RAINBOW TROUT STRAINS
CURRENTLY STOCKED IN BC WATERS

PRODUCED BY THE
FRESHWATER FISHERIES SOCIETY OF BC

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Freshwater Fisheries
Society *of* BC

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INTRODUCTION

The mandate of the Freshwater Fisheries Society of BC (FFSBC) is *"to conserve, restore and enhance the freshwater fish resources of British Columbia for the benefit of the public"*. To this end, the FFSBC is striving to implement stocking programs that support this mandate. When applied in a conservative and diligent manner, stocking programs can meet the objective of maintaining and developing quality angling opportunities without compromising conservation objectives to protect wild fish populations.

This document provides a short summary of the attributes and stocking locations of the main strains of rainbow trout currently managed by the FFSBC, as well as some background information related to strain development. More detailed information regarding strain history and management plans can be obtained through the FFSBC.

BIOGEOGRAPHY OF RAINBOW TROUT IN BC

The most recent study pertaining to the biogeography of rainbow trout in British Columbia was conducted by McCusker et al. (2000). This study evaluated phylogenetic relationships among *Oncorhynchus mykiss* populations in the Pacific Northwest including a large number of rainbow trout and steelhead populations within the province. This study then postulated likely glacial refugia and post-glacial dispersal and re-colonization using mitochondrial DNA data, as well allozyme data from earlier studies (Parkinson 1984, Carl et al. 1994, Cronin et al. 1993, Okazaki 1984, Nielsen et al. 1994) and discussions by McPhail and Lindsey (1986) and McPhail and Carveth (1992).

Overall, this study concluded that the ultimate source of rainbow trout and steelhead in BC originated from California where the genetic diversity is greatest. However, colonization in BC was not directly from California but rather via invasion from three glacial refugia. A southern interior (Columbia) and separate southern coastal refugium colonized south coastal and interior regions of B.C. In the north, a refugium near the Queen Charlotte Islands appears to have provided colonizers for both coastal and interior populations. In some areas, a sharp geographic separation between the resulting lineages is evident but other areas appear to represent contact zones where genetic material from more than one refugium exists.

To some extent, this study supports the older hypothesis that proposed the existence of two forms of *O. mykiss* including an interior redband form and a coastal form (Behnke 1992) in terms of geographic delineations. However, the genetics data suggests that these delineations are not necessarily straightforward. Furthermore, mitochondrial genotypes do not necessarily reflect the distinctive redband versus coastal morphological phenotype.

DEVELOPMENT OF STRAINS

It is generally accepted that not all rainbow trout are created equal. The present distribution of most freshwater fish species including rainbow trout in British Columbia is largely a result of the last glacial period. As the glaciers receded, rainbow trout and other fishes moved up into systems from glacial refugia (glacier-free areas) south of BC, as well as near the Queen Charlotte Islands, and colonized previously unoccupied waterbodies. Since this time, populations in these different waterbodies evolved to adapt to a specific suite of conditions associated with physical habitat, community and resources available. Many of these adaptations are at least partly genetically-based and heritable. Examples of such traits include feeding and spawning behaviour, size and appearance and habitat preferences or tolerances.

Awareness of these differences is useful in developing specific strains of rainbow trout for stocking programs. Knowledge of these differences also aids fisheries managers in selecting strains best suited to a particular water body in their region. The FFSBC has developed a number of rainbow trout strains suited to different conditions. To meet stocking requests and provide a consistent product, the FFSBC has developed a number of wild-type strains, as well as a domestic strain. The wild-type strains are maintained in a series of broodstock lakes. These lakes receive progeny from wild broodstock collections on a regular basis (e.g. every three years) to provide "genetic infusions" and minimize genetic drift or alterations over time. Use of these lakes minimizes the annual removal of broodstock from the original wild population and ensures adequate numbers are available annually. In addition, some broodstock lakes contain a "native" strain of rainbow trout. These fish are unmarked and believed to be the progeny of wild-spawning stocked fish. Their origins are varied. These native strains are not actively managed, and efforts to eliminate this component from the lakes continue. However, they are currently used to help meet stocking requests. The domestic strain has been maintained as a captive population within the hatchery system for at least several generations. Domesticated strains are easily maintained in a hatchery environment and are well suited to particular water bodies.

Management plans have been completed or at least initiated for most broodstock lakes to ensure that: (1) hatchery activities are conducted in a consistent and scientifically sound manner; (2) when appropriate, the broodstocks receive regular "infusions" of wild genetic material to maintain the genetic traits of the wild source; and, (3) impacts to the original wild source are minimized.

SUMMARY OF RAINBOW TROUT STRAINS IN BC

Almost 1,300 BC lakes were stocked with rainbow trout over the past three years (Table 1). The FFSBC currently depends on eight strains of rainbow trout to meet annual provincial stocking requests. Three of these strains are based strictly on wild populations (Blackwater, Tzenzaicut and Pennask), three are naturalized "native" populations (native

Dragon, native Premier and native Tunkwa), one is a captively maintained wild-type population (Gerrard) and one is a domesticated population (Fraser Valley). The Gerrard program relies on regular (every two years) input of eggs from the wild population to maintain a captive broodstock. In this case, a combination of wild (when wild broodstock numbers are high) and captively produced eggs are used to meet stocking requests. Table 2 summarizes the rainbow trout strains and broodstock lakes with recent FFSBC activity (i.e. past 10 years).

Table 1. Total number of lakes in BC stocked with different rainbow trout strains and treatments in 2000-2002.

	Treatment				
Strain	2N	3N	AF3N	AF	Total
Pennask	227	-	175	29	431
Blackwater	150	83	69	-	302
Tzenzaicut	112	-	-	-	112
Gerrard	20	3	-	-	23
FV Domestic	50	103	35	-	188
Tunkwa	66	-	-	-	66
Premier	74	-	-	-	74
Dragon	82	-	-	-	82
Total	781	189	279	29	1278

Table 2. Rainbow trout strains and associated broodstock lakes (as bullets), dates initiated and current stocking status.

Strain/broodstock	Date initiated	Egg production status
Pennask Lake	1929	Ongoing
• Beaver Lake	1992	Ongoing
• Premier Lake	1990	Ongoing
• Kostal Lake	1988	Exists as a remote refugium
Blackwater River	1986	Ongoing
• Dragon Lake	1994	Ongoing
• Genier Lake	1995	Terminated in 2000
Tzenzaicut Lake	1990	Ongoing
• Dragon Lake	1997	Ongoing (but plans are for termination)
• Tunkwa Lake	1999	Ongoing (but may be terminated)
Gerrard – Lardeau River	1966	Ongoing
• Gerrard – "captive"	1998	Ongoing
FV Domestic	1977	Ongoing
Green	1991	Terminated in 2001
"Native" Tunkwa Lake	1969	Ongoing
"Native" Premier Lake	1915	Ongoing
"Native" Dragon Lake	1981	Ongoing
Badger Lake	1978	Terminated in 1996
• Tunkwa Lake	1993	Terminated in 1999

APPROPRIATE STRAIN SELECTION

Selection of an appropriate rainbow trout strain and treatment for a particular water body will enhance angling opportunities, increase program efficiencies and minimize impacts to wild populations. A number of factors will determine the most appropriate strain and treatment to select. In some cases, only one strain may be appropriate whereas in other cases, any number of strains may work. There may be some instances where no strain is appropriate. In the future, selection may be further limited by a federally proposed ban on inter-watershed transfers to prevent disease transfer.

Factors that will determine the strain(s) and treatment most appropriate for a particular lake include:

Physical lake parameters:

- Region
- Temperature cool/cold
- pH high/normal
- Winterkill y/n
- Closed y/n
- Presence of inlets y/n
- Presence of outlets y/n
- Presence of shoal habitat y/n
- Surface area large/small
- Depth shallow/deep
- Oxygen depleted y/n

Biological lake parameters:

- Productive y/n
- Presence of fish y/n
- Presence of wild populations of rainbow trout y/n
- Presence of forage fish species y/n
- Presence of predator species y/n
- Presence of competitor species y/n

Management parameters:

- Fishery type family/trophy
- Surface/deep
- Daytime/evening
- Remote access y/n
- Low use/high use
- Urban setting y/n
- Priority high/low

AVAILABILITY OF SPECIALTY PRODUCTS

Release age

The FFSBC rears juveniles to be released at different ages (or sizes). To some extent, the age for release is determined by the method of release (e.g. remote access), the season for planned releases and hatchery rearing facility limitations. However, the most appropriate age/size for release will also be determined by a number of factors including the likelihood of winterkill, presence of predators/competition, priority of the system, and proximity to urban centres.
Release ages available:

Fall fry (<5 g): appropriate for remote access (most fish per volume) in a productive monoculture environment (i.e. no competition or predation), cost-efficiency (lowest cost per fish), and to reduce the incidence of early maturation under some conditions.
Fingerling (5-9 g): appropriate for remote access, cost-efficiency, some adaptive advantage associated with less time spent in hatchery.
Yearling (10-25 g): better survival especially where other species occur (competition/predation pressure), some cost-efficiency (compared to catchables), slight adaptive advantage over catchables.
Catchables: appropriate in urban setting or high creel areas, immediately available to fishery, most expensive to raise.

Non-reproductive treatments

In addition to the development of different strains, the FFSBC has gone one step further and developed special treatments for some of the strains to further enhance the angling experience while protecting wild populations through preventing potential genetic interactions. These treatments are triploidization and the creation of all-female stock. Such treatments increase the cost on a per-fish basis but the benefits can be substantial. Currently, the majority of lakes in BC are stocked with diploid (2N) rainbow trout. However, some treatment has been applied for releases into almost 40% of lakes to improve the fishery and minimize interactions with wild populations of fish (Table 1).

Triploidization (3N) – Currently, the FFSBC induces triploidy through the application of hydrostatic pressure shocking or heated water to the eggs shortly after fertilization. This technique results in the retention of the second polar body normally extruded shortly after fertilization creating three sets of chromosomes instead of the usual two sets. The result is sterility in both males and females. This triploidization method can achieve 100% triploidy if the technique has been optimized for the species.

The benefits of sterility include increased size due to the fact that energy usually diverted into reproductive development can go to somatic (body) growth, and the inability to reproduce or mate with other hatchery or wild individuals. Sterility is different depending on the sex of the fish. Female triploids are hormonally and functionally sterile

(i.e. no ovary development or behaviour changes). Male triploids are infertile but still produce hormones that cause changes associated with maturation including deterioration of flesh quality, early mortality and the development of testes and other secondary sex characteristics. In addition, they demonstrate "false" spawning behaviour, including migration and interactions with other fish on the spawning beds but an inability to reproduce.

All-female (AF) – The creation of an all-female population of fish is labour-intensive. The FFSBC produces all-female populations of fish by crossing sex-reversed females with normal females. To create sex reversed females, normal fry are exposed to testosterone derivatives to halt ovary development and produce normal testes. These "masculinized" females remain genetically female (XX) but functionally male although the sperm must be expressed by hand as these fish do not develop a sperm duct. Once mature they are crossed with normal XX females to create all-female progeny for release.

The benefits of all-female stock include slower maturation in females compared to males, and therefore more time available to the fishery, larger fish, and no male drop-out from the fishery associated with precocious maturation (or "jacking") and high post-maturation mortality. In addition, the stocking of all-female progeny in the absence of males effectively creates a functionally non-reproductive population.

All-female triploids (AF3N) – The production of AF3N fish for stocking derives the benefits of both processes. In addition, the double treatment ensures that the small percent of individuals that may be missed during the triploidization process are still unable to reproduce because all progeny are all females.

PENNASK LAKE RAINBOW TROUT

Strain Summary

Strain origin:	Pennask Lake, Region 3
Feeding ecology:	Insectivore, limnetic, most active at dusk
Wild-type appearance:	Relatively small, slow growing, lightly spotted
Angling qualities:	Good jumper
Lake type most suited to:	Pelagic area in small, highly productive monoculture lakes
Constraints:	Poor growth where other fish species occur
Specialty types available:	2N, AF, AF3N

Photo 1. Wild Pennask River strain female rainbow trout.

Strain Attributes

Feeding ecology - Pennask rainbow trout are not highly piscivorous and show no evidence of feeding on non-salmonid fish until age 2+ years (Godin and Tsumura 1991). Pennask rainbow are mid-water foragers. They feed primarily on benthic organisms such as Chironomid pupae or Cladocerans (K. Tsumura, pers. comm.) and are most active at dusk.

Size and appearance – Rainbow trout in Pennask Lake are generally small at maturity. However, when stocked into productive monoculture lakes, they will demonstrate a good growth rate and reach a large size prior to maturity. These fish are lightly spotted on the body with spots favouring a caudal/dorsal orientation, which is typical for interior trout.

Habitat preferences – Pennask rainbow trout are most successful in terms of growth and survival in highly productive monoculture lakes (e.g. Plateau area) where they do not have to compete with other non-salmonid fish populations. Within lakes, this strain is pelagic, preferring deep open water.

Angling qualities – Pennask rainbow trout have a reputation of being very aggressive and "sporty" (Read 1977). They are world-renowned by anglers for their fighting ability and tendency to jump when hooked.

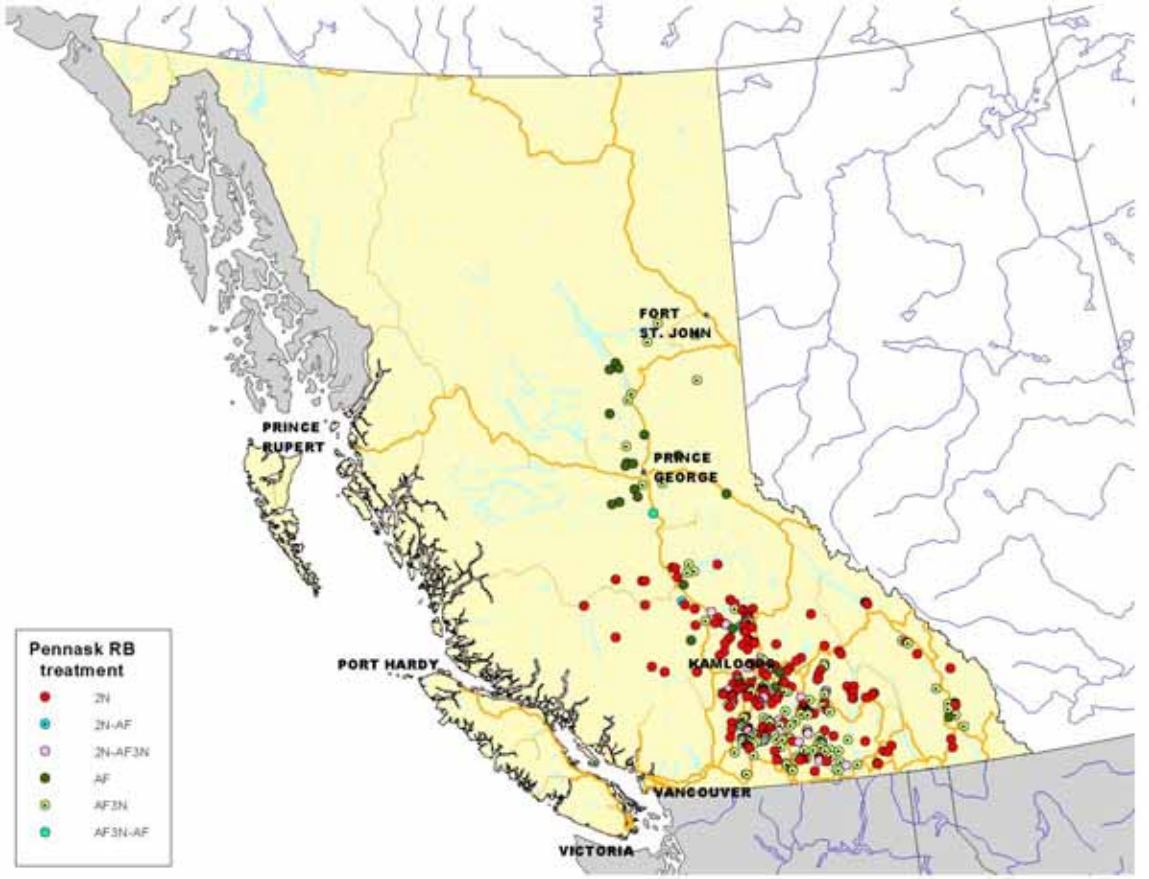

Figure 1. Provincial distribution of lakes stocked with Pennask Lake strain rainbow trout (1999-2002). Note that treatment combinations are included on the map.

BLACKWATER RIVER RAINBOW TROUT

Strain Summary

Strain origin:	Blackwater River, Region 5
Feeding ecology:	Piscivore, shallow shoals, most active during the day
Wild-type appearance:	Fast growing, heavily spotted
Angling qualities:	Aggressive fighter, easily targetted
Lake type most suited to:	High-use lakes with large shallow shoal areas and a non-salmonid fish community
Constraints:	Stock only in systems with no accessible outlets due to potential migratory behaviour
Specialty types available:	2N, 3N, AF3N

Photo 2. Blackwater strain immature male from Dragon Lake.

Strain Attributes

Feeding ecology - Blackwater rainbow trout prefer larger prey such as dragon fly nymphs, snails, mollusks and small non-salmonid fish. These fish may begin feeding on small non-salmonid fish as early as age 1+ year (Godin and Tsumura 1991) and are highly piscivorous at maturity. They are shoal foragers preferring to feed in shallow water and are more active during the daytime than other strains.

Size and appearance – This strain is considered to be relatively fast growing. In 1990, 282 Blackwater rainbow trout were angled by FFSBC staff to collect size and age data. These fish tend to have a wider girth than other wild strains. The Blackwater strain is more heavily spotted than the Pennask strain. They tend to have body spots from head to tail, with a heavier concentration of spots above the lateral line. This body-spotting pattern appears to be typical of coastal rainbow trout.

Habitat preferences – Blackwater rainbow trout demonstrate fast growth in lakes with a multi-species forage base. Given its riverine origin, this strain prefers shallow shoal areas in lakes that most likely mimic river conditions.

Angling qualities – The aggressive, shallow-water foraging behaviour demonstrated by Blackwater rainbow trout enables anglers to target this strain easily. This attribute combined with fast growth has resulted in the Blackwater strain becoming one of the most sought after strains by knowledgeable anglers in BC.

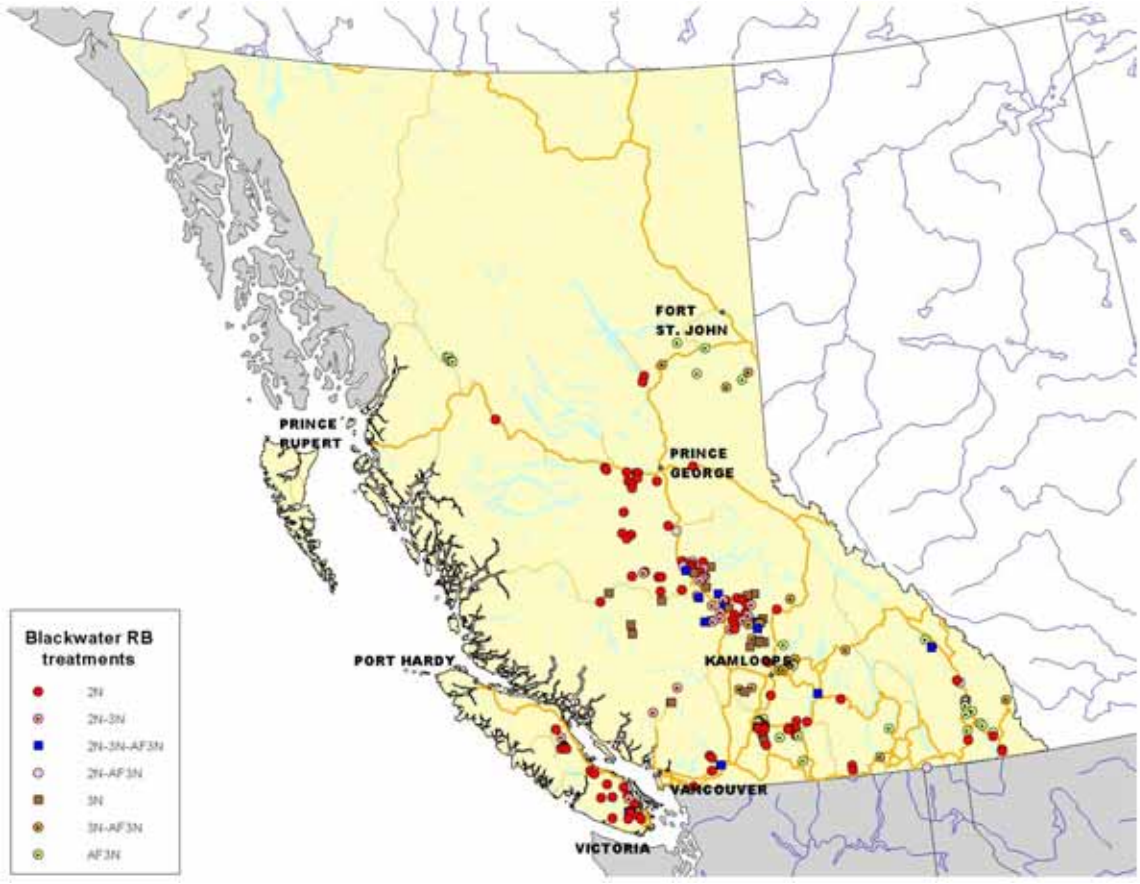

Figure 2. Provincial distribution of lakes stocked with Blackwater River strain rainbow trout (1999-2002). Note that treatment combinations are included on the map.

TZENZAICUT LAKE RAINBOW TROUT

Strain Summary

Strain origin:	Tzenzaicut Lake, Region 5
Feeding ecology:	Piscivore, limnetic, most active at dusk
Wild-type appearance:	Spots are large and sparse, dark red and yellow at maturity
Angling qualities:	Exceptional leaping, good fighter, good recovery
Lake type most suited to:	colder water, low productivity, multi-species communities
Constraints:	Limited baseline data available
Specialty types available:	2N

Photo 3. Mature male and female Tzenzaicut strain rainbow trout from Dragon Lake.

Strain Attributes

Feeding ecology - Tzenzaicut rainbow trout prefer to forage in open water where there is less competition from the large population of suckers found in the benthic areas of Tzenzaicut Lake. The fish are similar to the Pennask strain in their foraging habits but tend to be far more piscivorous, preying on juvenile non-salmonid fish (K. Tsumura, pers. comm.). They are most active at dusk. When raised in a hatchery, they tend to swim on the surface of the water which reflects their avoidance of the benthic areas in the wild (K. Scheer, pers. comm.). Under hatchery conditions, Tzenzaicut fry feed more aggressively in colder water.

Size and appearance - Tzenzaicut rainbow trout have a characteristic spotting pattern where the spots are large and concentrated towards the posterior end of the fish above the lateral line, and on the caudal fin. Spots are generally larger and fewer than on Blackwater or Pennask rainbow trout (K. Tsumura, pers. comm.). At maturity, a Tzenzaicut rainbow trout may have yellow-tinged sides, concentrated ventrally, quite similar to the coloration of cutthroat trout. Maturing adults take on a very dark red and yellow color in comparison to the Blackwater and Pennask strains.

Habitat preferences – Tzenzaicut rainbow trout thrive in low-productivity, cold lake systems containing a wide range of non-salmonid fish species. This strain is similar to the Pennask strain in that it is pelagic, preferring open water.

Angling qualities - At times, this strain can be caught using a wide range of prey imitating lures (i.e. chironomids to minnow imitations). When hooked, this fish is known to exhibit exceptional leaping abilities. The Tzenzaicut rainbow trout is a strong fish that fights hard and recovers well upon angler release.

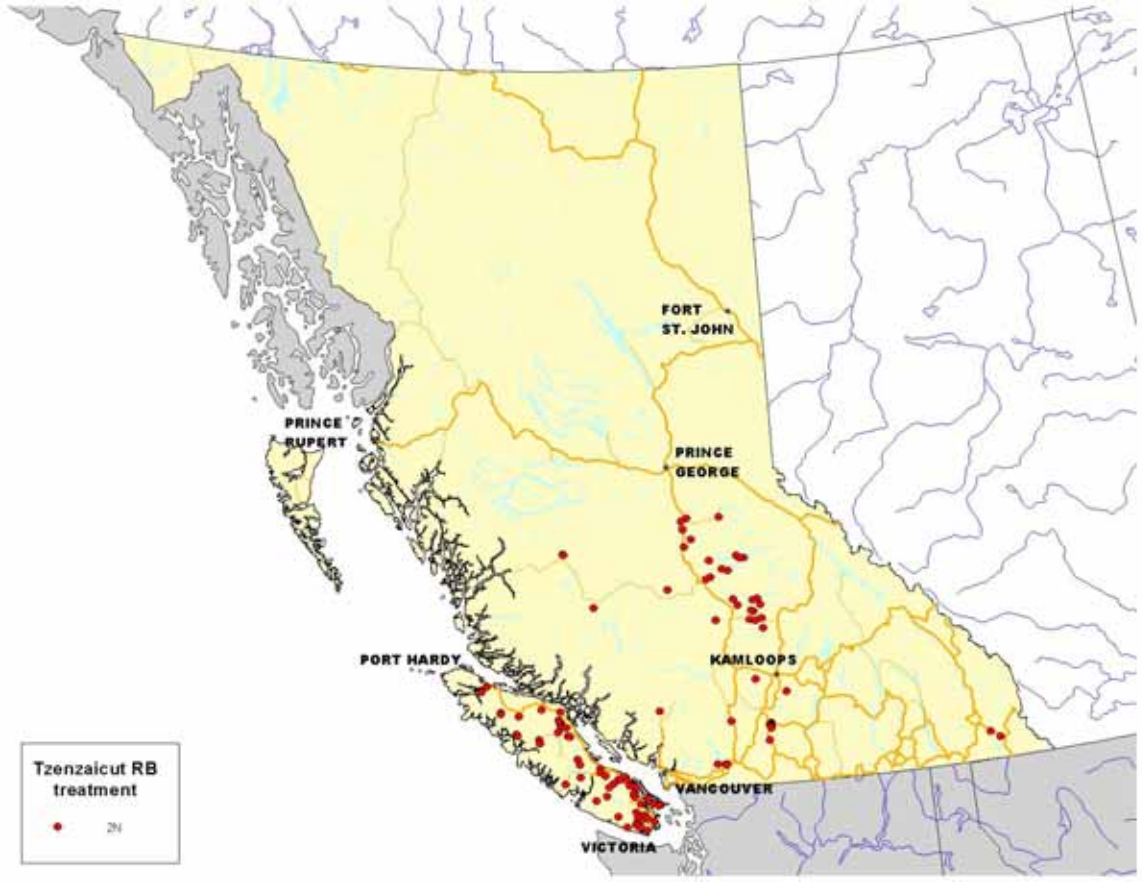

Figure 3. Provincial distribution of lakes stocked with Tzenzaicut Lake strain rainbow trout (1999-2002). Note that treatment combinations are included on the map.

GERRARD RAINBOW TROUT

Strain Summary

Strain origin:	Kootenay Lake/Lardeau River, Region 4
Feeding ecology:	Piscivore – preferably kokanee in deep, open water in summer, closer to surface during winter
Wild-type appearance:	Exceptionally large
Angling qualities:	Good fighter, trophy size
Lake type most suited to:	Large, deep, cool, well-oxygenated lakes with abundant kokanee presence
Constraints:	Unsuitable in systems with low/no kokanee production
Specialty types available:	2N, 3N

Photo 4. Mature male wild Gerrard strain rainbow trout.

Strain Attributes

Feeding ecology - Gerrard rainbow are piscivorous by nature, feeding primarily on kokanee salmon. They follow the kokanee migration in the lake, feeding in cold deep open waters during the summer months and closer to the surface during the winter months.

Size and appearance - The Gerrard strain is unusually large for a rainbow trout with mean weights (1986 -1996) of 9.1 kg for the males and 6.9 kg for the females.

Habitat preferences – Gerrard rainbow trout require large, deep, cool lakes with productive kokanee populations.

Angling qualities - The large size of this strain makes it an attractive trophy fish, and its size and strength provide a good fight for the angler. These fish are usually targeted by deep-water anglers using plugs, spoons, or gang trolls because of their feeding behaviour and habitat preferences. Fish up to 16.2 kg have been taken.

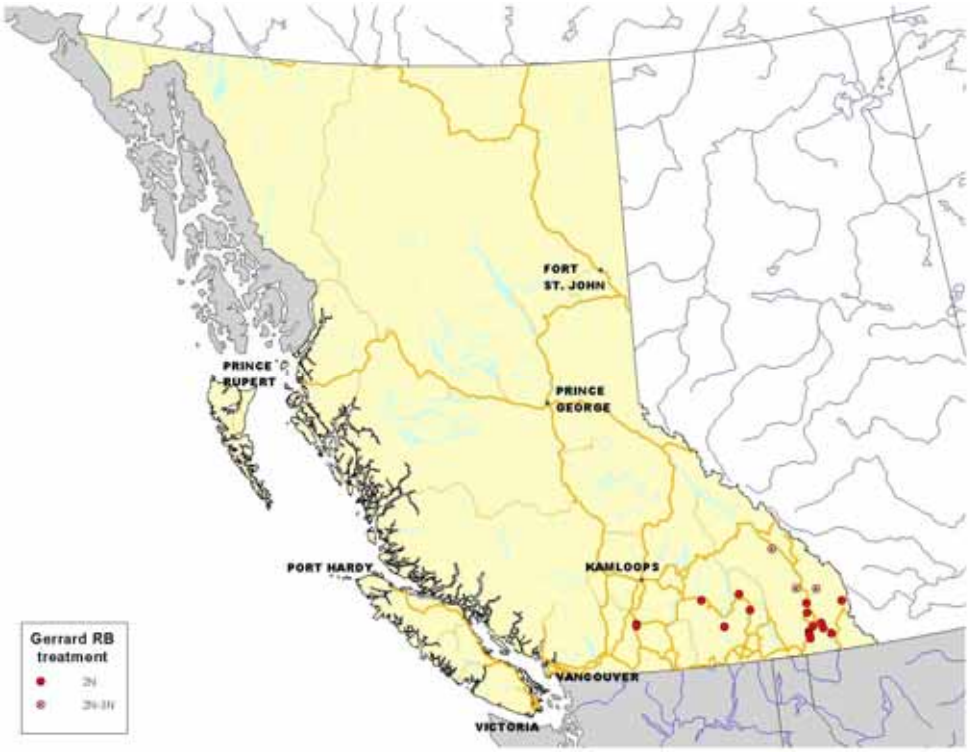

Figure 4. Provincial distribution of lakes stocked with Gerrard strain rainbow trout (1999-2002). Note that treatment combinations are included on the map.

FRASER VALLEY DOMESTICATED RAINBOW TROUT

Strain Summary

Strain origin:	McCleary strain, Trout Lodge Hatchery, WA
Feeding ecology:	range of invertebrates upon release
Wild-type appearance:	Heavily spotted on tail and body, wide girth, fast growing and relatively large
Angling qualities:	Not jumpers, but good fighters
Lake type most suited to:	Small productive lakes near urban centres
Constraints:	Productive lakes are best to achieve good growth
Specialty types available:	2N, 3N

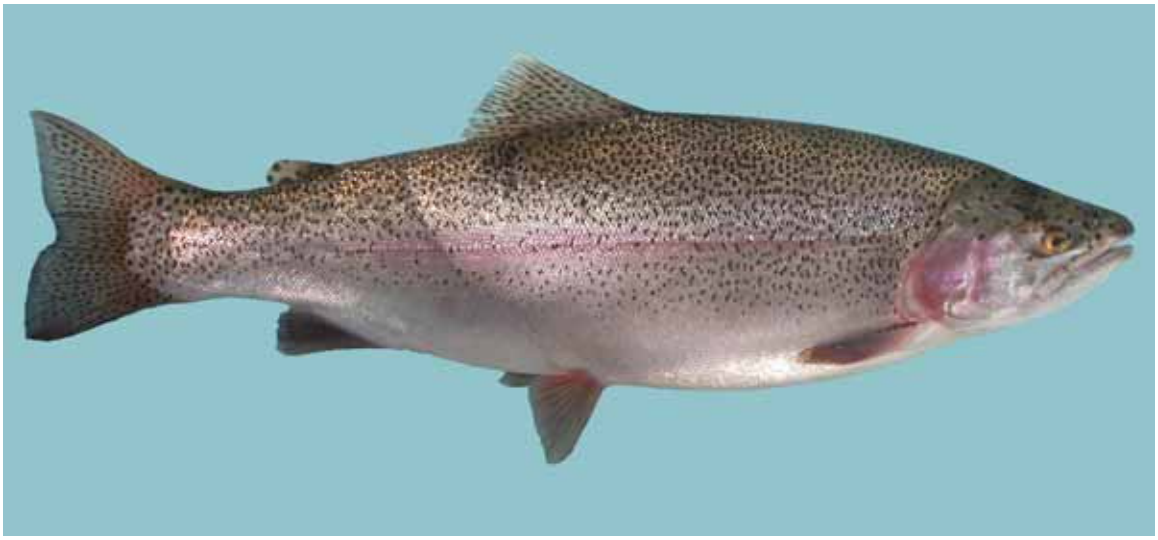

Photo 5. Fraser Valley 3N 4 year old adult.

Strain Attributes

Feeding ecology - The Fraser Valley domesticated rainbow trout (FV) are fed an artificial diet at the hatchery. Once released, this strain will adopt a wild strain diet of various invertebrates, based on post-stocking stomach content analysis.

Size and appearance – These rainbow trout appear to be fast-growing, achieving a relatively large size when stocked into productive lakes. The size of the Fraser Valley captive brood varies depending on the feeding strategy within the hatchery. These rainbow trout tend to have a large girth in comparison to other strains. Fraser Valley rainbow are heavily spotted above and below the lateral line, and on the caudal fin.

Habitat preferences – The FV strain is most successful when released into productive lakes.

Angling qualities - The FV strain exhibits a fast growth rate, achieving a reasonably large size for the angler when stocked into productive lakes. When hooked these fish typically do not jump. They will put up a good fight until they are brought to the net.

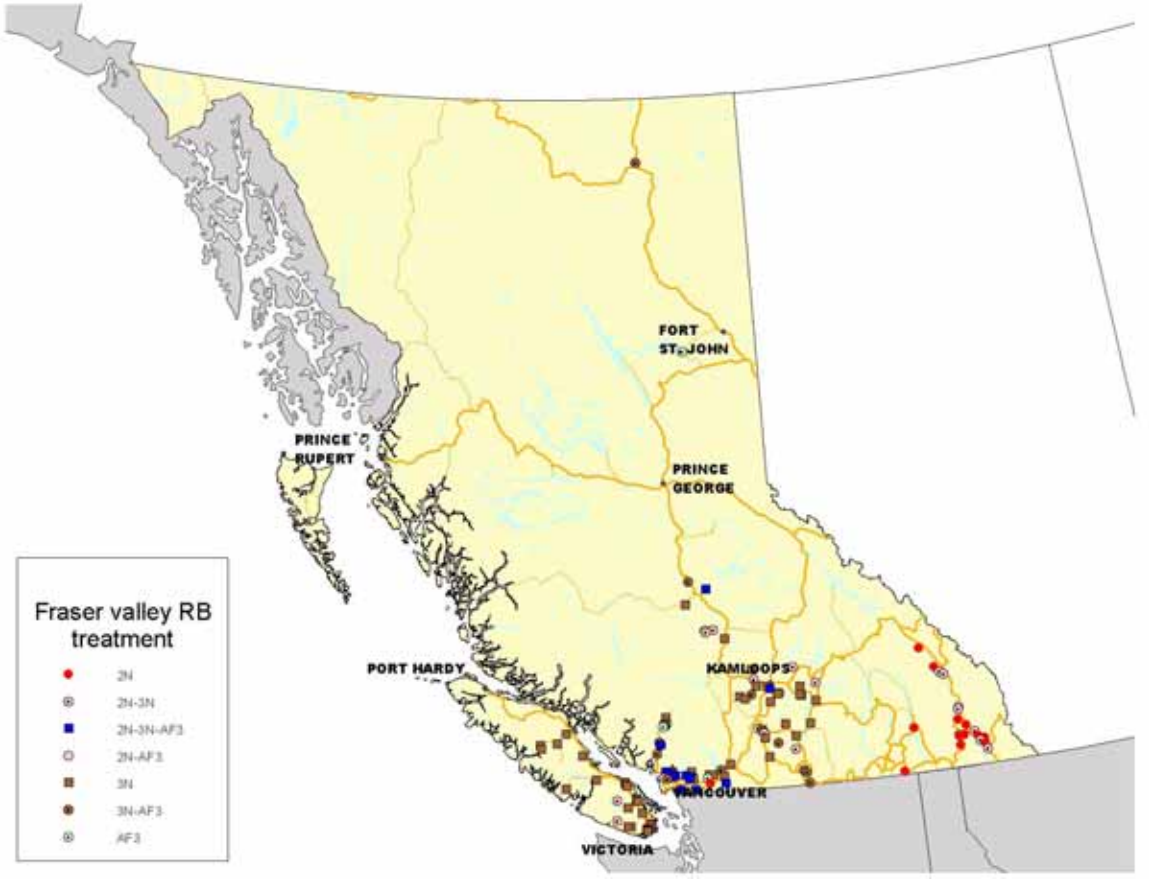

Figure 5. Provincial distribution of lakes stocked with Fraser Valley Domesticated strain rainbow trout (1999-2002). Note that treatment combinations are included on the map.

“NATIVE” (UNMARKED) RAINBOW TROUT

Strain Summary

Strain origin:	Varied
Feeding ecology:	Varied
Wild-type appearance:	Varied
Angling qualities:	Varied
Lake type most suited to:	No specific requirements, often used in lower priority lakes
Constraints:	
Specialty types available:	2N

Photo 6. Native Dragon Lake mature male. Note that this phenotype is considered to be a “normal” native form with relatively light spotting.

Photo 7. Native Dragon Lake mature male. Note that this phenotype is considered to be “Blackwater-like” in appearance and is heavily spotted.

Strain Attributes

Feeding ecology – Given the varied background, no specific feeding ecology is observed.

Size and appearance – Varied.

Habitat preferences – No specific requirements observed given varied background.

Angling qualities – No specific attributes observed given varied background.

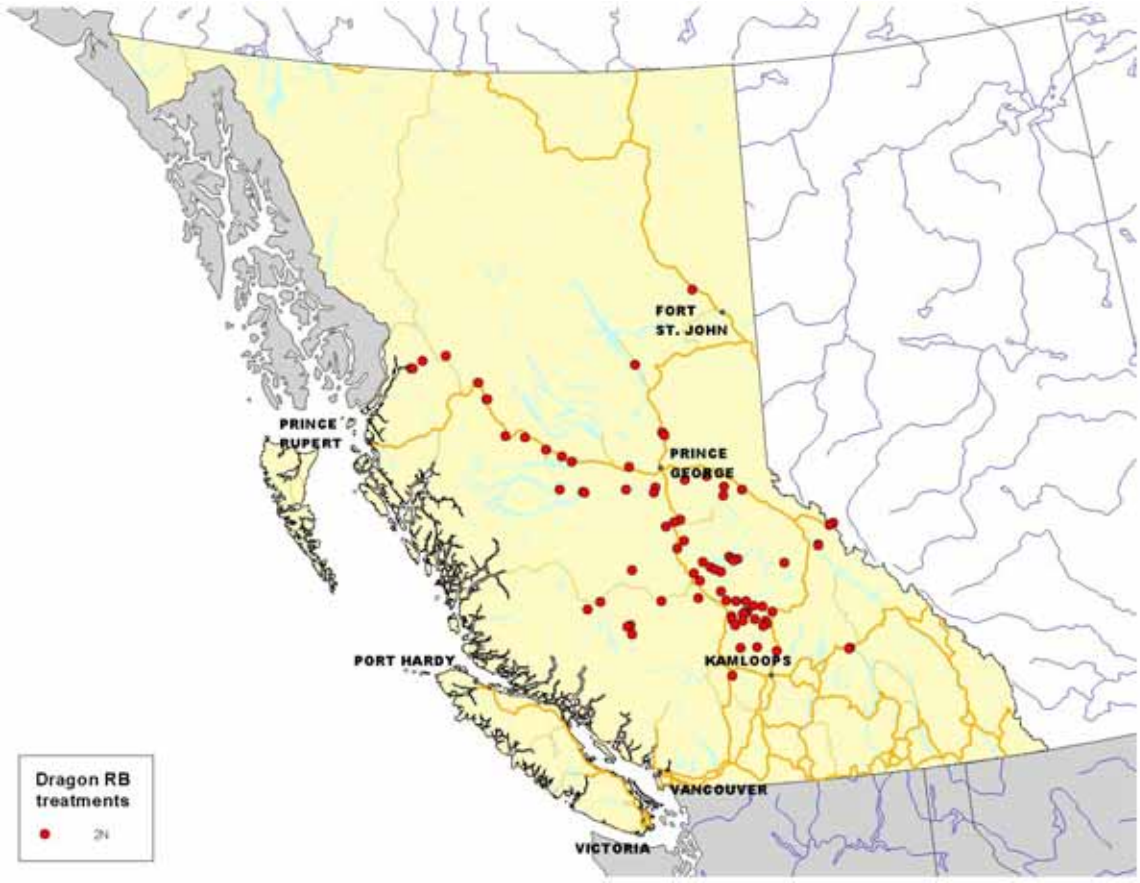

Figure 6 Provincial distribution of lakes stocked with unmarked Dragon Lake strain rainbow trout (1999-2002). Note that treatment combinations are included on the map.

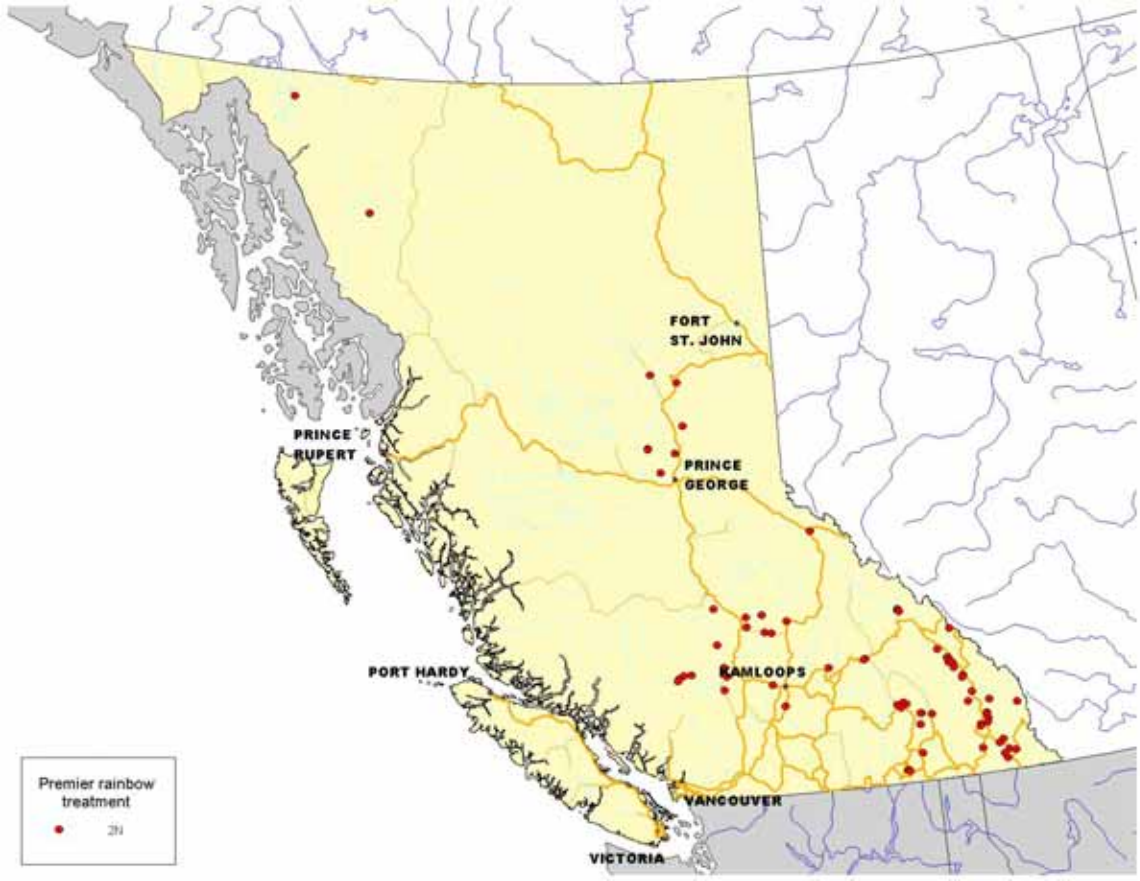

Figure 7. Provincial distribution of lakes stocked with unmarked Premier Lake strain rainbow trout (1999-2002). Note that treatment combinations are included on the map.

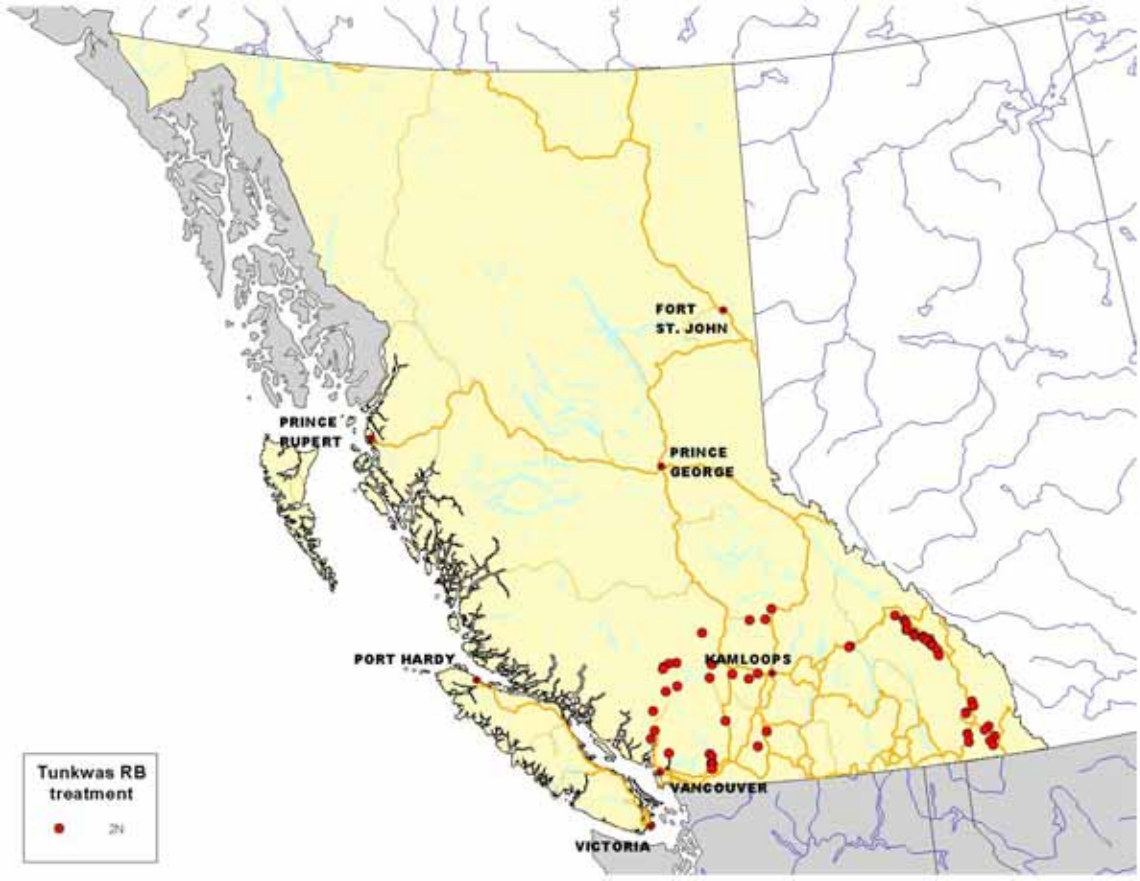

Figure 8. Provincial distribution of lakes stocked with unmarked Tunkwa Lake strain rainbow trout (1999-2002). Note that treatment combinations are included on the map.

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APPENDIX A – Glossary

Benthic – lake/stream bottom oriented.

Biogeography – The branch of biology which deals with the geographical distribution of animals and plants.

Broodstock – parent fish used to generate progeny for stocking.

Genetic drift – random, selectively neutral shift in gene allele frequencies over time, associated with limited population size.

Genotype – Genetic composition of an individual. Could refer to a single gene locus or multi-locus genotype.

Monoculture – When a single fish species occurs in a lake.

Phenotype – Physical, observable characteristics of an individual. Is the result of genotype and/or environment. Could include behaviour, physiology or morphology.

Piscivorous – fish-eating.

Refugium/refugia – a reserve. Glacial refugium refers to an area which remained glacier-free during the ice age. Genetic refugium refers to a protected or back-up location containing a specific population.