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MEMORANDUM

TO: Nechako Water Engagement Initiative

FROM: Heidi Regehr, Ph.D., R.P.Bio., Candace Ashcroft, B.Sc., and Jayson Kurtz, B.Sc., R.P.Biol, P.Biol., Ecofish Research Ltd.

DATE: January 19, 2022

FILE: 1316-07

RE: Potential effects of Nechako Reservoir operations on caribou

1. INTRODUCTION

During Main Table and Technical Working Group meetings of the Nechako Water Engagement Initiative (WEI), concerns were raised regarding potential effects of Rio Tinto operations of the Nechako Reservoir on caribou. The specific concern communicated was that floating and beached woody debris may be blocking caribou (*Rangifer tarandus*) movements on migration and when accessing calving areas. However, WEI participants were unsure of the extent of this effect, or if there were other effects on caribou from operations of the Nechako Reservoir. Given these concerns, Ecofish Research Ltd (Ecofish) was asked by the WEI Technical Working Group to assess potential effects on caribou from the Nechako Reservoir and Rio Tinto operations and identify potential management actions that could be implemented to address any such effects. This memo builds on a concurrent memo that scopes potential effects on wildlife in general (Regehr and Kurtz 2021), to specifically investigate caribou.

2. BACKGROUND: TWEEDSMUIR-ENTIAKO CARIBOU POPULATION STATUS, HABITAT USE, AND THREATS

The caribou population inhabiting the Nechako Reservoir area is the Tweedsmuir-Entiako caribou (TEC) population, which is a local population of the Northern Mountain Caribou population (*Rangifer tarandus* pop. 15). The Northern Mountain Caribou population is listed as Special Concern by COSEWIC (2014) and appears on Schedule 1 of the federal *Species at Risk Act* (SARA) (BC CDC 2021). The population is blue listed in BC and is included in the provincial Identified Wildlife Management Strategy (IWMS) under the provincial *Forest and Range Practices Act* (FRPA). The TEC population is also considered the northern group of the Southern Mountain Population (*Rangifer tarandus* pop. 1), found within the Southern Mountain National Ecological Area (SMNEA) (Environment Canada 2014).

The range of the TEC population is in west-central BC, ~ 200 km southwest of Smithers (Figure 1). Caribou in this local population migrate seasonally, although the patterns of land use by the TEC population has changed since the Nechako Reservoir was created. Flooding of ~45,000 ha of low elevation habitat during impoundment of the Nechako Reservoir in the 1950s is believed to have contributed to abandonment of the winter ranges north of Ootsa and Whitesail lakes (Cichowski 2015). However, forest harvesting, increased human access, altered predator-prey relationships, and reduced population size may also have contributed to this change (BC Parks 2006). Currently, caribou typically winter in the eastern portion of their range (Nechako Plateau) and summer in the western portion of their range (eastern edge of the Coast Mountains) (Figure 1).

Calving is a vulnerable time for caribou and calving areas are the most sensitive of all habitats (Seip and Cichowski 1996). For the TEC population, calving occurs in subalpine areas and in low elevation areas throughout the summer range, including on islands in Whitesail Lake (Cichowski 2015) (Figure 2). Caribou that calve on islands have higher success than those calving at other low elevation locations because the isolation of islands (by a water barrier) provides protection from predators; thus, selection of islands for calving is considered an anti-predator strategy (Seip and Cichowski 1996, Cichowski and MacLean 2005 cited in Cichowski 2015). Within the Nechako Reservoir, the degree of isolation of calving islands from the mainland can be affected by the elevation of water within the reservoir. Thus, because land links to islands increase ease of access for predators, the timing and magnitude of water level changes may affect the suitability of islands for caribou calving.

Multiple issues affecting the TEC population have been identified. In particular, habitat loss and habitat alteration through human activities (e.g., forest harvesting, agricultural use) and through natural disturbances (e.g., fire, pine beetle infestation) affect habitat suitability, and linear developments (e.g., roads) related to industrial activities may increase predator efficiency and human access which can, in turn, have direct effects on caribou (e.g., increased mortality). As described below, reservoir operations have also been identified as having the potential to affect caribou movements and calving success. Recommendations for restoration actions have been developed to address key threats and are outlined in the "Tweedsmuir-Entiako Caribou (*Rangifer tarandus*) Tactical Restoration Plan" (Cichowski *et al.* 2020) (also referred to here as the Tactical Restoration Plan).

Figure 1. Tweedsmuir-Entiako caribou range in west-central BC, as determined from radio-collared caribou from 1983 to 2018 (reproduced from Cichowski et al. 2020). Colours of data points reflect season of occurrence (blue and green data points indicate winter and summer locations of radio-collared caribou, respectively, and yellow and orange data points indicate spring and fall migration locations, respectively).

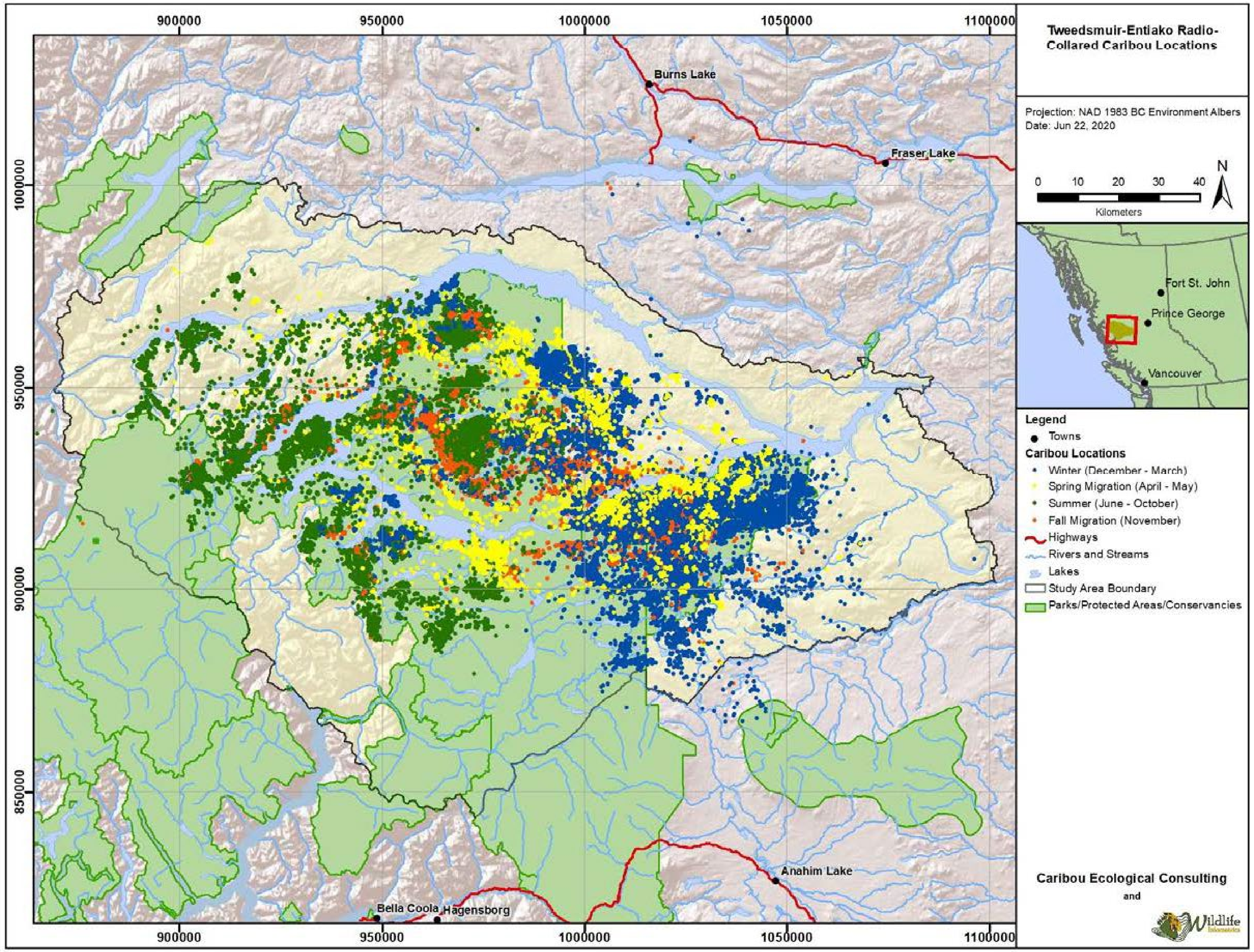
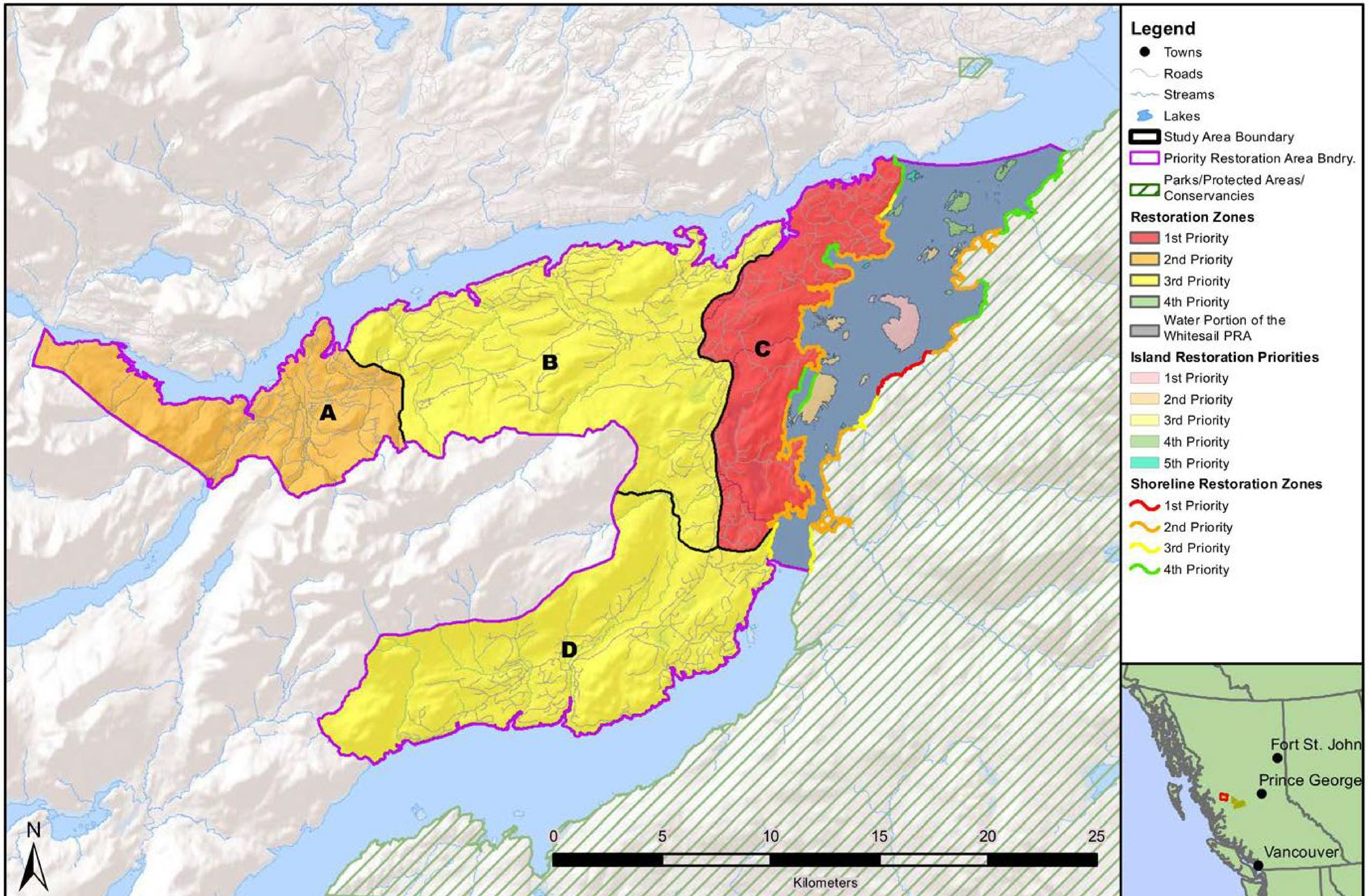


Figure 2. Calving islands in the Whitesail Priority Restoration Area in the Tweedsmuir-Entiako caribou range (reproduced from Cichowski et al. 2020). Calving islands are shown within the dark blue section of the reservoir, with colours of islands indicating island restoration priority.



3. METHODS

The primary method used to identify and evaluate potential effects of Nechako Reservoir operations on caribou was a desktop review of available information. Information was obtained from websites and documents available online. Input was also obtained from local resource professionals, including through a telephone meeting and email exchanges with Anne-Marie Roberts and Duncan McColl of the BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development (BC MFLNRORD), during which effects of Nechako Reservoir operations on caribou were discussed. Additional input was received via an email communication with Deborah Cichowski (Caribou Ecological Consulting) to obtain clarification regarding potential effects identified by her within key documents. Reports from the 1980s environmental assessment of the Kemano Completion Project were not available to review; however, a report documenting baseline wildlife studies (Environmental studies associated with the proposed Kemano Completion Hydroelectric Development. Volume 10: Wildlife resources; issued in 1984 by Envirocon Limited) has been requested which may provide additional information in the future.

In addition to the desktop information review, a specific analysis was conducted to assess the potential for reservoir drawdown to affect the connectivity of caribou calving islands to the mainland. The relative isolation of islands from the mainland is expected to affect the suitability of islands for calving, and because this differs by water elevation within the drawdown zone, reservoir water level elevations from the past 21 years (2001-2020) were overlain onto a digital elevation model (DEM) of the Nechako Reservoir. The DEM was created from contour data provided by Triton Environmental Consultants (Warburton 2021, pers. comm.) and was applied to Whitesail Lake, where identified calving islands are located. Contour data were derived from topography contours and planimetric features produced using photogrammetry techniques from federal aerial photography and TRIM contours of the Neckao Reservoir. Calving islands were identified from Cichowski *et al.* 2020 (see Section 2). The impact on the isolation of these calving islands as reservoir water levels change was evaluated by overlaying a range of operational reservoir water level elevations onto the DEM in 1 m incremental elevational bands and inspecting the resultant images for the presence of land links to calving islands. The water level elevations considered ranged from the minimum operating elevation for the Main (Ootsa Lake) Reservoir (2786.0 ft or 849.17 m) to the elevation when all land links to calving islands are flooded (2805.1 ft or 855 m). Water levels extending several m below the minimum operating elevation were also inspected to determine when land links could form to islands that were isolated at the current minimum operating elevation, and the elevation of 2789.0 ft (850.09 m) was specifically selected for inspection because this was the lowest water elevation that has occurred in the reservoir since 2002.

4. RESULTS

Three potential pathways of effects were identified through which caribou could be impacted by the Nechako Reservoir and Rio Tinto operations: 1) accumulation of shoreline woody debris obstructs caribou movements during migration and when accessing calving islands; 2) exposure of land links to caribou calving islands during reservoir drawdown improves predator access and therefore reduces suitability for calving; and 3) exposure of shorelines during reservoir drawdown affects caribou access to the reservoir. The identified potential effects, followed by management actions that could be implemented to address them, are described by pathway of effect below.

4.1. Accumulation of Woody Debris

4.1.1. Potential Effects

Obstruction of movement due to accumulations of woody debris along reservoir shorelines has been identified as an important potential effect on the TEC population that is related to reservoir operations. The woody debris (i.e., logs) is generated by trees that were flooded during impoundment of the Nechako Reservoir and that are breaking off, becoming mobile, and accumulating along the shorelines (Figure 3). This woody debris has been documented to be obstructing movement of caribou as they migrate seasonally and when they attempt to access calving islands in Whitesail Lake (Cichowski 2015, Cichowski *et al.* 2020). Observations that woody debris along shorelines impede caribou movements have been confirmed with contemporary telemetry data and local observations, which indicate a reduction in use of the calving islands in Whitesail Reach by caribou over time (1983 to present) (Lee and Flowers 2021). The loss of access to calving islands has the potential to impact calf survival and may impact the viability of the TEC population (Lee and Flowers 2021). It has also been observed that the rate of accumulation of woody debris has accelerated in recent years, and the risk that the caribou migration route through Whitesail Lake could be abandoned due to movement obstruction is considered high (DWB 2019, Roberts 2021, pers. comm.).

Figure 3. Accumulated shoreline woody debris in Whitesail Reach in 2019 (photo taken from the Society for Ecosystem Restoration in Northern British Columbia (SERNBC) website: https://sernbc.ca/projects/Whitesail-Reach-Woodland-Caribou-Habitat-Restoration-Project).

Two potential management actions that would reduce the effects of woody debris accumulation on caribou movements are recognized: operational changes and physical works. Each is discussed below.

4.1.1.1. Operations

Although movement obstruction of caribou from woody debris is related to impoundment of the Nechako Reservoir both from the flooding of standing timber and the interruption of debris transport downstream, how reservoir operations (water level management) affect the quantity or location of woody debris deposition along shorelines is unclear. Specific to the Nechako Reservoir, several studies have investigated the potential of harvesting standing, flooded trees (e.g., BC MoF 1998, Hatfield 1998) and have identified effects of floating woody debris on caribou as described above (e.g., Cichowski *et al.* 2020); however, none of these studies have investigated the relationship between reservoir water level fluctuations and woody debris behaviour (movements and deposition on shorelines). More broadly across North America and beyond, studies have been conducted on woody debris inputs to lakes and reservoirs, but few studies have investigated the distribution of shoreline woody debris. Most of these studies acknowledge that there are likely several factors that contribute to woody debris distribution, including wind, currents, ice movement, shoreline shape, and water level (e.g., Kramer and Wohl 2015); however, no studies have identified specific causes or conditions of debris deposition. In BC Hydro Water Use Planning, it was recognized that although specific operations may provide a short-term reduction in the extent to which woody debris that has been deposited on shorelines is mobilized (e.g., avoiding surcharging, holding reservoir low and stable), these operations are not cost-effective long-term solutions and physical debris management was generally adopted (BC Hydro 2005). Specific studies would be required to determine how operations could affect woody debris on the Nechako Reservoir.

4.1.1.2. Physical Works

The Tactical Restoration Plan (Cichowski *et al.* 2020) has identified physical works (i.e., woody debris removal) that could mitigate shoreline woody debris effects on caribou. The Tactical Restoration Plan identifies specific priority restoration areas, and clean-up of woody debris along reservoir and island shorelines is one of the restoration actions for the Whitesail Priority Restoration Area (which is located in the northwestern portion of the TEC range, in primarily low elevation summer range), where caribou movement obstruction during migration and when accessing calving islands has been identified. The Tactical Restoration Plan also developed criteria for selecting priorities for such shoreline clean-up. Four land-based restoration zones have been identified with highest priority assigned to the eastern most zone where caribou exit Whitesail Lake during spring migration, and shoreline segments and island groups have been delineated and prioritized in relation to use for calving. It should be noted that BC MFLNRORD is currently working on establishing a Wildlife Habitat Area (WHA) that will include the Whitesail Priority Restoration Area and this will incorporate an order to protect caribou calving habitat (Cichowski *et al.* 2020, Roberts 2021, pers. comm.).

A pilot project (Whitesail Reach Woodland Caribou Habitat Restoration Project[1]) has been implemented through SERNBC (Society for Ecosystem Restoration in Northern British Columbia) (DWB 2019, Lee and Flowers 2021) to address shoreline woody debris accumulations and additional works could be implemented following a similar approach to address effects of reservoir operations on caribou. The goal of this pilot project was to assess the feasibility of restoring access for caribou to the calving islands in Whitesail Reach through physical works, which involve the mechanised removal of woody debris in priority locations at select treatment sites, and evaluation of the effectiveness of these works through monitoring. An adaptive management framework is being used to evaluate and modify the approach and methods in accordance with feedback on restoration progress obtained from monitoring.

A Project Plan and Site Prescriptions report was developed for the pilot project physical works and for effectiveness monitoring (DWB 2019) and a monitoring report has been produced that provides

[1] https://sernbc.ca/projects/Whitesail-Reach-Woodland-Caribou-Habitat-Restoration-Project.

pre- and post-treatment monitoring results to date (Lee and Flowers 2021). Physical works were implemented by the Cheslatta Carrier Nation in 2019 (Figure 4) and involved the removal of woody debris from a total of 500 m of shoreline (~8.67 ha) and the creation of access trails through ~4.60 ha of woody debris in near and foreshore areas. Islands identified as important calving habitat for caribou were selected as candidates and these were ranked according to six criteria: documented caribou use, the amount of area available, debris density, accessibility, proximity to access, and proximity to anthropogenically disturbed areas. Sites with highest ranking were selected for treatment and pre-treatment monitoring, which involved the installation of remote cameras and conducting pre-treatment woody debris transects (drone flights for obtaining high-resolution aerial imagery was also planned but was deferred until 2020). The largest calving island in Whitesail Reach was chosen as the first candidate for shoreline debris removal in 2019. This island was selected because caribou use has been confirmed in the past five years, it has the highest accumulation of woody debris among islands assessed, and it can be easily accessed by barge and heavy machinery (Lee and Flowers 2021). According to the plans presented in the Project Plan and Site Prescriptions report (DWB 2019) and the first monitoring report (Lee and Flowers 2021), the physical works involved:

- Site reconnaissance – inspection of the site for issues that may affect the approach used for debris management, such as presence of sensitive features and requirements for machine work, and preparation of a detailed site plan;
- Clearing and grubbing – selection and creation of designated sites for clearing and grubbing (e.g., for burn piles, timber storage, and piling);
- Mechanized clearing of submerged and emergent standing timber – removal of timber from the nearshore and foreshore of the treatment sites; and
- Disposal of woody debris – woody debris was disposed of by piling and burning.

Transportation of merchantable timber and woody debris to ancillary sites by barge had also been planned (DWB 2019); however, the woody debris was severely waterlogged and none of it was removed from the island for processing (Lee and Flowers 2021).

Effectiveness monitoring is being completed to evaluate caribou use of treated and untreated islands and the feasibility of shoreline restoration physical works (Lee and Flowers 2021). Effectiveness monitoring involves:

- Remote camera monitoring – analyses of images from remote cameras (installed at 49 stations) are intended to document caribou and other wildlife (e.g., moose, wolves, and bears) occurrences at treated and untreated sites; detections are classified by number, sex, and age of individuals with the objective of allowing comparison of detection rates among time periods.

- GPS collars and telemetry of caribou – GPS data is being used to track use of calving islands by radio-collared caribou during the calving season (late May/early June).
- Woody debris monitoring – a modified Line Intersect Sampling (LIS) method (Marshall *et al.* 2000) is being used to allow quantification and comparison of the volume and mobility of woody debris among time periods; this involves establishing permanent transects along which woody debris diameters are measured and lengths and mobility are categorized; in addition, drone imagery has been obtained of treated and untreated sites post-treatment (obtaining pre-treatment imagery was not feasible) and use of ortho-mosaics created from aerial drone imagery is being investigated as an alternative to the labour intensive ground-based transect method.
- Vegetation monitoring – vegetation plots are established along woody debris transects within distance from shoreline categories (mainland, backshore, and foreshore); vegetation species and mean cover are summarized within plots to provide baseline vegetation information that may correlate with caribou use.

Initial monitoring results indicate that the network of cameras is extremely effective for wildlife detection, and it is anticipated that remote camera monitoring will allow comparison of caribou detection rates over a five-year monitoring period to evaluate effects of restoration on caribou (Lee and Flowers 2021). Changes in detection rates in the year following restoration were not found and were not expected given the recency of restoration and the limited spatial scope of the restoration area to date. Thus, a time lag is expected before effects of restoration will become apparent in caribou response. However, debris removal is anticipated to cause a net improvement of habitat quality over time. Post-treatment woody debris monitoring has not yet occurred due to time constraints, and a modified, less time intensive approach has been proposed for future years. Debris monitoring results will help to evaluate the persistence of shoreline conditions following woody debris removal, what types of sites will most benefit from the approaches employed for this pilot project, and to what extent site maintenance will be required.

It has been recommended that physical works (woody debris removal) are implemented at additional treatment areas in future years to improve our evaluation of the success and effectiveness of the implemented methods (Lee and Flowers 2021, Roberts 2021, pers. comm). Such physical works, along with associated effectiveness monitoring, present a good opportunity for implementation of management action to directly address effects of reservoir operations on caribou. Key potential partners for the implementation of physical works include SERNBC, the Cheslatta Carrier Nation, Canfor, and potentially Environment Canada. BC MFLNRORD may also be involved, although their involvement is anticipated to be focused on caribou monitoring rather than directly participating in, or providing funding for, physical restoration works (Roberts 2021, pers. comm).

Figure 4. Removal of woody debris within Whitesail Reach in 2019 as part of the Whitesail Reach Woodland Caribou Habitat Restoration Project (photo taken from SERNBC website: https://sernbc.ca/projects/Whitesail-Reach-Woodland-Caribou-Habitat-Restoration-Project).

4.2. Exposure of Land Links to Calving Islands

4.2.1. Potential Effects

Reservoir drawdown may create land links to caribou calving islands (Cichowski 2015, Cichowski 2021, pers. comm.) which has the potential to increase predation pressure on caribou during the vulnerable calving period in spring or to cause caribou to seek calving sites elsewhere, in potentially inferior locations. As discussed below, the reservoir water elevation at which identified calving islands (shown in Figure 2) are isolated from the mainland varies among islands. Further, because reservoir water elevation changes seasonally and annually, the isolation of calving islands during the calving period interacts with both magnitude and timing of reservoir water level fluctuations.

Results of applying operational reservoir water level elevations for the past 21 years (2000-2020) (Figure 5) to a DEM of the Nechako Reservoir indicated that at the minimum operating water elevation of 2786 ft (849.17 m), some of the identified calving islands are isolated from the mainland by water while others are not (Figure 6). Among islands that are isolated at the minimum operating water elevation is the large 1st priority island in the centre of the reach (shown in pink in Figure 2 and labelled on Figure 6), which is isolated from the mainland at the minimum operating water elevation by an ~150 m span of water (Figure 6). Modelling indicated that a land link to this 1st priority island only appears when water levels decrease to approximately 2782.2 ft (848 m) (Appendix A). Several other calving islands are also isolated from the mainland at the minimum operating water elevation (shown with yellow arrows in Figure 6).

Islands not isolated from the mainland at the minimum operating water elevation (shown with red arrows in Figure 6) include a group of islands near the northern extent of the calving islands (classified as 4th priority and shown in green in Figure 2, and labelled in Figure 6 and Figure 7). This group of islands do not become isolated until water elevations are between 2792 ft (851 m) and 2795 ft (852 m) (shown with yellow arrows in the upper image of Figure 7; see also Appendix A). Other islands that are not isolated at the minimum operating water elevation are islands in the western section of the reach (classified as 2nd priority and shown in orange in Figure 2, and labelled in Figure 6 and Figure 7). The land links to these islands are not flooded until water elevations approach 2805 ft (855 m) (lower image of Figure 7), which is above the maximum operating elevation (2800 ft (853.4 m); Figure 5). Little difference in terms of the isolation of calving islands was observed between the minimum operating water elevation (2786 ft) and the lowest water elevation that occurred since 2002 (2789 ft) (Appendix A).

Given the seasonality of reservoir water level fluctuations (Figure 5), the timing water levels relative to the calving period is an important consideration when evaluating effects of reservoir drawdown on caribou through the formation of land links to calving islands. Caribou calve in late May to early June (Cichowski 2015). Reservoir water level data for the past 21 years indicate that annual lows in water level have been typically observed in April and water levels are beginning to rise in May, although the extent of drawdown in spring has varied markedly among years (e.g., in 2003 water level in May was ~2794 ft and in 2014 and 2019 it was ~2790 ft) (Table 1, Figure 5). May averages were still within 2 ft of the annual minimum water level in all except four years and varied between 1.5 and 12.0 ft above the minimum operating water level (Table 1). Since 2003, lowest averages in May have been at or above 2790 ft (4 ft above the minimum operating water level). In June, water levels have typically risen to 2 to 4 ft above minimum annual levels and average June water levels ranged between 3.3 and 14.1 ft above the minimum operating water level in the last 21 years. Thus, water levels are typically near annual low levels when caribou are seeking out calving islands at the beginning of the calving period and then begin to rise.

In summary, results of DEM modelling applied to operational water level data indicate that although some identified calving islands are isolated at the minimum operating water elevation (2786 ft, 849.17 m) and are therefore expected to be usable by caribou for calving in all years (e.g., the large 1st priority island in the centre of the reach), others become isolated only at higher water elevations and their isolation during the calving period therefore varies among years. Several islands do not become isolated until ~2795.28 (852 m) water levels are reached (upper image of Figure 7). This water level had been reached in June in just over half of years since 2000 (57%) but had only been reached in May in about a fifth of years (19%; Table 1). Thus, it is likely that the majority of calving islands that have the potential to become isolated during the current operational regime (i.e., are isolated at the maximum operating elevation) have been isolated in late May in roughly a third of years since 2000 (Figure 5). Due to rising water levels in spring, calving islands that are isolated in late May and are selected for calving by caribou at that time are likely to remain isolated (and increase in degree of isolation) throughout the calving period.

Figure 5. Main Reservoir (Ootsa Lake) operating levels from 2000 to 2020. Minimum and maximum operating elevations are shown with solid lines and the elevation of 2795.3 ft, where several calving islands become isolated from the mainland, is shown with a dashed line.

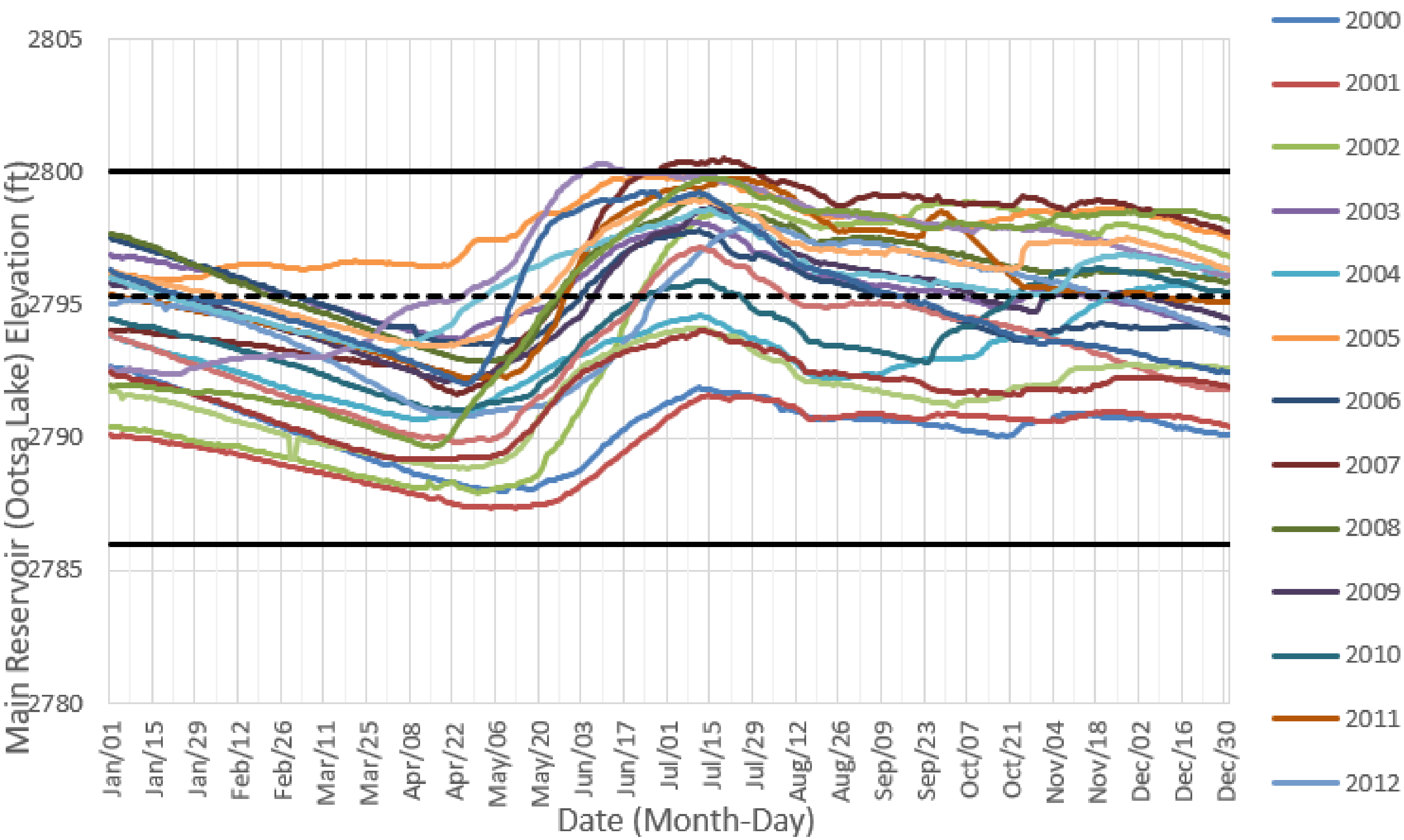


Figure 6. Reservoir water levels (blue) at the minimum operating water elevation (2786.0 ft, 849.17 m). Land links to calving islands are indicated with red arrows and isolated islands (without land links) are indicated with yellow arrows.

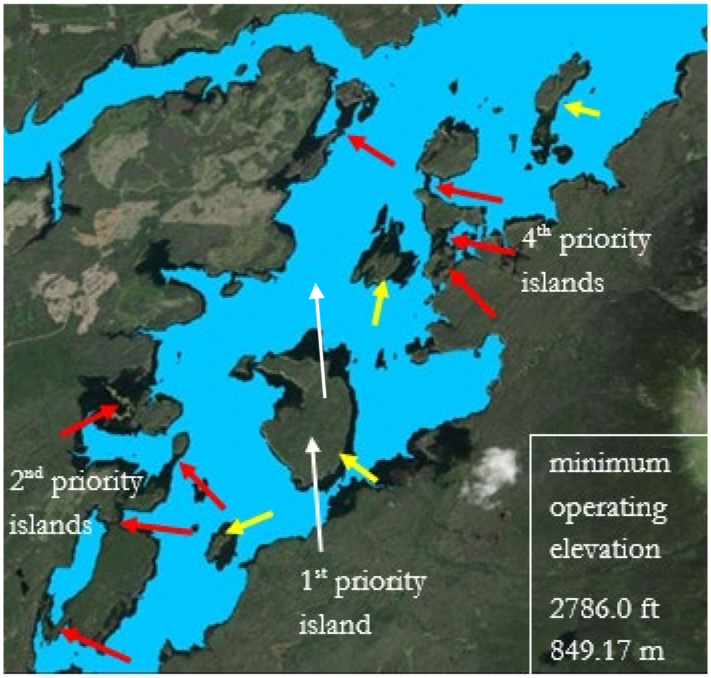
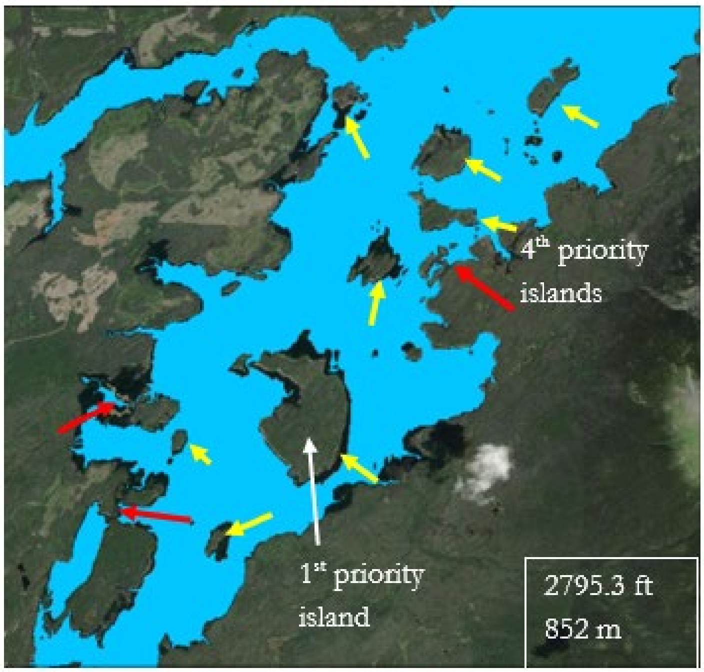


Figure 7. **Reservoir water levels (blue) at 2795.3 (852 m) when land links to the 4th priority northern islands become flooded (upper image), and at 2805.1 ft (855 m) when land links to the 2nd priority western islands become flooded (lower image). Note that the maximum operating elevation is 2800 ft (853.4 m). Land links to calving islands are indicated with red arrows and isolated islands (without land links) are indicated with yellow arrows.**



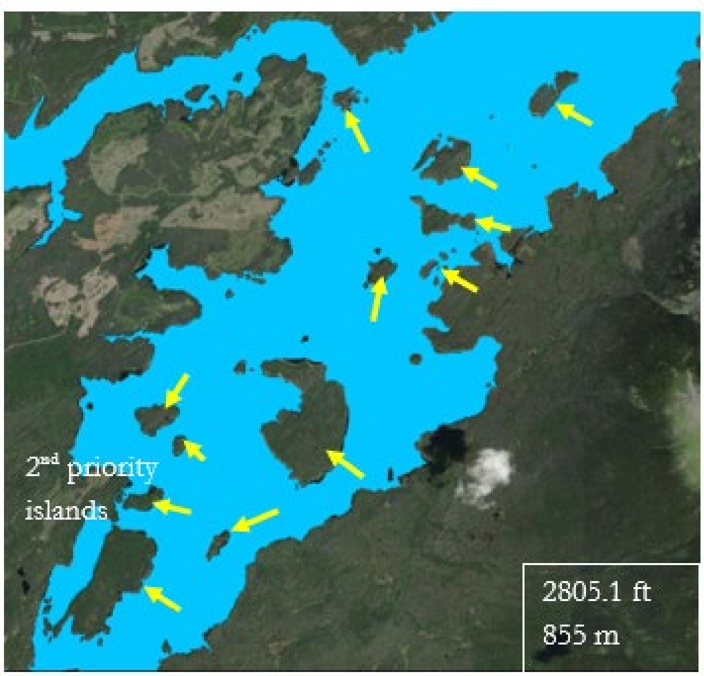


Table 1. Month of lowest annual water levels (main reservoir; Ootsa Lake) from 2000 to 2020 in comparison to water levels in May and June. Water level values, which are given in feet (ft), correspond to monthy averages.

	Lowest Water Level		Water Level in May (ft)		Water Level in June (ft)	
Year	Month	Water Level (ft)	May	Difference[1]	June	Difference[2]
2000	May	2788.21	2788.21	0.00	2790.10	1.89
2001	May	2787.50	2787.50	0.00	2789.35	1.85
2002	April	2788.16	2788.78	0.61	2793.90	5.74
2003	April	2793.94	2794.82	0.87	2797.08	3.13
2004	April	2790.83	2792.15	1.32	2793.69	2.86
2005	January	2796.02	2798.01	1.99	2799.57	3.55
2006	April	2793.78	2793.95	0.16	2796.64	2.85
2007	April	2792.15	2793.89	1.73	2798.86	6.71
2008	April	2793.27	2793.96	0.68	2797.51	4.24
2009	April	2792.36	2793.22	0.86	2796.44	4.08
2010	April	2791.19	2791.85	0.67	2794.66	3.47
2011	April	2792.60	2793.30	0.70	2798.22	5.62
2012	April	2791.07	2791.21	0.14	2793.54	2.48
2013	April	2790.02	2791.11	1.09	2794.62	4.60
2014	April	2788.99	2790.26	1.27	2793.31	4.32
2015	January	2792.50	2797.55	5.05	2800.05	7.55
2016	March	2793.63	2796.23	2.59	2797.58	3.95
2017	April	2793.55	2794.98	1.43	2798.01	4.46
2018	April	2792.56	2796.07	3.51	2798.96	6.41
2019	April	2789.21	2790.37	1.17	2793.06	3.86
2020	April	2790.18	2793.84	3.66	2797.61	7.43

[1] Difference between water level in May and lowest water level in a given year.

[2] Difference between water level in June and lowest water level in a given year.

4.2.2. Management Action

Results of DEM modelling indicate that some potential exists for reservoir water level management to affect the availability of caribou calving islands. Specifically, attaining slightly higher water levels in late May would maximize the availability of calving islands for caribou, given that under current operations, some islands are not isolated at this time in most years. For example, a target for water level management from the perspective of maximizing calving island availability could be attaining water levels of ~2795.28 (852 m) by late May, which is the water level when the majority of calving islands that have the potential to be isolated (i.e., are isolated at the maximum operating elevation) have become isolated. This would have occurred in roughly a third of years in the last 21 years. Three calving islands are not expected to attain isolation even under maximum operating elevations (2800 ft; Appendix A) and it is therefore not possible to affect the isolation of these islands through water management.

Although modelling results indicate that a greater number of calving islands could be made useful to caribou in more years through water management, the value of these islands to caribou for calving is an important consideration when making water use decisions. Modelling indicates that the island ranked as highest priority for restoration by the Tactical Restoration Plan (shown as 1st priority island in Figure 6 and in pink in Figure 2) (Cichowski *et al.* 2020) and several others are isolated at the current minimum operating water elevation and these islands are therefore available to caribou in all years. Islands that are not isolated at the minimum operating elevation and that could therefore be made more available through water management have mostly been ranked as 4th priority islands (one is a 2nd priority island) in the Tactical Restoration Plan (Cichowski *et al.* 2020). However, it should be noted that calving islands were prioritized for restoration based on their use by caribou for calving (Cichowski *et al.* 2020), and it is likely that increasing their probability of isolation in spring through water management would result in greater use (increasing their priority rating). It would also be useful to investigate if and how the degree of isolation of islands (width of water separating the island from other land masses) affects island use and effectiveness for predator avoidance during calving, since the degree of isolation of islands also generally increases as water levels increase, which can be controlled through water management.

It should be noted that maximizing calving island isolation through water management as a management action assumes that island calving sites are currently limited such that more caribou would calve on islands rather than in other locations if more islands were made available. Monitoring for the Whitesail Reach Woodland Caribou Habitat Restoration Project (see Section 4.1.1.2 suggests that this assumption is likely valid. Remote camera monitoring results indicated that the largest calving island (shown as 1st priority island in Figure 6 and in pink in Figure 2) was inhabited by two to three caribou cow-calf pairs during monitoring to date, and it was speculated that, due to the tendency of caribou to spatially segregate during calving (Bergerud and Page 1987), even the largest calving island may only support a small number of individuals (Lee and Flowers 2021). Additional monitoring data collected through the Woodland Caribou Habitat Restoration Project will improve our understanding of the degree to which calving islands are limited and the benefits of increasing calving island availability to the TEC population.

4.3. Exposure of Shorelines

4.3.1. Potential Effects

Reservoir operations have the potential to affect caribou through impacts of reservoir drawdown on the accessibility of shorelines. When reservoir water levels are low, shorelines become exposed that can be steep and muddy in some locations (McColl 2021, pers. comm). Such shorelines may affect the ease at which caribou are able to descend to the water and to climb back onto the shore when crossing the reservoir during migration or swimming to calving islands (Cichowski 2015). Access issues related to exposed shoreline and characteristics of the banks (steepness, presence of vegetation) have also been identified for other wildlife species (McColl 2021, pers. comm.). However, although this potential effect has been identified, no information was found during this review on the magnitude of the potential effect or the locations where shorelines may become difficult to access when reservoir water levels are low. Reservoir operating levels between 2000 and 2020 indicate that reservoir water levels are typically lowest in April (Table 1, Figure 5), which is when the spring caribou migration occurs (Figure 1), and are typically moderate in elevation in November, when the fall caribou migration occurs. Thus, adverse effects on shoreline access due to the magnitude of drawdown is most likely to be apparent in spring when caribou are undergoing their spring migration and when they are accessing calving islands.

4.3.2. Management Action

To our knowledge, enhancements/modifications of drawdown zone shorelines have not been considered or implemented. Investigation of the effects of reservoir drawdown on the accessibility of shorelines would improve our understanding of the extent to which drawdown may affect caribou movement. It could be determined if enhancements are feasible or needed for drawdown zone banks that occur within caribou movement pathways, in accordance with the timing of reservoir water levels during caribou migration periods and current bank characteristics. Riparian habitat enhancement is occurring at other BC Hydro reservoir systems in BC (e.g., Ballin *et al.* 2018, Miller and Hawkes 2020), and approaches similar to those could be implemented to improve bank and riparian habitat characteristics within the drawdown zone. This could improve ease of access, not just for caribou, but also for other wildlife species (McColl 2021, pers. comm.).

5. SUMMARY

Three key pathways of effects through which caribou could be impacted by reservoir operations were identified during this review: accumulations of woody debris along shorelines obstruct caribou movements during migration and when accessing calving islands, exposure of land links to caribou calving islands during reservoir drawdown reduce island suitability for calving, and exposure of shorelines during reservoir drawdown affects caribou access to the reservoir.

Accumulations of woody debris along the shores of the reservoir (including the shorelines of calving islands) that may obstruct caribou movement have resulted from reservoir inundation and this has been identified as the management issue of highest priority that is relevant to operations of the reservoir (Cichowski *et al.* 2020). The rate of accumulation of shoreline debris has accelerated in recent years, increasing the risk that the caribou migration route through Whitesail Lake could be abandoned and that calving islands become inaccessible. Although the potential for reservoir operations (water level management) to address this effect directly may be limited, physical works could be implemented, in collaboration with other partners, to remove and manage debris accumulations. It is recognized that it may be challenging to predict and control debris accumulations, and additional pilot projects that include monitoring of completed works need to be implemented to improve evaluation of program success and effectiveness prior to applying treatments more widely (Roberts 2021, pers. comm). Additionally, effort could also be expended on increasing our understanding of the relationship between the timing and magnitude of water level changes and woody debris behaviour, especially within caribou movement pathways.

Reservoir drawdown has the potential to adversely affect caribou because calving islands can be become connected to the mainland at low reservoir water levels through land links which reduces their effectiveness for predator avoidance (Cichowski 2015, Cichowski 2021, pers. comm.). Results of overlaying operational reservoir water level elevations onto a DEM of the Nechako Reservoir indicted that although some islands remain isolated at the minimum operating water elevation of 2786 ft (849.17 m) (including the largest calving island that has been ranked highest priority for restoration in the Tactical Restoration Plan), the reservoir bed is exposed between some calving islands and the mainland at this water level, creating land links that may reduce the suitability of these islands for calving by caribou. Water levels must reach ~2795.28 (852 m) before the majority of calving islands become isolated, which is roughly estimated to have occurred by late May in approximately one third of years between 2000 and 2020. Some potential therefore exists for increasing the availability of caribou calving islands during the calving period through reservoir water level management. However, water use planning decisions would benefit from confirmation of the benefits to the TEC population of improving isolation for specific calving islands. Some current uncertainties, such as the relative value of calving islands if all were isolated in spring, the extent to which island calving sites are limited, and the benefits of the degree of isolation (i.e., width of isolating channel of water), could be addressed from information obtained from monitoring implemented for the Whitesail Reach Woodland Caribou Habitat Restoration Project (Lee and Flowers 2021).

Drawdown may also cause shorelines within the drawdown zone to become difficult to access due to bank steepness and lack of vegetation which could affect caribou movements during migration or when accessing calving islands. The lowest annual reservoir water levels typically occur during the spring (April) and water levels are typically still low when calving begins (late May), thus adverse effects on shoreline access is most likely to be apparent when caribou are undergoing their spring migration and when they are accessing calving islands. Increased understanding of potential effects of reservoir drawdown on shoreline banks and their impacts caribou movements and potential for mitigation could be obtained by identifying shoreline bank characteristics within caribou movement pathways and determining if, when, and where access difficulties may occur.

In summary, the following recommendations have been made to address the identified potential effects of reservoir operations on caribou:

- Implement physical works to remove, manage, and monitor accumulations of woody debris along main shorelines and the shorelines of caribou calving islands to address caribou movement obstructions in accordance with recommendations made in the Tweedsmuir-Entiako Caribou (*Rangifer tarandus*) Tactical Restoration Plan (Cichowski *et al.* 2020); the works should be developed to complement the pilot project already initiated and be conducted in collaboration with potential partners (e.g., SERNBC, Cheslatta Carrier Nation, Canfor, potentially BC MFLNRORD, Environment Canada).

- Incorporate the effect of drawdown during the caribou calving period on the isolation of calving islands into the evaluation of trade-offs during the structured decision-making water use planning process, taking into consideration and addressing current uncertainties regarding the value of the calving islands to the TEC population that become isolated from the mainland at slightly higher water levels than currently exist in late May in most years.

- Investigate the effects of reservoir drawdown on the accessibility of shorelines to improve our understanding of the extent to which drawdown may affect caribou movement during key movement periods (migrations, movement to calving islands) and to determine if enhancements are feasible or needed for drawdown zone banks that occur within caribou movement pathways.

REFERENCES

Ballin, L., T. Gower, M. Bayly, M. Hocking, M. Sloan, H. Regehr, and D. Lacroix. 2018. JHTWORKS-3: Upper Campbell Reservoir Drawdown Zone Revegetation Treatment Report – Year 1. Draft V2. Consultant's report prepared for BC Hydro by Laich-Kwil-Tach Environmental Assessments Ltd. Partnership and Ecofish Research Ltd., January 12, 2018.

BC CDC (BC Conservation Data Centre). 2021. BC Species and Ecosystems Explorer. Government of British Columbia, Ministry of the Environment, Victoria, BC. Available online at: https://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/conservation-data-centre/explore-cdc-data/species-and-ecosystems-explorer

BC Hydro. 2005. Columbia Water Use Plan: Consultative Committee Report Volumes 1 and 2. Prepared on behalf of the Consultative Committee of the Columbia River Water Use Plan by BC Hydro. 924 pp.

BC MoF (BC Ministry of Forests). 1998. Nechako Reservoir drowned wood survey project. Report #1, Forest cover. Prepared for: Ministry of Forests, Prince Rupert Region Lakes District.

BC Parks. 2006. Management direction statement and ecosystem management plan for Entiako Provincial Park and Entiako Protected Area. BC Parks Ministry of Environment, Environmental Stewardship Division, November 2006. Available online at: https://bcparks.ca/planning/mgmtplns/entiako/entiako_mds.pdf?v=1617836692626. Accessed on October 25, 2021.

Bergerud, A.T., and R.E. Page. 1987. Displacement and dispersion of parturient caribou at calving as antipredator tactics. Canadian Journal of Zoology 65:1597-1606. Available online at: https://cdnsciencepub.com/doi/pdf/10.1139/z87-249. Accessed on October 25, 2021.

Cichowski, D., and N. MacLean. 2005. Tweedsmuir-Entiako caribou population – technical background information summary (1983-2003). Prepared for Ministry of Environment, Smithers, B.C. 199 p.

Cichowski, D. 2015. Tweedsmuir-Entiako caribou population status and background information summary. Consultant's report prepared for BC Ministry of Forests, Lands and Natural Resource Operations by Caribou Ecological Consulting, December 2015. Available online at: https://a100.gov.bc.ca/pub/acat/documents/r55188/TweedsmuirCaribouPopulationStatusandBackgroundInf_1542742511092_2741941772.pdf. Accessed on October 25, 2021.

Cichowski, D., R.S McNay, and V. Brumovsky. 2020. Tweedsmuir-Entiako Caribou (*Rangifer tarandus*) Tactical Restoration Plan. Prepared for BC Ministry of Forests, Lands, Natural Resources Operations and Rural Development. Smithers, BC. Available at: https://hctf.ca/wp-content/uploads/2020/10/TEC-Tactical-Restoration-Plan-Final-for-web.pdf. Accessed on October 25, 2021.

COSEWIC (2014) COSEWIC assessment and status report on the Caribou Rangifer tarandus, Northern Mountain population, Central Mountain population and Southern Mountain population in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xxii+113 pp. (www.registrelep-sararegistry.gc.ca/default_e.cfm). Available online at: https://www.registrelep-sararegistry.gc.ca/virtual_sara/files/cosewic/sr_Caribou_Northern_Central_Southern_2014_e.pdf. Accessed on October 25, 2021.

DWB (DWB Consulting Service Ltd.). 2019. Whitesail reach caribou calving islands rehabilitation: project plan and site prescriptions. Prepared for Society of Ecological Restoration in Northern BC (SERNbc) by DWB Consulting Service Ltd, March 2019. Available online at https://sernbc.ca/uploads/library/additional_related/Caribou_Recovery/Whitesail_Reach_Habitat_Recovery_Project_Plan_and_Site_Prescriptions_March_22_2019.pdf. Accessed on October 25, 2021.

Environment Canada. 2014. Recovery Strategy for the Woodland Caribou, Southern Mountain population (*Rangifer tarandus caribou*) in Canada. Species at Risk Act Recovery Strategy Series. Environment Canada, Ottawa. viii + 103 pp. Available online at: https://www.registrelep-sararegistry.gc.ca/default.asp?lang=En&n=5837FBB5-1. Accessed on October 25, 2021.

Hatfield (Hatfield Consultants Ltd.). 1998. Nechako Reservoir Impacts of Timber Salvage on Fish and Fish Habitat, 1997 Studies. Consultant report prepared for BC Ministry of Environment, Lands, and Parks, Skeena Region. Smithers, BC.

Kramer, N. and E. Wohl. (2015). Driftcretions: The legacy impacts of driftwood on shoreline morphology. Geophysical Research Letters, 42(14), 5855-5864.

Lee, J. and M. Flowers. 2021. Whitesail Reach woodland caribou habitat recovery project: effectiveness monitoring plan and early monitoring (2019 to 2020). Prepared for Ecosystem Restoration in Northern BC. 37 pp.

Marshall, P.L., G. Davis, and V.M. LeMay. 2000. Using line intersect sampling for Coarse Woody Debris. Forest Research Technical Report, BC Forest Service. 34 pp.

Miller, M.T. and V.C. Hawkes. 2020. CLBMON-9 Kinbasket Reservoir monitoring of revegetation efforts and vegetation composition analysis: Final Report—2008-2019. Unpublished Report by LGL Limited, Sidney, BC, for BC Hydro Generation, Water Licence Requirements, Burnaby, BC. 59 pp. + App. Available online at: https://www.bchydro.com/content/dam/BCHydro/customer-portal/documents/corporate/environment-sustainability/water-use-planning/southern-interior/clbmon-9-yr10-2020-04-20.pdfv. Accessed on October 25, 2021.

Regehr, H. and J. Kurtz. 2021. Potential effects of Nechako Reservoir operations on wildlife. Consultant's memorandum prepared for the Nechako Water Engagement Initiative by Ecofish Research Ltd., October 28, 2021.

Seip, D.R., and D.B. Cichowski. 1996. Population ecology of caribou in British Columbia. The Sixth North American Caribou Workshop; *Rangifer* Special Issue No. 9, 73-80. Available online at: file:///C:/Users/hregehr/Downloads/1223-Article%20Text-4660-1-10-20110107.pdf. Accessed on October 25, 2021.

Personal Communications

Cichowski, D. 2021. Caribou Ecological Consulting. Email communication with H. Regehr, Ecofish Research Ltd, on April 20, 2021.

McColl, D. 2021. Ecosystems Biologist at the Ministry of Forests, Lands, Natural Resource Operations & Development (FLNRORD). Telephone communication with H. Regehr, J. Kurtz, and Jennifer Carter, Ecofish Research Ltd., on March 23, 2021.

Roberts, A-M. 2021. Wildlife Ecologist at the Ministry of Forests, Lands, Natural Resource Operations & Development (FLNRORD). Telephone communication with H. Regehr, J. Kurtz, and Jennifer Carter, Ecofish Research Ltd., on March 23, 2021.

Warburton, D. 2021. Triton Environmental Consultants. Email communication with J. Carter, Ecofish Research Ltd. on February 17, 2021.

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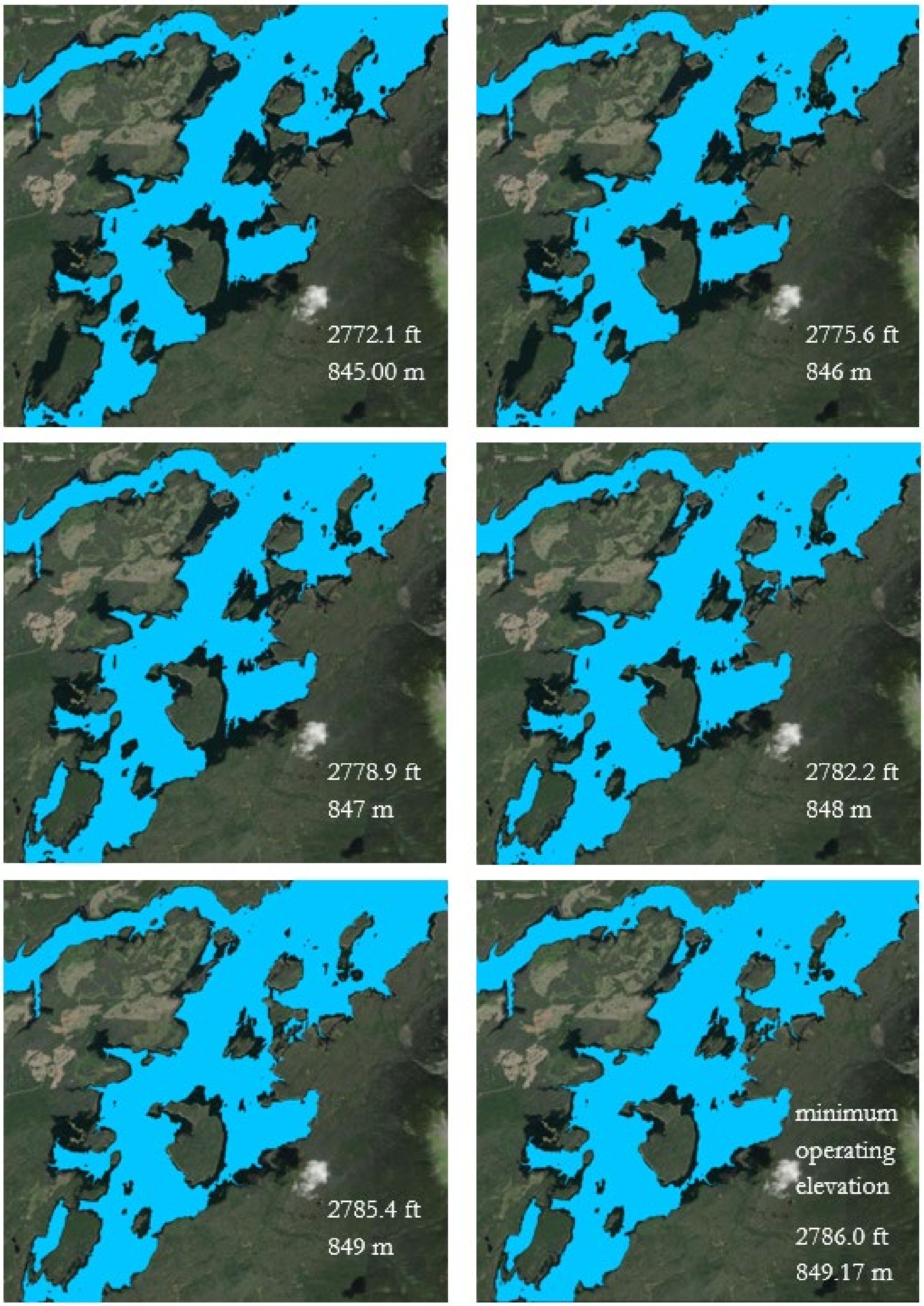
APPENDICES

Appendix A. Water levels (blue) at various reservoir water elevations.



Appendix A Continued.