Ecofish Research Ltd.
Suite 101 - 2918 Eby Street
Terrace, B.C. V8G 2X5

Phone: 250-635-7364
info@ecofishresearch.com
www.ecofishresearch.com

MEMORANDUM

TO: **Nechako Water Engagement Initiative**

FROM: **Xuezhong Yu, Ph.D., P.Eng., Jennifer Carter, B.Sc., R.P.Bio., Jayson Kurtz, B.Sc., R.P.Bio., P.Biol., and Jonathan Abell, Ph.D., E.P., Ecofish Research Ltd.**

DATE: **December 12, 2022**

FILE: **1316-09**

RE: **Review of Total Dissolved Gas Downstream of Skins Lake Spillway and Cheslatta Falls**

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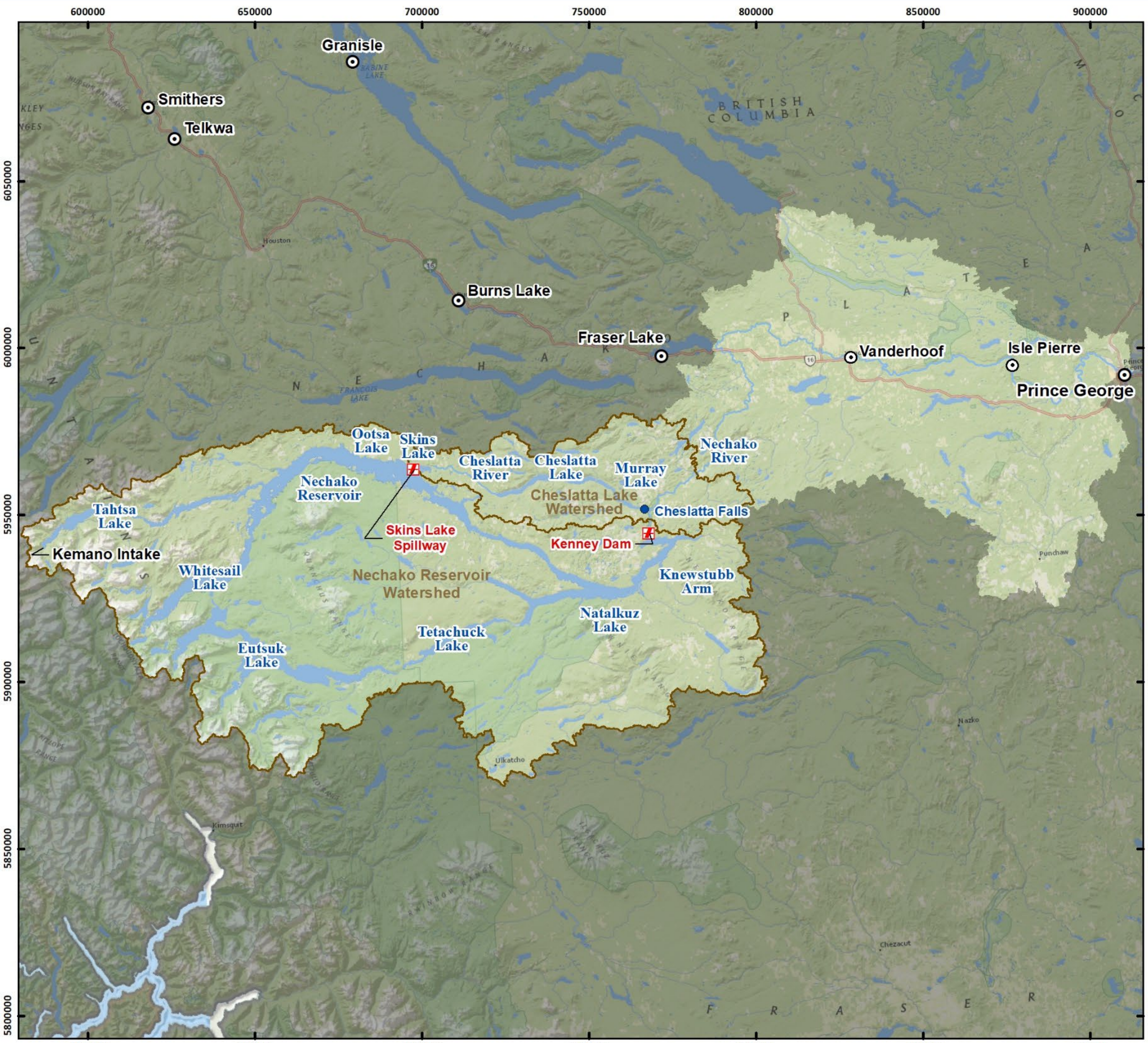
1. INTRODUCTION

During Main Table and Technical Working Group meetings of the Nechako Water Engagement Initiative (WEI), concerns were raised regarding potential effects of increased total gas pressure (TGP) on fish downstream of Skins Lake Spillway and Cheslatta Falls that may result from Rio Tinto operations (Map 1). Ecofish Research Ltd. (Ecofish) was asked by the WEI Technical Working Group to evaluate the relationship between Rio Tinto operations and TGP and make recommendations regarding next steps that could be taken to address or further assess potential effects to fish. This memo provides background to the issue of TGP including applicable TGP guidelines (Section 1) and provides a focused review of studies completed in the watershed regarding TGP and its effects on fish downstream of Skins Lake Spillway and Cheslatta Falls (Section 3). The Discussion (Section 4) considers data gaps, potential performance measures, and operational considerations.

NECHAKO RIVER

Project Overview



Legend

- Community
- Dam
- Lakes
- Fish Barrier

MAP SHOULD NOT BE USED FOR LEGAL OR NAVIGATIONAL PURPOSES

0 5 10 20 30 40 50 60 km

Scale: 1:1,625,000

NO.	DATE	REVISION	BY
1	2022-05-12	1316_NCH_SkinsLakeSpillway_4998_20220512	CGA
2			
3			
4			
5			

Date Saved: 2022-05-12
Coordinate System: NAD 1983 UTM Zone 9N

ECOFISH RESEARCH

Map 1

Path: M:\Projects-Active\1316\MXD\1316_NCH_SkinsLakeSpillway_4998_20220512.mxd

2. BACKGROUND

2.1. Total Gas Pressure

Water can dissolve specific amounts of atmospheric gases that depend on temperature and pressure. TGP is the sum of partial pressures of all constituents of total dissolved gas (TDG) in solution including nitrogen, oxygen, water vapor, and trace gases such as argon and carbon dioxide at the prevailing water temperature. Air is a mixture of several gases and dry air contains 78.08% nitrogen, 20.95% oxygen, 0.93% argon, 0.04% carbon dioxide, and small amounts of other gases. At equilibrium, TGP will be equal to the atmospheric pressure, and the water will be saturated with the component gases.

$$TGP = pN_2 + pO_2 + pH_2O$$

where

TGP = total gas pressure (mm Hg)

pN_2 = partial pressure of dissolved nitrogen, argon, and other trace gases (mm Hg)

pO_2 = partial pressure of dissolved oxygen (mm Hg)

pH_2O = vapor pressure of water (mm Hg)

TGP levels can also be expressed as excess gas pressure (ΔP) or percent of local atmospheric pressure (TGP%).

$$\Delta P = TGP - pAtm$$

$$TGP\% = (TGP \div pAtm) \times 100\%$$

where

ΔP = excess gas pressure (mm Hg)

$pAtm$ = atmospheric pressure (mm Hg)

Elevated levels of dissolved gases occur when water and entrained atmospheric gases are forced together under pressure in plunge pools below dam spillways and waterfalls. Spillway release at hydroelectric facilities and flow over waterfalls can potentially cause dissolved gas supersaturation (DGS), which is a condition that occurs when the partial pressures of atmospheric gases in solution exceed their respective partial pressures in the atmosphere. Water can be supersaturated (TGP > 100%) when water plunges to depth at the plunge pool of a dam or waterfall, and the potential for supersaturation depends on several factors that include spillway/waterfall discharge, upstream TGP, spillway/waterfall height, plunge pool presence/design, and spillway design (BC Hydro 2013; Weitkamp and Katz 1980). Additionally, when water temperatures rise, e.g., in reservoirs during spring and early summer, the solubility of dissolved gas in water decreases and gas supersaturation can occur (Harvey 1967). Turbulence at features such as riffles and canyons can also affect TGP by promoting degassing, which reduces TGP (Weitkamp and Katz 1980).

2.2. Effects of TGP on Fish

Individual gases can be supersaturated in water without adverse effects to aquatic organisms. However, when the sum of the partial pressures of all dissolved gases exceeds atmospheric pressure, there is the potential for gas bubbles to develop in water and associated aquatic organisms. This causes a condition known as gas bubble trauma (GBT), also known as gas bubble disease, which impairs swimming ability, increases susceptibility to infection and predation, and can cause death. DGS can affect all aquatic and marine organisms, including fish, invertebrates, and plants. Fish are the most sensitive organisms in marine and freshwater environments to adverse effects of DGS. Therefore, most research in the field has been focused on freshwater fish with the major emphasis on trout and Pacific salmon species (Weitkamp and Katz 1980; Colt *et al.* 1986; Fidler and Miller 1997).

Bubble growth can occur in the tissues (skin, fins, tails, mouth, and eyeballs) and circulatory system when the difference in TGP between blood or tissue and the external environment (water) is great enough to exceed dissipation that would occur naturally through diffusion and gill ventilation (Weitkamp and Katz 1980; Alderdice and Jensen 1985; Jensen 1987). Symptoms of GBT vary according to the level of supersaturation, duration of exposure and species and age (life cycle stage) of fish. Salmonids are among the least tolerant species of fish. Of the various life stages of salmonids, fingerling to smolt-sized fish are most susceptible to DGS, followed by adults, fry and eggs in that order (Alderdice and Jensen 1985).

GBT can be divided into chronic and acute toxicity, depending on the level of TGP and period of fish exposure, life cycle stage of the fish, and the combination of O_2/N_2 ratio, temperature, and atmospheric barometric pressure, variables which have a 'sparing' effect (Rowland 1986; Rowland and Jensen 1988). The chronic range extends from at least 105.1% to 109.7% TGP, and acute GBT begins around 110% TGP (Alderdice and Jensen 1985). A general boundary between chronic and acute toxicity may occur around 110% to 112% TGP (Alderdice and Jensen 1985; Rowland 1986; Rowland and Jensen 1988).

In addition to life cycle stage, other factors modify the response of fish to TGP. Water depth plays a key role in the ability of fish to hydrostatically compensate for TGP. TGP decreases approximately 1% for every 10 cm depth, hence a fish exposed to surface waters of 110% saturation would be exposed to 100% saturation at 1 m depth. Lower water temperature also provides protection against the formation of excess TGP. As water temperature decreases, the solubility of dissolved gases increases, resulting in lower levels of supersaturation. Higher oxygen-to-nitrogen ratios are believed to have a 'sparing' effect on the response of fish to excess TGP. When the water is supersaturated with TDG but the molar oxygen-to-nitrogen ratio approaches one, oxygen consumption in the tissues reduces the TDG pressure inside the fish and reduces the risk of GBT.

2.3. Fish Community

The Cheslatta system, Nechako River and its tributaries support a variety of fish species including anadromous and resident fish. Three anadromous Pacific salmon species (Sockeye (*Oncorhynchus nerka*), Coho (*O. kisutch*), and Chinook (*O. tshawytscha*) Salmon)) utilize the Nechako River for migration, spawning, or rearing (Carter and Kurtz 2022). Furthermore, the Cheslatta system and the Nechako River provides habitat for numerous resident species including White Sturgeon (*Acipenser transmontanus*), Bull Trout (*Salvelinus confluentus*), Dolly Varden (*S. malma*), Rainbow Trout (*O. mykiss*), Mountain Whitefish (*Prosopium williamsoni*), Pygmy Whitefish (*P. coulterii*), kokanee (*O. nerka*), Burbot (*Lota lota*), and various sculpin, sucker, and minnow species (Johnson *et al.* 2022). In the context of fish sensitivity to TGP, Rainbow Trout and sucker species are the most sensitive species to TGP those studied to date (Triton and Aspen 2005).

2.4. TGP Guidelines

Water quality guidelines are scientifically derived quantitative thresholds or narrative statements that are considered protective of values such as aquatic life (BC ENV 2019). Water quality guidelines do not have direct legal standing and guidelines exceedances do not mean that adverse effects will occur, but rather that further investigation may be warranted (BC ENV 2019).

For TGP, water quality guidelines for the protection of aquatic life have been established at a federal level by the Canadian Council of Ministers of the Environment (CCME 1999). At a provincial level, the BC government has also developed TGP water quality guidelines for the protection of aquatic life (Table 1; BC MOE 2004). These provincial guidelines were developed to specifically protect life in BC waters and are therefore considered the most applicable TGP guidelines in relation to the Nechako River (although the federal guidelines are broadly consistent with the BC guidelines).

Table 1. **Summary of guidelines for total gas pressure (TGP) in British Columbia (BC MOE 2004).**

Water Use	Recommended Guideline
Drinking Water Supply	None Proposed
Freshwater and Marine Aquatic Life	Maximum $\Delta P < 76$ mmHg (or < 110% at sea level)
Background Levels Higher than Recommended Guidelines	No increase in ΔP or %TGP
Hatchery Environments	Maximum $\Delta P = 24$ mmHg (or 103% at sea level; $\Delta P = 0$ mmHg when pO_2 is <100 mmHg)
Wildlife	None Proposed
Livestock Water Supply	None Proposed
Irrigation	None Proposed
Primary-contact Recreation	None Proposed

Provincial TGP guidelines were derived following two principles: (1) the guidelines should protect fish in natural waterbodies from the effects of swim bladder overinflation; (2) the guidelines should protect fish in hatchery environments (Fidler 2004). The BC TGP guidelines set 110% TGP as the upper acceptable limit for the protection of freshwater and marine aquatic life, which is also adopted by CCME Dissolved Gas Supersaturation guidelines (CCME 1999) and US Water Quality Standards (US EPA 1986). Additional restrictions are required for hatchery environments where shallow water, crowding, and added exposure to diseases increases stress beyond that encountered in natural environments (Fidler and Miller 1997).

Application of the primary provincial TGP guideline of 110% may be conservative in some situations where fish are subject to short duration exposure and/or fish can swim to depth and achieve depth compensation (Fidler 2004; BC Hydro 2013), as further discussed below. Thus, reliance on the provincial guideline without considering those other factors can result in unnecessary costly mitigation. For context, BC Hydro has defined alternative management thresholds that are less conservative than the present water quality guidelines in some cases by incorporating variables such as duration of exposure and water depth (BC Hydro 2013). BC Hydro uses their TDG management thresholds to determine the need for mitigative actions, additional monitoring/study and agency notification.

TGP criteria have been proposed for salmonids in the Nechako River. In salmonids, symptoms of chronic GBT were observed after exposure to levels of TGP above 104–105% (Jensen 1987). Acute GBT symptoms are observed at and above 110%, along with continuing chronic symptoms (Alderdice and Jensen 1985; Jensen 1987). Levels of risk for salmonids in the Nechako River corresponding to excess TGP were proposed based on prediction of 50% mortality, informed by multivariate analysis of literature data and field studies in the watershed (Table 2; Jensen 1987).

When considering Table 2, it is important to note that exposure time and depth have a major influence on the potential for GBT to arise in fish at a specific level of TGP. For example, model predictions that informed the thresholds in Table 2 indicate that, at TGP of <120%, 50% mortality would only occur if depth is shallow and exposure duration is long, e.g., 20 days at TGP of 112.7% and depth of 0.1 m (Jensen 1987). Biological risk is substantially reduced at depth > 1 m and fish can recover promptly from GBT if they can swim to depth to increase ambient hydrostatic pressure, or leave the high TGP environment for sufficient time to allow the excess dissolved gas to dissipate (Weitkamp and Katz 1980; Fidler and Miller 1997; Weitkamp 2008).

Table 2. Levels of risk to TGP for salmonids in the Nechako River (Jensen 1987).

Level of Risk[1]	Range of TGP
No Risk	< 104% TGP
Low Risk	104-109% TGP
Moderate Risk	109-112% TGP
High Risk	> 112% TGP

[1] These risks do not apply to eggs, which are more resistant to gas supersaturation (by 6 to 9% TGP).

3. REVIEW OF TGP AND GBT STUDIES IN THE NECHAKO WATERSHED

TGP and GBT have been investigated in the Nechako River by government agencies and the Aluminium Company of Canada (Alcan) since 1974 (Clark 1977; Rowland 1986). Particularly detailed studies were conducted in the late 1980s as part of Alcan's proposed Kemano Completion Project (KCP). The studies include monitoring TGP and associated effects of DGS on salmonids at Cheslatta Falls and Skins Lake Spillway. Furthermore, a TGP modelling study was conducted to support the design of a Cold Water Release Facility (CWRF) at Kenney Dam (Triton and Aspen 2005). Key information from these studies is summarized by location in the following subsections.

3.1. Cheslatta Falls and Nechako River

3.1.1. TGP Monitoring

Numerous studies have investigated TGP at Cheslatta Falls and GBT in the Nechako River. As described below, these studies monitored TGP levels in the Nechako River downstream of Cheslatta Falls, and spatial/temporal variation in TGP was analyzed.

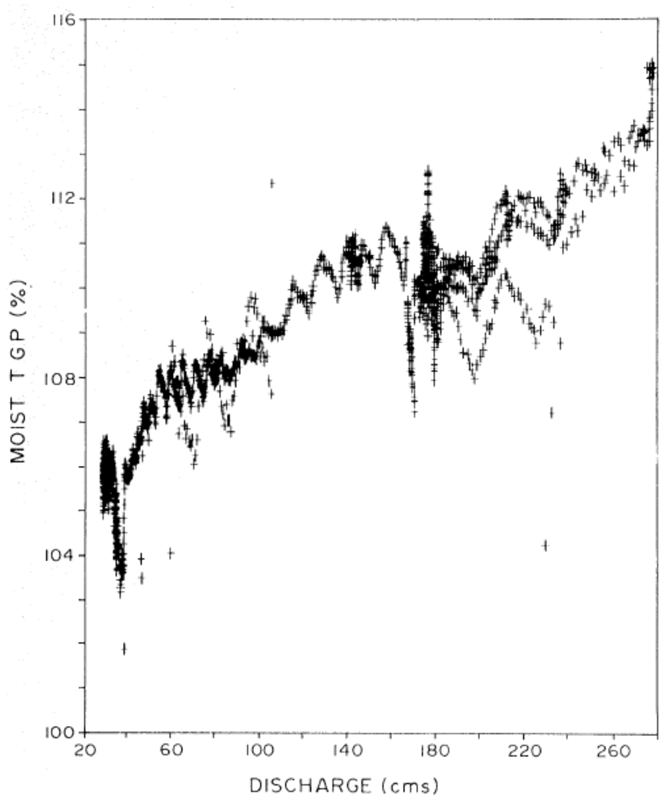
TGP levels are believed to have increased in the Nechako River after the filling of the Nechako Reservoir and commencement of operation of the Skins Lake Spillway. Although pre-development TGP data were not recorded in the Nechako River, levels were estimated to likely have been close to 100% (Rowland 1986). The mean annual discharge (MAD) from the Cheslatta system and over Cheslatta Falls was approximately 5 m^3/s prior to the operation of the Skins Lake Spillway in 1956 (Golder 2005). MAD at Cheslatta Falls increased after diversion from Nechako Reservoir; Skins Lake Spillway operations are variable but recent MAD at SLS is ~75 m^3/s (1990-2020).

Water plunging at the base of Cheslatta Falls is the primary cause of high levels of TGP in the Nechako River (Servizi 1987). TGP values below Cheslatta Falls measured in 2004 (averaging 117.5% in May and 115% in October) were greater than TGP levels measured below the Skins Lake Spillway (averaging 114% in May and 112% in October). Upstream of Cheslatta Falls, TGP degassing would occur downstream of the Skins Lake Spillway because the lakes chain could improve retention time and improve the dissipation of supersaturated gas (see Section 3.2.1).

Several trends in TGP are apparent as water flows over Cheslatta Falls and into the Nechako River (Rowland and Jensen 1988). First, TGP increases when water flows over Cheslatta Falls and is plunged to depth in the plunge pool at the base of the falls. During the survey in May 2004, TGP levels upstream of Cheslatta Falls were 105% and increased to 117–118% below Cheslatta Falls. Second, there is a positive correlation between discharge over Cheslatta Falls and TGP level. TGP measured at a site 500 m downstream of Cheslatta Falls ranged from 101.9% to 115.0% during July 12 and September 23, 1986 while the discharge at Water Survey of Canada (WSC) station 08JA017 (Nechako River below Cheslatta Falls) ranged from 35.4 m^3/s to 278 m^3/s (Figure 1). River discharge of 170 m^3/s or greater gave rise to TGP levels of 110% or more downstream of Cheslatta Falls (Rowland 1986). Third, at a specific flow, there is generally a decrease in TGP with increasing distance downstream of Cheslatta Falls, except during summer, when solar heating can cause river temperatures to increase downstream, causing an increase in TGP. Finally, cyclic diurnal variations in TGP occur under some flow and atmospheric conditions (Rowland and Jensen 1988).

There are two periods when conditions in the Nechako River can cause excess TGP that put fish at risk resulting from GBT (Jensen 1987). These periods occur in mid-June to mid-July (when maximum solar heating can occur) and in mid-July to mid-August (when increased flows are necessary for cooling as part of the Summer Temperature Management Program).

Figure 1. **TGP versus discharge at Cheslatta Falls (reproduced from Rowland and Jensen 1988).**



3.1.2. Effects of TGP on Fish

Field studies in the Nechako River in July and August of 1985 and 1986 showed that Nechako River salmonid (juvenile chinook, rainbow trout, and mountain whitefish) exhibited GBT signs when held in cages near the water surface. The field study in 1985 observed extensive hemorrhaging in the fins and eyes of fish exposed at the test sites, which can be symptomatic of gas bubble trauma (Rowland 1986). In addition, the mortality rates at the Cheslatta Falls test site seemed to be strongly correlated with the magnitude of gas supersaturation (Rowland 1986; Rowland and Jensen 1988). After 10 days of exposure during a field survey in 1986, fish in cages where fish were held near the surface or where fish had access to the surface (volitional cage) were subject to approximately twice the mortality of fish held at depth, where the water pressure compensated for excess gas pressure (Jensen 1987; Rowland and Jensen 1988). However, this trend did not continue after this period. Total mortality near the base of Cheslatta Falls was 55%, 63% and 75% in surface, volitional and 1-m-deep cages after 20 days of exposure, respectively. However, the mortality that occurred in the latter 9 days of exposure could have been due to factors other than gas supersaturation, such as the confined space of the test cages, lack of food, and capture, holding, and transportation of fishes (Rowland and Jensen 1988).

Although GBT signs were observed in the Nechako River, data on fish production in the river collected by the Nechako Fisheries Conservation Program indicated that the salmon stocks in the river were being maintained at levels approaching pre-Kenney Dam levels (Triton and Aspen 2005; NFCP 2005). This observation suggested that GBT was not causing a population-level effect in the fish community.

3.2. Skins Lake Spillway and Cheslatta System

3.2.1. TGP Monitoring

Relatively little information on TGP and GBT was identified for Skins Lake Spillway and the Cheslatta system. TGP levels in the Cheslatta system were monitored in 2004, but observations regarding the occurrence of GBT in fish were not available.

Field studies by Triton and Aspen (2005) indicated that TGP levels in the Cheslatta system were generally lower than in the Nechako River. TGP values below the Skins Lake Spillway ranged from 113% to 115% on May 10, 2004 and ranged from 111% to 113% on October 2, 2004. Daily discharge for Skins Lake Spillway, Nechako Reservoir (08JA013) on May 10 and Oct 2, 2004 was 53.2 m^3/s and 29.5 m^3/s, respectively. Spilled water is discharged into a chain of lakes (Skins, Cheslatta, and Murray Lake) that are expected to reduce TGP levels by increasing retention time, increasing the area of air-water gas exchange, and potentially diluting with cooler bottom waters. TGP values decreased to 109–110% on May 10, 2004 and to 108% on October 2, 2004 at the monitoring site at the inflow to Cheslatta Lake and continued to decrease to 105% and 98-100% at the outlet of Murray Lake on May 10, 2004 and October 2, 2004, respectively. However, TGP levels during the periods of highest discharge and temperature are unknown.

3.2.2. Effects of TGP on Fish

The biological effects of elevated TGP have not been studied in the Cheslatta River system. TGP levels decrease to about 110% upstream of Cheslatta Lake and access to deep habitats in lakes may provide sufficient depth compensation for fish in the Cheslatta River system. Therefore, GBT is not expected to be an issue in the Cheslatta River system for normal levels of discharge over Skins Lake Spillway. However, the effects of TGP on fish during the periods of highest discharge and temperature may temporarily cause stress or mortality.

3.3. Kenney Dam

3.3.1. TGP Modelling

A steady-state model was used to evaluate the effect of planned water release at Kenney Dam on TGP at Cheslatta Falls (Triton and Aspen 2005). TGP levels below the dam were estimated based on data from BC Hydro's Seven Mile Dam on the Pend d'Oreille River, which has a similar spillway to that proposed for Kenney Dam. The field data at Seven Mile Dam suggested that a 10% increase in TGP can occur as water flows over Kenney Dam. Modelling results indicated that TGP levels will decrease in a downstream direction between Kenney Dam and Cheslatta Falls. In the modelling scenarios, TGP levels at Cheslatta Falls ranged from 106.4% to 109.5% for Nechako Canyon flows of 14.2 m^3/s to 509 m^3/s, that were not higher than levels currently observed. In a worst case, TGP levels immediately below Cheslatta Falls could be limited to approximately 117%, which is similar to those observed at Cheslatta Falls in 2004.

3.3.2. Effects of TGP on Fish

Biological effects of gas supersaturation downstream of Kenney Dam were not modelled or analyzed.

4. DISCUSSION

4.1. Data Gaps

TGP levels during extremely high flow events have not been measured in the Nechako River. The maximum discharge during TGP monitoring was 293 m^3/s in 1985, however the annual maximum instantaneous discharge has ranged from 176 m^3/s to 622 m^3/s for Nechako River below Cheslatta Falls (08JA017) during the period of 1980 to 2021. High flows are expected to produce higher levels of TGP at the base of Cheslatta Falls, and such TGP levels are expected to remain elevated for a longer distance downstream in the Nechako River, compared to conditions at lower flows. Additionally, TGP levels at Skins Lake Spillway and throughout the Cheslatta system were only monitored in 2004 (Triton and Aspen 2005), and maximum TGP and water temperature are unknown.

The spatial extent of dissolved gas supersaturation has not been investigated in the Nechako River. Previous surveys have focused on TGP monitoring and GBT observation downstream of Cheslatta Falls, but no investigation and analysis were conducted to characterize dissipation of TGP and identify the locations where TGP levels decreased to below the maximum recommended thresholds in guidelines.

4.2. Preliminary Performance Measures

Performance measures are metrics for evaluating how changes in flow affect a particular interest or issue. The following section(s) describe favourable flow scenarios, performance measures, and/or objectives for the key issues discussed earlier in this document. This information is provided for consideration by the WEI Technical Working Group and Main Table to support the structured decision-making process. It is important to recognize that the draft performance measures, etc. presented here might be revised, replaced, or ignored depending on the specific needs and interest of the WEI.

There are several uncertainties (Section 4.1) that limit our understanding of the links between TGP and Rio Tinto operations. Nonetheless, it is possible to identify potential preliminary performance measures (PMs) to evaluate biological risks to fish associated with TGP in the Nechako River, based on existing information collected in the watershed about TGP and knowledge of its biological effects.

Two preliminary PMs described below have been identified for initial consideration by the WEI Technical Working Group. These PMs may be refined during the Water Use Planning process, e.g., if additional information becomes available or if redundancy is identified with other PMs.

- PM1: Average # days/year when discharge ≥ 170 m^3/s over Cheslatta Falls.

TGP monitoring at Cheslatta Falls (Figure 1) indicates that TGP >110% when discharge over the falls > 170 m^3/s. 110% is the provincial TGP guideline BC MOE (2004) and corresponds to the low end of a "moderate" category of risk identified for salmonids in the Nechako watershed (Table 2). PM1 therefore describes the duration when TGP is predicted to exceed 110% in the Nechako River. Higher values for PM1 denote higher biological risk.

Assumptions that underpin PM1 are that TGP >110% when discharge ≥ 170 m^3/s and that TGP >110% presents a biological risk to fish in the Nechako River. PM1 does not explicitly consider risks upstream of Cheslatta Falls, where existing information indicates that TGP is of lower biological risk.

- PM2: Mean annual TGP below Cheslatta Falls on days when discharge ≥ 170 m^3/s over Cheslatta Falls.

The relationship between discharge over Cheslatta Falls and TGP levels downstream can be expressed with the following linear regression equation:

$$\text{Eq. 1} \qquad y = 105.14 + 0.029x \ (R^2 = 0.82)$$

where y is TGP as percent saturation and x is mean daily discharge in m^3/s. Eq. 1 is based on data collected at discharge of ~30–280 m^3/s during monitoring below Cheslatta Falls (Figure 1; Rowland and Jensen 1988).

PM2 is calculated by using Eq. 1 to estimate mean daily TGP for each day included in the discharge time series when mean daily discharge ≥ 170 m^3/s[1]. Mean daily values of TGP are then averaged for each year, with an overall average then calculated based on average values for all years in the time series. Higher values for PM2 denote higher biological risk.

[1] Based on Eq. 1, the threshold discharge is slightly lower (167.6 m^3/s); however, the rounded value is used here for simplicity, recognizing that TGP is affected by multiple other factors (see variance in data in Figure 1).

As for PM1, PM2 quantifies estimated risk to fish in the Nechako River, although PM2 accounts for the positive correlation between TGP and discharge. Thus, PM1 (a superior indicator of the duration of effects) and PM2 (a superior indicator of the magnitude of TGP) are intended to be complementary. Assumptions that underpin PM2 are the same as those for PM1, plus the assumption that TGP levels below Cheslatta Falls increase linearly with discharge in accordance with Eq.1. It is recognized that Eq. 1 is based on data collected over thirty years ago; however, the lack of current data is not expected to be an important source of error because generation of TGP is expected to be principally related to the physical configuration of Cheslatta Falls and the associated plunge pool, which are not expected to have changed substantively since the monitoring was conducted.

4.3. Operational Considerations

The relationship between Rio Tinto operations and TGP levels in the Nechako River was not explicitly evaluated in previous studies. Flow releases at Skins Lake Spillway are positively correlated with TGP levels (Figure 1) and reducing reservoir release at Skins Lake Spillway could reduce TGP levels in the Nechako River. TGP levels are expected to be lower than 110% downstream of Cheslatta Falls when Skins Lake Spillway release is lower than 170 m^3/s. The operational feasibility of reducing water release from Nechako Reservoir to limit the occurrence of discharge > 170 m^3/s at Cheslatta Falls, while meeting various water use requirements in the Nechako River, is uncertain and would require further evaluation.

5. CONCLUSION

This document outlines general information on TGP and GBT and summarizes existing information about gas supersaturation and its biological effects at key locations in the Nechako River system. Key findings of previous surveys and outcomes from this review are:

- TGP conditions are generally well characterized for the Nechako River at Cheslatta Falls and Skins Lake Spillway. There is a positive correlation between discharge over Cheslatta Falls and TGP levels downstream, and TGP can exceed 110% (provincial guideline) when discharge exceeds 170 m^3/s at Cheslatta Falls.
- GBT studies at Cheslatta Falls and in the Nechako River downstream showed that juvenile Chinook were adversely affected by gas supersaturation, and the mortality rates below Cheslatta Falls were strongly positively correlated with TGP.
- There are several information gaps. TGP levels during extremely high flow events have not been recorded in the Nechako River and therefore TGP surveys may be required to investigate TGP below Cheslatta Falls at flow greater than 290 m^3/s. TGP surveys at Skins Lake Spillway and down the Cheslatta system would also be valuable during periods of high discharge, particularly in the early summer when warming and photosynthesis can elevate background

TGP. Additional TGP monitoring is also desirable to determine the spatial extent of dissolved gas supersaturation in the Nechako River.

- Two potential preliminary PMs are proposed for consideration by the WEI Technical Working Group.

Yours truly,

Ecofish Research Ltd.
EGBC Permit #1002952

Prepared by:	Reviewed by:
Xuezhong Yu, Ph.D., P.Eng.	Jonathan Abell, Ph.D., E.P.
Water Resources Engineer	Environmental Scientist, Limnologist

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