

Review of Regional Cumulative Effects Assessment

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Prepared for:
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For:
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Executive Summary

Halket Environmental Consultants was engaged by O-Pipon-Na-Piwin Cree Nation to review the Regional Cumulative Effects Assessment for Hydroelectric Developments on the Churchill, Burntwood and Nelson River Systems, conducted by Manitoba and Manitoba Hydro. After reviewing the assessment we were surprised by the lack of suitable scoping and analyses and also the lack of assessment concerning mitigation measures. Therefore, we, O-Pipon-Na-Piwin Cree Nation (OPCN) wish to comment on the parts of the document that pertain to our traditional territory: Southern Indian Lake (SIL), the Churchill River from Missi Falls to Fidler Lake and the South Bay channel down to Notigi. This territory is represented in the RCEA by Hydraulic Zones 4, 5 and 6, respectively and the South Indian and Baldock terrestrial regions.

OPCN were not consulted before the approach to the RCEA was conceived and implemented by Manitoba and Manitoba Hydro. If OPCN had been, the RCEA would be a very different document because it would have addressed the changes that occurred to the environment and community because of the Churchill River Diversion in a much more substantive manner.

Best practice for Cumulative Effects Assessment (CEA) recommends that analyses of changes are conducted through comparisons of states of the environment at different points in time, referred to as cases. The RCEA fails to establish a pre-development case, an immediate post-development case, a current case and reasonably foreseeable future development cases. Because this practice is not employed, the RCEA does not adequately assess cumulative effects of hydroelectric development in OPCN's region of interest.

For the Physical Environment, Water and Land RSCs we find that the comprehensive studies conducted by DFO and other scientists for the Lake Winnipeg , Churchill and Nelson River Study Board (LWCNRB) before and immediately after the CRD became operational present more than enough data to establish pre-development reference and immediate post-development cases. Coupled to OPCN's traditional knowledge of the area during this time, we find it preposterous that these two cases were not established.

The early studies by DFO scientists also made predictions about the effects of the CRD on the future aquatic environment of Southern Indian Lake, the main focus of this review. The RCEA failed to follow-up on these predictions, some of which were particularly prescient considering the state of SIL today. The failure to establish a future development case has resulted in the failure to predict when the lake and downstream rivers will recover from the CRD and what that recovery will look like.

Another disappointment with the document is the failure to recognize shoreline as a major area of concern in the RCEA. This is the zone that bore the brunt of the impacts of the CRD from flooding, erosion and sedimentation, and habitat loss. The portioning of the shoreline between the Physical Environment, Water and Land marginalized the impacts on this zone and reduced the weight that should have been accorded to the effects on the shoreline and near-shore areas.

The RCEA's analyses are hampered by the lack of recent monitoring data, either because the data were not collected, or collected in a fashion that was not compatible with past techniques. This is inexcusable. Monitoring plans must be modified to duplicate past techniques so that the

data gathered is comparable. There have been 43 years since the CRD. Manitoba and Manitoba Hydro have missed an opportunity to gather this information.

We find that the RCEA wanting in regards to the assessment of hydroelectric development in OPCN's traditional area. The TOR immediately disqualified it as CEA because the TOR precluded direct consultation with affected communities; it is not retrospective, forward-casting, nor comprehensive in its analyses. It does not account for changes to riparian and littoral habitats. For these reasons we recommend that the RCEA be reworked to include consultation with OPCN, establishment of pre-development and post development cases and inclusion of shoreline and near-shore as areas of concern that require further assessment.

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I. Introduction

Halket Environmental was engaged by O-Pipon-Na-Piwin Cree Nation (OPCN) to review the Regional Cumulative Effects Assessment (RCEA) for Hydroelectric Developments on the Churchill, Burntwood and Nelson Rivers. The review focuses on the parts of the RCEA that pertain to the region of Southern Indian Lake (SIL) and the area immediately downstream on the Churchill River and Rat River (Hydraulic Zones 4, 5 and 6 and Southern Indian and Baldock Terrestrial Zones). After reviewing Manitoba Hydro and Manitoba's regional cumulative effects assessment of these areas, we were surprised by the inadequacy of the assessment, its departure from CEA best practices, and the lack of insight into the effects of the Churchill River Development (CRD) on OPCN and the environment. In our opinion, we do not think the RCEA presents an adequate assessment of the effects of the CRD on SIL and downstream environment for the following reasons.

OPCN were not consulted in a meaningful way during the planning stage of the RCEA. We feel that if our input had been sought by Manitoba and Manitoba Hydro the document would be very different in that it we would have advised that the RCEA:

- follow best practice recommendations for a CEA contained within the Canadian Environmental Assessment Act Guidelines;
- at a minimum, establish pre-development reference condition, an immediate post-construction, present day development and future development cases; and
- identify shoreline and near-shore areas as an area that deserves consideration and use appropriate Valuable Components (VC) and metrics to assess the changes to the shoreline.

Incorporating this advice into the planning of the RCEA would have resulted in better assessment that would have addressed the major impacts of the CRD on the environment. In the section "Approach to the RCEA" (Phase II, People p.3.2-5), Manitoba and Manitoba Hydro state:

"In recent projects such as the Wuskwatim and Keeyask Generation Projects, Manitoba Hydro has employed project planning processes that engage local communities meaningfully and early on in the development of these new generation projects. A similar approach is used in the route selection and environmental assessment processes for new transmission lines."

Why was this early consultation process not followed for the RCEA?

Another disappointment with the document is the failure to quantify the changes in Regional Study Components (RSCs) and Metrics for the Physical Environment. Of the Key Drivers/Stressors and Regional Study Components, Water Regime and Sediment/Erosion would probably be the easiest to quantify, considering this is what is measured most of the time by Manitoba Hydro and MCWS. Also the assessment of the metrics used to assess RSCs in the Land and Water sections are weak, either because the data was not collected or there was a failure to repeat methodologies used in scientific studies prior to the CRD.

For the Water RSCs we find that the studies conducted by DFO scientists before and immediately after the CRD in SIL and the downstream rivers can provide a comprehensive description of the state of the environment for a pre-development baseline case and an early post development case. There is also OPCN's traditional knowledge of SIL and the rivers to supplement these two background cases.

Forty years have passed since the CRD and considering the time and monitoring programs that have occurred since the CRD, it is hard to believe that the RCEA has failed to establish a current state of the environment case and a future development case for our region.

The studies for the Lake Winnipeg, Churchill and Nelson River Study Board report (1974) also made predictions about the effects of CRD on SIL. The RCEA has failed to follow-up on these predictions, some of which were wrong and others particularly prescient.

Shorelines and the near-shore areas, the regions most affected by CRD deserve separate consideration in a CEA. This is where erosion occurs, the majority of the sediments eroded from the shore are deposited in the near-shore area, mantling and destroying this habitat and providing the source for the materials that have reduced the clarity of the water and in turn reduced the photic zone which has affected primary productivity and the rest of the ecosystem.

Section 2 present backgrounds on the history of OPCN and the effects of the CRD on the community and Southern Indian Lake. Section 3 reviews the approach taken by Manitoba and Manitoba Hydro to the RCEA and compares it to CEAA best practice guidelines. our criticism of the approach. Section 4 reviews the RCEA, focusing on the assessment of the Physical Environment, Water and Land. Section 5 provides an alternative process for addressing OPCN concerns with the assessment and Section 6 describes our conclusions and recommendations.

2. Background

2.1. O-Pipon-Na-Piwin Cree Nation (OPCN)

O-Pipon-Na-Piwin Cree Nation has been living along the shores of Southern Indian Lake and the Churchill River for centuries. However, OPCN have only been recognized by Canada as a Cree Nation since 2005. This late recognition of OPCN's status as a Cree Nation has resulted to some extent, in our opinion, to OPCN's objections to the CRD being overlooked by the Government of Canada, Province of Manitoba and Manitoba Hydro.

Why were OPCN not formally recognized as an independent Cree Nation before 2005 with traditional territory encompassing Southern Indian Lake and Churchill River? The reason can be traced back to Canada's policy to amalgamate bands for Treaty arrangements in the 1870s, making one band's leader the Chief, and converting the other Chiefs into Councillors of an amalgamated Treaty band. Therefore, OPCN was lumped in with the Nelson House Band until 2005.

The earliest written references to the people of Southern Indian Lake is found in the journal of Captain James Knight of the Hudson Bay Company in 1717 when he refers to visits to his trading post by the "Meshinnepee Indians", or Great Water Indians. Details of their portages in

the journal confirm that they were from Southern Indian Lake. Captain James Knight records that a Cree Nation occupied the Great Southern Indian Lake in 1717.

Before the Churchill River Diversion OPCN was a prosperous nation living on the bounty of Southern Indian Lake. The Churchill River Diversion drastically altered OPCN's way of life, ruining the environment and moving OPCN's people into poverty and social despair. In 2013 the Winnipeg Free Press published the following article by Steve Duscharme, president of the South Indian Lake Commercial Fishermen's Association. It still has resonance today.

"In the 1970s, the provincial government allowed Manitoba Hydro to divert the second largest river in the province and flood the fourth largest lake, displacing a vibrant community in the process.

The project, known as Churchill River Diversion, was contentious. A provincial election was lost over it. Eventually though, a scaled-back version of the diversion went ahead, having been sold to the citizens of Manitoba on the basis it would contribute to a brighter future and be operated according to water flows and levels as set out in a 1973 interim Water Power Act licence.

This was the moral contract that allowed for our community of South Indian Lake to be forcibly moved and our environment turned upside down. This is what we believed to be the deal. Sadly, that contract has been largely ignored.

Instead of requiring Hydro to finalize the interim licence — as was supposed to happen shortly after construction — the government has allowed the utility to continually and flagrantly stretch the terms of the licence.

As for the promised brighter future, we're still waiting.

The water on our lake first went up in 1976. Southern Indian Lake is essentially a widening of the Churchill River, which flows eastward across the province, emptying into Hudson Bay at the town of Churchill. The Missi Falls Control Structure blocks the eastern outflow of the lake, causing it to rise. The swollen lake overflows southward through a man-made channel into a 300-plus kilometre diversion route down the Rat-Burntwood River system. That system then empties into the Nelson River where Manitoba Hydro's primary dams are located.

The diversion increases the power producing potential of the Nelson River dams by up to 40 per cent. It also turns our lake into a reservoir in which Hydro can store water for when it is needed.

Hydro's benefits come at our expense. The effects of the Churchill River Diversion are drastic. More than 800-square-kilometres of land are permanently flooded. Thousands of kilometres of critical shoreline habitat are affected. We see severe shoreline destabilization and erosion. Natural fluctuations of water throughout the seasons — which are essential for the health of shoreline ecosystems — are a thing of the past. The dams to the east and south of us prevent natural fish migration.

Our lake is sick and dying — the result of "clean" hydro.

The diversion has also created a legacy of social, economic and cultural harm. First was the indignity of the Manitoba government imposing the project on us without our consent. Second, the community of South Indian Lake was forced to move because of the flooding. This move created lasting trauma for many of our people.

Then our fur industry and prized fishery — the economic base of our community — started to decline.

Prior to the Churchill River Diversion, the whitefish fishery on Southern Indian Lake was the second largest of its kind in North America, producing a million pounds of Grade A whitefish annually. In the years after the water went up, the numbers dropped to 600,000 pounds. The decline has continued. Last season we got less than 100,000 pounds of all types of fish combined.

The fishery was the cornerstone of our community for generations. Its collapse means a dismal future for the many households that relied on fishing. It also reduces options for our youth.

Southern Indian Lake was originally established because of the great abundance of fish and fur for both domestic and commercial purposes. For generations we were prosperous, culturally vibrant and economically independent.

We know our lake will never return to its original glory, but we feel if Hydro were required to live up to the seemingly long-forgotten original licence terms, we would at least have a fighting chance to rebuild our fishery and our future.

The 1973 interim licence required Hydro to maintain the lake level between 844 and 847 feet above sea level. Most important in our view, it allowed Hydro a maximum draw down of the lake within any 12-month period of two feet. Those were the terms on which the project was sold to our people. That is how we believed it was going to be operated.

In 1978 Hydro asked to test the diversion operations over an increased range of water level fluctuations. This "testing" — in violation of licence terms — persisted over the years, with the government's knowledge. In 1986, the government gave written permission for what it called the Augmented Flow Program, which essentially replaced the terms of the Churchill River Diversion licence. It allowed Hydro to flood the lake by another half foot, and instead of a maximum two-foot drawdown of the lake in any 12-month period, the new maximum was 4.5 feet.

Never did Hydro or the government come to our community to consult us about this. This fundamentally changed what we believed to be our moral contract with the government, but we did not consent to it.

Nor has the government ever required a comprehensive environmental review of this project that drastically alters the second largest river and fourth largest lake in the province as well as the 300-km diversion route.

The government continues to approve the augmented-flow program annually.

Now, Hydro has finally applied to have the 40-year-old interim licence finalized, but the version they want finalized is the augmented flow water regime, not the original one. Hydro's application includes no changes to what has become business as usual for them. We find this shocking. Change is what we have desperately needed for decades. Business as usual is the destruction of our people and lands."

"Business as usual" has continued with the lack of consultation by Manitoba and Manitoba Hydro during the RCEA process. Their approach to the RCEA informed only by their own information and experience. OPCN was not consulted when the approach to the RCEA was being planned.

If OPCN had been consulted, the RCEA would be different. We would have suggested a different approach that would have addressed the changes to our lake and rivers, one being as Steve Ducharme pointed out above, the changes to and destruction of SIL's shoreline.

We do not find that the RCEA that is supposed to describe the cumulative effects of CRD on OPCN's traditional waters and lands, does an adequate job of the assessment. In the following section we describe the four main actions of the CRD that affected SIL and provide descriptions of what SIL was like before and after the CRD.

2.2. Churchill River Diversion (CRD)

The Churchill River Diversion (CRD) diverts the waters of the Churchill River at Southern Indian Lake to the Nelson River. The CRD is a cornerstone of hydroelectric development in northern Manitoba, supplying on average a quarter of the flow in the Nelson River downstream of Split Lake. This additional flow powers five hydroelectric generating stations along the Burntwood and lower Nelson Rivers, especially during the winter to meet peak energy demands. Revenue generated by the waters of CRD at these downstream dams exceeded \$300 million in 2015. The CRD adds another level of protection to Manitoba's power supply during winters when outflows from Lake Winnipeg may be constricted by ice.



Figure 1. Map of Southern Indian Lake and Churchill River Diversion features.

Southern Indian Lake is a large multi-basin lake, composed of seven natural basins, 5 of which are strung along the main natural flow path of the Churchill River (Fig. 1). Before the CRD, the Churchill River entered SIL at Basin 0, Opachuanau Lake, downstream of Leaf Rapids and flowed through Basins 1 to 4, until exiting at Missi Falls in the northeast corner of Basin 4. Basins 5, 6 and 7 were off-line basins which fed into the main flow path. This alignment of the basins and flow pattern, evolving over thousands of years, had produced a stable, highly productive and

healthy ecosystem. The CRD changed the alignment and flow pattern by diverted the majority of the Churchill River's flow at Basin 2 into Basin 6 and down the South Bay Channel and into the Nelson River system resulting in a much poorer and less productive ecosystem on the lake and along the river.

Manitoba Hydro controls all outflow from Southern Indian Lake through operation of two control structures at Missi Falls and Notigi, built in 1973 to 1976. Once operational, the control structure at Missi Falls, at the northern end of SIL, raised the water level of SIL by 10 feet by blocking most of the water flowing out of SIL and rerouting it into the South Bay Channel. This raising of the water level of the lake allowed the water to reach a height high enough to flow down the newly excavated channel into the Rat River, a headwater tributary of the Burntwood-Nelson River system. The control station at Notigi regulates the flow entering the Burntwood-Nelson River system from the Rat River.

Manitoba Hydro now operates SIL as a hydroelectric reservoir, filling it during the open water period and drawing it down during the winter under the terms of the Interim License and a deviation from these terms called the Augmented Flow Program which is approved by the province on an annual basis. Presently, the terms of the Augmented Flow Program (AFP) allow SIL to be filled to a maximum level of 847.5 ft above sea level in the fall and drawn down through the winter to a minimum level of 843 ft asl in the spring. The annual cycle of filling and drawing down of SIL is shown by the water levels recorded from 2000 to 2015 at the Water Survey of Canada Hydrometric Station at South Indian Lake (Fig 2A). The operation of SIL in this fashion allows Manitoba Hydro to achieve maximum hydroelectric generation through the winter, when it is most needed. Operating decisions are made such that flow releases through Missi Falls and Notigi CS result in maximized electricity generation, while staying within the limits set out in the Interim Licence and AFP. Under the terms of the Interim License, outflows from Missi Falls are allowed to go as low as 500 cfs in the summer and 1500 cfs in the winter. At Notigi outflows are allowed to be as high as 35,000 cfs in the summer and 34,000 cfs in the winter as long as they don't break license limits at Thompson and other downstream communities.

Typically SIL is filled to a maximum level of 847.5 ft above sea level in the fall and drawn down through the winter to a minimum level of 843 ft asl in the spring as shown by the water levels measured at the Water Survey of Canada Hydrometric Station at South Indian Lake (Fig 2A). The operation of SIL in this fashion allows Manitoba Hydro to achieve maximum hydroelectric generation through the winter, when it is most needed.

The current operation of SIL by Manitoba Hydro is very different from the lake's pre-CRD regime. In the sixteen years of water level record shown in Figure 2A the maximum water level was reached in 12 of the sixteen years, while the minimum water level was reached in 8 of the years. In the sixteen years prior to the CRD shown in Figure 2B, the maximum water level was reached in two of the sixteen years prior to the CRD and minimum water level reached in one out of the sixteen years.

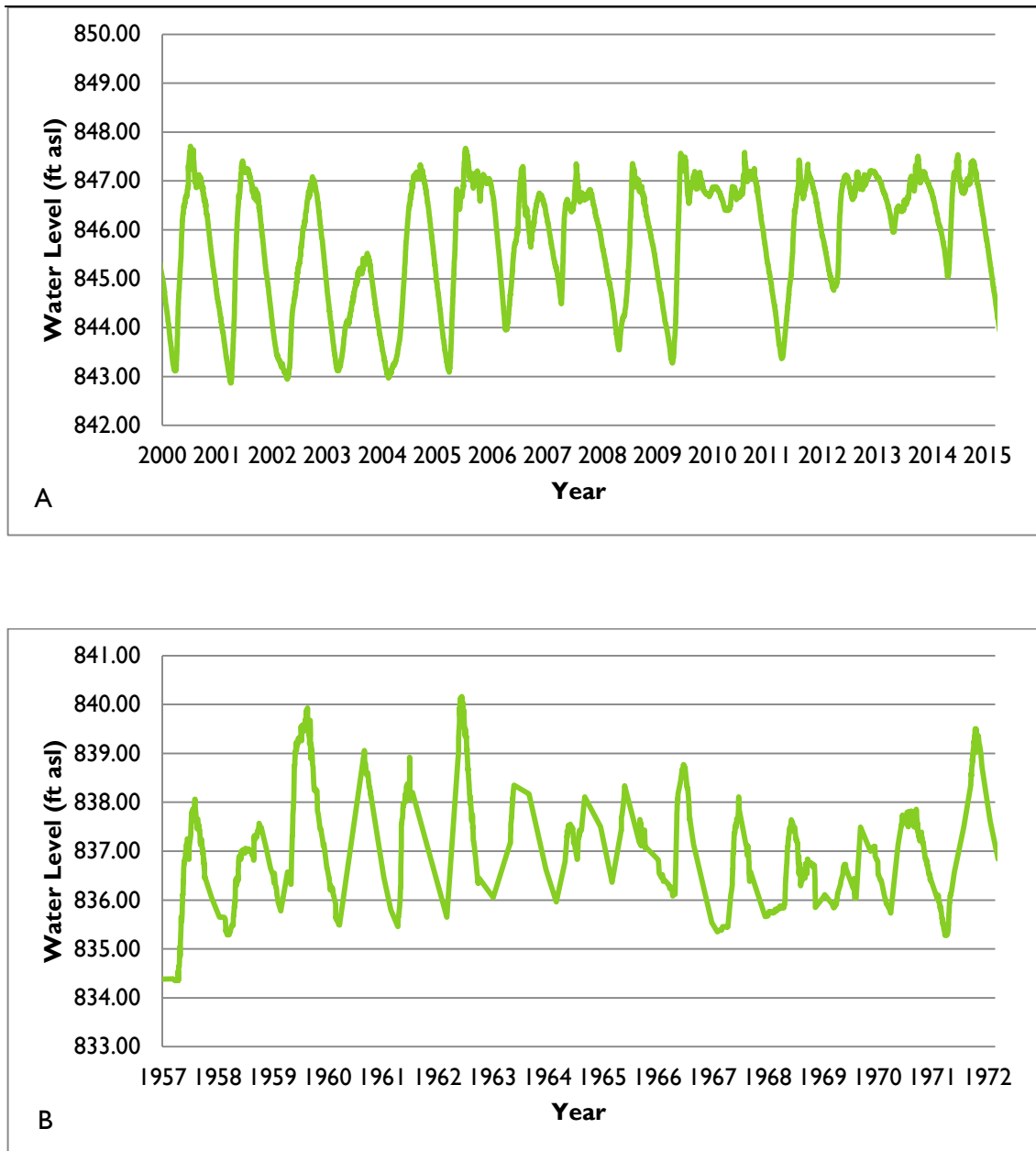


Figure 2. Southern Indian Lake Water Levels recorded at South Indian Lake (Water Survey of Canada Station Number 06EC001): A, from 2000 to 2015 and B, from 1957 to 1972.

The changes that have happened to SIL can be traced back to four separate actions of the CRD. They are:

1. raising SIL's water level by an average of 10 feet (3 m), resulting in a new shoreline;
2. changing the flow pattern within Southern Indian Lake, essentially transforming the large northern basins from river basins to dead-end reservoirs;
3. preventing fish from moving upstream into SIL from the lower Churchill River; and
4. raising and lowering the water level by as much as 4.5 feet on a yearly basis, the AFP.

The combination of these actions caused and continues to cause the deterioration in the health of SIL's ecosystem.

2.2.1. Raising SIL's water level

By raising SIL's water level by an average of 10 feet, the surface area of SIL was increased from 1977 to 2391 sq. km (Newbury et al, 1984) and a new shoreline was created. This new shoreline was longer than the pre-CRD shoreline and composed of very different earth materials. Before the CRD, 88% of the shore was bedrock controlled. After the CRD, only 14% of the new shore was in rock. In Basins 3 and 4 the change in shoreline is more dramatic: Pre-CRD 93% was bedrock controlled to Post-CRD level of 7% (Newbury et al, 1984). This is a very significant change because underwater, a rocky bottom has a high diversity of potential habitats harboring emergent plants and surfaces that attract attached algae (periphyton). Pockets between rocks collect decaying organic material, food for many creatures that inhabit the shore. A rocky shore also offers protection to fish and other creatures and spawning habitat. A sandy or finer grained bottom presents a much more uniform habitat, offering much less shelter and diversity.

With the higher water level after the CRD, rock shores composed less than 10% of the new shore line in the major basins of SIL. The majority of the new shore was composed of fine materials: sand, silt and clay. Sandy bottoms contain relatively little organic matter (food) for organisms and poor protection from predatory fish. Higher plant growth is typically sparse in sandy sediment, because the sand is unstable and nutrient deficient. A clay or silt bottom, unless colonized by plants, presents a similar habitat as a sandy bottom.

The new shore, lying in a permafrost environment, eroded in a different fashion than reservoirs in more temperate or warmer regions. The ground forming the new shore is frozen, insulated by a blanket of organic forest material. With water contact, the ground thaws and loses its structural strength, the fine materials under the blanket dissolving into a chunky, muddy mass. The mass is then eroded and transported offshore by wave action. The fine loose particles become suspended in SIL and the clay chunks settle out in the nearshore where continued wave action helps to abrade and smooth the chunks to ever smaller, skimming stone shaped particles that, with the continued wash of the waves, provide a resupply of fine sediments for suspension in SIL's waters (Newbury, Beatty and McCullough, 1978; Newbury and McCullough, 1984). On windy days plumes of this fine mud can be seen moving from the shore out into SIL proper. The overlying blanket of forest material eroded from the shore supplies a continuous source of fresh organics to SIL as evidenced by the vast accumulation of woody debris along the shore.

Before the CRD, the Churchill River was the main source of sediment entering SIL, transporting 200,000 tonnes per year (Hecky and McCullough, 1984a). Shore erosion was minimal because most of the shore was composed of rock. Once the water level was raised, Newbury and McCullough (1984) estimated an additional 4,000,000 tonnes per year of mineral sediment were eroded from the shore – twenty times the amount of material entering SIL before the CRD. Consequently, the water of SIL lost clarity and SIL in general became a darker place. Light transmission, or penetration into the water of SIL, dropped by a factor of two or more due to suspended materials resulting from shore erosion (Bodaly et al. 1984a; Hecky, 1984).

Water clarity is important because it governs the depth that light can penetrate the waters of SIL. This depth, in turn, defines the range that photosynthetic organisms, algae and plants, can live. The loss of clarity in the water column, therefore, decreases the region of primary productivity or “bread basket” of SIL. This zone, the base of the food chain for SIL, provides the food for organisms higher up in the food chain. Patalas and Salki (1984) concluded that declining water clarity, as evidenced by reduced Secchi disk visibility, was one of the reasons for decreased productivity and compositional changes in the zooplankton community. Also, the cloudier the water, the more difficult it becomes for fish and other high level consumers to find their prey. Reduced underwater light intensity and visibility were probably the most significant environmental changes in SIL according to Hecky (1984), yet data on critical light levels for feeding, schooling, and other aspects of fish behavior are poorly known or unknown for Whitefish (Bodaly et al. 1984b). Hecky went on to postulate that in the larger basins of SIL, primary productivity of algae is light limited, whereas before CRD, primary productivity was phosphorus limited.

Besides the loss of water clarity, the mantling of the nearshore environment with sediment may have contributed to the collapse of SIL’s Whitefish population in two ways: first, by covering preferred Lake Whitefish spawning habitat – rocky bottoms – with sediment; and second, by covering eggs with a film of fine sediment during the incubation period under ice.

Lake Whitefish spawn in the fall over rocky bottoms in 2 to 20 feet of water (Ayles, 1976). However, the amount of suitable spawning beds was significantly reduced after the CRD. Before CRD, Cleugh, Ayles and Baxter (1974) estimated that over 90% of the nearshore bottom was composed of rock, ideal habitat for spawning, in Basins 1 to 5 while after the CRD less than 10% of the shore was rock, the rest in fine grained sediments and organics.. An estimate from 2013 CAMP habitat map of Basin 4 suggests that bedrock was exposed in 27% of the underwater shore. This reduction in suitable bedrock habitats for spawning would have had an unfavorable impact on SIL’s Whitefish stocks in Southern Indian Lake since the CRD.

Second, a fine covering of sediment was shown by Fudge and Bodaly (1984b) to reduce the hatching success of Lake Whitefish eggs. The fine covering deprives the eggs of needed oxygen during the incubation period. A study by North/South Consultants concluded that sedimentation rates measured in 2011/12 (North/South Consultants, 2013) were quite similar to those measured in the late 1970s and early 1980s. The thickness of sediment that settled on SIL’s bottom over the winter varied from 0.4 to 4.3 mm. The amounts of sediment measured at sites in Basin 4 that were known Lake Whitefish spawning areas were the highest of all the sites examined in 2011/12, averaging more than 4 mm in depth. This study demonstrates that significant sedimentation is occurring on Lake Whitefish spawning beds over the egg incubation period and the amount of sedimentation, based on Fudge and Bodaly’s work, is sufficient to cause decreased egg survival. These two factors alone could account for the demise of SIL’s Whitefish fishery; but other factors are also at work in SIL.

Another aspect of the flooding of SIL is the increased mercury levels in fish. Fish such as Northern Pike and Walleye that eat other fish contain more mercury than do fish that eat zooplankton and insects like Whitefish. When reservoirs are initially flooded, bacteria in the flooded soils convert inorganic mercury to methylmercury, a form of mercury easily accumulated by plankton, insects, and fish. Whitefish, Walleye and Northern Pike mercury

levels experienced the typical boost associated with initial reservoir flooding (Fig. 4). The levels have subsided, but Northern Pike and Walleye remain at the level of the Health Canada standard as shown in Figure 4. The mercury levels, 40 years after impoundment, were expected to decrease to pre-CRD levels. However, looking at Figure 4, this does not seem to be the case. For Northern Pike and Walleye, the levels have plateaued at around the Health Canada standard over the last ten years. This is concerning and may be related to the ongoing erosion of the shore and steady introduction of new organic material to SIL.

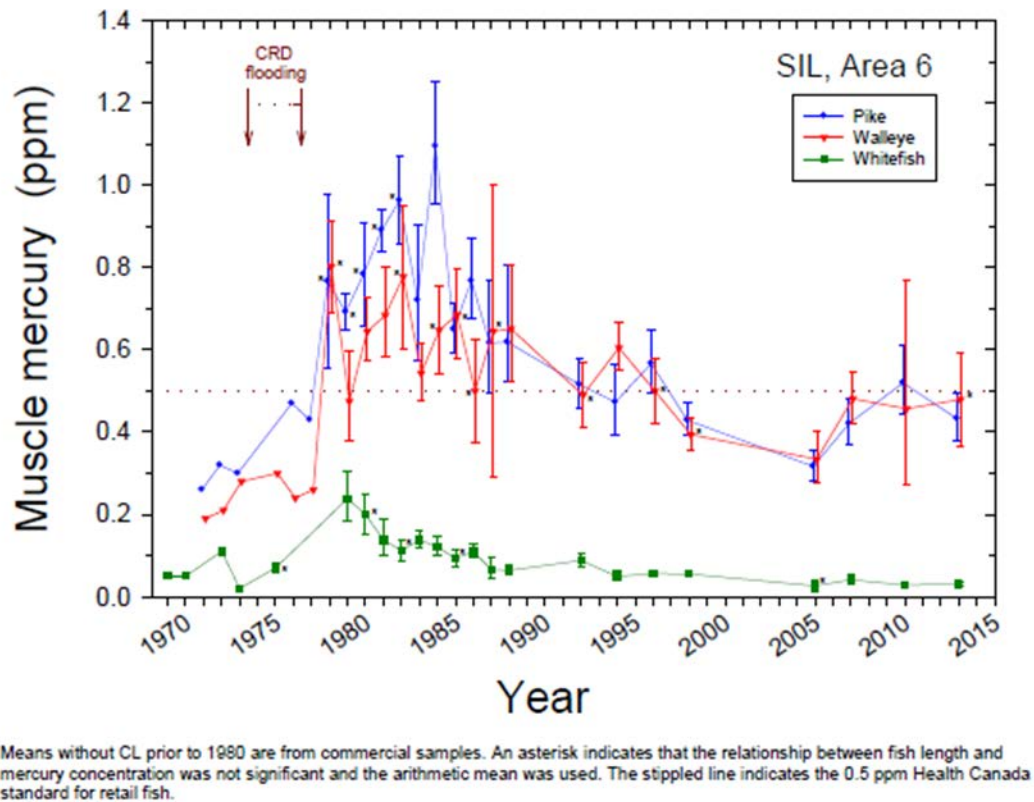


Figure 3. Mean (95% Confidence Limits [CL]) Length Standardized Muscle Mercury Concentrations of Northern Pike, Walleye, and Lake Whitefish From Area 6 (South Bay) of Southern Indian Lake for 1969–2013. (RCEA Phase II, Figure 5.5.4-1).

2.2.2. Changing the flow pattern of SIL

The flow patterns in Southern Indian Lake were changed radically by diverting the flow of the Churchill River down the South Bay channel to the Burntwood and Nelson River systems. Before the CRD, the Churchill River flowed from south to north, entering by Basin 0 and exiting at Basin 4 as shown in the comparison of block models in Figure 4. The diversion down the South Bay channel caused the flow to do a U-turn, entering at Basin 0 and exiting through Basin 6, effectively isolating Basins 3 and 4 from the main flow of the Churchill River (Fig.4). This change to the flow pattern caused a number of effects on SIL; among them were changes in residence times, average temperatures and productivity in each Basin (McCullough, 1981; Hecky, 1984; Hecky and Guiford, 1984 and Patalas and Salki, 1984).

Each basin responded differently to the change in flow pattern. Basins 0, and 1 were the least affected by the change in flow pattern as the Churchill River main flow stream continued through these basins. Basins 3, 4 and 6 were by far the most affected. Basins 3 and 4 are now cut-off from the majority of flow from the Churchill River. Basin 6, an off-stream basin before the CRD, now receives the majority of the flow from the Churchill River.

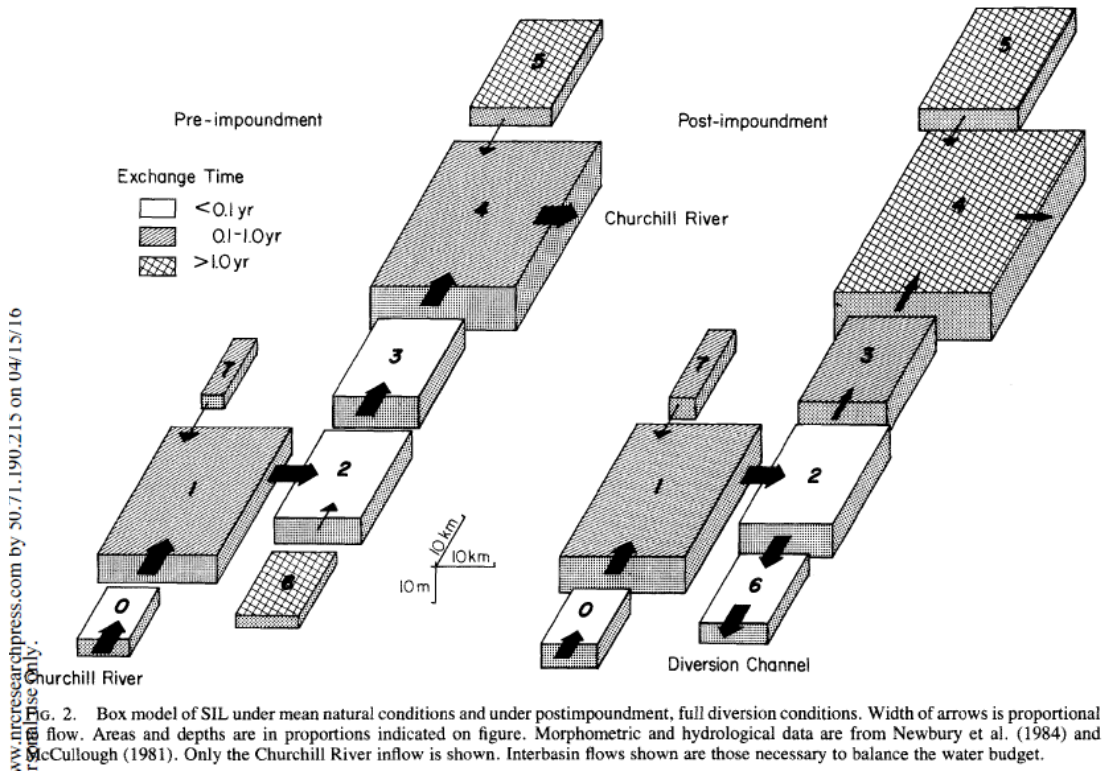


Figure 4: Box model of Southern Indian Lake (after McCullough, 1981)

Weagle and Baxter (1974) first warned about the interference caused by the CRD on fish movement in their study of the fisheries of SIL for the Winnipeg, Churchill and Nelson Rivers Study Board before the CRD. "If the whitefish in Southern Indian Lake orient in any manner to the present current or to anything carried by the current, the present migrations during spawning could be seriously affected by the diversion. After diversion the current will no longer flow toward the spawning grounds in the northern areas of SIL but to the south. South Bay has very little shoreline compatible with whitefish spawning at present and after diversion and the rise in water level it will have even less. Because of the lack of previous work on this subject and a general lack of knowledge about fish movement in the Southern Indian Lake the above are purely speculative comments. If the migration is affected, a serious reduction in Whitefish stocks could occur in future years. There are no mitigation measures that could cope with such a situation if it develops."

A measure of the changes that occurred in the Basins due to the increase in water level and rerouting of the flow caused by the CRD is given by a comparison of residence times before and

after diversion. Residence time is a measure of time it takes for a particle of water to make its way through SIL, or basin in this case. The measure is important for determining the effect on a number of physical, chemical and biological processes at work in a Lake. For example, the longer a particle spends in SIL, the more chance it has of settling out, reacting with other substances or being eaten. Residence time depends on two factors, flow and volume and, therefore, is a good measure for assessing change due to the first two actions of the CRD: flooding and change in flow patterns. In Figure 4 changes in the flow pattern are shown by the difference in arrow sizes while changes in basin volumes are shown by the changes in the box sizes.

Table 1. Comparison of Residence Times Between pre-CRD and post-CRD SIL.

	Residence Time (days)								
	Lake Average	Basin 0	Basin 1	Basin 2	Basin 3	Basin 4	Basin 5	Basin 6	Basin 7
Pre-CRD	186	4	44	19	20	84	548	1533	142
Post-CRD	263	8	62	28	146	511	1022	33	266

Adapted from Newbury, McCullough and Hecky, 1984.

The residence times presented in Table 1 further develop the theme of Figure 3. Residence time in Basin 4, the largest basin in Southern Indian Lake, increased post-CRD from 84 days to 511 days. This indicates that the time it takes to freshen the water of the Basin is six times longer post-CRD. Basin 3's water takes seven times as long to freshen post-CRD while residence time in Basin 6 reversed, flushing approximately 46 times faster. These are significant changes to the circulation pattern in SIL. However, the residence times post-CRD in Table 1 do not portray the residence times in SIL today, because the post-CRD residence times were calculated from average conditions present between 1977 and 1979 (McCullough, 1981). For his calculations McCullough assumed that the average annual flow at Missi Falls was 7760 cfs. Under the terms of the AFP, the minimum flows can be as low as are 500 cfs in the summer and 1500 cfs in the winter at Missi Falls. When SIL is operated under these minimum flow conditions, the residence times reported in Table 1 for Basins 2, 3, 4 and 5 will be greater. For instance, in five out of the last 20 years, the average annual flow measured at Missi Falls has been lower than 2000 cfs.

The change in residence times may well have caused a huge change in the physical and biochemical dynamics of the basins although metrics that could gauge the direct effect have not been fully measured. The change in flow pattern alters the nutrient dynamics in SIL's basins 3 and 4 by reducing the loading from the Churchill River to these basins. However, with the substantial increase in residence time in Basins 3 and 4, nutrient recycling – the uptake of nutrients by living plants and animals, their death and decay and redistribution of the nutrients – may play a much more important role in determining nutrient levels in the Basins post-CRD, and especially nutrients in organic form eroded from the shore. This may be the reason that total phosphorus levels before the CRD are similar to the levels measured before the CRD levels. A different story may develop from an examination of the fractions of inorganic, plant available phosphorus versus organic, and particulate versus dissolved phosphorus in the total phosphorus

sample. Inorganic dissolved forms are plant available while organic and particulate forms must be dissociated from their host before becoming plant available. It is from these proportions of TP that the complete nutrient story on algae growth can be understood.

Another effect of the change in flow patterns relates to the temperatures in SIL. According to a study of the water temperature of SIL by Hecky (1984), the average overall water temperature of SIL decreased by 1 - 2° C because of the changes in flow patterns and water clarity after the CRD. This estimate is a whole Lake average, and therefore not necessarily indicative of the temperature gains and losses in each basin. Hecky (1984) calculated that Basins 3 and 4 average temperature loss was greater than 2.0° C with a decrease in maximum temperatures of over 4° C.

Hecky (1984 p.1.) states “Five years of observation beginning 2yr before the year of impoundment and continuing for 2 yr after impoundment indicate that lake temperatures, light available for photosynthesis, and Secchi disk transparencies have all declined. Increased mean depths, loss of riverine heat input because of diversion, and radiative losses because of backscattering from increased concentrations of suspended solids have caused a significant 1-2°C cooling of the different basins of the lake and increased the natural south to north temperature gradient during the lake's heating period.”

A decrease in water temperature would have an effect on spawning activity of Lake Whitefish, and on the length of time that ice covers SIL. Fall water temperature triggers the spawning activity of Whitefish according to a study by Weagle and Baxter (1974). In their study, no ripe or spent Lake Whitefish were encountered in their nets until water temperature dropped from 4° to 3° C in the fall. When water temperature reached 2° C, there appeared to be a rush of spawning activity and within four days at this temperature 80% of the mature fish netted had spawned. Lowering of temperature in SIL would affect the timing of spawning by pushing it forward. It would also have a major impact on other activities. For example, lowering of the annual temperature would lengthen the time that ice will cover SIL and shorten the open water period. This may have an effect on Lake Whitefish fry, for instance, prolonging their time spent under ice cover.

Three factors, decreases in water clarity, changes in nutrient loading and lowering of temperature would have an effect on primary productivity. Hecky, Harper and Kling (1974) predicted that based on their study of SIL, the post-CRD productivity of the lower of Basins 3 and 4 would decline by one-half to two-thirds. Chlorophyll *a* levels, usually used as an alternate measure of amount of algae growing in a lake, decreased in Basins 2, 3, and 4, and were relatively unchanged in Opachuanau Lake and Basins 5 and 6, and were moderately lower in Areas 1 and 7 when comparing pre-CRD (1972) to post-CRD (1977–1980) data. Salki *et al.* (1999) collected limnological data in SIL in 1998 at many of the stations sampled between 1972 and 1988 and reported on changes since impoundment and diversion. The authors noted that average chlorophyll *a* concentrations in the northern regions of SIL (*i.e.*, Basins 3 to 5) between 1977 and 1998 were 31.1% lower than the “pre-diversion mean (1972–1975) of 5.31 µ g/L”, likely due to reduced input of both nutrients and heat (*i.e.*, due to reduced influence of the warmer Churchill River water) with CRD.

A note of caution on chlorophyll *a* as a measure of primary productivity was voiced by Hecky, Harper and Kling (1974), in their examination of the relationship between chlorophyll *a* and amount of algae biomass in SIL. The authors cautioned that chlorophyll *a* was not a good predictor of productivity in Southern Indian Lake, because of the broad range of algae types in SIL and the differing amounts of chlorophyll content in the cells of the algae species that make up the community. Therefore a change in the community make-up would not necessarily be reflected in the chlorophyll levels.

Comparing the zooplankton community before and after the CRD, Patalas and Salki (1984) note “In the main water bodies north of the diversion route, abundances declined by 60% and biomass by 50%. A 2-3°C drop in northern basin water temperatures, related to diversion, reduced growth rates by approximately 20% and resulted in a 60% decline in crustacean production.” The change in water temperature has also influenced the Mayfly populations around SIL. Giberson and others (1991) point out the high correlation between air temperatures and Mayfly populations, suggesting that because Mayflies are at the northern extent of their range, they may be particularly susceptible to changes in air temperature. They suggest that the colder than normal years in the early 1980s may have been the cause of the crash of the Mayfly population. This correlation should not be mistaken for causation and an investigation of SIL’s water temperature was not undertaken.

A lengthier ice cover season combined with the reduced flushing and replenishment of dissolved oxygen by the Churchill River flow in Basins 3 and 4 may well cause oxygen starvation in the early spring, just before break-up, especially in nearshore areas of SIL. Oxygen starvation is usually experienced first in the nearshore or shallow areas of SIL under ice-cover, because the reservoir of dissolved oxygen is less here than it is in deeper areas of SIL. However, there are no model simulations to investigate this possibility. My experience with modelling compensation lakes has shown that low dissolved oxygen levels occur often along the margins of lakes in the late spring and especially in years of unusually long winter ice cover, leading to fish kills in the nearshore areas (Jiang and others, 2015). Hecky and Ayles (1974, p19) warn about this dynamic,

“In inundated areas with substantial vegetative cover, inundation could pose some special problems. Decaying vegetation can produce an oxygen demand and can lead to reduced oxygen levels which are detrimental to fish and zoobenthos. Very low oxygen levels are currently observed under ice in the Moose Lake portion of the Kettle Reservoir where flooding was most extensive and water exchange with the Nelson River is limited. Similar conditions may occur in those portions of Southern Indian Lake where flooding is extensive and flushing poor.”

2.2.3. Preventing fish from moving upstream into SIL

The gated control structures at Missi Falls and Notigi cut SIL off from its downstream environment. Fish can move through the Control Structures to the lower Churchill River and Wapisi Lake, but cannot return to Southern Indian Lake as the control structures do not provide means for fish passage. This results in a net loss of fish in SIL to the downstream.

There is evidence that immediately after the CRD began operation; schools of fish were trapped below the control structure with no way to return to SIL. In 1981, a fisheries Branch officer reports thousands of Whitefish trying to return to SIL (Mb Hydro, 2015). A report by Barnes

and Bodaly (1994) on Whitefish stranded below Missi Falls purported that high flows may contribute to the depletion of fish stocks in SIL. In 1986, the number of Whitefish below Missi Falls was “almost 90,000 in the autumn and most of these fish were physiologically ready to spawn. Morphological comparisons indicated that most of these fish originated from Southern Indian Lake and were apparently attempting to return to it. Flows through the dam in this year were high and similar to those before the diversion of the Churchill River. In 1987, there were fewer fish of SIL origin below the control dam and the numbers decreased over the summer. Discharge through the dam was much lower in 1987 than before the diversion.” (Barnes and Bodaly, 1994, p.1).

The Southern Indian Lake Environmental Steering Committee sponsored four years of hydro-acoustic fish movement studies at Missi Fall (North/South, 2008, 2009, 2010 and 2011). These recent studies confirm that fish do leave SIL in the summer and early fall. For example, in 2010, between August 26 and October 13, 4862 fish were detected leaving SIL through Missi Falls Spill Gate #4; albeit mostly small bodied fish (North/South Consultants, 2010). Since there is no way for fish to return to SIL, a net loss of fish occurs in SIL’s stock (Barnes and Bodaly, 1994; Bodaly, 2013). These studies did not measure fish movement in the autumn as the hydro-acoustic measuring equipment was pulled out of the gate before the Whitefish’ spawning migration started.

2.2.4. Raising and lowering the water level by 4.5 feet on a yearly basis

The water level fluctuations experienced by SIL are not natural. Lake water levels before CRD rose and fell by an average of 2.7 feet on a yearly basis (Fig 2). Under the AFP, the maximum range of water levels experienced on Southern Indian Lake is now much higher and more regular (Fig. 2). SIL is filled during the summer and fall to a maximum level of 847.5 ft asl under the AFP. The water level is then drawn down during the winter and spring to a minimum level of 843.0 ft asl. The effect of this operation on SIL’s ecosystem has not been investigated. However, a relatively strong literature base exists for other lakes around the world, generally demonstrating that water level fluctuations that are different from normal impair ecosystem functioning, ultimately leading to declines in water clarity, and destruction of shore habitat (Coops and others, 2003; Beklioglu and others, 2007; Gasith and Gafny, 1990; Lindstrom, 1973; Wantzen and others, 2008; Zohary and Ostrovsky, 2011).

In our opinion all four actions have contributed in various ways to change the physical and biochemical environment and behavior of the ecosystem in SIL. Three of these actions – the change in flow patterns, prevention of fish movement upstream into SIL, and raising and lowering water levels on a yearly basis – can be changed or altered. How these actions combine to affect SIL’s ecosystem requires further investigation and would have been the focus of an approach to a cumulative effects assessment of the lake. A comparison of what SIL was like before CRD and what it is like now will help to inform the choice of VC’s that OPCN would have identified if they had been consulted at the start of the review process.

2.3. The Pre-CRD lake

Southern Indian Lake is a series of inter-connected basins or widenings in the Churchill River rather than a lake proper. Pre-CRD, it was by all accounts a productive riverine system with clear waters, sand and rock beaches, a vibrant and healthy shore (littoral zone) composed of many different habitats, and a healthy and productive fishery (Ayles 1973, Hecky and Ayles 1974; Hecky, Harper and Kling 1974; Patalas and Salki, 1974). SIL was arguably the most productive northern commercial fishery of the time in Canada (Ayles, 1973).

Southern Indian Lake is big. Prior to the CRD SIL had a surface area of 734 sq. miles (1930 sq. km) and average water level elevation of 837 ft asl (255 m asl). According to Cleugh, Ayles and Baxter (1974), there were 1309 islands covering an area of 136 sq. miles (353 sq. km). The average depth of SIL was 30 feet (9.2 m) with a maximum depth of 121 feet (37 m). The length of the shore including islands was 1350 miles (2,170 km).

Pre-CRD, 88% of the shore was rock. The other 12% percent was composed of loose materials consisting of cobbles, sand and mud (silt and/or clay) beaches (Newbury and McCullough, 1984). Importantly, the shore of SIL was stable, the result of thousands of years of sculpting by currents and winds. Little to no overall erosion of the shore pre-CRD was noted by Newbury and McCullough (1984) or by Manitoba Hydro (2015b), with the exception of areas in South Bay (Basin 6).

Water levels on SIL fluctuated by an average of 2.7 feet each year (Fig. 2B). The highest levels were experienced in the late summer and the lowest just before ice melt-out in the spring. In some years the annual range was in the order of 4 feet and others less than 2.5 feet. The long-term response to cycles of wet and dry periods is also evident in the pre CRD water levels (Fig. 2B).

SIL is composed of seven natural basins with each basin defined by narrows at the upstream and downstream ends (Fig 1). Pre-CRD, the Churchill River flowed through Opachuanau Lake (Basin 0) and Basins 1, 2, 3 and 4, exiting at the northeast corner of Basin 4 at Missi Falls. The other three basins, 5, 6 and 7, emptied into the Churchill River. The flow of the Churchill River through Southern Indian Lake played a major role in determining the productivity and health of the basins forming SIL. Hecky, Harper and Kling (1974) found that basins on the main flow path of the Churchill River had higher productivity than the off-line basins. This was due in large part to the influence of the Churchill River flow on water clarity, temperature and nutrient supply.

Water clarity is an important determining factor of the health and potential productivity of a lake as it indicates the depth of light penetration, which governs the depth that photosynthetic organisms – plants, algae and bacteria – can live and thrive. The waters of the pre-CRD Lake were clear. Water clarity in Basins 0 to 4 was influenced by the sediment carried into SIL by the Churchill River and varied depending on the Basin's position on the Churchill River. This was confirmed by Secchi disk measurements conducted in SIL by Cleugh (1974) and Hecky (1984).

A Secchi disk is a round disk painted black and white which is lowered into the water until it disappears, whereupon the depth is recorded. In Basin 1, average water clarity was in the 5 to 6 foot range. Clarity improved as the water moved from Basin 1 to Basin 4 with Basin 4's clarity in the 8 to 10 foot range. The water became increasingly clearer because more and more

suspended sediment in the flow of the Churchill River settled out as the water passed through each basin along the main flow path. For the off-line basins, water clarity depended on the nature of the earth materials along the shore. Basin 6's shores were composed mainly of (finer and more easily suspended) clay materials and had the cloudiest water, with Secchi disk depths of 4-5 feet, while Basin 5, with a wealth of sandy shores, was the clearest, rivaling Basin 4 in clarity, because sand is only suspended under rough water conditions.

The supply of nutrients, the food that photosynthetic organisms rely on for growth, was also influenced by the Churchill River flow pattern. Those basins located along the main flow path received their nutrients from the Churchill River, thereby receiving nutrients from as far away as the Alberta and Saskatchewan prairies; whereas the off-stream basins only received nutrients from their local drainages.

Hecky, Harper and Kling (1974) reported on the productivity (the rate at which plants and other light dependent organisms grow) of SIL by estimating phytoplankton biomass and algae composition by season and basin. They found productivity in SIL was dependent on two factors, nutrients and light, the amounts of each varying between basins. The highest productivity was in Basin 4 where, because of the clarity of the water, light could penetrate to greater depth and nutrients from the Churchill River limited the amount of growth. In Basin 6 this was reversed, and light, which only penetrated to shallow depth because of the poor water clarity, limited the amount of growth.

Hamilton's 1974 survey of the zoobenthos (animals living on the bottom of SIL) found the most abundant groups of animals were fresh-water shrimp, fingernail clams, insects, and worms. Hamilton (1974) concluded that the number of creatures inhabiting SIL's bottom was considerably more than should be expected from a northern lake of this size. He attributed the richness of these fauna to the influence of the Churchill River on SIL and noted that this same phenomenon has been observed to a lesser extent for other lakes on the Churchill River in northern Saskatchewan.

Ayles (1976 p.24), in describing SIL Whitefish fishery, said, "This higher productivity is reflected in the relative numbers of whitefish taken in different areas of SIL. There were more than three times as many whitefish taken from through-flow areas of the main lake than there were from South Bay (Basin 6), a body of water not receiving Churchill flows. The catch/effort of whitefish caught was greater from Southern Indian Lake than from other shield lakes in northern Canada. Commercial production of whitefish from this lake was correspondingly high as well."

Prior to the CRD, the fish community of Southern Indian Lake, as represented by fish captured in index gill nets, consisted of ten species: Burbot, Cisco, Goldeye, Longnose Sucker, Northern Pike, Sauger, Yellow Perch, Lake Whitefish, Walleye and White Sucker. Skaptason's (1926) mentioning of sturgeon existing in the "Indian lakes" is the only known published reference to Lake Sturgeon possibly having existed in SIL. However, in conversations with local fishers at least three said they caught Sturgeon in SIL prior to CRD.

Whitefish made up over 90% of the commercial fish taken on Southern Indian Lake prior to CRD (Weagle and Baxter, 1973). An interesting observation regarding the spawning behavior of Whitefish in SIL was made by Ayles (1974, p 15):

“In Southern Indian Lake changes in whitefish distribution in early September suggest that movements of whitefish just prior to spawning may be migration to a specific location. It appears that the area north of Long Point (Basin 4) is a primary spawning area for whitefish and although this species undoubtedly spawns throughout the whole lake, concentrations of whitefish in Basin 4 are much greater during the spawning period than at other times of the year. The established pattern of commercial fishing substantiates the hypothesis that many whitefish are migrating to one area in SIL to spawn. Local commercial fishermen concentrate their fishing efforts in the more southern part of SIL during spring and summer and it is not until the late summer and winter that they move to Basin 4.”

Mercury was measured in tissue samples of Whitefish, Northern Pike and Walleye caught pre-CRD. The levels of mercury in fish tissue for the three species were below the Health Canada guideline of 0.5 ppm: Mean levels for Whitefish were between 0.06 and 0.13 ppm, Northern Pike, between 0.17 and 0.36 ppm and Walleye between 0.19 and 0.36 (Manitoba and MB Hydro, 2015).

The science that reports on the state of SIL prior to the CRD, paints a picture of a healthy, vibrant and pristine ecosystem with a rich fishery.

2.4. The Post-CRD SIL

In contrast to the healthy Lake before the CRD, SIL today is a very different place. Over 80% of lake shore is composed of predominantly fine grained materials (Hecky and McCullough, 1984a). Bedrock, sand, and gravel beaches virtually disappeared. In their place along the lakeshore are uninterrupted stretches of woody debris mantling mud beaches. Water clarity has been reduced significantly, especially along the shore, and the commercial fishery has collapsed.

At a community meeting with O-Pipon-Na-Piwin Cree Nation (OPCN) in April 2016, members of South Indian Lake described their experiences with the changes in SIL. This community has borne the brunt of the changes that have occurred in SIL and their experiences provide another avenue to understanding the extent of the changes that have occurred on SIL since the CRD. When asked about the changes and current state of SIL, they identified numerous plants, animals and habitats that are no longer present on SIL, or are present in diminished numbers. Among the many observations, they highlighted:

- Erosion of the shoreline
- Mud beaches choked with woody debris which make access to the shore very difficult and absence of sand beaches;
- Cloudiness of the water and water quality. They noted that close to shore on windy days, visible plumes of cloudy water can be seen extending from the shore to the middle of SIL. Also, at the mouths of creeks feeding into SIL the water sometimes has a reddish color;
- Disappearance of many plants, and animals, including insects, frogs and fish;
- Drawdown of the water level on SIL. The winter drawdown lowers the ice cover and exposes once submerged shores to air and ice, harming habitats for riparian animals and

fish spawning grounds. The lowering of the ice also weakens the ice, making travel over the ice treacherous;

- Reduced numbers, poor condition and reduced size of Lake Whitefish.

OPCN commercial fishers on Southern Indian Lake have expressed their concerns about the number, size, health and changes to the habitats of fish since the start of the CRD.

Conversations with fishers and trappers highlight some of these concerns. They are:

- Absence or reduced populations of muskrat and beaver and other riparian species. They attribute the reduction to the drawdown of water in the lake over the winter which freezes out their dens or lodges;
- Fish passage from the lower Churchill River is blocked by the Missi Falls control structure;
- Absence of large Whitefish and the poor quality of the fish and changes in the contents of their stomachs.
- Absence of flies and crayfish.

The South Indian Lake Environmental Steering Committee (SILESC) was set up in 2003 to address concerns by fisher and trappers by sponsoring scientific studies to look into their concerns. The studies have concentrated on fish, their habitat and movement, and results of these studies inform the discussions that follow on the state of SIL and causes for the changes to the lake.

The first effect of the Churchill River Diversion on Southern Indian Lake occurred on August 8, 1973 when the south channel at Missi Falls was closed by cofferdam to begin construction of the Missi control structure. Following the closure all water of the Churchill River was diverted through the North Channel causing Southern Indian Lake to rise approximately 2 feet for a period of approximately 2 years. Impoundment of Southern Indian Lake was completed on October 15, 1976 when the water level was raised to the full supply level, another 8 feet.

Erosion of the mainly clay materials along the new shoreline, which started immediately after the water level was raised continues with no current estimate of the time it will take to return to pre-CRD conditions. Many islands have disappeared, undermining by erosion because of the raised water level. The fine materials eroded from the shore mantle the shallows in the form of mud banks and are continuously re-suspended during windy weather, causing murky conditions along the shore extending out into the deep waters of SIL. Table 2 summarizes the measured erosion rates from studies on SIL. The data paint a picture of very little erosion prior to the CRD, to significant erosion for the thirty years after the CRD, varying from 15 to 50 feet per year depending on the shore location measured. Photographs, provided by OPCN community members, some of which are included in this report, suggest that erosion at these rates is still occurring, although no studies have been conducted by the Province or Manitoba Hydro since 2006 to confirm the observations.

Table 2. Rates of erosion before and after the CRD.

Stage	Erosion Rate in ft/y (m/y)	Note	Reference
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Pre-CRD	2.6-5.2 (0.8-1.6)	1954-1970 Air photograph analysis	(MH 2015)
	No Erosion	1975-1976 Surveying data	Newbury and McCullough (1984)
Post-CRD	≤ 39.4 (12.0)	1976-1980 Surveying data	Newbury and McCullough, (1984)
	≤ 18.7 (5.7)	1976-1983) Air photograph analysis on 20 sites	McCullough (1987)
	16.4-49.2 (5.0 – 15.0)	1976 to 1984 Landsat image and air photograph analyses	MH (2015b)
	8.6-16.4 (2.5 – 5.0)	1990-2006 Landsat image and Air photograph analyses	MH (2015b)
	No measurements	2006-2016	

Table 3. Average Secchi Disk depths measured in Southern Indian Lake.

Year	Basin 1	Basin 4	Basin 6
	ft (m)	ft (m)	ft (m)
1974	5.2 (1.6)	10.2 (3.1)	5.6 (1.7)
1975	3.6 (1.1)	8.9 (2.7)	4.6 (1.4)
1976	3.6 (1.1)	7.5 (2.3)	2.9 (0.9)
1977	2.6 (0.8)	4.9 (1.5)	2.3 (0.7)
1978	2.9 (0.9)	3.6 (1.1)	2.3 (0.7)
2008	-	6.6 (2.0)	-
2009	3.3 (1.0)	5.6 (1.7)	-
2010	-	2.3 (0.7)	2.0 (0.6)
2011	-	4.3 (1.3)	-
2012	2.9 (0.9)	4.3 (1.3)	-

Compiled from data in Hecky, 1984 and CAMP, 2008-2012

Water clarity, as measured by Secchi disk depth, has been reduced significantly (Table 3). A reduction by more than one-half in water clarity has occurred since the CRD, from 9 to 10 feet before pre-CRD to 4 feet on average in Basin 4 post-CRD. What is notable in Table 3 is that water clarity has not shown much, if any, improvement with the passage of time since the CRD.

The cause of the reduced clarity of the water is clearly the erosion of fine particulate material from the shores of SIL. However, the Secchi Disk data in Table 3 do not tell the whole story. In recent years, the data are based on a series of measurements, mainly taken in the deep water areas of SIL under calm conditions. Little data is available for the near shore areas under windy or storm conditions. This lack of data for the nearshore hides the fact that the clarity of the

water in these areas is worse than the conditions further from shore. As pointed out in the community meeting, under windy conditions, visible plumes of murky water can be seen extending from the nearshore outwards to the deeper areas of SIL, as shown in the photograph at the start of this section.

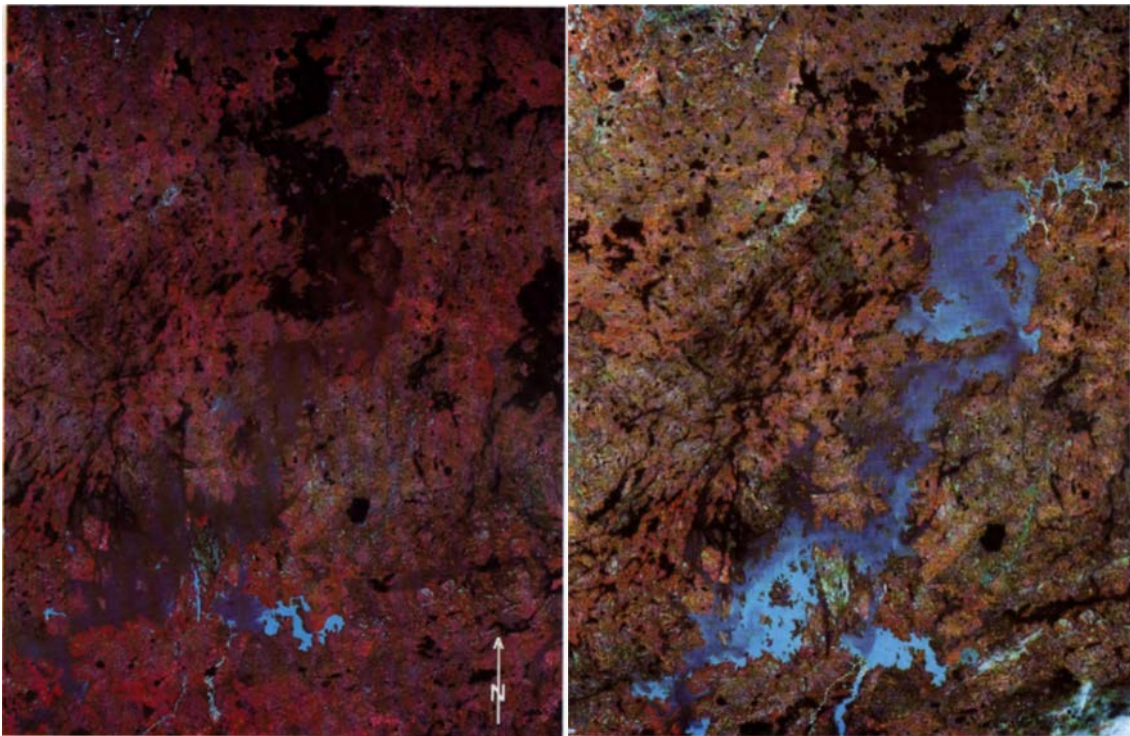


Figure 5: (A) 29 July 1973, and (B) 24 June 1978. Images of SIL during impoundment, with partial diversion.

Confirmation of the difference in water clarity between the pre- and post-CRD SIL is found in a study of Landsat imagery by Hecky and McCullough (1984b). Two figures from their study illustrate the difference, one from 1973 and the other from 1978. In Figure 5A and 5B, areas of greater sediment concentration in the water appear lighter blue. Clearer water appears as darker blue while clear water is almost black. A good barometer for the clearness of the water is given by the color of the surrounding lakes unaffected by the CRD. These lakes are black, attesting to the clarity of their water.

In Figure 5A, the effect of the Churchill River flow on SIL prior to the start of the CRD can be seen. The waters become clearer as the water makes its way from Basin 0 to Basin 4: Basin 4 and Basin 5 having the clearest water because more and more suspended sediments in the Churchill River's water settle out as the flow moves through Basins 0 to 4. Because 88% of the shoreline of SIL is bedrock controlled there is a limited amount of new suspended sediment available from shoreline erosion. Of note in Figure 5A is the color of the water in Basin 6. The shoreline of basin 6 is composed of easily erodible fine materials and the color of the water reflects the high suspended sediment concentration coming from shoreline erosion in this basin. As a matter of fact, an early prediction on the state of SIL after the CRD suggested that the turbidity in the whole lake would be similar to Basin 6.

In contrast to the color of the water in SIL before the CRD, Figure 5B, taken in 1978, shows the effect of the CRD on SIL's water clarity. Except for Basin 5, the most northerly basin, the water of SIL is light blue in color, comparable to the pre-CRD water clarity in Basin 6. The contrast between pre- and post-CRD is perhaps most striking in Basin 4 where the difference in color, and therefore clarity, between the images is greatest. Unlike the shoreline around the other basins of SIL which are mainly composed of clay rich materials, the shoreline of Basin 5 is composed of larger sized material, mainly sand, which settles out far more quickly in water. Hence, the water of Basin 5 is much clearer than the other basins of SIL.

Figure 1, a 2017 Google image, confirms that there has been no noticeable improvement in SIL's water clarity since 1978. Water clarity, is still much reduced in Basins 0 to 4, a testament to the fine sediments eroded from the post-CRD shoreline.

Sedimentation studies sponsored by the SILESC (North/South Consultants, 2013) confirm that the rates of sedimentation in SIL continue in the range measured shortly after the start of the CRD. These rates would be expected to be much higher than rates before the CRD, considering the difference in the make-up of the shorelines and increased erosion after the CRD. Hecky and McCullough (1984a) calculate that erosion immediately after CRD increased the sediment supply to SIL by a factor of 20 times and that the majority of the sediment is deposited in the nearshore area, the littoral zone, mantling this biologically productive zone. Erosion of the shoreline and near shore deposition of the sediments continues today as is shown in the photographs at the start of each section and commented on by OPCN members. Mud beaches now comprise the majority of the littoral habitat in SIL.

Mayflies experienced a crash in their population immediately after the CRD, and have recovered only to approximately half of their pre-CRD numbers (Giberson and others, 1991). From a series of studies on the population of insects and worms that live in the offshore sediments of SIL, Wiens and Rosenberg (1984) concluded that the population increased immediately after flooding, especially in the shallower offshore areas, but had decreased substantially by the third year after the CRD.

At the community meeting, OPCN fishers commented on the change in the stomach contents of Whitefish since the CRD. Mr. John Baker, stated that Whitefish stomach contents were plump and full of lightly colored contents before the CRD whereas today they are skinny and contain dark fibrous matter. The results of a SILESC sponsored study of the of small organisms or animals living on the bottom of SIL (Capar et al., 2011) which are the food for Whitefish and a pre-CRD study by Hamilton (1974) on the same animals sheds light on this observation by the fishers.

In 2011, the average count of the animals, mainly insect larvae, fresh-water shrimp, finger-nail clams, and snails, living on the bottom of Basin 4 was 1,124 organisms per square metre, which was higher than the count by Manitoba and Manitoba Hydro's Coordinated Aquatics Monitoring Program (CAMP) study for the same year which reported an average of 488 of these organisms per square metre. The contrast between these recent post-CRD study results with those of Hamilton's work on the pre-CRD lake is striking. Hamilton's 1974 survey found that the whole lake average was 3,429 organisms per square metre with an average of 4,161 organisms per square metre in Basin 4. Hamilton (1974) stated that "It is clear that the zoobenthos of

Southern Indian Lake is considerably richer than would ordinarily be expected in a lake of this size at this latitude. The physical and chemical influence of the Churchill River has almost certainly had a very positive effect on the production of zoobenthos in Southern Indian Lake.” (Hamilton 1974 p. 12).

Another interesting aspect of the studies is the difference in the make-up of the animals living on the bottom of SIL. Pre-CRD, fresh water shrimp was the most abundant benthic organism in all basins excepting South Bay (Hamilton, 1974). After CRD the shrimp population has been displaced by insect larvae, mainly composed of midge larvae. This could possibly be the reason for the observation of lightly colored stomach contents prior to the CRD as opposed to darker colored contents after the CRD.

Perhaps one of the most damning indicators of the present health of SIL is the crash of the commercial fishery (Fig. 6). Pre-CRD, the commercial fishery on Southern Indian Lake was the largest in northern Canada. The catch per unit effort of Whitefish was greater from Southern Indian Lake than from other shield lakes in northern Canada (Ayles, 1976). Commercial production of Whitefish from Southern Indian Lake was correspondingly high as well, averaging 400,000 kg annually. Today, the commercial catch of Whitefish has declined dramatically to the point where the commercial fishery has collapsed.

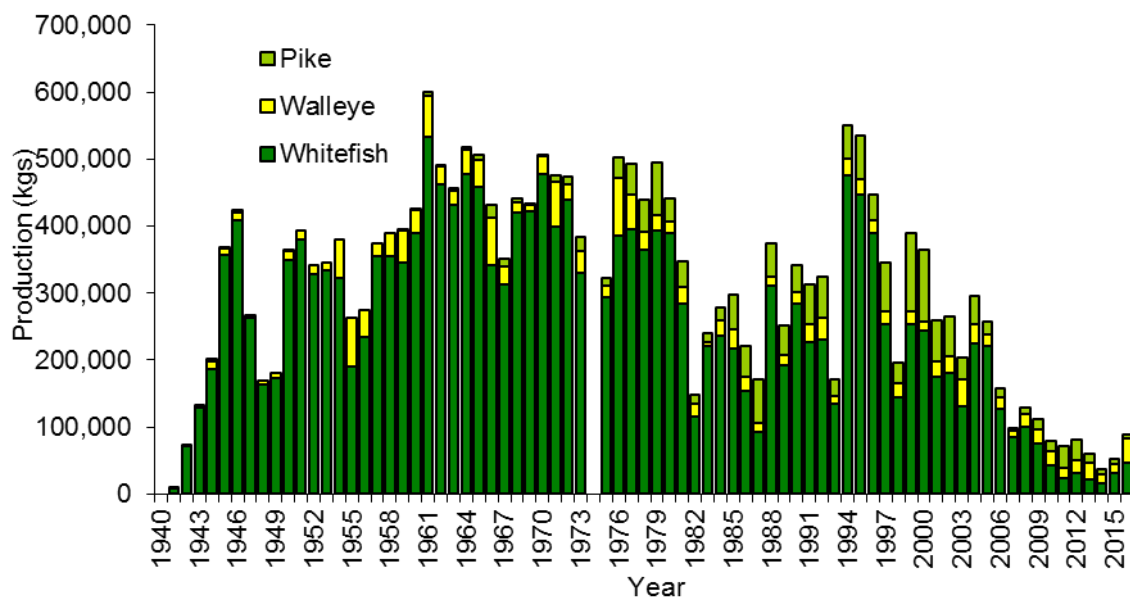


Figure 6. Commercial Northern Pike, Walleye and Whitefish catches for Southern Indian Lake. (Macdonald, 2017).

Fish production records date back to 1941, and SIL has produced every year since, except for 1974. Production has varied over the years with a number of factors capable of contributing to the year to year changes in production, including:

- size and condition of fish stocks,

- whitefish grade and its impact on fish prices,
- fish price and subsidy/compensation programs,
- infrastructure issues,
- fishing conditions,
- employment alternatives,

For example, the fishery was non-existent in 1974 because of alternative employment opportunities during the development of the Town of Leaf Rapids, the Ruttan Mine and the Churchill River Diversion. Nonetheless, the graph shown in Figure 6 is a striking indictment of SIL's present health, depicting the demise of a once flourishing species in SIL.

Another facet of the collapse of the Whitefish fishery is the commercial grade of Whitefish that are present in SIL today. The fishery before the CRD produced the highest grade of Whitefish, export class. Currently, the grade of Whitefish caught is cutter class, the lowest commercial grade for Whitefish. The drop in the commercial grade corresponds with a decline in other physical characteristics of Whitefish since the CRD pointed out by fishers on SIL and noted in a number of recent reports on Whitefish in SIL. These characteristics include: old, slow growing fish dominated by a couple of year classes; small maximum size; poor condition factor; and evidence for non-annual spawning (Michaluk and Remnant, 2012; Aiken and Remnant, 2013; Aiken, 2014; Manitoba and Manitoba Hydro, 2015).

Mercury concentrations in Lake Whitefish, Northern Pike and Walleye increased significantly after the water level of SIL was raised (Fig. 3). In Basin 6, Whitefish mercury levels peaked in 1978, two years after impoundment, and have since declined to near pre-flooding levels, in line with concentrations in reference lakes. Mercury levels in the tissue of Northern Pike and Walleye peaked 8 to 10 years after CRD at levels 50% higher than The Health Canada standard of 0.5 ppm. Current average mercury levels in the fish tissue of Northern Pike and Walleye hover around the Heath Canada standard of 0.5 ppm and are higher than the U.S. Environmental Protection Agency's standard of 0.3 ppm.

From Figures 3 and 6, we would infer that mercury concentration has affected the Northern Pike and Walleye fish population, which was never a big part of the catch in SIL. Whitefish do not appear to be critically affected by mercury levels but are less abundant and of poorer quality while Walleye and Northern Pike are high in mercury. The evidence suggests that there has been a change in the populations and health of the fish inhabiting these waters.

After living with the effects of the CRD for the last 40 years and our review of the RCEA, we have misgivings about the way the RCEA was conducted and find that the assessment of our region of interest does not accord with our experience. In the next section we review the approach to the RCEA and best practice guidelines for CEAs followed by our suggestions to improve upon the current RCEA.

2.5. Manitoba Hydro Regional Cumulative Effects Assessment (RCEA)

The Manitoba Clean Environment Commission (CEC) oversees reviews of the environmental impacts of major resource development projects in the province. The CEC has repeatedly called on the Province of Manitoba to require developers to determine the environmental effects of their current project in combination with the effects of existing projects: i.e., to conduct cumulative effects assessments (CEAs). The CEC's call for a CEA had also been included among recommendations for Manitoba Hydro's Wuskwatim projects and at least three other projects prior to Bipole III (CEC 2013, p. 125).

2.5.1. Origin in Clean Environment Commission recommendations

The Environmental Impact Statement (EIS) for Manitoba Hydro's Bipole III Project was supposed to have included a CEA, following the Canadian Environmental Assessment Act process (Manitoba Clean Environment Commission [CEC] 2013, p. 105). Instead, the Bipole III EIS wavered in its definition of the baseline condition and in its inclusion of past and prospective future developments. Consequently, Manitoba Hydro did not complete a proper CEA.

Like they had in several other reports, the CEC provided the following non-licensing recommendation in their report on Bipole III:

"11.1 Manitoba Hydro implement a cumulative effects assessment approach that goes beyond the minimal standard of the 1999 CEAA guidelines and is more in line with current "best practices." At a minimum, this approach would:

- *assess effects in close vicinity to the Project as well as in the regional context;*
- *assess effects during a longer period of time into the past and future;*
- *consider effects on VECs due to interactions with other actions, and not just the effects of the single action under review;*
- *in evaluating significance, consider other than just local, direct effects; and*
- *include all past, current and reasonable foreseeable actions."*

(CEC 2013, p.112)

Despite the CEC's non-licensing recommendation for a strong approach to cumulative assessments a later recommendation in the Bipole III report was that:

"13.2 Manitoba Hydro, in cooperation with the Manitoba Government, conduct a Regional Cumulative Effects Assessment for all Manitoba Hydro projects and associated infrastructure in the Nelson River sub-watershed; and that this be undertaken prior to the licensing of any additional projects in the Nelson River sub-watershed after the Bipole III Project."

(CEC 2013, p.126)

Prior to the release of CEC Bipole III Report, Manitoba Hydro submitted the EIS for yet another northern Manitoba development on the Nelson River, the Keeyask Generation Project; again the scope of the EIS was supposed to include a CEA (CEC 2014 p. 7) and again

the CEC was not satisfied by the CEA undertaken by Manitoba Hydro (CEC 2014, p. 45). The absence of a strong CEA in the Keeyask Generation EIS caused the CEC to again make a non-licensing recommendation that:

“12.1 The Manitoba Government establishes provincial guidelines for cumulative effects assessment best practices and include specific direction for proponents in project guidelines.”

(CEC 2014, p.140)

2.5.2. Previous experience of Manitoba Hydro conducting Cumulative Effects Assessments

As noted above, in the environmental assessments conducted for transmission and generation projects, Manitoba Hydro had never completed a comprehensive CEA to the satisfaction of the Manitoba Clean Environment Commission, nor had the Province of Manitoba established clear guidelines for conducting a CEA.

2.5.3. Previous experience of Province of Manitoba conducting Cumulative Effects Assessments

At the time RCEA was jointly undertaken by Manitoba and Manitoba Hydro:

- There were no provincial guidelines for CEA best practices;
- The regulatory body (Manitoba Conservation and Water Stewardship [MCWS]) was not independent to the process but, as the lead government agency, was a partner in the RCEA;
- As an agency, MCWS had no experience conducting, overseeing, or assessing a comprehensive CEA; and
- Despite repeated requests and recommendations from the CEC, MCWS had never historically required the completion of formal CEAs prior to the issuance of Project licences.

In summary, neither of the two parties conducting the RCEA was experienced in completing a CEA, there was no independent regulator overseeing the process, and there is no mention in the report of an outside body with CEA experience being engaged by Manitoba Hydro or MCWS to review the objectives, the process, or the final report.

2.5.4. Cumulative Effects Assessment processes carried out elsewhere.

The absence of any comprehensive CEA ever being completed in Manitoba means there was no local process for reference. However, there were both a federal agency and a federal process (Hegmann et al. 1999) available. For reference, we examined the Canadian Environmental Assessment Agency technical guidance for a CEA process (CEAA 2015); it includes the following recommended steps:

- I. A scoping process that begins by acquiring scientific evidence and input from the public and Aboriginal groups. Scoping includes several steps to identify:

- a. potential valued components (VCs),
- b. VC sensitivity to the Project and other past and future developments through cause-and-effect pathways,
- c. the identification of VC-appropriate spatial and temporal scales of assessment,
- d. selection of appropriate metrics and associated benchmarks, thresholds, and methods of analyses,
- e. establishment of a reference condition to represent the pre-development natural state of the VCs,
- f. identification of reasonably foreseeable future developments,

The outcome of scoping is the selection of the VCs that are carried forward for analyses;

2. An analysis stage that assesses the cumulative effects of the Project, and past and reasonably foreseeable future Projects, on each VC at the VC-appropriate spatial and temporal scales. The analyses should respect the source-pathway-receptor model to establish the relationship between the disturbances and the VC. Project effects that continue to affect the VC into the future must be recognized and accounted for;
3. Identification of mitigation measures should be incorporated throughout the scoping and analyses stages. Existing and proposed mitigation that can remove or reduce effects should inform VC selection and analyses;
4. Determination of significance of cumulative effects on each VC following mitigation;
5. Development of a follow-up program to verify the effectiveness of mitigation measures and assess the actual effects of cumulative development.

For each step, there should be documentation associated with all decisions, e.g., selection or exclusion of VCs, assumptions made, setting of temporal and spatial boundaries, and methods of analyses.

3. Comparison of RCEA Process and CEEA Best Practices

Instead of following the CEEA process and its associated guidelines, under the terms of reference (TOR) the Phase I RCEA report was to describe hydroelectric developments in the ROI and compile and list all Settlement Agreements, information on environmental effects, and available studies and monitoring programs. The Phase II report was to be

“...an assessment of the environmental effects of hydro development based on all available existing information, and utilizing to the degree possible the attributes of methodologies for environmental effects assessment and post-project assessment...” (Appendix 1A of RCEA Phase I Report).

Consequently, if a VC had not been included in a historic environmental assessment or monitoring plan, or if neither Manitoba Hydro nor MCWS had collected data pre- and post-development, then the process allowed the parties to ignore the effects of hydroelectric development on the VC.

3.1. Terms of Reference

The RCEA Terms of Reference followed from CEC non-licensing recommendation 13.2 in the Bipole III report, as quoted in Section 2.3.1 above. The final Terms of Reference appear in Appendix 1A of the Phase I RCEA Report (2014).

From a CEC suggestion made during the Keeyask Generation Project hearings, the RCEA was further limited to be retrospective, and would consist only of an examination of existing information.

3.1.1. Limitation of cumulative effects assessment to Manitoba Hydro developments

The CEC Bipole III recommendation 13.2 was inconsistent with CEAA best practices for CEA in that it failed to account for non-Manitoba Hydro developments. The CEC recommendation to limit the assessment of environmental changes over time only to those arising from Manitoba Hydro Projects was adopted in the Terms of Reference.

3.1.2. Geographical extent and division of Region of Interest (ROI)

Another important feature of the CEC Bipole III recommendation 13.2 was that the effects assessment was limited to Projects in the Nelson River sub-watershed. To their credit, Manitoba Hydro and MCWS expanded the region of interest to include the Churchill and Burntwood River systems. The spatial extent of the Region of Interest (ROI) was expanded to include the larger area

“...because it encompasses the main areas directly affected by Manitoba Hydro developments associated with the Lake Winnipeg Regulation (LWR), Churchill River Diversion (CRD) and associated transmission projects.” (p. I-10 Phase I Report).

The ROI around Southern Indian Lake (SIL) was determined as the extent of the SIL registered trapline (RTL) system. Within the ROI, the assessment of aquatic species will be limited to waterways and the assessment of migratory terrestrial species may expand beyond the ROI (pp. I-0 to I-11 Phase I report).

3.1.3. Temporal extent

In limiting the scope of the assessment to existing information in regions affected by Manitoba Hydro projects, the Terms of Reference had important consequences:

- There was no determination of reference conditions (i.e., no attempt to assess a pre-development state of the environment);
- There was no attempt to account for future effects that might arise from other, reasonably foreseeable developments;
- There was no attempt to account for future effects that might arise from changes arising from past Projects.

These limitations are contrary to CEAA best practices for CEAs. Section 1.3 of Phase I Report states that that data for pre-hydroelectric development and early development periods are inadequate by current standards then notes that conditions in that period will be limited to that existing information. For SIL and OPCN's traditional areas, we strongly disagree that pre-development data are inadequate; the extensive scientific studies conducted by DFO provide detailed information on pre-development conditions.

3.1.4. RCEA Process for selecting Regional Study Components (RSCs)

With the limitation to work from existing information, a new scoping process did not occur as part of RCEA. This prevented the inclusion of new public and Aboriginal concerns to be

brought forward, as would have occurred had CEAA best practices been followed. Instead, the RCEA assessment was based on a review and synthesis of past and on-going studies and monitoring; programs limited by information and scoping processes at the time of their initiation.

In a typical CEA process, the scoping of VCs is a prospective exercise. Environmental changes and the effectiveness of mitigation actions are anticipated and VCs are selected where there are potential residual effects to features of scientific, public, or Aboriginal concern. In the case of the RCEA, many of the residual environmental effects have already occurred or are in the process of occurring. Consequently there was the opportunity for more certain selection of VCs for assessment.

For OPCN, it meant that we were not invited to make our concerns known or to draw attention to damaging effects which had already occurred and which are getting worse. The detrimental effects of shoreline erosion and sedimentation caused by the CRD have been obvious since the 1970s but are not covered by environmental monitoring and were not well represented by any RSCs in the RCEA process.

3.2. Resulting RCEA Process

The resulting process for the RCEA was presented in the Phase II Report:

“1.3.3 Regional Cumulative Effects Assessment: General Methods

- *This Phase II report is based on a review, synthesis and analyses of the numerous environmental and socio-economic studies, post-project environmental reviews, environmental impact assessments for proposed developments and monitoring programs that have been conducted by Manitoba Hydro, Manitoba, Canada, and affected First Nations and others over the last 50 years. These include both publicly available information, as well community-based information that has been shared with Manitoba and Manitoba Hydro for the purposes of the RCEA.*
- *There are some cases where the Phase II assessment includes the analysis of collected but not previously analyzed or interpreted data, or new analyses of existing data to account for differences in data collection methods.*
 - Sources of information that have informed the RCEA include, but are not limited to, the following:
 - *pre-hydroelectric development environmental and socio-economic studies conducted for resource management, scientific, or other purposes;*
 - *post-hydroelectric development studies and data sets completed for resource management, scientific, or other purposes;*
 - *environmental and socio-economic impact assessment studies conducted for LWR and CRD;*
 - *monitoring programs to assess and manage impacts of existing facilities, including long-term fish population and water quality monitoring studies, and the effectiveness of major mitigation works;*
 - *environmental assessment processes, including environmental impact statements, public engagement outcomes and regulatory proceedings, for all major developments including the*

Wuskwatim Generation, Wuskwatim Transmission, Bipole III Transmission, and Keeyask Generation, Transmission and Infrastructure Projects (2000 to present);

- *environmental assessment studies for hydroelectric facilities that were planned/studied but not constructed (e.g., the Conawapa Generation Project);*
- *long-term component-specific monitoring programs such as water quality monitoring, fish population monitoring, and the monitoring of mercury levels in fish;*
- *system-wide on-going monitoring programs such as the CAMP;*
- *pre- and post-hydroelectric development monitoring programs for the physical environment including the collection of hydrometric data, erosion, ice conditions, and sediment transport;*
- *site-specific studies to address specific issues and concerns expressed by the affected First Nations and communities;*
- *studies to determine project effects to quantify losses under the Northern Flood Agreement (NFA) claims process. It should be noted that the studies conducted by or for individuals, First Nations, communities or organizations are considered confidential and have only been used in the RCEA with the express permission of the party for whom the studies were conducted;*
- *information from the NFA Claims Process, including Arbitration Proceedings and associated transcripts and information provided to the NFA Arbitrator;*
- *research into specific topics, including methylmercury, Lake Sturgeon, and reservoir greenhouse gases;*
- *community-led Aboriginal traditional knowledge (ATK) studies and other community-based studies that are in the public domain.*
- *pre- and post-hydroelectric project studies and reports that were conducted for reasons other than hydroelectric development (e.g., resource management, other developments etc.);*
- *pre- and post-hydroelectric development aerial photographs and/or satellite imagery for the characterization of habitat;*
- *historical reports by Natural Resource Officers working in the ROI;*
- *research conducted by others on the effects of hydroelectric development, including university practicums, Master's and/or Ph.D. theses, other university researchers and organizations (e.g., Interchurch Inquiry 1975; Loney 1995); and*
- *pre- and post-hydroelectric development community planning studies that are in the public domain."*

(Phase II Report, pp. I.3-9 to I.3-10).

3.3. Shortcomings of RCEA process

Best practices for CEAs explicitly include establishing a pre-development reference condition, and including all historic developments, approved developments, and foreseeable

developments. They are not restricted to a single industry or a single developer. Best practices also include a clear scoping process based on likelihood of effects on VCs of concern and not limited primarily by existing information. Compared with best practices for CEA, the RCEA process failed to include:

- reference conditions in the pre-development period;
- consideration of developments other than hydroelectric;
- assessment of reasonably foreseeable developments and changes;
- assessment of future changes likely to arise from existing developments. For OPCN these include on-going erosion from historic CRD, even without further development;
- a scoping process that included informed scientific, public and Aboriginal concerns in the selection of VCs (or RSCs as they are termed in the RCEA).

The Scope and General Methods (Section 1.3) of the Phase II Report provides a list of reasons why reference conditions for RSCs could not be established (commonly an absence of quantitative historic data). In some cases where historic data do exist, the Report cites incompatibility between historic methods and methods currently used. There is no explanation why historic methods and sampling locations were not replicated to provide current and comparable data; indeed, best practices when changing environmental monitoring methods for the same metric is to run historic and replacement data collection concurrently for a period of time to establish methodological equivalency or to build correction factors.

The selection of RSCs was to represent the overall effects of all hydroelectric developments in the ROI (Phase I Report, p 5-1). The importance of the RSCs to the residents of the ROI was determined from information acquired through previous hearings, claims, and reports, rather than through a new scoping process. The objective of representing overall effects within the ROI may have resulted in RSCs better representing effects for some geographic areas than for others. For the Physical Environment section, the approach taken did not include the identification of RSCs and did not include an assessment of effects of hydroelectric development.

3.4. Public input and Aboriginal consultation

- A public engagement process was to be developed early in Phase II (Section 1.2.3 Phase I Report).
- The community was not consulted.
- Public outreach program (p.1.2-7) left up to CEC after the RCEA completed. Affected nations and communities were not consulted prior to designing approach to RCEA. The RCEA states that
“In recent projects such as the Wuskwatim and Keeyask Generation Projects, Manitoba Hydro has employed project planning processes that engage local communities meaningfully and early on in the development of these new generation projects. A similar approach is used in the route

selection and environmental assessment processes for new transmission lines.” (Phase II Report, p.3.2-5).

One has to wonder why this laudable principle was not followed when considering the scoping for the RCEA.

4. Assessment processes as applied in RCEA Phase II

4.1. Division of RCEA into effects on People, Physical Environment, Land, and Water

The main Section headings from the RCEA Phase II report are:

1. Introduction and Approach;
2. History of Hydroelectric Development project description in the Region of Interest;
3. People;
4. Physical Environment;
5. Water; and
6. Land

Thus, the headings broadly conform to the requirements under the TOR (i.e., people, water, and land).

For the purposes of evaluating the Physical Environment and Water sections, the Churchill, Nelson and Burntwood River Systems are divided into 4 areas. Of these, two of the areas are of interest to OPCN. They are Areas 3 and 4. Area 3 covers Opachuanau Lake, SIL and South Bay channel down to Split Lake. Area 4 covers the reach of the Churchill River from Missi Falls to Churchill. Within these two areas are three linked Hydraulic Zones that are of primary concern to OPCN. They are (See RCEA Areas and Hydraulic Zone Overview in the RCEA Region of Interest, Map 4.1.1-1. and Water Regime, Map 4.3.1-1):

- **Hydraulic Zone 4** contains Southern Indian Lake, Opachuanau Lake and the Churchill River downstream of Leaf Rapids;
- **Hydraulic Zone 5**, which covers the entire reach of the lower Churchill River from the Missi Falls CS; and
- **Hydraulic Zone 6** includes the diversion channel from South Bay on SIL and extends up to the Notigi CS.

Each Hydraulic Zone is addressed separately in the RCEA for the Physical Environment and Water Sections. Hydraulic Zones 5 and 6 are downstream of Hydraulic Zone 4.

Land, on the other hand has a different regional categorization, based on a primary division by ecozones. While this may be appropriate for wholly terrestrial VCs, it does not conform to the hydraulic divisions, making the interface between the two incompatible. Further, as the shoreline zone is not specifically included as a system of interest and as no shoreline, littoral, or riparian VCs are considered, the RCEA division of the ROI into terrestrial regions and Hydraulic Zones

precludes an appropriate assessment of shoreline related effects of development, e.g., erosion and sedimentation.

4.2. Physical Environment

The Physical Environment is discussed under the headings of Environmental Setting, Water Regime, Erosion and Sedimentation and Project Footprint. None of these categories is treated as a VC, but rather they are termed drivers or stressors and described in a way that avoids a direct assessment of change. In describing the approach, Manitoba and Manitoba Hydro state that:

“While the Physical Environment component of the report will provide context and information on general effects within the RCEA ROI, its emphasis is on the impacts to those hydraulic reaches directly affected by the CRD, LWR and generating stations.” (Phase II Report, p. 4.1-1).

And, therefore, analyses of the changes in water regime, erosion and sedimentation are not fully addressed.

The sections under Environmental Setting: regional climate, geology, soils, topography, permafrost and peatlands are adequately described. However, our skepticism on the way the RCEA unfolds starts with the weakness of the analyses of Water Regime and Erosion and Sedimentation. Both of these are at the core of everything that has gone wrong with the environment and both continue to have a profound effect on our ecosystem and people.

The Physical Environment does include a broad description of the physical effects of flooding and water regime alteration; and erosion and slumping of shorelines; alteration to sediment loads; and sedimentation. However, the changes that have occurred to the water, erosion and sediment regimes of SIL and the downstream rivers are not fully explored. Mitigation measures are not discussed. The land/water interface is not clearly specified in the TOR and therefore the effect of water regime on shoreline erosion and sedimentation processes is not fully explored and an analysis of mitigation measures was not considered. We find the analysis shallow at best for the following reasons.

4.2.1. Water Regime

Assessment of Water Regime is covered by just two key drivers or stressors. These are:

- Key Hydraulic Features and Indicators; and
- Ice Conditions.

Key Hydraulic Features uses two metrics to judge change in Hydraulic Zone 4: monthly average water levels, recorded daily since 1956, at the Water Survey of Canada station at South Indian Lake and residence time.

From the examination of the monthly average water levels at South Indian Lake the effects assessment concludes that

“As shown in Figure 4.3.3-1, the available data indicates that the seasonal water level pattern on SIL is similar to the pre-CRD Phase II Report.” Phase II Report, p. 4.3-50).

There is no analysis the regularity of the fluctuations in water level as shown in Figures 2A, B. There is also little mention of water surface slopes within each basin before or after the CRD. With the reduced flow at Missi Falls after the CRD, one would expect the slope of the water surface in Basins 3 and 4 of SIL to be nearly flat or maybe to slope southward. However before the CRD, the water surface would have sloped northwards towards Missi Falls.

Residence time, a metric that relates to the changes in currents in the lake due to CRD is poorly examined and interpreted. Residence time is an important metric because it is a measure of the time available for physical, chemical and biological reactions to occur in a particular area. However, the evaluation is based on a fairly rudimentary analysis of the water budget for SIL by McCullough in 1981. The calculated residence times for the basins of SIL are presented in Table 1 and in RCEA Part 11, Table 4.3.3-2.

McCullough made several assumptions when calculating the residence times for the basins. The major ones were that the average annual flow at Missi Falls was 7600 cfs and that the waters in each basin were well mixed. As a matter of concern, McCullough (1981, p. 16) writes

“The water exchange times indicated are for the whole volume of each basin. In fact the main flow of Churchill River water follows a reasonably discrete path through each basin, as through the whole lake, (Cleugh, 1974; Patalas and Salki, 1974) and mixing with lake waters is incomplete and not described by these water budgets.”

There is no follow-up on how residence time and currents might be affected by the range in flows experienced over the last 40 years. For instance in 2015 the average flow at Missi Falls was below 2000 cfs while in 2017, flow was at an all-time high of over 100,000 cfs. Hecky, Harper and Kling (1974) considered residence time would have important consequences on the ecosystem of SIL and warned that if residence time is reduced to the minimum levels that would occur under the Interim License minimum flow conditions at Missi Falls that there would be a catastrophic impact on primary productivity in Basins 3 and 4 and on Lake Whitefish.

The pre-CRD SIL showed pronounced gradients from east to west in Basins 3 and 4 in water surface temperatures, water quality and phytoplankton. This was due according to Cleugh (1974), Hecky (1974), Hecky, Harper and Kling (1974), Patatlas and Salki (1974) to the main flow of the Churchill River being confined to the eastern shore of SIL by the narrows between basins. The flow of the Churchill River is now mostly rerouted down the South Bay Channel and the northern basins of the lake isolated from the current of the Churchill River. The narrows that confined the current have grown because of flooding and erosion. Long Point, for example, is now an island. Yet, there is no analysis of this spatial change in the mixing dynamic of SIL.

Another facet of the water regime on SIL that is not considered in the RCEA is the role of the AFP, the regular, annual cycle of raising and lowering of the water surface by 4.5 feet Fig . No analysis of this facet of the Water Regime is presented, and, importantly, no discussion or analysis on mitigation as this factor could be adjusted. The failure by Manitoba and Manitoba Hydro to look at the role of the AFP is unacceptable. Water level fluctuations caused by

reservoir operations are far from natural and the damage caused to the ecosystem is the focus of a growing branch of science on lakes around the world. None of the science on the effects of water level fluctuations in lakes (see for instance Lindstrom, 1973; Leira and Cantonati, 2008; and Wantzen et al. 2008, Zohary and Ostrovsky, 2010) was applied to the analysis of the effects of the AFP on SIL.

4.2.2. Ice Conditions

Ice conditions on SIL are assessed by a three line paragraph in Section 4.3.3.2.4, p.4.3-53.

“Pre-CRD, the ice cover on SIL was usually formed in late fall and used extensively as a roadbed for winter transportation especially near the settlement at South Indian Lake. Post-CRD, as forecasted by the LWCNRSB, the ice cover near the South Indian Lake Settlement became poor or non-existent (LWCNRSB 1974).”

Ice conditions are important to OPCN as people travel on Opachwana Lake, SIL and the Churchill and Rat River systems for the 6 to 7 months of the year when ice is present. There is not any mention of the fluctuations in water levels caused by the AFP that makes travel on the ice treacherous. Nor are there analyses on the effects of the changed currents and winter drawdown on ice cover. There is also no quantification of the length of the ice cover season for SIL and downstream river systems. The early science on SIL predicted cooler temperatures for the lake after CRD and therefore a longer ice cover season. An appropriate scoping exercise at the beginning of the RCEA would have allowed for the inclusion of VCs that would consider changes to ice conditions and the CEA of a changing ice regime on the aquatic ecosystem.

Another area of concern that OPCN would like to point out is the woody debris, continuously eroded from the shore that becomes frozen in the ice and presents a dangerous obstacle to safe winter travel on the lake and downstream river systems. Hit a log frozen into the ice at over 20 km/hr and you are likely to be hurt or killed. Manitoba and Manitoba Hydro know about these conditions because they sponsor programs such as debris management and safe ice trails to make our environment safer, yet they are not mentioned in the physical assessment.

4.2.3. Erosion

Erosion of the new shorelines is one of the primary reasons for the changes to our environment. The erosion has resulted in cloudier water in the lake and quite possibly reductions in water temperature and primary productivity which cascade into the health of the ecosystem. An estimate of when erosion will stabilize and return shorelines to some semblance of the pre-CRD shoreline would, we suggest, be an overriding question that the RCEA would answer. Unfortunately, this question remains unanswered.

The results of erosion studies are presented in a zone-by-zone approach. For Hydraulic Zone 4, the largest Hydraulic Zone in the RCEA with an area of 2,310 km² and shoreline that is 5,630 km long.

“The increase in water levels associated with the CRD changed many of the shorelines on Southern Indian Lake from stable bedrock-controlled shorelines into highly unstable shorelines formed in surficial deposits, some of which were ice-rich. Various estimates of the percentage of bedrock-controlled shorelines prior to the CRD have been presented in the literature, ranging from 76%

(Newbury and McCullough 1984) to 88% (Newbury et al. 1984), whereas following impoundment this number was estimated as 14% (Newbury et al. 1984).” Phase II Report, p.4.4-62).

A good start to the analysis, but it really goes no further. “considerable erosion monitoring was conducted by the DFO on Southern Indian Lake in the 1970s and 1980s, and no erosion monitoring has been conducted since 1992. Consequently, no current information is available on the total amount of erosion that has occurred since the CRD or on whether shorelines are stabilizing, and limited documentation is available on pre- versus post-CRD erosion rates”. p. 4.4-64. RCEA Part II. That the early studies on erosion have not been followed up on is a gross failure of the monitoring plans conducted since CRD by Manitoba and Manitoba Hydro.

New information was presented from fairly recent studies of Landsat imagery and aerial photographs. “Landsat images from 1978 and 2010 were analyzed to identify the areas where at least 90 m (300 ft) of erosion has occurred across Southern Indian Lake.” (Part II, p. 4.4-64.) And in summary the RCEA reports “Landsat analysis from 1978 to 2010 across Southern Indian Lake indicated that a large amount of erosion had occurred in the north part of the lake, where as much as 160 to 350 m (525–1,148 ft) of shoreline recession (5 to 11 m/y [16.4-36.1 ft/y]) was observed at several sites. South Bay also showed a large amount of erosion, but with recession rates only as high as about 3 m/y (9.8 ft). Other parts of the lake showed less erosion, mainly due to shorter fetch and an abundance of bedrock shorelines. In total, it was estimated that 628 ha (1,552 ac) of land in Hydraulic Zone 4 had eroded between 1978 and 2010, with 322 ha (796 ac) classified as mineral erosion and 306 ha (756) dominantly represented as peatland disintegration. However, these estimates should be regarded as minimums, as they are based only on the areas showing at least 90 m (300 ft) of erosion.’

(Part II, p.4.4-73). Unfortunately, no recent analysis of Landsat images to update these numbers or more importantly, estimates of the amounts of land surface between the shoreline and bedrock contact is attempted, which would allow estimates of the time to stabilization of the shoreline and improvement to the overall health of the lake. Because future development cases are overlooked in the RCEA, the drive to forecast when change for the better may occur on the lake is overlooked.

The upper part of Hydraulic Zone 5 experienced an entirely different erosion dynamic after the CRD than did Hydraulic Zone 4, although there is really no assessment of erosion in the RCEA of this zone. Here the flow in the Churchill River was greatly reduced. Prior to CRD, we assume that the Churchill River would have eroded its bed down to bedrock along its course to Fidler Lake. A reduction in flow would not be expected to increase erosion along the upper part of the river, although alluvial materials, deposited since the last ice-age, would be expected to continue to erode and deposit along its course in a much reduced fashion.

In Hydraulic Zone 6, on the other hand, which is now receiving most of the flow from the Churchill River, a huge change in the erosion dynamic would be expected. However, Manitoba and Manitoba Hydro rely on the result of erosion study site, located near the Notigi CS in a zone experiencing minimum erosion as attested to in the analysis of Landsat imagery.

“Landsat analysis indicated that 5,202 ha of land had eroded in Hydraulic Zone 6 between 1976 and 2014, but this estimate should be regarded as a minimum, as it is based only on the areas showing at least 90 m (300 ft) of erosion. (Phase II Report, p. 4.4-92.).

Even at a minimum, this is a large amount of land. At an average depth of a metre, this represents 52,020,000 cubic metres of sediment supplied to the Rat River System over this time. This equates to roughly 500 truck-loads of sediment being dumped into the South Bay Channel every day.

Again, no forward looking case is presented on when conditions will return to a semblance of a pre-development condition.

4.2.4. Sedimentation

For the assessment of sedimentation in Hydraulic Zone 4, a study of the sediment budget for SIL is quoted.

“Hecky and McCullough (1984) discussed the effects of impoundment and diversion on Southern Indian Lake, in terms of estimated internal vs. external loadings, eroded material retention and deposition locations. They noted that approximately 86% of the lake’s perimeter was composed of unconsolidated overburden after flooding, compared to the 80% stable shorelines under pre-hydroelectric development conditions. The (inorganic) shoreline materials were largely described as glacio-lacustrine deposits, consisting of clay and sand. They constructed a four year sediment budget for Southern Indian Lake covering the period from 1975 (before full impoundment) to 1978 (diversion fully operational). Hecky and McCullough estimated that the sediment output from the lake increased from a natural level of about 120,000 tonnes (132,000 tons) in 1975 to 400,000, 600,000 and 550,000 tonnes (440,000; 660,000; 606,000 tons) in 1976, 1977 and 1978, respectively. They concluded that one of the impacts of the diversion was an increase in total sediment inputs and outputs into and from Southern Indian Lake.” (Phase II Report, p.4.4-77).

We agree with the accuracy of the above quote, but find it misleading. Hecky and McCullough in the same paper state that

“Before the CRD, the Churchill River was the main source of sediment entering SIL, transporting 200,000 tonnes per year (Hecky and McCullough, 1984a). Shore erosion was minimal because most of the shore was composed of rock. Once the water level was raised, Newbury and McCullough (1984) estimated an additional 4,000,000 tonnes per year of mineral sediment were eroded from the shore – twenty times the amount of material entering SIL before the CRD and most of this material was deposited in the near shore area.” (Hecky and McCullough, 1984 p. 567).

The authors go on to state that although

“Total sediment export at outflows from SIL increased after impoundment (4-5 times) but not nearly in proportion to the increase in sediment input (I +E), as the lake retained at least 90% of the eroded input.” (Hecky and McCullough, 1984 p. 567).

This last statement explains the context of the first quote, but the quote that is used in the RCEA does not really characterize fully the huge change in sediment regime experienced in the lake.

What is important to note here is that Hecky and McCullough (1984) go on to suggest that this “90% of the eroded input” is deposited in the near shore of the lake. Why then do Manitoba and Manitoba Hydro rely on measurements of TSS and Turbidity, the metrics used to assess sedimentation, measured in the middle of the lake on calm days to characterize the sedimentation regime of the lake. Surely, a proper scoping of the RCEA at its outset would have raised the flag that measurements taken in the central part of the lake would not represent near shore conditions and that the near-shore is an area that was and is undergoing major change and deserves more scrutiny in the RCEA.

Another point to be made here is the reliance of the RCEA on a study that evaluated a sediment budget for the years 1975 to 1978. The AFP was not in effect during this time period as experimentation with the program began in 1979. Therefore, we would suspect that erosion and sedimentation would have increased above these amounts after 1979 as the full 4.5 foot wash of the shoreline, allowed under the AFP license terms ensued after this date.

Table 4.4.2-7: 1972 to 2010 Sediment Parameters in Hydraulic Zone 4

Historical Geographic Area			Parameter	Time Periods ²				
				Pre-Dev.	Const.	Post-Dev.	After 10 yrs	After 30 yrs
0	Upper Churchill River near Granville Lake	TSS (mg/L)	-	-	4.92	3.75	3.9	
		Turbidity (NTU)	3.84	4.48	4.49	4.39	4.0	
1	D/S ¹ of Opachuanau Lake	TSS (mg/L)	-	-	-	-	3.9	
		Turbidity (NTU)	-	-	-	-	8.89	
6	Near the Community of South Indian Lake	TSS (mg/L)	-	8.06	7.78	5.53	-	
		Turbidity (NTU)	3.6	6.0	8.54	6.78	-	
	South Bay	TSS (mg/L)	-	-	-	-	5.5	
		Turbidity (NTU)	-	-	-	-	12	
4	SIL near Missi Falls	TSS (mg/L)	-	5.25	6.23	5	-	
		Turbidity (NTU)	2.79	2.01	6.75	2.36	-	
	SIL Area 4	TSS (mg/L)	-	-	-	-	6.5	
		Turbidity (NTU)	-	-	-	-	3.35	

1. D/S: downstream

2. Time periods:

Pre-hydroelectric development (“Pre-Dev.”): 1971–1972/73 data, reported by Williamson and Ralley (1993),

During construction (“Const.”): 1974–1976 data, reported by Williamson and Ralley (1993),

Immediately Post-hydroelectric development (“Post-Dev.”): 1977–1984 data, reported by Williamson and Ralley (1993),

10yrs after construction (“After 10 yrs”): 1987–1989/92 data, reported by Williamson and Ralley (1993),

30yrs after construction (“After 30 yrs”): 2008–2010 data, reported by CAMP (2010)

The above discussion adds a different perspective to interpreting the levels for TSS and turbidity reported in Table 4.4.2.7 (Part II, p. 4.4-79). There are no “pre-development” to “after 30 years” levels that can be compared, except for the station at Upper Churchill near Granville Lake. The levels at this station suggest that inflowing Churchill River water has not changed that much. There is no description of how many sampling points were used to establish these levels,

or where the sampling stations are located. Knowing that there are only three CAMP stations, located in the central parts of the basins of the lake, tells us little about the dynamics of TSS and turbidity in the near-shore.

The RCEA gives fairly short shrift to studies by Environment Canada which provide contrary info regarding sedimentation in the lake but do support previous studies on SIL.

“Federal Ecological Monitoring Program reports (Environment Canada and DFO 1987, 1988, 1989a, b, c, 1990) documented the sedimentation studies, observations, and assessments initiated under this program. The findings of FEMP were consistent with other historical studies and were presented in a two-volume report. The FEMP final report noted the effects of the CRD on the sedimentation environment in SIL as being an increase in turbidity, sediment concentrations and, sediment outputs from the lake. Suspended sediment concentration increased from 5 mg/L before development to 30–50 mg/L after development.” (Phase ii Report, p 4.4-78).

Are the 30-50 mg/L levels noted in the above quote incorporated into Table 4.4.2.7?

In Hydraulic Zone 5 and 6, the sedimentation story is not much different although two vastly different experiences to the CRD have been experienced by the two zones. For Hydraulic Zone 5.

“The available data do not support a detailed calculation and comparison of pre- and post-CRD annual sediment loads in the lower Churchill River. However, considering that flow in the lower Churchill River is lower due to CRD while pre- and post-CRD suspended sediment conditions are similar, it may be reasonably concluded that CRD has reduced the annual sediment load transported down the lower Churchill River.” (Phase ii Report, p4.4-87)

And

“The diversion was estimated to cause the total sediment load at the Notigi CS to be about 26 times greater than the load in the river before diversion” (Vitkin and Penner 1979).” (Phase II Report, p 4.4-101).

For these two zones there is a scarcity of recent data to characterize the present day states of these waterways. Also, there is a complete absence of data concerned with the near shore environments of the rivers and lakes within these systems. Therefore, it is not surprising that there is no assessment of sedimentation in these systems.

In summary, there are no RSCs identified for the physical environment and consequently there are no specific assessments of the effects of hydroelectric development on the physical environment. Section 4.4.1.1 Background includes a broad description of the physical effects of flooding and water regime alteration including erosion and slumping of shorelines; alteration to sediment loads; and sedimentation. However, the effects of hydroelectric development on these features and processes are never assessed directly.

Destruction of shorelines, changes in access between land and water, and the effects of sedimentation on the aquatic environment are all things that have affected the lives and environment of the people of OPCN. The on-going shoreline erosion, slumping, and

sedimentation are a continued source of destruction caused by the altered flows and water regulation from the CRD. None of these were addressed directly in the RCEA process.

4.3. Water Regional Study Components

The RSCs used to assess effects on water are: Water Quality, Fish Community, Lake Sturgeon, and Mercury in Fish, Fish Quality, Seals and Beluga. Our areas of interest concern Hydraulic Zones 4, 5 and 6. Hydraulic Zone 4 is upstream and feeds both Hydraulic Zones 5 and 6. So, one would expect that changes experienced in Zone 4 to influence the Zones 5 and 6. Furthermore, the story of water needs to elaborate on how changes to hydrology and physical environment affect water quality and then aquatic health including primary productivity and fish and overall ecosystem health. However, our review suggests that the story is incomplete because the data necessary for a full assessment of this chain of factors is not available. Also, the assessment does not consider a major component of the ecosystem, the littoral zone.

4.3.1. Water quality RSC

The overall approach to the RCEA's attempt to assess cumulative effects for water quality is shown in linkage diagram presented in the Phase II Report (Figure 5.2.1-I, Phase II). The diagram depicts in detail the linkages between the development and physical environment and then highlights the potential effects on water quality. The problem is that the stories that should come out of this are not followed through on in the assessment; mainly because of the failure to establish a pre-development base case and development cases and limitations with recent water quality data. On P.5.2-18, the RCEA states,

“Key data limitations include:

- *The primary data limitation relates to the absence, or limited amount, of data for pre-hydroelectric development. This precludes direct comparisons of conditions before and after hydroelectric development in some instances.*
- *For some waterbodies post-hydroelectric development data are lacking or limited.*
- *Water quality data have been collected by a number of organizations and agencies over the period of record and sampling and/or analysis methods have varied which may affect comparability of data.*
- *Water quality sampling generally does not provide information for high wind or storm events as these conditions preclude sampling from a boat or fixed wing aircraft. Therefore a comprehensive assessment of effects of hydroelectric development on TSS and related parameters is not possible.”*

We would argue that the first bullet does not apply to Hydraulic Zone 4, SIL, and to Zones 5 or 6, but the other three bullets are credible. There was a wealth of monitoring data collected by DFO scientists before and immediately after the CRD compared to the sparsity of data collected over the last 20 years. This is supported by the number of sampling sites shown in Map 5.2.8-3, p. 5.2-128 of the Phase II Report. The LWCNRSB sites shown on the map were operated between 1972 and 73. The DFO sites were in operation between 1974 and the late 1980s while the CAMP program began in 2007, approximately 20 years after DFO research.

There are over 30 LWCNRSB monitoring sites and 17 DFO sites that were used to characterize the lake before CRD and shortly after CRD. There are only 4 CAMP sites from which to infer current water quality conditions.

For the portion of Hydraulic Zone 5, Missi Falls to Fidler Lake there are 5 LWCNRSB monitoring sites, 1 DFO site and 4 CAMP sites. For Hydraulic Zone 6, there are 9 pre-CRD sites, 22 monitored by DFO from 1974 to 1980s and 6 CAMP sites.

Meaningful conclusions can be drawn from a comparison of the LWCNRSB and DFO sites for the pre-CRD and immediate post-CRD period up to the late 1970s and this is the data used to assess processes and change in the DFO studies published from 1979 to 1984. However, we do not see how valid conclusions can be drawn from comparisons between these early case processes and current conditions considering the lack of monitoring sites operated on the lake today. There are just not enough sites to depict water quality conditions on the lake over the last two decades. Therefore, we don't see how meaningful conclusions can be drawn from a comparison of the measurements between the data sets collected for the early and late 1970s, and those of today. Especially, considering that the CAMP stations are only monitored under fair weather conditions on the lake.

Other aspects of the RCEAs treatment of Water Quality that we find wanting are:

- We know for a fact that there is good information on temperature, especially on the pre-CRD lake and immediately following the CRD. However, the spatial patterns of water surface temperatures on the lake as well as seasonal patterns are not examined in any meaningful way. Instead, the focus is on one aspect: stratification, which appears to be weak at best in the pre- and post-CRD lake and therefore of little consequence. A spatial and temporal analysis of changes in temperature is important to understanding, changes in ice cover, water quality, primary productivity and migration of fish.
- There simply is not enough spatial data collected over the last twenty years to provide a full analysis of the changes to water clarity in SIL and the downstream rivers. Recent data are restricted to deep water sites, and the data are collected on calm days.
- There is a reliance on total values for water quality parameters with little analysis of the fractions that make up the total values. For, example it would be valuable to know the make-up of the sediments that compose TSS in the Lake and Rivers. Organic versus inorganic fractions and size distribution of the particles that make up the TSS. It would seem that TSS has remained fairly uniform pre- and post-CRD, but water clarity and turbidity have changed. This infers that the size of the particles that make up the TSS concentration have gotten smaller for the post-CRD lake. Regarding total phosphorus: what is the proportion that is plant available (Orthophosphate)? What is the proportion of dissolved phosphorus versus particulate? Has the ratio changed? Organic versus Inorganic? Metals, total versus dissolved?
- The use of Chlorophyll *a* as a measure of biomass or primary production. No attempt was made in the RCEA to relate levels of Chlorophyll *a* to biomass. Why use it as a measure when Hecky, Harper and Kling (1974) already warned against using Chlorophyll *a* as a measure of biomass as the correlation between the two was low in their analysis (r-

squared of around 0.2.). There has been no follow-up on the methodology, including sample timing, used by Hecky, Harper and Kling to understand primary production in the lake after CRD. This failure to follow-up on this comprehensive study of primary production by Hecky, Harper and Kling (1974) leaves a huge gap in the data collected by recent monitoring programs on SIL. No recent information on the make-up of the base of the food chain in the lake is provided, except for the unsubstantiated Chlorophyll *a* data.

4.3.2. Fish communities RSC

There is a substantial body of knowledge on the fish community, especially Whitefish. The indicators and metrics used point to an overall decline in the health and abundance of Whitefish in SIL.

“Information provided by SIL fishers, scientific evidence, and the closure of much of the SIL commercial fishery suggests that Lake Whitefish capture rates are continuing to decline in all areas of the lake. There are other characteristics of the Lake Whitefish population in SIL Area 4 that have led to concern, which include: old, slow growing fish that are dominated by two older year classes; small maximum size; poor condition factor; and evidence for non-annual spawning.

A number of concerns have been expressed regarding the changes observed in the SIL fish community, particularly with respect to populations of Lake Whitefish and Walleye. These concerns have been broadly categorized into four factors, including: changes to spawning habitat; change in emigration; change in food availability; and effects of the commercial fishery.” (Phase II Report, 5.3-139).

However, the RCEA does not follow-up the abundance and health of Whitefish.

The fish community according to the RCEA has also changed in Hydraulic Zones 5 and 6 after the CRD.

4.3.3. Lake Sturgeon RSC

There is almost no data on Lake Sturgeon for SIL and little data on the upper sections of rivers immediately downstream of the lake. It is surprising that Lake Sturgeon was chosen as a RSC for this region. Therefore this RSC does not have any bearing on the assessment.

4.3.4. Mercury in Fish RSC

The latest data on this important issue is only up to 2013 and the sampling presented in the RCEA for SIL only covers Basin 6. The points of greatest interest are discussed below.

- It looks like the mercury levels shown in Figure 4 (a copy of Fig in the RCEA Phase II Report) for Walleye and Northern Pike are not recovering to pre-CRD levels, but hovering around the Canada Health Guideline. This is a definite change in the health of these populations of fish in the lake and downstream rivers.
- With few exceptions (e.g., Northern Pike and Walleye from Rat Lake) current (2010–2014) mean concentrations in on-system waterbodies are all below the 0.5 ppm standard for the commercial sale of fish, but individual (large) Northern Pike and Walleye fish may reach concentrations of 1 ppm. Mean concentrations in Northern Pike and Walleye for the large number of off-system lakes in the ROI have always been lower than 0.5 ppm, although variability among lakes and over time has been substantial, including standard means as high

as 0.38 ppm. Standard means for whitefish from off-system lakes have been generally below 0.05 ppm. (Phase II Report, P.5.5-99).

- Looking at the data for Hydraulic Zones 4 and 5, we suggest that the average is around .5 ppm and that large bodied fish may be well above it. Trend does not look like it is coming down to pre-CRD level, but has plateaued.

4.3.5. Fish quality RSC

- Reliance on subjective metric, palatability.
- T. Crassus infestation rates in Whitefish increased after the CRD, but may be decreasing in SIL in recent years. Commercial whitefish fishery was closed because of downgrading of class from export to cutter/other. Last few years, RCEA reports that the Fresh Water Fish Marketing Board has returned Area 3 and 4 to export class. But the not sure why this has occurred. Fishers may be fishing in select areas where cyst infections are traditionally low.

4.4. Land Regional Study Components

The land based RSCs selected to represent the effects of hydroelectric development are mostly linked to habitat based indicators and metrics. Those of greatest interest are discussed below including brief descriptions of some key findings as reported in the Phase II Report.

4.4.1. Intactness RSC

- The calculation of intactness was limited for some features, including shoreline erosion as *“Land loss due to hydroelectric development flooding and subsequent shoreline recession, or land gain due to dewatering, was not reliably mapped for some reaches of the regulated system because the georectification of the digital waterbody data was poor.”* (Phase II Report, p. 6.2-10).
- Cumulative effects of hydroelectric development on Baldock TR of Western Boreal Shield were limited, mostly confined to land loss to flooding from the CRD. There were effects to travel on Issett Lake and the Rat Lake and Notigi Reservoir.
- Cumulative effects of hydroelectric development on South Indian TR in Taiga Shield were limited; 82% of change was flooding from CRD while 15% was dewatering downstream from Missi CS. They are reported as ecologically acceptable (Phase II Report, p. 6.2-77)

4.4.2. Terrestrial Habitat RSC

- From Phase II Report Table 6.3.1-I

RSC or RSC Subcomponent	Indicator	Metric
Shoreline Ecosystems	Shore zone habitat composition	Length (km) of each shore zone and offshore habitat type, with emphasis on priority types (e.g., marsh, beach meadow, floodplain) Length (km) of shoreline with a tall shrub band, by width Bank stability Inland habitat type
Human alteration		Waterbody morphology Dominant flow and fetch Bank and beach zone characteristics Percentage of shoreline length altered Percentage of shoreline length in human features, by type Length (km) of shoreline with debris accumulation, by type

- The detail in terrestrial habitat mapping were limited. Manitoba Hydro ascribes this limitation to a shortage of available data and the time available to complete the RCEA. Regardless of the reasons presented, inadequate habitat detail compromises the ability of Manitoba Hydro to conduct a proper CEA of habitat and of wildlife RSCs whose indicators Manitoba Hydro chose to base on appropriate habitat classification. The data did not support the fine level of detail used in recent environmental assessments within the ROI (Phase II Report pp. 6.3-14 to 6.3-15);
- The assessments of terrestrial habitat presented in the Phase II Report were generally comparisons of pre- and post-development habitat areas.
 - There were numerous limitations to the assessment of development effects on shoreline habitat. Many are enumerated in Section 6.3.1.5.5 and collectively they compromise the ability of the RCEA process to make statements about the effects of development on shoreline, particularly in the regions of interest to OPCN. Shoreline habitats rather than upland habitats are most susceptible to changes in water level and its fluctuation.
 - An important example is that the tall shrub zone was selected as a focal habitat for the assessment of effects on shoreline ecosystems, there was little tall shrub habitat in the pre-development period and limited available information on current shoreline vegetation conditions in either the Southern Indian or Baldock Terrestrial Regions Appendix 6.3B shows that the pre-development shoreline habitat analyses results as having no tall shrub zone on 90% of the SIL TR shoreline and no tall shrub zone for 83% of the Baldock TR (Phase II Report Table 6.3B-8). In the post-development existing environment 65% of the SIL TR shoreline was not classified for shrubs and 33% of the shoreline had no tall shrub zone; for the Baldock TR 97% was not classified for tall shrubs (Phase II Report Table 6.3B-13). Consequently, there was little ability to assess cumulative effects of hydroelectric projects on vegetation from the pre-development condition. This was not a consequence of there not being data for the pre-development

period but a failure to classify shoreline vegetation with a meaningful metric and an absence of complete 2013 classification.

- In Baldock TR, 72% of the existing environment mapped shoreline had shoreline debris; debris was absent in the pre-development state (Phase II Report Table 6.3.2-41). In Southern Indian TR, debris was absent pre-development while 38% of the mapped shoreline had shoreline debris (approximately 1/3 of the shoreline was mapped post-development, Table 6.3.5-24)
- The assessment for the Baldock TR, from both community information and shoreline assessments is that increased debris and erosion have made access to shorelines difficult for people and wildlife (Phase II Report p. 6.3-155). A similar acknowledgement is made for the Southern Indian TR on p. 6.3-324.
- In the Southern Indian TR, there was detailed vegetation mapping based on aerial photographs completed for the areas surrounding SIL and the Churchill River and pre-development human infrastructure and native habitat composition were determined for the entire TR (Phase II Report pp. 6.3-300 to 6.3-301). Shorezone wetlands (all riparian peatlands) comprised 0.2% of the mapped wetlands that made up 76% of the mapped habitat in the TR.
- The waterbodies affected by the CRD had 4653 km of shoreline pre-CRD and data were available to characterize 98% (4536 km) of pre-development shore zone terrestrial habitat (Phase II Report pp. 6.3-303). Of the 35% of the shoreline mapped for shoreline debris, there was no debris mapped pre-development (p. 6.3-306).
- In the Southern Indian TR there was little change in the absolute or relative abundance of any habitat type from pre-development to 2013. Most affected habitat was wetland.

4.4.3. Waterfowl RSC

- The indicator chosen for assessing cumulative effects to waterfowl was habitat; particularly wetland habitat. As noted under the terrestrial habitat RSC above, there were many limitations imposed by the inadequate efforts made by Manitoba Hydro in habitat data acquisition and analysis. This is true for all habitat based RSC indicators.
- In the Baldock TR, construction and operation of the CRD reduced shoreline habitat quality along the Rat, Notigi, and Burntwood Rivers through flooding and the accumulation of woody debris. The post-development shore zone and offshore waterfowl habitat in the Baldock TR was estimated at less than 1% of the pre-development level (Phase II Report Tables 6.4B-7 and 6.4B-8). Regardless of waterfowl populations in the region, accessible waterfowl habitat along major river systems was lost to the people. Detailed information was not provided on waterfowl distribution elsewhere in the TR.
- Though not a productive waterfowl nesting area, Southern Indian Lake was an important staging area. All shore zone and offshore wetland habitat in the Southern Indian TR was lost following CRD (Phase II Report Tables 6.4B-15 and 6.4B-16). Periodic releases of water from Miss Falls CS compromises downstream nesting habitat.
- The RCEA acknowledges that SIL residents have repeatedly reported reduced waterfowl availability in the years since CRD: *“Aboriginal traditional knowledge indicates that waterfowl*

habitat was lost throughout the major river systems in the RCEA ROI due to increased water levels. In some areas, such as SIL (Taiga Shield Ecozone) and the Outlet Lakes area (Eastern Boreal Shield Ecozone), impacts have severely reduced harvest opportunities and caused harvesters to locate to new areas.” (RCEA Phase II Report p 6.4-75).

4.4.4. Aquatic furbearers RSC

- Beaver population sizes and the amount of beaver habitat were selected as the indicators for the aquatic furbearer RSC. On-system beaver habitat was based on shoreline attributes. As noted under the terrestrial habitat RSC above, there were many limitations imposed by the inadequate efforts made by Manitoba Hydro in habitat data acquisition and analysis.
- In the Baldock and Southern Indian TRs it was estimated that much less than 1% of pre-development primary beaver habitat was lost (RCEA Phase II Report Tables 6.6A-1 and 6.6A-4). Effectively no primary beaver habitat was lost to hydroelectric development.
- On-system beaver habitat losses were also assessed to be limited. In the Baldock TR less than 1% of the pre-development shoreline was assessed as beaver habitat, all of which was determined to have been lost to development. In the Southern Indian TR only 35% of the post-development shoreline was classified, limiting pre- and post-development shoreline comparisons. In the pre-development state the same 35% of the shoreline contained less than 1% beaver habitat, all of which was lost to development. The habitat loss did not consider the effects of annual water drawdown. Presumably, its inclusion would support the total loss of beaver habitat along affected waterways, though the absolute amount as assessed would be small.
- There were no post-development estimates of beaver population size in either the Baldock or Southern Indian TR. ATK attributes observed declines to hydroelectric development related fluctuating water flows levels, erosion and debris buildup (Phase II Report p. 6.6-24 and p. 6.6-57).

4.4.5. Moose RSC

- There are few population surveys that have generated data that meet standards for wildlife assessment. In the area of interest to OPCN, there was a survey conducted in 1985, partial survey coverage in 1986/87 and again in 1992/93 and as a 2000 Game Hunting Area (GHA) 9 moose survey – the areas are not comparable for any of the surveys and the methods are not well described. The Phase II Report (p. 6.10-11) suggests hopefully that: “...it may still be possible to make some generalizations on the size of moose populations in the RCEA ecozones.” but the report is to be an assessment of cumulative effects, not a speculative generalization. More correctly, the report (pp. 6.10-11 to 6.10-12) notes: “The lack of GHA survey data for northern Manitoba limits the ability to extrapolate density estimates to RCEA ecozones.” It was uninformative and the inclusion of the population indicator and its speculative results represents wasted effort.
- A number of surrogate metrics were used to assess the effects of hydroelectric development on moose. A large effort appears to have been exerted in conducting this work but most of it was wasted on unsupported approaches and sparse data.
 - Habitat features (“high quality” habitat; “high quality” riparian habitat, fragmentation) are used as indicators of the effects of hydroelectric development on moose. However,

there are no empirical data used to establish the relationship between habitat features and moose density or behaviour. There is reference made to a few primary scientific literature sources but no clear link between the (limited) available habitat classification data and any credible sources in the primary literature.

- As suggested in the sections on habitat, waterfowl, and beaver it is thought that shoreline moose habitat on major waterways, including Southern Indian Lake, was largely lost and affected by debris accumulation in both the Baldock and Southern Indian TRs (pp. 6.10-40 to 6.10-44 and pp. 6.10-139 to 6.10-140).
- Hunter harvest levels are largely inferred from changes in access by land, without actual measures of hunter kill. The importance of water based access for hunting is mentioned for the Taiga Shield (including the Southern Indian TR). *“Moose hunting on Southern Indian Lake was once associated with fishing activities, especially in late fall, and most moose were taken along the shoreline of the lake”* (Phase II Report p. 6.10-149).
- Disease and parasites are raised as potential factors in moose population decline, but there are no empirical data to support parasites and disease limiting moose in northern Manitoba. Further, at the Bipole III hearings Manitoba Hydro made the argument that there was no evidence of disease and parasite effects on moose populations in the province.
- It is possible that there were few effects of hydroelectric development on regional moose populations. However, access of people and moose to shorelines has likely affected hunting opportunities. As noted in the Phase II Report (p. 6.10-21) in the pre-development period: *“Increased moose numbers were particularly evident from canoe surveys of the area, which indicated high numbers of moose along shorelines.”*
- Despite the weakness in the methods, the assessment of the cumulative effects on moose in the Taiga Shield concludes: *“In summary, while overall the moose population in the Taiga Shield Ecozone does not seem to have been substantially affected by hydroelectric development, appreciable changes have taken place in their distribution and use of areas surrounding Southern Indian Lake and the lower Churchill River. After a period of nearly 40 years since the major alteration of these areas by the CRD, it is not apparent that the resulting negative habitat changes are markedly improving in a way that moose will benefit in the near future.”*

4.5. Failures of RCEA assessment methodology

OPCN finds that the RCEA does not fully examine the concerns we have regarding the effects of the CRD and AFP on our community and environment. Had we been consulted at the outset we feel that the RCEA would have addressed our concerns and would be different document. We believe that if the RCEA had followed CEAA Best Practice Guidelines and employed a full scoping stage that included consultation with OPCN at the outset that OPCN’s experience and opinions would have been incorporated into the approach to the RCEA. The major failings of the assessment methodology are:

- Failure to consult with OPCN during the scoping stage is perhaps the most obvious failing as OPCN’s concerns and ideas are not fully covered in the RCEA. We also note that in the RCEA there was a plan to do this that was not followed. *“Early in Phase II, Manitoba and Manitoba Hydro will work to determine an appropriate public engagement*

process for the RCEA. This process will include opportunities for Aboriginal and other communities in the Region of Interest, as well as other interested parties, to provide their perspectives on the cumulative effects of hydroelectric development in the Region of Interest.”

- One of the advantages of early consultation with us would have been an emphasis on shorelines beginning in the scoping stage. For our environment, the shorelines in Hydraulic Zones 4, 5 and 6 and in the Southern Indian and Baldock Terrestrial Regions are where the majority of change has occurred. The RCEA is hampered by failing to include any RSCs that relate to shoreline processes and then partitioning potential effects on shoreline environments between Land and Water. Therefore by not giving shoreline the weight it is due as a separate category of the assessment, it is basically marginalized.
- The failure to establish pre-development reference conditions, an immediate post-development case, a present day case, and future development cases. The assessment of change and magnitude of change are derived from the comparison of the cases. This, simply put, was not done in the RCEA.
- The inability to establish the present day development case in the analysis. In our area, especially, there is very good data from which to establish the pre-development conditions and the post-development condition. Manitoba and Manitoba Hydro have failed in planning their follow-up monitoring plans to follow the methodologies of the earlier programs. This failure results in the poor data available to assess the present day environment.
- The current aquatic monitoring program, CAMP, is not up to providing the information necessary for a CEA. It must be modified to duplicate the monitoring programs that were initiated by LWCNRSB and DFO in the 1970s and 1980s. The lack of appropriate terrestrial monitoring programs is a concern and hampers the assessment. And a huge gap exists in the data for the assessment of shoreline habitat and assessment.

Our review of the RCEA also finds that:

- Shoreline ecosystem mapping was incomplete for the existing environment period in the Southern Indian TR, comprising about 1/3 of the SIL shoreline; the selected area for classification was non-random. In the pre-development period over 98% of shoreline ecosystem mapping was complete. This represents a failure of the RCEA process that affects determinations of the cumulative effects of hydroelectric development on littoral and riparian habitats, and on wildlife whose assessments are based on habitat metrics.
- When there are data available for the pre-development period, there should be no excuses for Manitoba Hydro to provide current data for comparison. The absence of current (post-development) data or changes from pre-development monitoring or measurement locations or methodologies should not be accepted as a reason for an absence of CEA. Differences between current and historic data that preclude comparison should have been addressed by Manitoba and Manitoba Hydro prior to data collection. The regulator, MCWS, was responsible for holding Manitoba Hydro to an appropriate standard.

- On p. 6.3-314 of RCEA Phase II Report it is stated that “*Reaches with both pre-hydroelectric development and existing environment shore zone mapping for at least one attribute comprised 35% of shoreline length.*” While factually correct, the statement obscures the fact that over 98% of the shoreline was classified for the pre-development period. The absence of comparable pre- and post-development data lies with the failure of Manitoba Hydro to classify the existing environment at the time of the RCEA analyses.
- The shoreline areas that were classified for habitat were not randomly selected. For example, the pre-development shoreline in Southern Indian TR (Table 6.3B-5) was approximately 55% bedrock. In a comparison of pre-and post-development shoreline bank material only 2% of the 1621 km of pre-development shoreline used in the comparison was bedrock. This sort of bias compromises any objective comparisons between pre- and post- development scenarios. It should be avoided through use of appropriate scientific methodology and where it has not been avoided, the bias should be highlighted in the RCEA Report, and the methods used for selecting areas for comparison must be explained. Another example of bias is the diminishing of the sedimentation dynamic in SIL by taking Hecky and McCullough’s findings out of context. Hecky and McCullough estimate that after the CRD there is was a 20-fold increase in the sediment supply to the lake of which 90% is deposited in the near-shore area. The quote of their findings used in the RCEA “Total sediment export at outflows from SIL increased after impoundment (4-5 times)” is also true, but misleading.
- Habitat assessment for wildlife was based on crude and subjective categorizations of habitat features associated with the poorly and incompletely mapped and categorized habitat (see discussions elsewhere in this document). The extensive work conducted to evaluate moose habitat has no relationship to modern wildlife resource evaluation practices (e.g., the use of resource selection functions to yield relative habitat values): there are no clear methods described, nor clear citations as to which primary literature was considered most relevant and why. Consequently the results of habitat based effects assessments are effectively meaningless.
- In Section 6.10.1.5 of the Phase II Report there is an extensive list of limitations in data available for assessing cumulative effects on moose. Coupled with poor methodology, the assessment is not reliable.
- OPCN consultants’ experience with other CEAs suggests that the pre-development baseline data for Physical Environment and Water in our area is among the best data bases they have encountered. Comprehensive, spatial and temporal data are available to characterize the pre-development case for Hydraulic Zone 4 and, to a lesser extent Zones 5 and 6. Why this case is not presented and why the present day and future cases are not developed and compared to the pre-development case is a huge failing of the RCEA. Because the cases were not developed, the RCEA lacks the drive to quantify change and effects for the Physical Environment and Water RSCs.
- Lack of adequate present day data to assess change adequately in Physical Environment and Water VCs. For example, for the assessment of Water in Hydraulic Zone 4, the condition of SIL over the last ten years is inferred from the data collected at 4 water quality monitoring stations. SIL has a surface area of over 2000 sq. km. The size of

the SIL is equivalent to a ten kilometre strip running from Winnipeg to Grand Forks, ND with an average depth of 10 m. Data from only 4 monitoring stations will vastly under represent the conditions in a lake of this size.

- The lack of measurable metrics for the analysis of Physical Environment. If there was a category that could be easily quantified, then it would be the Physical Environment. For example, how have currents changed in Hydraulic Zone 4? There is no real quantitative approach to assessing the change. For example, in Basin 4 of SIL, an explanation of how the flow moves and disperses as it moves through Basin 4 to Missi Falls would allow us to assess impacts on water temperature, DO, water clarity, primary productivity and fish movement by comparing present trends to the studies conducted prior to the CRD and just after its implementation. In Hydraulic Zone 6, what is the difference in the range of velocities experienced under average flow conditions pre- and post-CRD? The failure to quantify change in these and other metrics is a drawback of the current RCEA.
- There are important RSCs missing from the Water category. For example primary productivity and zooplankton, the base of the food chain. There is a huge gap in the pathway of effects from water quality to fish community. The only measure of primary productivity used in the RCEA is Chlorophyll *a*. This is not adequate as it is a surrogate measure of primary productivity. Where are primary productivity and other levels of the food chain assessed before leading to fish and aquatic health?
- For example, in assessing primary productivity using Chlorophyll *a*, the RCEA states that “Patalas and Salki (1984) indicated that chlorophyll *a* concentrations decreased in Areas 2, 3, and 4, were relatively unchanged in Opachuanau Lake and Areas 5 and 6, and were moderately lower in Areas 1 and 7 when comparing pre-CRD (1972) to post-CRD (1977–1980) data.”

It is illuminating to refer to the context of the study that prompted this quote. The abstract for the report says (Patalas and Salki , 1984, p.1.):

“Planktonic crustaceans in Southern Indian Lake were surveyed in 1972 before impoundment, during 1975 when water levels rose above the recorded high level, and then annually from 1977 to 1980 after full impoundment and diversion. Synoptic data were collected in each of these years in midsummer during July or August from a set of 53 stations covering all regions of the lake. Vertical hauls were made at each station using twin nets of 77-µm mesh and 25-cm mouth diameter. In 1972, the crustacean plankton fauna of Southern Indian Lake was composed mainly of 15 copepod and 15 cladoceran species. At least 25 of these species were truly pelagic, while 5 were littoral. Cyclopoids comprised 46% of total crustacean abundance, calanoids 33%, and cladocerans 21%. Dominant species within these three groups were Cyclops bicuspidatus thornasi (37.6% of total abundance), Diaptomus ashlandi (20.1 %), and Chydorus sphaericus (8.9%). Total abundance averaged 76 individuals ind L⁻¹ comparable to more southerly waters such as Lake Ontario (80 ind L⁻¹) and Lake Winnipeg (53-108 ind L⁻¹) (K. Patalas. 1975. Int. Ver. Limnol. Verh. 19: 504-511). Throughout the lake, total crustacean abundances varied from 10 ind L⁻¹ near the Churchill River inflow to between 108 and 200 ind L⁻¹ in a few well protected areas. From 50 to 100 ind L⁻¹ occurred within the main body of Southern Indian Lake. In 1975, an unusually high water year, lake mean plankton abundance was 61 ind L⁻¹. Following diversion in 1976, no dramatic changes in species composition were

observed. However, the mean abundance of crustaceans decreased to 40-46 ind \cdot L⁻¹ during the period 1977-80. Regional zooplankton responses were varied. No significant changes occurred in areas adjacent to the Churchill River inflow, with pre- and post-diversion densities being 35 and 36 ind \cdot L⁻¹, respectively.

In the main water bodies north of the diversion route, abundances declined by 60% and biomass by 50%. A 2-3°C drop in northern basin water temperatures, related to diversion, reduced growth rates by approximately 20% and resulted in a 60% decline in crustacean production. Not all groups of crustaceans responded similarly to impoundment and diversion. Lakewide average numbers of cladocerans declined from 16 to 4 ind \cdot L⁻¹ and the area of their distribution was reduced particularly in northern regions of the lake following impoundment. Cyclopoids declined from 35 to 16 ind \cdot L⁻¹ but showed no change in their distribution. These reductions were related to decreased water temperatures, lower midsummer chlorophyll a concentrations, and decreased water transparencies. The mean abundance of calanoids as a group did not change, but the abundance and distribution of individual species were variably altered. Smaller calanoid species showed either no change or a decrease in their numbers and distribution. Larger species, e.g. *Limnocalanus macrurus*, *Senecella calanoides*, and *Diaptomus sicilis*, were significantly more abundant and widespread following diversion. Similar increases in *Mysis relicta* were also observed. These large species, preferred food items for both whitefish and cisco, are cold stenotherms, inhabiting deeper water layers. Their increased abundance is likely associated with decreased water transparency offering better protection against predatory fish, decreased water temperature creating more favorable conditions, and increased water depth enlarging the volume of deeper waters suitable for these species.”

The above discussion of the findings of the authors work begs two questions of the RCEA: Where is a discussion of this study and similar studies by DFO scientists, including those on primary productivity by Hecky and Guilford (1984), phytoplankton by Hecky Harper and Kling (1974) and Ayles (1974). And where is the recent follow-up information? The full findings of these early studies by DFO scientists go largely unreported in the RCEA.

4.6. Net effects of failures of RSC selection and assessment methods

The net effects of the failures of RSC selection and assessment methods is the weakness of the conclusions about the effects of the CRD or the failure to follow up with suggested remedial action.

- In regards to SIL and water quality RSC concludes with “Effects in SIL included a shift in some basic water chemistry characteristics (alkalinity, specific conductance, hardness, and some major cations) in relation to a change in the flow path and influence of the upper Churchill River. Data suggest a decrease in chlorophyll a (a measure of productivity) but are not definitive. There is evidence that increased shoreline erosion following CRD caused a reduction in water clarity in the lake and this effect may still be occurring today.” (Phase II Report, p. 5.2-209). The weak summary is basically an indictment of current water quality monitoring plans not being up to the task of comparison with the data collected by DFO scientists in the 1970s.
- The assessment of changes to fish correctly points out that “Churchill River Diversion resulted in major changes to fish habitat in SIL and along the diversion route.” And

that *“While there have been some shifts in species composition within SIL, the largest change has been a fairly consistent overall lake-wide decline in CPUE of total catch, Lake Whitefish, and Walleye, when pre-CRD (1972–1975), immediate post-CRD (1976–1982), and current (2008–2013) time periods are compared. And that “ In SIL Area 4 (where most of the commercial fishing occurred until 2012), the Lake Whitefish population is currently characterized by old, slow growing fish that reach a small maximum size and are in poor condition”.* (Phase II Report, p. 5.3-198). Because of the failure of selecting appropriate metrics for other RSCs, the reasons for this decline are not known. Importantly, we know that fish health and populations are affected by CRD, but the not knowing the reasons for this, negates any attempt at exploring mitigation measures. For instance, if we found that the change in the currents after CRD had decreased the nutrient supply, thereby diminishing primary productivity which then food for fish thus impacting there health and population. Then increasing the limits of the Interim License to allow more flow to escape from Missi Falls would increase the flush of nutrients from the Churchill River and would be a mitigation measure that could be considered.

- *“Based on the entire data set for the ROI, mean mercury concentrations of piscivorous fish species from on-system waterbodies have regularly and often substantially exceeded the 0.5 ppm Health Canada standard for the commercial sale of fish”.* (Phase II Report, p. 5.5-98). This is a major concern. Why? Because erosion is still continuing and methyl mercury is continuing to work its way up the food chain. When will this situation improve? That is a question that is not answered in the RCEA.
- Cumulative effects of all developments on terrestrial habitat metrics were considered *“...generally low in 2013”* and *“Corresponding conditions for ecosystem diversity, wetland function and shoreline ecosystems were generally the same as for the terrestrial habitat metrics. Cumulative effects of all human development on most priority habitat types, high quality wetlands and shoreline ecosystems, except for those associated with large rivers, were still well within the low magnitude range for cumulative effects.”* (Phase II Report, p. 6.3-322 to 6.3-323).
- The RCEA report acknowledges that *“Shoreline erosion, sedimentation, and the accumulation of debris continue today, almost 40 years after flooding, in many locations on the regulated system”* and that *“...hydroelectric development created high magnitude cumulative effects on large river shoreline ecosystems.”* (Phase II Report, p. 6.3-323 to p. 6.3-324) yet these changes are not well represented by any of the RSCs chosen for the assessment. The existence of negative effects from on-going shoreline erosion has been evident since CRD operation began. The absence of meaningful valued components and on-going monitoring programs is inexcusable. A scoping exercise at the beginning of the RCEA process would have identified appropriate VCs. The acknowledgement that the accumulation of additional effects is continuing makes it clear that the temporal limits of the RCEA are inadequate as it is not yet possible to assess the final effects of developments from the 1970s.
- The selection of metrics and the methods of comparison obscure the effects of the CRD and water regulation on shorelines.

- The use of terrestrial habitat as an indicator for other RSCs (including waterfowl and beaver) means that absent data or deficiencies in habitat classification either before or after development compromises the assessment of cumulative effects of those other indicators.
- The selection of beaver as the RSC to represent aquatic furbearers eliminated the ability to determine the effects of hydroelectric development on aquatic furbearers in both the Southern Indian and Baldock Terrestrial Regions. If the manner in which their habitat was characterized was correct, beavers on the large lakes and river systems were rare and were therefore not an RSC that could provide much information regarding cumulative effects on shorelines of controlled waterbodies.
- The RCEA Phase II Report notes a concern that widespread moose population decline may be obscuring the effects of hydroelectric development. This is why a proper CEA accounts for all factors that may affect VCs.

4.7. Influence of historical monitoring decisions by Manitoba Hydro and Manitoba Conservation and Water Stewardship

We take exception to the RCEA's characterization of the baseline data being inadequate to establish conditions in SIL before the CRD. Our experience and our consultants' experience with EIAs and CEAs suggest that the baseline data and studies are more than adequate for establishing baseline limnologic conditions on SIL. We however do find that conditions on the lower Churchill River were not as well characterized. We find that there are very good and comprehensive studies carried out by DFO and Fresh Water Institute scientists to characterize aquatic baseline conditions on SIL prior to CRD. There is also good follow-up on these studies immediately after the flooding with some studies continuing into the early eighties. For instance Hecky et al. (1979, p.1) state:

"In 1974 the Freshwater Institute initiated a program of studies on Southern Indian Lake in northern Manitoba (Fig. 1) to document what would be the effects of impoundment of the lake and diversion of the Churchill River from it. Impoundment and diversion were part of a larger hydro-electric development plan which had been the subject of the Federal-Provincial Lake Winnipeg, Churchill and Nelson Rivers Study (L.W.C.N.R. Study Board 1975). This study had attempted to identify and to quantify as far as possible the ecological, economic, and sociological impacts of the hydro-electric development. The Fisheries and Marine Service through its Freshwater Institute had been the lead agency for the Fisheries-Limnology sector of the study and had reported for the years 1972 and 1973 morphometric, physical, chemical, and biological observations on Southern Indian Lake (S. I.L.), other lakes on the Churchill River below S.I.L. and a number of small lakes on the Rat and Burntwood Rivers which would receive diverted Churchill River water (Hecky and Ayles 1974a, b). The earliest physical, chemical, and biological observations on S. I.L. were made by MacTavish (1952).

This data report presents, in detail, physical observations on S.I.L., i.e. temperature, light penetrations, electrical conductivity, suspended material and related parameters. These fundamental physical observations collected with uniform methods and instruments before, during and after the impoundment of S. I .L. and diversion of the Churchill River should prove valuable to the environmental assessment of future developments of similar nature, to investigators interested in

modelling physical processes, and to biologists attempting to relate physical environmental changes to biological parameters.”

What a prescient statement, but none of this data or the chemical and biological data collected by Fresh Water Institute scientists at work on the lake has been followed up on by present monitoring plans. Across the board in the OPCN region of interest there has been a gross failure by MCWS and MB Hydro to follow up on the earlier monitoring data after the mid-eighties. The idea presented through-out the RCEA that proper comparisons could not be made between the data sets is true, but it is the failure of the current monitoring plans, not the earlier ones.

Examples of the incompatibility and poor planning are:

- Temperature, major ions and nutrients were not measured at the same times and places as studies prior to the CRD. This compromises the assessment of changes in these parameters. Only four monitoring sites are active on SIL today compared with over 20 sites in the 1970s;
- Water clarity measurements are not taken close to shore where clarity is the worst, because shoreline erosion is the source of the suspended sediments that cloud the water;
- Benthic studies being are conducted at different places and times than the in studies conducted prior to and immediately after the CRD;
- Gill nets with lengths, depths, mesh sizes and placements, and set orientation (parallel or perpendicular to current) are different than those used in the earlier DFO and other agency studies;
- No attempt was made to measure species composition of phytoplankton planktonic zooplankton and macrophytes in later studies;
- Temperature, major ions and nutrients are not measured at the same times and places as studies prior to the CRD. This compromises the assessment of changes in these parameters;
- Using Chlorophyll a as a measure of productivity without correlating it to the phytoplankton community. Hecky, Harper and Kling (1974) did correlate with the phytoplankton community in the early 1970s and found it was not a good surrogate measure of productivity.

We find it hard to believe that the good studies prior to and shortly after the inception of CRD were not replicated by Manitoba and Manitoba Hydro.

5. An Alternative Framework to Address Concerns of OPCN

OPCN recommends that the RCEA be reopened and reworked along the lines of the CEA process described in Canadian Environmental Assessment Agency technical guidance for a CEA process (CEAA 2015).

We recommend that the process adhere to the following processes:

- Consultation with OPCN and other affected people and organizations in our area of interest.
- A consultative approach to scoping that includes the identification of four cases.
 - Pre-development reference conditions (suggest 1972 to 1974);
 - Immediate post-development case (1976 to 1980);
 - Present day development case (2015 to 2017);
 - Future development case/s (2037 or 20??); and
- Analysis and Assessment.
- Mitigation measures
- Future monitoring plan recommendations.

5.1. Consultative process and Scoping process

We would see the consultative and scoping processes as interactive.

- Get local acceptance for SIL sub-ROI temporal extent. For OPCN the pre hydroelectric development stage can (and possibly did) include a period up to the initiation of construction of the CRD. The temporal period for the SIL sub-region should also include the immediate post development case and the present day case and extend into the future, as riparian and littoral zones are continuing to change as erosion and sedimentation occur;
- Get local acceptance of SIL sub-ROI spatial extent. For OPCN, this would include defining the terrestrial and aquatic ROIs (or at least verifying the chosen areas). The overall extent may or may not have changed from that chosen, but had a study category related to riparian and littoral ecology been included, it could have been explicitly defined to focus the assessment;
- Get local acceptance of SIL sub-ROI study categories (the evaluated categories included people, physical environment, land, and water). For OPCN this may have led to explicit inclusion of riparian and littoral zones affected by erosion and sedimentation. Community concerns about the changes experienced after the CRD point directly at the shoreline and are outlined on June 2017 Presentation Slide 103 of 258 to include a number of factors;
- Consult and develop local RSCs for the SIL sub-region, including terrestrial and aquatic RSCs sensitive to changes in riparian and littoral environments; and
- Define the future development case. A crucial question that OPCN expected to be answered by the RCEA is “When will SIL and the downstream rivers recover from the CRD and what will that recovery look like? The answer to this question lies in defining the future development cases and is missing from the RCEA.

One obvious question in building the approach to the future development case is “When will SIL return to a semblance of its pre-development state?” This may happen when the shoreline of SIL has returned to bedrock control. A return to bedrock control of the shoreline would more than likely mitigate some of the harmful effects of CRD. We would expect rates of erosion and sedimentation to return to the negligible rates experienced pre-development and riparian and littoral zones and water clarity return to conditions similar to the pre-CRD state. The answer to two simple questions could lead to the prediction of when recovery will take place.

- Where is the bedrock contact along the new shoreline of the Lake? and
- What are the rates of erosion along the present shoreline?

Determining the answers would lead to an understanding of the time-line involved for recovery of the lake. The stabilization of the lake may well coincide with the stabilization of the two downstream Hydraulic Zones. This type of analysis is missing from the RCEA.

We would suggest modifying the categories of Physical Environment, Water, Land and People used in the RCEA by adding Shoreline and other categories that may be identified. Changes to the shoreline are a major category of changes that continually come up with our members, whether they are discussing SIL or the Rat and Churchill Rivers. The shoreline is the boundary zone of the land and water and the richest habitat of a lake. Despite occupying a small fraction of the landscape, shorelines and nearshore habitats hold tremendous ecological value. Natural shorelines provide critical spawning and nursery areas for fish, feeding and nesting habitat for shorebirds, habitat for fur bearing animals and amphibians, and are central to processes that dictate water quality. With shoreline added a new set of VCs would have be considered for evaluation.

5.2. Analysis and Assessment

- Locate appropriate data sources for pre-impact period. If data are not available, model pre-impact conditions. Presently, RSCs were selected from a set of components for which data were available – a bias preventing inclusion of things not foreseen as important prior to the development;
- The standard approach is to match pre-impact, post-impact, and current data then analyze effects if there are comparable data from different periods; if current data are not comparable, then they should collect current data to match historic methods and study areas (i.e., go back to historic locations and match the collection methods);
- Project the effects of CRD and AFP into the future to examine future effects of erosion and sedimentation on RSCs. While the RCEA process does not consider future hydroelectric developments, it should have considered ongoing changes resulting from historic developments(mining)and ongoing water regulation as well as climate change.

5.3. Measures to Mitigate Effects

We would identify possible mitigation measures. These would include :

- the role of protective measures for shoreline including the modification to the terms of the AFP.

- a fish ladder at Missi Falls.
- modification to terms of the Interim Water Power License. For example increasing the minimum flow at Missi Falls.

5.4. Future monitoring plans

The CEA process must inform current monitoring plans. One area of immediate improvement that we see would advise is the updating of current monitoring plans by the replication of monitoring sites and adoption of the monitoring methodologies used in the LWCNRSB and DFO studies of the 1970s and 1980s.

6. Conclusion

Our Review of the RCEA finds that:

- OPCN was not consulted before the approach to the RCEA was conceived and implemented by Manitoba and Manitoba Hydro.
- Best practice for Cumulative Effects Assessment (CEA) recommends that analyses of changes are conducted through comparisons of states of the environment at different points in time, referred to as cases. The RCEA fails to establish a pre-development case, an immediate post-development case, a current case and reasonably foreseeable future development cases. Because this practice is not employed, the RCEA does not adequately assess cumulative effects of hydroelectric development in OPCN's region of interest.
- For the Physical Environment, Water and Land RSCs, we find that the comprehensive studies conducted by DFO and other scientists for the Lake Winnipeg , Churchill and Nelson River Study Board (LWCNRSB) before and immediately after the CRD became operational present more than enough data to establish pre-development reference and immediate post-development cases. Coupled to OPCN's traditional knowledge of the area during this time, we find it preposterous that these two cases were not established.
- The early studies by DFO scientists also made predictions about the effects of the CRD on the future aquatic environment of Southern Indian Lake, the main focus of this review. The RCEA failed to follow-up on these predictions, some of which were particularly prescient considering the state of SIL today. The failure to establish a future development case has resulted in the failure to predict when the lake and downstream rivers will recover from the CRD and what that recovery will look like.
- Another disappointment with the document is the failure to recognize shoreline as a major area of concern in the RCEA. This is the zone that bore the brunt of the impacts of the CRD from flooding, erosion and sedimentation, and habitat loss. The portioning of the shoreline between the Physical Environment, Water and Land marginalized the impacts on this zone and reduced the weight that should have been accorded to the effects on the shoreline and near-shore areas.
- The RCEA's analyses are hampered by the lack of recent monitoring data, either because the data were not collected at all, or collected in a fashion that was not compatible with

past techniques. This is inexcusable. Monitoring plans must be modified to duplicate past techniques so that the data gathered is comparable. There have been 43 years since the CRD. Manitoba and Manitoba Hydro have missed an opportunity to gather this information.

For these reasons we recommend that the RCEA be reopened and reworked along the lines of the CEAA guidance for a proper CEA as outlined below:

- I. A scoping process that begins by acquiring scientific evidence and input from the public and Aboriginal groups. Scoping includes several steps to identify:
 - a. potential valued components (VCs),
 - b. VC sensitivity to the Project and other past and future developments through cause-and-effect pathways,
 - c. the identification of VC-appropriate spatial and temporal scales of assessment,
 - d. selection of appropriate metrics and associated benchmarks, thresholds, and methods of analyses,
 - e. establishment of a reference condition to represent the pre-development natural state of the VCs,
 - f. and identification of immediate post development case and present day case and a reasonably foreseeable future development case,

The outcome of scoping is the selection of the VCs that are carried forward for analyses;

2. An analysis stage that assesses the cumulative effects of the Project, and past and reasonably foreseeable future Projects, on each VC at the VC-appropriate spatial and temporal scales. The analyses should be based on assessment cases (i.e., reference conditions, immediate post-development, current, reasonably foreseeable future conditions) and respect the source-pathway-receptor model to establish the relationship between the disturbances and the VC. Project effects that continue to affect the VC into the future must be recognized and accounted for;
3. Identification of mitigation measures should be incorporated throughout the scoping and analyses stages. Existing and proposed mitigation that can remove or reduce effects should inform VC selection and analyses;
4. Determination of significance of cumulative effects on each VC following mitigation;
5. Development of a follow-up program to verify the effectiveness of mitigation measures and assess the actual effects of cumulative development.

For each step, there should be documentation associated with all decisions, e.g., selection or exclusion of VCs, assumptions made, setting of temporal and spatial boundaries, and methods of analyses.

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