WATER SURVEY OF CANADA STATIONS PERTAINING TO THE NASS HABITAT CAPABILITY MODEL

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Abstract

The Water Survey of Canada stations within the Nass River watershed and proximate areas were examined with respect to the Nass habitat capability model. The location, mean annual discharge, drainage area, water yield and biogeoclimatic classifications were summarized for each station within or adjacent to the Nass River watershed. Mean annual discharge and water yield will be used in the Nass habitat capability model to estimate stream width and the percentage of useable stream area for steelhead rearing. Comparisons of the water yield estimates from the three pairs of adjacent watersheds in similar biogeoclimatic zones indicated that extrapolated water yield estimates could under or overestimate the actual water yield from 10 to 104 percent. Also, the location of each station was illustrated on maps to aid fisheries biologists.

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1.0 Introduction

Tautz *et al.* (1992) developed three types of steelhead (*Oncorhynchus mykiss*) carrying capacity models based on physical and biological parameters for the Skeena River and its tributaries. The physical parameters used by Tautz *et al.* (1992) included the mean annual discharge, watershed area, water yield and water temperature. Similar models are being developed for summer and winter steelhead in the Nass River watershed and therefore a review of physical data from the Water Survey of Canada (WSC) gauging stations within or adjacent to the Nass River watershed was necessary.

One parameter of particular interest to the steelhead carrying capacity models was the mean annual discharge (MAD). MAD was used by Tautz *et al.* (1992) as a criteria for steelhead distribution and to estimate stream width and percentage of useable width for steelhead. Tautz *et al.* (1992) used MAD to estimate water yield (WY) by dividing by the watershed area:

$$WY = MAD \,/\, \text{Watershed Area}$$

where MAD was measured at WSC stations within a stream reach. However, if a WSC station did not exist within a reach, then MAD was estimated using information from another gauging station on the same stream course (either upstream or downstream). Alternatively if one did not exist there, then the water yield of an adjacent watershed with a WSC station and the watershed area of the stream reach were used to estimate MAD (Tautz *et al.* 1992). In the Skeena River watershed, WSC stations were present on 21 of the 75 (28%) reaches and 22 (29%) of the reaches had WSC stations located at either upstream or downstream locations (Bocking and English 1992). The remaining 32 reaches used estimates from WSC stations located in adjacent watersheds (Bocking and English 1992).

Only four WSC stations with MAD and water yield estimates were located within the Nass River watershed, far fewer than the 52 stations in the Skeena River watershed. The absence of WSC information within the Nass River watershed has resulted in the Nass Habitat capability model relying on MAD estimates from adjacent watersheds. However WSC stations were also rare in adjacent watersheds and therefore K.K. English (personal communication) proposed to estimate MAD using the watershed area and an estimate of water yield from watersheds within the same biogeoclimatic zone. Drainage characteristics such as basin aspect, elevation, precipitation, and snow pack levels may contribute to the error in extrapolating water yield estimates across watersheds. Also, error may result from variable proportions of different biogeoclimatic zones within a watershed.

The objective of this report was to locate WSC stations within and adjacent to the Nass River watershed and summarize the MAD and drainage area information necessary to estimate water yield. Spatial heterogeneity in water yield was examined by comparing water yield estimates from different WSC stations within the same biogeoclimatic zones.

2.0 Study Area

The Nass River originates in the Skeena Mountains of north-western British Columbia and flows south-west for approximately 400 km into Portland Inlet (Figure 1). The Nass River watershed is the third largest watershed entirely contained within British Columbia and drains approximately 20 500 km^2 (Alexander and Koski 1995). The Nass River has nine main tributaries: Ishkheenickh, Tseax, Tchitin, Cranberry, White, Meziadin, Bell-Irving, Kwinageese rivers and Damdochax Creek. Common fish species in the Nass River watershed include sockeye salmon (*O. nerka*), chinook salmon (*O. tshawytscha*), coho salmon (*O. kisutch*), pink salmon (*O. gorbuscha*), chum salmon (*O. keta*), steelhead trout, cutthroat trout (*O. clarki*), Rocky Mountain whitefish (*Prosopium williamsoni*), bull char (*Salvelinus confluentus*), Dolly Varden char (*S. malma*), largescale sucker (*Catostomus macrocheilus*), redside shiner (*Richardsonius balteatus*), peamouth chub (*Mylocheilus caurinus*) and northern squawfish (*Ptychocheilus oregonesis*; McPhail and Carveth 1994). In contrast to the nearby Skeena River watershed, lake trout (*S. namaycush*), lake whitefish (*Coregonus clupeaformis*), pygmy whitefish (*Prosopium coulteri*), lake chub (*Couesius plumbeus*), longnose dace (*Rhinichthys cataractae*), white sucker (*Catostomus commersoni*) and burbot (*Lota lota*) have not been reported in the Nass River watershed (McPhail and Carveth 1994). The Nass River watershed lies within two ecoprovinces (Coastal Mountains and Sub-Boreal Interior) and contains six biogeoclimatic zones: Alpine Tundra, Sub-Boreal Spruce, Engelmann Spruce-Subalpine Fir, Interior Cedar-Hemlock, Mountain Hemlock, Coastal Western Hemlock (Pojar and Nuzsdorfer 1988).

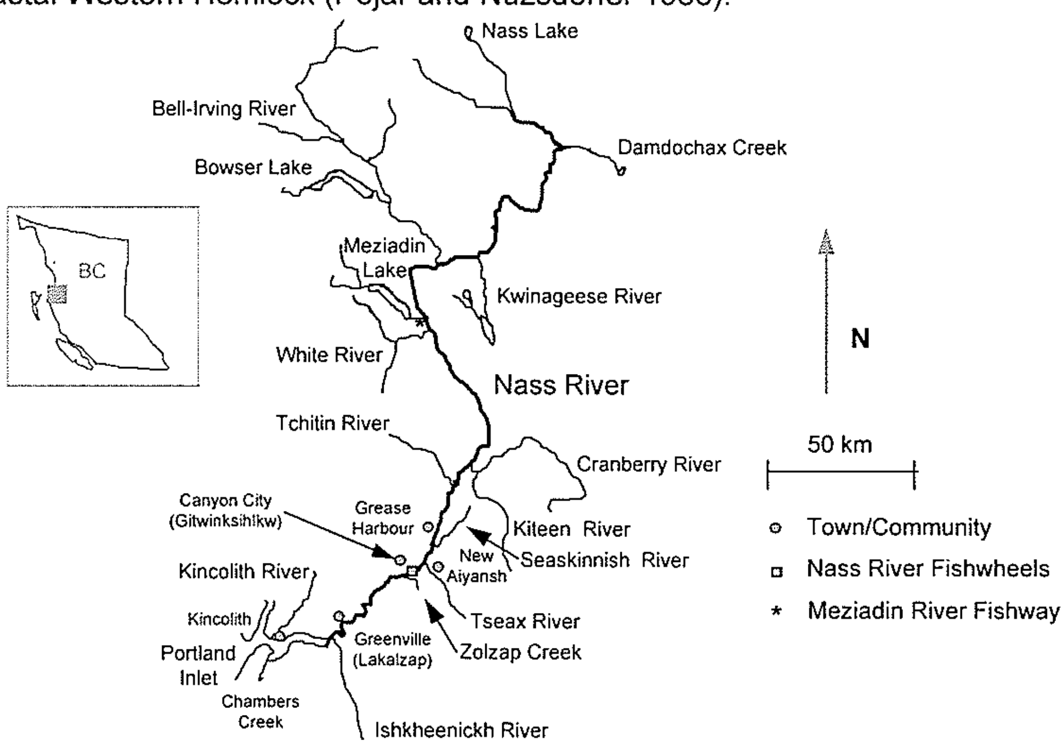

Figure 1. The Nass River watershed and major tributaries.

3.0 Methods

Water Survey of Canada data was summarized from the Historical Streamflow Summary (Anonymous 1989) and from unpublished Water Survey of Canada data (L. Campo, personal communication; D. Harris, personal communication). Biogeoclimatic classifications (zones, subzones and variants) of watersheds with WSC stations were obtained from 1 : 500 000 scale maps of the Prince Rupert Forest Region (Pojar and Nuzsdorfer 1988). The error in extrapolating water yield estimates to adjacent watersheds within similar biogeoclimatic zones was estimated by:

$$\%\ Error = \frac{(predicted - observed)}{observed}$$

where the predicted value was the water yield of the adjacent watershed and the observed value was the actual water yield of the watershed.

4.0 Results

4.1 Nass River Watershed

Four WSC stations were located within the Nass River watershed that had mean annual discharge information related to the Nass habitat capability model (Figure 2). Water yield estimates ranged from 0.0371 m^3/s / km^2 in the Craven Creek watershed (08DA009) to 0.0679 m^3/s / km^2 in the Surprise Creek watershed (08DA005; Table 1). The Bell-Irving and Nass river WSC stations were in watersheds with a variety of biogeoclimatic classifications. In the Nass River watershed, summer steelhead were reported from the Bell-Irving, Cranberry, Kiteen, Kwinageese, Meziadin, Seaskinnish and Tseax rivers and Zolzap and Damdochax creeks, whereas winter steelhead were reported from the Kincolith, Ishkheenickh and Tseax rivers and Chambers Creek (Figure 1; Alexander and Koski 1995; Koski and English 1996; Parken 1997; M. Beere, personal communication). The Interior Cedar Hemlock biogeoclimatic zone was common in the Bell-Irving River watershed, and was common in other Nass River watersheds without WSC stations which harbour populations of summer steelhead. The water yield estimate from the Nass River at Shumal WSC station (08DB001) may be less applicable than other WSC stations in the Nass River watershed because the station measured water yield from a large area which included a variety of biogeoclimatic zones.

Table 1. WSC stations within the Nass River watershed pertaining to the Nass habitat capability model (listed from downstream to upstream).

	WSC Station			
Station name	**Nass River at Shumal**	**Surprise Creek**	**Bell-Irving River below Bowser River**	**Craven Creek**
Major Watershed	**Nass River**	**Meziadin River**	**Bell-Irving River**	**Bell-Irving River**
Station number	08DB001	08DA005	08DA010	08DA009
Latitude	56 15 50N	56 06 35N	56 16 45N	56 58 05N
Longitude	129 05 10W	129 28 33W	129 08 40 W	129 27 57W
Drainage area (km^2)	18 500	221	5 160	118
MAD (m^3/s)	781.0	15.01	288.7	4.38
Standard deviation	79.59	1.950	21.08	0.718
Standard error	12.28	0.375	8.60	0.239
Years monitored (n)	1930-1995 (42)	1968-1995 (27)	1989-1995 (6)	1987-1995 (9)
Water Yield (m^3/s / km^2 ; MAD/drainage area)	0.0422	0.0679	0.0560	0.0371
Biogeoclimatic zones, subzones, and variants[1]	ICHvc, MHb, ICHmc2, MHa, CWHws2, AT, SBSmc, ESSFi	ICHvc, ESSFi, AT	ICHvc, ESSFi, SBSmc, AT	ESSFi, SBSmc, AT

1. Abbreviations for biogeoclimatic zones, subzones and variants were defined in Table 2.

Table 2. Abbreviations for biogeoclimatic zones, subzones and variants (Pojar and Nuzsdorfer 1988).

Abbreviation	Biogeoclimatic Zone	Biogeoclimatic Subzone	Biogeoclimatic Subzone Variant
ICHvc	Interior Cedar Hemlock (ICH)	Very Wet Cold ICH	NA
ICHmc2	Interior Cedar Hemlock (ICH)	Moist Cold ICH	Upper Nass Basin
ICHmc3	Interior Cedar Hemlock (ICH)	Moist Cold ICH	Lower Nass Basin
ESSFi	Engelmann-Spruce Subalpine Fir (ESSF)	Subcontinental Northern Forested and Parkland ESSF	NA
SBSmc	Sub-Boreal Spruce (SBS)	Moist Cold SBS	NA
AT	Alpine Tundra	Undifferentiated	NA
CWHws1	Coastal Western Hemlock (CWH)	Wet Submaritime CWH	Submontane
CWHws2	Coastal Western Hemlock (CWH)	Wet Submaritime CWH	Montane
CWHvm	Coastal Western Hemlock (CWH)	Very Wet Maritime CWH	Undifferentiated
CWHvh	Coastal Western Hemlock (CWH)	Very Wet Hypermaritime CWH	NA
MHa	Mountain Hemlock (MH)	Maritime Forested and Parkland MH	NA
MHb	Mountain Hemlock (MH)	Submaritime Forested and Parkland MH	NA

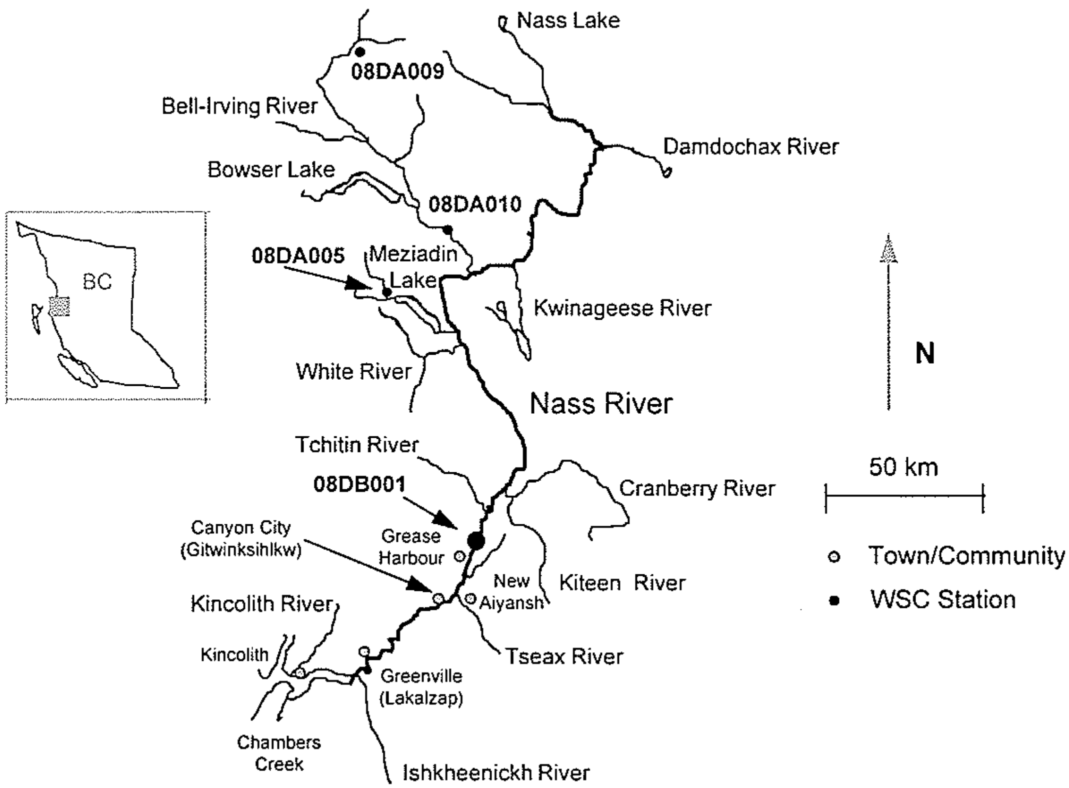

Figure 2. Locations of Water Survey of Canada stations within the Nass River watershed.

4.2 Skeena River Watershed

Four WSC stations were located within the Skeena River watershed that had mean annual discharge information related to the Nass habitat capability model (Figure 3). Water yield estimates ranged from 0.0241 m^3/s / km^2 in the Kispiox River watershed (08EB004) to 0.1169 m^3/s / km^2 in the Exchamsiks River watershed (08EG012; Table 3). The biogeoclimatic classifications of the selected Skeena River WSC stations were similar to the biogeoclimatic classifications of the watersheds in the lower and mid Nass River. Three of these watersheds were partially in the Coastal Western Hemlock biogeoclimatic zone and the water yield estimates from these WSC stations (Exchamsiks, Kitsumkalum, Zymagotitz) may be applicable to winter steelhead tributaries in the lower Nass River (Chambers Creek and Ishkheenickh River). The Kispiox WSC station water yield estimates may be applicable to summer steelhead tributaries in the Cranberry to Kwinageese rivers area (mid Nass River watershed). The water yield estimate in the Exchamsiks (0.117 m^3/s / km^2) River watershed was almost double the water yield estimates in the Kitsumkalum (0.057 m^3/s / km^2; 08EG006) and Zymagotitz (0.063 m^3/s / km^2; 08EG011) river watersheds, in spite of occurring within similar biogeoclimatic zones.

The water yield estimate for the Kispiox River watershed (0.024 $m^3/s / km^2$) was similar to the water yield estimate from Craven Creek (0.037 $m^3/s / km^2$) in the Nass River watershed, although the biogeoclimatic zones differed.

Table 3. WSC stations within the Skeena River watershed pertaining to the Nass habitat capability model (listed from downstream to upstream).

Station name	Station			
	Exchamsiks	**Zymagotitz**	**Kitsumkalum**	**Kispiox**
Station number	08EG012	08EG011	08EG006	08EB004
Latitude	54 21 47N	54 31 07N	54 34 55N	55 28 00n
Longitude	129 18 41W	128 43 40W	126 39 37W	127 44 31W
Drainage area (km^2)	370	376	2 180	1 870
MAD (m^3/s)	43.27	23.72	123.25	45.03
Standard deviation	4.750	2.878	9.323	7.343
Standard error	0.853	0.509	4.661	1.380
Years monitored (n)	1965-1995 (31)	1961-1994	1931-1949 (4)	1967-1995 (29)
Water Yield ($m^3/s / km^2$; MAD/drainage area)	0.1169	0.0631	0.0565	0.0241
Biogeoclimatic zones, subzones, and variants[1]	CWHvm, MHa, AT	CWHws1, AT, CWHws2, MHb	CWHws1, AT, CWHws2, MHb	ICHmc3, ESSFi

1. Abbreviations for biogeoclimatic zones, subzones and variants were defined in Table 2.

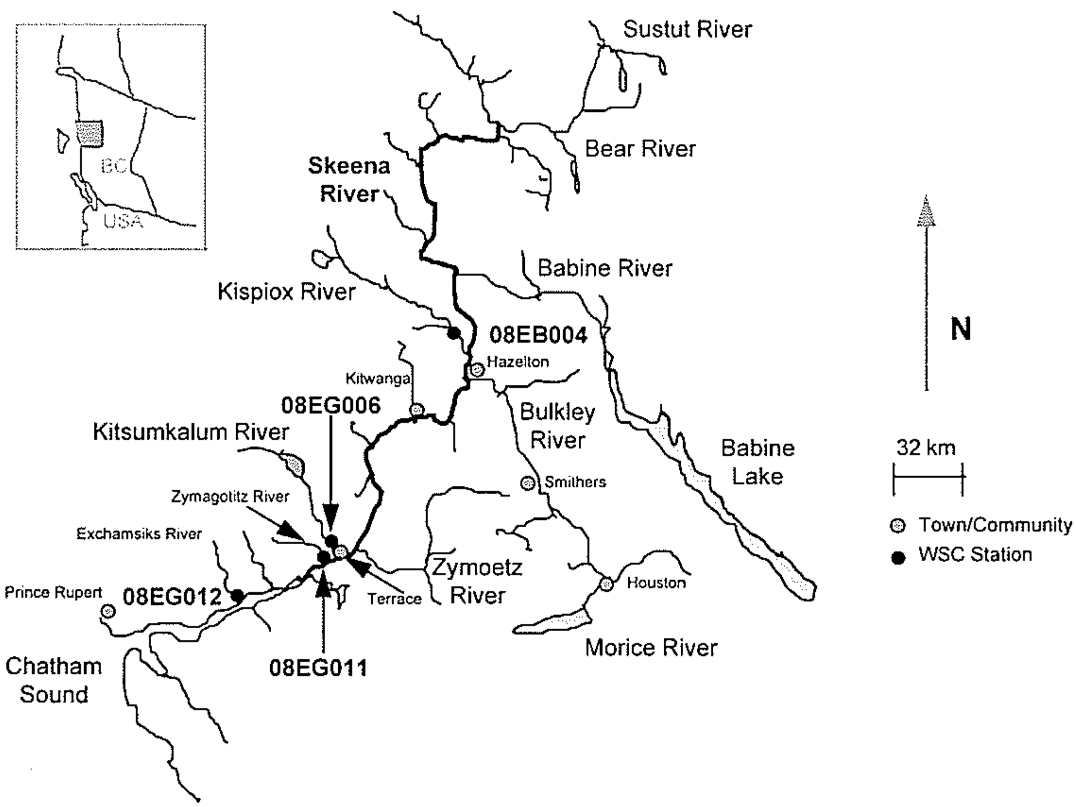

Figure 3. Locations of Water Survey of Canada stations within the Skeena River watershed.

4.3 Alice Arm (Observatory Inlet)

Three WSC stations were located in Alice Arm of Observatory Inlet (Figure 4). Water yield estimates ranged from 0.0459 m^3/s / km^2 in the Lime Creek watershed (08DB010) to 0.0938 m^3/s / km^2 in the Kitsault River watershed (08DB011; Table 4). The Alice Arm WSC stations were in the Coastal Western Hemlock and Mountain Hemlock biogeoclimatic zones. The biogeoclimatic classifications of the Alice Arm watersheds were similar to the biogeoclimatic classifications of lower Nass River tributaries with winter steelhead populations (Chambers Creek and Ishkheenickh River). Water yield estimates in the Lime Creek (0.046 m^3/s / km^2) watershed were approximately half of the water yield estimates in the Kitsault River watershed (0.094 m^3/s / km^2), in spite of occurring in similar biogeoclimatic zones.

Table 4. WSC stations within Alice Arm pertaining to the Nass habitat capability model.

Station name	Station: Lime Creek near the mouth	Station: Patsy Creek near the mouth	Station: Kitsault River above Klayduc Creek
Station number	08DB010	08DB012	08DB011
Latitude	55 27 15N	55 25 08n	55 33 40N
Longitude	129 28 48w	129 24 57W	129 30 11W
Drainage area (km^2)	39.4	4.68	242
MAD (m^3/s)	1.81	0.2248	22.7
Standard deviation	0.497	0.0459	3.326
Standard error	0.128	0.0162	0.889
Years monitored (n)	1977-1995 (15)	1988-1995 (8)	1982-1995 (14)
Water Yield (m^3/s / km^2 ; MAD/drainage area)	0.0459	0.0480	0.0938
Biogeoclimatic zones, subzones, and variants[1]	CWHws1, CWHws2, MHa	MHa	CWHws1, CWHws2, MHa, MHb, AT

1. Abbreviations for biogeoclimatic zones, subzones and variants were defined in Table 2.

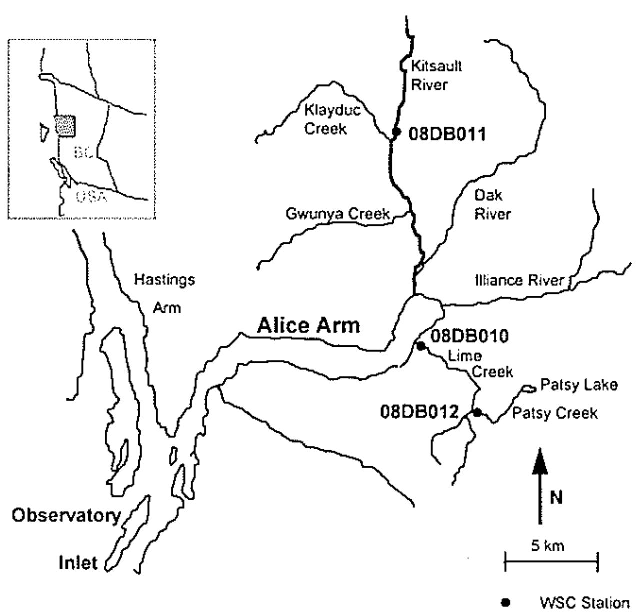

Figure 4. Locations of Water Survey of Canada stations within the Alice Arm area.

4.4 Chatham Sound

One WSC station was located in Chatham Sound on Union Creek near Port Simpson (Figure 5). The estimated water yield was 0.1194 $m^3/s / km^2$ (08DB002; Table 5). The biogeoclimatic classification of the WSC station was Coastal Western Hemlock (very wet hypermaritime subzone). The water yield for Union Creek (0.119 $m^3/s / km^2$) was similar to the water yield for the Exchamsiks River (0.117 $m^3/s / km^2$) which had part of the watershed within the Coastal Western Hemlock zone. The Union Creek WSC station may have limited application to Nass River watershed tributaries, since Chambers Creek was the only watershed within a similar biogeoclimatic zone and subzone. Also, the Union Creek WSC station only had one year (1930) of MAD information.

Table 5. WSC station in Chatham Sound pertaining to the Nass habitat capability model.

Station name	Union Creek Near Port Simpson
Station number	08DB002
Latitude	54 38 45N
Longitude	130 15 45W
Drainage area (km^2)	60.3
MAD (m^3/s)	7.2
Standard deviation	NA
Standard error	NA
Years monitored (n)	1930 (1)
Water Yield ($m^3/s / km^2$; MAD/drainage area)	0.1194
Biogeoclimatic zones, subzones, and variants[1]	CWHvh

1. Abbreviations for biogeoclimatic zones, subzones and variants were defined in Table 2.

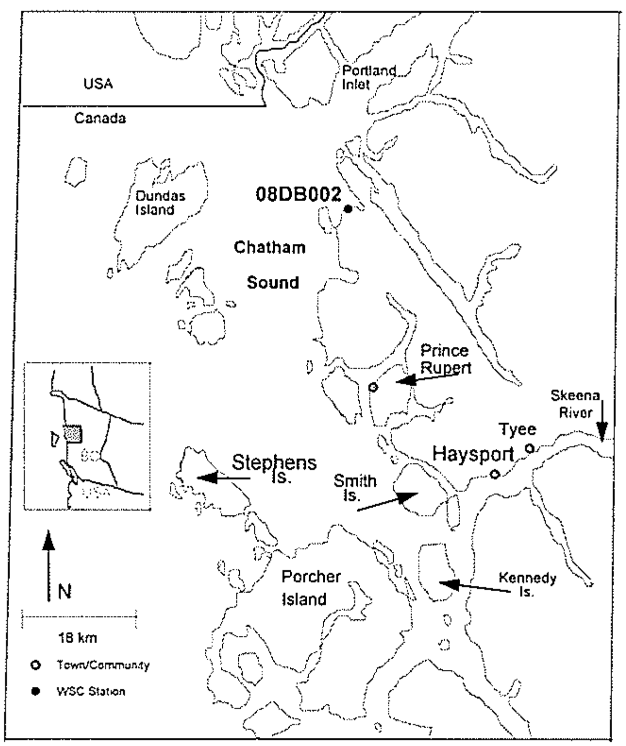

Figure 5. Location of Water Survey of Canada station 08DB002 within Chatham Sound.

4.5 Upper Klappan River (Stikine River Watershed)

Two WSC stations were located in the upper Klappan River (Figure 6). Water yield estimates were 0.0372 m^3/s / km^2 in the Klappan River watershed at Headwaters Plateau (08CC003) and 0.0511 m^3/s / km^2 in the Unnamed Creek watershed at site number 10 (08CC002; Table 6). Both WSC stations were in the Engelmann Spruce Subalpine Fir biogeoclimatic zone and the water yield estimates may be applicable to upper Nass River tributaries. The water yield values differed between the two watersheds in spite of occurring within the same biogeoclimatic zone.

Table 6. WSC stations within the upper Klappan River watershed pertaining to the Nass habitat capability model (listed from downstream to upstream).

Station name	Station	
	Unnamed Creek at Site Number 10	**Klappan River at Headwaters Plateau**
Station number	08CC002	08CC003
Latitude	57 13 02N	57 15 00N
Longitude	129 06 28W	129 03 12W
Drainage area (km^2)	29.2	16.6
MAD (m^3/s)	1.49	0.617
Standard deviation	0.176	0.1023
Standard error	0.0586	0.0362
Years monitored (n)	1987-1995 (9)	1988-1995 (8)
Water Yield (m^3/s / km^2 ; MAD/drainage area)	0.0511	0.0372
Biogeoclimatic zones, subzones, and variants[1]	ESSFi	ESSFi

1. Abbreviations for biogeoclimatic zones, subzones and variants were defined in Table 2.

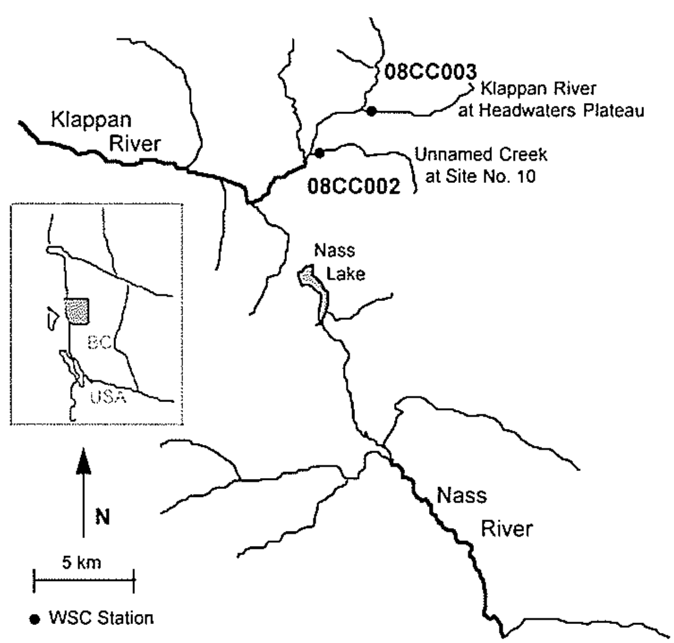

Figure 6. Locations of Water Survey of Canada stations within the upper Klappan River area.

4.6 Adjacent Watersheds

The water yields of adjacent watersheds within similar biogeoclimatic zones were compared to examine the potential error involved in extrapolating water yield estimates within biogeoclimatic zones. Three pairs of adjacent watersheds were identified from the Skeena River watershed, Alice Arm and upper Klappan River watershed.

In the Skeena River watershed, the Zymagotitz River watershed is west of the Kitsumkalum River watershed (Figure 3) and both rivers occur in the Coastal Western Hemlock, Mountain Hemlock and Arctic Tundra biogeoclimatic zones. Water yield estimates were 0.0631 $m^3/s / km^2$ for the Zymagotitz River watershed and 0.0565 $m^3/s / km^2$ for the Kitsumkalum River watershed. If the water yield estimate from the Kitsumkalum River watershed was extrapolated to the Zymagotitz River watershed the water yield would be underestimated by 10.4 percent ((0.0565-0.0631)/0.0631). Similarly, if the water yield from the Zymagotitz River watershed was extrapolated to the Kitsumkalum River watershed the water yield would be overestimated by 11.7 percent ((0.0631-0.0565)/0.0565).

In Alice Arm, the Lime Creek watershed is south of the Kitsault River watershed (Figure 4) and both rivers occur in the Coastal Western Hemlock and Mountain Hemlock biogeoclimatic zones. However, the Kitsault River watershed also occurred in the Arctic Tundra biogeoclimatic zone. Water yield estimates were 0.0459 $m^3/s / km^2$ for the Lime Creek watershed and 0.0938 $m^3/s / km^2$ for the Kitsault River watershed. If the water yield estimate from the Kitsault River watershed was extrapolated to the Lime Creek watershed the water yield would be overestimated by 104 percent ((0.0938-0.0459)/0.0459). Similarly, if the water yield from the Lime Creek watershed was extrapolated to the Kitsault River watershed, the water yield would be underestimated by 51.1 percent ((0.04590-0.0938)/0.0938).

In the upper Klappan River watershed, the Klappan River at Headwaters Plateau watershed is south of the Unnamed Creek at Site Number 10 watershed (Figure 6) and both rivers occur in the Engelmann-Spruce Subalpine Fir biogeoclimatic zone. Water yield estimates were 0.0372 $m^3/s / km^2$ for the Klappan River at Headwaters Plateau watershed and 0.0511 $m^3/s / km^2$ for the Unnamed Creek at Site Number 10 watershed. If the water yield estimate from the Unnamed Creek at Site Number 10 watershed was extrapolated to the Klappan River at Headwaters Plateau watershed the water yield would be overestimated by 37.4 percent ((0.0511-0.0372)/0.0372). Similarly, if the water yield from the Klappan River at Headwaters Plateau watershed was extrapolated to the Unnamed Creek at Site Number 10 watershed, the water yield would be underestimated by 27.2 percent ((0.0372-0.0511)/0.0511).

5.0 Discussion

Considerable variability in water yield estimates existed within watersheds in the same biogeoclimatic zones. Extrapolated water yield estimates were found to under or overestimate the actual WSC estimate from 10 to 104 percent, based on the three pairs of adjacent watersheds examined. The variability in water yield estimates between watersheds may result from differences in characteristics such as basin aspect, elevation, precipitation and snow pack levels. Therefore, water yield estimates that are extrapolated between watersheds may differ from the actual water yield. This error will have a direct effect on the total useable area estimates in the steelhead carrying capacity model being developed for the Nass River. Changes in useable area were directly proportional to changes in steelhead carrying capacity estimates, but were independent of estimates for recruits per spawner, allowable harvest rates and Beverton-Holt A values (Bocking and English 1992).

The effectiveness of extrapolating water yield values within biogeoclimatic zones to estimate the total useable area has not been investigated. However, Bocking and English (1992) reported small negative errors (-0.1 to -0.5%) in water yield resulted in total useable area estimates being reduced from 2.5 to 15.7 percent. Similarly, positive errors (0.1 to 0.5%) in water yield resulted in total useable area estimates being increased from 2.3 to 10.0 percent (Table 6 in Bocking and English 1992). Therefore, the Skeena steelhead carrying capacity model (Tautz *et al.* 1992) was sensitive to small errors in water yield. The Nass habitat capability model may also be sensitive to small errors in water yield because it was similar in structure to the Skeena steelhead carrying capacity model.

Until the level of error involved in extrapolating water yield values within biogeoclimatic zones can be substantiated, a conservative estimate of the total useable habitat should be used. This conservative approach cannot be overstated, since none of the known major steelhead producing Nass River tributaries have WSC stations on them. Overestimates in water yield will over-inflate the steelhead carrying capacity estimates. The variability in the observed MAD (and water yield) was indicative of environmental and measurement variability within a watershed, but was not indicative of the variability (or error) in extrapolating the water yield values across watersheds.

6.0 Recommendations

1. The effectiveness of using water yield estimates from other watersheds within a similar biogeoclimatic zone must be investigated because none of the WSC stations occurred on known major summer or winter steelhead producing tributaries in the Nass River. The investigation would indicate whether the useable area was generally under or overestimated and possibly determine the amount of error in predicting the total useable area. The effectiveness could be investigated by comparing the observed stream width with the estimates predicted from the extrapolated water yield or by adding WSC stations to known steelhead producing Nass River tributaries. Until these investigations are completed, the extrapolated water yield estimates used in the Nass habitat capability model could be modelled for conditions where the actual estimates were over or underestimated by 30 percent.

2. The addition of more WSC stations within the Nass River watershed would benefit the Nass habitat capability model by assessing the adequacy of extrapolating water yield estimates across watersheds. WSC stations could be located on some of the major summer steelhead producing streams (Cranberry, Kwinageese, and Damdochax) and major winter steelhead producing streams in the lower watershed (Ishkheenickh, Kincolith).

3. I recommend the Fisheries Branch coordinate their efforts with Water Survey of Canada and establish a WSC station on a known summer or winter steelhead stream where empirical habitat data (stream width), water chemistry (total alkalinity, total suspended solids, conductivity etc.), water temperature (growth season length; G7), and population monitoring/sampling (adults and/or juveniles) would occur. The Nass habitat capability model would benefit by substantiating some of the model's predictions.

7.0 Acknowledgements

I thank Lynne Campo and Davin Harris of the Water Survey of Canada for providing historical and current WSC data and station locations. I thank Dana Atagi for the many useful comments and advice during data analysis and critical reviews. I thank Mark Beere and Krista Morten for critical reviews and comments. I thank Dr. Ted Down for securing the funding for the preparation of this review. Funding for the preparation of this review was provided by the Common Land Information Base.

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9.0 Appendix

Appendix A. MAD data for the WSC station at Bell-Irving River below Bowser River (08DA010).

Year	MAD (m^3/s)
1989	NA
1990	290
1991	303
1992	303
1993	296
1994	293
1995	247

Appendix B. MAD data for the WSC station at Craven Creek (08DA009).

Year	MAD (m^3/s)
1987	4.00
1988	4.30
1989	4.60
1990	4.59
1991	5.73
1992	4.46
1993	3.45
1994	4.86
1995	3.40

Appendix C. MAD data for the WSC station on the Nass River at Shumal (08DB001).

Year	MAD (m^3/s)
1930	824
1931	856
1933	826
1934	906
1948	710
1959	786
1960	832
1961	912
1962	818
1963	806
1964	873
1965	673
1966	767
1967	904
1968	755
1969	798
1970	731
1971	719
1972	815
1973	736
1974	803
1975	646
1976	877
1977	674
1978	702
1979	740
1980	820
1981	837
1982	635
1983	670
1984	660
1985	698
1986	770
1987	872
1988	819
1989	764
1990	795
1991	897
1992	893
1993	764
1994	771
1995	647

Appendix D. MAD data for the WSC station Surprise Creek (08DA005).

Year	MAD (m^3/s)
1968	13.7
1969	14.3
1971	14.7
1972	14.3
1973	14.1
1974	17.3
1975	14.1
1976	13.3
1977	11.7
1978	14.4
1979	15.4
1980	14.4
1981	18.2
1982	12.8
1983	12.4
1984	13.3
1985	10.8
1986	15.9
1987	16.4
1988	16.1
1989	15.5
1990	15.5
1991	16.7
1992	17.4
1993	17.1
1994	17.9
1995	17.5

Appendix E. MAD data for the WSC station on the Exchamsiks River (08EG012).

Year	MAD (m^3/s)
1965	38.4
1966	42.9
1967	53.2
1968	44.9
1969	43.8
1970	36.1
1971	38.6
1972	46.4
1973	39.0
1974	47.0
1975	40.3
1976	43.9
1977	41.7
1978	41.0
1979	44.3
1980	47.0
1981	44.1
1982	36.9
1983	37.6
1984	37.0
1985	39.5
1986	43.3
1987	47.3
1988	45.5
1989	45.8
1990	42.7
1991	56.8
1992	49.8
1993	43.9
1994	44.2
1995	38.5

Appendix F. MAD data for the WSC station on the Kitsumkalum River (08EG006).

Year	MAD (m^3/s)
1931	133
1935	113
1948	118
1949	129

Appendix G. MAD data for the WSC station on the Zymagotitz River (08EG011).

Year	MAD (m^3/s)
1961	27.1
1962	25.1
1965	20.0
1966	24.7
1967	28.9
1968	22.2
1969	22.6
1970	20.9
1971	22.3
1972	27.1
1973	21.5
1974	25.6
1975	20.1
1976	29.5
1977	21.0
1978	22.2
1979	22.5
1980	23.7
1981	25.7
1982	20.5
1983	19.7
1984	22.4
1985	22.2
1986	22.4
1987	26.8
1988	25.1
1989	23.4
1990	21.7
1991	30.4
1992	27.0
1993	22.4
1994	22.4
1995	NA

Appendix H. MAD data for the WSC station on the Kispiox River (08EB004).

Year	MAD (m^3/s)
1967	55.7
1968	47.8
1969	43.7
1970	40.1
1971	39.6
1972	62.1
1973	45.6
1974	55.0
1975	38.7
1976	61.1
1977	38.9
1978	38.9
1979	39.8
1980	44.5
1981	42.5
1982	36.7
1983	40.5
1984	39.4
1985	44.3
1986	42.2
1987	43.4
1988	46.1
1989	42.7
1990	47.4
1991	56.1
1992	53.7
1993	42.9
1994	46.3
1995	30.1

Appendix I. MAD data for the WSC station on Lime Creek (08DB010).

Year	MAD (m^3/s)
1977	1.54
1981	1.81
1982	1.19
1984	1.41
1985	2.00
1986	1.79
1987	1.97
1988	2.00
1989	1.59
1990	1.56
1991	3.36
1992	1.97
1993	1.91
1994	1.61
1995	1.41

Appendix J. MAD data for the WSC station on Patsy Creek near the mouth (08DB012).

Year	MAD (m^3/s)
1988	0.228
1989	0.225
1990	0.217
1991	0.318
1992	0.247
1993	0.209
1994	0.195
1995	0.159

Appendix K. MAD data for the WSC station on Kitsault River above Klayduc Creek (08DB011).

Year	MAD (m^3/s)
1982	18.7
1983	19.1
1984	19.9
1985	22.4
1986	20.1
1987	23.0
1988	23.4
1989	22.5
1990	21.9
1991	31.0
1992	27.5
1993	23.5
1994	24.1
1995	20.6

Appendix L. MAD data for the WSC station on Union Creek near Port Simpson (08DB002).

Year	MAD (m^3/s)
1930	7.2

Appendix M. MAD data for the WSC station on the Klappan River near Headwaters Plateau (08CC003).

Year	MAD (m^3/s)
1988	0.682
1989	0.721
1990	0.604
1991	0.590
1992	0.773
1993	0.532
1994	0.579
1995	0.461

Appendix N. MAD data for the WSC station on Unnamed Creek at site number 10 (08CC002).

Year	MAD (m^3/s)
1987	1.45
1988	1.49
1989	1.89
1990	1.46
1991	1.48
1992	1.54
1993	1.43
1994	1.47
1995	1.21