FWCP Arctic Grayling Monitoring Framework for the Williston Reservoir Watershed

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1.0 BACKGROUND

1.1 Issue and purpose

Williston Reservoir, formed following construction of the 183-m high W.A.C. Bennett Dam in 1967, flooded roughly 350 km of the Peace, Finlay, and Parsnip river valleys (Hirst 1991). Prior to impoundment, Arctic Grayling (*Thymallus arcticus*) were widespread and abundant in tributary streams of these valleys (Withler 1959; Bruce and Starr 1985). Afterwards, however, Arctic Grayling were essentially extirpated from the flooded lower reaches of the Parsnip and Finlay rivers and upper reach of the Peace River, and from most of the tributary streams to these reaches where they had formerly thrived (Northcote 1993; Stamford et al. 2015). Self-sustaining populations of Arctic Grayling now appear restricted to just eight of the larger watersheds (Parsnip, Nation, Omineca, Osilinka, Mesilinka, Ingenika, Finlay, Toodoggone) in reaches not affected by reservoir drawdown.

The Fish and Wildlife Compensation Program (FWCP) was established to conserve and enhance fish and wildlife resources affected by BC Hydro dam construction. The FWCP *Streams Action Plan* (FWCP 2014) identifies four over-arching strategic objectives for the conservation and enhancement of priority fish species, of which the Arctic Grayling is one, in the Peace Basin:

Conservation – Maintain or improve the conservation status of species or ecosystems of concern.

Conservation – Maintain or improve the integrity and productivity of ecosystems and habitats.

Sustainable use – Maintain or improve opportunities for sustainable use, including harvesting and other uses.

Community engagement – Build and maintain relationships with stakeholders and aboriginal communities.

In 2016, a major study was conducted by FWCP (Stamford et al. 2017) to evaluate the existing knowledge base relative to these strategic objectives, and fulfill objective *1b-1* of the *Streams Action Plan*:

> Review existing information (including provincial management plan), summarize status and trends of Arctic Graying and its habitats, undertake actions that are within the FWCP scope and lead directly to the development of conservation and enhancement actions, and develop a cost-effective monitoring program to assess status and trends.

This monitoring framework report is a companion document to the Stamford et al. (2017) information synthesis, and has three objectives: 1) to summarize the key findings of the Stamford et al. (2017) information synthesis, 2) to delineate a monitoring framework that supports conservation and enhancement actions, and 3) to present critical information gaps along with potential monitoring needs in a tabular form that facilitates future work.

The purpose of this companion document is to guide future projects to fulfill actions *1b-2*,[1] *1b-3*,[2] and *1b-4*[3] in the *Streams Action Plan*. It is not a substitute for the larger Stamford et al. (2017) information synthesis, however, which contains extensive reference material and watershed-specific background information. Therefore, both should be consulted and referenced by proponents wishing to develop detailed proposals for FWCP-funded Arctic Grayling studies.

1.2 Background biological information

Life History. A detailed life history review for the Arctic Grayling (with emphasis on Williston Reservoir watershed populations) is presented in Section *2.2* of the Stamford et al. (2017) information synthesis. Key points from this review are paraphrased below, but the Stamford et al. (2017) document should be consulted for further information and references.

The Stamford et al. (2017) review identifies two key life history characteristics that define the Arctic Grayling species: 1) its potential for long, complex migrations among critical habitats,[4] which may span hundreds of kilometers between overwintering, spawning and summer feeding areas that often include different river systems, and 2) specific habitat requirements that may have narrow ranges of tolerance. The implications of these life history characteristics are that life history and locations of critical habitats must be known with relatively high precision, for conservation and enhancement actions to be effective at recovering the abundance and distribution of Williston Arctic Grayling.

Natal streams utilized for spawning and early rearing provide productive environments for rapid growth. Newly-emerged Arctic Grayling fry are weak swimmers, and a key habitat requirement is the availability of low velocity areas along channel margins (and including side channels, back channels, and alcoves) located in relatively close proximity to the spawning area. Williston Arctic Grayling fry are thought to remain in the vicinity of the natal area during the first part of summer, and by fall they drift or move downstream into larger stream reaches (e.g. Parsnip River, Ingenika River mainstems) to overwinter. In the Williston watershed, these downstream reaches are utilized by juveniles 100-200 mm (age-1+ to age-2+) throughout the year, and also correspond with overwinter habitat utilized by subadult and adult Arctic Grayling. Beginning in their second or third year of life, subadult Arctic Grayling join adults in making migrations from overwintering locations, often in an upstream direction, to summer feeding habitats in runs and pools of smaller, clear stream reaches, which depending on the population may be in different streams. Clear stream reaches appear to be critical for summer rearing of subadults and adults,

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[1] Implement high priority habitat restoration options for Arctic Grayling

[2] Undertake Arctic Grayling monitoring as per recommendations of the monitoring program and develop specific, prioritized recommendations for habitat-based actions which correspond to the monitoring results.

[3] Review Arctic Grayling monitoring results, refine and implement specific plans in response, as needed. Identify limiting factors to direct conservation and enhancement efforts.

[4] Habitats necessary to complete the life cycle, and which have the potential to limit population productivity.

likely because they are highly dependent on sight for feeding (Stamford et al. 2017, Section *2.2* and references therein).

Once maturity is reached, Williston Arctic Grayling undertake spring migrations to suitable spawning habitat beginning during the late-April/early-May period, with timing apparently associated with water temperature. Spawning in the Parsnip watershed appears to occur between late-May and late-June, at sites located mostly in the lower reaches of the Anzac and Table rivers and in the Parsnip mainstem. In these larger stream reaches, multiple-channel and side-channel locations with abundant small gravel appear to be preferentially selected. It remains unclear at what size and age Williston Arctic Grayling become mature, or how long they live (Stamford et al. 2017, Section *2.2* and references therein).

Limiting factors. Limiting factors are those that have the potential to affect the productivity of fish populations. Potential factors limiting Arctic Grayling productivity in the Williston Reservoir watershed are reviewed in Section *2.3* of Stamford et al. (2017), and include: 1) availability of rearing space at key life stages, 2) aquatic ecosystem productivity, 3) parasitism and disease, 4) interspecific competition, 5) predation, 6) habitat degradation, and 7) angling exploitation. With the exception of parasitism and disease, moderate-to-high support for all these potential limiting factors exists in the biological literature (Stamford et al. 2017, Section *2.3* and references therein). These factors are variously considered to have moderate-to-high likelihoods of affecting Arctic Grayling distribution and abundance within the Williston Reservoir watershed, but direct evidence for their operation in the basin is generally lacking (Stamford et al. 2017).

Relative to pre-impoundment conditions, the most significant factors limiting potential Arctic Grayling productivity in the upper Peace Basin have probably been physical habitat and ecological changes, along with interrupted connectivity among populations, resulting from the flooding of critical habitats. Arctic Grayling of the Williston Reservoir watershed do not appear to be adapted to a lake-dwelling life history, as indicated by the lack of lake-dwelling populations, the loss of populations in direct tributaries to the reservoir, and by a failed introduction experiment in Calais Lake in the Nation River watershed (reviewed in Stamford et al. 2017). Juvenile rearing and subadult/adult overwintering locations for Arctic Grayling within the Williston watershed tend to be located downstream of spawning reaches in larger mainstem rivers (Stamford et al. 2017, Section *2.3.1* and references therein). This pattern of downstream movement during ontogeny, coupled with the flooding that transformed mainstem river habitat into a large lake, is a leading potential hypothesis for the extirpation of grayling from a minimum of 24 tributaries to Williston Reservoir following inundation (Stamford et al. 2015). Having a better understanding of this potential limiting factor is key to successfully re-colonizing this lost range.

2.0 ARCTIC GRAYLING MONITORING FRAMEWORK

2.1 Key monitoring data requirements

In the process of delineating knowledge gaps that limit the ability to initiate conservation and enhancement actions, Stamford et al. (2017) identify four types of monitoring data most relevant to the Streams Action Plan strategic objectives:

1. Population data indicating conservation status and risk. ‘Conservation status’ can be defined as an estimate of overall population viability, or health. In British Columbia, Arctic Grayling conservation status is currently being estimated on the basis of four indicators: 1) *Distribution* (km), 2) *Abundance* of adult grayling, 3) *Trend* in abundance, and 4) *Threats* (Stamford et al. 2015). Conservation status is the key indicator of success with respect to *Streams Action Plan* strategic objectives for conservation and sustainable use (Section *1.1* above). Furthermore, conservation status estimates also provide a basis for prioritizing conservation/enhancement actions and monitoring requirements, with high priority populations being those that are at risk or potentially at risk, have high value for British Columbians, and have a high recovery potential if actions are undertaken. These conservation status estimates are made at the spatial scale of the ‘core area,’ which can be defined as a population or group of populations made up of individuals that are genetically similar and demographically linked. Eight core areas have been identified for the upper Peace Basin upstream of the W.A.C. Bennet Dam: Parsnip, Nation, Omineca, Ingenika, Williston, Upper Peace, Lower Finlay, and Upper Finlay/Toodoggone (Figure 1). Stamford et al. (2017) utilize this system of core areas to organize information about conservation status and critical habitats, and to identify information gaps and potential monitoring needs needed to address them.

2. Information delineating critical habitats. Critical habitats are those utilized during key life history stages and where limiting factors may operate. For conservation and enhancement actions to be effective in boosting the productivity of Arctic Grayling populations, they must target a limiting factor operating within critical grayling habitat. Because conservation and enhancement actions may come at a significant financial cost, precision requirements for estimates of critical habitats are high (±1 km or less depending on the enhancement action).

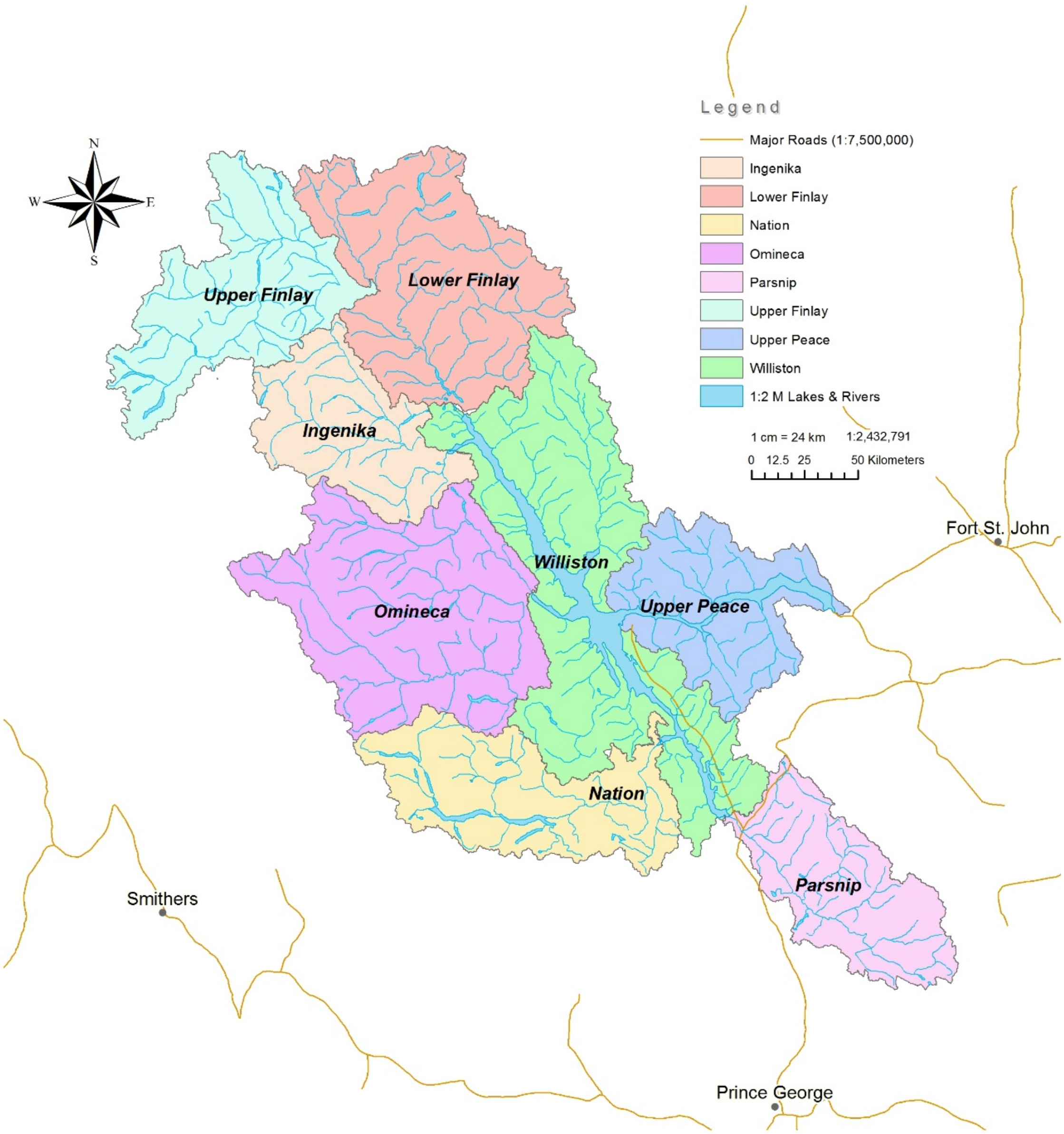

Figure 1. Arctic Grayling 'core areas' (putative metapopulations) comprising the range of Arctic Grayling in the Williston Reservoir watershed (reprinted from Stamford et al. 2017).

3. Information indicating potential limiting factors. Monitoring data that directly demonstrates limiting factors is relatively rare, but this is key information guiding potential conservation and enhancement strategies. If the factor targeted during enhancement activities is not limiting the population, then increased Arctic Grayling abundance at the completion of the life cycle is by definition unlikely. Limiting factors can be assessed in several ways: 1) directly in controlled or natural experiments, such as stream fertilization experiments (e.g. Wilson et al. 2008), 2) indirectly utilizing fish habitat assessment (e.g. Johnston and Slaney 1996) or threats assessment methodologies, or 3) indirectly using correlation studies or professional judgments. In the absence of prior information about limiting factors, conservation and enhancement actions should be treated as experiments, so that good effectiveness monitoring can provide an indication of limiting factors to guide future projects, as well as a basis for 'tuning' the enhancement prescription to improve the results.

4. Information about the effectiveness of enhancements. Effectiveness monitoring is a key component of adaptive management, and is necessary for assessing the cost-effectiveness of conservation/enhancement actions, estimating failure rates for physical habitat structures, identifying unintended ecological consequences, and acquiring feedback necessary for fine-tuning the approach. As mentioned in the preceding paragraph, effectiveness monitoring following conservation and enhancement actions may also be important in building a knowledge base with respect to limiting factors.

2.2 Recommended sequence of monitoring needs

Within Arctic Grayling core areas of the Williston Reservoir watershed, a quick start to on-the-ground conservation and enhancement actions is not feasible until information gaps related to population data, critical habitats and limiting factors are addressed. Monitoring studies need to be ordered in a logical sequence, with each step depending upon successful accomplishment of prior steps:

> **Step 1**. Acquire population data (abundance, trend, distribution) and indicators of aquatic ecosystem health (threats) for the purposes of: 1) delineating critical habitats 2) assessing conservation status (and the need for conservation and enhancement actions), 3) prioritizing among candidate locations for conservation and enhancement actions, and 4) establishing a quantitative baseline for effectiveness monitoring.
>
> **Step 2**. Identify critical habitats utilized by key Arctic Grayling life stages, at the level of geographic accuracy suitable for delineating conservation and enhancement actions (e.g. ± 1 km).
>
> **Step 3**. Assess potential limiting factors (see preceding section) operating within critical habitats, in order to design and initiate conservation and enhancement actions.
>
> **Step 4**. Implement conservation and enhancement actions based on achievements of previous objectives, and acquire quantitative population data (abundance, trend, distribution)

necessary to assess the effectiveness of conservation and enhancement actions (and refine knowledge of limiting factors – see preceding section).

Studies to be conducted during steps 1 and 2 are the first priority for FWCP, because population data and critical habitat information are the basic requirements for all conservation and enhancement actions (i.e. baseline data). Furthermore, successful achievement of these objectives may lead directly to habitat conservation-based actions (e.g. riparian land securement).

Studies of limiting factors may require careful study design and adequate replication, and therefore it is unlikely that all potential limiting factors can be adequately understood prior to the initiation of enhancement actions. Therefore, as indicated in the preceding section, effectiveness monitoring should be a requirement of all significant enhancement projects.

3.0 MONITORING STUDY RECOMMENDATIONS

3.1 Key information gaps

Within the information synthesis (Stamford et al. 2017), more than 80 information gaps are identified that potentially limit the ability to initiate conservation and enhancement actions, most of which are related to missing or imprecise information about critical habitats and conservation status.

Such a large number of potential starting points for grayling studies is potentially overwhelming, and therefore this total list was analyzed for recurring themes among core areas. Several recurring information gaps of relatively high immediacy[5] were discerned, and corresponding monitoring needs identified (Table 1). These high priority monitoring needs mostly address steps 1 and 2 of the recommended monitoring sequence (see preceding section).

[5] In Stamford et al. (2017), immediacy was subjectively rated based on the expected consequences of not doing the proposed action, in terms of the ability of FWCP to conduct conservation and enhancement actions.

Table 1. Recurring, high priority information gaps that limit the ability of FWCP to initiate conservation and enhancement actions for Arctic Grayling in the Williston Reservoir watershed, and potential monitoring needs to address them. ID values are for reference and do not indicate order of importance.

ID	Core area	Information gap	Monitoring need	Report section	Link to conservation/ enhancement actions
1	Parsnip, Ingenika	Lack of population data for assessing total adult abundance and trend (since 2007).	Estimate total abundance, and trend within existing index reaches (snorkeling surveys).	*5.1.2* (Parsnip); *5.4.2* (Ingenika)	Will enable: 1) conservation status assessment for core area; 2) prioritization among core areas and sub-basins for conservation/ enhancement actions; 3) identification of index reaches for monitoring trend; 4) delineation of summer-rearing critical habitats for conservation and enhancement actions (e.g. stream fertilization, land securement); 5) improved knowledge of ecological interactions with predators (if coordinated with Bull Trout monitoring locations).
2	Parsnip (upstream of Table R), Nation, Omineca, Ingenika, Lower Finlay	Lack of population data for assessing total adult abundance and trend, and for delineating critical habitats for subadult/adult rearing; unknown feasibility for abundance monitoring.	Feasibility study of potential for adult grayling abundance monitoring (e.g. underwater visibility, snorkeling detection probability estimates), combined with estimation of critical summer rearing habitats for subadult/adult grayling (e.g. snorkeling).	*5.1.2*, *5.1.3* (Parsnip); *5.2.2*, *5.2.3* (Nation); *5.3.2*, *5.3.3* (Omineca); *5.4.3* (Ingenika); *5.5.2*, *5.5.3* (Lower Finlay)	Will enable: 1) conservation status assessment for core area; 2) prioritization among core areas and sub-basins for conservation/ enhancement actions; 3) identification of index reaches for monitoring trend; 4) delineation of summer-rearing critical habitats for conservation and enhancement actions.
3	All	Lack of assessment of aquatic ecosystem health (habitat threats).	GIS indicator-based assessment of aquatic ecosystem health; Fish Habitat Assessment Procedures.	*5.1.2, 5.2.2, 5.3.2, 5.4.2, 5.5.2, 5.6.2, 5.7.2*	Will enable: 1) conservation status assessment for core area; 2) prioritization among core areas and sub-basins for restoration/ enhancement actions (e.g. riparian restoration, road deactivation).

Table 1, continued.

	Core area	Information gap	Monitoring need	Report section	Link to conservation/ enhancement actions
4	All	Lack of critical habitat information for key life stages: spawning/natal areas.	Movement studies (e.g. radio telemetry); studies of newly-emerged fry distribution.	*5.1.3, 5.2.3, 5.3.3, 5.4.3, 5.5.3, 5.6.3, 5.7.3*	1) Enhancements of low-velocity margin habitats may target a key factor limiting recruitment; 2) will enable spawning habitat protection; 3) identification of potential sources of gametes for recolonization experiments.
5	All	Lack of critical habitat information for key life stages: juvenile rearing/ overwintering.	Inventory methods targeting juvenile life stage (100-200 mm): seine netting, electrofishing, snorkeling; otolith microchemistry.	*5.1.3, 5.2.3, 5.3.3, 5.4.3, 5.5.3, 5.6.3, 5.7.3*	Loss of juvenile rearing/overwintering habitat due to flooding is a leading plausible explanation for extirpation of grayling from Williston Reservoir streams. A good understanding of juvenile habitat requirements in other core areas is key to identifying candidate streams and enhancements that will enable successful recolonization.
6	All	Relatively limited understanding of fine-scale population structure and gene flow within and among core areas.	Molecular genetic studies (tissues to be collected during studies identified above); movement studies (e.g. otolith microchemistry).	*5.1.2, 5.2.2, 5.3.2, 5.4.2, 5.5.2, 5.6.2, 5.7.2, 6.0*	Will enable: 1) more accurate knowledge of core area boundaries and conservation status; 2) better understanding of potential for movements within the reservoir.
7	Williston, Upper Peace	Unknown present-day distribution of grayling	Inventories targeting adult and juvenile life stages; environmental DNA (requires feasibility assessment).	*5.7.2, 5.7.3*	Will enable: 1) conservation actions to protect remnant populations, if present; 2) studies of key habitat requirements necessary for recolonization (to inform future enhancements); 3) identification of potential sources of gametes for recolonization experiments.
8	Williston, Upper Peace	Poor understanding of factors driving extirpation in small-to-medium size tributaries to the reservoir	Recolonization experiments in candidate streams, in combination with studies of habitat use and predator abundance.	*5.7.2, 5.7.3*	Recolonization of the lost range in Williston Reservoir tributaries would potentially be the single most significant enhancement, but actions must not threaten the conservation status of existing populations.

3.2 Guidance for grant applicants

This report is one of four key information sources to guide grant seekers looking to develop Arctic Grayling monitoring projects through the FWCP's annual intake of grant applications. These four sources of background information are:

1. *Streams Action Plan*. Specifically, objectives 1b-2, 1b-3 and 1b-4 of the FWCP Peace Basin *Streams Action plan* (FWCP 2014).

2. *This document*. Table 1, along with the sequence of monitoring needs laid out in Section *2.3,* provide a general roadmap for proponents. Table 1 is accessible, alerts potential proponents to high-priority study opportunities in an efficient manner, and is sufficiently non-prescriptive to encourage innovation and submissions from a broad range of potential proponents.

3. *Stamford et al. (2017) information synthesis*. An essential step for proponents during proposal development is to familiarize themselves with the existing knowledge base (if available) specific to the core area and sub-basin of interest, which is summarized for them on a core area-by-core area basis within the pages, tables, and figures of Stamford et al. (2017).

4. *Yearly guidance from FWCP*. In addition to these three background documents, guidance on fwcp.ca and the grant application information kit for each funding cycle should also be considered by potential proponents, because additional prioritization of data gaps and associated monitoring needs for Arctic Grayling may occur in future years.

Grant applicants should demonstrate that they have reviewed these sources for Arctic Grayling guidance, and indicate how their proposed project addresses high priority objectives in the intended sequence.

FWCP has not identified any one particular core area(s) (Figure 1) as the first priority for monitoring needs (and subsequent conservation and enhancement actions), because the knowledge base justifying such a prioritization (e.g. conservation status assessments) is too weak for most core areas. Additionally, FWCP strategic objectives concerning sustainable use and community engagement (Section *1.1*) are best served by distributing studies across the entire footprint impact area for the W.A.C. Bennett dam, as soon as it is feasible to do so. The broad geographic scope and relatively non-prescriptive nature of Table 1, along with annual grant intake process, ensures that grant seekers have equal opportunity regardless of where they are situated, are able to propose work in watersheds of high First Nations' and community interest, and can incorporate traditional and local knowledge to support prioritization of monitoring needs.

Monitoring needs 1-7 identified in Table 1 were delineated based on the recommended sequence for identifying and prioritizing monitoring studies (Section *2.3* above), and should therefore all be considered to be of high priority for immediate implementation via the FWCP's annual grant intake. Monitoring action 8 recolonization experiments in the Williston and Upper Peace core areas, depends on results from monitoring needs 4, 5, 6, and 7, and will need to be reviewed and supported by FWCP partners prior to potential implementation. This monitoring need is of major potential significance, but may pose a risk to existing populations depending on the approach taken. Therefore, the approach applied to address this monitoring need will need direction from the FWCP Peace Region Board and will require careful scrutiny and approval by the BC Ministry of Forests, Lands, and Natural Resource Operations (MFLNRO), the lead agency responsible for Arctic Grayling conservation. Therefore, this need is not considered to be eligible for an FWCP grant at this point in time.

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