially-toxic cyanobacteria have been increasing over the past three decades. Environmental degradation of Lake Diefenbaker may be expected to arise from Phase 1 activities in particular, as the propose project with move water into the catchment area for the reservoir, including potential returns of fertilizers and pesticides via the natural drainage formed by Anerley, Stockwell and Coteau lakes that flow towards Lake Diefenbaker in the Phase 1 region (Figure 1). Similarly, intensification of fertilization associated with irrigation is expected to increase nutrient flow into the historical stream channel on the west side of Phase 2, and in turn the North Saskatchewan River (Figure 2).

Given that agricultural runoff now supplies most of the nutrient inflow to Buffalo Pound Lake (Hall et al. 1999a; Leavitt et al. 2006; Swarbrick et al. 2020), it seems likely that agricultural intensification in Phase 3 will further degrade water quality in that ecosystem. Buffalo Pound already exhibits among the worst water quality in the Qu'Appelle River system, with very high levels of toxic cyanobacteria during much of the summer and fall (Hayes et al. 2020; Swarbrick et al. 2020). Addition of water to the eastern end of Buffalo Pound to increase flow to downstream lakes may push these degraded waters downstream, creating further impairment of water quality in downstream lakes. Research in my laboratory shows that potentially-toxic blooms of cyanobacteria are already present in the waters of the Qu'Appelle River before it it flows into Pasqua Lake. This lake is immediate adjacent to Pasqua First Nations reserve (Bergbusch et al. 2021).

3B. Our recent research shows that the rates of oxygen loss from Qu'Appelle lakes were among the highest in the world (Jane et al. 2021). Specifically, the Qu'Appelle Arm of Lake Diefenbaker exhibits rates of oxygen loss that were ranked in the highest 5% of 400 study lakes in the Northern Hemisphere (Jane et al. 2021), and which are expected to increase due to global warming (Carr et al. 2019). Oxygen loss arises from having too much nutrient-fuelled biological production, which subsequently sinks, dies, decomposes, and consumes oxygen out of deepwater. These losses are enhanced by global warming, which is forecast to be twice as great in the Canadian Prairies as the worldwide average (Asong et al. 2016; Dibike et al. 2016). Large fish species, such as the world-record lake trout found in Lake Diefenbaker, may be particularly susceptible to death due to low oxygen levels in deep water. Such declines in oxygen levels are expected to increase due to elevated nutrient runoff from all phases of the LDIP.

4. Effects of multiple pollutants on the Qu'Appelle River drainage basin.

4a. In my professional opinion, any change in water flow arising from Phase 3 must be evaluated in the context of a cumulative impacts assessment that includes both Phases 1 and 2 of the LDIP, as well as current activities within the Qu'Appelle River drainage basin. Water quality in the Qu'Appelle River system is already degraded by a combination of agricultural nutrient runoff (Hall et al.1999b; Bogard et al. 2012, 2020), point-source pollution from cities (Regina, Moose Jaw, Lumsden, Fort Qu'Appelle, etc.) (Leavitt et al. 2006; Dixit et al. 2000), and changes in river flow due to climate change and industrial water extractions (Vogt et al. 2018; Haig et al. 2020), as well as poorly documented but likely impactful activities such as shoreline modification by cottagers and local land owners and loss of regional wetlands (refs). Presently, water quality degradation appears to be related mainly to atmospheric warming and nutrient influx (Hall et al. 1999b; Vogt et al. 2018; Hayes et al. 2021); however, freshwater in the Qu'Appelle River catchment has been regularly targeted for extraction in support of solution potash mines and other industrial activities (e.g., fracking). Further changes in water use and quality should be considered in context of these multiple stressors as part of an impacts assessment.

There is precedent for conducting a cumulative impacts assessment for the Qu'Appelle River catchment. For example, in 2012, a case was heard by the Canadian federal court as regards the matter between the plantiffs (Standing Buffalo Dakota First Nation) and the defendant (Canada, as represented by the Attorney General of Canada) concerning the potential effects of water withdrawl from the Qu'Appelle River system and associated changes in the natural and engineered flow within of river and its tributaries in support of regional potash solute mines. The federal government did not contest the case, but instead returned the issue to the Government of Saskatchewan to conduct a cumulative impacts assessment. To the best of my knowledge, this assessment was never completed and the matter has been sidelined due to currently unfavourable economic conditions in the commodities market. However, the fact that a water transfer much smaller than the LDIP resulted in federal recognition that a cumulative impacts assessment should be conducted, suggests that a similar evaluation should be required for the LDIP, the largest infrastructure project in the history of the Province.

Summary

In conclusion, I think the LDIP would benefit immensely from an impacts assessment under the 2019 *Impacts Assessment Act* of Canada. Specifically, I see an impacts assessment as an excellent opportunity to avoid environmental damages to fish and fish habitat, aquatic species, and migratory birds. Further, because proposed program of projects would be evaluated under both the SEAA and the CIAA, the LDIP will provide an excellent opportunity for the federal and Saskatchewan governments to promote cooperation and coordinated actions with as regards impacts assessments. Finally, as many First Nations are potentially impacted by the proposed projects, the LDIP provides a superb opportunity to promote communication and cooperation with aboriginal peoples with respect to treaty rights, sovereignty, and environmental protection.

I hope this is useful in your deliberations. Let me know if I can provide further insights. I've added line numbers so you can more easily identify areas of interest.

Please contact me if you require further details. I can be reached by phone (<personal information removed>) or email (<email address removed>).

Sincerely,

<Original signed by>

Peter R. Leavitt PhD FRSC FRSB
Fellow of the Royal Society of Canada
Fellow of the Royal Society of Biology (UK)
Sustaining Fellow of the Association for the Sciences of Limnology and Oceanography (ASLO)
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Director, Institute of Environmental Change and Society
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