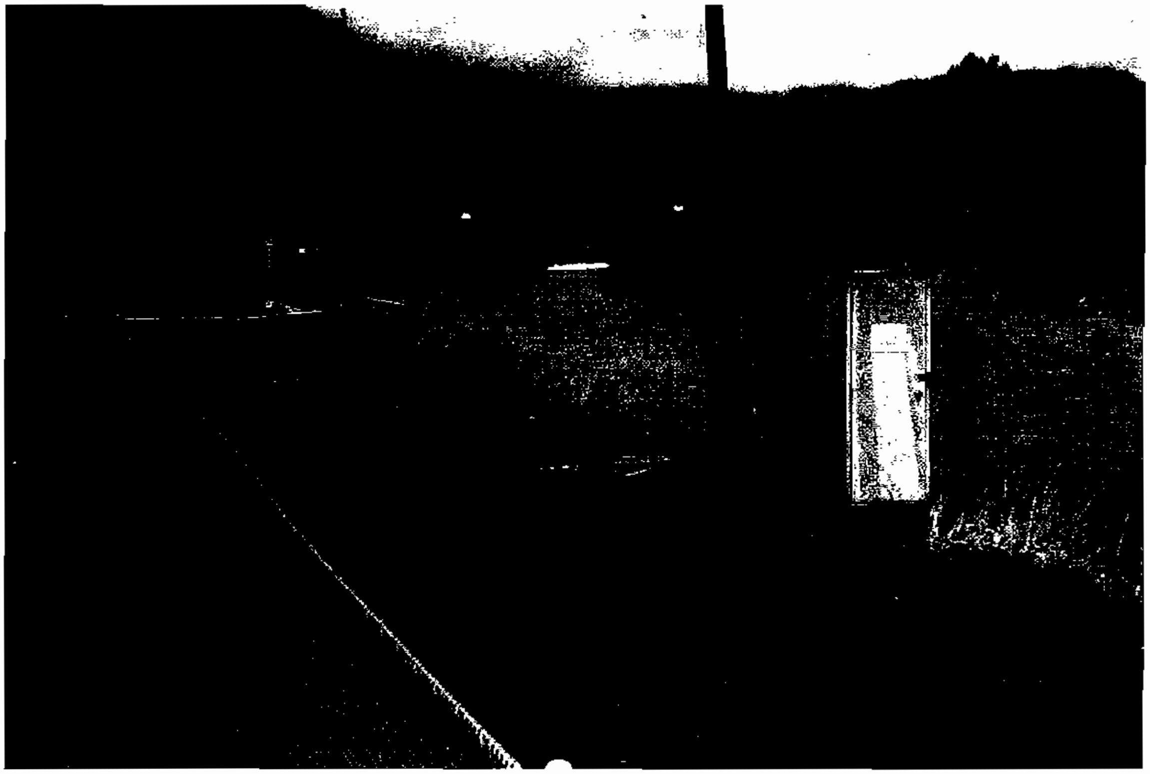
#152

British Columbia

Ministry of Environment, Lands & Parks

Streamflow in the Southern Interior Region



W. Obedkoff, P.Eng.

Water Inventory Section
Resources Inventory Branch

December 1998

PROVINCE OF BRITISH COLUMBIA
MINISTRY OF ENVIRONMENT
LANDS AND PARKS

Streamflow

in the

Southern Interior Region

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1 INTRODUCTION

Hydrologic investigations require summarizing and analyzing available hydrologic data using standard periods, methods and formats so that the information is consistent and allows direct comparison from one site to another. To fulfill this goal a project was initiated in the 1995-1996 fiscal year with funding by the Corporate Resource Inventory Initiative (CRII). The culmination of this project was the production of the report, *British Columbia Streamflow Inventory* (BCSI), by the Resources Inventory Branch in the 1997-1998 fiscal year. That report presents a summary of streamflow data compiled in datasheet, map and graphical forms and covers the whole province. The purpose of this information is to enable hydrologists and engineers to make hydrologic estimates for water management and the planning and preliminary design of water resource projects.

A separate project, which is a direct progression of the above work, was initiated in the 1998-1999 fiscal year and was also funded by CRII. The purpose of this study was to characterize the variability of streamflow parameters in ministry Regions, based on the summary data and hydrologic zones defined in the BCSI report. This approach with subregional hydrologic zones, or subzones, and graphs will provide more accurate estimates suitable for design streamflows to be applied to ungauged watersheds. The subzones are a product of the application of additional hydrologic data and regionalization procedures to those applied in the study of the BCSI report. This work will form the basis of a future revision of the BCSI hydrologic zones.

This report of the latest CRII study covers the ministry Southern Interior region that incorporates Hydrologic Zone 12B and the contiguous portions of its neighboring hydrologic zones, as defined in the BCSI report. The report contains summary data extracted from the BCSI report, the graphical procedures and results used to derive the subzones and the procedures for making streamflow estimates at ungaged watersheds. However, before any estimates are finalized using this report, reference should be made to the Water Inventory Section hydrology report and map libraries and the Ministry library in Victoria for comparison and any additional hydrologic data that may prove useful.

2 REGIONAL HYDROLOGIC SUMMARIES

This report covers the Ministry of Environment, Lands and Parks' Southern Interior Region, with headquarters in Kamloops. The primary hydrologic zone in this region is 12B, as defined in the BCSI report, with 9B and 15 on the west and 13 on the east side. Five subzones were defined in Hydrologic Zone 12B and one in 13 (shown in Figure 1) as a result of the groupings of subzone watersheds and graphical analyses. These subzones are designated in small case letters, *a* to *f*, and are presented in the sections below. Subsequent Ministry Region reports will have subzones designated in such letters to form a unique identity set for the whole province that will differentiate it from the hydrologic zone numbering system. (Subzones *g* and *h*, shown in Figure 1, will be described in the Kootenay Region report). Subzone data summaries are listed for these groups in Table 1 and form the basis for design streamflow graphs presented in the following sections. This table is an excerpt of an Excel spreadsheet that contains all the watershed streamflow summary data and graphs in electronic format and is available on disk to the reader for reference and chart formatting.

3 MEAN ANNUAL RUNOFF

Runoff was regionalized on a graphical basis with plots of basin unit mean annual runoff (mm) versus basin median elevation (m) in semilogarithmic graphs. The normal period of 1961-1990 was used for each hydrometric station, as given in the BCSI report. For many of the datasheets that had missing median elevations, drainage boundaries were defined, areas digitized and median elevations calculated. Parallel straight lines, which are regression fit by eye, were drawn to represent the six subzones of Hydrologic Zone 12B and the neighbouring zones. (The relationships were drawn as straight lines on a semilog graph, but these would plot as curves in an arithmetic graph.) Visual positioning rather than statistical regression was used because each point was not always given the same weight due to physical or physiographic characteristics of the watershed. The vertical location (intercept) and slope of each line was positioned to reflect the runoff-elevation variation of each subzone. The runoff point of a watershed through which a subzone boundary was drawn plots between two subzone curves to reflect the relative area runoff contribution of each subzone to the watershed. Examples of such watersheds with the boundary between Subzones *a* and *b* are the Tulameen, Similkameen and Pasayten rivers; the runoff of each of these points is defined precisely by the location of each curve. The subzones are shown in Figure 1 at a scale of 1:3,000,000. A larger map (73 x 83 cm) at a scale of 1:1,000,000 is available with a finer stream hierarchy for more detailed study application. The subzone curves with all the subzone points are shown in Figure 2.

Runoff at an ungauged watershed in the southern interior can be estimated by use of the regionalized information presented in this report. The general procedure would consist of locating the topic watershed on a map (Figure 1), identifying the subzone and its design curve and then making the estimate. If the basin of interest is located near or within one of the observed watersheds more weight would be given its point and a parallel line would be drawn through it (or close by) in Figure 2 to the projected area of the basin. If the basin straddles a boundary, the point would be located between the subzone curves in proportion to the areas within each subzone. Runoff estimates based on the above procedure would be for a mean annual period; estimates for other recurrence intervals could be made by reference to the frequency relationships in individual data sheets of the BCSI report. As well, monthly estimates of runoff can be derived by prorating the annual estimates by use of monthly runoff distributions of the same datasheets.

4 PEAK FLOW

Peak flow was regionalized on a graphical basis with plots of unit annual peak discharge (L/s/km^2) versus drainage area (km^2) in log-log graphs. The graphical envelop-curve form was adopted to demonstrate the multiple scale effects of regional flood variation. Unit peak flow varies inversely with drainage area due to increased storage effects with increased area and decreased uniform storm intensity with increased area. Peak flow graphical regionalizations generally use log-log plots with envelop curves because the variance of individual plot points is easier to explain for streamflow characteristics of short duration (e.g., floods) rather than of long duration (e.g., annual runoff). For the latter, regionalizations generally use regression plots to demonstrate unexplained variance, since an explanation for the position of a plot point is more difficult due to the dominance of geographic, geologic and storage effects in large drainage areas.

The annual maximum instantaneous discharge for a 10-year return period of the total period of record was used for each hydrometric station, as given in the BCSI report. Figure 3 shows parallel straight lines that were drawn to envelop the points in each of six subzones of Hydrologic Zone 12B and the neighbouring zones and represent the maximum values applicable in each subzone. (The relationships were drawn as straight lines on a log-log graph, but these would plot as curves in an arithmetic graph.) The subzone points plot on or below each subzone curve; those that plot below do so due to a physical or a basin characteristic reason that would explain its plot position. The peak flow point of a watershed through which a subzone boundary was drawn plots between two subzone curves to reflect the relative area peak flow contribution of each subzone to the watershed. Examples of such watersheds with the boundary between Subzones *a* and *b* are the Similkameen and Pasayten rivers that plot between curves *a* and *b*. The final location of the western boundary of Subzone *a* has not yet been defined but would run through the upper portions of the Coquihalla and Tulameen watersheds and these points have been plotted above curve *a*, for reference.

Peak flow at an ungauged watershed in the southern interior can be estimated by use of the regionalized information presented in this report. The general procedure would consist of locating the topic watershed on a map (Figure 1), identifying the subzone and its design curve and then making the estimate. If the basin of interest is located near or within one of the observed watersheds more weight would be given its point and a parallel line would be drawn through it (or close by) in Figure 3 to the projected area of the basin. If the basin straddles a boundary the point would be located between the subzone curves in proportion to the areas within each subzone. Peak flow estimates based on the above procedure would be for a 10-year return period; estimates for other recurrence intervals could be made by reference to the frequency relationships in individual data sheets of the BCSI report.

5 LOW FLOW

Low flow was regionalized on a graphical basis with plots of minimum discharge (m^3/s) versus drainage area (km^2) in log-log graphs with regional curves drawn to represent low flow zones. It was generally found that such zones are much larger, covering larger drainage areas than hydrologic subzones, and are best represented by a series of curves that converge as drainage area increases. This demonstrates the scale effects of both drainage area and regional low flow variation.

The seven-day average minimum daily discharge for a 10-year return period of the total period of record was used for each hydrometric station, as given in the BCSI report. Low flow plots for the southern interior region for summer (June-September) and annual periods are shown in Figures 4 and 5, respectively. Neither plot shows well-defined trends for the various subzones, except for Subzone *f*. Applicable regional curves from the BCSI report for the South Interior and Southeast Mountains Low Flow Zones are superimposed in the figures for reference in the procedure for estimating low flow at ungaged watersheds, described below.

Low flow at an ungauged watershed in the southern interior can be estimated by use of the regionalized information presented in this report. The general procedure would consist first of locating the topic watershed on a map (Figure 1) and identifying the subzone and then its location in the plots (identified by clusters of subzone symbols) of Figures 4 and 5. If the basin of interest is far from those of observed basin-points one of the two design curves shown (Southeast Mountains for Subzone *f* or South Interior for Subzones *a* to *e*) or one superimposed from Figures 8 or 9 of the BCSI report could be used. If the basin is located near or within one of the observed basins a sloping line (one that would fit the convergence of the two reference curves or those of the BCSI report) would be drawn through its basin-point to the projected area of the topic basin to make the required estimate. Low flow estimates based on this procedure would be for a 10-year return period; estimates for other recurrence intervals could be made by reference to the frequency relationships in individual data sheets of the BCSI report.

6 HYDROLOGIC ZONES

The hydrologic zones adopted in this study are those originating and described in the BCSI report and shown in its Figure 1. The basic approach used to define these zones employed maps of hydrologic characteristics and geomorphologic features. This phase of the zone identification was mostly subjective, with zone boundaries being drawn based on hydrologic judgement of the variation of mapped parameters. However, the low flow zones of the BCSI study were based on actual regional graphical plots of measured low flow data. The BCSI low flow zone boundaries are therefore, objective, and are more precise than the hydrologic zone boundaries of predecessor hydrologic zone studies. In the BCSI study the low flow zone boundaries were first used to define broad preliminary hydrologic zones, and these were in turn subdivided using the subjectively defined mapping information to form the final hydrologic zone boundaries.

In this study subzone boundaries were defined using graphical plots of measured streamflow data that were not available for the BCSI study. The new graphical procedures described in the above sections for mean annual runoff and unit peak flow are independent and in addition to the low flow graphical analysis of the BCSI study. A perusal of Figure 1 will show that most of the common-border subzone boundaries of this study follow precisely or very closely those of the BCSI hydrologic zones. The remaining subzone boundaries only subdivide the hydrologic zones. The exceptions are the inaccuracies on the western portion of Subzone *f* and on the eastern portion of Subzone *c*. This anomaly will be resolved in a future revision of the BCSI hydrologic zones.

STREAMFLOW IN THE SOUTHERN INTERIOR REGION

Hydrometric Station Name	Number	Hydrologic Subzone	Median Elevation (m)	Normal Annual Runoff (mm) Subzone a	Subzone b	Subzone c	Subzone d	Subzone e	Subzone f	10-Year Peak Flow (m³/s)	Drainage Area (km²)	(L/s/km²) Subzone a	Subzone b	Subzone c	Subzone d	Subzone e	Subzone f	10-Year 7-Day Low Flow June-September Drainage Area (km²)	(m³/s) Subzone a	Subzone b	Subzone c	Subzone d	Subzone e	Subzone f	10-Year 7-Day Low Flow Annual Drainage Area (km²)	(m³/s) Subzone a	Subzone b	Subzone c	Subzone d	Subzone e	Subzone f
Coldwater - Brookmere	8LG048	a	1430	697						116	311	372						311	0.472						311	0.356					
Coldwater - Merritt	8LG010	a	1160	291						127	914	139						914	0.276						914	0.260					
Coquihalla - Needle	8MF062	a	1380	1332						49.3	79.8	618						79.8	0.401						79.8	0.345					
Similkameen-Goodfellow	8NL070	a	1680	629						128	407	315						407	0.896						407	0.500					
Spius	8LG008	a	1290	423						172	767	224						767	0.475						767	0.443					
Tulameen - Princeton	8NL024	a	1400	389						390	1790	218						1790	1.43						1790	1.30					
Tulameen - Vuich	8NL071	a	1530	870						157	253	622						253	0.291						253	0.262					
Ashnola	8NL004	b	1890		223					166	1060		156					1060		1.01					1060		0.645				
Beak	8LG064	b	1450		147					9.25	85.9		108					85.9		0.007					85.9		0.006				
Bellevue	8NM035	b	1540		157					11.6	74.5		155					74.5		0.001					74.5		0.002				
Bull - Crump	8NM133	b	1530		88					3.31	48.2		69					48.2		0.005					48.2		0.005				
Camp	8NM134	b	1450		130					2.58	36.5		71					36.5		0.024					36.5		0.018				
Clark	8NM146	b	1360		143					1.92	16.2		118					16.2		0.001					16.2		0.0004				
Dayes	8NM137	b	1290		104					2.36	33.4		71					33.4		0.001					33.4		0.001				
Greata	8NM173	b	1280		56					1.44	42.3		34					42.3		0.006					42.3		0.006				
Hedley	8NL060	b	1680		202					55.3	378		146					378		0.282					378		0.085				
Keremeos	8NL045	b	1320		115					12.1	184		66					184		0.093					184		0.083				
Nicola (ab Lake)	8LG049	b	1230		77					52.4	1580		33					1580		0.052					1580		0.035				
Pasayten	8NL069	b	1740		464					123	562		219					562		1.07					562		0.502				
Pennask	8LG016	b	1680		295					18.1	79.8		227					79.8		0.037					79.8		0.034				
Shatford	8NM037	b	1530		123					12.8	96.9		132					96.9		0.017					96.9		0.015				
Similkameen - Hedley	8NL038	b	1460		273					699	5660		123					5660		4.74					5660		3.56				
Similkameen - Princeton	8NL007	b	1590		383					369	1940		190					1940		2.52					1940		1.40				
Similkameen-Nighthawk	08NL022	b	1480		225					765	9190		83					9190							9190						
Smith	8NL034	b	1580		117					10.6	127		83					127		0.017					127		0.016				
Soukup	8NL035	b	1330		60					1.41	24.6		57					24.6		0.006					24.6		0.005				
Testalinden	8NM164	b	1270		70					0.8	13		62					13		0.002					13		0.002				
Tonasket	12439300	b								6.16	156		39					156		0.001					156		0.0003				
Vaseux	8NM171	b	1680		237					23.5	116		203					116		0.060					116		0.049				
Whipsaw	8NL036	b	1450		173					18.5	186		99					186		0.081					186		0.067				
Wolfe	8NL041	b	1380		77					9.04	213		42					213		0.037					213		0.016				
Boundary - Greenwood	8NN001	c	1240			189				49.2	475			104				475			0.108				475			0.091			
BX	8NM020	c	1130			168				4.57	55.9			82				55.9			0.006				55.9			0.005			
Coldstream	8NM142	c	1120			124				3.85	59.4			65				59.4			0.010				59.4			0.009			
Inonoaklin	8NE110	c	1470			400				63.3	296			214				296			0.317				296			0.200			
Kettle - Ferry	8NN013	c								449	5750			78				5750			2.300				5750			2.05			
Kettle - Laurier	8NN012	c								775	9840			79				9840			4.75				9840			4.48			
Mission	8NM116	c	1340			232				81.7	816			100				816			0.468				816			0.299			
Pearson	8NM172	c	1560			388				16.5	74.6			221				74.6			0.088				74.6			0.054			
Trapping	8NN019	c	1350			317				25.3	144			176				144			0.052				144			0.047			
Vance	8LC040	c	1040			194				5.78	69.9			83				69.9			0.035				69.9			0.026			
W Kettle - Carmi	8NN022	c	1380			257				133	1170			114				1170			0.362				1170			0.327			
W Kettle - McCulloch	8NN015	c	1620			477				59.6	230			259				230			0.115				230			0.107			
Ambusten	8LF081	d	1505				26			0.55	32.9				17			32.9				0.004			32.9				0.002		
Anderson	8LF084	d	1810				100			3.06	32.2				95			32.2				0.012			32.2				0.004		
Bethsaida	8LG065	d	1550				89			1.5	15.5				96			15.5				0.005			15.5				0.002		
Guichon	8LG056	d	1340				53			2.2	78.2				28			78.2				0.009			78.2				0.007		
Hat	8LF015	d	1320				33			14.4	681				21			681				0.068			681				0.061		
Hat - upper	8LF061	d	1410				51			14.5	352				41			352				0.056			352				0.051		
Scottie *	8LF089	d	1400				47			3.97	141				28			141							141						
Bonaparte - Bridge	8LF062	e	1310					133		25.0	686					36		686					0.261		686					0.070	
Bridge - Lake Inflow		e	1160					77			793																				
Criss	8LF007	e	1190					116		41.7	471					89		471					0.014		471					0.013	
Deadman	8LF027	e	1190					60		27.9	870					32		870					0.219		870					0.111	
Ewer	8NM176	e	1470					215		7.00	49.1					143		49.1					0.032		49.1					0.024	
Fishtrap	8LB024	e	1340					177		13.0	135					96		135					0.069		135					0.047	
Joe Ross *	8LF094	e	1260					71		5.79	100					58		100					0.002		100						
Lambly	8NM165	e	1390					252		11.3	75.3					151		75.3					0.041		75.3					0.025	
Nicola (Merritt)	8LG007	e								150	4350					34		4350					1.65		4350					1.07	
Nicola (Spences Br.)	8LG006	e								312	7280					43		7280					2.82		7280					2.05	
Paul	8LB012	e	1102					98		2.11	55.7					38		55.7					0.002		55.7					0.001	
Salmon - Falkland	8LE020	e	1190					82		32.7	1020					32		1020					0.570		1020					0.462	
Salmon - Salmon Arm	8LE021	e	1130					99		42.9	1440					30		1440					0.666		1440					0.574	
Salmon - Salmon Lake	8LE075	e	1350					154		12.5	142					88		142					0.051		142					0.023	
Terrace	8NM138	e	1490					265		5.42	34.8					156		34.8					0.003		34.8					0.002	
Watching *	8LF049	e	1310					185		9.04	79.5					114		79.5					0.054		79.5					0.029	
Whiteman	8NM174	e	1450					180		13.0	109					119		109					0.020		109					0.019	
Adams	8LD001	f	1280						741	309	3090						100	3090						44.2	3090						12.6
Bowron - Wells	8KD001	f	1170						652	53.6	448						120	448						2.75	448						1.46
Cariboo	8KH003	f	1420						943	512	3260						157	3260						41.7	3260						12.5
Clearwater - Lake	8LA007	f	1650						1442	792	2950						268	2950						61.2	2950						15.5
Eagle	8LE024	f	1390						1314	303	906						334	906						9.78	906						4.63
Jordan	8ND014	f	1610						2010	202	271						745	271						4.53	271						1.20
Kirbyville	8ND019	f	1710						1728	61.8	110						562	110						3.92	110						0.423
Mitchell	8KH014	f	1640						1530	56.8	251						226	251						8.97	251						1.37
Murtle	8LA004	f	1530						970	258	1380						187	1380						15.3	1380						5.40
N Thompson - Birch	8LB047	f	1200						1056	904	4450						203	4450						59.8	4450						13.8
Seymour	8LE027	f	1380						1380	297	818						363	818						8.59	818						3.18
Shuswap - Enderby	8LC002	f	1270						604	474	4690						101	4690						29.2	4690						22.4

Table 1 Watershed Streamflow Summary

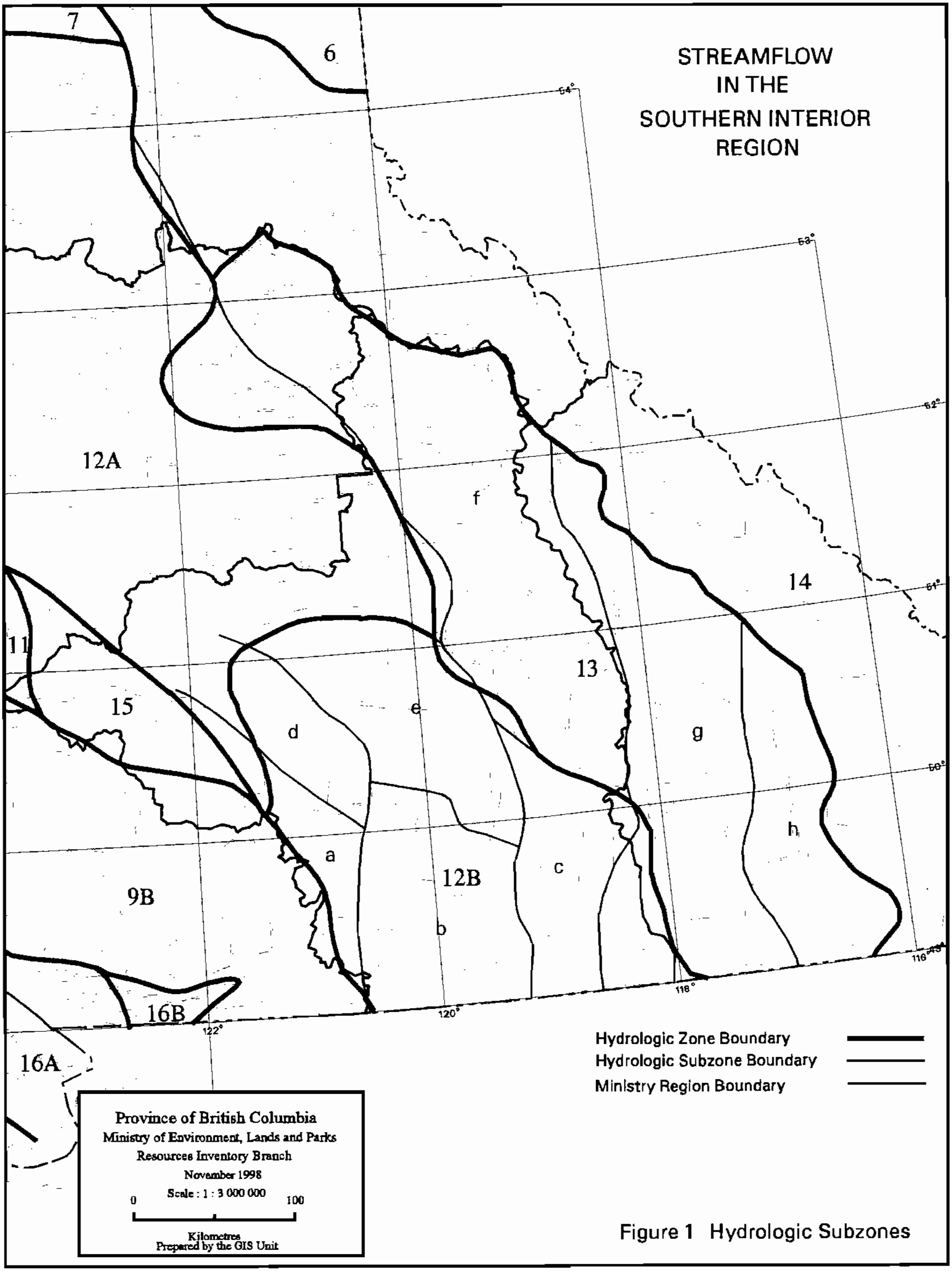


Figure 1 Hydrologic Subzones

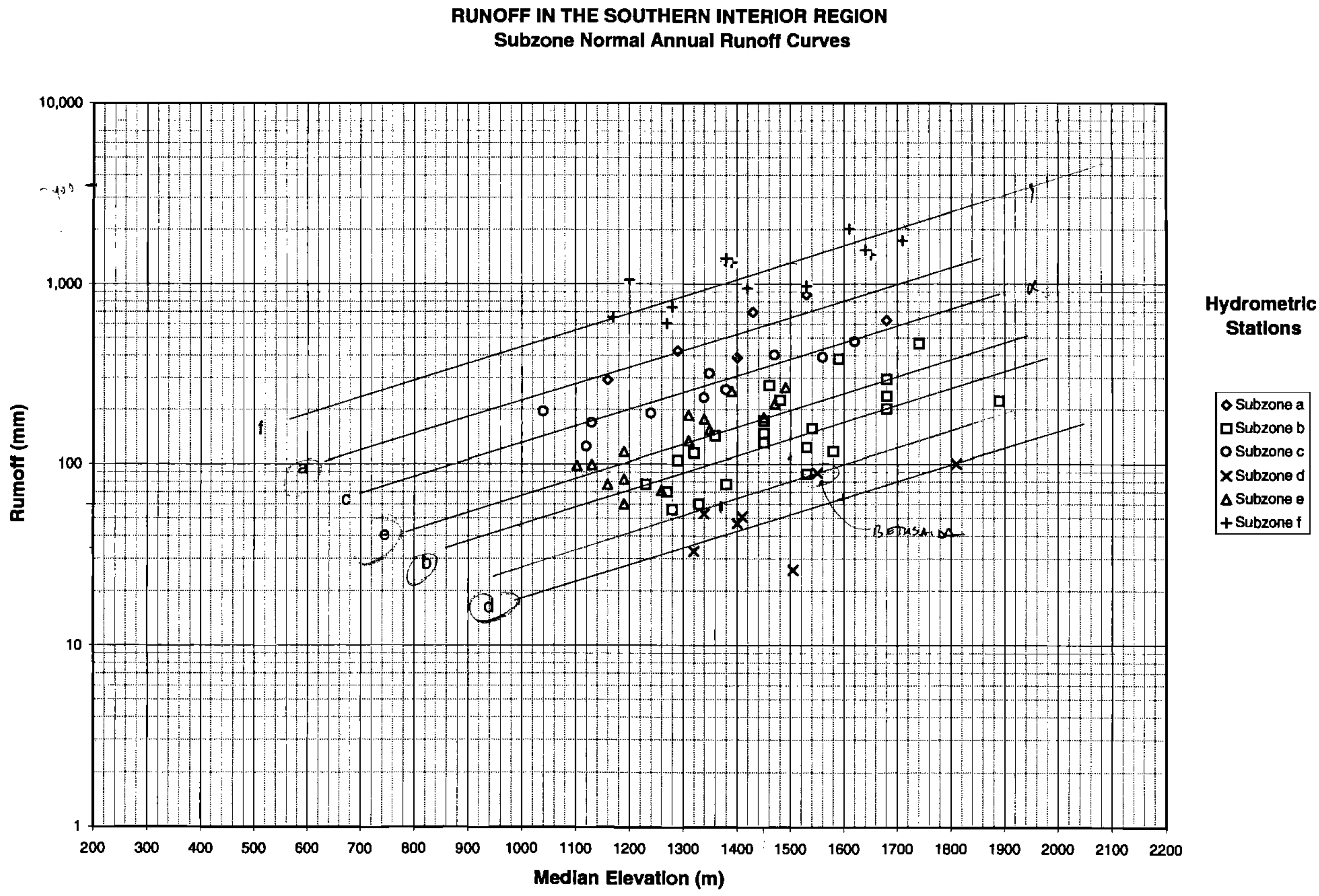
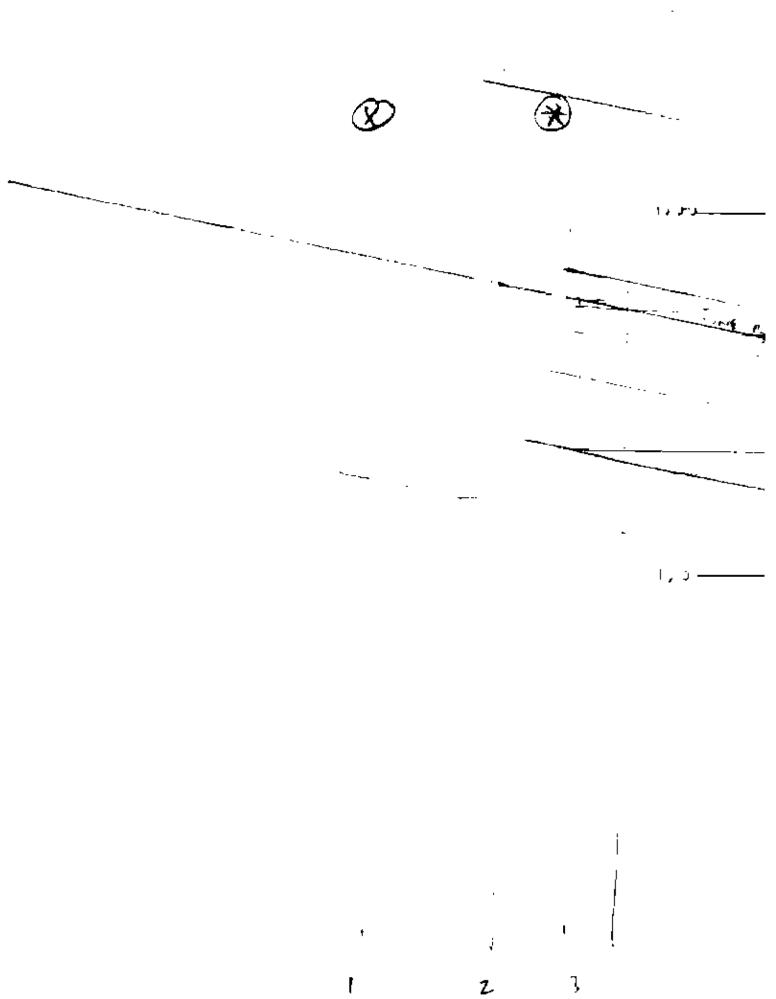


Figure 2 Watershed Runoff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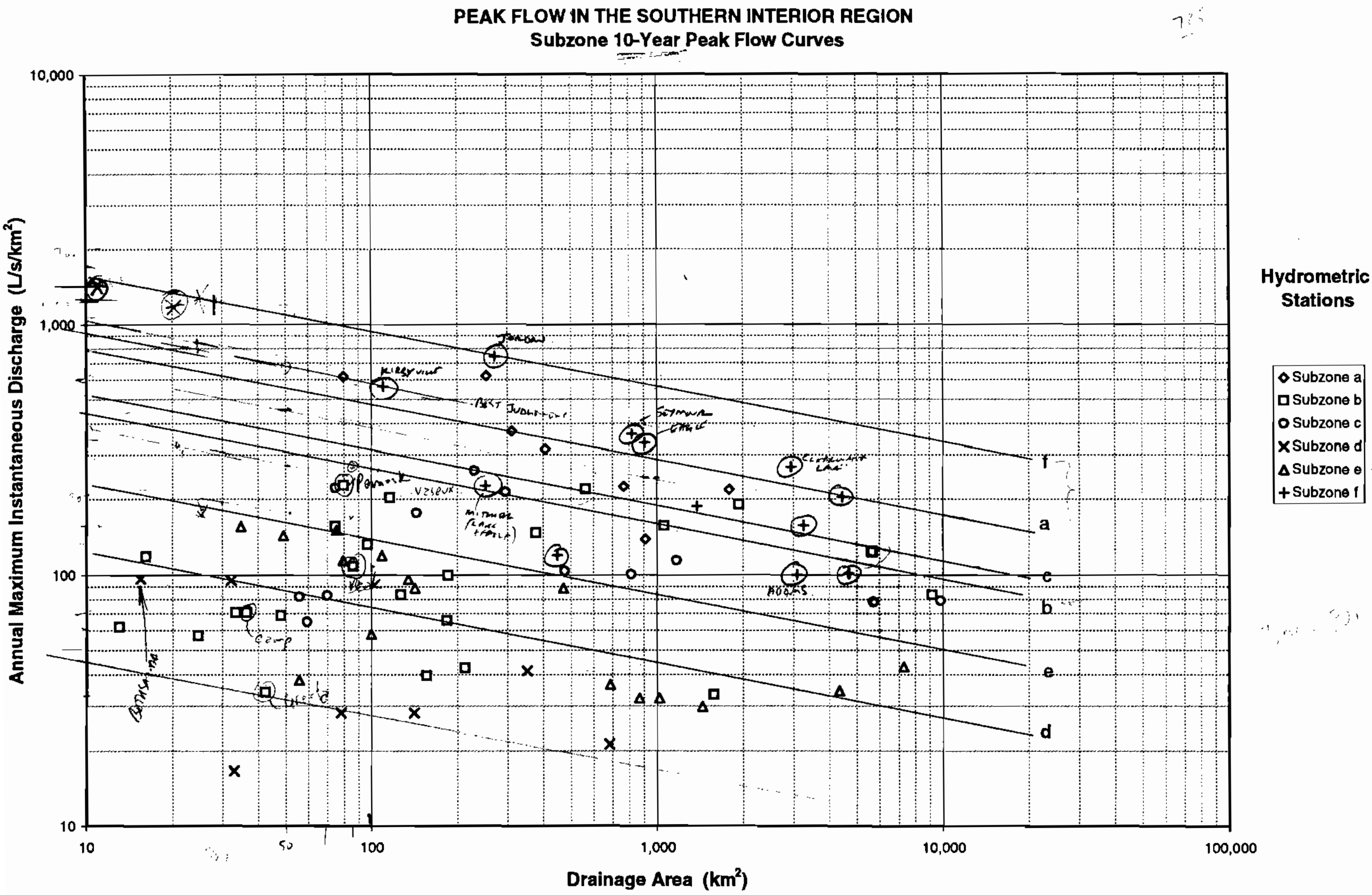

Figure 3 Watershed Peak Flow

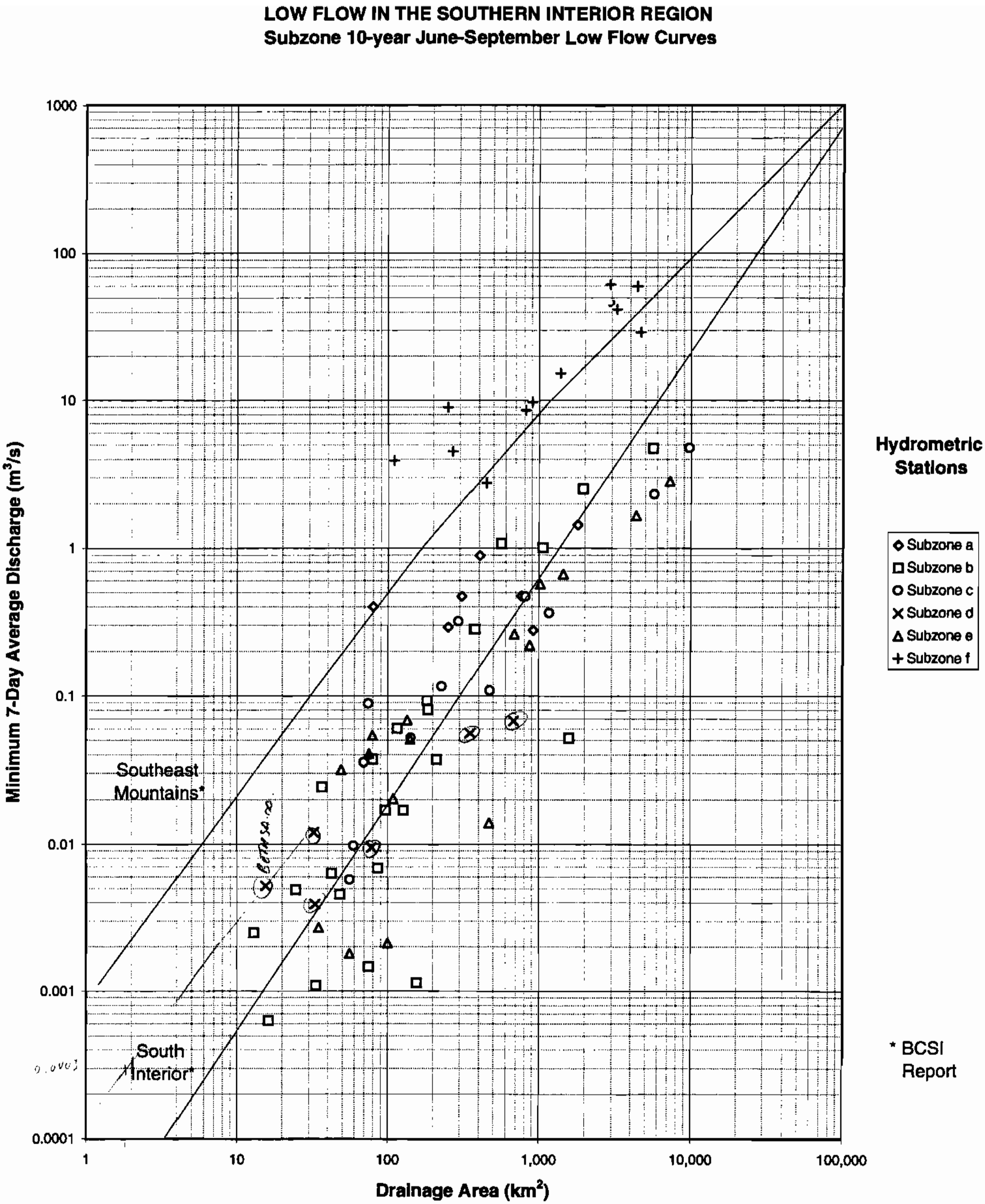

Figure 4 Watershed June-September Low Flow

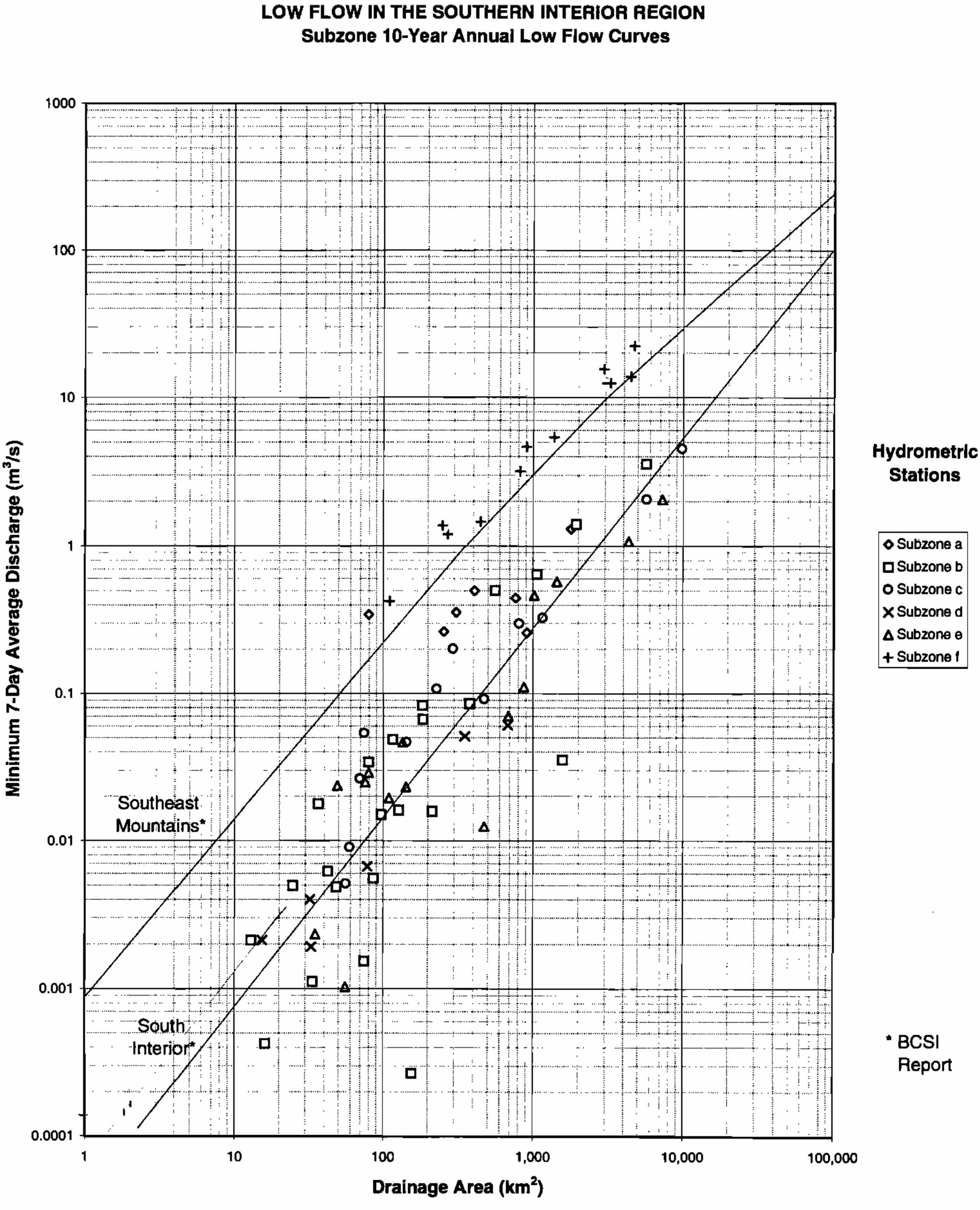

Figure 5 Watershed Annual Low Flow

PROVINCE OF BRITISH COLUMBIA
MINISTRY OF SUSTAINABLE RESOURCE MANAGEMENT

Streamflow

in the

Southern Interior Region

Supplement

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Aquatic Information Branch

April 2003

REPORT SUPPLEMENT

Hydrologic Zones

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This section has been added as a supplement to the report to cross-reference its Hydrologic **Subzones** to the Hydrologic **Zones** defined in the final of a series of Ministry regional streamflow reports, *Streamflow in the Lower Mainland and Vancouver Island* (SLMVI), produced in April 2003. Six regional reports have now been published that cover the province and complete the revised edition of Hydrologic **Zones** from those of the BCSI report (see Introduction). The 2003 **Zones** are shown in Figure S-1 at a scale of 1:7,500,000. The Hydrologic **Subzones** defined in this report and their cross-referenced **Zone** labels are shown in Figure S-2 as a large-sheet foldout map (see pocket at back of report). This figure shows the area at a larger scale of 1:1,000,000 to that of Figure 1 and with a finer stream hierarchy for more detailed study application. Additional features in Figure S-2 are plots of Environment Canada hydrometric stations with labelled numbers, descriptive names and watershed boundaries. Note that the relative sizes of watersheds can easily be interpreted/compared in most cases at this scale to provide the user with direct references in applying the regional graphical procedures for estimating various streamflows at ungauged sites.

The regional procedures outlined in the report for estimating streamflow characteristics at ungauged watersheds for **Subzone** references are applicable to the 2003 Hydrologic **Zones.** The discussion of boundary relationships of **Subzones** and 1998 Hydrologic **Zones** in Section 6 can be referred to the revised boundaries of the 2003 **Zones.** In the final **Zone** definition of the SLMVI report the **Subzones** of this and subsequent regional reports were relabelled with **Zone** numbers. The **Zone** boundaries themselves are essentially those of the **Subzones,** but with some minor revisions, as updated summary data became available for successive regional reports (listed in Table S-1 on page 15). Reports produced since 2001 have incorporated up-to-date data with a revised normal period from 1961-1990 to 1971-2000 for datasheets, summaries and all design graphs. Since this report is based on the hydrometric data for the older normal period any future updating and revision may produce revised streamflow design curves and hydrologic zone boundaries.

The following Table S-1 lists a cross-reference of small-case lettered Hydrologic **Subzones** of this and other subsequent Ministry regional reports and the numbered 2003 Hydrologic **Zones** of the SLMVI report. Note that the regional report for Omineca-Peace also has a supplement section with a detailed 1:1,300,000 scale map because one had not been produced in its report. However, the Cariboo report does not have a supplement report detailed map, but its region is overlapped by the Southern Interior and Omineca-Peace supplement maps and is therefore covered for applying the regional graphical procedures for estimating various streamflows at ungauged sites.

Table S-1 Reports and Hydrologic Zone Index

Streamflow Report		Hydrologic Zone		
Region	Date	1998-02	2003	Name
Southern Interior	Dec. 1998	a	25	Eastern South Coast Mountains
- Supplement	Apr. 2003	b	24	Southern Thompson Plateau
		c	23	Okanagan Highland
		d	17	Northern Thompson Plateau
		e	15	Fraser Plateau
		f	14	Northern Columbia Mountains
Cariboo	Sept. 1999	i	16	Southern Quesnel Highland
		j	25	Eastern South Coast Mountains
		k	26	Central South Coast Mountains
Omineca-Peace	Sept. 2000	l	13	Upper Fraser Basin
- Supplement	Apr. 2003	m	7	Southern Rocky Mountain Foothills
		n	6	Southern Interior Plains
		o	4	Northern Interior Plains
		p	3	Northern Rocky Mountains
		q	12	McGregor Basin
Skeena	Jun. 2001	m	8	Nechako Plateau
		r	2	Stikine Plateau
		s	1	Northern Coast Mountains
		t	5	Northern Central Uplands
		u	9	Southern Hazelton Mountains
		v	10	Central Coast Mountains
		w	11	Queen Charlotte Islands
Kootenay	Jan. 2002	g	22	Lower Columbia Basin
		h	21	Lower Kootenay Basin
		x	18	Upper Columbia Basin
		y	19	Upper Kootenay Basin
		z	20	Central Kootenay Basin
Lower Mainland and	Apr. 2003		27	Western South Coast Mountains
Vancouver Island			28	Eastern Vancouver Island
			29	Western Vancouver Island

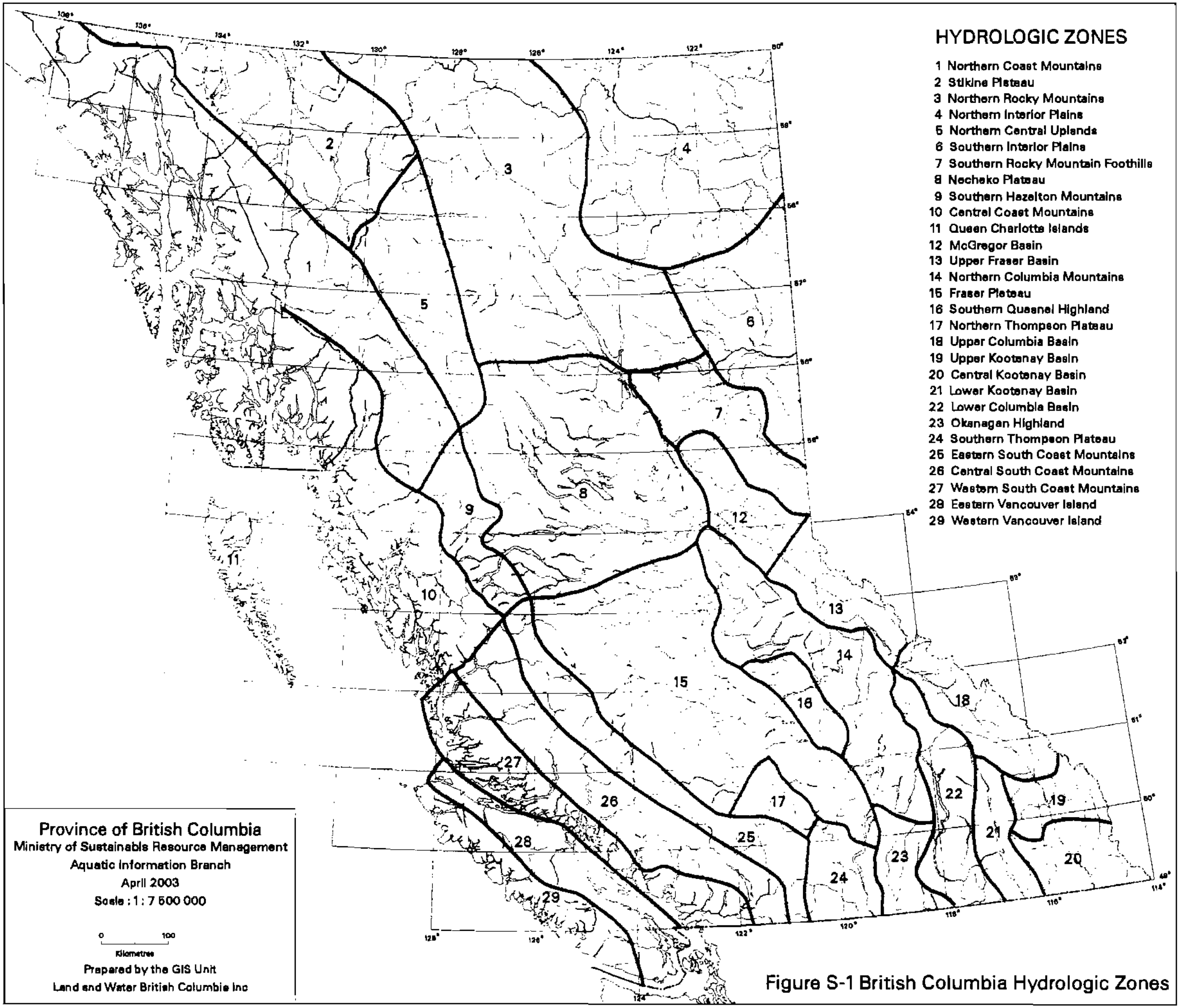

Figure S-1 British Columbia Hydrologic Zones