Trout Creek Water Use Plan
Fisheries Report

Overview of Fish and Fish Habitat Resources, and Aquatic Ecosystem Flow Requirements in Trout Creek

northwest hydraulic consultants ltd.
Vancouver, BC

September 2005

Table of Contents

Acknowledgements

This report was prepared by Barry Chilibeck, M.A.Sc., P.Eng. of **northwest hydraulic consultants** with the assistance of three key individuals from the **Ministry of Environment**. Mr. Steve Matthews, R.P. Bio. was the project coordinator and provided overall document review and oversight. Mr. Phil Epp, P.Ag. provided technical revisions and flow transect data that greatly enhanced the final product. Mr Ron Ptolemy, R.P. Bio. provided critical technical analyses – especially of the derived flow-habitat relationships for Trout Creek – that are the key products of the report. Their efforts and commitment to this endeavour are appreciated.

Executive Summary

Trout Creek, as the second largest tributary watershed to Okanagan Lake, provides domestic and agricultural water supply, as well supporting important sport fish – notably rainbow trout and kokanee. Water storage and intake water diversion result in altered stream flows. As a result, there are over 13 km of stream channel in the lower reaches of the creek below the Summerland intake which have reduced streamflows. These reduced flows decrease the amount of suitable, available habitat which can result in reduced productivity and overall numbers of fish.

Historical water use practices resulted in conflicts between the District of Summerland, and Fisheries and Oceans Canada and the Ministry of Water, Land and Air Protection Fisheries staff. Using the provincial water use planning process, a supportable documented plan has been developed to ensure fish and fish habitat are protected, and a secure water supply is ensured. Part of the process has been to examine available data, analyze and determine functional relationships between measures and conduct a comparative study or trade-off analysis. For Trout Creek, the primary measures are water and fish habitat.

In order to provide a rationale for the assessment of streamflows for fish in the Okanagan, fundamental flow principals have been developed. These detail *naturalized, conservation, optimum* and *baseflows* which are important measures relating back to productivity of fish habitat. Estimates for naturalized and conservation flows at the District of Summerland intake were developed in previous studies and optimal and base flow results were developed based on the analysis of test sections of habitat in lower Trout Creek. The primary fish performance measure was rainbow parr 1+ rearing habitat which was estimated using weighted usable widths (WUW), and a secondary measure was kokanee spawning and incubation habitat.

Naturalized streamflows have been calculated for the Trout Creek Watershed in previous studies as ranging from 2.5 m^3/s to 2.9 m^3/s, with the applicable naturalized mean annual discharge (MAD) at the District of Summerland water system intake being estimated at 2.54 m^3/s. Conservation flows are based on percentages of MAD and are estimated to be between 5.09 and 0.51 m^3/s depending on the month of the year.

Weighted usable width[1] (WUW_{dv}) and % weighted usable width ($\%WUW_{dv}$) were calculated for the range of transect flows. Streamflows from 0.019-2.811 m^3/s at the canyon site and from 0.022-4.909 m^3/s at the lower channel site for rainbow parr habitat were used. Flows ranging from 0.015-1.664 m^3/s at the canyon sites and from 0.032-3.251 m^3/s at lower channel were examined for kokanee spawning-incubation habitat.

[1] Weighted usable width analyses utilized hydraulic components of depth and velocity in calculation of suitability

Correlations for all sites were strong and good functional relationships were developed through regression and curve-fitting techniques for the rainbow trout 1+ rearing habitat. A streamflow that appears to maximize available habitat was estimated at 1.4-1.5 m^3/s, approximately 48-52% MAD, for the range of streamflows investigated. The correlation and functional relationships for WUW and streamflow were also strong for the kokanee spawning habitat. However, an optimum flow for kokanee spawning-incubation habitat could not be identified for the canyon site. An optimum flow for kokanee spawning and incubation is estimated at 0.8 m^3/s, approximately 28% MAD, over the range of flows surveyed for the lower channel site.

Camp Creek is a tributary of Trout Creek with a relatively natural flow regime and a real-time Water Survey of Canada hydrometric gauging station near its mouth (Figure 1). This provides an opportunity to estimate naturalized flows in Trout Creek on a real-time basis by using a multiplier to scale up from the relatively small Camp Creek sub-basin to the larger Trout Creek Watershed. Multipliers between 6 to 14:1 were reviewed to examine their representativeness of estimated naturalized flows for the Trout Creek watershed, as well as potential reduction in habitat as estimated by WUW.

Results indicate that the lesser of either a 10:1 Camp Creek multiplier or the conservation flow standard will provide similar amounts of habitat at either site. Reductions to lower Camp Creek multipliers will reduce the amount of suitable habitat for rainbow parr in Trout Creek. Absolute quantitative losses of habitat resulting from changes within the envelope of expected minimum flows in the proposed Trout Creek water use plan could be relatively large. These losses in WUW depend solely on multipliers selected during contemplated in-season flow adjustments. At the riffle site in the lower reach, losses of suitable rearing habitat are significant, but more importantly, reduced migration flows for kokanee may develop that would limit their access to spawning habitat.

As noted, weighted usable width and other measures are simple metrics for productive fish habitat, and other factors potentially influenced by streamflow should be considered along with physical habitat. Considerable negative impacts to habitat quality and productivity could result from reduced streamflows in Trout Creek. These impacts include increased solar heating and temperature impacts, loss of productive benthic invertebrate habitat and reduced drift (food), reduced cover and increased predation, increased stress and disease with reduced survival. Quantitative fish biology and synoptic study of individual fish, their growth and health is required to better assess the critical elements of physical habitat, food and nutrients, and water quality that constitute productive fish habitat in Trout Creek, and how these habitat elements are interrelated and affected by streamflow.

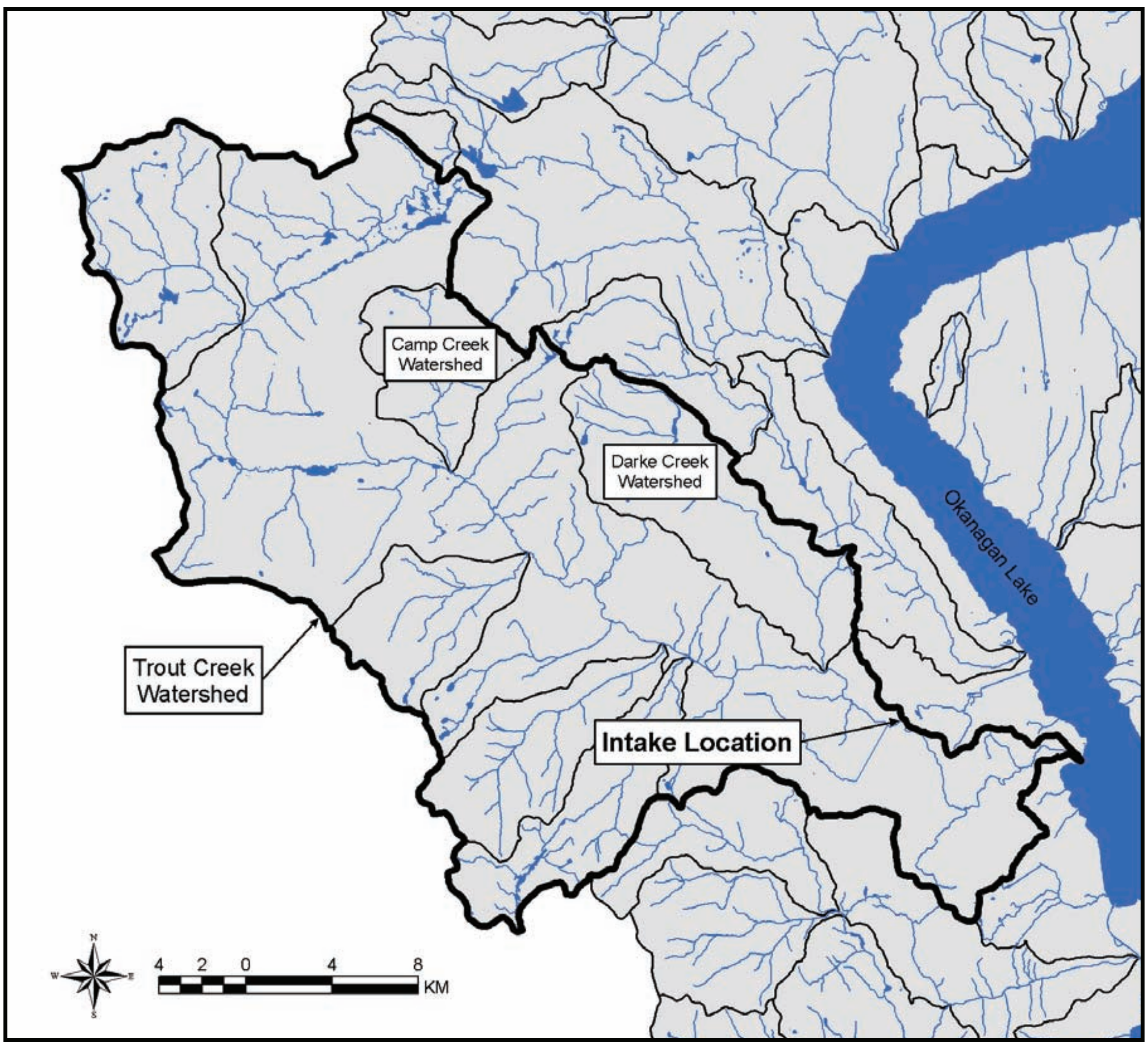
The water use planning process used limited biological and hydrological data. No directed biological studies were undertaken to determine actual fish utilization in lower Trout Creek (e.g. rainbow trout parr), and considerable uncertainty surrounds the spawning distribution and habitat use of kokanee. A critical shortcoming of the assessment and analysis of fish habitat is the reliance on the habitat characteristics and analysis results of a single riffle site in each of the canyon reach and the channelized reach of the lower system. Additional sites should be selected and monitoring stations benchmarked for consistent application of sites and sections. Analyses should also investigate natural, undisturbed pool-riffle macrohabitat features in the middle watershed above the intake and below Thirsk reservoir to develop flow-habitat measures for these reaches. Physical and flow-related barriers in the creek should be reviewed to ensure adequate access or extended access to utilize all available habitats – especially for kokanee which may have flow-limited access to spawning habitats.

In concert with the biological work, a hydrometric station to collect real-time streamflow and temperature data should be installed in the lower reaches of the creek below the water intake. Consistent gauging and flow records are vital if meaningful flow-habitat investigations are to be considered in the future. Finally, water quality improvements specifically related to reducing suspended sediment from the continual seepage-related slides within the upper canyon reach should be reviewed, and concepts and costs prepared to remediate the issue.

1.0 Background

The Trout Creek watershed drains a southwestern portion of the Okanagan Valley, and is the second largest drainage entering Okanagan Lake (758.8 square kilometres). From forested plateau headwaters, it drops south and east entering Okanagan Lake at Summerland. The estimated naturalized mean annual discharge of Trout Creek at the mouth is approximately at 2.9 m^3/s (**nhc** 2004) and the naturalized mean annual discharge of Trout Creek without the Darke Creek sub-basin (operated by a separate water utility) at the District of Summerland water intake is 2.54 m^3/s. Land use activities include agriculture (primarily tree fruit and other products) and urban development in the lower watershed; range, grazing and forestry occur in the rest of the watershed. Water use impacts are predominantly related to water supply development for the District of Summerland which includes development of storage (8 reservoirs) and water withdrawal at the main intake located approximately 13 km upstream of the mouth.

Figure 1 Trout Creek Watershed



Currently, Trout Creek supports populations of stream resident and adfluvial (e.g. migrants from lake habitats) rainbow trout, kokanee and a variety of other species. Kokanee and rainbow trout support important recreational fisheries in Okanagan Lake, and at its peak in the late 1980's, the Okanagan Lake fishery supported over 70,000 angler-days. The fishery would translate into direct and indirect expenditures of more than nine million dollars annually ($9.0M) at current angler-day dollar values. Based on limited data, including historical photos, anecdotal reports and drainage size, Trout Creek was once a major contributor to kokanee and rainbow trout production in Okanagan Lake Basin. However, current fish production is thought to be well below historic levels due to loss of habitat associated with water and land use.

Okanagan Lake kokanee populations have suffered major declines due to loss of stream habitat and impacts in the lake environment. In response to this decline, the kokanee fishery was closed in 1995 and a comprehensive kokanee recovery program was implemented. To date, over three million dollars ($3.0M) has been expended on Okanagan Lake kokanee recovery programs, including habitat and fish management programs aimed at increasing the stock or biomass of kokanee in the system. This recovery plan has also directed significant resources toward assessing streamflow and water use in the key tributary streams including Trout Creek and identifying flow requirements that will address fish conservation and production goals. The ultimate goal of the program is to develop water management agreements in collaboration with water users and purveyors in these tributary systems that will provide water for both people and fish over the long term.

2.0 Trout Creek Fish Populations and Distribution

The following section provides a summary of fish populations and their distribution in the Trout Creek watershed. Fish sampling is undertaken as part of general assessments related to forestry and instream work activities. FISS / FishWizard queries (DFO/MWLAP 2004) identified approximately 50 sampling locations that indicate widespread utilization of most reaches by rainbow trout (*Oncorhynchus mykiss*), as well as eastern brook trout (*Salvelinus fontinalis*), prickly sculpin (*Cottus asper*), mountain whitefish (*Prosopium williamsoni*), largescale sucker (*Catostomus macrocheilus*), longnose dace (*Rhynichthys cataractae*) and kokanee (*Oncorhynchus nerka*).

Fish inventory information is more prevalent for the upper watershed due to stream sampling requirements associated with forest development in these areas. There are no sampling data available for the section extending from the upstream end of the canyon to the start of the crown forest section, with the exception of an inventory of dead fish immediately downstream of the District of Summerland intake following a de-watering event in August of 2003.

For the basis of this document and the Trout Creek Water Use Planning process, rainbow trout and kokanee are used as the indicator species for assessing flow / habitat impacts and benefits based on their high level of sensitivity to water quality, water quantity and physical habitat conditions. A fundamental assumption is the aquatic ecosystem is adequately protected if the flow-related habitat requirements of these species are addressed. As such, the focus of the document is on the attributes, habitats and issues related to rainbow trout and kokanee.

2.1 Rainbow Trout and Kokanee in Trout Creek

There are large populations of rainbow trout and eastern brook trout in the upper watershed. Resident rainbow trout utilize the entire length of Trout Creek – up to and including the headwater lakes – and many of the tributary streams. Adfluvial rainbow trout from Okanagan Lake are limited to the lower reaches which are accessible from the lake during spring freshet. The canyon section of Trout Creek also supports large numbers of rainbow trout and a variety of other species depending on location and habitat type. All other fish species, with the exception of longnose dace, are only present from the downstream end of the canyon to the lake due to the barriers described below. Longnose dace are present throughout the canyon section of Trout Creek.

Periodic kokanee enumeration surveys have been conducted over the past 20 years, and escapements have typically been low (generally <100 spawners) largely due to insufficient flow and high water temperatures that limit migration upstream past the mouth. More intensive spawner enumerations have been conducted over the past 4 years. These recent surveys indicate Trout Creek will attract significant numbers of spawning kokanee – up to 3,000 fish have been recorded – when streamflows are adequate to provide migration and access to spawning habitats and the in-lake population is sufficiently large.

There is limited information available on preferred kokanee spawning habitats and their location. Typically the majority of fish have been observed downstream of the Highway 97 bridge which is attributed to the low flows and relatively poor migration and access flows during the kokanee migration period. Kokanee spawning habitat is limited throughout the modified channel section downstream of the canyon, and gravel quantity/quality appears to be higher downstream of Highway 97 bridge based on observations. Patches of gravel are available in the canyon section where hydraulic conditions may contribute to improved egg-to-fry survival compared to the lower reach.

At the present time, the extent of upstream adfluvial rainbow trout and kokanee migration is relatively unknown. It is thought to be limited to the lower end of the canyon section due to a series of natural obstacles causing impassable hydraulic barriers. There are at least 5 identified potential barriers for kokanee migration during the upstream migration period, and plans to provide passage and access to higher quality habitat in the system have been prepared (**nhc** 2003). Barriers for adfluvial trout migration are relatively difficult to assess due to the timing of the migration, and relatively few and difficult conditions in which to observe migrating fish. Improved passage hydraulics during rising streamflows in spring and the swimming performance of the larger trout would suggest further upstream migration than kokanee but the upper limit has not been determined.

2.2 Rainbow Trout and Kokanee Life History Information

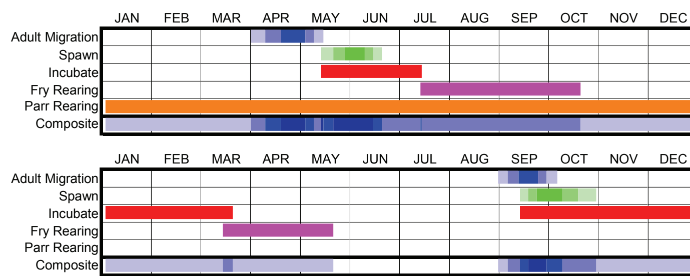
Rainbow trout spawning migration begins in early April, and spawning can extend to early June. Egg and alevin incubation extends into mid-to-late July when emergence occurs and fry become free-swimming. Resident rainbow trout fry will migrate to preferred habitat within the stream and occupy riverine habitats for the remainder of their life history. Adfluvial rainbow trout fry will either migrate to the lake or spend 1 to 2 years rearing in stream habitats before migrating to the lake during spring freshet. This life history is inferred from other similar streams as the exact life history in Trout Creek is not known.

Kokanee spawning migration can start as early as late August and concludes by mid October. Incubation extends from early April to late May when fry swim out of the gravel and migrate to the lake. A periodicity chart for both rainbow trout and kokanee is presented in Figure 2 which details timing for rainbow trout and kokanee life stages. Life histories of other fish species utilizing Trout Creek are not discussed, but their specific flow and habitat requirements are generally addressed by the requirements of these two salmonid species.

Figure 2 Trout Creek Fish Periodicity Chart

Rainbow	Start	End	Peak	Wt	Bin	m3/s	°C
Adult Migration	Apr 01	May 15	Apr 30	1	3	6.2	4.9
Spawn	May 15	Jun 21	Jun 07	1	3	9.9	9.8
Incubate	May 15	Jul 15		1	1	7.9	12.0
Fry Rearing	Jul 15	Oct 21		1	1	1.1	15.4
Parr Rearing	Jan 01	Dec 31		1	1	2.6	7.8

Kokanee	Start	End	Peak	Wt	Bin	m3/s	°C
Adult Migration	Sep 01	Oct 07	Sep 21	1	3	0.7	13.9
Spawn	Sep 15	Oct 31	Oct 01	1	3	0.7	9.5
Incubate	Sep 15	Mar 21		1	1	0.6	3.9
Fry Rearing	Mar 15	May 21		1	1	5.5	4.7
Parr Rearing							



3.0 Trout Creek Fish Habitat

This section reviews the qualitative and quantitative habitat requirements for both rainbow trout and kokanee relative to their freshwater environment. Specific concerns relative to life stage requirements and limiting factors to fish production are also briefly discussed. With respect to specific habitats within Trout Creek, there is insufficient data to provide an overview or context relative to the distribution and use by specific species. Initial fish distribution data indicates that fish, predominantly rainbow trout, utilize most if not all accessible, suitable aquatic habitats within the Trout Creek watershed.

3.1 Physical Habitats

Freshwater fish that reside in riverine environments require a relatively wide and diverse range of habitats and features in which to rear, feed and reproduce to sustain significant populations. These habitats include aquatic (water) and adjacent riparian (land) areas which significantly influence aquatic habitat values.

Generally, streamflows and channel structure determine the amount and suitability of instream habitats. Important aquatic habitats are typically identified by the hydraulic feature they represent during normal streamflows. Riffle habitats provide benthic invertebrate production (food items), feeding areas, refugia habitat and spawning areas. Pool habitats can provide feeding and holding area, cover and refuge habitat, and over-wintering habitat.. Transitions and variations between these two major habitats also provides key habitats, such as the tail-out of pools.

Riparian habitats provides many important functions including: contributing large woody debris; providing temperature regulation through shading; increasing bank stability this vegetation; and contributing detritus and insect drop (food items) to the stream ecosystem. With respect to fish habitat, critical or limiting habitats can be identified that require special consideration with respect to impacts on fish populations. With salmonids in riverine environments, these can include: off-channel habitats that provide refugia and over-wintering habitat; rearing and cover habitats generated by large woody debris, complex and varied channel morphology; and spawning habitat with relatively stable, suitably-sized substrates.

The complexity and diversity of aquatic habitats is greatly influenced by the watershed setting, hydrology and stream morphology. Physical processes related to water flow, sediment erosion and deposition, and channel and riparian inter-relationships are responsible for the regeneration and renewal of aquatic habitats. Alluvial, free-stone stream and river systems can have a wide range of habitat types that reflect hydrological characteristics, land-use and glacial histories, and these systems often provide the greatest habitat complexity. Modifications and impacts to these processes often illustrate that these stream and river systems also possess the greatest sensitivities as well. Sustainability of these ecosystems is typically linked to protection of both biological and physical processes.

3.2 Water Quality

Salmonids – rainbow trout and kokanee – require clean, cold freshwater that is free of harmful contaminants or pollutants. While these fish can live in a wide range of habitat conditions, they require fresh water that is highly saturated with dissolved oxygen (DO) with moderate temperatures and free of elevated levels of suspended sediment. Optimum temperatures for rearing and fish growth range from 10-18°C and water temperatures exceeding 24°C can result in mortality or severe sub-lethal impacts depending on the period of exposure.

Suspended sediment or turbidity is a water quality parameter that can significantly influence fish and fish habitat. Elevated levels of suspended sediment can have a range sub-lethal impacts including stress, reduced feeding and growth, increased predation, as well as habitat-related impacts and mortality at higher levels. Habitat impacts include: infill of spawning areas reducing inter-gravel circulation and smothering eggs; infilling of rearing habitats; and smothering and displacement of benthic invertebrates. Levels of suspended sediment – as measured by total suspended solids – as low as 75 mg/L above clear background conditions can cause a negative response in rearing rainbow trout.

While deleterious substances or pollutants that kill fish are harmful and not wanted in stream environments, some concentrations of dissolved nutrients in streamflows are beneficial. In BC streams like Trout Creek, dissolved nitrogen and phosphorus in the correct ratio to each other and at very low levels, stimulates primary productivity (algal growth) that in turn increases secondary productivity (benthic invertebrates) resulting in increased fish growth and production. Nutrients play an important role in determining overall productivity of the aquatic ecosystem.

3.3 Streamflows

Streamflows and channel characteristics or morphology combine to form macrohabitats (i.e. pools, riffles, runs, etc.) within the stream channel, the extent (area) and hydraulics characteristics (e.g. depths and velocities) within those habitats. The amount and suitability of hydraulic habitats relative to life history needs of fish is a fundamental concept in instream flow assessment. Physical habitat, hydraulic habitat, water quality, food and nutrients and streamflows are all important variables that affect fish productivity. However, streamflow is often considered the principle variable when considering instream flow needs for fish. The timing, magnitude, duration and frequency of flows determine hydraulic attributes related to issues such as invertebrate production, fish habitat suitability, woody debris flux, water temperature and maintenance of channel processes.

4.0 Trout Creek Fish Habitat Impacts

Land and water use activities have the potential to cause impacts to fish habitats and corresponding decrease in the productive capacity and fish production. A wide range of impacts resulting from land development activities starting from first settlement in the valley have greatly reduced fish habitat quantity and quality in Trout Creek. These impacts include:

- agricultural, industrial and domestic water use that reduces flows and the amount of suitable aquatic habitat for fish.
- construction of water storage that modifies streamflow hydrology that disrupts fish life history requirements, and alters channel formation and maintenance processes.
- loss of channel length, habitat features, and riparian vegetation resulting from channelization and diking associated with flood protection works – considerable impacts are found in the lower reaches of Trout Creek..
- increased sedimentation/turbidity associated with land-use activities like forest harvesting activities, road construction and instream works. A natural slide located within Trout Creek canyon is also contributing significant amounts of fine sediment to the stream, but irrigation practices may be contributing to slide instability by elevating groundwater levels.

Important to note that many longstanding footprint impacts can be rectified through redesign, structural changes and habitat restoration. Operational impacts – such as water use and impacts to habitat – can only be changed by modifying the activity to mitigate or prevent the impact. However, the at-times weak correlation and variation of streamflow to absolute fish production makes the determination of streamflow requirements difficult if not impossible to conclude. Development and documentation of BC Flow Standards and the use of metrics specific to Trout Creek fish and fish habitats provides an improved background for determining the impacts of modified hydrology and water use on fisheries resources.

4.1 Conservation and Protection of Fish and Fish Habitat

Fish habitat and associated fish populations are protected under the federal *Fisheries Act,* and the management of the Trout Creek fisheries resource is the responsibility of the Ministry of Environment. Under section 35(1) of the *Fisheries Act*, any activities which result in harmful alteration, disruption or destruction of fish habitat (HADD) is a violation and may be subject to investigation, prosecution and other actions. Under section 22(3) of the *Fisheries Act*, there is provision for the release of water from a dam sufficient for the safety of fish and ova (deposited eggs).

5.0 Fish Flow Principles

The Ministry of Water Land and Air Protection, with the support of Fisheries and Oceans Canada, has engaged with the District of Summerland, First Nations and stakeholders in a proactive Water Use Planning process. This forward-looking endeavour engages cooperation, stewardship and social responsibility within a framework data collection, planning and option analysis. For the purposes of identifying requirements and establishing instream flows for streams in the Okanagan Region including Trout Creek, flows standards and principles have been developed to aid in the development of appropriate instream flows.

In Trout Creek, the streamflow – habitat relationship has been assessed downstream of the water intake in the lower canyon reach and lower reaches that have been modified by flood control works. With associated impacts on channel morphology and fish habitat, the lower reach of Trout Creek below the canyon is modified and is not representative of a natural flow-habitat relationship that would exist in an undisturbed reach. Similarly, the canyon section has a much narrower channel section with larger substrate, and in not representative of the more typical cobble-gravel stream reaches found elsewhere in the watershed.

The wider modified channel section and the narrower canyon section represent the limits of channel types found in Trout Creek, and the streamflows derived through analysis are also likely representative of the limits or bounds of what flows would be assessed in other sections. As a result of the transect locations and the utilization of fish throughout the lower reaches extending up into the canyon, optimum fish rearing and spawning/incubation requirements will be based on both the canyon reach and the lower modified reach.

5.1 Naturalized Streamflows

Naturalized streamflows are estimates of the natural flows that would occur in the watershed in the absence of any flow manipulation (such as storage reservoir management and water withdrawals at intakes). Natural streamflows vary from day to day, month to month, and year to year in response to hydrological conditions within the watershed. Natural streamflows can not be measured directly in regulated systems because the management of the water resources within the watershed alters the flow at any point in time so naturalized flows are used to approximate natural flows. Various techniques are used to calculate naturalized flows, including watershed models, water balances and extrapolation from other watersheds.

Naturalized streamflows have been calculated for the Trout Creek watershed in several hydrological studies (Letvak 1989, **nhc** 2001 and **nhc** 2004) and there is general agreement that the mean annual discharge (MAD) is in the range of 2.5 m^3/s to 2.9 m^3/s, with peak flows occurring during spring freshet in May and lowest flows typically occurring in late summer, fall and winter. Naturalized mean monthly flows (MMF) for the Trout Creek watershed (with and without the Darke Creek sub-basin) at the point of diversion by Summerland are shown in Table 1.

5.2 Watershed Conservation Flows

Conservation flows are based on a generalized model of habitat response to varying flow percentages of mean annual discharge for a wide range of streams in BC. They integrate species life stage requirements with naturalized hydrograph changes to represent an ecosystem perspective, and are based on a combination of provincial standards and stream specific flow/habitat relationships. These flows address the fundamental ecosystem requirements of aquatic habitats including channel formation/maintenance, invertebrate production, and fish production.

Streamflows less then the conservation flow targets will result in an eventual significant reduction in available fish habitat and associated fish production. There is potential for improvements in fish habitat above these flows, but generally these streamflows represent overall ecosystem requirements that support sustainable fish production. Unlike natural baseflows, conservation flows do not vary with changing water supply conditions or in situ hydrological conditions because the general habitat potential is directly related to mean annual flow through depth, velocity and flow relationships. Accordingly, conservation flows only vary within a year according to specific fish species life history requirements, not on a year-to-year basis.

The watershed area upstream of the point-of-diversion (without Darke Creek contributions to streamflow) were used to reference conservation flow requirements. Darke Creek is excluded from consideration because it is managed by another water utility which influences the flows from that sub-basin. Conservation flows have been further refined for Trout Creek based on an assessment of past studies and methods (**nhc** 2004), such that the relevant portion of the estimated MAD for the entire watershed was transferred to the point-of-diversion. Table 1 provides a summary of Trout Creek mean monthly flows and conservation flows below the District of Summerland water intake.

Table 1 Trout Creek Conservation Flows at Point-of-Diversion

Month	MMF w Darke Cr (m^3/s)	MMF w/o Darke Cr (m^3/s)	Conservation Flows (m^3/s)		
			% MAD	MMF w Darke	MMF w/o Darke
January	0.48	0.45	20	0.54	0.51
February	0.49	0.46	20	0.54	0.51
March	0.63	0.59	20	0.54	0.51
April	2.74	2.58	100	2.70	2.54
May	13.22	12.44	200	5.41	5.09
June	8.52	8.02	100	2.70	2.54
July	2.58	2.43	40	1.08	1.02
August	1.09	1.03	30	0.81	0.76
September	0.78	0.73	25	0.68	0.64
October	0.69	0.65	20	0.54	0.51
November	0.66	0.62	20	0.54	0.51
December	0.56	0.53	20	0.54	0.51
Average	2.70	2.54	-	1.39	1.30

Note: MMF = Mean Monthly Flow, MAD = Mean Annual Discharge, and w = with and w/o = without

5.3 Natural Baseflows

Natural Baseflows are typically the non-freshet streamflows in a system which are supported by groundwater and not by runoff. The natural baseflow is also responsive to current hydrological conditions within the watershed, and can vary within year and year-to-year in response to snow pack conditions. They can be derived from instream monitoring or through the use of a representative stream with real time flow data.

Natural baseflows are flows that support the base or natural minimum amount of fish habitat in a stream and to which local fish populations have ecologically adapted. Natural baseflows are the minimum flow levels required to ensure sustained local fish production, often coinciding with the most sensitive of fish life stages (e.g. adult migration, spawning, egg incubation, and juvenile rearing).

Average year natural baseflows are represented by the post freshet mean monthly flows in Table 1. Lower values for natural baseflows will be encountered in drier than average years with the result that natural baseflows will be less than conservation flows in those years. Trout Creek specific impacts of flows less than conservation flows can be examined by consideration of: timing and duration of instream flows (Section 5.4), optimum flows for fish (Section 5.5) and potential impacts to fish and fish habitat (Section 5.6).

5.4 Timing and Duration of Instream Flows

Migration and spawning flows, out migration, geomorphic and off-channel connectivity flows are standards that require flows of relatively short periods to satisfy optimum conditions. Trout Creek has a wide range of annual inflow conditions that may or may not provide the conditions required for these short duration flow standards in years of low inflow. This is especially true on shoulder months when the impacts of storage refill may be greater than in high annual inflow years.

However, based on the historic flows, the naturalized streamflows would appear to provide more than adequate flows for geomorphic, and other, processes that require relatively large freshet flows in relation to MAD, and the relatively small amount of storage relative to the total annual flow would indicate that typically this flow standard will be achieved in most years with normal streamflows.

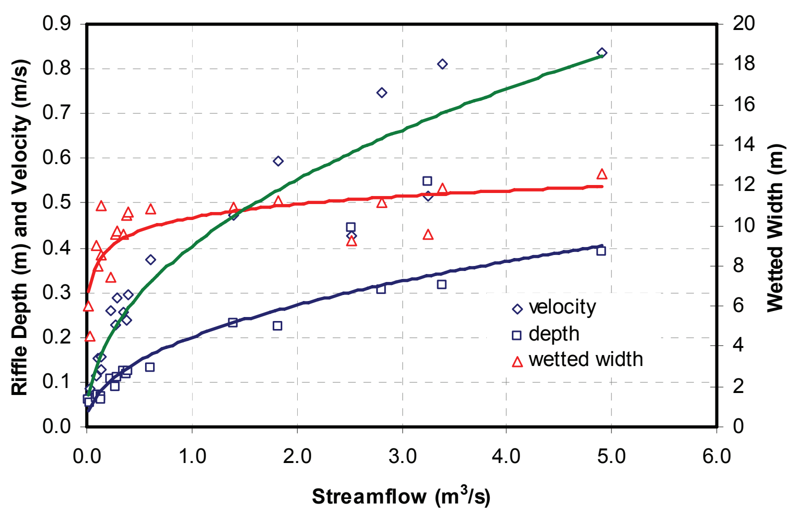
One critical period is April through to early May where early freshet flows are required for rainbow trout migration and spawning. Historical streamflow data indicates that flows approaching optimum are achieved, and only in years with low annual inflows are streamflows less than optimum for this lifestage requirement. However, even in low inflow years a freshet flow does occur, albeit at a greatly reduced ratio to the mean of high inflow years.

For kokanee, fish distribution and spawning habitat utilization is influenced by the flows available for migration and access to suitable habitats. If streamflows are low during migration, kokanee are forced to utilize the lower reaches of Trout Creek below Highway 97. If streamflows are sufficient, kokanee migration is provided into the lower portions of the canyon.

As preliminary guidance, an estimated passage flow can be calculated using hydraulic geometry of the critical or limiting riffle habitat in a manner similar to Thompson (1972). Provision of a mean minimum depth through the riffle equal to 100% of the mean body depth of the migrating fish provide adequate passage conditions in the relatively coarse riffle substrate. This was estimated through examination of the cross section characteristics and visual inspection. Some areas of the riffle will be shallower and some deeper, but connectivity will likely be established through the riffle section.

Using an estimated kokanee body depth of 100 mm with the analysis of riffle depths and velocities at both the lower modified and upper canyon site, a preliminary minimum passage flow of 0.3 m^3/s is required, and Figure 3 illustrates the riffle hydraulics used to estimate this value. To ensure kokanee migration and access to limited spawning habitats – which overlap with the critical period streamflow (CPSF) – the minimum migration flow should be provided during this period through use of the suggested flow for kokanee spawning and incubation suggested in Section 5.5.2.

Figure 3 Streamflow, Riffle Depth and Velocity and Wetted Width at the Lower Channel Riffle



To ensure these migration requirements are met for fish life history requirements, flow duration should be specified in the water use plan, along with timing and magnitude of flows. Accordingly, a weekly or biweekly flow schedule may be required along with biological monitoring to better determine the flows, duration and timing required to provide the life stage requirements – especially for kokanee migration and spawning during the CPSF.

Concerns are reduced for upstream adult trout migration which may only occur over a period of days or weeks and require only short period of flows greater than 100% MAD, typically during early freshet when these streamflows are available. However, planned future storage development in Trout Creek watershed and reservoir refilling that occurs during freshet could potentially impact these flows. Monitoring and assessment may be required in the future.

5.5 Optimum Flows for Fish Habitat

Optimum flows are streamflows that maximize the limiting or critical habitat for a specific fish species according to the hydraulic suitability requirements using depth, velocity and substrate in a weighted usable area or weighted usable width analysis (WUA or WUW). Depth and velocity can be used alone in the hydraulic suitability analysis where it is undertaken in a prime macrohabitat type relative to the lifestage. For example, in a parr habitat-limited stream, optimum flows would be those that produce a depth and velocity that maximizes parr rearing suitability in riffle habitat. Streamflows in excess of the optimum flows do not increase available fish habitat. While optimum flows are not a required flow for Trout Creek, they provide a metric for determining the amount of habitat loss and associated fish production for specified flows.

Based on life history information for Okanagan Lake tributary streams, rainbow trout parr habitat and kokanee spawning/incubation habitat are limiting habitats with respect to fish production of those species. Total habitat represented by weighted usable width (WUW_{dv}) and relative habitat – % weighted usable width ($\%WUW_{dv}$) – were calculated for the range of transect flows at both the canyon and lower channel sites in representative glide and riffle habitats. Unit habitat measures – %WUW – were used to normalize the data and reduce standard errors associated with analyses. For rainbow trout parr, optimum flow is developed from analyses undertaken on riffle habitat sections at the canyon and highway transect stations. For kokanee, optimum flows are developed from glide habitats in both locations.

5.5.1 Rainbow Trout

Weighted usable width[2] (WUW_{dv}) and % weighted usable width ($\%WUW_{dv}$) were calculated for the range of transect flows ranging at the canyon from 0.019-2.811 m^3/s and at lower channel sites from 0.022-4.909 m^3/s. Correlations for all sites were strong and good functional relationships were developed through regression and curve-fitting techniques.

At the canyon site, habitat increased markedly to approximately 1.0 m^3/s, and then increased slightly in response to increased flows to 1.5 m^3/s. Habitat did not exhibit a clear maximized function over the range of flows, however incremental gains in habitat appear to be maximized at approximately 0.25 m^3/s by the %WUW function. At the lower channel site, habitat increased markedly to approximately 1.3 m^3/s, and then decreased to 4.9 m^3/s. Fish habitat exhibited a clear maximized function over the range of flows, and incremental gains in habitat appear to be maximized at approximately 0.2 m^3/s by the %WUW function and weighted habitat as a percent of total width declined as flows increased.

A definitive optimum flow for rainbow trout parr habitat could not be identified at the canyon site, and further sampling at flows between 0.75 to 1.50 m^3/s is required to improve the analysis. Optimum flow for the lower channel site was approximately 1.2 m^3/s, and this flow would appears to maximize habitat at the canyon site as well.

[2] Weighted usable width analyses utilized hydraulic components of depth and velocity in calculation of suitability

Figure 4 Streamflow vs WUW for RB 1+ rearing habitat in Trout Creek Canyon Riffle

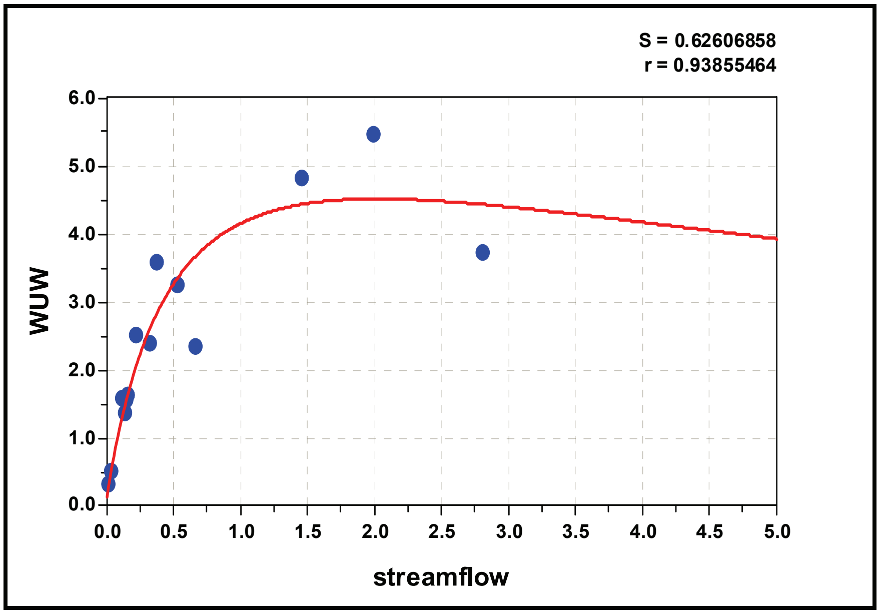


Figure 5 Streamflow vs % WUW for RB 1+ rearing habitat in Trout Creek Canyon Riffle

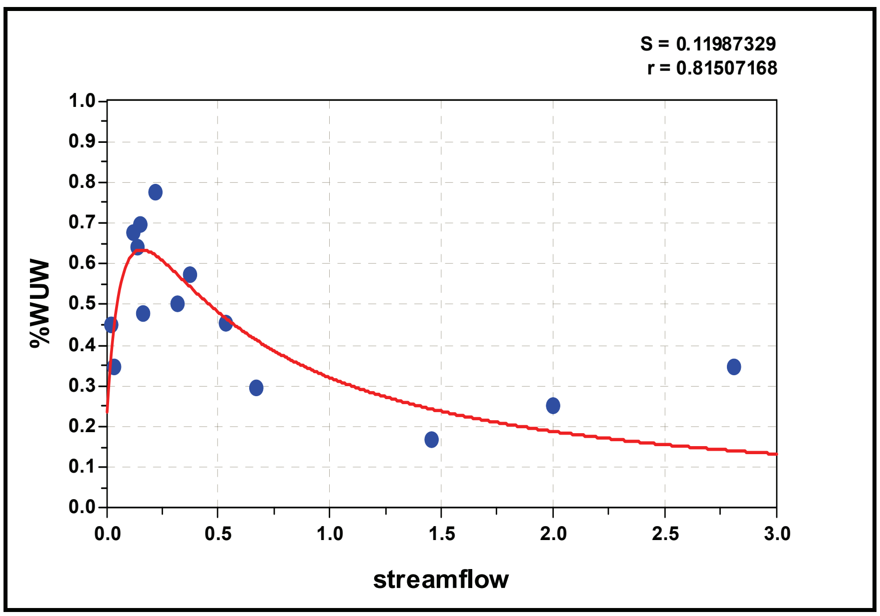


Figure 6 Streamflow vs WUW for RB 1+ rearing habitat in Trout Creek Lower Channel Riffle

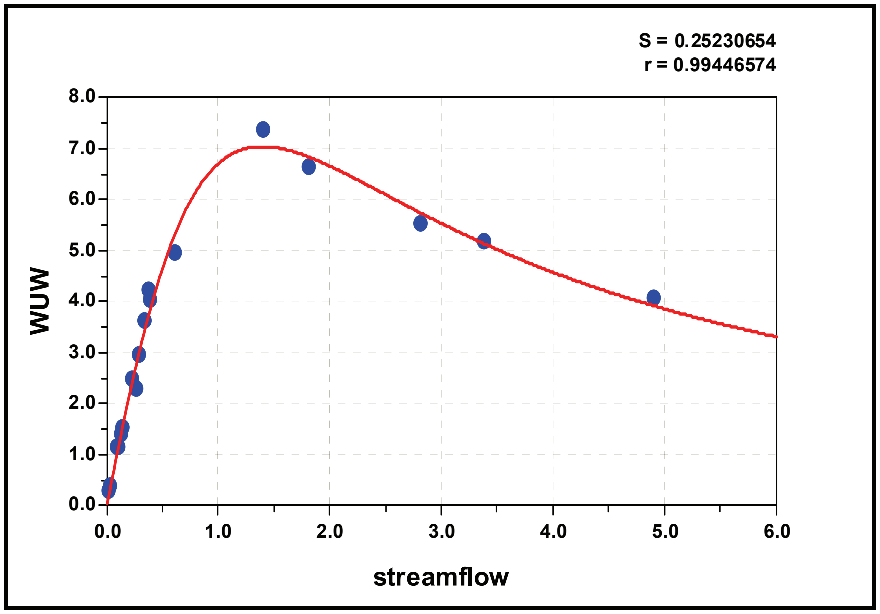
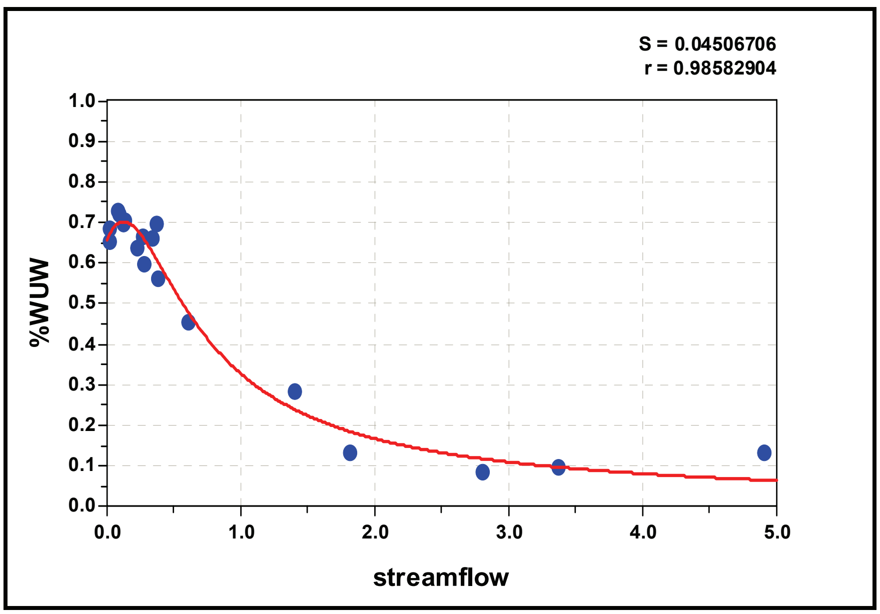


Figure 7 Streamflow vs % WUW for RB 1+ rearing habitat in Trout Creek Lower Channel Riffle



5.5.2 Kokanee

Weighted usable width (WUW_{dv}) and % weighted usable width ($\%WUW_{dv}$) were calculated for the range of transect flows ranging from at the canyon from 0.015-1.664 m^3/s and at lower channel sites from 0.032-3.251 m^3/s. Correlations were strong and functional relationships were developed for the canyon site and the lower channel site.

At the canyon site, an optimum value was not obtained but incremental gains in habitat appear to be maximized at approximately 0. 5 m^3/s by the %WUW function. At the lower site, the habitat relationship appears to be optimum at approximately 0.8 m^3/s and decreasing with either increasing or decreasing flows.

Based on the results of these sections, an optimum flow for kokanee spawning and incubation is estimated at 0.8 m^3/s, approximately 28% MAD, over the range of flows surveyed. Based on visual observation of both sample sites and habitat conditions in lower Trout Creek, the author suggests that kokanee are likely substrate limited in habitats above Highway 97, up into the canyon sections.

Figure 8 Streamflow vs WUW for KO spawning and incubation habitat in Trout Creek Canyon Glide

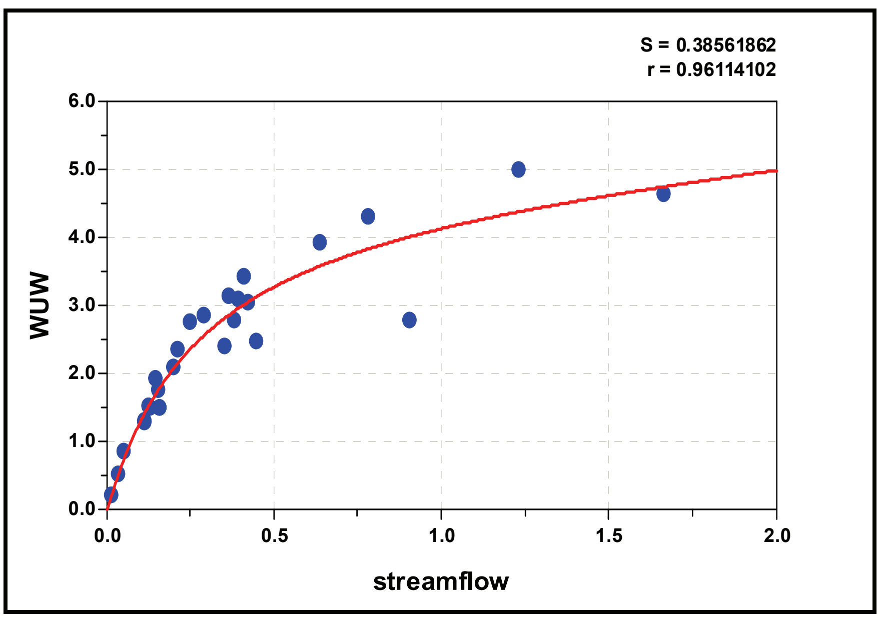


Figure 9 Streamflow vs % WUW for KO spawning and incubation habitat in Trout Creek Canyon Glide

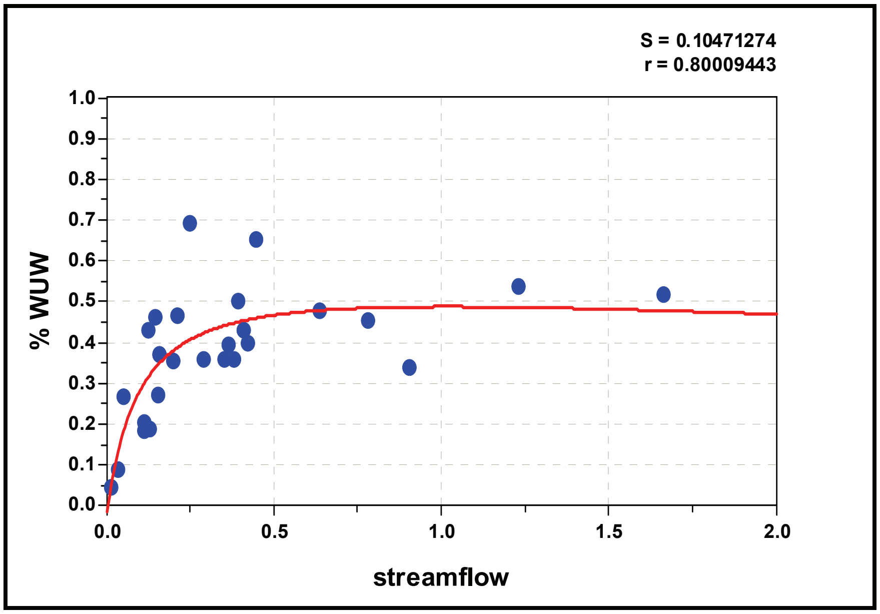


Figure 10 Streamflow vs WUW for KO spawning and incubation habitat in Trout Creek Lower Channel Glide

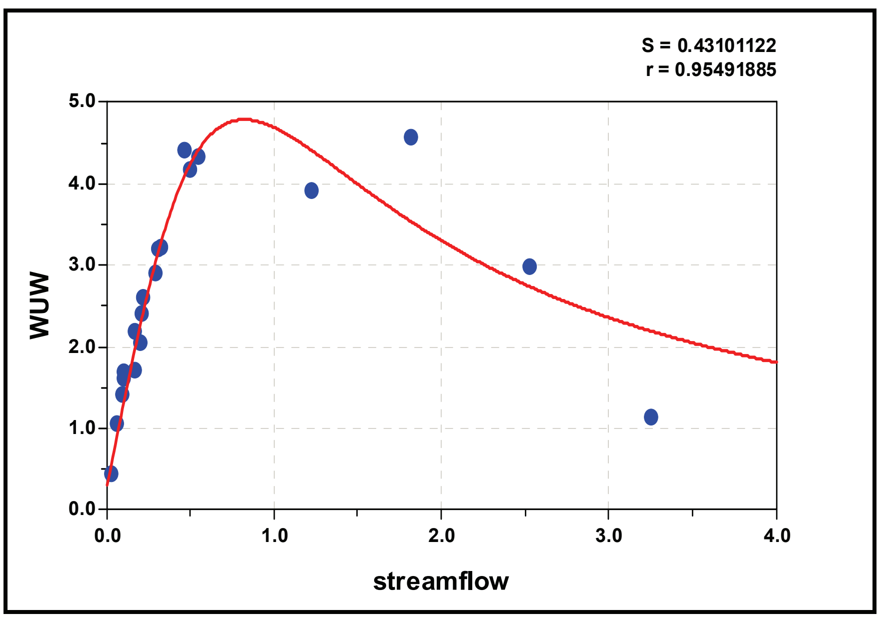
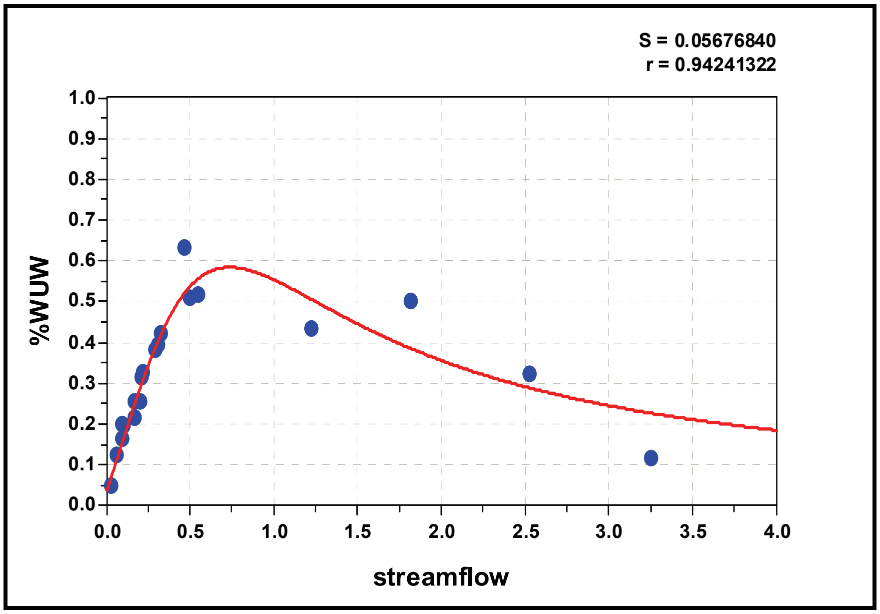


Figure 11 Streamflow vs % WUW for KO spawning and incubation habitat in Trout Creek Lower Channel Glide



5.6 Potential Impacts to Fish and Fish Habitat

Using the fish flow principles explained earlier, optimum or suggested maximized, conservation and naturalized flows in Trout Creek below the diversion were compared using rainbow trout parr habitat estimated by weighted usable width (WUW) in the canyon and lower channel test riffle habitats.

The WUP 10:1 multiplier used as a basis for ensuring naturalized instream flows for Trout Creek below the intake over June to October period – relative to conservation and naturalized flows – is illustrated in Table 2. Using the month of September as an example, the change in rainbow trout parr habitat is approximately 12% from 14:1 to 10:1 and a further 23% from 10:1 to 6:1 in the canyon. In the lower channel, the habitat change is approximately 18% from 14:1 to 10:1 and a further 33% from 10:1 to 6:1.

The habitat relationships in Table 2 illustrate the analysis of average values compiled over the period of hydrological record. To examine the full impacts of potential fish habitat - flow trade-off inherent in the water use plan process, yearly representative streamflows were compared to the fish habitat measures (WUW). Accordingly, 14, 10 and 6 times multipliers of mean monthly Camp Creek streamflows for 1987, 2000 and 2003 where compared and Table 3 summarizes the results. Net changes in habitat were estimated at both the canyon and lower channel sites with higher changes in total habitat noted at both sites over the range of flows due to the steep nature of the flow-habitat curve.

Table 2 RB 1+ Rearing Habitat Weighted Usable Width for Naturalized Monthly Flows using Estimated Camp Creek Streamflows

Flow Condition (m^3/s)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Conservation Flows	0.51	0.51	0.51	2.54	5.09	2.54	1.02	0.76	0.64	0.51	0.51	0.51
Naturalized Flows	0.48	0.49	0.63	2.74	13.22	8.52	2.58	1.09	0.78	0.69	0.66	0.56
Mean Camp Creek Flows[1]	0.04	0.04	0.05	0.21	0.66	0.41	0.13	0.07	0.05	0.05	0.05	0.05
6:1 Camp Creek Multiplier	-	-	-	-	3.95	2.44	0.79	0.41	0.32	0.30	-	-
10:1 Camp Creek Multiplier	-	-	-	-	6.59	4.06	1.32	0.68	0.53	0.49	-	-
14:1 Camp Creek Multiplier	-	-	-	-	9.22	5.69	1.85	0.95	0.74	0.69	-	-
Estimated WUW RB 1+ Canyon (m)												
Conservation Flows	-	-	-	-	n.a.[2]	4.50	4.20	3.88	3.64	3.32	-	-
6:1 Camp Creek Multiplier	-	-	-	-	n.a.	4.52	3.93	2.99	2.61	2.51	-	-
10:1 Camp Creek Multiplier	-	-	-	-	n.a.	n.a.	4.41	3.73	3.37	3.28	-	-
14:1 Camp Creek Multiplier	-	-	-	-	n.a.	n.a.	4.54	4.14	3.84	3.75	-	-
Estimated WUW RB 1+ Lower Channel (m)												
Conservation Flows	-	-	-	-	n.a.	6.05	6.75	6.05	5.48	4.74	-	-
6:1 Camp Creek Multiplier	-	-	-	-	4.62	6.17	6.16	4.03	3.27	3.10	-	-
10:1 Camp Creek Multiplier	-	-	-	-	n.a.	4.53	7.04	5.71	4.86	4.65	-	-
14:1 Camp Creek Multiplier	-	-	-	-	n.a.	n.a.	6.80	6.62	5.95	5.75	-	-

[1] Mean monthly flows for the period of 1966 to 2003.
[2] n.a. – streamflow is in excess of range for estimation for weighted usable width (WUW)

Table 3 Estimates of RB 1+ Rearing Habitat Weighted Usable Width for Various Trout Creek Streamflow Conditions

Flow Condition (m^3/s)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Trout Creek Conservation Flows	0.51	0.51	0.51	2.54	5.09	2.54	1.02	0.76	0.64	0.51	0.5	0.51
1987 Camp Creek Flows[1]	0.044	0.042	0.054	0.270	0.538	0.104	0.049	0.030	0.026	0.025	0.028	0.029
2000 Camp Creek Flows	0.047	0.036	0.040	0.334	0.508	0.262	0.130	0.052	0.044	0.040	0.039	0.033
2003 Camp Creek Flows	0.029	0.032	0.036	0.106	0.322	0.132	0.033	0.020	0.019	0.024	0.023	0.025
6:1 Multiplier - 1987 Camp Creek					3.228	0.624	0.294	0.180	0.156	0.150		
10:1 Multiplier - 1987 Camp Creek					5.380	1.040	0.490	0.300	0.260	0.250		
14:1 Multiplier - 1987 Camp Creek					7.532	1.456	0.686	0.420	0.364	0.350		
6:1 Multiplier - 2000 Camp Creek Flows					3.048	1.572	0.780	0.312	0.264	0.240		
10:1 Multiplier - 2000 Camp Creek Flows					5.080	2.620	1.300	0.520	0.440	0.400		
14:1 Multiplier - 2000 Camp Creek Flows					7.112	3.668	1.820	0.728	0.616	0.560		
6:1 Multiplier - 2003 Camp Creek Flows					1.932	0.792	0.198	0.120	0.114	0.144		
10:1 Multiplier - 2003 Camp Creek Flows					3.220	1.320	0.330	0.200	0.190	0.240		
14:1 Multiplier - 2003 Camp Creek Flows					4.508	1.848	0.462	0.280	0.266	0.336		
Estimated WUW RB 1+ Canyon												
Trout Creek Conservation Flows					n.a.[2]	4.50	4.20	3.88	3.64	3.32		
6:1 Multiplier - 1987 Camp Creek	-	-	-	-	n.a.	3.61	2.50	1.83	1.65	1.61	-	-
10:1 Multiplier - 1987 Camp Creek	-	-	-	-	n.a.	4.22	3.26	2.53	2.32	2.26	-	-
14:1 Multiplier - 1987 Camp Creek	-	-	-	-	n.a.	4.46	3.74	3.03	2.81	2.76	-	-
6:1 Multiplier - 2000 Camp Creek Flows	-	-	-	-	n.a.	4.50	3.91	2.58	2.34	2.21	-	-
10:1 Multiplier - 2000 Camp Creek Flows	-	-	-	-	n.a.	4.49	4.40	3.35	3.10	2.96	-	-
14:1 Multiplier - 2000 Camp Creek Flows	-	-	-	-	n.a.	n.a.	4.54	3.82	3.59	3.46	-	-
6:1 Multiplier - 2003 Camp Creek Flows	-	-	-	-	4.54	3.93	1.95	1.37	1.32	1.56	-	-
10:1 Multiplier - 2003 Camp Creek Flows	-	-	-	-	n.a.	4.41	2.67	1.96	1.89	2.21	-	-
14:1 Multiplier - 2003 Camp Creek Flows	-	-	-	-	n.a.	4.54	3.18	2.42	2.35	2.69	-	-

Estimated WUW RB 1+ Lower Channel												
Trout Creek Conservation Flows					n.a.	6.05	6.75	6.05	5.48	4.74		
6:1 Multiplier - 1987 Camp Creek	-	-	-	-	5.29	5.42	3.07	1.98	1.73	1.67	-	-
10:1 Multiplier - 1987 Camp Creek	-	-	-	-	3.63	6.79	4.62	3.12	2.76	2.67	-	-
14:1 Multiplier - 1987 Camp Creek	-	-	-	-	n.a.	7.04	5.72	4.11	3.67	3.56	-	-
6:1 Multiplier - 2000 Camp Creek Flows	-	-	-	-	5.48	7.00	6.11	3.23	2.80	2.57	-	-
10:1 Multiplier - 2000 Camp Creek Flows	-	-	-	-	3.81	5.96	7.03	4.81	4.26	3.96	-	-
14:1 Multiplier - 2000 Camp Creek Flows	-	-	-	-	n.a.	4.87	6.83	5.91	5.38	5.06	-	-
6:1 Multiplier - 2003 Camp Creek Flows	-	-	-	-	6.73	6.16	2.16	1.36	1.29	1.61	-	-
10:1 Multiplier - 2003 Camp Creek Flows	-	-	-	-	5.30	7.04	3.39	2.18	2.08	2.57	-	-
14:1 Multiplier - 2003 Camp Creek Flows	-	-	-	-	4.18	6.81	4.42	2.94	2.82	3.44	-	-

[1] Mean monthly flows for the annual year specified.
[2] n.a. – streamflow is in excess of range for estimation for weighted usable width (WUW)

6.0 Water Use Plan Instream Flows

The minimum instream flows required under the Water Use Plan for Trout Creek will be the lesser of a representation of natural flow based on multipliers of the flow measured at the WSC site on Camp Creek, or the monthly conservation flow, referenced to immediately below the District of Summerland water intake. Flows based on the multipliers of Camp Creek flows are the minimum required flow whenever the multiplied flow is less than the Conservation Flow during the months of June through October.

As demonstrated in Tables 2 and 3, a 10:1 Camp Creek multiplier will provide approximately 95% of the habitat for rainbow trout parr that would have been provided by conservation flows at both the canyon and the lower channel riffle sites in August under naturalized flows, and about 78 to 85% of the comparable conservation flow habitat at Camp Creek 2000 flows - a relatively average year. As such a 10:1 Camp Creek multiplier is seen as being a reasonable representation of naturally varying flows that will provide a similar level of habitat to those provided by conservation flows in average to wetter years.

Also as demonstrated in Table 3, useable habitat for rainbow trout parr is significantly less than that provided by conservation flows in very dry years like 1987 and 2003 because the flow that is being multiplied has already diminished naturally. For example, a 10:1 Camp Creek multiplier only provides 38 to 52% of the conservation flow habitat in flows of August of 2003. The reduction is large due to the steep nature of the flow / habitat relationships at both sites at lower flows, and is greater in the later part of the summer than it is in June and July because of the declining flows later in the season. The reduced habitat that results from maintaining a 10:1 multiplier in the dry years is accepted because natural flows would likely have been significantly less than conservation flows in those dry years.

Further reductions in the multipliers to help balance supply and demand in dry years are resisted because of the increased impact on fish habitat with reduced flows and multipliers. It was recognized that there are challenges in balancing supply and demand within the existing water storage infrastructure. As such, progressively lower multipliers were agreed to in the Water Use Plan as successive stage level water restrictions are implemented. The Stage 2 and Stage 3 reductions focus on June and July as that part of the season is where a lower multiplier will have less of an impact on fish habitat than in August and September.

Future modification of multiplier – either increasing or decreasing the multiple of Camp Creek flows – will be considered based on ongoing flow, consumption and reservoir level measurements. Adjustments downward will reduce stream flows and the available suitable habitat for fish during the critical period stream flows (CPSF) when conditions are critical for fish growth and survival. Flows should also be adjusted upwards if measurements indicate that the multipliers are significantly less than the natural base flows (e.g. significant consumption is occurring at the expense of natural base flow rather than storage).

Irrespective of required flows, benefits to fish and fish habitat can be realized by additional stream flows up to and including the optimal flows. Additional flows above the minimum requirements may be requested when it can be demonstrated that provision of additional flows will not adversely affect the probability of filling reservoirs in the following year.

The proposed water use plan flows should satisfy conditions for spawning and incubation of both rainbow trout and kokanee under most years, but an accurate assessment can only be completed *in situ* during actual fish migrations and spawning periods. Streamflow requirements regarding migration, and timing and duration of instream flows were discussed in Section 5.4.

7.0 Summary

Weighted usable width[3] (WUW_{dv}) and % weighted usable width ($\%WUW_{dv}$) were calculated for the range of transect flows. Streamflows from 0.019-2.811 m^3/s at the canyon site and from 0.022-4.909 m^3/s at the lower channel site for rainbow parr habitat were used. Flows ranging from 0.015-1.664 m^3/s at the canyon and sites from 0.032-3.251 m^3/s at lower channel were examined for kokanee spawning-incubation habitat.

Correlations for all sites were strong and good functional relationships were developed through regression and curve-fitting techniques for the rainbow trout 1+ rearing habitat. A streamflow that appears to maximize available habitat was estimated at 1.4-1.5 m^3/s, approximately 48-52% MAD, for the range of streamflows investigated. The correlation and functional relationships for WUW and streamflow were also strong for the kokanee spawning habitat. However, an optimum flow for kokanee spawning-incubation habitat could not be identified for the canyon site. An optimum flow for kokanee spawning and incubation is estimated at 0.8 m^3/s, approximately 28% MAD, over the range of flows surveyed for the lower channel site.

Results indicate that the instream flows based on the lesser of either a 10:1 Camp Creek multiplier or the conservation flow standard, will provide similar absolute amounts of habitat in average to wetter conditions and that these amounts will diminish in a near-linear manner at lower flows down to those experienced in dry years like 1987 and 2003. Reduced multiples of Camp Creek flow used as a naturalized flow for lower Trout Creek result in significantly reduced suitable habitat at both sites in moving from 10:1 to 6:1 multiplier.

A shortcoming of the assessment and analysis of fish habitat undertaken for this study is the reliance on the habitat characteristics of only two sites in canyon and lower channel reaches of Trout Creek with riffle and glide habitat types. Although thought to be relatively representative of limiting habitat types in the system, quantitative habitat analyses did not include substrate or a cover component and relied solely on hydraulic characteristics.

---

[3] Weighted usable width analyses utilized hydraulic components of depth and velocity in calculation of suitability

Potential inconsistencies in data collection and no correlation to sampled fish use or densities is also highlighted.

Absolute quantitative losses of habitat – as measured by estimates of WUW – resulting from changes within the envelope of expected minimum flows in the proposed Trout Creek water use plan change near linearly. However, weighted usable width and other measures are simple metrics for productive fish habitat and other factors, potentially influenced by streamflow, should be considered along with physical habitat.

Considerable negative impacts to habitat quality and productivity could result from reduced streamflows in Trout Creek. These impacts include increased solar heating and temperature impacts, loss of productive benthic invertebrate habitat and reduced drift (food), reduced cover and increased predation, increased stress and disease with reduced survival. Quantitative fish biology and synoptic study of individual fish, their growth and health is required to better assess the critical elements – physical habitat, food and nutrients, and water quality – that constitute productive fish habitat in Trout Creek and how these habitat elements are interrelated and affected by streamflow.

8.0 Future Requirements: Data Gaps & Monitoring

The water use plan process presents a unique opportunity to find innovative solutions by means of analysis and comparative examinations of trade-offs between inter-related values or measures. However, the WUP process is incomplete without monitoring and evaluation to ensure the assumptions regarding data and analyses were valid. Monitoring also ensures that decision results are documented – both positive and negative – so that after some predetermined period, adjustments can be made on the basis of better information and understanding. Suggested reconditions for implementation and monitoring of a water use plan on Trout Creek would include:

1. The WUP process undertaken in Trout Creek used limited biological data. No directed biological studies were undertaken to determine actual fish utilization in lower Trout Creek. (e.g. rainbow trout parr), and considerable uncertainty surrounds the spawning distribution and habitat use of kokanee. Basic biological inventory, habitat utilization and fish standing stock studies should be completed over a wider, more representative range of habitat types in Trout Creek..

2. Additional transect sites should be selected and monitoring stations benchmarked for consistent application of future studies and monitoring. Analyses should also investigate natural, undisturbed pool-riffle macrohabitat features in the middle watershed above the intake and below Thirsk reservoir to develop flow-habitat measures for these reaches.

3. There are significant habitat values below the canyon site – especially within the modified reach to the highway and below to the delta. Habitat values and flows required to protect them may not be represented in this analysis. Fish habitats should be assessed

in the lower reaches and efforts made to provide more suitable habitat with the proposed WUP streamflows through channel restoration activities.

4. Physical and flow-related barriers in the creek should be reviewed to ensure adequate access or extended access to utilize all available habitats – especially for kokanee which may have flow-limited access to spawning habitats. Implementation of increased storage in the Trout Creek watershed could impact rainbow trout spawning depending on timing, regulation of reservoir refilling and runoff conditions.

5. In concert with the biological work, a hydrometric station to collect real-time streamflow and temperature data should be installed in the lower reaches of the creek below the water intake. Consistent gauging and flow records are vital if meaningful flow-habitat investigations are to be considered in the future.

6. Finally, water quality improvements, specifically related to reducing suspended sediment from the continual seepage-related slides within the upper canyon reach, should be reviewed, and concepts and costs prepared to remediate the ongoing detrimental issue.

9.0 References

British Columbia Fisheries and Fisheries and Oceans Canada. nd. *Fish Wizard - FISS Database*. Internet. http://pisces.env.gov.bc.ca/. Accessed February 2005.

Letvak, D.B. 1989. *Water Supply Analysis for Trout Creek and the District of Summerland.* ReportW3576. Ministry of Environment, Water Management Branch. August 1989.

nhc 2001. *Hydrology, Water Use and Conservation Flows for Kokanee Salmon and Rainbow Trout in the Okanagan Lake Basin, BC.* Prepared for BC Fisheries, Fisheries Management Branch. August 2001.

nhc 2004. *Instream Flow Estimates for Trout Creek*. Prepared for the Ministry of Environment, Okanagan Region. March 2004.

Thompson, K. 1972. *Determining stream flows for fish life. Proceedings of the Instream low Requirement Workshop*, Pacific Northwest River basins Commission. Portland Oregon. Pp 31-49.