APPENDIX A

Study Methodology

APPENDIX A – STUDY METHODOLOGY

A.1 TASK 1: GIS ANALYSIS

To provide basic information for each sub-basin and residual area in the Basin, the following information was compiled using Geographic Information System (GIS) (ArcView) software:

- Drainage areas of sub-basins and residual areas;
- Minimum and maximum elevations of sub-basins and residual areas;
- Median elevations of sub-basins and residual areas;
- Location (i.e. latitude and longitude) of each node;
- Location (i.e. latitude and longitude) of all known hydrometric stations in the Basin, including those operated by Water Survey of Canada (WSC) and other parties;
- Area and median elevation of the drainage areas upstream of the hydrometric stations (if unavailable from other sources), and
- Boundaries of provincial hydrologic zones.

A.2 TASK 2: COMPILE AND SCREEN HYDROMETRIC DATA

All current and former hydrometric stations in the Okanagan Basin (see Section 4.0) were organized by node (Appendix B). This includes stations operated by the WSC and those operated independently. While the latter group of stations have relatively short records and the data was collected according to varying standards (depending on the operator's objectives), the station records nonetheless can provide useful insight into the hydrology of some streams. Independent hydrometric data was provided to the study team by Dobson Engineering Ltd. (on behalf of from several water purveyors), Mr. Phil Epp of the Ministry of Environment, and the Oceola Fish and Game Club (Appendix B).

The list of hydrometric stations was screened to determine which stations could potentially be useful for the study. Those stations particularly useful for the study had the following characteristics:

- They have records of *natural* streamflows,

- They have records of streamflow throughout the year,
- They contain at least some streamflow records during the 1996-2006 standard period, and
- The overall record of streamflows is generally greater than five (5) years.

While these characteristics are desirable, a relatively small number of stations in the Okanagan Basin have these characteristics. It was therefore necessary to include other stations lacking some of the desired characteristics in order to provide at least some basic insight to the hydrology in parts of the Basin. A total of 94 stations were identified as having some potentially useful information for the study (Appendix B). Of these, 35 were employed to development regional runoff relations (see Section A.3).

For those hydrometric stations identified as potentially useful for the study, the following steps were taken:

- Mean *daily discharge* data from all hydrometric stations in the Okanagan Basin were obtained from Environment Canada (2008a) and others (Section 4.0).
- Mean daily discharge data were reduced to mean *weekly discharge* and organized in a standard spreadsheet template.
- Mean *weekly unit discharge* (L/s/km^2) was calculated for each station by dividing mean weekly discharge by the drainage area upstream of the stream gauge. The calculation of unit discharge permits comparisons between streams with differing drainage areas. In effect, it indicates the amount (or rate) of water produced on a unit area (i.e. km^2) of the watershed.

A.3 TASK 3: DEVELOP UPDATED REGIONAL RUNOFF RELATIONS

In order to identify runoff patterns in the Basin, regional relations developed by Mr. Bill Obedkoff of MOE in 1998 were updated. These relations and describe how mean annual runoff varies with elevation and geographic location in Interior British Columbia (Obedkoff 1998). The updated relations were prepared in order to estimate the annual runoff *normalized* for the 1996-2006 period at any location in the Okanagan, based on the median elevation and the drainage area upstream of the point-of-interest (determined by GIS). Since this information can support estimates of aquifer recharge it was made available in November 2008 to the consulting team investigating groundwater for the OWSDP. The annual runoff predicted by the updated regional relations describes the general pattern of runoff in the Basin and also provides a basis from which monthly and weekly runoff can be estimated with knowledge (or estimation) of the distribution of runoff at the location of interest. This is particularly useful in ungauged basins. The following summarizes the methods used to develop the updated regional runoff relations.

Based on a review of all available streamflow records (Section A.2), 35 hydrometric stations distributed throughout the Okanagan and nearby surrounding Basin areas were identified (Table A.1 and Map 1) as suitable to support the analyses. These stations have most if not all the desirable characteristics listed in Section A.2 and were considered representative of the annual runoff patterns.

For each station, mean annual discharge (in units of m^3/s) for each year of record were compiled and converted to *mean annual unit discharge, i.e. runoff* (in units of mm). In order to make comparisons for the 1996-2006 standard normal period, mean annual runoff data was normalized. While there are different approaches to adjust data of different periods so that they reflect a normal (or common) period, a relatively straightforward approach was adopted for this study. It involved scaling the mean annual runoff for the available period of record at each station by a factor that reflected how runoff over the specific period of record compared to the 1996-2006 period. This factor was based on averaging the patterns of runoff from 14 stations listed in Table A.1 that operated between 1996 and 2006 and have records of natural streamflows. Although the patterns of mean annual runoff vary slightly between the 14 stations, the overall average pattern was considered reasonably consistent in the region (Figure A.1). The normalized runoff for each of the 35 hydrometric stations is presented in Table A.1.

Table A.1 List of hydrometric stations used to develop updated regional runoff relations.

Provincial Hydrologic Zone (refer to Map 1)	**Station no.**	**Station name** (* indicates stations outside the Okanagan Basin)	**Natural** (bold) / **Regulated** (not bold)	**Years of record**	**Median Elevation (m)**	**Normal Annual Runoff 1996-2006 (mm)**
24/b	**08LG064**	**Beak Creek at the mouth***	**Natural**	**1983-2000**	**1450**	**177**
24/b	**08NM035**	**Bellevue Creek near Okanagan Mission**	**Natural**	**1911-1986**	**1540**	**164**
24/b	**08NM133**	**Bull Creek near Crump**	**Natural**	**1965-1986**	**1530**	**90**
24/b	**08NM134**	**Camp Creek at the mouth near Thirsk**	**Natural**	**1965-2007**	**1450**	**126**
24/b	**08NM137**	**Daves Creek near Rutland**	**Natural**	**1965-1986**	**1290**	**110**
24/b	**08NM242**	**Dennis Creek near 1780 m contour**	**Natural**	**1985-2007**	**1893**	**499**
24/b	**08NM173**	**Greata Creek near the mouth**	**Natural**	**1970-2007**	**1280**	**65**
24/b	**08NL050**	**Hedley Creek near the mouth***	**Natural**	**1973-2006**	**1680**	**197**
24/b	08NL045	Keremeos Creek below Willis Intake*	Regulated	1971-2006	1320	110
24/b	08LG049	Nicola River above Nicola Lake*	Regulated	1915-2007	1230	88
24/b	**08LG016**	**Pennask Creek near Quilchena***	**Natural**	**1920-2006**	**1680**	**290**
24/b	08NM037	Shatford Creek near Penticton	Regulated	1911-2007	1530	124
24/b	08NL022	Similkameen River near Nighthawk*	Regulated	1928-2006	1480	203
24/b	**08NM164**	**Testalinden Creek in canyon**	**Natural**	**1969-1986**	**1270**	**69**
24/b	**08NM240**	**Two-forty Creek near Penticton**	**Natural**	**1983-2007**	**1769**	**416**
24/b	**08NM241**	**Two-forty-one Creek near Penticton**	**Natural**	**1983-2007**	**1768**	**378**
24/b	**08NM015**	**Vaseux Creek above Dutton Creek**	**Natural**	**1919-1982**	**1591**	**179**
24/b	**08NM171**	**Vaseux Creek above Solco Creek**	**Natural**	**1970-2007**	**1680**	**265**
23/c	08NM020	BX Creek above Vernon intake	Regulated	1921-1999	1130	180
23/c	**08NM142**	**Coldstream Creek above municipal intake**	**Natural**	**1967-2007**	**1120**	**143**
23/c	08NM116	Mission Creek near East Kelowna	Regulated	1946-2007	1340	258
23/c	**08NM172**	**Pearson Creek near the mouth**	**Natural**	**1970-1987**	**1560**	**399**
23/c	**08NN019**	**Trappping Creek near the mouth***	**Natural**	**1965-2006**	**1350**	**338**
23/c	**08LC040**	**Vance Creek below Deafies Creek***	**Natural**	**1970-2006**	**1040**	**240**
23/c	**08NN022**	**West Kettle River below Carmi Creek***	**Natural**	**1973-1996**	**1380**	**285**
23/c	**08NN015**	**West Kettle River near McCulloch***	**Natural**	**1949-2006**	**1620**	**502**
15/e	**08NM146**	**Clark Creek near Winfield**	**Natural**	**1968-1982**	**1360**	**154**
15/e	**08NM177**	**Deep Creek at Young Road**	**Natural**	**1970-1975**	**770**	**37**
15/e	**08NM176**	**Ewer Creek near the mouth**	**Natural**	**1971-1986**	**1470**	**228**
15/e	08NM165	Lambly Creek above Terrace Creek	Regulated	1970-1995	1390	247
15/e	08LE020	Salmon River at Falkland*	Regulated	1911-2007	1190	102
15/e	08LE021	Salmon River at Salmon Arm*	Regulated	1911-2007	1130	124
15/e	**08LE075**	**Salmon River at Salmon Lake***	**Natural**	**1965-2002**	**1350**	**167**
15/e	08NM138	Terrace Creek near Kelowna	Regulated	1965-1992	1490	267
15/e	**08NM174**	**Whiteman Creek above Bouleau Creek**	**Natural**	**1971-2006**	**1450**	**204**

Following the approach of Obedkoff (1998), all normalized runoff data were first stratified by provincial hydrologic zone (see Map 1) and then plotted against median elevation of the drainage area on semi-log graph paper (Figure A.2). The best-fit relations for the three main provincial hydrologic zones in the Okanagan[1] were then fitted by eye using professional judgement since not all stations are given equal weighting. This is necessary since some stations have regulated streamflow, some have relatively short records, and some stations may be influenced to a greater extent by surface water-groundwater interactions (see Section 3.6).

A suite of parallel lines on semi-log graph paper (curvilinear on arithmetic paper) reflect the general pattern of increasing runoff with elevation and increasing runoff from the south to the north as one moves from hydrologic zone “24/b” to “15/e” to “23/c” (Obedkoff, 1998). In order to provide a practical tool for this and other OWSDP studies, the above-noted dataset was further stratified into 12 sub-regional “hydrologic groups” that reflect reasonably uniform runoff characteristics. These groups were identified based on the normalized runoff statistics, reported streamflow characteristics in the Okanagan, and professional experience. While there is a gradual transition of runoff characteristics from one group to the next, for this study the groups were defined along sub-basin or residual areas boundaries. Runoff relations for each “hydrologic group” are provided in Appendix B. Map 1 shows the locations of each group. For each group there is a best-fit relation to estimate the *expected value* of the normalized annual runoff as well as the likely upper and lower estimates of annual runoff. It is important to note that the upper and lower limits were estimated by eye and were not statistically derived. The ranges in estimates vary by group depending on the within-group runoff variation. Discussion of the pattern of regional runoff identified in the Basin is provided in Section 5.0 of the main report.

[1] A fourth provincial hydrologic zone is present at the extreme north end of the Okanagan Basin. However due to its small size this zone was not included.

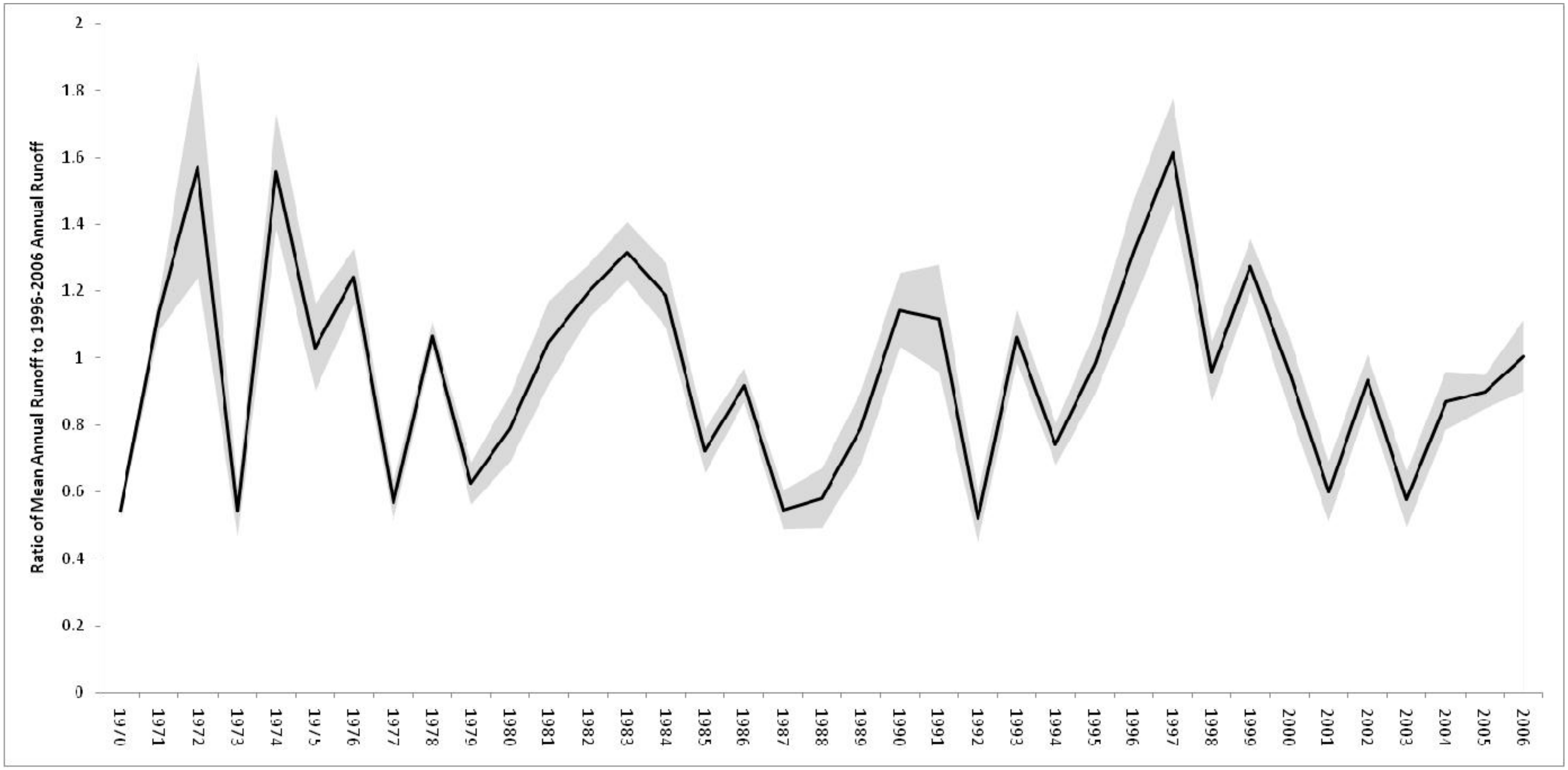


Figure A.1 Regional average ratio of mean annual runoff to 1996-2006 normal annual runoff (based on natural streamflow records from 14 hydrometric stations).

Note: Values above 1.0 indicate years when the Okanagan Basin overall experienced higher than normal runoff, while those below 1.0 indicate lower than normal runoff. Gray area indicates +/- 2 standard deviations about the mean.

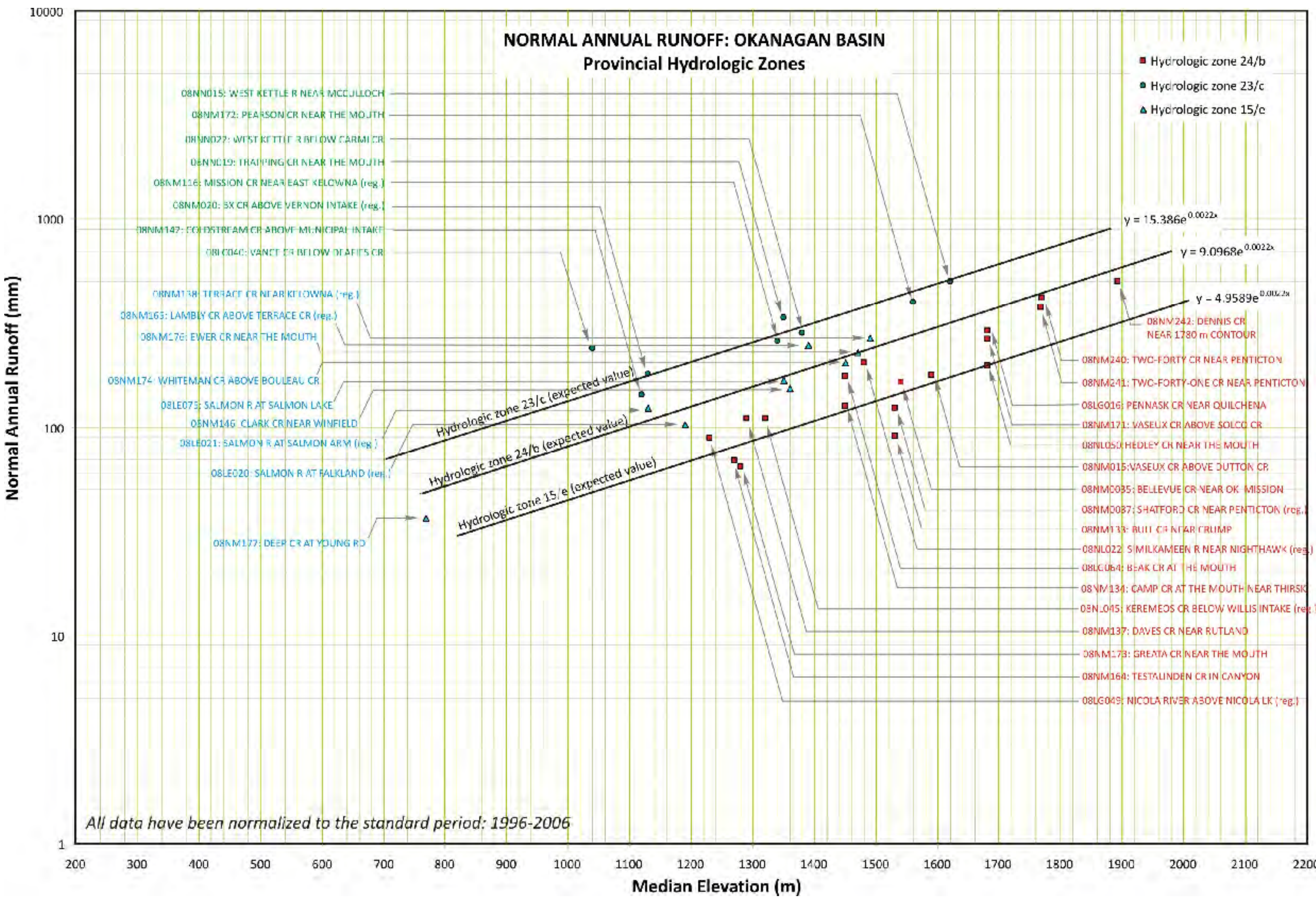


Figure A.2 Normal (1996-2006) annual runoff relations for the Okanagan Basin, stratified by provincial hydrologic zone.

A.4 TASK 4: ANALYSIS AND FILLING OF GAPS IN HYDROMETRIC RECORDS

Once all the potentially useful hydrometric data had been compiled (Appendix B), the next step involved systematically screening all the potentially useful information one sub-basin at a time. The purpose of the screening was to confirm the methods to be used for estimating natural streamflows at each of the nodes and to confirm the usefulness of the data available within each sub-basin. During this step, the smaller gaps in hydrometric records were filled. This typically involved identifying relations between the hydrometric records from the station having missing data and the hydrometric records at one or more nearby stations having records for the period of missing data.

A.5 TASK 5: REVIEW KEY REPORTS IN THE OKANAGAN INFORMATION DATABASE

The Okanagan Information database, developed in Phase 1 of the OWSDP and updated thereafter, was used to identify key reports that could be useful for developing and/or confirming estimates of natural streamflows. Included within the database are many stream-specific hydrology studies conducted by Ministry of Environment staff, professional consultants, and university researchers. The most relevant reports are listed in Appendix D. In several sub-basins, this information proved to be supplementary to actual hydrometric records; however, in other sub-basins, this information provided the only data available and was key in developing some streamflow estimates (Section 2.10).

A.6 TASK 6: REVIEW WATER MANAGEMENT AND USE REPORT

As indicated in Section 1.3.1, the process of streamflow naturalization involves the use of hydrometric records and estimates of water use and management (i.e. water storage, release, and diversions). This information was obtained from the Water Management and Use (WMU) Study (Dobson Engineering Ltd. 2008).

Streamflow naturalization was done for the three largest streams in the Okanagan: Vernon, Mission and Trout Creeks, using a detailed update of the water management and use data for these sub-basins was completed after the 2008 Dobson Engineering study was published (see Section A.7). Naturalization was also completed for Trepanier Creek.

A.7 TASK 7: REFINE WATER MANAGEMENT AND USE DATA

A technical memorandum outlining the methods and assumptions used in the refinement of data presented in Dobson (2008) is provided in Appendix E. In summary, water balance parameters that directly influence streamflow naturalization were revised for Vernon Creek sub-basin (Nodes 1, 2, and 12), Mission Creek sub-basin (Node 22), and Trout Creek sub-basin (Node 42). The goal was to gain additional confidence in the following parameters over the 1996-2006 standard period:

- The weekly volume of water imported to the sub-basin (if any),
- The weekly volume of water captured into or released from storage in the sub-basin, and
- The weekly volume of water extracted from surface sources in the sub-basin.

Vernon, Mission, and Trout Creeks were chosen not only because they represent the three largest sub-basins in the Okanagan (providing 42% of the total average streamflow in the Basin), but also because Vernon and Mission Creeks have long (regulated) streamflow records that facilitate streamflow naturalization. While the (regulated) streamflow record for Trout Creek has considerably more gaps, it is nevertheless useful for developing naturalized streamflow estimates in conjunction with other methods such as regionalization. Although there are several other sub-basins where water use and management data could have been re-examined in order to facilitate streamflow naturalization, alternative techniques were available to reasonably estimate natural streamflows in those (smaller) sub-basins - although at the cost of slightly greater levels of uncertainty.

Following the revisions, it was evident that, in some cases, some original WMU data was reasonable, but for others the revised estimates differed considerably (Appendix E), and these differences would have significantly affected streamflow naturalization results. Revised data were uploaded to the Okanagan Water Database, and used for this study.

A.8 TASK 8: SUMMARIZE NATURAL STREAMFLOWS

Natural streamflow records provide a direct means to determine natural runoff patterns at the mouths of each of the streams of interest. A major challenge is that although 42 hydrometric stations with natural streamflow records have operated in the Okanagan Basin (Appendix B), only nine Water Survey of Canada stations and one independent station have records that fall within the 1996-2006 standard period (Table A.2). Furthermore, only one station (Vaseux Creek near the mouth) has natural streamflow records (albeit for a short period) in the 1996-2006 period near the mouth of a stream of interest (i.e. at a node).

Table 2.2 List of hydrometric stations with at least some records of natural streamflows in the 1996-2006 period.

Node	Sub-basin	WSC Station[1]	Year	Status	Drainage area (km^2)	Median elevation (m)
1	Vernon Creek	**08NM142, Coldstream Creek Above Municipal Intake**	1967-present	Active	58.5	1,120
14	Whiteman Creek	**08NM174, Whiteman's Creek Above Bouleau Creek**	1970-present	Active	109	1,450
22	Mission Creek	Pooley Creek above Pooley Ditch (South East Kelowna Irrigation District)	2007-2007	Active	-	-
32	Peachland Creek	**08NM173, Greata Creek near the Mouth**	1970-present	Active	41	1,280
42	Trout Creek	**08NM134, Camp Creek at Mouth near Thirsk**	1965-present	Active	34	1,450
46	Penticton Creek	08NM240, Two-Forty Creek near Penticton	1983-present	Active	5.0	1,769
		08NM241, Two-Forty-One Creek near Penticton	1983-present	Active	5.0	1,768
		08NM242, Dennis Creek near 1780 metre Contour	1985-present	Active	3.7	1,893
66	Vaseux Creek	**08NM171, Vaseux Creek Above Solco Creek**	1970-present	Active	117	1,680
		08NM246, Vaseux Creek near the Mouth[2]	2006-present	Active	296	1,535

Notes:
1) The five (5) stations shown in bold have the most useful natural streamflow records in the Okanagan Basin for assessing natural streamflow patterns and are considered the primary reference stations in the Basin.
2) This is the only station with natural streamflow records near the mouth of a stream of interest (i.e. node) in this study.

To support Part Two of this study, weekly streamflow data from the above-noted nine WSC stations were summarized in a standard spreadsheet template and forwarded to the study team calibrating the MIKE SHE hydrologic model. Once Part One is completed, natural streamflow estimates at all sub-basin and residual area nodes will be available for calibration and checking purposes.

As a result of the limited natural streamflow records near nodes, there were only three streams (Whiteman, Peachland and Vaseux Creeks) where the available records (within their respective sub-basins) could be used to directly estimate natural streamflows at the mouths of their respective streams (i.e. nodes). The process however involved extending the available data both spatially and temporally so that streamflows reflected conditions at the mouth during the complete 1996-2006 period. In general, the steps included:

- Calculating the unit discharges in L/s/km^2 (or runoff in mm) for each of the hydrometric stations with natural streamflow data (Section A.2);
- Identifying and applying the sub-regional relations between unit discharge or runoff and elevation in the Basin (Section A.3). In general, this involved determining the median elevation of the drainage areas at the hydrometric station and at the mouth of each stream. As runoff is directly related to median elevation (Section A.3), a reduction in elevation typically results in a reduction in unit runoff.
- In order to fill gaps in records and extrapolate records so that the complete 1996-2006 period was reflected, natural streamflow records from the five hydrometric stations shown in bold in Table A.2 were used as reference.

Specific methods of estimation for each stream are discussed further in Appendix J.

A.9 TASK 9: NATURALIZE REGULATED STREAMFLOW RECORDS

As indicated above, naturalization of gauging records involves obtaining and adjusting measurements of regulated flows by accounting for the effects of water storage and withdrawal. The resulting flows are therefore estimated, not measured, and are referred to as *naturalized* to avoid confusion with measured *natural* flows from non-regulated streams

(Section 2.8). Where records of *regulated* streamflows are available, the process of *naturalization* effectively removes the human effect from the streamflow record. In general, the process involves the following:

- Compiling weekly regulated streamflow records (i.e. those affected by human water use/regulation);
- Compiling weekly water use and management information; and
- Estimating naturalized streamflows by accounting for water held and released from storage, water extracted, and water returned to the stream upstream of each node.

While conceptually simple, there are several factors that complicate this task:

- The streamflow records are often incomplete, requiring considerable gap filling and/or record extension (similar to that described in Section A.8);
- The streamflow records are often upstream of the mouth and therefore do not necessarily reflect all significant water use in the sub-basin; and
- The confidence in the water use estimates can vary by location and over the standard period at a given tributary.

Originally, this study planned to use streamflow naturalization on up to seven streams in the Basin. However, given some uncertainty in the WMU database (Section A.6), revised water use and management estimates were developed only for the **Vernon, Mission and Trout Creek** sub-basins (Appendix F). These estimates in turn were the basis for streamflow naturalization in Vernon, Mission and Trout Creeks. Since there was also sufficient streamflow data and information available to estimate water use for Trepanier Creek, its streamflows were also naturalized.

The details of the methods used for each sub-basin are provided in Appendix J.

A.10 TASK 10: ESTIMATE NATURAL FLOWS IN REMAINING TRIBUTARIES AND RESIDUAL AREAS

In order to estimate natural streamflows and runoff in all remaining tributaries and residual areas, several methods were used depending on the nature of the available information. Since the streamflow estimates were to be used for calibration or checking of the MIKE SHE hydrologic model, it was important that the methods be documented and that the confidence in the results is made explicit (Sections A.13 and 6.0 of main report). As a general rule, estimates were to be as closely associated as possible with measured hydrometric data. Streamflows in nearby representative streams along with sub-regional runoff relations were therefore the primary references. Selection of the representative station(s) and development of streamflow estimates in ungauged basins and basins with records other than for the 1996-2006 period required considerable professional judgment. Where estimates were of lower confidence, higher levels of uncertainty were necessarily assigned to the data. The specific methods used for streamflow estimation in ungauged basins are provided in Appendix K.

A.11 TASK 11: INVESTIGATE SURFACE WATER - GROUNDWATER INTERACTION

Observations at several Okanagan locations suggest that surface-groundwater interactions may be significant, particularly where streams cross alluvial fans, which also represent alluvial aquifers. This topic was investigated to help aid in the estimation of flows at the mouths of streams that at least partially overlie alluvial aquifers. The investigation included a review of the literature and the WSC hydrometric network to identify if existing data upstream and downstream of alluvial aquifers could provide some insight. The review was documented in a technical memorandum prepared for the Working Group on November 6, 2008 (Polar Geoscience Ltd. 2008) and is summarized in Section 3.6. Since surface water – groundwater interaction is of direct relevance to the groundwater investigation, these findings were also forwarded to the groundwater study team.

A.12 TASK 12: ASSIGN DATA QUALITY RATINGS

In order to provide confidence to the overall study, it was paramount that data quality and uncertainty were tracked throughout Part One. To provide a consistent measure of uncertainty, the framework developed for the OWSDP and presented in Table A.3 was adopted. All weekly streamflow estimates were therefore assigned data error rating from 1 to 5 and a data quality rating from 1 to 5. A data error rating of 1 would reflect hydrometric data collected at a WSC station[2]. However, since not one node has a complete record of natural streamflows, some degree of extrapolation or gap filling was necessary for all nodes. Therefore, in no cases were data error ratings of 1 assigned to the data.

Table A.3 Data error and data quality rating framework used in the study.

Rating	Data Error
1	less than or equal to 10%
2	greater than 10% and less than or equal to 25%
3	greater than 25% and less than or equal to 50%
4	greater than 50% and less than or equal to 100%
5	greater than 100%

Rating	Data Quality
A	Entirely from measurements at the node
B	Combination of measurements at the node and modelling
C	Modelled, based on other areas of the Okanagan Basin
D	Modelled, but with limited or questionable data
E	Expert judgment

A.13 TASK 13: QUALITY ASSURANCE AND QUALITY CONTROL

During Part One, all efforts were made to minimize the potential for introducing errors to the estimates. This began by designating a technical leader responsible for conducting and overseeing all technical work in Part One, then designating a small team to ensure consistency. Specific tasks were designated to each team member, consistent with their

[2] Class "A" hydrometric data are considered accurate to +/-7%.

level of experience. Data error and quality was tracked throughout Part One. Furthermore, a series of checks of calculations were made.

The first check involved a systematic comparison of the preliminary natural / naturalized streamflow estimates with information reported in previous hydrologic studies and with available hydrometric records on the same stream (Appendix D). In order to minimize potential bias, the check was conducted by members of the team not directly involved in developing the preliminary estimates. In most cases only annual and monthly streamflow information was available, so all weekly streamflow records developed in this study were converted to monthly and annual values. Upon completing the review, differences and similarities were assessed, and adjustments were made to the preliminary estimates if they were necessary. In some cases, detailed studies revealed local information (e.g. the presence of zero flow conditions during some times of the year) that the study team had not previously known.

As a second check of the natural streamflow estimates, the annual water balance for the following five areas were calculated for 1996-2006:

- Area 1: Kalamalka/. Wood Lake (including all contributing area upstream of the outlet of Kalamalka Lake);
- Area 2: Okanagan Lake (including all contributing area upstream of the outlet of Okanagan Lake);
- Area 3: Skaha Lake (including all contributing area between the outlets of Okanagan Lake and Skaha Lake);
- Area 4: Okanagan River: Okanagan Falls to Oliver [including all contributing area to Okanagan River between the hydrometric stations at Okanagan Falls (08NM002) and near Oliver (08NM085)]; and
- Area 5: Okanagan River: Oliver to Oroville, WA [including all contributing area to Okanagan River between the hydrometric stations near Oliver (08NM085) and at Oroville, WA (08NM127).

The annual water balance for each of the above-noted areas takes the form:

Volume of water in – Volume of water out = Volumetric change in storage ... [Eq A.1]

Using the water balance parameters adopted by the OWSDP, the general annual water balance equation is as follows:

$[Q_{upstream} \bullet \Delta t + (QS + \sum DSN \bullet \Delta t) + PL + RFS + DL \bullet \Delta t + QT \bullet \Delta t] - [Q_{out} + EL + ES] = \Delta SL$... [Eq A.2]

where,

$\Delta t = 1$ year

$Q_{upstream} \bullet \Delta t =$ Incoming volumetric runoff in the Okanagan River (ML). This term is based directly on the Water Survey of Canada streamflow records on the Okanagan River (at Penticton, Okanagan Falls, and Oliver). The term does not apply to Area 1.

$(QS + \sum DSN) \bullet \Delta t =$ Natural volumetric runoff from all contributing areas (ML). This was calculated by summing the natural runoff estimates developed in Part One of this study.

PL = Volume of precipitation directly onto lake surfaces (ML). This term is based on the precipitation estimates developed by Duke et al. (2008a). Precipitation in mm was converted to volumes based on lake surface areas identified in this study (Appendix F).

RFS = Volume of surface return flows due to human activity (e.g. wastewater treatment plant outflows) (ML). This term was based on wastewater treatment plant outflows presented by Dobson Engineering Ltd. (2008) for 2006. The year-to-year variation was assumed to mimic the variation in water use (*ES*).

DL • Δt = Volume of groundwater discharged as underflow to lakes (ML). This value is unknown and is a topic currently being investigated by the groundwater study for the OWSDP. It is important to note that the uncertainty in this term restricts the inferences that can be made using the annual water balance.

QT • Δt = Volume of water imported from outside natural contributing area (ML). This is based on information provided by Dobson Engineering Ltd. (2008) as well as several major water suppliers.

$Q_{out} \bullet \Delta t_{t}$ = Residual or outgoing volumetric runoff in mainstem river (ML). This term is based directly on the Water Survey of Canada streamflow records on Vernon Creek at the outlet of Kalamalka Lake and the Okanagan River (at Penticton, Okanagan Falls, Oliver, and Oroville, WA.).

EL = Volume of water lost to evaporation from lake surface (ML). This term is based on lake evaporation estimates developed by Schertzer and Taylor (2008) which are subject to revision since these estimates may underestimate actual values.

ES = Volume of water extracted from surface sources for human use (ML). This term is based on estimates of water use by Polar Geoscience Ltd. (2009) for Area 1 and Dobson Engineering Ltd. (2008) for Areas 2-5. While the study team is confident in the estimates for Area 1, there is some uncertainty in the estimates for Areas 2-5 (Section 2.6). Nevertheless, the estimates are likely reasonable for the purposes of the annual water balance check.

ΔSL = Volumetric change in lake storage (ML). This is based directly on the lake level records on Kalamalka Lake, Okanagan Lake, Skaha Lake, and Osoyoos Lake.

The conversion of lake level changes to volumetric changes was based on the lake storage tables developed during this study (Appendix G).

The results of the annual water balance checks are presented in Section 6.2 and Appendix L.

A.14 TASK 14: BASEFLOW SEPARATION

Following review of the natural streamflow estimates, weekly streamflow data for each of the nodes can be analyzed by baseflow separation, which involves analysis of the streamflow hydrograph and estimating the relative contributions of baseflow (the longer-term delayed flow from groundwater) and quickflow (the short-term response to rainfall and snowmelt events). The goal is to understand the magnitude and dynamics of groundwater discharge to the study streams. Several graphical methods and models are available to achieve baseflow separations (Brodie and Hostetler, undated).

As emphasized by Brodie and Hostetler (undated), the assumption that baseflow equals groundwater discharge is not always valid. Water can be released from streams over different time scales from different storage locations such as lakes, wetlands, snow or streambanks. Since the streamflow record represents the net water balance, baseflow is also influenced by any water losses from the stream such as direct evaporation, transpiration from riparian vegetation, or seepage into aquifers along specific reaches (Sections 2.11 and 3.6). While regulation and direct extractions from the stream are accounted for in the natural/naturalized streamflow data, there is a possibility that nearby groundwater pumping can affect baseflow. Therefore, careful consideration of the overall water balance for the stream is required in interpreting the baseflow component.

Upon review of baseflow separation methods, for consistency purposes, separations will be calculated using the MIKE SHE model in Part 2 of this study. MIKE SHE separates hydrographs into three separate groupings: overland flow, interflow (or quickflow), and baseflow (DHI 2008). MIKE SHE routes quickflow and baseflow via a linear reservoir method, while overland flow is routed by the finite difference method (DHI 2008). By using MIKE SHE, the subjectivity of graphical techniques used for separations is removed; thereby, maintaining data control and increasing reproducibility.

Baseflow separations will occur when the MIKE SHE model is calibrated using the naturalized streamflow data presented in this report. Once calibrated, the MIKE SHE model will provide four separate outputs for each stream hydrograph: the calibrated naturalized streamflow (total flow) separated into overland flow, quickflow, and baseflow.

A.15 TASK 15: DATA SUMMARY AND REPORTING

All data developed during Part One was summarized in a standard MS Excel spreadsheet format, which was developed to simplify its use by the team members conducting Part Two. Each summary provides the basic physiographic information for each node and provides the mean weekly discharge (m^3/s) between January 1, 1996 and December 31, 2006 (and where possible also for January 1 to December 31, 1995). Data error and quality ratings are provided with all estimates. In addition, all data for 1996-2006 was converted to MS Access and uploaded to the OK Water Database.

Once Part Two of the study is complete, modeled streamflow data will be available. At that time, a final suite of streamflow estimates for each node will be developed by considering the uncertainty of the estimates from both Parts One and Two, and these final data will be uploaded to the Okanagan Water Database.

All relevant reports and sources of information identified during Part One that were not identified in the Okanagan Information Database are listed in Appendix H. Summaries of these references were uploaded to the Okanagan Information Database.

APPENDIX B

Nodes and Hydrometric Stations

in the Okanagan Basin

Table B.1 Nodes and hydrometric stations in the Okanagan Basin.

Node (Node Characteristics)	Sub-basin / Residual area description	Drainage Area (km^2)	Median Elevation (m)	Minimum Elevation (m)	Maximum Elevation (m)	Location of node (mouth of stream) Lat.	Location of node (mouth of stream) Long.	Provincial Hydrologic Zones (where sub-basin / residual area falls in more than one zone distribution within each zone in % is indicated)	Hydrologic Group (see text for discussion)	Hydrometric Stations: Hydrometric Stations within sub-basin or residual area (operated by Water Survey of Canada unless noted otherwise). Stations in red were used (along with others outside the Okanagan) in developing regional hydrologic relations (see text for discussion)	Streamflow	River flow	Lake or Reservoir Level	Diversion / Canal	Natural (green shade) / Regulated (blue shade)	Years of Record	Station status	Drainage Area (km^2)	Median Elevation (m)	Location of hydrometric station Lat.	Location of hydrometric station Long.	Notes	Potentially useful for hydrology / modeling study (see text for discussion)
1, 2, 12	Vernon Creek	Drainage area above Kalamalka and Wood Lakes = 537.3 km^2. Drainage area above outlet of Kalamalka Lake = 572.0 km^2. Drainage area of Vernon Creek at the mouth = 749.3 km^2.	Median elevation of drainage area above Kalamalka and Wood Lakes = 1041 m. Median elevation of drainage area above outlet of Kalamalka Lake = 998 m. Median elevation of Vernon Creek watershed above the mouth = 914 m	342 +/-	1655	50.25	-119.35	Drainage area above Kalamalka and Wood Lakes falls within zones 15 (60%) and 23 (40%). Drainage area above outlet of Kalamalka Lake falls within zones 15 (60%) and 23 (40%). Drainage area above Vernon Creek at the mouth falls within zones 14 (1%), 15 (34%), and 23 (65%).	1	08NM146, Clark Creek near Winfield	✓				Natural	1968-1982	Discontinued	15.3	1360	50.05	-119.33	Continuous record	Yes
										08NM142, Coldstream Creek Above Municipal Intake	✓				Natural	1967-2006	Active	58.5	1120	50.26	-119.08	Continuous record	Yes
										08NM235, Ribbleworth Creek near Oyama	✓				Natural	1973-1979	Discontinued	12.5	971	50.08	-119.38	Continuous record 1975-1979	Yes
										08NM020, BX Creek Above Vernon Intake	✓				Regulated	1921-1999	Discontinued	55.7	1130	50.30	-119.21	Continuous record 1959-1999	Yes
										08NM123, BX Creek Below Swan Lake Control Dam	✓				Regulated	1910-1978	Discontinued	120	-	50.28	-119.28	Continuous record 1973-1978	Yes
										08NM125, BX Creek Above Swan Lake Control Dam	✓				Regulated	1959-1979	Discontinued	-	-	50.29	-119.26	Continuous record	Yes
										08NM124, Coldstream Creek near Lavington	✓				Regulated	1910-1979	Discontinued	61.9	-	50.25	-119.07	Continuous record 1969-1979	Yes
										08NM154, Coldstream Creek at the Mouth	✓				Regulated	1969-1970	Discontinued	-	-	50.23	-119.25	Continuous record	Yes
										08NM179, Coldstream Creek Above Kalavista Diversion	✓				Regulated	1970-1982	Discontinued	207	-	50.23	-119.26	Continuous record	Yes
										08NM048, Oyama Creek Above Wood Lake Irrigation Intake	✓				Regulated	1921-1987	Discontinued	-	-	50.12	-119.33	Continuous record 1973-1987	Yes
										08NM021, Vernon Creek at Vernon	✓				Regulated	1921-1960	Discontinued	593	-	50.26	-119.27	Continuous record	Yes
										08NM022, Vernon Creek at Outlet of Swalwell Lake	✓				Regulated	1921-1998	Discontinued	62.4	-	50.04	-119.24	Continuous record 1969-1998	Yes
										08NM065, Vernon Creek at Outlet of Kalamalka Lake	✓				Regulated	1927-2006	Active	572	997	50.24	119.27	Continuous record 1959-2006	Yes
										08NM160, Vernon Creek near the Mouth	✓				Regulated	1969-1999	Discontinued	751 (WSC), 744 (GIS)	-	50.26	-119.31	Continuous record 1969-1982, seasonal record 1984-1999	Yes
										08NM181, Winfield Creek at inlet to Wood Lake	✓				Regulated	1971-1973	Discontinued	-	-	50.05	-119.41	Continuous record 1969-1987	Yes
										08NM143, Kalamalka Lake at Vernon Pumphouse			✓		Regulated	1967-2006	Active	-	-	50.23	-119.27	Continuous record	Yes
										08NM062, Swalwell Lake near Okanagan Center			✓		Regulated	1926-1992	Discontinued	-	-	50.04	-119.24		Yes
										Middle Vernon Creek at the Remiche Road Bridge Crossing (Oceola Fish and Game Club)	✓				Regulated	2004-2007	Discontinued	-	-	50.05	-119.41		No
										08NM008, Vernon Creek above diversions	✓				Regulated	1919	Discontinued	-	-	50.02	-119.40		No
										08NM009, Vernon Creek at Inlet to Wood Lake	✓				Regulated	1919-1987	Discontinued	151	-	50.05	-119.41		No
										08NM043, Vernon Creek near Okanagan Centre	✓				Regulated	1919-1963	Discontinued	90.1	-	50.01	-119.34	Seasonal record 1926-1930 and 1960-1963	No
										08NM162, Vernon Creek at inlet to Ellison Lake	✓				Regulated	1969-1974	Discontinued	-	-	50.01	-119.39		No
										08NM175, Vernon Creek Below Arda Dam	✓				Regulated	1972-1979	Discontinued	102	-	50.02	-119.32		No
										08NM182, Vernon Creek at outlet of Ellison Lake	✓				Regulated	1971-1974	Discontinued	-	-	50.02	-119.40		No
										Vernon Creek at Outflow Swalwell/Beaver Lake (Old WSC Location) (Oceola Fish and Game Club)	✓				Regulated	2004-2007	Discontinued	-	-	50.04	-119.26		No
										Vernon Creek downstream from old Hiram Walker Spillway (Oceola Fish and Game Club)	✓				Regulated	2004-2007	Discontinued	-	-	50.01	-119.39		No
										Vernon Creek downstream from DLC Intake (Oceola Fish and game Club)	✓				Regulated	2004-2007	Discontinued	-	-	50.01	-119.38		No
										08NM163, Crooked Lake at the Outlet			✓		Regulated	1970-1981	Discontinued	-	-	50.06	-119.20		No
										08NM067, Ellison Lake Near Winfield			✓		Regulated	1968-1980	Discontinued	-	-	49.98	-119.40		No
										Ellison/Duck Lake (Oceola Fish and Game Club)			✓		Regulated	2004-2007	Discontinued	-	-	50.00	-119.40		No
										08NM183, Kalamlaka Lake at Outlet of Oyama Canal			✓		Regulated	1971-1979	Discontinued	-	-	50.11	-119.38	Seasonal and continuous records	No
										08NM224, Oyama Lake at the Outlet			✓		Regulated	1961-1986	Discontinued	-	-	50.12	-119.28		No
										08NM066, Wood Lake at Inlet to Oyama Canal			✓		Regulated	1928-1973	Discontinued	-	-	50.11	-119.38	Continuous record 1964-1973	No
										08NM028, Oyama Creek Oyama Diversion				✓	Regulated	1920-1931	Discontinued	-	-	50.12	-119.33		No
										08NM236, Vernon Creek diversion to WOCID				✓	Regulated	1973-1978	Discontinued	-	-	50.02	-119.32		No
										08NM044, Vernon Creek Okanagan Centre Diversion				✓	Regulated	1919-1963	Discontinued	-	-	50.01	-119.34		No
3	Deep Creek	217.5	675	342 +/-	1645	50.35	-119.31	14 (83%), 15 (5%), 23 (12%)	2	08NM177, Deep Creek at Young Road	✓				Natural	1970-1975	Discontinued	115	770	50.46	119.18	Continuous record	Yes
										08NM119, Deep Creek at Armstrong	✓				Regulated	1951-1982	Discontinued	135		50.45	-119.20	Continuous record 1974-1982	Yes
										08NM153, Deep Creek at the Mouth	✓				Regulated	1969-1975	Discontinued	306		50.35	-119.29	Continuous record	Yes
										08NM075, Deep Creek near Vernon (Station No. 3)	✓				Regulated	1930-1967	Discontinued	207		50.36	-119.28		No
4	Residual Area W-1	19.0	586	342 +/-	1234	-	-	15	2														
5	Irish Creek	30.6	899	342 +/-	1425	50.35	-119.32	15	2	08NM052, Irish Creek near Vernon	✓				Natural	1922	Discontinued	-	-	50.36	-119.34	Record limited to a single year	No
6	Residual Area W-2	36.2	827	342 +/-	1353	-	-	15	2														
7	Residual Area E-1	38.2	556	342 +/-	837	-	-	15	2														
8	Equesis Creek	203.9	1173	342 +/-	1778	50.28	-119.40	15	3	08NM176, Ewer Creek near the Mouth	✓				Natural	1971-1986	Discontinued	52.8	1470	50.37	-119.50	Continuous record 1972-1986	Yes
										08NM161, Equesis Creek near the Mouth	✓				Regulated	1969-1982	Discontinued	199	-	50.29	-119.41	Continuous record 1977-1982	Yes
										08NM024, Equesis Creek near Vernon	✓				Regulated	1911-1926	Discontinued	179	-	50.31	-119.44		No
9	Residual Area W-3	2.7	394	342 +/-	537	-	-	15	2														
10	Nashwito Creek	86.8	1242	342 +/-	1835	50.27	-119.44	15	3	08NM047, Naswhito Creek near Ewing's Landing	✓				Natural	1912-1921	Discontinued	-	-	50.29	-119.46	-	No
11	Residual Area W-4	17.0	685	342 +/-	1175	-	-	15	2														
13	Residual Area E-2	124.4	550	342 +/-	1066	-	-	15 (90%), 24 (10%)	2	08NM152, Brandts Creek near the Mouth	✓				Regulated	1969-1975	Discontinued	-	-	49.89	-119.49		No
14	Whiteman Creek	204.3	1340	342 +/-	2039	50.23	-119.44	15	3	08NM174, Whiteman's Creek Above Bouleau Creek	✓				Natural	1970-2006	Active	109	1450	50.21	-119.54	Continuous record 1971-2006. Drainage area is based on Obedkoff (1998); WSC reports a drainage area of 112 km^2.	Yes
										08NM046, Whiteman Creek near Vernon	✓				Regulated	1920-1970	Discontinued	197	-	50.23	-119.45	Seasonal record; Median elevation assumed similar to Whiteman Creek at the mouth.	No
										08NM180, Whiteman Creek at the Mouth	✓				Regulated	1970-1972	Discontinued	197	-	50.23	-119.45	Drainage area assumed similar to station 08NM046. Median elevation assumed similar to Whiteman Creek at the mouth	No

Node Characteristics										Hydrometric Stations													
Node	Sub-basin / Residual area description	Drainage Area (km^2)	Median Elevation (m)	Minimum Elevation (m)	Maximum Elevation (m)	Location of node (mouth of stream) Lat.	Long.	Provincial Hydrologic Zones (where sub-basin / residual area falls in more than one zone distribution within each zone in % is indicated)	Hydrologic Group (see text for discussion)	Hydrometric Stations within sub-basin or residual area (operated by Water Survey of Canada unless noted otherwise). Stations in red were used (along with others outside the Okanagan) in developing regional hydrologic relations (see text for discussion)	Streamflow	River flow	Lake or Reservoir Level	Diversion / Canal	Natural (green shade) / Regulated (blue shade)	Years of Record	Station status	Drainage Area (km^2)	Median Elevation (m)	Location of hydrometric station Lat.	Long.	Notes	Potentially useful for hydrology / modeling study (see text for discussion)
15	Residual Area W-5	32.8	744	342 +/-	1587	-	-	15	2														
16	Shorts Creek	184.9	1350	342 +/-	1903	50.13	-119.49	15	4	08NM151, Shorts Creek at the Mouth	✓				Regulated	1969-1982	Discontinued	185	-	50.13	-119.51	Continuous record	Yes
17	Residual Area W-6	56.6	761	342 +/-	1326	-	-	15	2														
18	Lambly Creek	243.3	1281	342 +/-	1893	49.93	-119.51	15 (93%), 24 (7%)	4	08NM139, Esperon Creek near Kelowna	✓				Regulated	1965-1981	Discontinued	13	-	50.07	-119.69	Continuous record 1967-1981	Yes
										08NM003, Lambly Creek near the Mouth	✓				Regulated	1910-1975	Discontinued	272	-	49.93	-119.51	Continuous record 1969-1974	Yes
										08NM141, Lambly Creek below Terrace Creek	✓				Regulated	1967-1971	Discontinued	-	-	49.98	-119.57	Continuous record	Yes
										08NM165, Lambly Creek above Terrace Creek	✓				Regulated	1970-1998	Discontinued	76.1	1390	49.99	-119.61	Continuous record	Yes
										08NM166, Lambly Creek Below Bald Range Creek	✓				Regulated	1970-1982	Discontinued	229		49.96	-119.56	Continuous record	Yes
										08NM138, Terrace Creek near Kelowna	✓				Regulated	1965-1992	Discontinued	31.3	1490	50.07	-119.67	Continuous record 1967-1992	Yes
										08NM058, Lambly Creek near Kelowna	✓				Natural	1910-1927	Discontinued	-	-	49.96	-119.55	Continuous record	No
										North Lambly Creek below Tadpole Reservoir (Dobson)	✓				Regulated	2007	Active	-	-	50.04	-119.76		No
										Esperon Reservoir at the Outlet (Dobson)			✓		Regulated	2007	Active	-	-	50.08	-119.75		No
										Bighorn Reservoir at the Spillway (Dobson)			✓		Regulated	2007	Active	-	-	50.07	-119.67		No
19	Residual Area W-7	37.0	605	342 +/-	1409	-	-	15 (1%), 24 (99%)	5	08NM167, Lambly Creek Diversion to Rose Valley Lake				✓	Regulated	1970-1978	Discontinued	-	-	49.91	-119.56		No
										Lambly Creek Diversion to Rose Valley Lake (Dobson)_				✓	Regulated	2001-2007	Active	-	-	49.75	-119.56		No
20	Mill (Kelowna) Creek	222.8	983	342 +/-	1666	49.88	-119.50	15 (84%), 23 (7%), 24 (9%)	7	08NM036, Scotty Creek near Rutland	✓				Natural	1911-1964	Discontinued	35	1165	49.93	119.37	Seasonal record	Yes
										08NM145, Bulman Creek at the Mouth	✓				Regulated	1968-2004	Discontinued	12.7		50.00	-119.25	Continuous record	Yes
										08NM053, Kelowna Creek near Kelowna - Lower Station	✓				Regulated	1922-1998	Discontinued	221	1013	49.90	119.42	Continuous record 1922-1998	Yes
										08NM117, Kelowna Creek at Rutland Station	✓				Regulated	1950-1975	Discontinued	162	-	49.92	-119.39	Continuous record 1970-1975	Yes
										08NM026, Kelowna Creek near Rutland (Upper station)	✓				Regulated	1911-1922	Discontinued	-	-	49.99	-119.35		No
										08NM061, Kelowna Creek near Rutland	✓				Regulated	1924-1931	Discontinued	77.7	-	49.98	-119.35		No
										Mill Creek downstream of GEID Intake (Dobson)	✓				Regulated	2005-2007	Active	-	-	49.98	-119.35		No
										08NM234, Moore Lake Reservoir at the Dam			✓		Regulated	1973-1986	Discontinued	-	-	50.03	-119.22		No
										Mill Creek / Postill Reservoir Sluiceway (Dobson)			✓		Regulated	2005-2007	Active	-	-	50.00	-119.21		No
										Postill Reservoir at the Outlet (Dobson)			✓		Regulated	2005-2007	Active	-	-	50.00	-119.21		No
										James Reservoir at the Outlet (Dobson)			✓		Regulated	2007	Active	-	-	49.95	-119.25		No
21	Residual Area E-3	10.4	357	342 +/-	373	-	-	24	6														
22	Mission Creek	844.7	1345	342 +/-	2170	49.84	-119.49	15 (5%), 23 (76%), 24 (19%)	8	08NM137, Daves Creek near Rutland	✓				Natural	1965-1986	Discontinued	31.1	1290	49.87	-119.27	Continuous record 1967-1986	Yes
										08NM172, Pearson Creek near the Mouth	✓				Natural	1970-1987	Discontinued	73.6	1560	49.89	-119.06	Continuous record	Yes
										08NM225, Belgo Creek near the Mouth	✓				Regulated	1976-1982	Discontinued	190	-	49.87	-119.15	Continuous record	Yes
										08NM232, Belgo Creek Below Hilda Creek	✓				Regulated	1976-2007	Active	70.7	1430	50.00	119.07	Continuous record 1978-2007	Yes
										08NM011, Hydraulic Creek at Outlet of McCulloch Reservoir	✓				Regulated	1919-1986	Discontinued	-	-	49.78	-119.18	Continuous record 1976-1980 an 1984-1986	Yes
										08NM116, Mission Creek near East Kelowna	✓				Regulated	1946-2007	Active	811	1340	49.88	-119.41	Continuous record 1967-2007	Yes
										Mission Creek below BMID Intake (Dobson)	✓				Regulated	2004-2007	Active	-	-	49.85	-119.28		Yes
										Mission Creek upstream of Gordon Drive (MOE)	✓				Regulated	2006-2007	Active	-	-	49.84	-119.48		Yes
										Mission Creek upstream of E. Kelowna Rd. (MOE)	✓				Regulated	2007	Active	-	-	49.86	-119.39		Yes
										Stirling Creek Diversion to McCulloch Reservoir - Old WSC Location (Dobson)				✓	Regulated	2004-2007	Active	-	-	49.73	-119.22		Yes
										08NM018, Hilda Creek near Rutland	✓				Natural	1920	Discontinued	-	-	50.00	-119.07	Record limited to a single year	No
										08NM004, KLO Creek near Kelowna	✓				Natural	1919-1922	Discontinued	-	-	49.82	-119.36	Continuous record	No
										08NM210, Pooley Creek Above Pooley Ditch	✓				Natural	1973-1979	Discontinued	18.1	-	49.75	-119.34	Seasonal record	No
										Pooley Creek Above Pooley Ditch (Old WSC Location) (Dobson)	✓				Natural	2004-2007	Active	-	-	49.75	-119.34		No
										08NM017, Belgo Creek near Rutland	✓				Regulated	1920-1921	Discontinued	-	-	50.00	-119.08		No
										08NM010, Hydraulic Creek near the Mouth	✓				Regulated	1919-1982	Discontinued	89.6	-	49.84	-119.33	Continuous record 1976-1982	No
										Hydraulic Creek above Sterling Ditch (Dobson)	✓					2004-2007	Active		-	49.75	-119.22		No
										08NM129, Joe Rich Creek near Rutland	✓				Regulated	1964-1987	Discontinued	44.8	-	49.86	-119.13	Continuous record	No
										08NM226, KLO Creek at McCulloch Road	✓				Regulated	1976-1982	Discontinued		-	49.82	-119.36	Continuous record	No
										08NM229, Loch Katrine Creek at the Outlet of Graystoke Lake	✓				Regulated	1977-1998	Discontinued	16.1	-	49.98	-118.87	Continuous record	No
										08NM016, Mission Creek near Rutland	✓				Regulated	1919-1946	Discontinued	622	-	49.85	-119.34		No
										08NM233, Mission Creek Above Pearson Creek	✓				Regulated	1977-1982	Discontinued	233	-	49.89	-119.06		No
										08NM239, Mission Creek below BMID intake	✓				Regulated	1980	Discontinued	-	-	49.85	-119.28		No
										Pearson Creek at WSC (MOE)	✓				Regulated	2006-2007	Active	-	-	49.89	-119.06		No
										08NM216, Browne Lake Reservoir above the Dam			✓		Regulated	1973-1977	Discontinued	-	-	49.82	-119.19		No
										08NM215, Fish Lake at the Outlet			✓		Regulated	1973-1977	Discontinued	-	-	49.80	-119.19		No
										Fishhawk Reservoir at the Outlet (Dobson)			✓		Regulated	2007	Active	-	-	50.03	-118.86		No
										08NM230, Graystoke Lake at the Outlet			✓		Regulated	1977-1998	Discontinued	-	-	49.98	-118.87	Seasonal record	No
										Graystoke Reservoir at the Outlet (Dobson)			✓		Regulated	2007	Active	-	-	49.99	-118.87		No
										08NM231, Ideal Lake near the Outlet			✓		Regulated	1963-1980	Discontinued	-	-	50.01	-119.10		No
										Ideal Reservoir at the Outlet (Dobson)			✓		Regulated	2007	Active	-	-	50.01	-119.10		No
										08NM213, McCulloch Reservoir at McCulloch Dam			✓		Regulated	1973-1986	Discontinued	-	-	49.78	-119.18		No
										Loch Long Reservoir at the Outlet (Dobson)			✓		Regulated	2007	Active	-	-	49.97	-118.90		No
										08NM217, Long Meadow Lake Reservoir above the Dam			✓		Regulated	1973-1977	Discontinued	-	-	49.81	-119.17		No
										08NM019, BMID diversion near Kelowna				✓	Regulated	1920-1930	Discontinued	-	-	49.86	-119.30		No
										Canyon Creek Diversion to McCulloch Reservoir (Dobson)				✓	Regulated	2004-2007	Active	-	-	49.74	-119.27		No

Node Characteristics										Hydrometric Stations													
Node	Sub-basin / Residual area description	Drainage Area (km²)	Median Elevation (m)	Minimum Elevation (m)	Maximum Elevation (m)	Location of node (mouth of stream) Lat.	Long.	Provincial Hydrologic Zones (where sub-basin / residual area falls in more than one zone distribution within each zone in % is indicated)	Hydrologic Group (see text for discussion)	Hydrometric Stations within sub-basin or residual area (operated by Water Survey of Canada unless noted otherwise). Stations in red were used (along with others outside the Okanagan) in developing regional hydrologic relations (see text for discussion)	Streamflow	River flow	Lake or Reservoir Level	Diversion / Canal	Natural (green shade) / Regulated (blue shade)	Years of Record	Station status	Drainage Area (km²)	Median Elevation (m)	Location of hydrometric station Lat.	Long.	Notes	Potentially useful for hydrology / modeling study (see text for discussion)
										08NM039, Hydraulic Creek Diversion near Kelowna				✓	Regulated	1919-1968	Discontinued	-	-	49.83	-119.35		No
										08NM040, Hydraulic Creek Southeast Kelowna Diversion				✓	Regulated	1920-1930	Discontinued	-	-	49.83	-119.37		No
										08NM205, Hydraulic Creek diversion to SEKID				✓	Regulated	1976-1980	Discontinued	-	-	49.84	-119.34		No
										08NM060, KLO Diversion near Kelowna				✓	Regulated	1922-1968	Discontinued	-	-	49.84	-119.37		No
										08NM057, Mission Creek Rutland Diversion				✓	Regulated	1922-1930	Discontinued	-	-	49.88	-119.39		No
										08NM207, Myra Ditch Below KLO Creek				✓	Regulated	1973-1985	Discontinued	-	-	49.75	-119.27		No
										Myra Ditch below KLO Creek - Old WSC Location (Dobson)				✓	Regulated	-	-	-	-	49.75	-119.27		No
23	Residual Area E-4	6.9	446	342 +/-	739	-	-	24	6														
24	Bellevue Creek	92.9	1384	342 +/-	2166	49.82	-119.51	24	6	**08NM035, Bellevue Creek near Okanagan Mission**	✓				**Natural**	**1911-1986**	**Discontinued**	**73.3**	**1540**	**49.79**	**-119.46**	**Continuous record 1969-1986**	**Yes**
										08NM156, Bellevue Creek at the Mouth	✓				**Regulated**	**1969-1972**	**Discontinued**	**-**	**-**	**49.82**	**-119.49**	**Continuous record**	**Yes**
25	Residual Area E-5	155.3	888	342 +/-	1609	-	-	24	6														
26	McDougall Creek	53.0	1071	342 +/-	1563	49.82	-119.60	15 (11%), 24 (89%)	5	08NM014, McDougall Creek near Westbank	✓				Regulated	1920-1929	Discontinued	-	-	49.88	-119.59		No
27	Residual Area W-8	25.1	711	342 +/-	1456	-	-	24	5	08NM198, Westbank Creek at the Mouth	✓				Regulated	1972-1975	Discontinued	-	-	49.82	-119.62		No
28	Powers Creek	144.6	1242	342 +/-	1868	49.82	-119.62	15 (1%), 24 (99%)	4	**08NM033, Powers Creek Above Westbank Diversion**	✓				**Natural**	**1920-1974**	**Discontinued**	**128**	**1317**	**49.86**	**119.67**	**Seasonal record 1965-1974**	**Yes**
										Powers Creek at Bear Main (Dobson)	✓				**Natural**	**2007**	**Active**	**-**	**-**	**49.95**	**-119.75**		**Yes**
										Powers Creek upstream of Jackpine Creek (Dobson)	✓				**Natural**	**2007**	**Active**	**-**	**-**	**49.94**	**-119.73**		**Yes**
										08NM157, Powers Creek at the Mouth	✓				**Regulated**	**1969-1982**	**Discontinued**	**144**	**-**	**49.81**	**-119.63**	**Continuous record**	**Yes**
										Powers Creek at Gellatly Rd (MOE)	✓				**Regulated**	**2004-2006**	**Active**		**-**	**49.81**	**-119.63**		**Yes**
										08NM034, Powers Creek Westbank Diversion	✓				Regulated	1919-1931	Discontinued	-	-	49.85	-119.67	Seasonal record 1920-1931	No
										08NM059, Powers Creek Below Westbank Diversion	✓				Regulated	1912-1987	Discontinued	139	-	49.84	-119.65	Continuous record	No
										08NM136, Lambly Lake Diversion to Powers Creek				✓	Regulated	1965-1972	Discontinued	-	-	49.95	-119.71		No
29	Residual Area W-9	13.5	616	342 +/-	1012	-	-	24	5														
30	Trepanier Creek	257.9	1228	342 +/-	1911	49.78	-119.71	24	5	**08NM041, Trepanier Creek near Peachland**	✓				**Regulated**	**1919-2006**	**Active**	**179**	**1267**	**49.83**	**119.79**	**Continuous record 1973-1979 and 1983-2006**	**Yes**
										08NM155, Trepanier Creek at the Mouth	✓				**Regulated**	**1969-1981**	**Discontinued**	**254**	**-**	**49.79**	**-119.71**	**Continuous record**	**Yes**
										Trepanier Creek at Hwy 97 (MOE)	✓				**Regulated**	**2006-2007**	**Active**	**-**	**-**	**49.78**	**-119.71**		**Yes**
										Trepanier Creek downstream of Hwy 97C (MOE)	✓				**Regulated**	**2006-2007**	**Active**	**-**	**-**	**49.81**	**-119.74**		**Yes**
										Trepanier Creek upstream of Hwy 97C (MOE)	✓				**Regulated**	**2006-2008**	**Active**	**-**	**-**	**49.81**	**-119.75**		**Yes**
										08NM013, Jack Creek at the Mouth	✓				Regulated	1919	Discontinued	-	-	49.82	-119.75		No
31	Residual Area W-10	16.3	676	342 +/-	1072	-	-	24	5														
32	Peachland Creek	144.9	1209	342 +/-	1837	49.74	-119.76	24	5	**08NM173, Greata Creek near the Mouth**	✓				**Natural**	**1970-2006**	**Active**	**41**	**1280**	**49.79**	**-119.85**	**Continuous record**	**Yes**
										08NM159, Peachland Creek at the Mouth	✓				**Regulated**	**1969-1982**	**Discontinued**	**150**	**-**	**49.74**	**-119.76**	**Continuous record**	**Yes**
										08NM140, Peachland Creek Above Diversions	✓				**Regulated**	**1966-1982**	**Discontinued**	**122**	**-**	**49.75**	**-119.80**	**Continuous record 1973-1982**	**Yes**
										08NM029, Peachland Creek near Peachland	✓				Regulated	1919-1922	Discontinued	-	-	49.76	-119.81		No
										08NM201, Peachland Creek below diversion to Peachland Lake Reservoir	✓				Regulated	1973	Discontinued	-	-	49.84	-119.97		No
										08NM202, Peachland Lake Reservoir Outflow	✓				Regulated	1973-1982	Discontinued	80.3	-	49.83	-119.96		No
										08NM220, Peachland Lake near Peachland			✓		Regulated	1973-1984	Discontinued	-	-	49.83	-119.97		No
										08NM218, McDonald Creek Diversion to Peachland Creek				✓	Regulated	1973-1979	Discontinued	-	-	49.87	-119.99		No
										08NM030, Peachland Creek Municipal Irrigation Diversion				✓	Regulated	1919-1926	Discontinued	-	-	49.76	-119.82		No
										08NM219, Peachland Creek Diversion to Peachland Lake				✓	Regulated	1973-1979	Discontinued	-	-	49.84	-119.97		No
33	Residual Area W-11	23.0	590	342 +/-	1098	-	-	24	9														
34	Chute Creek	79.3	1354	342 +/-	2035	49.65	-119.63	24	6	08NM007, Chute Creek near Naramata	✓				Natural	1920-1922	Discontinued	-	-	49.68	-119.53		No
35	Residual Area E-6	19.3	814	342 +/-	1466	-	-	24	6														
36	Eneas Creek	91.4	935	342 +/-	1764	49.61	-119.65	24	9	**08NM228, Eneas Creek near Summerland**	✓				**Regulated**	**1974-1975**	**Discontinued**	**-**	**-**	**49.68**	**-119.77**	**Continuous record**	**Yes**
										08NM227, Garnet Lake near Summerland			✓		Regulated	1973-1981	Discontinued	-	-	49.69	-119.77		No
37	Residual Area W-12	26.4	628	342 +/-	1134	-	-	24	9														
38	Robinson Creek	20.0	1220	342 +/-	1694	49.61	-119.60	24	6														
39	Residual Area E-7	2.3	513	342 +/-	757	-	-	24	6														
40	Naramata Creek	41.1	1330	342 +/-	1906	49.60	-119.60	24	6														
41	Residual Area E-8	13.1	736	342 +/-	1238	-	-	24	6														
42	Trout Creek	768.3	1330	342 +/-	2019	49.56	-119.62	24	9	**08NM133, Bull Creek near Crump**	✓				**Natural**	**1965-1986**	**Discontinued**	**46.9**	**1530**	**49.62**	**-119.90**	**Continuous record 1969-1986**	**Yes**
										08NM134, Camp Creek at Mouth near Thirsk	✓				**Natural**	**1965-2007**	**Active**	**34**	**1450**	**49.72**	**-120.02**	**Continuous record**	**Yes**
										08NM158, Trout Creek at the Mouth	✓				**Regulated**	**1969-1982**	**Discontinued**	**764**	**-**	**-**	**-119.63**	**Continuous record**	**Yes**
										Trout Creek at Canyon Mouth - Old WSC Location (MOE)	✓				**Regulated**	**2004-2007**	**Active**	**-**	**-**	**49.57**	**-119.65**		**Yes**
										08NM023, Darke Creek northwest fork	✓				Natural	1921-1922	Discontinued	-	-	49.71	-119.87	Seasonal record	No
										08NM025, Darke Creek at Meadow Valley	✓				Regulated	1921-1922	Discontinued		-	49.67	-119.81		No
										08NM054, Trout Creek near Faulder	✓				Regulated	1921-1954	Discontinued	704	-	49.59	-119.75	Seasonal record	No
										08NM237, Trout Creek below Thirsk Lake	✓				Regulated	1936-1978	Discontinued	-	-	49.71	-120.05	-	No
										08NM042, Trout Creek near Summerland	✓				Regulated	1920-1928	Discontinued	-	-	49.57	-119.65		No
										08NM238, Thirsk Lake near the Outlet			✓		Regulated	1979-1987	Discontinued	-	-	49.73	-120.09		No
										08NM055, Trout Creek Summerland Diversion				✓	Regulated	1922-1931	Discontinued	-	-	49.60	-119.76	Seasonal record	No
43	Residual Area W-13	27.5	717	342 +/-	1384	-	-	24	9														
44	Turnbull Creek	22.3	1282	342 +/-	1864	49.56	-119.58	24	6														
45	Residual Area E-9	22.2	725	342 +/-	1484	-	-	24	6														

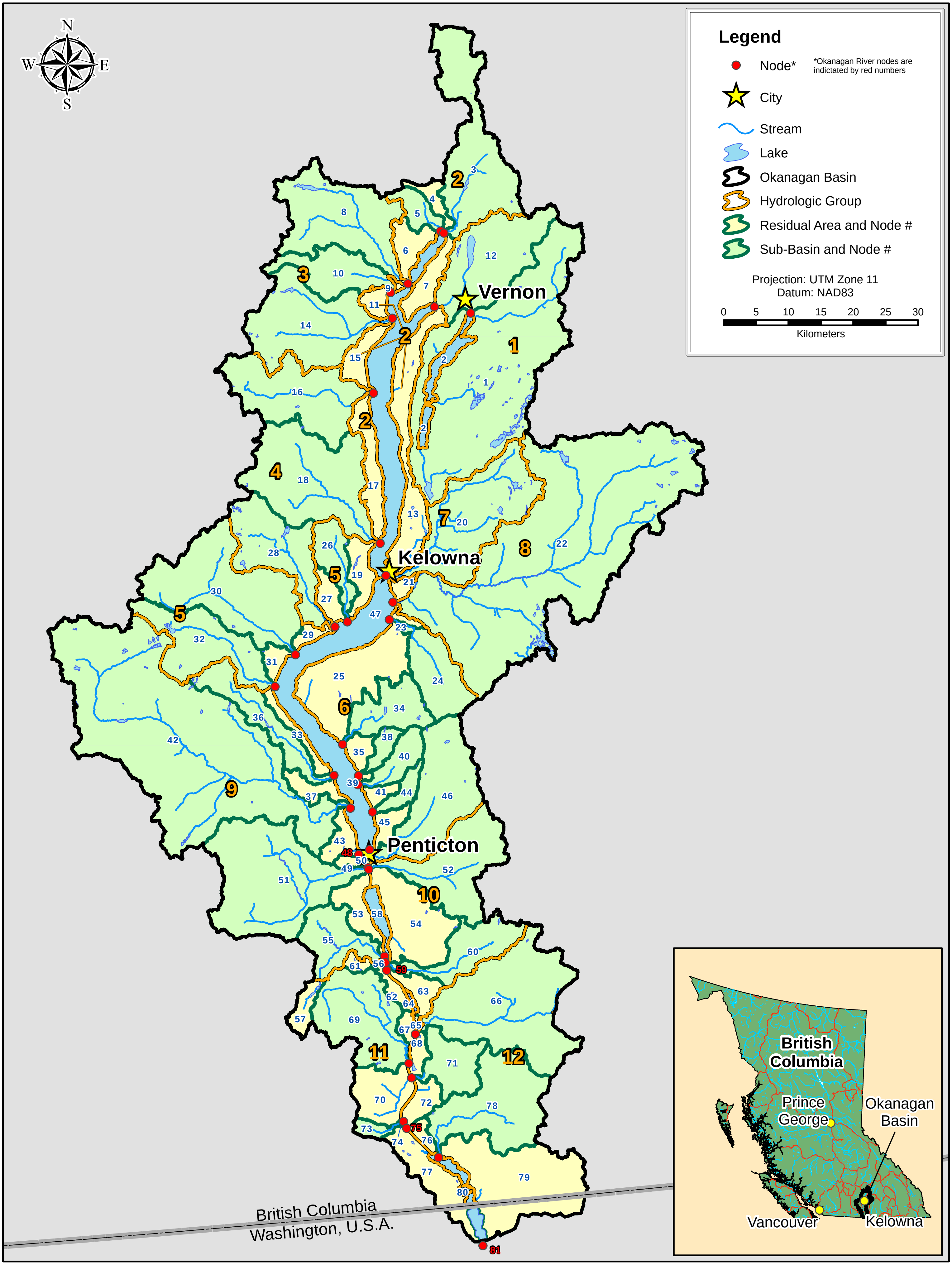
Node Characteristics										Hydrometric Stations													
Node	Sub-basin / Residual area description	Drainage Area (km^2)	Median Elevation (m)	Minimum Elevation (m)	Maximum Elevation (m)	Location of node (mouth of stream) Lat.	Long.	Provincial Hydrologic Zones (where sub-basin / residual area falls in more than one zone distribution within each zone in % is indicated)	Hydrologic Group (see text for discussion)	Hydrometric Stations within sub-basin or residual area (operated by Water Survey of Canada unless noted otherwise). Stations in red were used (along with others outside the Okanagan) in developing regional hydrologic relations (see text for discussion)	Streamflow	River flow	Lake or Reservoir Level	Diversion / Canal	Natural (green shade) / Regulated (blue shade)	Years of Record	Station status	Drainage Area (km^2)	Median Elevation (m)	Location of hydrometric station Lat.	Long.	Notes	Potentially useful for hydrology / modeling study (see text for discussion)
46	Penticton Creek	181.7	1492	342 +/-	2144	49.50	-119.59	24	6	**08NM240, Two-Forty Creek near Penticton**	✓				**Natural**	**1983-2006**	**Active**	**5.0**	**1769**	**49.65**	**119.40**	**Continuous record, established for the Upper Penticton Experimental Watershed (MOF)**	**Yes**
										08NM241, Two-Forty-One Creek near Penticton	✓				**Natural**	**1983-2006**	**Active**	**5.0**	**1768**	**49.65**	**119.39**	**Continuous record, established for the Upper Penticton Experimental Watershed (MOF)**	**Yes**
										08NM242, Dennis Creek near 1780 metre Contour	✓				**Natural**	**1985-2006**	**Active**	**3.7**	**1893**	**49.62**	**119.38**	**Continuous record, established for the Upper Penticton Experimental Watershed (MOF)**	**Yes**
										08NM118, Penticton Creek at the Mouth	✓				**Regulated**	**1950-1972**	**Discontinued**	**177**	**-**	**49.50**	**-119.58**	**Seasonal and continuous records**	**Yes**
										08NM168, Penticton Creek Above Dennis Creek	✓				**Regulated**	**1970-1999**	**Discontinued**	**35.5**	**-**	**49.62**	**-119.42**	**Continuous record**	**Yes**
										08NM170, Penticton Creek Below Harris Creek	✓				**Regulated**	**1970-1981**	**Discontinued**	**153**	**-**	**49.52**	**-119.52**	**Continuous record**	**Yes**
										Penticton Creek at Van Horne (Dobson)	✓				**Regulated**	**2007**	**Active**	**-**	**-**	**49.50**	**-119.59**		**Yes**
										08NM076, Penticton Creek Above Diversion	✓				Natural	1910-1941	Discontinued	-	-	49.49	-119.55	Seasonal record 1936-1941	No
										08NM031, Penticton Creek Below Diversion	✓				Regulated	1919-1921	Discontinued	-	-	49.49	-119.56		No
										08NM068, Nickel Plate Reservoir Outflow	✓				Regulated	1975-1976	Discontinued	-	-	49.61	-119.35		No
										08NM069, Read Creek near Penticton	✓				Regulated	1911-1930	Discontinued	-	-	49.59	-119.38		No
										08NM169, Greyback Lake at the Outlet			✓		Regulated	1970-1987	Discontinued	-	-	49.63	-119.42		No
										08NM032, Penticton Creek Main Diversion				✓	Regulated	1919-1966	Discontinued	-	-	49.49	-119.56	Seasonal record	No
										08NM063, Penticton Creek Lot 19 Diversion				✓	Regulated	1926-1954	Discontinued	-	-	49.51	-119.56	Seasonal record	No
47	Okanagan Lake	Drainage area above Okanagan Lake= 5610.4 km^2. Drainage area above outlet of Okanagan Lake = 5960.3 km^2	Median elevation of drainage area above lake = 1,215 m. Median elevation above the outlet of Okanagan Lake= 1,174 m	Lake elevation = 342 +/-	Maximum elevation of drainage above Okanagan Lake = 2,170 m	49.50	-119.61	Drainage area above station falls within zones: 14 (3%), 15 (34%), 23 (18%) , 24 (45%)	n/a	**08NM083, Okanagan Lake at Kelowna**			✓		**Regulated**	**1943-2006**	**Active**	**Drainage area above Okanagan Lake= 5610.4 km^2. Drainage area above outlet of Okanagan Lake = 5960.3 km^2**	**Median elevation of drainage area above lake = 1,215 m. Median elevation above the outlet of Okanagan Lake= 1,174 m**	**49.89**	**-119.50**	**Continuous record**	**Yes**
										08NM071, Okanagan Lake at Penticton			✓		**Regulated**	**1920-1974**	**Discontinued**			**49.50**	**-119.61**	**Continuous record**	**Yes**
48	Okanagan River at Penticton	5962.4 km^2; (drainage area reported by WSC is 6090 km^2)	Median elevation of drainage area above station = 1,174 m	337	2170	49.50	-119.62	Drainage area above station falls within zones: 14 (3%), 15 (35%), 23 (17%) , 24 (45%)	n/a	**08NM050, Okanagan River at Penticton**		✓			**Regulated**	**1910-2006**	**Active**	**5962.4 km^2; (drainage area reported by WSC = 6090 km^2)**	**Median elevation of drainage area above station = 1,174 m**	**49.50**	**-119.62**	**Continuous record 1921-2006**	Yes
49	Residual Area W-14	7.3	527	339	1021	-	-	24	9														
50	Residual Area E-10	3.1	355	339	370	-	-	24	6														
51	Shingle Creek	281.4	1273	339	2200	49.48	-119.60	24	9	**08NM038, Shingle Creek Above Kaleden Diversion**	✓				**Natural**	**1920-1977**	**Discontinued**	**44.8**	**1537**	**49.51**	**119.80**	**Seasonal record**	**Yes**
										08NM037, Shatford Creek near Penticton	✓				**Regulated**	**1911-2007**	**Active**	**101**	**1530**	**49.42**	**-119.79**	**Continuous record 1966-2007**	**Yes**
										08NM150, Shingle Creek at the Mouth	✓				**Regulated**	**1969-1982**	**Discontinued**	**308**	**-**	**49.48**	**-119.60**	**Continuous record 1969-1979**	**Yes**
										08NM070, Riddle Creek near West Summerland	✓				Natural	1930-1931	Discontinued	-	-	49.51	-119.79	Continuous record	No
52	Ellis Creek	160.6	1428	339	2019	49.48	-119.60	23 (6%), 24 (94%)	10	**08NM135, Ellis Creek at Penticton**	✓				**Regulated**	**1965-1979**	**Discontinued**	**-**	**-**	**49.48**	**-119.59**	**Continuous record**	**Yes**
										Ellis Creek near the Mouth (Dobson)	✓				**Regulated**	**2007**	**Active**	**-**	**-**	**49.48**	**-119.60**		**Yes**
										Ellis Creek at Atkinson St. (MOE)	✓				**Regulated**	**2006-2007**	**Active**	**-**	**-**	**49.48**	**-119.59**		**Yes**
										08NM074, Ellis Creek near Penticton	✓				Natural	1933-1955	Discontinued	-	-	49.47	-119.39		No
										08NM056, Ellis Creek South Main Diversion				✓	Regulated	1910-1966	Discontinued	-	-	49.48	-119.56		No
										08NM122, Ellis Creek North Main Diversion				✓	Regulated	1955-1957	Discontinued	-	-	49.48	-119.56		No
53	Residual Area W-15	40.9	715	337 +/-	1418	-	-	24	9														
54	Residual Area E-11	122.1	1019	337 +/-	1949	-	-	24	10	08NM005, McLean Creek near Okanagan Falls	✓				Natural	1921-1926	Discontinued	20.7	-	49.35	-119.52	Seasonal record	No
55	Marron River	82.4	877	337 +/-	1574	49.36	-119.58	24	9	08NM049, Horn Creek near Kaleden	✓				Regulated	1920	Discontinued	-	-	49.40	-119.65		No
56	Residual Area W-16	0.8	451	337 +/-	624	-	-	24	11														
57	Residual Area W-17	23.8	1200	793	1623	-	-	24	11														

Node Characteristics										Hydrometric Stations													
Node	Sub-basin / Residual area description	Drainage Area (km^2)	Median Elevation (m)	Minimum Elevation (m)	Maximum Elevation (m)	Location of node (mouth of stream)		Provincial Hydrologic Zones (where sub-basin / residual area falls in more than one zone distribution within each zone in % is indicated)	Hydrologic Group (see text for discussion)	Hydrometric Stations within sub-basin or residual area (operated by Water Survey of Canada unless noted otherwise). Stations in red were used (along with others outside the Okanagan) in developing regional hydrologic relations (see text for discussion)	Streamflow	River flow	Lake or Reservoir Level	Diversion / Canal	Natural (green shade) / Regulated (blue shade)	Years of Record	Station status	Drainage Area (km^2)	Median Elevation (m)	Location of hydrometric station		Notes	Potentially useful for hydrology / modeling study (see text for discussion)
						Lat.	Long.													Lat.	Long.		
58	Skaha Lake	Drainage area above Skaha Lake= 6659 km^2. Drainage area above outlet of Skaha Lake = 6678.7 km^2	Median elevation of drainage area above Skaha lake = 1177 m. Median elevation above Skaha lake at the mouth = 1175m	337 +/-	Maximum elevation of drainage area above lake =2199m	49.35	-119.58	Drainage area above lake falls within zones: 14 (3%), 15 (31%), 23 (15%), 24 (51%)	n/a	**08NM084, Skaha Lake at Okanagan Falls**			✓		**Regulated**	**1943-2006**	**Active**	**-**	**-**	**49.43**	**-119.57**	**Continuous record**	**Yes**
59	Okanagan River at Okanagan Falls	6,860	Median elevation of drainage area above station = 1175 m	337	2199	49.34	-119.58	Drainage area above station falls within zones: 14 (3%), 15 (31%), 23 (15%), 24 (51%)	n/a	**08NM002, Okanagan River at Okanagan Falls**		✓			**Regulated**	**1915-2006**	**Active**	**6860**	**-**	**49.34**	**-119.58**	**Continuous record**	**Yes**
60	Shuttleworth Creek	89.5	1379	334	1885	49.34	-119.58	24	n/a	**08NM149, Shuttleworth Creek at the Mouth**	✓				**Regulated**	**1969-1971, 2006**	**Active**	**89.5**	**1379**	**49.34**	**119.58**	**Continuous record; drainage area determined by GIS**	**Yes**
										08NM006, Shuttleworth Creek near Okanagan Falls	✓				Regulated	1921-1964	Discontinued	85.2	-	49.33	-119.52	Seasonal record	No
61	Residual Area W-18	9.3	778	558	1372	-	-	24	11	08NM147, Horn Creek near Olalla	✓				Natural	1968-1977	Discontinued	15	-	-	-119.75	Seasonal record	No
										08NM148, Twin Lakes near Olalla			✓		Regulated	1968-1977	Discontinued	-	-	49.32	-119.73		No
62	Residual Area W-19	15.5	587	324	946	-	-	24	11														
63	Residual Area E-12	27.9	640	324	1362	-	-	24	10														
64	Vaseux Lake	Drainage area above Vaseux Lake= 6821.0 km^2. Drainage area above outlet of Vaseux Lake = 6823.9 km^2	Median elevation of drainage area above Vaseux Lake = 1175 m; Median elevation of drainage area above outlet of Vaseux Lake = 1175m	324	2199	49.27	-119.53	Drainage area above lake falls within zones: 14 (3%), 15 (30%), 23 (15%), 24 (52%)	n/a	**08NM243, Vaseux Lake near the Outlet**			✓		**Regulated**	**1991-2006**	**Active**	**-**	**-**	**49.27**	**-119.52**	**Continuous record**	**Yes**
65	Residual Area E-13	2.3	345	316	373			24	10	08NM114, Oliver Canal near Oliver				✓	Regulated	1934-1972	Discontinued	-	-	49.25	-119.53		No
66	Vaseux Creek	295.6	1535	317	2301	49.24	-119.53	23 (10%), 24 (90%)	12	**08NM171, Vaseux Creek Above Solco Creek**	✓				**Natural**	**1970-2006**	**Active**	**117**	**1680**	**49.25**	**-119.32**	**Continuous record 1964-1982**	**Yes**
										08NM246, Vaseux Creek near the Mouth	✓				**Natural**	**2006-2007**	**Active**	**295.5**	**1535**	**49.25**	**119.53**	**Continuous record, short period**	**Yes**
										08NM015, Vaseux Creek Above Dutton Creek	✓				**Natural**	**1919-1982**	**Discontinued**	**255**	**1591**	**49.26**	**119.47**		**Yes**
67	Residual Area W-20	11.5	496	297	914			24	11														
68	Residual Area E-14	15.8	403	294	852			24	12														
69	Park Rill	158.6	841	297	1595	49.20	-119.55	24	11	**08NM120, Park Rill near Oliver**	✓				**Regulated**	**1951-1970**	**Discontinued**	**160**	**-**	**49.24**	**-119.57**	**Seasonal record**	**Yes**
70	Residual Area W-21	70.3	725	284	1853	-	-	24	11	08NM199, Unnamed Ditch above Packing House Outfalls in Oliver				✓	Regulated	1972-1973	Discontinued	-	-	49.18	-119.55		No
										08NM178, Unnamed Ditch at Oliver				✓	Regulated	1970-1972	Discontinued	-	-	49.18	-119.55		No
71	Wolfcub Creek	71.2	979	297	1721	49.18	-119.55	24	12	08NM121, Wolfcub Creek near Oliver	✓				Regulated	1952	Discontinued	-	-	49.18	-119.53		No
72	Residual Area E-15	28.7	453	279	952			24	12														
73	Testalinden Creek	13.6	1195	285	1857	49.13	-119.57	24	11	**08NM164, Testalinden Creek in Canyon**	✓				**Natural**	**1969-1986**	**Discontinued**	**13**	**1270**	**49.12**	**-119.60**	**Continuous record 1969-1979, Seasonal 1980-1986**	**Yes**
										08NM130, Testalinden Creek near Oliver	✓				Regulated	1965-1968	Discontinued			49.12	-119.59	Continuous record	Yes
74	Residual Area W-22	0.37	291	282	371	-	-	24	11														
75	Okanagan River near Oliver	7,590.0	Median elevation of drainage area above station =1180 m	291	2296	49.16	-119.55	Drainage area above station falls within zones: 14 (2%), 15 (28%), 23 (14%), 24 (56%)	n/a	**08NM085, Okanagan River at Oliver**		✓			**Regulated**	**1944-2006**	**Active**	**7590**	**-**	**49.11**	**-119.57**	**Continuous record 1953-2006**	**Yes**
										08NM197, Okanagan River below the S.O.L.I.D Canal		✓			Regulated	1972	Discontinued	-	-	49.26	-119.53		No
										08NM001, Okanagan River near Fairview		✓			Natural	1914	Discontinued	-	-	49.14	-119.58	Record limited to a single year	No
76	Residual Area E-16	12.2	354	276	782	-	-	24	12														
77	Residual Area W-23	62.4	516	271	1206	-	-	24	11														

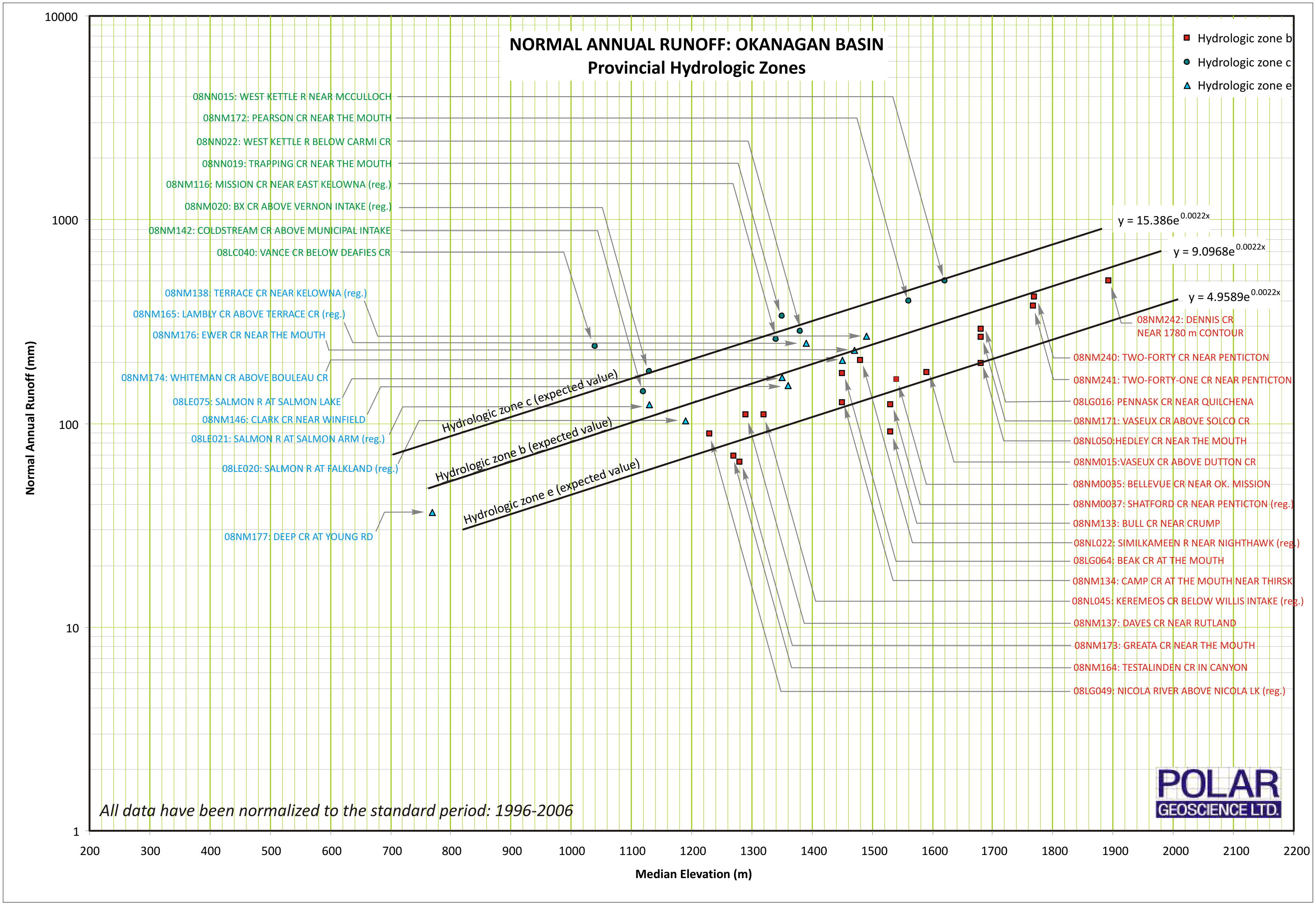
Node Characteristics										Hydrometric Stations													
Node	**Sub-basin / Residual area description**	**Drainage Area (km²)**	**Median Elevation (m)**	**Minimum Elevation (m)**	**Maximum Elevation (m)**	**Location of node** (mouth of stream)		**Provincial Hydrologic Zones** (where sub-basin / residual area falls in more than one zone distribution within each zone in % is indicated)	**Hydrologic Group** (see text for discussion)	**Hydrometric Stations within sub-basin or residual area** (operated by Water Survey of Canada unless noted otherwise). Stations in **red** were used (along with others outside the Okanagan) in developing regional hydrologic relations (see text for discussion)	**Streamflow**	**River flow**	**Lake or Reservoir Level**	**Diversion / Canal**	**Natural** (green shade) / **Regulated** (blue shade)	**Years of Record**	**Station status**	**Drainage Area (km²)**	**Median Elevation (m)**	**Location of hydrometric station**		**Notes**	**Potentially useful for hydrology / modeling study** (see text for discussion)
						Lat.	**Long.**													**Lat.**	**Long.**		
78	Inkaneep Creek	184.8	1227	276	2312	49.07	-119.51	24	12	**08NM200, Inkaneep Creek near the Mouth**	✓				**Regulated**	**2006-2007**	**Active**	**227**	**1227**	**49.25**	**119.53**	**Continuous record**	**Yes**
										08NM012, Inkaneep Creek near Oliver (Lower Station)	✓				Natural	1911-1950	Discontinued	164	-	49.12	-119.49	Seasonal record 1920-1929 and 1941-1950	No
										08NM082, Inkaneep Creek near Oliver (Upper Station)	✓				Natural	1941-1977	Discontinued	70.4	-	49.12	-119.36	Seasonal record 1941-1950	No
79	Residual Area E-17	160.4	1054	276	1676	-	-	23 (19%), 24 (81%)	12	08NM126, Haynes Creek near Osoyoos	✓				Natural	1912-1964	Discontinued	17.6	-	49.02	-119.39	Seasonal record 1959-1964	No
80	Osoyoos Lake	Drainage area above Osoyoos Lake = 8001.0 km². Drainage area above outlet of Osoyoos Lake = 8024.3 km²	Median elevation of drainage area above Osoyoos Lake = 1169 m. Median elevation of drainage area above outlet of Osoyoos Lake = 1167 m.	270 +/-	Maximum elevation of drainage area above lake =2305m	48.95	-119.43	Drainage area above lake falls within zones: 14 (2%), 15 (26%), 23 (14%), 24 (58%)	n/a	**08NM073, Osoyoos Lake near Oroville**			✓		**Regulated**	**1929-2006**	**Active**	**-**	**-**	**48.96**	**-119.44**	**Continuous record 1930-2007**	**Yes**
										08NM113, Osoyoos Lake near Osoyoos			✓		**Regulated**	**1977-2004**	**Discontinued**	**-**	**-**	**49.03**	**-119.46**	**Continuous record**	**Yes**
81	Okanagan River at Oroville	8280 (WSC)	Median elevation of drainage area above station = 1167 m	270	2305	48.94	-119.43	Drainage area above lake falls within zones: 14 (2%), 15 (26%), 23 (14%), 24 (58%)	n/a	**08NM127, Okanogan River at Oroville**		✓			**Regulated**	**1942-2006**	**Active**	**8280**	Median elevation of drainage area above station = 1167 m	**48.93**	**-119.42**	**Continuous record**	**Yes**
										08NM131, Okanogan River at Bridge Street at Oroville		✓			Regulated	1939-1992	Discontinued	8110	-	48.94	-119.43		No
										08NM132, Okanogan River at Zosel Millpond at Oroville		✓			Regulated	1939-1986	Discontinued	8280	-	48.93	-119.42		No

APPENDIX C

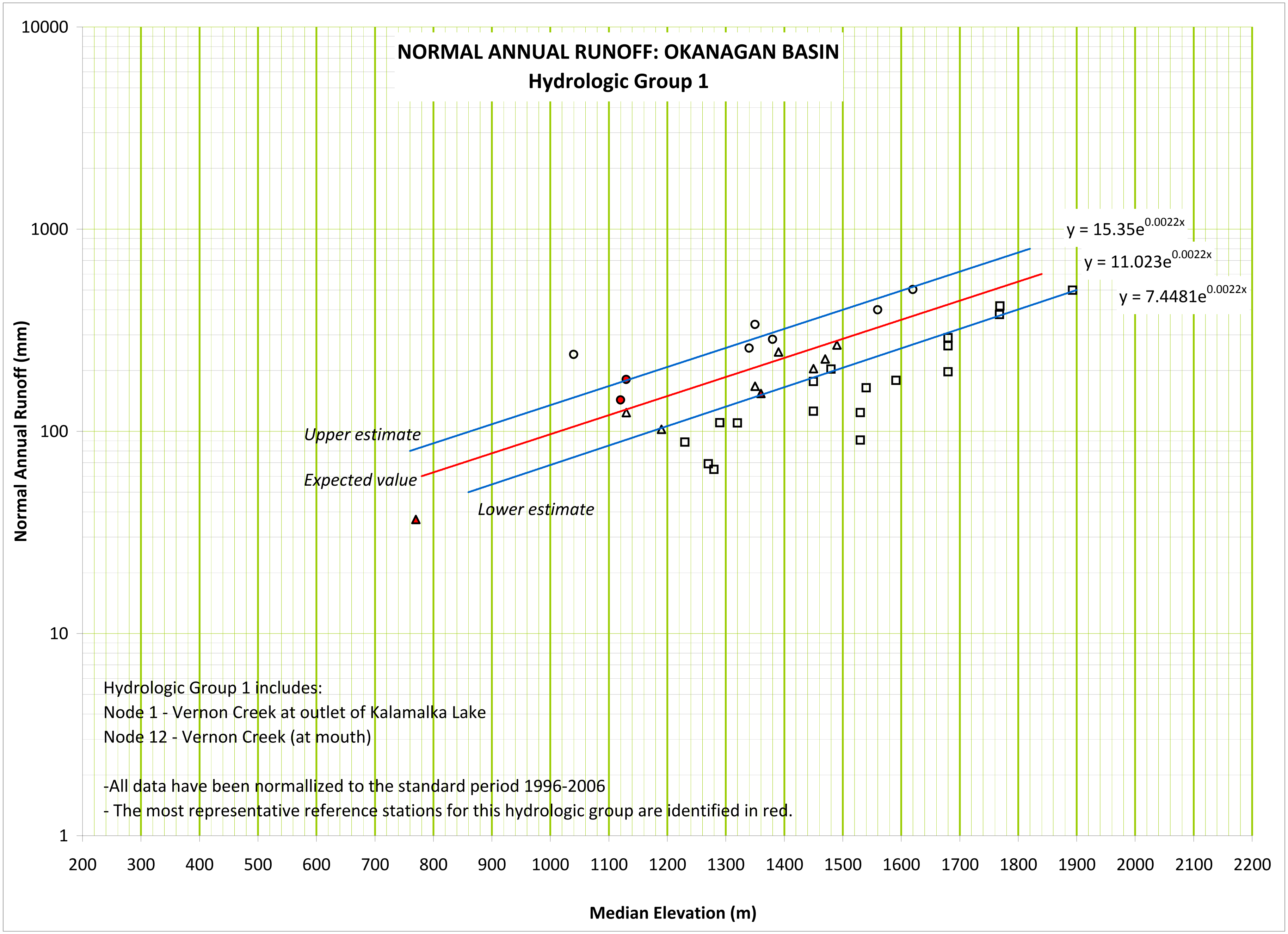
Regional Runoff Relations for the Okanagan Basin

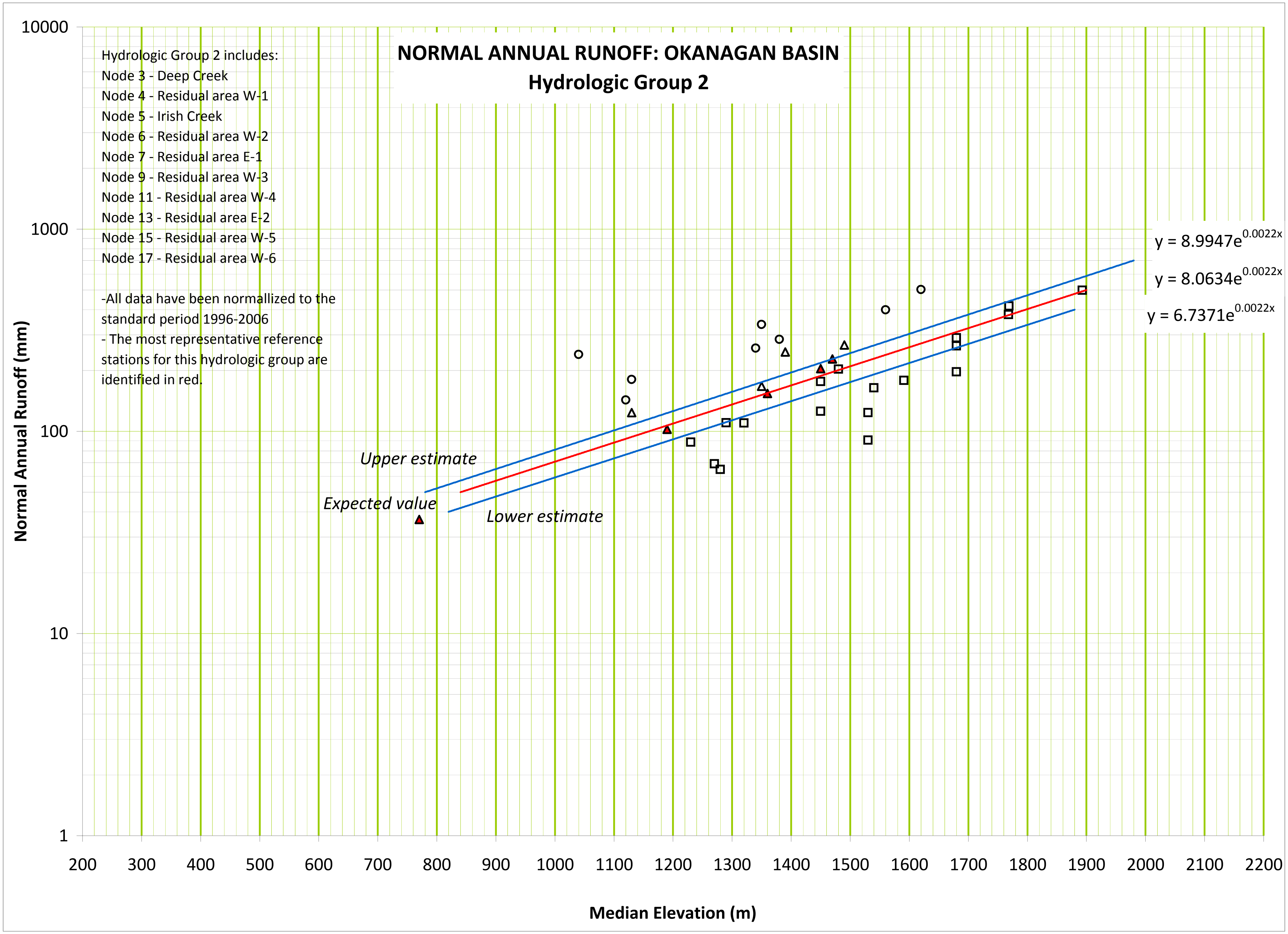


Legend
Node*
*Okanagan River nodes are indictated by red numbers
City
Stream
Lake
Okanagan Basin
Hydrologic Group
Residual Area and Node #
Sub-Basin and Node #
Projection: UTM Zone 11
Datum: NAD83
0 5 10 15 20 25 30
Kilometers
N
S
E
W
Vernon
Kelowna
Penticton
British Columbia
Washington, U.S.A.
British Columbia
Prince George
Okanagan Basin
Vancouver
Kelowna

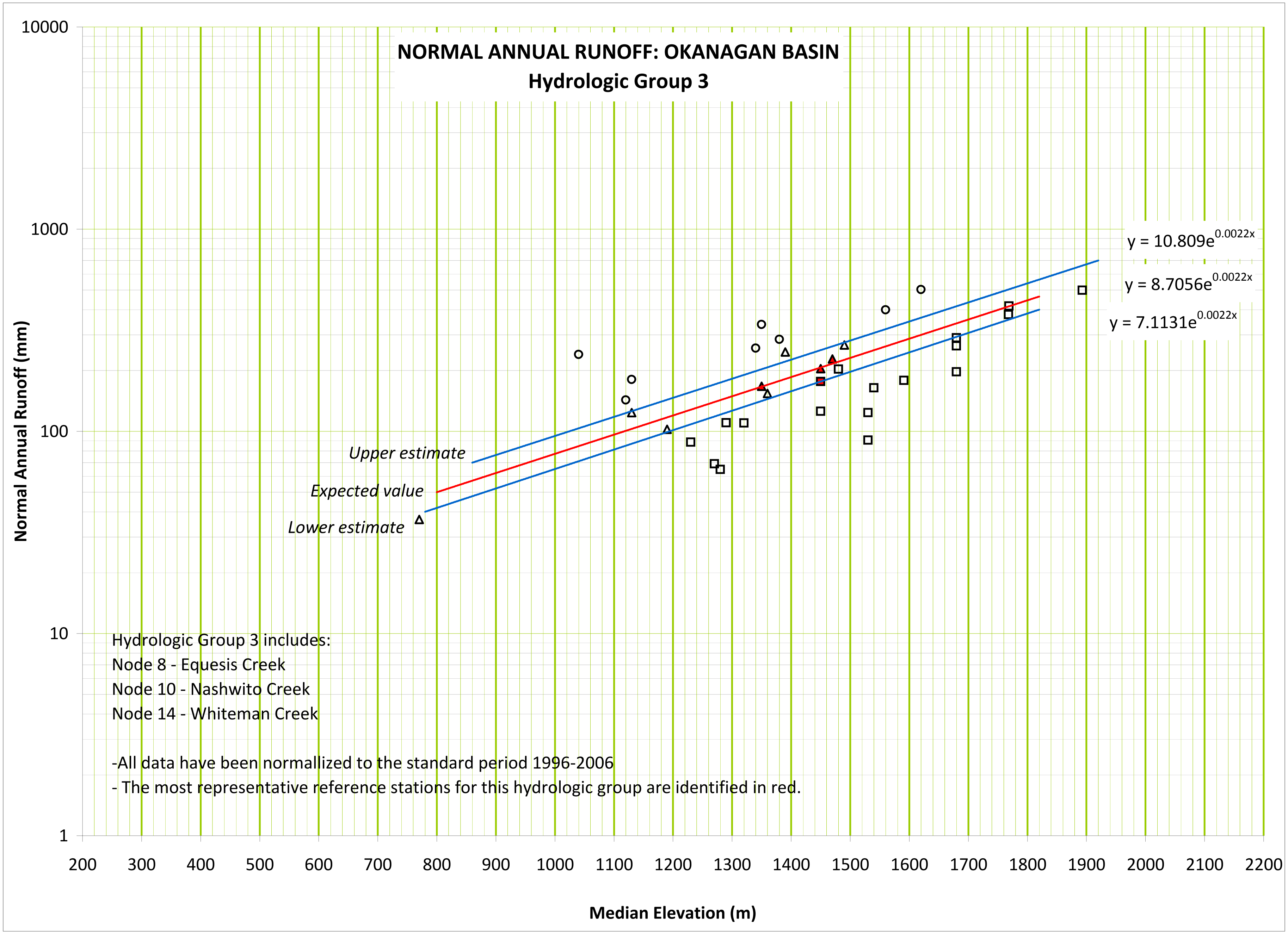


NORMAL ANNUAL RUNOFF: OKANAGAN BASIN
Provincial Hydrologic Zones
Hydrologic zone b
Hydrologic zone c
Hydrologic zone e
y = 15.386e^0.0022x
y = 9.0968e^0.0022x
y = 4.9589e^0.0022x
Hydrologic zone c (expected value)
Hydrologic zone b (expected value)
Hydrologic zone e (expected value)
08NN015: WEST KETTLE R NEAR MCCULLOCH
08NM172: PEARSON CR NEAR THE MOUTH
08NN022: WEST KETTLE R BELOW CARMI CR
08NN019: TRAPPING CR NEAR THE MOUTH
08NM116: MISSION CR NEAR EAST KELOWNA (reg.)
08NM020: BX CR ABOVE VERNON INTAKE (reg.)
08NM142: COLDSTREAM CR ABOVE MUNICIPAL INTAKE
08LC040: VANCE CR BELOW DEAFIES CR
08NM138: TERRACE CR NEAR KELOWNA (reg.)
08NM165: LAMBLY CR ABOVE TERRACE CR (reg.)
08NM176: EWER CR NEAR THE MOUTH
08NM174: WHITEMAN CR ABOVE BOULEAU CR
08LE075: SALMON R AT SALMON LAKE
08NM146: CLARK CR NEAR WINFIELD
08LE021: SALMON R AT SALMON ARM (reg.)
08LE020: SALMON R AT FALKLAND (reg.)
08NM177: DEEP CR AT YOUNG RD
08NM242: DENNIS CR NEAR 1780 m CONTOUR
08NM240: TWO-FORTY CR NEAR PENTICTON
08NM241: TWO-FORTY-ONE CR NEAR PENTICTON
08LG016: PENNASK CR NEAR QUILCHENA
08NM171: VASEUX CR ABOVE SOLCO CR
08NL050:HEDLEY CR NEAR THE MOUTH
08NM015:VASEUX CR ABOVE DUTTON CR
08NM0035: BELLEVUE CR NEAR OK. MISSION
08NM0037: SHATFORD CR NEAR PENTICTON (reg.)
08NM133: BULL CR NEAR CRUMP
08NL022: SIMILKAMEEN R NEAR NIGHTHAWK (reg.)
08LG064: BEAK CR AT THE MOUTH
08NM134: CAMP CR AT THE MOUTH NEAR THIRSK
08NL045: KEREMEOS CR BELOW WILLIS INTAKE (reg.)
08NM137: DAVES CR NEAR RUTLAND
08NM173: GREATA CR NEAR THE MOUTH
08NM164: TESTALINDEN CR IN CANYON
08LG049: NICOLA RIVER ABOVE NICOLA LK (reg.)
Normal Annual Runoff (mm)
10000
1000
100
10
1
Median Elevation (m)
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
All data have been normalized to the standard period: 1996-2006
POLAR GEOSCIENCE LTD.

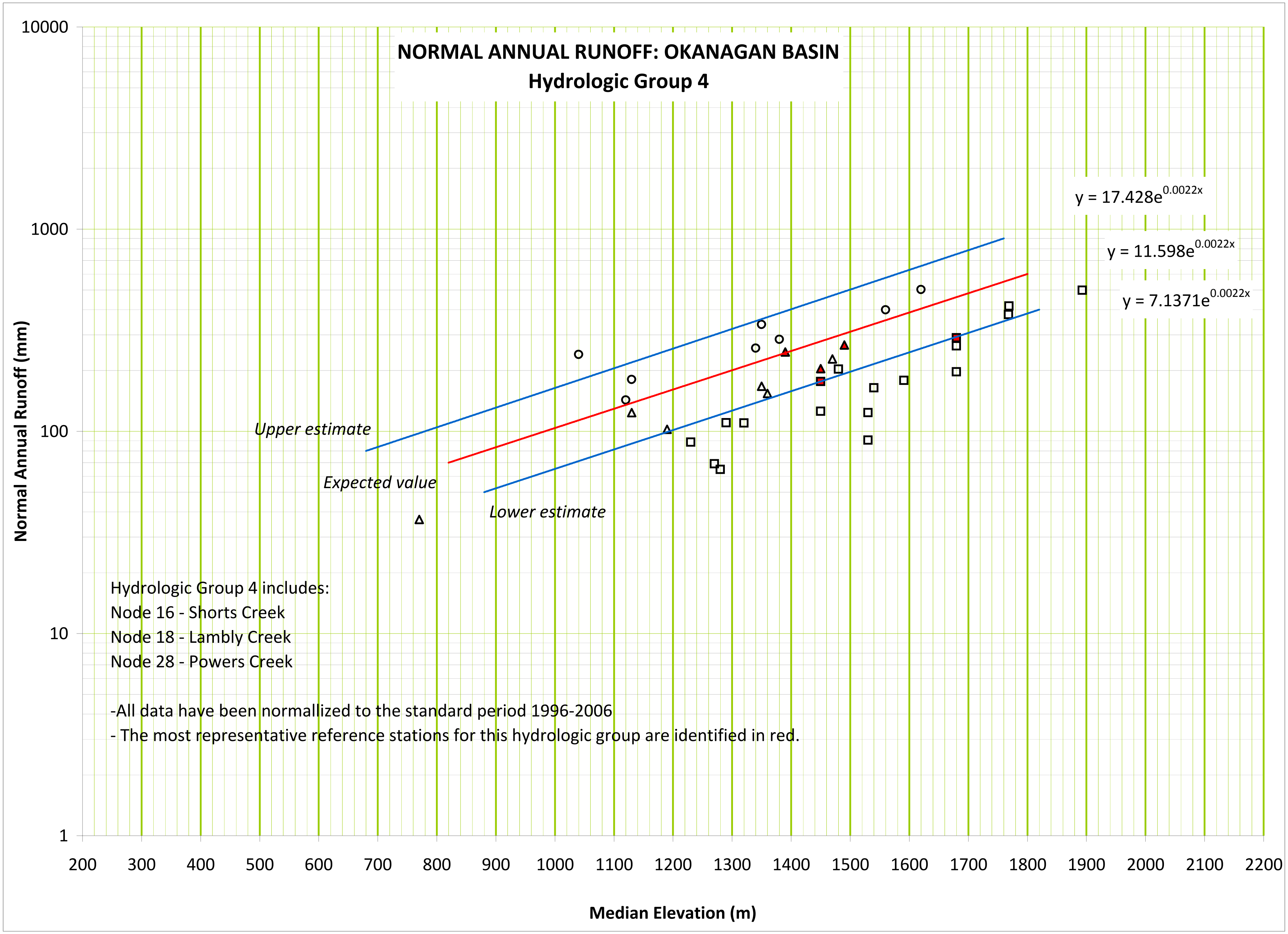

NORMAL ANNUAL RUNOFF: OKANAGAN BASIN
Hydrologic Group 1
Normal Annual Runoff (mm)
10000
1000
100
10
1
Median Elevation (m)
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
y = 15.35e^0.0022x
y = 11.023e^0.0022x
y = 7.4481e^0.0022x
Upper estimate
Expected value
Lower estimate
Hydrologic Group 1 includes:
Node 1 - Vernon Creek at outlet of Kalamalka Lake
Node 12 - Vernon Creek (at mouth)
-All data have been normallized to the standard period 1996-2006
- The most representative reference stations for this hydrologic group are identified in red.

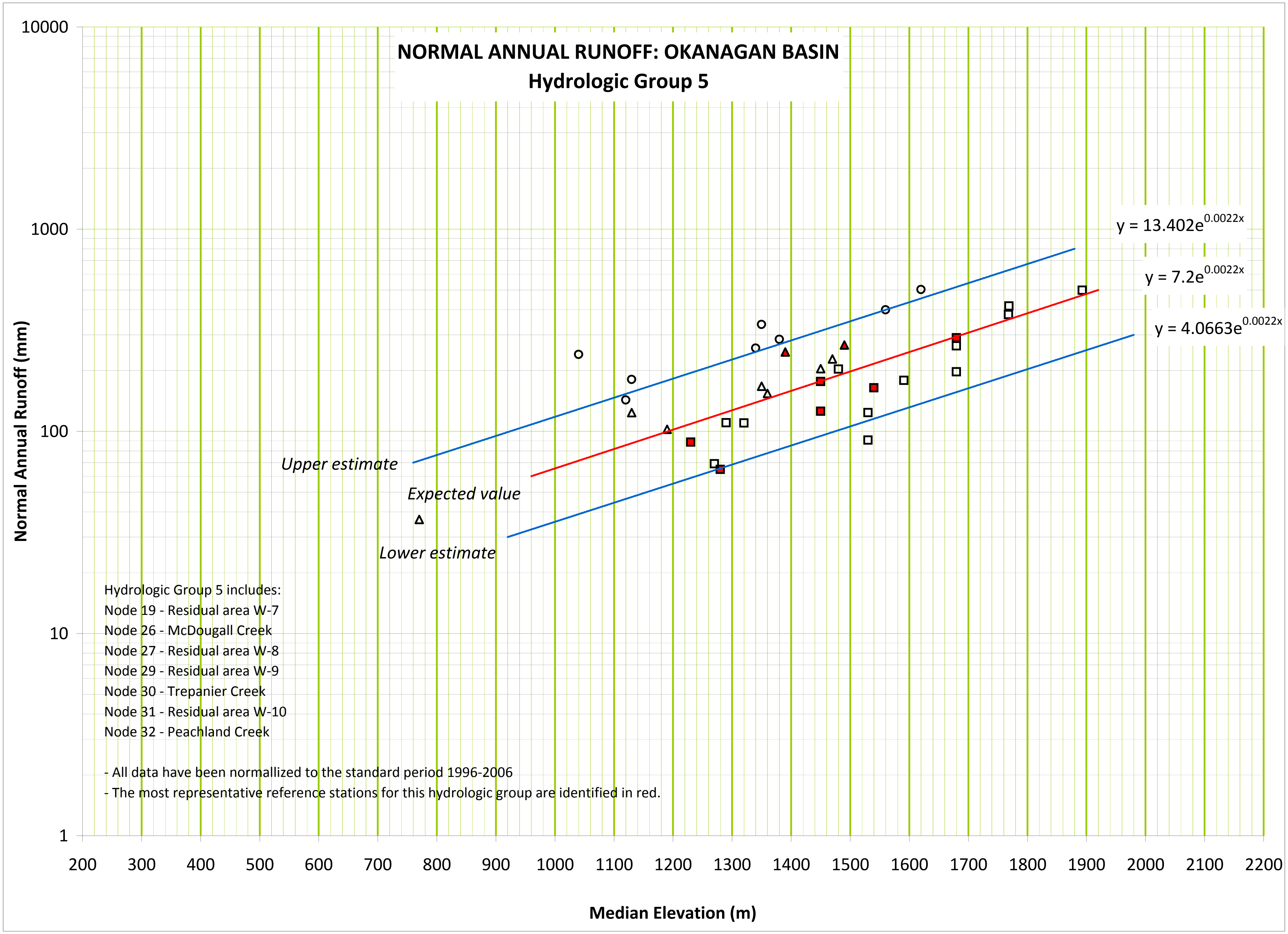


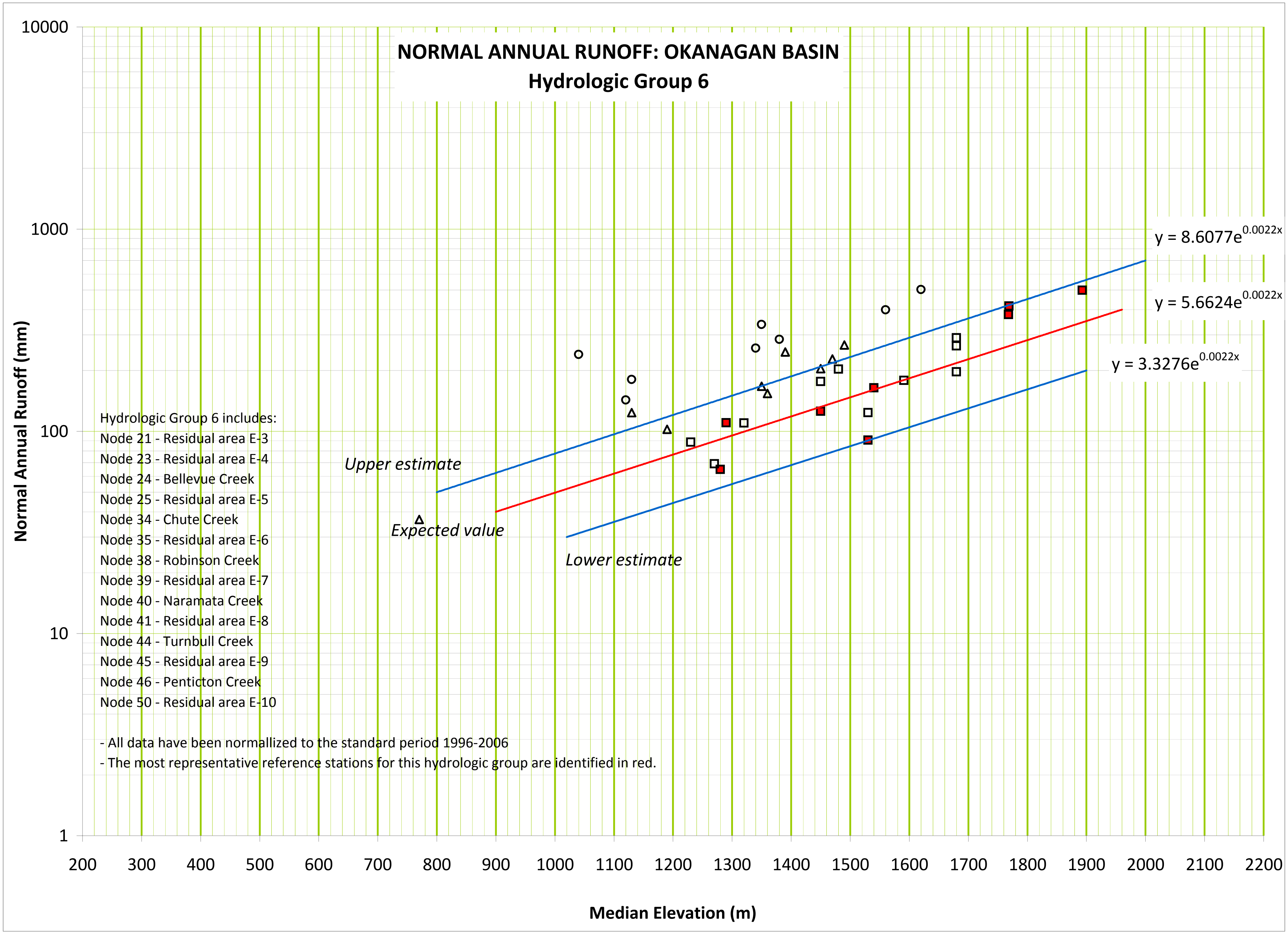
NORMAL ANNUAL RUNOFF: OKANAGAN BASIN
Hydrologic Group 2
Hydrologic Group 2 includes:
Node 3 - Deep Creek
Node 4 - Residual area W-1
Node 5 - Irish Creek
Node 6 - Residual area W-2
Node 7 - Residual area E-1
Node 9 - Residual area W-3
Node 11 - Residual area W-4
Node 13 - Residual area E-2
Node 15 - Residual area W-5
Node 17 - Residual area W-6
-All data have been normallized to the standard period 1996-2006
- The most representative reference stations for this hydrologic group are identified in red.
y = 8.9947e^0.0022x
y = 8.0634e^0.0022x
y = 6.7371e^0.0022x
Upper estimate
Expected value
Lower estimate
Normal Annual Runoff (mm)
Median Elevation (m)
10000
1000
100
10
1
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200



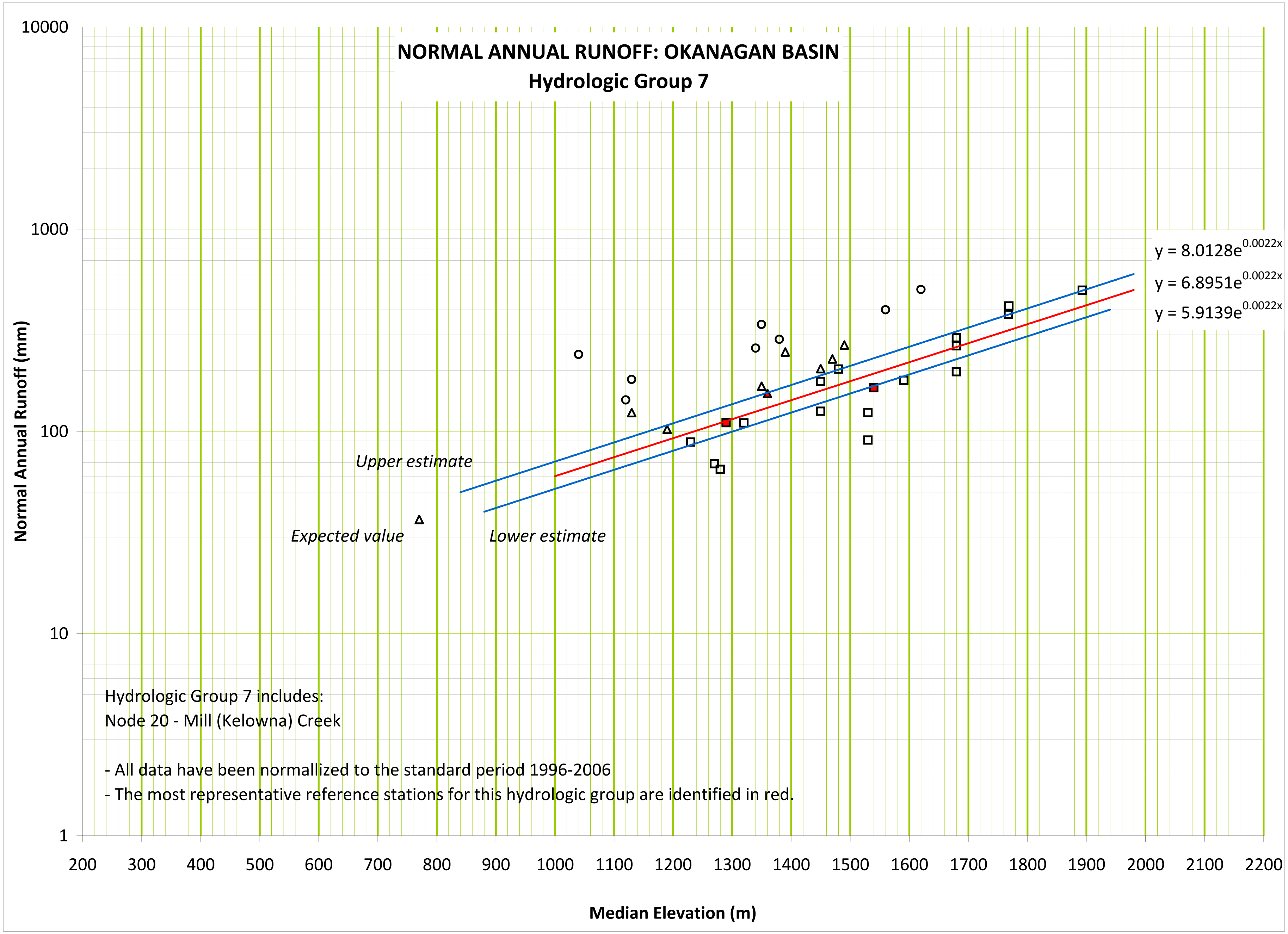
NORMAL ANNUAL RUNOFF: OKANAGAN BASIN
Hydrologic Group 3
y = 10.809e^0.0022x
y = 8.7056e^0.0022x
y = 7.1131e^0.0022x
Upper estimate
Expected value
Lower estimate
Hydrologic Group 3 includes:
Node 8 - Equesis Creek
Node 10 - Nashwito Creek
Node 14 - Whiteman Creek
-All data have been normallized to the standard period 1996-2006
- The most representative reference stations for this hydrologic group are identified in red.
Normal Annual Runoff (mm)
10000
1000
100
10
1
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
Median Elevation (m)

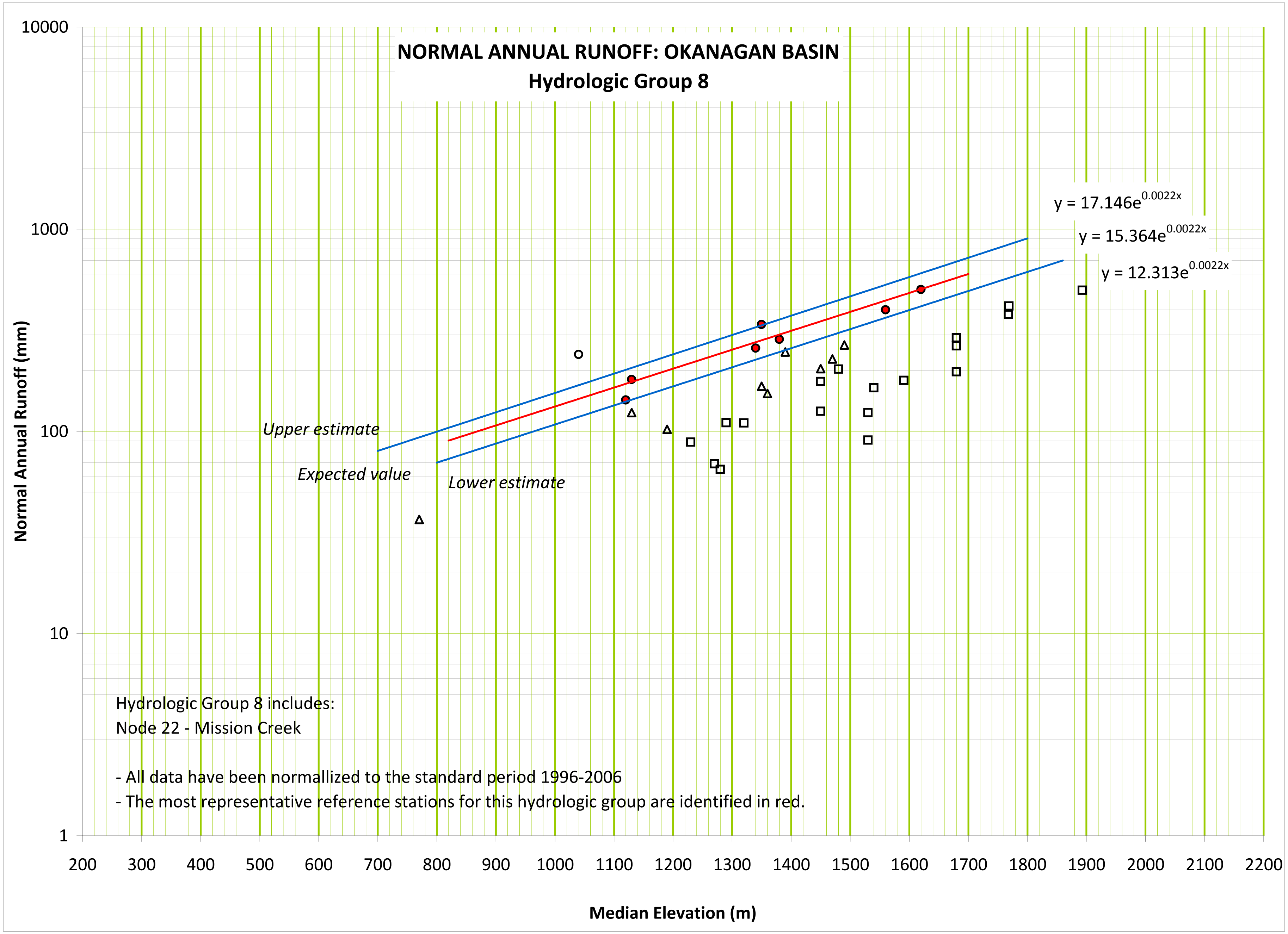

NORMAL ANNUAL RUNOFF: OKANAGAN BASIN
Hydrologic Group 4
y = 17.428e^0.0022x
y = 11.598e^0.0022x
y = 7.1371e^0.0022x
Upper estimate
Expected value
Lower estimate
Hydrologic Group 4 includes:
Node 16 - Shorts Creek
Node 18 - Lambly Creek
Node 28 - Powers Creek
-All data have been normallized to the standard period 1996-2006
- The most representative reference stations for this hydrologic group are identified in red.
Normal Annual Runoff (mm)
Median Elevation (m)
10000
1000
100
10
1
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200

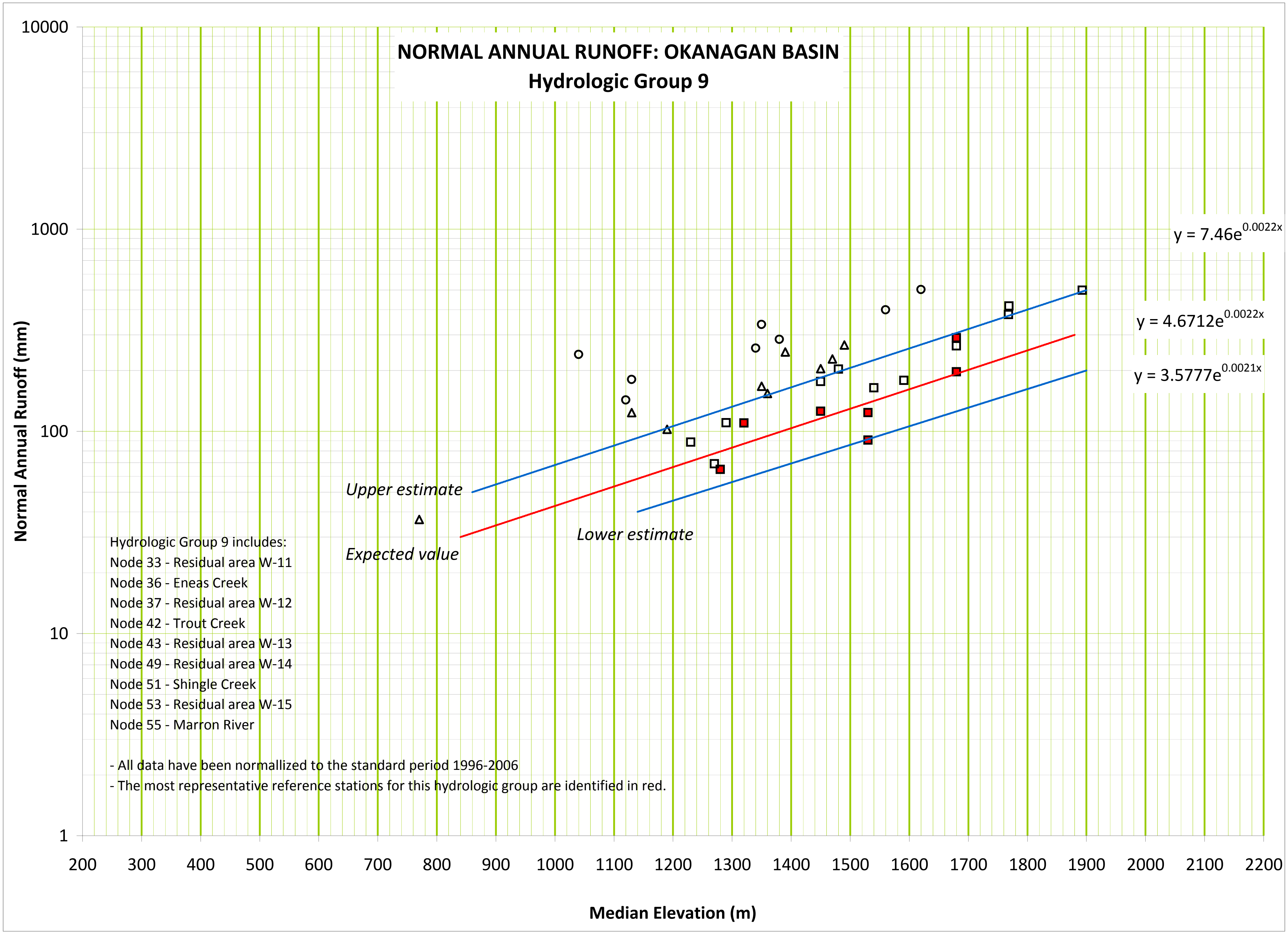

NORMAL ANNUAL RUNOFF: OKANAGAN BASIN
Hydrologic Group 5
y = 13.402e^0.0022x
y = 7.2e^0.0022x
y = 4.0663e^0.0022x
Upper estimate
Expected value
Lower estimate
Hydrologic Group 5 includes:
Node 19 - Residual area W-7
Node 26 - McDougall Creek
Node 27 - Residual area W-8
Node 29 - Residual area W-9
Node 30 - Trepanier Creek
Node 31 - Residual area W-10
Node 32 - Peachland Creek
- All data have been normallized to the standard period 1996-2006
- The most representative reference stations for this hydrologic group are identified in red.
Normal Annual Runoff (mm)
10000
1000
100
10
1
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
Median Elevation (m)



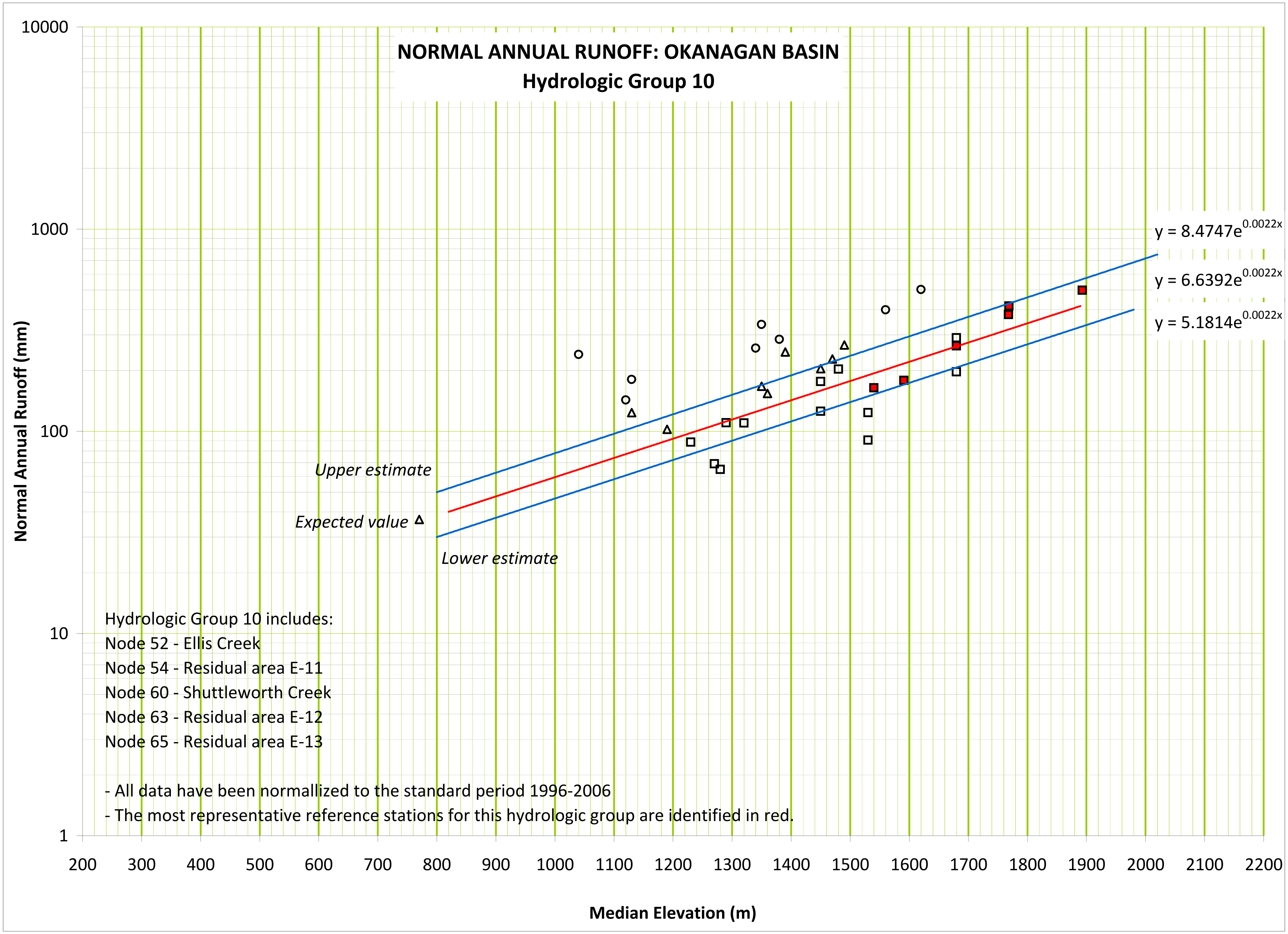
NORMAL ANNUAL RUNOFF: OKANAGAN BASIN
Hydrologic Group 6
10000
1000
100
10
1
Normal Annual Runoff (mm)
y = 8.6077e^0.0022x
y = 5.6624e^0.0022x
y = 3.3276e^0.0022x
Upper estimate
Expected value
Lower estimate
Hydrologic Group 6 includes:
Node 21 - Residual area E-3
Node 23 - Residual area E-4
Node 24 - Bellevue Creek
Node 25 - Residual area E-5
Node 34 - Chute Creek
Node 35 - Residual area E-6
Node 38 - Robinson Creek
Node 39 - Residual area E-7
Node 40 - Naramata Creek
Node 41 - Residual area E-8
Node 44 - Turnbull Creek
Node 45 - Residual area E-9
Node 46 - Penticton Creek
Node 50 - Residual area E-10
- All data have been normallized to the standard period 1996-2006
- The most representative reference stations for this hydrologic group are identified in red.
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
Median Elevation (m)


NORMAL ANNUAL RUNOFF: OKANAGAN BASIN
Hydrologic Group 7
y = 8.0128e^0.0022x
y = 6.8951e^0.0022x
y = 5.9139e^0.0022x
Upper estimate
Expected value
Lower estimate
Normal Annual Runoff (mm)
Median Elevation (m)
10000
1000
100
10
1
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
Hydrologic Group 7 includes:
Node 20 - Mill (Kelowna) Creek
- All data have been normallized to the standard period 1996-2006
- The most representative reference stations for this hydrologic group are identified in red.

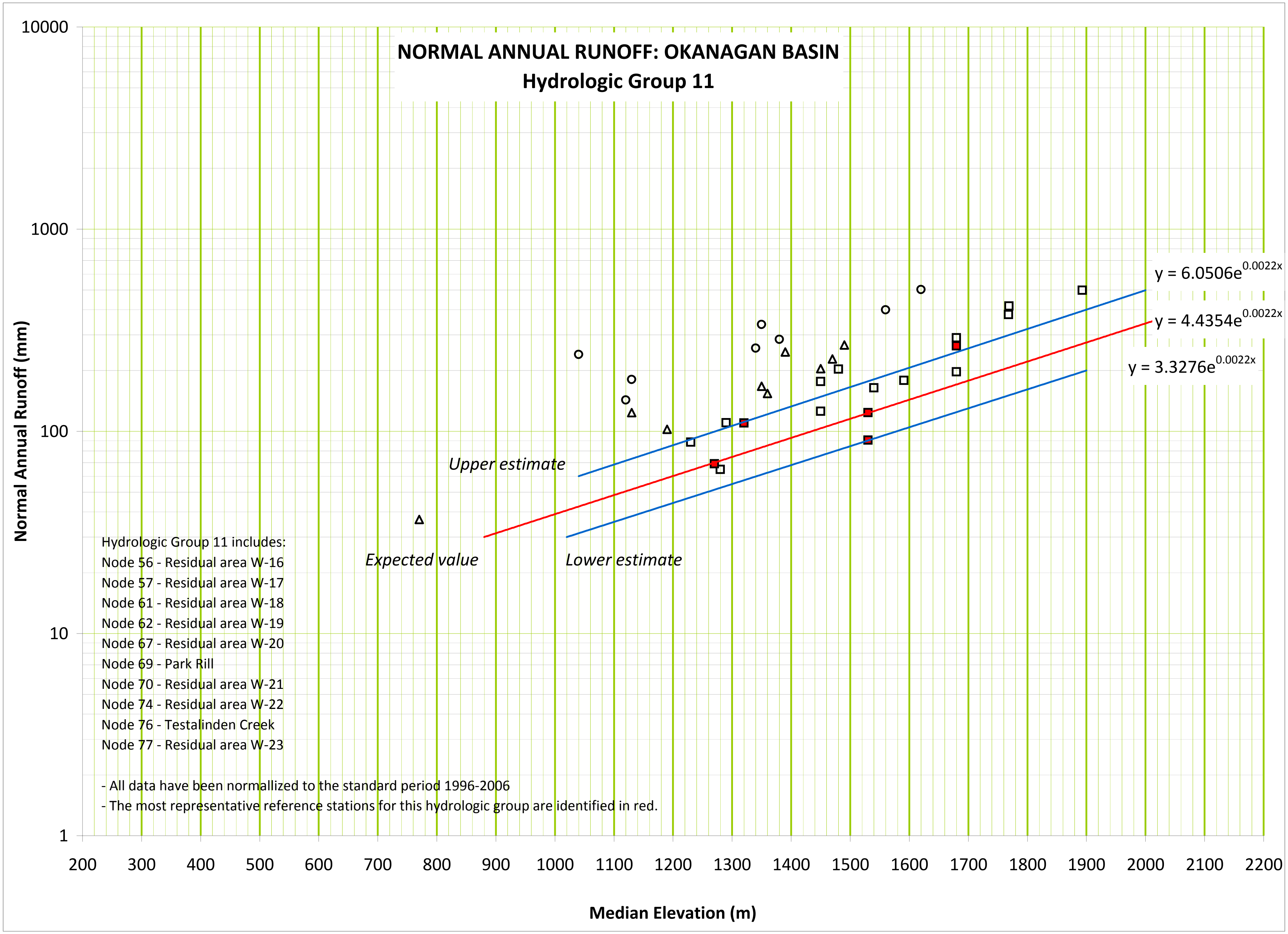

NORMAL ANNUAL RUNOFF: OKANAGAN BASIN
Hydrologic Group 8
y = 17.146e^0.0022x
y = 15.364e^0.0022x
y = 12.313e^0.0022x
Upper estimate
Expected value
Lower estimate
Normal Annual Runoff (mm)
10000
1000
100
10
1
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
Median Elevation (m)
Hydrologic Group 8 includes:
Node 22 - Mission Creek
- All data have been normallized to the standard period 1996-2006
- The most representative reference stations for this hydrologic group are identified in red.

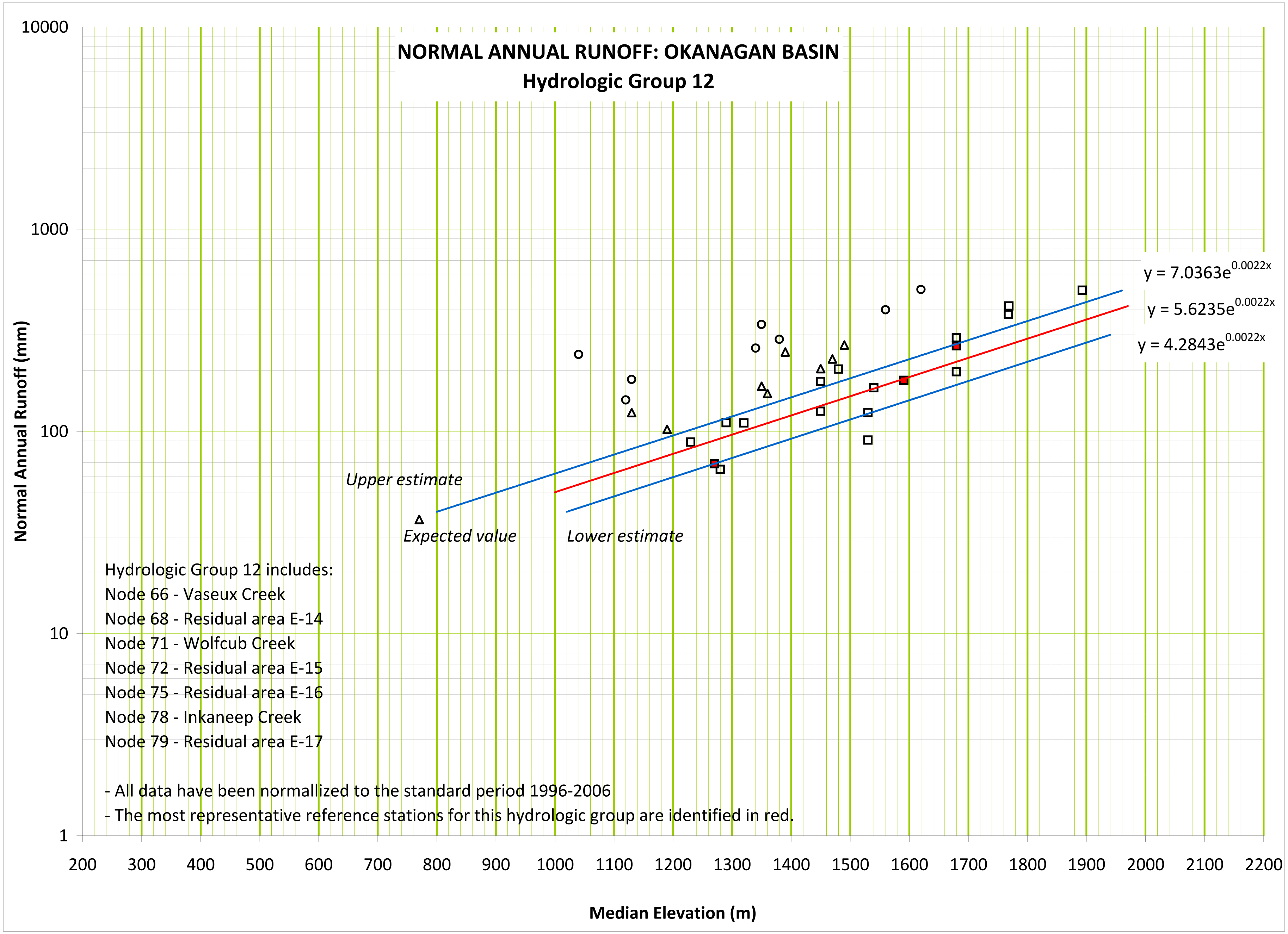


NORMAL ANNUAL RUNOFF: OKANAGAN BASIN
Hydrologic Group 9
Normal Annual Runoff (mm)
Median Elevation (m)
10000
1000
100
10
1
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
y = 7.46e^0.0022x
y = 4.6712e^0.0022x
y = 3.5777e^0.0021x
Upper estimate
Expected value
Lower estimate
Hydrologic Group 9 includes:
Node 33 - Residual area W-11
Node 36 - Eneas Creek
Node 37 - Residual area W-12
Node 42 - Trout Creek
Node 43 - Residual area W-13
Node 49 - Residual area W-14
Node 51 - Shingle Creek
Node 53 - Residual area W-15
Node 55 - Marron River
- All data have been normallized to the standard period 1996-2006
- The most representative reference stations for this hydrologic group are identified in red.



NORMAL ANNUAL RUNOFF: OKANAGAN BASIN
Hydrologic Group 10
Normal Annual Runoff (mm)
Median Elevation (m)
10000
1000
100
10
1
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
y = 8.4747e^0.0022x
y = 6.6392e^0.0022x
y = 5.1814e^0.0022x
Upper estimate
Expected value
Lower estimate
Hydrologic Group 10 includes:
Node 52 - Ellis Creek
Node 54 - Residual area E-11
Node 60 - Shuttleworth Creek
Node 63 - Residual area E-12
Node 65 - Residual area E-13
- All data have been normallized to the standard period 1996-2006
- The most representative reference stations for this hydrologic group are identified in red.


NORMAL ANNUAL RUNOFF: OKANAGAN BASIN
Hydrologic Group 11
Normal Annual Runoff (mm)
Median Elevation (m)
10000
1000
100
10
1
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
y = 6.0506e^0.0022x
y = 4.4354e^0.0022x
y = 3.3276e^0.0022x
Upper estimate
Expected value
Lower estimate
Hydrologic Group 11 includes:
Node 56 - Residual area W-16
Node 57 - Residual area W-17
Node 61 - Residual area W-18
Node 62 - Residual area W-19
Node 67 - Residual area W-20
Node 69 - Park Rill
Node 70 - Residual area W-21
Node 74 - Residual area W-22
Node 76 - Testalinden Creek
Node 77 - Residual area W-23
- All data have been normallized to the standard period 1996-2006
- The most representative reference stations for this hydrologic group are identified in red.



NORMAL ANNUAL RUNOFF: OKANAGAN BASIN
Hydrologic Group 12
Normal Annual Runoff (mm)
10000
1000
100
10
1
Median Elevation (m)
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
y = 7.0363e^0.0022x
y = 5.6235e^0.0022x
y = 4.2843e^0.0022x
Upper estimate
Expected value
Lower estimate
Hydrologic Group 12 includes:
Node 66 - Vaseux Creek
Node 68 - Residual area E-14
Node 71 - Wolfcub Creek
Node 72 - Residual area E-15
Node 75 - Residual area E-16
Node 78 - Inkaneep Creek
Node 79 - Residual area E-17
- All data have been normallized to the standard period 1996-2006
- The most representative reference stations for this hydrologic group are identified in red.

APPENDIX D

Key Hydrologic Studies Identified Using the Okanagan Information Database

Table D.1 Key hydrologic studies identified using the Okanagan Information Database that cover the Okanagan Basin.

Key Hydrologic Studies Identified using the Okanagan Information Database
Barr, L.J. 1988. Okanagan Region Low Flow Estimates. Memorandum dated May 20, 1988. Ministry of Environment and Parks, Water Management Branch.
Canada-British Columbia Okanagan Basin Agreement. 1974. Main Report of the Consultative Board. Office of the Study Director, Penticton, B.C. March 1974.
Canada-British Columbia Okanagan Basin Agreement. 1974. Technical Supplement I: Water Quantity in the Okanagan Basin. Office of the Study Director, Penticton, B.C.
Canada-British Columbia Okanagan Basin Agreement. 1974. Technical Supplement III: Water Quantity Alternatives and Supporting Water Quantity Data. Office of the Study Director, Penticton, B.C.
Canadian Okanagan Basin Technical Working Group. 2004. Okanagan Fish/Water Management Tool. Online at http://www.essa.com/okfwm/
Cheng, J.D. 1979. Low Flow Characteristics of Tributary Streams in the Okanagan Basin.
Cohen, S. (ed.) and Kulkarni, T. (ed.). 2001. Water Management & Climate Change in the Okanagan Basin. Environment Canada & University of British Columbia.
Cohen, S., D. Nielsen, and R. Welbourn (editors). 2004. Expanding the dialogue on climate change & water management in the Okanagan Basin, British Columbia - Final Report. Environment Canada, Agriculture and Agri-Food Canada, and University of British Columbia.
Coulson, C.H. and Obedkoff, W. 1988. British Columbia Streamflow Inventory. B.C. Ministry of Environment, Lands and Parks. March, 1988.
Forest Research Extension Partnership (FORREX). 2003. Effects of Forest Management Activities on Streamflow in the Okanagan Basin, British Columbia: Outcomes of a Literature Review and a Workshop. FORREX, Kamloops, B.C. FORREX Series 9.
Letvak, D.B. 1980. Annual Runoff Estimates for West Side of Okanagan Valley. B.C. Ministry of Environment. January, 1980.
Letvak, D.B. 1988. Runoff in Okanagan Valley 1983-87. Memorandum dated May 3, 1988. Ministry of Environment and Parks, Water Management Branch. File S2109, Study 272.
Merritt, W.S., Alila, Y., Barton, M., Taylor, B., Cohen, S. Unknown date. Exploring impacts of climate change on the hydrology of the Okanagan Basin. Unpublished.
Ministry of Environment (MOE), Okanagan Basin Implementation Board, 1982, Summary Report on the Okanagan Basin Implementation Agreement. September, 1982.
Obedkoff, W. 1971. Inventory of storage and diversion and their effect on flow records in the Okanagan River Basin. Canada-British Columbia Okanagan Basin Agreement, Water Quantity Studies. Task #36 - Estimation of Available Water Supply. Department
Obedkoff, W. 1973. Regionalization of Sub-Basin Hydrology. Preliminary Report No. 38. Prepared for the Okanagan Study Committee. March, 1973.

Table D.1 Cont'd.

Key Hydrologic Studies Identified using the Okanagan Information Database
Obedkoff, W. 1990. Okanagan Tributaries. Hydrology Section Report. May 1990.
Obedkoff, W. 1994. Okanagan Basin Water Supply. Ministry of Environment, Lands and Parks. March, 1994.
Reksten, D.E. 1973. Regionalization of Okanagan Sub-basin runoff from basin characteristics. Canada - British Columbia Okanagan Basin Agreement Water Quantity Studies. Task 53 - Regionalization of sub-basin hydrology. Department of Lands, Forests and Parks.
Summit Environmental Consultants Ltd. (Summit). 1999. Improved Seasonal Inflow Forecasting Models for Okanagan and Kalamalka Lakes. Prepared for the Ministry of Environment, Lands, and Parks. March, 1999.
Summit Environmental Consultants Ltd. (Summit). 2004. Okanagan Basin Study: Phase 1 - Information Review and Workshop (Proposal). Prepared for Land and Water British Columbia Inc. November, 2004.

Table D.2 List of relevant hydrologic studies identified using the Okanagan Information Database that focus on specific streams.

Node	Description	Potentially useful references for streamflow estimation
1	Vernon Creek at outlet of Kalamalka Lake	• Associated Engineering. 2004. Greater Vernon Water Master Water Plan - Addendum. Prepared for Greater Vernon Water. • Coulson, C.H. 1972. Report on Kalamalka-Wood Lake Basin Water Resource Management Study, Preliminary Report for Project 3 Annual Runoff Relationship. • District of Lake Country. 2005. Water supply and distribution system information provided to L. Uunila of Summit by Jack Allingham, Utility Manager. • Letvak, D.B. 1992. Kalamalka-Wood Lake Water Supply Hydrology. • McNeil, R.Y. 1991. Report on the Derivation of an Operating Rule Curve for Duteau Creek Reservoirs. • Reksten, D.E. 1971. 1971 Runoff Conditions in the Kalamalka-Wood Lake Drainage Basin. • Reksten, D.E. 1991. North Okanagan Low Flows (Vernon Cr, Deep Cr and Equesis Cr). B.C. Ministry of Environment, Water Management Branch, File S2108-3P, Study #350
3	Deep Creek	• Reksten, D.E. 1991. North Okanagan Low Flows (Vernon Cr, Deep Cr and Equesis Cr). B.C. Ministry of Environment, Water Management Branch, File S2108-3P, Study #350
8	Equesis Creek	• Letvak, D.B. 1994. Equesis Creek Water Supply Hydrology - 1994. • Reksten, D.E. 1991. North Okanagan Low Flows (Vernon Cr, Deep Cr and Equesis Cr). B.C. Ministry of Environment, Water Management Branch, File S2108-3P, Study #350
12	Vernon Creek (at mouth)	• Associated Engineering. 2004. Greater Vernon Water Master Water Plan - Addendum. Prepared for Greater Vernon Water.
18	Lambly Creek	• Dobson Engineering Ltd. (Dobson). 2001. Interior Watershed Assessment Update for the Lambly Creek Watershed. Prepared for Riverside Forest Products Ltd. And the Small Business Forest Enterprise Program (Penticton). December, 2001. • Dobson Engineering Ltd. (Dobson). 2002. Interior Watershed Assessment Update for the Lambly Creek Watershed. Prepared for Riverside Forest Products Ltd. February, 2002. • Letvak, D.B. 1989. Lambly Creek / Lakeview I.D. • Reksten, D.E. 1970. Preliminary Report on Lambly Creek Water Yield for Lakeview Irrigation District. Department of Lands, Forests, and Water Resources, Water Resources Service, File 0242512-15. • Summit Environmental Consultants Ltd (Summit). 2004. Trepanier Landscape Unit Water Management Plan, Volumes 1 and 2. Prepared for Regional District of Central Okanagan, Kelowna, B.C. and Ministry of Sustainable Resource Management, Kamloops, B.C. June 2004.
20	Kelowna (Mill) Creek	• Coulson, C.H. 1983. Memorandum re. Kelowna (Mill) Creek Flood Flows. • Reksten, D.E. 1973. Kelowna Creek Water Supply for Glenmore and Ellison Irrigation Districts.
22	Mission Creek	• Coulson, C.H. 1971. Review of Mission Creek Hydrology Study. • Hunter, H.I. 1971. Hydrology Study of Mission Creek Basin (South East Kelowna Irrigation District). Hydrology Division, File 0256957. • Lowen, D.A. and D.B. Letvak. 1981. Report on Groundwater - Surface Water Interrelationship Lower Mission Creek, B.C. • Obedkoff, W. 1978. Southeast Kelowna Irrigation District (S.E.K.I.D.) Watershed Hydrology. Memorandum to C.H. Coulson, Water Investigations Branch, March 1, 1978. • Reksten, D.E. 1972. Mission Creek Water Yield for Black Mountain Irrigation District. • Reksten, D.E. 1973. Update of Hydrology Studies for South East Kelowna Irrigation District ARDA Project. Water Investigation Branch, File 0256957. • Reksten, D.E. 1977. Mission Creek Folio Area.

Table D.2 Cont'd.

Node	Description	Potentially useful references for streamflow estimation
26	McDougall Creek	• Summit Environmental Consultants Ltd (Summit). 2004. Trepanier Landscape Unit Water Management Plan, Volumes 1 and 2. Prepared for Regional District of Central Okanagan, Kelowna, B.C. and Ministry of Sustainable Resource Management, Kamloops, B.C. June 2004.
28	Powers Creek	• Dobson Engineering Ltd. 2001. Stream Channel Monitoring Program for the Powers Creek Watershed (2000 Report - Year 1). Prepared for Riverside Forest Products Ltd. • Dobson Engineering Ltd. (Dobson). 2002. Interior Watershed Assessment Update for the Powers Creek Watershed. Prepared for Riverside Forest Products Ltd. February, 2002. • Summit Environmental Consultants Ltd (Summit). 2004. Trepanier Landscape Unit Water Management Plan, Volumes 1 and 2. Prepared for Regional District of Central Okanagan, Kelowna, B.C. and Ministry of Sustainable Resource Management, Kamloops, B.C. June 2004.
30	Trepanier Creek	• Cairns, R. 1992. Trepanier Creek Investigation Report. Ministry of Environment, Lands, and Parks. April, 1992. • Dobson Engineering Ltd. (Dobson). 1998. Watershed Assessment Report for the Trepanier Creek Watershed. Prepared for Gorman Brothers Lumber Ltd. November, 1998. • Hunter, H.I. 1978. Trepanier Creek Water Yield. Hydrology Division, Water Investigations Branch. June 16, 1978. • Reksten, D.E. 1973. Runoff Estimates for Trepanier Creek Watershed. • Summit Environmental Consultants Ltd (Summit). 2004. Trepanier Landscape Unit Water Management Plan, Volumes 1 and 2. Prepared for Regional District of Central Okanagan, Kelowna, B.C. and Ministry of Sustainable Resource Management, Kamloops, B.C. June 2004. • Trumbley Environmental Consulting Ltd. 1997. Peachland/Trepanier Creek Watershed Fisheries Habitat Assessment Procedure 1996. Prepared for District of Peachland, May 29, 1997. Project No. TO96129-WR
32	Peachland Creek	• Dobson Engineering Ltd. (Dobson). Interior Watershed Assessment for the Peachland Creek Watershed. Prepared for Riverside Forest Products Ltd. September, 1999. • Summit Environmental Consultants Ltd (Summit). 2004. Trepanier Landscape Unit Water Management Plan, Volumes 1 and 2. Prepared for Regional District of Central Okanagan, Kelowna, B.C. and Ministry of Sustainable Resource Management, Kamloops, B.C. June 2004. • Trumbley Environmental Consulting Ltd. 1997. Peachland/Trepanier Creek Watershed Fisheries Habitat Assessment Procedure 1996. Prepared for District of Peachland, May 29, 1997. Project No. TO96129-WR
36	Eneas Creek	• Reksten, D.E. 1973. Eneas Creek Flows.
40	Naramata Creek	• Obedkoff, W. 1982. Memorandum re. Naramata Irrigation District Study Tributary Annual Runoff Estimates. • Obedkoff, W. 1987. Naramata Creek Peak Flow Estimates. Memorandum dated September 16, 1987. Ministry of Environment and Parks, Water Management Branch. File S2106, Study 263.

Table D.2 Cont'd.

Node	Description	Potentially useful references for streamflow estimation
42	Trout Creek	• Associated Engineering. 1997. District of Summerland Water System Master Plan. Prepared for the District of Summerland, October 1997. • Cheng, J.D. 1981. Hydrologic Impact of Salvage Logging in the Trout Creek Watershed near Penticton, B.C. • Fitzpatrick, Joe. 2004. District of Summerland Water Coordination 2004 Report. Submitted to District of Summerland, November 26, 2004. • Letvak, D.B. 1989. Water Supply Analysis for Trout Creek and the District of Summerland. B.C. Ministry of Environment, Water Management Branch, File W3576. • Reksten, D.E. 1971. Available Hydrometeorological Data in the Trout Creek Watershed. • Reksten, D.E. 1972. Flood Flows in Trout Creek Basin. • Riordan, Sarah. 1986. The History of Summerland's Water System. Prepared for the Summerland Heritage Advisory Committee, August 1986. • Water Management Consultants. 2003. Trout Creek Hydrology and Operations Review (Draft). Prepared for District of Summerland, June 2003. • Weiss, E. 1981. Trout Creek Water Supply Study.
46	Penticton Creek	• City of Penticton. 2005. Water supply and distribution system information provided to L. Uunila of Summit by Brent Edge, Water Supervisor. • Schnorbus, M.A., R.D. Winkler, and Y. Alila. 2004. Modelling forest harvesting effects on maximum daily peak flow at Upper Penticton Creek. Ministry of Forests, Research Branch, Victoria, B.C. Extension Note 67. http://www.for.gov.bc.ca/hfd/pubs/docs • Thyer, M., J. Beckers, D. Spittlehouse, Y. Alila, and R. Winkler. 2004. Diagnosing a distributed hydrologic model for two high-elevation forested catchments based on detailed stand- and basin-scale data. Water Resources Research, Vol. 40, 1-20. • Winkler, R., D.L. Spittlehouse, B.A. Heise, T.R. Giles and Y. Alila. 2003. The Upper Penticton Creek Watershed Experiment: A Review at Year 20. Water Stewardship: How Are We Managing? Annual Conference of the Canadian Water Resources Association, Vancouver, BC.
66	Vaseux Creek	• Coulson, C.H. 1978. Vaseux Creek Water Supply for April 15 to June 15.
78	Inkaneep Creek	• Obedkoff, W. 1986. Inkaneep Creek Irrigation Study.

APPENDIX E

Technical Memorandum outling Revisions to Water Management and Use Data used in this study

Box 5721, 1005 Balsam Place, Squamish, BC, V8B 0C2

TECHNICAL MEMORANDUM

DATE	January 19, 2009
TO:	Brian Guy
CC:	
FROM:	Lars Uunila
RE:	Verification and revisions to selected water balance parameters for Vernon Creek (Nodes 1, 2, 12), Mission (Node 22), and Trout Creeks (Node 42)
FILE:	Polar No. 102001

Introduction

This memo summarizes the steps taken to verify and refine selected water use and management (water balance) parameters for the Vernon, Mission and Trout Creek sub-basins. The work was initiated on December 9, 2008 following concerns over the accuracy of selected database terms prepared by Dobson Engineering Ltd. (Dobson) during the Okanagan Basin Water Management and Use Study. A large part of this concern stems from inconsistencies between data summarized in the Final Water Management and Use Report (that was deemed satisfactory) and the accompanying database. Furthermore, based on a selected audit of water balance terms in the database developed by Dobson at several locations water use, water imports and exports could not be reconciled.

Since inaccuracies in the database could potentially cascade through several studies underway, interim measures to correct for such inaccuracies were urgently required. A general work plan was developed, which would cover two main aspects:

1. Part 1: Essential work necessary to provide satisfactory water use and management data required for streamflow naturalization; and
2. Part 2: Work necessary to verify water use linkages between sub-basins, source and end users (including water suppliers).

The scope of work summarized herein is limited to Part 1. Based on recent Working Group discussions (January 14, 2008), Part 2 may be incorporated directly into the Ministry of Agriculture's Irrigation demand model. This approach has potential to improve the ease of future scenario modeling.

Work Scope for Part 1

The main goal of Part 1 was to gain reasonable confidence in the following water use and management parameters that directly affect the accuracy of streamflow naturalization[1]:

[1] Streamflow naturalization is a process to estimate the natural streamflow based on a regulated streamflow record. It involves the removal of the effect of withdrawals, imports, and regulation of the water upstream of the point-of-interest.

- *Q_T (database term ID 15)* : volume of water imported from outside the contributing area of node *i* during time *t*,
- *Q_R (database term ID 12)*: the volume of water captured into (+) or released from (-) storage in node *i* during time *t*,
- *E_S (database term ID 16)*: volume of water extracted from surface sources in node *i* during time *t*.

Since alterations to the Water Management and Use database are time consuming, the scope of work was limited to the following three sub-basins:

- Vernon Creek (Nodes 1, 2, and 12),
- Mission Creek (Node 22), and
- Trout Creek (Node 42).

These three sub-basins were chosen not only because they represent the three largest sub-basins in the Okanagan, but also because Vernon and Mission Creeks have long (but regulated) streamflow records that facilitate streamflow naturalization. While the (regulated) streamflow records for Trout Creek have considerably more gaps they are nevertheless useful for developing naturalized streamflow estimates in conjunction with other estimation methods such as regionalization and various modeling techniques.

Although there are several other sub-basins where water use and management data could be re-examined in order to facilitate streamflow naturalization, alternative techniques are available to reasonably estimate natural streamflows in those (smaller) sub-basins - although at the cost of slightly greater levels of uncertainty.

Suggested Additional Water Balance Terms

As a refinement of the current water balance terms, we have identified additional terms to improve communication and facilitate reconciliation of water balance terms:

- ***Q_T_surf_imp***: volume of water imported to node *i* over time *t*, which directly enters the <u>stream network</u>;
- ***Q_T_surf_exp***: volume of water exported to node *i* over time *t*, which directly enters the <u>stream network</u>;
- ***Q_T_res_imp***: volume of water imported to node *i* over time *t* that enters a <u>reservoir</u>. This distinction is made to avoid the risk of "double counting" since this term represents water that will be reflected downstream by the term *Q_R*
- ***Q_T_res_exp***: volume of water exported to node *i* over time *t* that enters a reservoir. This distinction is made to avoid the risk of "double counting" since this term represents water that will be reflected by the term Q_R
- ***Q_T_dist_imp***: volume of water imported to node *i* over time *t*, which enters the <u>distribution system</u> (and not directly to the stream network). This distinction is made since this water does not directly report to nor influence streamflows in node *i*.
- ***Q_T_dist_exp***: volume of water exported to node *i* over time *t*, which enters the <u>distribution system</u> (and not directly to the stream network). This distinction is made since this water does not directly report to nor influence streamflows in node *i*.
- ***E_S_bulk***: total bulk volume of water extracted from node *i* during time *t* from surface water sources. This includes water extracted by all users including major water suppliers and independent water licensees. The term E_S_bulk is used since it is unknown if the ***E_S*** term presented by Dobson (2008) includes the independent water licensees or not.

Import and export terms for ***Q_T*** are used to clearly identify which node water is coming from and going to. So in every instance where water crosses a divide there are equal import and export terms on opposite sides of the divide. As a result of the above-noted changes, use of the original terms ***Q_T*** and ***E_S*** should be avoided. The term ***Q_R*** remains unchanged however.

Of the noted variations of the original term ***Q_T***, knowledge of ***Q_T_surf_imp*** and ***Q_T_surf_exp*** are the key ones for streamflow naturalization. In the three sub-basins investigated (Vernon, Mission, and Trout) however, there are no instances where these apply. Instances of ***Q_T_res_imp*** were identified in the Mission and Trout Creek sub-basins and ***Q_T_dist_imp*** and ***Q_T_dist_exp*** were identified in all three sub-basins. While important for water balance modeling, these last four parameters were not necessary for streamflow naturalization and were therefore not evaluated.

Verification and Refinement Methods

The following sections, organized by sub-basin and water balance parameter, summarize the methods and assumptions used to develop revised estimates for the selected sub-basins.

The work was led by Lars Uunila, P.Geo. of Polar Geoscience Ltd. (Polar) with technical assistance provided by Drew Lejbak, M.Sc. and Dan Austin, M.G.I.S. of Summit Environmental Consultants Ltd. (Summit), Antonio Faccini of AF Consulting Ltd. (AF), and Bob Hrasko, P.Eng. of Agua Consulting Ltd. (Agua). A kick off meeting was held at the Black Mountain Irrigation District office on December 15, 2008. At this meeting information was reviewed, and assignments were confirmed. As a result, Polar and Summit were principally responsible for Vernon and Trout Creek revisions while Agua and AF were responsible for Mission Creek revisions.

Vernon Creek (Nodes 1, 2, and 12)

E_S_bulk

There are two major water suppliers in the Vernon Creek sub-basin: Greater Vernon Water (GVW) and District of Lake Country (DLC). Establishing an accurate estimate of the bulk water use in the sub-basin involved re-examining existing data and obtaining some new data from these suppliers as well as considering the number of independent water users in the sub-basin. These are described below.

Greater Vernon Water (GVW)

Greater Vernon Water (GVW) sources water from:

- Duteau Creek (within the Shuswap River watershed),
- Kalamalka Lake,
- Deer Creek,
- Okanagan Lake, and
- Groundwater.

For the purposes of this assignment, estimates of Deer Creek and Kalamalka Lake bulk water use were the key objectives. Water from Duteau Creek is considered an import to the distribution system and therefore does not directly affect streamflows within the Vernon Creek sub-basin. Groundwater and Okanagan Lake water use are relatively small and also do not directly affect streamflows in the sub-basin.

Dobson (2008) reported estimates of annual and monthly bulk water use data for GVW; however, the methods used to distribute the annual values into monthly and weekly estimates were not indicated. The following identifies the assumptions that were necessary to arrive at independent estimates required to verify the data reported by Dobson (2008):

1. Based on a review of data obtained independently from North Okanagan Water Authority (2002) and Clark (2008), the annual estimates of bulk water use presented in Appendix B of Dobson (2008) were assumed to be reasonable.
2. Renee Clark (GVW Senior Water Quality Technologist) provided actual water use data for Duteau and Deer Creeks for 1997-2003 – data that was not explicitly presented in Dobson (2008).
3. The annual ***E_S_bulk*** values were estimated as follows:
    a. The distribution of bulk water usage by source reported in 2007 by GVW (Clark 2008) was assumed constant (Duteau Creek = 62.6%; Kalamalka Lake = 31.7%; Deer Creek = 2.4%; BX Creek = n/a; Okanagan Lake = 0.2%; Groundwater = 3.1%).
    b. For 1997-2003, the actual Duteau Creek and Deer Creek water use data was subtracted from the total annual water use estimates from all sources. The remainder was split between the Kalamalka Lake source and groundwater (GW), based on the 2007 GVW distribution. As a result, the Kalamalka Lake source represents 91.1% of the remainder of the annual bulk water use, while groundwater represents 8.9%. Okanagan Lake water use was disregarded.
    c. For 1996 & 2004-2006, actual water use data was not available for any sources. As a result, for Duteau Creek and Deer Creek the 1997-2003 average annual bulk water use from these sources was calculated with respect to the total bulk water use (Duteau = 66.7%; Deer = 3.0%). These percentages were assumed representative of the missing years and were applied to the annual bulk volumes. The remainder of the annual bulk volume was split between the Kalamalka Lake intake and groundwater, as noted above.
4. The monthly ***E_S_bulk*** values were estimated as follows:
    a. For the Kalamalka Lake intake, the monthly water use distribution for the City of Vernon, reported in the GVW drought management plan (GVS 2002) was assumed representative.
    b. For Deer Creek, actual data was available for 1997-2003. For all other years, the average percentage of the 1997-2003 monthly distribution was assumed representative (May = 1.5%; June = 16.1%; July = 42.8%; August = 36.6%; September = 3.0%).
5. The weekly ***E_S_bulk*** values were estimated as follows:
    a. For the Kalamalka Lake intake, the weekly estimates assumed an even usage of water for each day of the month. A 5-week moving average was then applied to smooth the results.
    b. For Deer Creek, actual data was available for 1997-2003. For all other years, the weekly estimates assumed an even usage of water for each day of the month. A 5-week moving average was used to smooth the results.

District of Lake Country (DLC)

Dobson (2008) reported estimates of annual and monthly bulk water use data for DLC for 2002-2006, partial data for 1996-1998 & 2000-2001, and no data for 1999. The following identifies the assumptions that were necessary to arrive at independent estimates required to check the data reported by Dobson (2008):

1. Patti Hansen (DLC Water Quality Technician) provided actual water use data for the three major DLC water systems:
    a. Winfield Okanagan Center Water System (WOCWS);
    b. Oyama Water System (OWS); and
    c. Wood Lake Water System (WLWS)

2. The annual ***E_S_bulk*** values for DLC were estimated as follows:
    a. Actual annual bulk water use data was available for:
        i. WOCWS (1996-1998 & 2002-2006);
        ii. OWS (1999-2006); and
        iii. WLWS (1996-1998 & 2000-2006).
    b. For the DLC water systems missing annual bulk water use data, estimates were developed from the 2002-2006 distribution, as these were the only years with overlapping records by all three water systems. The 2002-2006 average water use percentage split between all DLC water systems was assumed the same each year (WOCWS = 58.5%; WLWS = 29.3%; OWS = 12.2%).
3. The monthly ***E_S_bulk*** values for DLC were developed from the average monthly distributions calculated from the actual DLC bulk water use data for each water system.
4. The weekly ***E_S_bulk*** values for DLC were estimated by assuming an even usage of water for each day of the month. A 5-week moving average was used to smooth the results.

<u>Independent Water Licenses</u>
In order to account for the number of water users that independently obtain water, we assumed that the volume of water licensed represented the volume of water used each year. No adjustment was made for water use in any given year, although it is likely that water use would be higher in the drier years and lesser in the wetter years. The assumption above is considered conservative and likely overestimates water use on average. The methods below were used to estimate the water use by the independent water licensees.

1. Independent water licences for the Vernon Creek watershed (minus the major water suppliers GVW and DLC) were grouped into three categories:
    a. Water licences on streams feeding Kalamalka and Wood Lakes (Node 1),
    b. Water licences on Kalamalka and Wood Lakes (Node 2); and
    c. Water licences on streams feeding Vernon Creek downstream of Kalamalka Lake (Node 12).
2. The annual ***E_S_bulk*** values for each group were assumed equal to the total licensed volume available for extraction.
3. The monthly ***E_S_bulk*** values for each group were estimated by distributing the annual volumes into monthly volumes according to the type of water licence. For agricultural, domestic and small waterworks, following distributions were assumed:

Month	**Agricultural water use (%)**	**Domestic (indoor and outdoor) water use (%)**	**Waterworks (%)**
January	0	3.6	3.0
February	0	3.6	2.8
March	0.5	3.9	3.0
April	4.0	5.9	4.0
May	13.7	11.4	9.0
June	15.0	12.1	15.0
July	24.6	17.6	20.0
August	25.0	17.8	24.0
September	13.4	11.2	9.0
October	3.8	5.7	4.0
November	0	3.6	3.2
December	0	3.6	3.0
Annual	**100**	**100**	**100**
Source:	Summit (2004)	Summit (2004)	Greater Vernon Water 2007 water use records (Hansen 2008)

For other water licences (e.g. enterprise, processing, stockwatering), water use was assumed constant throughout the year.

4. Weekly ***E_S_bulk*** values for each group were then estimated by developing a weekly distribution that was consistent with the monthly water use patterns.

Q_R (Upland reservoirs in Node 1)

No data is available on reservoir operations (e.g. reservoir levels, inflows or outflows) for 1996 to 2006 for the storage reservoirs in the Vernon Creek sub-basin (Node 1). The following identifies the steps taken and the necessary assumptions used to arrive at estimates of Q_R for Node 1.

1. All major reservoirs in the uplands were identified. This includes:
    a. Swalwell Lake (licensed storage 11925 ML),
    b. Crooked Lake (licensed storage 4932 ML),
    c. Oyama Lake (licensed storage 6150 ML),
    d. Dammer Lake (licensed storage 263 ML), and
    e. King Edward Lake (licensed storage 1356 ML).
2. Since we have no available information on actual storage volumes, we assumed live storage is equal to licensed storage. The total licensed storage for all reservoirs is 24,847 ML.
3. Water use from each system was estimated based on the bulk water use data provided by the major water suppliers (District of Lake Country and Greater Vernon Water). From this data, the distribution of water use on a weekly basis was determined for 1996-2006.
4. Natural inflows to reservoirs were estimated as follows:
    a. Reservoir level records for Swalwell Lake (08NM062) and Crooked Lake (08NM163) as well as outflows from Swalwell Lake (08NM022) were compiled. Data was only available for 1970-81 for all three gauges, so this was the period used for analysis.
    b. Gaps in reservoir level records were filled assuming a linear change between known lake levels.
    c. The average weekly outflows from Swalwell Lake for 1970-81 were calculated.
    d. The end of week lake levels on both Crooked and Swalwell Lakes were identified, and the change in storage was calculated for each reservoir assuming lake areas of 1.946 km^2 (Crooked) and 3.055 km^2 (Swalwell) by assuming vertical shorelines.
    e. Inflows were calculated by summing the outflows and total change in reservoir storage (i.e. both lakes).
    f. The 1970-81 inflows were compared with the 1970-81 streamflows for Coldstream Creek above the municipal intake (WSC 08NM142) – this is the nearest station with a natural record covering both 1970-81 and 1996-2006. Whiteman Creek was also considered, but its correlation was lower than Coldstream Creek. Weekly scaling factors were identified to predict 1996-2006 unit reservoir inflows based on Coldstream Creek streamflow records.
    g. Using GIS, the total drainage area (102.9 km^2) and the median elevation (1,420 m) were identified for all contributing areas above the upland storage reservoirs in the Vernon Creek basin. Based on regional hydrologic relations, the expected annual runoff for the total contributing area is estimated at 250 mm.
    h. Based on the records for Coldstream Creek, total weekly inflows (to all reservoirs) were estimated and values were adjusted to ensure average 1996-2006 runoff is consistent with the regionally-based runoff estimate of 250 mm.
    i. Inflow estimates were compared with estimates developed by Letvak (1977, 1987) to ensure they were reasonable.

5. In each year we assumed the total reservoir capacity is at 35% (16,151 ML) on November 30 (in Week 48). This is an assumption reported in the Water Management and Use Final Report. It represents the only assumed "fixed point" in the reservoir operations.
6. We assumed that filling of reservoirs occurs only between April 2 and July 1 (Weeks 14-26) based on the estimated natural inflows. Once total reservoir capacity is reached (24,847 ML), water is spilled. Spilled water is ignored in the analysis. In some years reservoirs are filled, and in some they are not – depending on the natural inflow for that year.
7. We assumed that the total volume of water captured during weeks 14 to 26 is released over weeks 14-52 of that year and weeks 1-13 of the following year based on the 1996-2006 weekly distribution of actual water use. This distribution is based on bulk water use data from District of Lake Country and Greater Vernon Water. Note that relatively small volumes were assumed to be released during winter and early spring. In reality, this water is likely supplied by natural inflows downstream of the reservoirs.
8. The parameter Q_R is calculated for each week (1996-2006) by subtracting the water released from the water captured each week. Positive values represent net reservoir filling; negative values represent reservoir releases. Note that we have adopted this convention to be consistent with the Dobson Engineering Ltd. database.

Q_R (Kalamalka/Wood Lake - Node 2)

In order to evaluate the regulation effect of Kalamalka/Wood Lake[2] on streamflows of Vernon Creek several steps were taken, as follows:

1. Daily streamflow records for 1996 to 2006 at Vernon Creek at the outlet of Kalamalka Lake (08NM065) were compiled. The net weekly outflow (ML) from Kalamalka Lake for 1996 to 2006 was calculated based on these records.
2. Daily water level records from Kalamalka Lake at Vernon Pumphouse (08NM143) were compiled and converted to geodetic elevations. Daily lake elevations were converted to weekly values for 1996 to 2006. The combined Kalamalka and Wood Lake storage volumes were estimated based on the lake elevations and lake rating curves developed by the GIS staff at Summit Environmental Consultants Ltd. Weekly net change in lake storage volume was calculated for 1996 to 2006.
3. Lake evaporation data for Kalamalka/Wood Lake were compiled from the Okanagan Water database (on December 9, 2008) and reduced to weekly values.
4. Net weekly inflows to Kalamalka/Wood Lake were calculated by summing the net outflow from Kalamalka/Wood Lake, the change in lake storage, and the evaporation over each week from 1996 to 2006.
5. Weekly bulk water extraction (***E_S_bulk***) for all streams draining into Kalamalka/Wood Lake and from the lakes directly were compiled for 1996 to 2006 (see above). These values includes bulk water use by Greater Vernon Water, District of Lake Country, and independent water licensees.
6. The reservoir component of streamflow from all upland reservoirs (***Q_R***) for all upland reservoirs that feed to Kalamalka/Wood Lake were compiled (see ***Q_R*** for Node 1 above).
7. Natural weekly inflows to Kalamalka/Wood Lake were calculated by summing the net inflow with the estimated bulk water extraction (***E_S_bulk***) and reservoir component of streamflows (***Q_R*** for Node 1).
8. Natural outflows from Kalamalka/Wood Lake were estimated by developing a water balance model for the lake. This model assumed an initial natural lake elevation of 391.0 m on January 1, 1996 and operated by summing gains (natural inflow) and losses (natural outflow and evaporation) from the lake at a weekly time step. Natural outflows were estimated using

[2] Kalamalka and Wood Lake were considered together as one reservoir for this analysis.

Haestad Flow Master hydraulic modeling software assuming a natural channel with a width of 4.0 m, slope of 0.01 and roughness value of 0.035. All assumed values were based on field observation and measurement made on December 18, 2008 by Lars Uunila, P.Geo.

9. The regulation effect of Kalamalka/Wood Lake on streamflows in Vernon Creek (***Q_R*** in Node 2) was determined on a weekly basis by subtracting the recorded (net or regulated) outflow from the estimated natural inflow. Positive values represent net reservoir filling; negative values represent reservoir releases. Note that we have adopted this convention to be consistent with the Dobson Engineering Ltd. database.

Q_R (Node 12)

There are no known reservoir operations in Node 12 that feed the stream network.

Mission Creek (Node 22)

E_S_bulk

Black Mountain Irrigation District and South East Kelowna Irrigation District

There are two major water suppliers in the Mission Creek sub-basin: Black Mountain Irrigation District (BMID) and South East Kelowna Irrigation District (SEKID). Establishing an accurate estimate of the bulk water use in the sub-basin involved re-examining existing data as well as meeting and calling representatives of BMID and SEKID to obtain independent records from those suppliers. In addition, independent water users with water licences were also considered. The steps taken are described below.

1. Surface water withdrawals by SEKID from the Mission Creek sub-basin were compiled from two sources: Summary Spreadsheet supplied by SEKID and Kelowna Joint Water Committee (KJWC) (2005). The spreadsheet had complete monthly data for 1996 to 2006.
2. Groundwater usage by SEKID on a monthly basis was compiled from two sources: Summary Spreadsheet supplied by SEKID and Kelowna Joint Water Committee (KJWC) (2005). The spreadsheet had incomplete data on groundwater pumpage. It only provided flows from 1 of 3 wells (O'Reilly Well) for years 2002 – 2006 on a monthly basis. The KJWC information was also incomplete providing annual flows from each of the 3 wells for years 1996 to 2004.
3. Surface water usage by BMID on an annual basis was compiled. Information sources included the KJWC (2005) and Agua Consulting (2007). Both sources provided information on annual basis and covered the period of 1996 to 2006.
4. Groundwater usage for BMID on an annual basis was compiled. Information sources included the KLWC (2005) and Agua Consulting (2007). Both sources provided information on an annual basis and covered the period of 1996 to 2006.
5. ***E_S_bulk*** data was compared between Dobson (2008) and the independent sources noted above. The differences were calculated as a percentage of the annual water use obtained from KJWC report, SEKID spreadsheet and BMID reports. The differences for BMID annual water use were typically lower than 5%, but in some years the differences were considerable: 2004 (10.3%), 1997 (19%). The difference in 2004 might be explained by the fact that monthly water use data for the last 4 months of the year were missing in the Dobson database. The 1997 data in Dobson (2008) was suspicious since it was exactly the same as data for year 2000. Differences for SEKID were lower with only 2005 data having an error in the range of 27%. However, Dobson did not present any surface water use data from SEKID for 1996 to 2002.
6. For BMID surface water withdrawals in the Mission Creek sub-basin, the Dobson data was considered reasonable, but was refined by estimating missing data for 2004 by averaging the monthly flows for years 1996, 1999 – 2003, and 2002 – 2006. The Dobson data for 1997 was discarded and replaced with the estimated annual values from Agua (2007). Monthly

estimates were developed for 1997 by assuming an average monthly distribution based on the available Dobson data.

7. For SEKID surface water withdrawals from the Mission Creek sub-basin, the incomplete Dobson data was discarded in favor of the complete dataset obtained from SEKID.

Independent Water Licenses

In order to account for the number of water users that independently obtain water we assumed that the volume of water licensed represented the volume of water used each year. No adjustment was made for water use in any given year, although it is likely that water use would be higher in the drier years and lesser in the wetter years. The assumption above is considered conservative and likely overestimates water use on average. The methods below were used to estimate the water use by the independent water licensees.

1. The annual ***E_S_bulk*** values were assumed equal to the total licensed volume available for extraction.
2. The monthly ***E_S_bulk*** values were estimated by distributing the annual volumes into monthly volumes according to the type of water licence. For agricultural, domestic and small waterworks, following distributions were assumed:

Month	**Agricultural water use (%)**	**Domestic (indoor and outdoor) water use (%)**	**Waterworks (%)**
January	0	3.6	3.0
February	0	3.6	2.8
March	0.5	3.9	3.0
April	4.0	5.9	4.0
May	13.7	11.4	9.0
June	15.0	12.1	15.0
July	24.6	17.6	20.0
August	25.0	17.8	24.0
September	13.4	11.2	9.0
October	3.8	5.7	4.0
November	0	3.6	3.2
December	0	3.6	3.0
Annual	**100**	**100**	**100**
Source:	Summit (2004)	Summit (2004)	Greater Vernon Water 2007 water use records (Hansen 2008)

For other water licences (e.g. enterprise, processing, stockwatering), water use was assumed constant throughout the year.

3. Weekly ***E_S_bulk*** values for each group were then estimated by developing a weekly distribution that was consistent with the monthly water use patterns.

Q_R

The following summarizes the steps taken to independently estimate ***Q_R*** for Mission Creek:

1. McCulloch Reservoir level data provided by SEKID was considered reliable, however due to substantial data gaps the BMID reservoir storage data, it could not be used without considerable analysis and gap filling, which was deemed too time consuming. We therefore assumed the McCulloch Reservoir operational patterns would be representative of the BMID reservoirs given their proximity, location and similar customer base.
2. SEKID supplied McCulloch Reservoir release data for 2002 to 2006 in a spreadsheet extracted from their SCADA system. This data provided instant flows released from

McCulloch Reservoir at 1 pm each day from January 10, 2001 to December 31, 2006. A few days of data were missing. Gaps were filled by interpolating and assuming a linear change over time and assuming the 1 pm release represented the average daily release.

3. The monthly change in McCulloch Reservoir storage volume between 2002 and 2006 was calculated based on available reservoir level records.
4. The McCulloch Reservoir filling/emptying pattern was applied to all BMID reservoirs in the Mission Creek sub-basin. It was assumed that the last reservoir level measurement of the year was constant to March 31 of the next year. Storage volume and storage volume changes for each month were calculated.
5. Based on some simplifications for a weekly time step and relatively small reservoirs, it was assumed that ***Q_R*** would be reflected by the change in reservoir storage volume. The value ***Q_R*** is defined as Outflow(natural) – Outflow(regulated). Given: Inflow(regulated) = Inflow(natural), and assuming Inflow(natural) = Outflow(natural), then Inflow(natural) = Inflow(regulated) = Outflow(natural). By definition: Change in storage = Inflow (regulated)-Outflow(regulated), so Change in storage = Outflow (natural) – Outflow (regulated) = ***Q_R***.
6. While monthly storage volumes at McCulloch reservoir were supplied by SEKID for years 1997 – 2006, 1996 data was missing. Data for 1996 was estimated assuming that storage variation changes as a function of water usage. In 1996 monthly surface water usage was known and it was found that the highest correlation was with year 2003 data. Using the monthly water usage data for years 1996 and 2003 and the storage volume variation for year 2003 and assuming a linear ratio, the 1996 volume storage change was estimated.
7. Monthly McCulloch Reservoir volume changes for 1996 to 2006 were disaggregated into weekly estimates.
8. Since there is no storage data at Brown, Fish and Long Meadows Lakes, the McCulloch Reservoir volume changes were increased by a correction factor of 5.7% to account for storage in Brown Lake, Fish Lake and Long Meadow Lakes. The 5.7% factor was obtained as the ratio of storage developed for Brown Lake, Fish Lake and Long Meadow Lakes divided by storage developed at McCulloch Reservoir. The source information for developed storage is the KJWC (2007).
9. The available BMID reservoir storage data was used to obtain storage volumes at weekly intervals. The available data provides the stored volume at the first day of the month and 15th day of each month. Adjustments were carried out on the BMID data to obtain 1996 to 2006 volumes at the weekly time step.
10. Q_R was calculated by totaling the estimated weekly volume of water stored and released from all BMID and SEKID reservoirs in the Mission Creek sub-basin.

Q_T_res_imp (Stirling Creek to Mission Creek)

One surface water import was identified in the Mission Creek sub-basin - the diversion of Stirling Creek (in the Kettle River watershed) to McCulloch Reservoir by Southeast Kelowna Irrigation District (SEKID). SEKID were contacted to obtain all information they could provide on this diversion. Since about October 2003, Dobson Engineering Ltd. has been responsible for gauging the flows in Stirling Creek, which are diverted into McCulloch Reservoir. However, only monthly data (for the summer period) were provided for 2004 to 2006. Estimates of monthly flows for 1996 to 2003 were made by identifying the patterns of runoff at Two-Forty One Creek near Penticton (08NM241) for 1996-2003 with respect to the 2004-2006 average runoff. Weekly values were estimated based on the monthly data assuming a linear change between one month and another. Zero imports were assumed during the winter months (November to April).

Trout Creek (Node 42)
E_S_bulk

District of Summerland

The District of Summerland is the principal water supplier in the Trout Creek sub-basin. Dobson (2008) reported actual annual and monthly bulk water use data for the District of Summerland. This data was checked against water use data in Agua Consulting Inc. (2008) and was found to be reasonably consistent. However, the weekly estimates of ***E_S_bulk*** provided in the database do not reconcile with the monthly and annual data in the report. We therefore assumed the monthly and annual data provided by Dobson (2008) was correct and used it to re-calculate the weekly water use estimates. Water use during a given month was assumed constant. However, to minimize sudden changes in the dataset from one month to another, a 5-week moving average was used to smooth the results.

Independent Water Licenses

In order to account for the number of water users that independently obtain water we assumed that the volume of water licensed represented the volume of water used each year. No adjustment was made for water use in any given year, although it is likely that water use would be higher in the drier years and lesser in the wetter years. The assumption above is considered conservative and likely overestimates water use on average. The methods below were used to estimate the water use by the independent water licensees.

4. The annual ***E_S_bulk*** values were assumed equal to the total licensed volume available for extraction.
5. The monthly ***E_S_bulk*** values were estimated by distributing the annual volumes into monthly volumes according to the type of water licence. For agricultural, domestic and small waterworks, following distributions were assumed:

Month	**Agricultural water use (%)**	**Domestic (indoor and outdoor) water use (%)**	**Waterworks (%)**
January	0	3.6	3.0
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March	0.5	3.9	3.0
April	4.0	5.9	4.0
May	13.7	11.4	9.0
June	15.0	12.1	15.0
July	24.6	17.6	20.0
August	25.0	17.8	24.0
September	13.4	11.2	9.0
October	3.8	5.7	4.0
November	0	3.6	3.2
December	0	3.6	3.0
Annual	**100**	**100**	**100**
Source:	Summit (2004)	Summit (2004)	Greater Vernon Water 2007 water use records (Hansen 2008)

For other water licences (e.g. enterprise, processing, stockwatering), water use was assumed constant throughout the year.

6. Weekly ***E_S_bulk*** values for each group were then estimated by developing a weekly distribution that was consistent with the monthly water use patterns.

Q_R
Fortunately there is a reasonable record of reservoir storage volumes for the reservoirs operated by the District of Summerland. This record was provided in digital spreadsheet form by David Sellars of Water Management Consultants Ltd. The following identifies the steps taken and the necessary assumptions used to arrive at estimates of ***Q_R*** for Node 42.

1. The daily reservoir storage volume data for District of Summerland reservoirs were compiled. Data for 1996 to 2003 was available.
2. We confirmed that the reservoir data represents all the major reservoirs operated by the District of Summerland (i.e. Headwaters 1, Headwaters 2, Headwaters 3, Headwaters 4, Thirsk, Whitehead, Crescent, Isintok, and Tsuh). The Meadow Valley Irrigation District operates Darke Lake reservoir (fed partially by Munroe Lake outflows), however the only information known on the Darke Lake reservoir is its live storage of 743 ML (Letvak 1989). This represents about 6% of the total reservoir capacity of nine (9) District of Summerland reservoirs (about 11,500 ML).
3. Gaps in the daily reservoir storage volume record between 1996 and 2006 were filled by assuming linear change between one level and another. For larger gaps and for missing data in 2004-2006 the percentage of total storage on a given date was approximated using data obtained for McCulloch Reservoir operated by SEKID in the Mission Creek sub-basin. Some smoothing was necessary to ensure realistic water level changes over time.
4. Weekly changes in total reservoir volume (ML) were calculated for 1996 to 2006. These changes represent the reservoir component of streamflow (***Q_R***).
5. To account for Darke Creek reservoir operations, an additional 6% was added to all weekly filling or release data for Summerland.

Q_T_res_imp
Trout Creek Water Use Plan Consultative Committee (2005) indicate that Finley and Lapsley Creeks, which are located in the Eneas Creek sub-basin, are diverted into Darke Lake (reservoir) in the Trout Creek watershed. This is done to meet all water demands by the Meadow Valley Irrigation District, which has an intake located on Darke Creek.

Actual bulk diversion volumes were not available; however, Letvak (1989) indicated that 500 acre-feet from Lapsley Creek are licensed for diversion from Lapsley Creek (to Darke Lake in the Trout Creek sub-basin). This diversion was assumed to occur from April 1 to June 30 during freshet.

The annual diversion volume was distributed into weekly estimates based on the percentage distribution of the naturalized Eneas Creek hydrographs (weeks 14 – 26 only) for 1996-2006 prepared by Polar (2009).

Summary
In summary, water balance parameters that directly influence streamflow naturalization were revised for Vernon Creek (Nodes 1, 2, and 12), Mission Creek (Node 22), and Trout Creek (Node 42). In some cases the differences between the revised data and the original Dobson database (as of December 2008) were small, but in several cases the differences were considerable and could have resulting in significant errors. In some cases, the database values developed by Dobson (2008) were simply incorrect and have now been corrected. The revised data described herein will be uploaded to the Okanagan Water database and will reduce uncertainty in streamflow naturalization in the three largest sub-basins in the Okanagan.

Attachments

The following spreadsheet files provide the revised weekly time series data:

File	**Sub-basin**	**Revised data**
Revised WMU data Vernon Cr.xls	Vernon Creek (Nodes 1, 2, and 12)	E_S_bulk (Node 1) E_S_bulk (Node 2) E_S_bulk (Node 12) Q_R (Node 1) Q_R (Node 2) Q_R (Node 12)
Revised WMU data Mission Cr.xls	Mission Creek (Node 22)	E_S_bulk (Node 22) Q_R (Node 22) Q_T_res_imp (Node 22)
Revised WMU data Trout Cr.xls	Trout Creek (Node 42)	E_S_bulk (Node 42) Q_R (Node 42) Q_T_res_imp (Node 42)

With the assistance of ESSA Technologies, we intend to upload these data to the Okanagan Water database.

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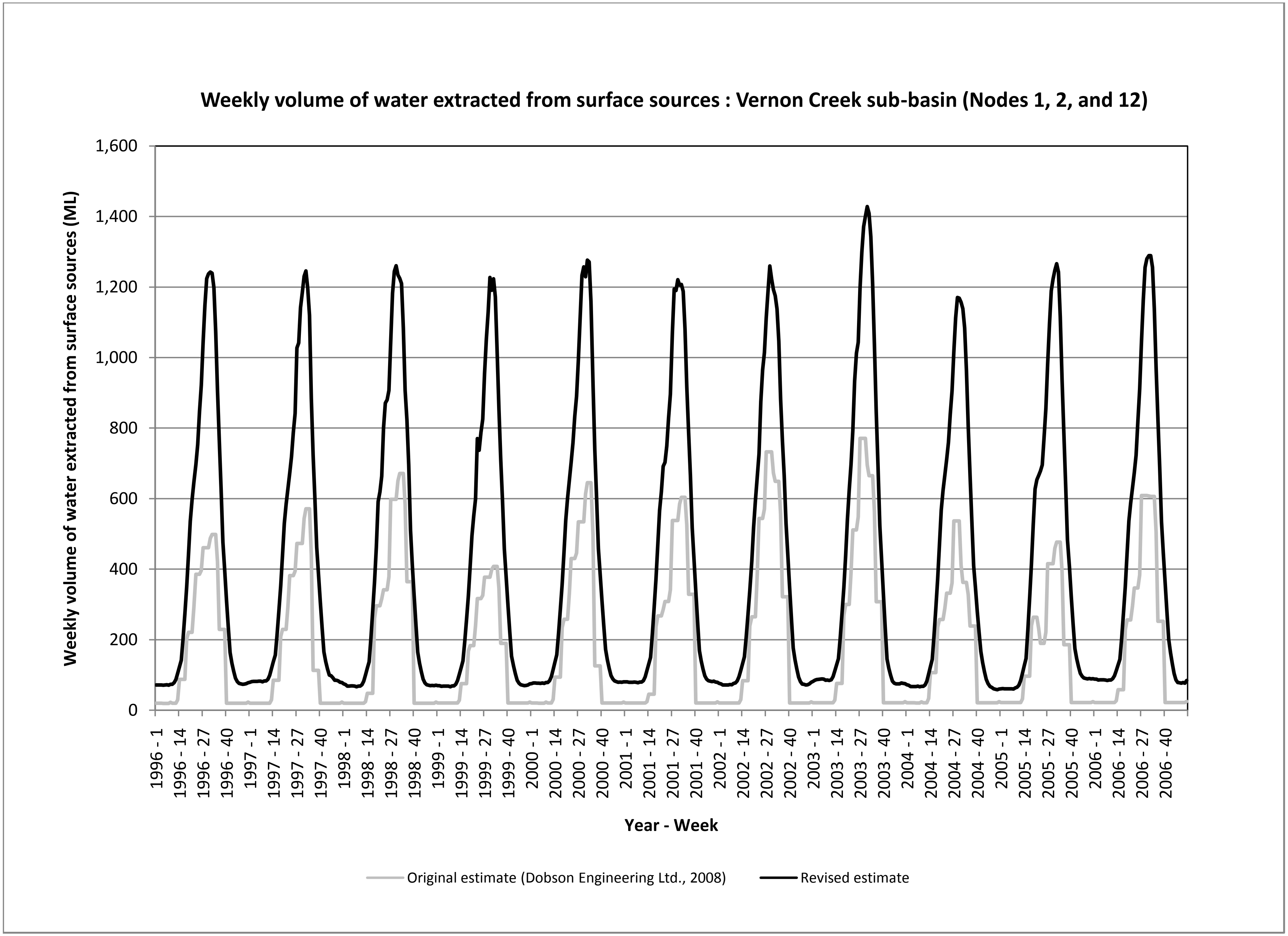
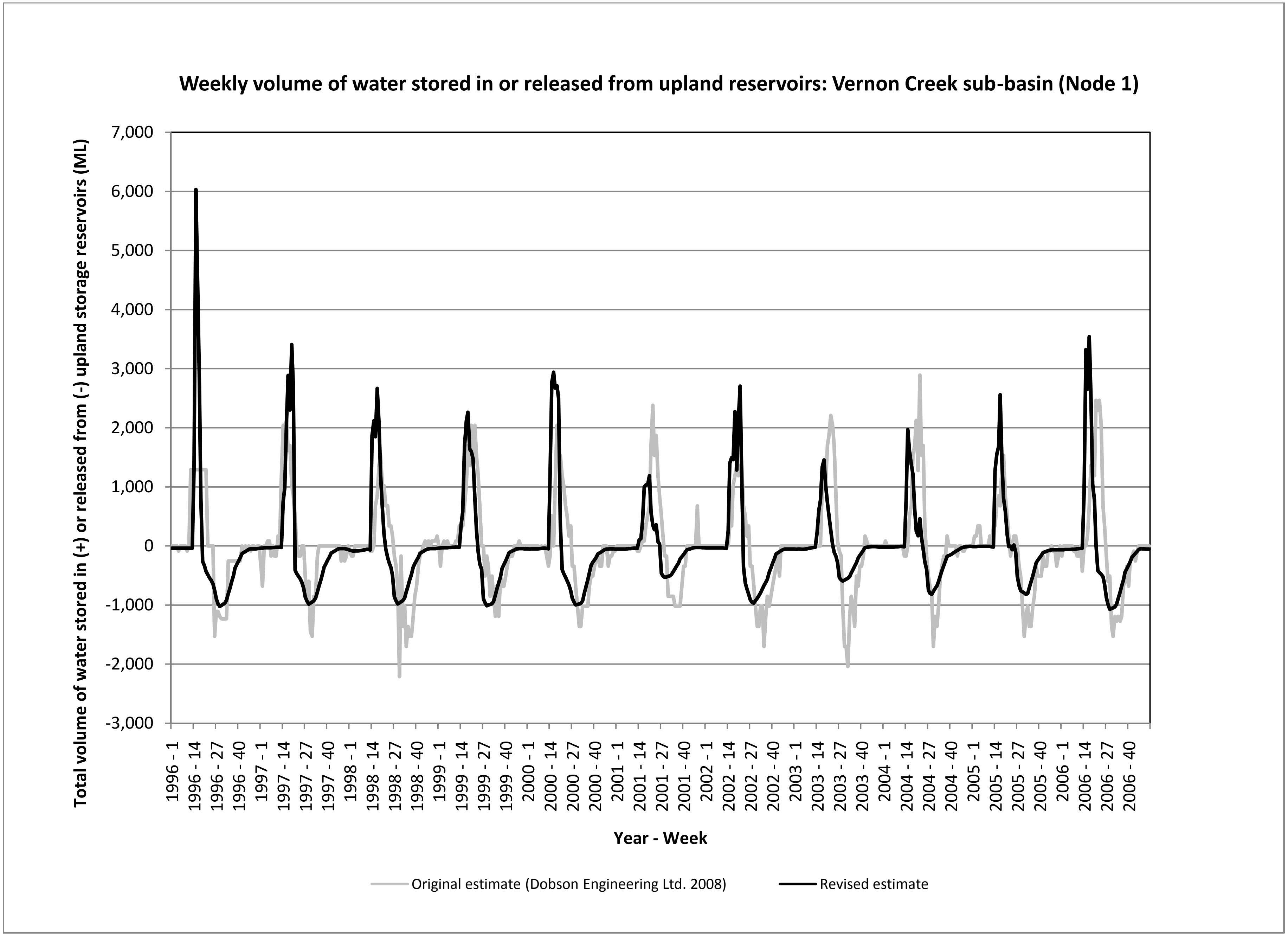
APPENDIX F

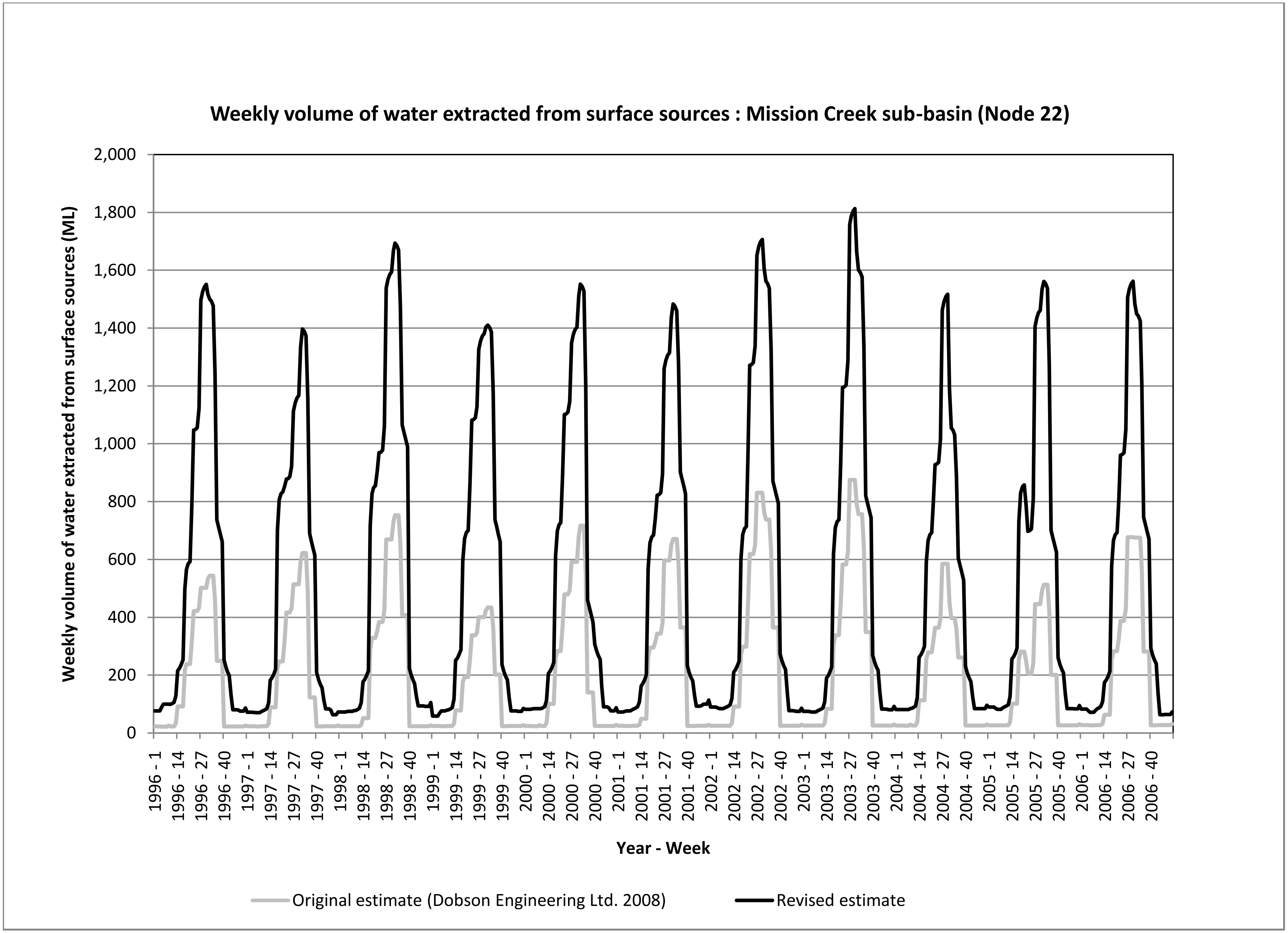
Revised Water Management and Use Data for Vernon, Mission and Trout Creeks



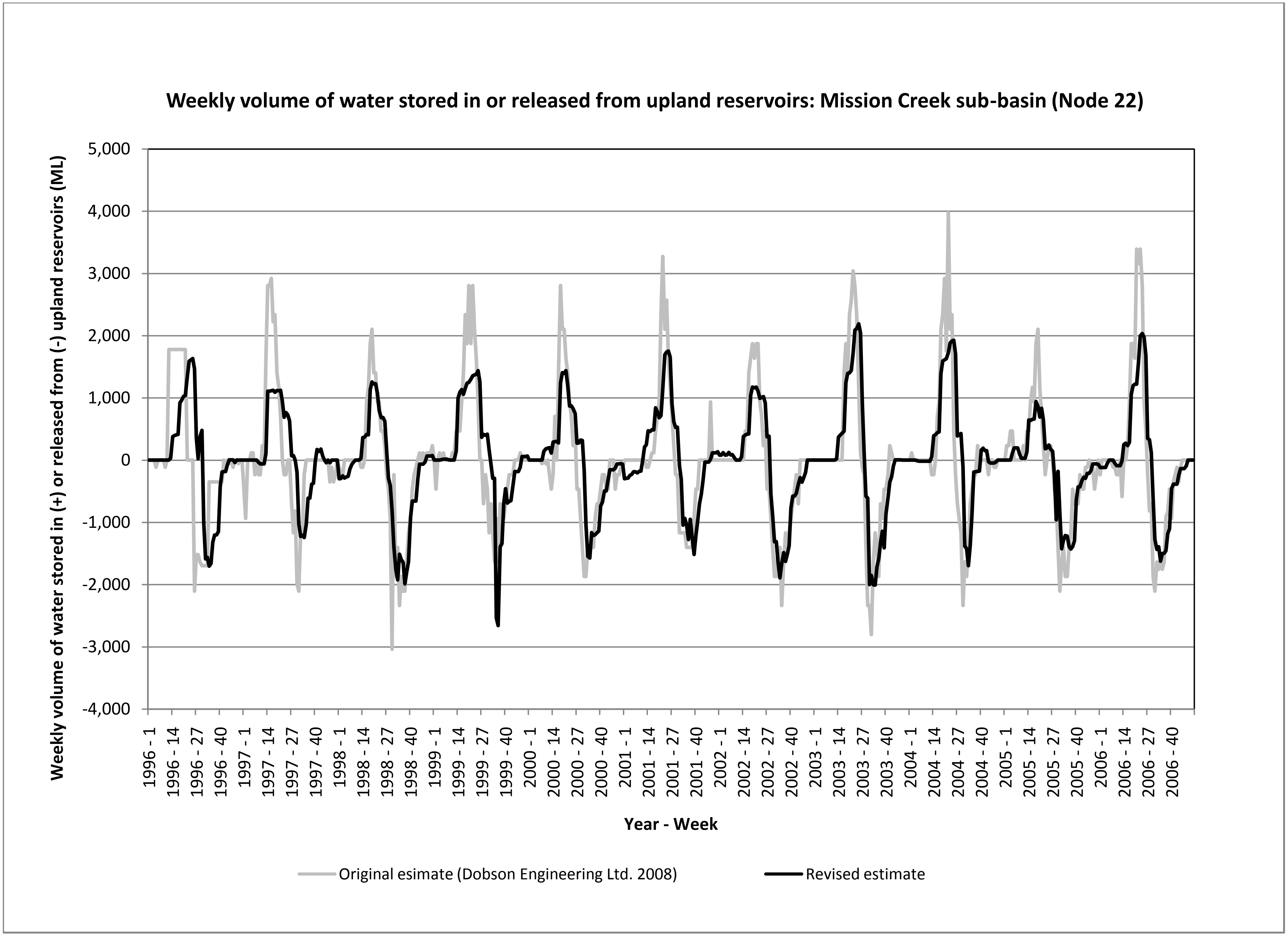
Weekly volume of water extracted from surface sources : Vernon Creek sub-basin (Nodes 1, 2, and 12)
Weekly volume of water extracted from surface sources (ML)
0
200
400
600
800
1,000
1,200
1,400
1,600
1996 - 1
1996 - 14
1996 - 27
1996 - 40
1997 - 1
1997 - 14
1997 - 27
1997 - 40
1998 - 1
1998 - 14
1998 - 27
1998 - 40
1999 - 1
1999 - 14
1999 - 27
1999 - 40
2000 - 1
2000 - 14
2000 - 27
2000 - 40
2001 - 1
2001 - 14
2001 - 27
2001 - 40
2002 - 1
2002 - 14
2002 - 27
2002 - 40
2003 - 1
2003 - 14
2003 - 27
2003 - 40
2004 - 1
2004 - 14
2004 - 27
2004 - 40
2005 - 1
2005 - 14
2005 - 27
2005 - 40
2006 - 1
2006 - 14
2006 - 27
2006 - 40
Year - Week
Original estimate (Dobson Engineering Ltd., 2008)
Revised estimate



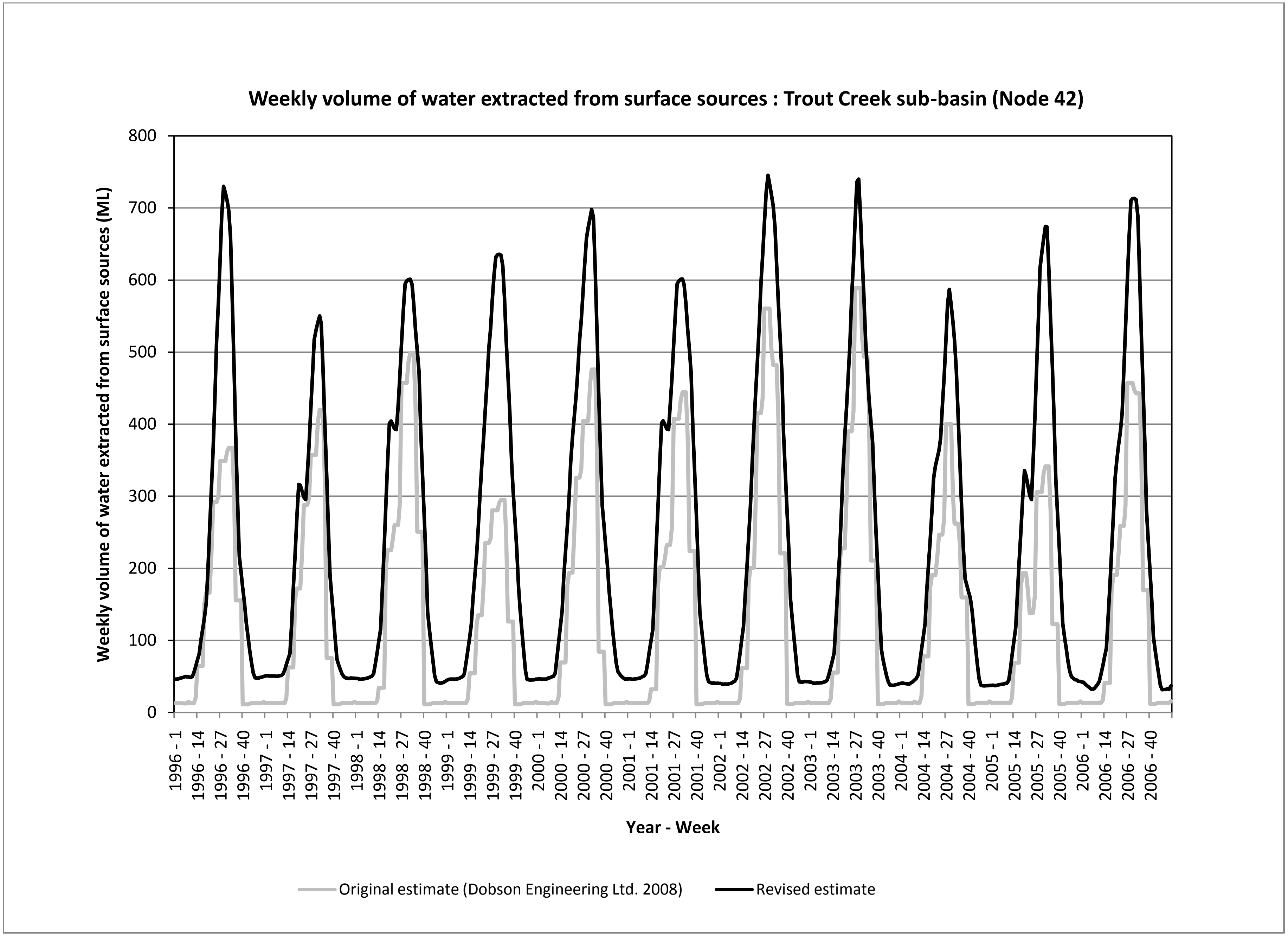
Weekly volume of water stored in or released from upland reservoirs: Vernon Creek sub-basin (Node 1)
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
-1,000
-2,000
-3,000
Total volume of water stored in (+) or released from (-) upland storage reservoirs (ML)
1996 - 1
1996 - 14
1996 - 27
1996 - 40
1997 - 1
1997 - 14
1997 - 27
1997 - 40
1998 - 1
1998 - 14
1998 - 27
1998 - 40
1999 - 1
1999 - 14
1999 - 27
1999 - 40
2000 - 1
2000 - 14
2000 - 27
2000 - 40
2001 - 1
2001 - 14
2001 - 27
2001 - 40
2002 - 1
2002 - 14
2002 - 27
2002 - 40
2003 - 1
2003 - 14
2003 - 27
2003 - 40
2004 - 1
2004 - 14
2004 - 27
2004 - 40
2005 - 1
2005 - 14
2005 - 27
2005 - 40
2006 - 1
2006 - 14
2006 - 27
2006 - 40
Year - Week
Original estimate (Dobson Engineering Ltd. 2008)
Revised estimate

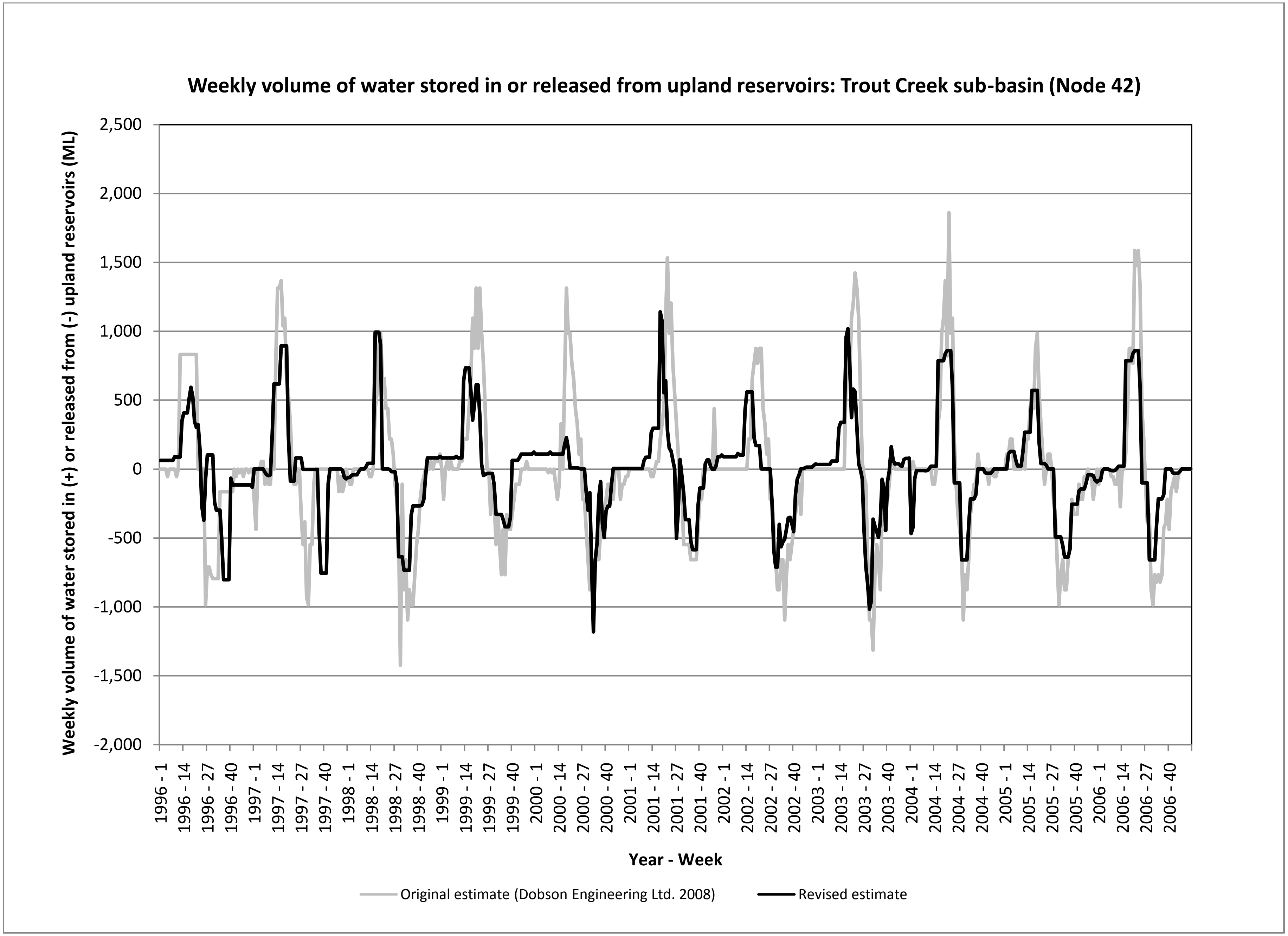


Weekly volume of water extracted from surface sources : Mission Creek sub-basin (Node 22)
Weekly volume of water extracted from surface sources (ML)
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
1996 - 1
1996 - 14
1996 - 27
1996 - 40
1997 - 1
1997 - 14
1997 - 27
1997 - 40
1998 - 1
1998 - 14
1998 - 27
1998 - 40
1999 - 1
1999 - 14
1999 - 27
1999 - 40
2000 - 1
2000 - 14
2000 - 27
2000 - 40
2001 - 1
2001 - 14
2001 - 27
2001 - 40
2002 - 1
2002 - 14
2002 - 27
2002 - 40
2003 - 1
2003 - 14
2003 - 27
2003 - 40
2004 - 1
2004 - 14
2004 - 27
2004 - 40
2005 - 1
2005 - 14
2005 - 27
2005 - 40
2006 - 1
2006 - 14
2006 - 27
2006 - 40
Year - Week
Original estimate (Dobson Engineering Ltd. 2008)
Revised estimate



Weekly volume of water stored in or released from upland reservoirs: Mission Creek sub-basin (Node 22)
Weekly volume of water stored in (+) or released from (-) upland reservoirs (ML)
5,000
4,000
3,000
2,000
1,000
0
-1,000
-2,000
-3,000
-4,000
1996 - 1
1996 - 14
1996 - 27
1996 - 40
1997 - 1
1997 - 14
1997 - 27
1997 - 40
1998 - 1
1998 - 14
1998 - 27
1998 - 40
1999 - 1
1999 - 14
1999 - 27
1999 - 40
2000 - 1
2000 - 14
2000 - 27
2000 - 40
2001 - 1
2001 - 14
2001 - 27
2001 - 40
2002 - 1
2002 - 14
2002 - 27
2002 - 40
2003 - 1
2003 - 14
2003 - 27
2003 - 40
2004 - 1
2004 - 14
2004 - 27
2004 - 40
2005 - 1
2005 - 14
2005 - 27
2005 - 40
2006 - 1
2006 - 14
2006 - 27
2006 - 40
Year - Week
Original esimate (Dobson Engineering Ltd. 2008)
Revised estimate


Weekly volume of water extracted from surface sources : Trout Creek sub-basin (Node 42)
Weekly volume of water extracted from surface sources (ML)
0
100
200
300
400
500
600
700
800
1996 - 1
1996 - 14
1996 - 27
1996 - 40
1997 - 1
1997 - 14
1997 - 27
1997 - 40
1998 - 1
1998 - 14
1998 - 27
1998 - 40
1999 - 1
1999 - 14
1999 - 27
1999 - 40
2000 - 1
2000 - 14
2000 - 27
2000 - 40
2001 - 1
2001 - 14
2001 - 27
2001 - 40
2002 - 1
2002 - 14
2002 - 27
2002 - 40
2003 - 1
2003 - 14
2003 - 27
2003 - 40
2004 - 1
2004 - 14
2004 - 27
2004 - 40
2005 - 1
2005 - 14
2005 - 27
2005 - 40
2006 - 1
2006 - 14
2006 - 27
2006 - 40
Year - Week
Original estimate (Dobson Engineering Ltd. 2008)
Revised estimate



Weekly volume of water stored in or released from upland reservoirs: Trout Creek sub-basin (Node 42)
Weekly volume of water stored in (+) or released from (-) upland reservoirs (ML)
2,500
2,000
1,500
1,000
500
0
-500
-1,000
-1,500
-2,000
1996 - 1
1996 - 14
1996 - 27
1996 - 40
1997 - 1
1997 - 14
1997 - 27
1997 - 40
1998 - 1
1998 - 14
1998 - 27
1998 - 40
1999 - 1
1999 - 14
1999 - 27
1999 - 40
2000 - 1
2000 - 14
2000 - 27
2000 - 40
2001 - 1
2001 - 14
2001 - 27
2001 - 40
2002 - 1
2002 - 14
2002 - 27
2002 - 40
2003 - 1
2003 - 14
2003 - 27
2003 - 40
2004 - 1
2004 - 14
2004 - 27
2004 - 40
2005 - 1
2005 - 14
2005 - 27
2005 - 40
2006 - 1
2006 - 14
2006 - 27
2006 - 40
Year - Week
Original estimate (Dobson Engineering Ltd. 2008)
Revised estimate

APPENDIX G

Okanagan Mainstem Lake

Storage Tables

Okanagan Mainstem Lake Storage Tables

Developed by Summit Environmental Consultants Ltd.

Wood Lake

Elevation (m)	Lake surface area (ha)	Volume (ML)
388.25	821.28	127,530
388.50	826.21	129,589
388.75	831.15	131,661
389.00	836.12	133,745
389.25	843.41	135,844
389.50	847.19	137,957
389.75	850.91	140,080
390.00	854.57	142,212
390.25	858.18	144,352
390.50	861.74	146,502
390.75	865.31	148,661
391.00	868.88	150,829
391.20	871.76	152,570
391.50	876.09	155,191
391.70	879.00	156,946
392.00	883.37	159,590
392.25	887.04	161,803
392.50	890.72	164,025
392.75	894.42	166,257
393.00	898.14	168,497
393.25	901.88	170,747
393.50	905.63	173,007
393.75	909.40	175,276
394.00	914.05	177,554
394.25	916.91	179,843
394.50	919.85	182,139

Notes:
1) Normal operating range = 391.2 m to 341.7 m
2) Calculations were restricted to the area above the Oyama Canal outlet.
3) Bathymetric data obtained from Canadian Hydrographic Service

Kalamalka Lake

Elevation (m)	Lake surface area (ha)	Volume (ML)
388.25	2,380.95	1,473,629
388.50	2,391.74	1,479,594
388.75	2,403.25	1,485,588
389.00	2,415.84	1,491,612
389.25	2,429.25	1,497,668
389.50	2,440.33	1,503,755
389.75	2,451.67	1,509,870
390.00	2,463.44	1,516,014
390.25	2,476.20	1,522,188
390.50	2,489.29	1,528,395
390.75	2,502.66	1,534,635
391.00	2,521.70	1,540,909
391.20	2,532.97	1,545,963
391.50	2,550.41	1,553,588
391.70	2,562.40	1,558,701
392.00	2,585.38	1,566,416
392.25	2,591.48	1,572,887
392.50	2,597.76	1,579,373
392.75	2,604.23	1,585,876
393.00	2,612.29	1,592,395
393.25	2,617.85	1,598,932
393.50	2,623.47	1,605,484
393.75	2,629.12	1,612,051
394.00	2,634.79	1,618,631
394.25	2,640.65	1,625,226
394.50	2,646.52	1,631,837

Notes:
1) Normal operating range = 391.2 m to 391.7 m
2) Calculations were restricted to the area above Kalamalka Lake outlet.
3) Bathymetric data obtained from Canadian Hydrographic Service

Okanagan Lake

Elevation (m)	Lake surface area (ha)	Volume (ML)
338.50	32,078.81	23,268,858
338.75	32,222.00	23,349,233
339.00	32,370.04	23,429,972
339.25	32,536.42	23,511,101
339.50	32,806.61	23,592,833
339.75	32,972.53	23,675,059
340.00	33,136.62	23,757,693
340.25	33,298.54	23,840,737
340.50	33,458.76	23,924,184
340.75	33,617.85	24,008,030
341.00	33,795.15	24,092,273
341.34	34,005.98	24,207,516
341.50	34,110.76	24,262,007
341.75	34,274.92	24,347,486
342.00	34,491.04	24,433,383
342.25	34,614.14	24,519,762
342.48	34,729.58	24,599,507
342.75	34,865.36	24,693,461
343.00	35,025.10	24,780,783
343.25	35,149.68	24,868,502
343.50	35,273.79	24,956,531
343.75	35,397.48	25,044,871
344.00	35,563.86	25,133,519
344.25	35,694.72	25,222,585
344.50	35,831.12	25,311,992
344.75	35,966.45	25,401,738
345.00	36,101.99	25,491,824
345.25	36,278.94	25,582,401
345.50	36,373.06	25,673,217

Notes:

1) Normal operating range = 341.44 m to 342.48 m

2) Calculations were restricted to the area above Okanagan Lake Outlet Dam.

3) Bathymetric data obtained from Canadian Hydrographic Service

Skaha Lake

Elevation (m)	Lake surface area (ha)	Volume (ML)
334.75	1,673.60	443,812
335.00	1,684.29	448,009
335.25	1,695.04	452,233
335.50	1,705.84	456,485
335.75	1,729.71	460,781
336.00	1,747.67	465,128
336.25	1,765.24	469,519
336.50	1,782.66	473,954
336.75	1,800.27	478,433
337.00	1,818.23	482,956
337.25	1,835.53	487,523
337.50	1,852.91	492,134
337.80	1,873.88	497,724
337.90	1,880.90	499,601
338.00	1,890.67	501,485
338.25	1,906.91	506,232
338.50	1,923.22	511,020
338.75	1,939.58	515,849
339.00	1,997.74	520,718
339.25	2,014.51	525,733
339.50	2,029.42	530,789
339.75	2,046.09	535,883
340.00	2,082.62	541,026
340.25	2,092.49	546,261
340.50	2,139.44	551,574
340.75	2,143.39	556,971

Notes:

1) Normal operating range = 337.80 m to 337.90 m

2) Calculations were restricted to the area above Skaha Lake Outlet Dam.

3) Bathymetric data obtained from Canadian Hydrographic Service

Vaseux Lake

Elevation (m)	Lake surface area (ha)	Volume (ML)
324.50	152.55	10,900
324.75	158.17	11,288
325.00	165.20	11,691
325.25	172.09	12,113
325.50	181.58	12,553
325.75	197.08	13,026
326.00	237.37	13,544
326.25	261.11	14,170
326.50	276.28	14,842
326.75	289.53	15,552
327.00	294.64	16,283
327.25	298.37	17,025
327.40	299.69	17,473
327.50	300.57	17,773
327.60	301.43	18,074
327.75	302.72	18,527
328.00	305.44	19,287
328.25	307.13	20,053
328.50	308.79	20,823
328.75	311.99	21,597
329.00	317.64	22,385
329.25	328.25	23,190
329.50	357.52	24,041
329.75	382.91	24,968
330.00	403.27	25,951
330.25	418.36	26,978
330.50	431.59	28,041

Notes:

1) Normal operating range = 327.40 m to 327.60 m

2) Calculations were restricted to the area above McIntyre Dam.

3) Bathymetric data obtained from Province of B.C.

Osoyoos Lake

Elevation (m)	Lake surface area (ha)	Volume (ML)
274.00	944.48	242,899
274.25	1,855.51	247,502
274.50	1,884.70	252,177
274.75	1,915.49	256,927
275.00	1,948.21	261,756
275.25	1,983.85	266,670
275.50	2,024.57	271,680
275.75	2,071.16	276,798
276.00	2,155.22	282,070
276.25	2,369.45	287,930
276.50	2,396.73	293,895
276.75	2,412.50	299,909
277.00	2,439.78	305,961
277.25	2,453.99	312,064
277.50	2,468.17	318,204
277.75	2,477.43	324,381
278.00	2,504.65	330,593
278.25	2,523.93	336,880
278.50	2,543.15	343,215
278.75	2,562.58	349,598
279.00	2,613.58	356,030
279.25	2,651.73	362,609
279.50	2,685.59	369,283
279.75	2,719.99	376,043
280.00	2,770.15	382,892
280.25	2,809.59	389,867
280.50	2,852.09	396,945
280.75	2,894.26	404,130

Notes:

1) Normal operating range = 277.06 m to 277.83 m

2) Calculations were restricted to the area above Zosel Dam.

3) Bathymetric data obtained from Province of B.C.

APPENDIX H

References Added to the Okanagan Information Database during this Study

Table H.1 Selected references added to the Okanagan Information Database during Part One of this study.

References Added to the Okanagan Information Database
Agua Consulting Inc. 2008. District of Summerland 2008 Water Master Plan. August 2008.
Anonymous. 2005. Trout Creek Water Use Plan: Reservoir Operating Agreement.
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APPENDIX I

Summary of Naturalized Streamflows in the Okanagan Basin by Node

Table I.1 Summary of naturalized streamflows in the Okanagan Basin by node.

Node	Description	Normal* Annual Discharge (m^3/s)	Node	Description	Normal* Annual Discharge (m^3/s)
00	Inflows to Kalamalka Lake	1.73	38	Robinson Creek	0.046
1	Vernon Cr. at outlet of Kalamalka Lk.	1.32	39	Residual Area E-7	0.001
3	Deep Creek	0.717	40	Naramata Creek	0.129
4	Residual Area W-1	0.018	41	Residual Area E-8	0.012
5	Irish Creek	0.045	42	Trout Creek	2.08
6	Residual Area W-2	0.057	43	Residual Area W-13	0.020
7	Residual Area E-1	0.033	44	Turnbull Creek	0.060
8	Equesis Creek	0.743	45	Residual Area E-9	0.020
9	Residual Area W-3	0.002	46	Penticton Creek	0.518
10	Nashwito Creek	0.340	49	Residual Area W-14	0.003
11	Residual Area W-4	0.020	50	Residual Area E-10	0.001
12	Vernon Creek (at mouth)	2.03	51	Shingle Creek	0.654
13	Residual Area E-2	0.107	52	Ellis Creek	0.752
14	Whiteman Creek	1.08	53	Residual Area W-15	0.029
15	Residual Area W-5	0.043	54	Residual Area E-11	0.242
16	Shorts Creek	1.32	55	Marron River	0.084
17	Residual Area W-6	0.077	56	Residual Area W-16	0.000
18	Lambly Creek	1.43	57	Residual Area W-17	0.027
19	Residual Area W-7	0.032	60	Shuttleworth Creek	0.361
20	Mill Creek	0.840	61	Residual Area W-18	0.007
21	Residual Area E-3	0.004	62	Residual Area W-19	0.008
22	Mission Creek	7.82	63	Residual Area E-12	0.024
23	Residual Area E-4	0.003	65	Residual Area E-13	0.001
24	Bellevue Creek	0.336	66	Vaseux Creek	1.53
25	Residual Area E-5	0.197	67	Residual Area W-20	0.005
26	McDougall Creek	0.089	68	Residual Area E-14	0.007
27	Residual Area W-8	0.027	69	Park Rill	0.113
28	Powers Creek	0.817	70	Residual Area W-21	0.049
29	Residual Area W-9	0.012	71	Wolfcub Creek	0.090
30	Trepanier Creek	1.22	72	Residual Area E-15	0.014
31	Residual Area W-10	0.017	73	Testalinden Creek	0.018
32	Peachland Creek	0.442	74	Residual Area W-22	0.000
33	Residual Area W-11	0.013	76	Residual Area E-16	0.005
34	Chute Creek	0.279	77	Residual Area W-23	0.027
35	Residual Area E-6	0.021	78	Inkaneep Creek	0.481
36	Eneas Creek	0.078	79	Residual Area E-17	0.291
37	Residual Area W-12	0.016			

*** Normal means "averaged over period 1996-2006".**

Table I.1 cont'd.

Node	Description	Normal Monthly Discharge (m^3/s)											
		Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
00	Inflows to Kalamalka Lake	0.747	0.795	1.01	5.33	6.23	2.95	0.876	0.613	0.480	0.375	0.518	0.571
1	Vernon Cr. at outlet of Kalamalka Lk.	0.437	0.328	0.275	0.794	3.28	3.88	2.05	1.65	1.10	0.706	0.458	0.305
3	Deep Creek	0.542	0.743	0.888	1.43	1.03	0.795	0.430	0.315	0.279	0.357	0.464	0.509
4	Residual Area W-1	0.000	0.001	0.008	0.039	0.074	0.046	0.015	0.011	0.008	0.005	0.001	0.000
5	Irish Creek	0.001	0.002	0.006	0.119	0.286	0.097	0.013	0.001	0.000	0.000	0.003	0.001
6	Residual Area W-2	0.010	0.013	0.019	0.136	0.301	0.115	0.026	0.011	0.007	0.010	0.015	0.012
7	Residual Area E-1	0.000	0.001	0.016	0.073	0.139	0.087	0.029	0.020	0.014	0.009	0.001	0.000
8	Equesis Creek	0.135	0.165	0.244	1.76	3.89	1.49	0.338	0.136	0.089	0.125	0.198	0.157
9	Residual Area W-3	0.000	0.000	0.001	0.004	0.007	0.004	0.001	0.001	0.001	0.000	0.000	0.000
10	Nashwito Creek	0.035	0.049	0.095	0.788	1.909	0.761	0.156	0.037	0.018	0.032	0.064	0.045
11	Residual Area W-4	0.000	0.001	0.009	0.043	0.082	0.051	0.017	0.012	0.008	0.005	0.001	0.000
12	Vernon Creek (at mouth)	1.02	1.13	1.23	2.34	4.38	4.74	2.51	1.99	1.40	1.09	0.958	0.854
13	Residual Area E-2	0.000	0.004	0.051	0.234	0.446	0.278	0.092	0.064	0.046	0.029	0.003	0.000
14	Whiteman Creek	0.175	0.215	0.371	2.18	5.68	2.51	0.568	0.173	0.122	0.165	0.258	0.205
15	Residual Area W-5	0.000	0.002	0.021	0.094	0.180	0.112	0.037	0.026	0.019	0.012	0.001	0.000
16	Shorts Creek	0.205	0.255	0.447	2.68	6.99	3.09	0.692	0.203	0.140	0.194	0.308	0.243
17	Residual Area W-6	0.000	0.003	0.037	0.169	0.323	0.201	0.066	0.047	0.033	0.021	0.002	0.000
18	Lambly Creek	0.173	0.230	0.448	2.97	7.84	3.43	0.737	0.174	0.103	0.161	0.289	0.216
19	Residual Area W-7	0.000	0.001	0.015	0.070	0.134	0.083	0.027	0.019	0.014	0.009	0.001	0.000
20	Mill Creek	0.487	0.504	0.574	2.13	2.45	1.27	0.483	0.439	0.391	0.354	0.405	0.424
21	Residual Area E-3	0.000	0.000	0.002	0.009	0.017	0.011	0.004	0.002	0.002	0.001	0.000	0.000
22	Mission Creek	1.58	1.45	2.09	11.6	29.2	28.6	7.64	2.02	1.89	2.11	2.39	1.74
23	Residual Area E-4	0.000	0.000	0.002	0.007	0.014	0.009	0.003	0.002	0.001	0.001	0.000	0.000
24	Bellevue Creek	0.011	0.012	0.032	0.466	1.95	1.20	0.190	0.018	0.020	0.040	0.037	0.017
25	Residual Area E-5	0.014	0.015	0.025	0.270	1.10	0.681	0.113	0.018	0.019	0.030	0.029	0.017
26	McDougall Creek	0.000	0.000	0.006	0.254	0.560	0.149	0.050	0.007	0.011	0.004	0.001	0.000
27	Residual Area W-8	0.000	0.001	0.013	0.060	0.115	0.071	0.024	0.017	0.012	0.008	0.001	0.000
28	Powers Creek	0.161	0.173	0.255	1.41	4.30	1.98	0.464	0.187	0.157	0.178	0.206	0.180
29	Residual Area W-9	0.001	0.002	0.005	0.022	0.049	0.034	0.010	0.006	0.004	0.003	0.002	0.001
30	Trepanier Creek	0.169	0.153	0.227	1.76	7.06	3.32	0.725	0.270	0.235	0.241	0.212	0.195
31	Residual Area W-10	0.002	0.003	0.007	0.031	0.068	0.047	0.014	0.008	0.005	0.004	0.003	0.002
32	Peachland Creek	0.115	0.111	0.145	0.585	2.11	1.04	0.358	0.189	0.141	0.132	0.140	0.127
33	Residual Area W-11	0.001	0.002	0.006	0.023	0.052	0.035	0.010	0.006	0.004	0.003	0.002	0.001
34	Chute Creek	0.019	0.021	0.036	0.382	1.56	0.965	0.160	0.025	0.027	0.043	0.041	0.024
35	Residual Area E-6	0.002	0.004	0.009	0.038	0.086	0.059	0.017	0.011	0.006	0.005	0.004	0.002
36	Eneas Creek	0.008	0.006	0.013	0.137	0.443	0.213	0.053	0.018	0.011	0.008	0.011	0.009
37	Residual Area W-12	0.000	0.001	0.009	0.036	0.071	0.044	0.014	0.007	0.001	0.000	0.000	0.000

Table I.1 cont'd.

Node	Description	Normal Monthly Discharge (m^3/s)											
		Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
38	Robinson Creek	0.000	0.000	0.001	0.062	0.284	0.172	0.023	0.000	0.001	0.002	0.001	0.000
39	Residual Area E-7	0.000	0.000	0.001	0.003	0.006	0.004	0.001	0.001	0.000	0.000	0.000	0.000
40	Naramata Creek	0.001	0.002	0.008	0.179	0.762	0.467	0.071	0.004	0.005	0.011	0.011	0.004
41	Residual Area E-8	0.000	0.001	0.007	0.027	0.054	0.034	0.010	0.006	0.001	0.000	0.000	0.000
42	Trout Creek	0.420	0.390	0.482	2.46	9.98	7.17	1.81	0.611	0.428	0.456	0.490	0.441
43	Residual Area W-13	0.000	0.001	0.011	0.045	0.090	0.056	0.017	0.009	0.001	0.000	0.000	0.000
44	Turnbull Creek	0.000	0.000	0.002	0.082	0.365	0.222	0.031	0.001	0.001	0.003	0.002	0.000
45	Residual Area E-9	0.000	0.001	0.011	0.045	0.090	0.056	0.017	0.009	0.001	0.000	0.000	0.000
46	Penticton Creek	0.011	0.012	0.042	0.721	3.036	1.865	0.291	0.022	0.025	0.054	0.051	0.020
49	Residual Area W-14	0.000	0.000	0.002	0.008	0.016	0.010	0.003	0.002	0.000	0.000	0.000	0.000
50	Residual Area E-10	0.000	0.000	0.001	0.003	0.005	0.003	0.001	0.001	0.000	0.000	0.000	0.000
51	Shingle Creek	0.100	0.097	0.107	0.404	2.647	2.947	0.672	0.226	0.142	0.141	0.149	0.115
52	Ellis Creek	0.068	0.069	0.127	1.21	4.08	2.42	0.439	0.081	0.084	0.126	0.124	0.075
53	Residual Area W-15	0.000	0.001	0.016	0.067	0.134	0.083	0.026	0.014	0.001	0.000	0.000	0.000
54	Residual Area E-11	0.044	0.043	0.065	0.435	1.187	0.679	0.147	0.047	0.047	0.060	0.060	0.044
55	Marron River	0.024	0.028	0.045	0.201	0.354	0.177	0.052	0.029	0.021	0.021	0.025	0.024
56	Residual Area W-16	0.000	0.000	0.000	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000
57	Residual Area W-17	0.000	0.001	0.015	0.062	0.124	0.077	0.024	0.013	0.001	0.000	0.000	0.000
60	Shuttleworth Creek	0.041	0.040	0.076	0.673	1.887	1.068	0.214	0.046	0.046	0.066	0.067	0.041
61	Residual Area W-18	0.000	0.000	0.004	0.016	0.033	0.021	0.006	0.003	0.000	0.000	0.000	0.000
62	Residual Area W-19	0.000	0.000	0.004	0.018	0.036	0.023	0.007	0.004	0.000	0.000	0.000	0.000
63	Residual Area E-12	0.000	0.001	0.013	0.055	0.110	0.068	0.021	0.012	0.001	0.000	0.000	0.000
65	Residual Area E-13	0.000	0.000	0.001	0.002	0.005	0.003	0.001	0.000	0.000	0.000	0.000	0.000
66	Vaseux Creek	0.258	0.256	0.395	2.75	7.55	4.39	0.959	0.278	0.280	0.359	0.360	0.259
67	Residual Area W-20	0.000	0.000	0.003	0.011	0.022	0.014	0.004	0.002	0.000	0.000	0.000	0.000
68	Residual Area E-14	0.000	0.000	0.004	0.016	0.031	0.019	0.006	0.003	0.000	0.000	0.000	0.000
69	Park Rill	0.013	0.017	0.047	0.309	0.566	0.269	0.064	0.021	0.009	0.008	0.013	0.011
70	Residual Area W-21	0.014	0.016	0.026	0.117	0.205	0.103	0.030	0.017	0.012	0.012	0.015	0.014
71	Wolfcub Creek	0.007	0.009	0.025	0.208	0.476	0.248	0.051	0.011	0.007	0.009	0.011	0.007
72	Residual Area E-15	0.000	0.001	0.008	0.032	0.063	0.040	0.012	0.007	0.001	0.000	0.000	0.000
73	Testalinden Creek	0.001	0.001	0.006	0.052	0.099	0.045	0.009	0.001	0.000	0.000	0.001	0.001
74	Residual Area W-22	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
76	Residual Area E-16	0.000	0.000	0.003	0.011	0.022	0.014	0.004	0.002	0.000	0.000	0.000	0.000
77	Residual Area W-23	0.000	0.001	0.015	0.062	0.125	0.078	0.024	0.013	0.001	0.000	0.000	0.000
78	Inkaneep Creek	0.085	0.094	0.171	1.05	2.22	1.25	0.315	0.121	0.088	0.092	0.110	0.083
79	Residual Area E-17	0.068	0.074	0.117	0.609	1.326	0.715	0.178	0.079	0.065	0.073	0.079	0.067

Table I.1 cont'd.

		Normal Weekly Discharge (m^3/s)												
Node	**Description**	**Week 1**	**Week 2**	**Week 3**	**Week 4**	**Week 5**	**Week 6**	**Week 7**	**Week 8**	**Week 9**	**Week 10**	**Week 11**	**Week 12**	**Week 13**
00	Inflows to Kalamalka Lake	0.792	0.737	0.591	0.895	0.687	0.852	0.754	0.785	0.922	0.933	0.929	1.13	1.33
1	Vernon Cr. at outlet of Kalamalka Lk.	0.471	0.470	0.430	0.400	0.384	0.349	0.327	0.300	0.269	0.287	0.277	0.285	0.302
3	Deep Creek	0.581	0.563	0.529	0.660	0.663	0.767	0.836	0.892	0.858	1.06	1.17	0.912	0.920
4	Residual Area W-1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.004	0.006	0.007	0.009	0.019
5	Irish Creek	0.000	0.000	0.000	0.003	0.002	0.003	0.003	0.003	0.002	0.004	0.007	0.009	0.011
6	Residual Area W-2	0.011	0.010	0.010	0.012	0.012	0.013	0.013	0.013	0.012	0.013	0.019	0.024	0.028
7	Residual Area E-1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.007	0.012	0.014	0.016	0.035
8	Equesis Creek	0.138	0.133	0.129	0.157	0.162	0.167	0.172	0.172	0.155	0.174	0.249	0.311	0.358
9	Residual Area W-3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.002
10	Nashwito Creek	0.037	0.035	0.033	0.045	0.047	0.050	0.052	0.053	0.047	0.059	0.097	0.128	0.151
11	Residual Area W-4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.004	0.007	0.008	0.010	0.021
12	Vernon Creek (at mouth)	1.05	1.03	0.95	1.05	1.04	1.11	1.15	1.18	1.12	1.33	1.43	1.19	1.21
13	Residual Area E-2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.008	0.022	0.038	0.044	0.053	0.114
14	Whiteman Creek	0.182	0.173	0.168	0.202	0.205	0.212	0.222	0.229	0.218	0.263	0.386	0.478	0.543
15	Residual Area W-5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.009	0.015	0.018	0.021	0.046
16	Shorts Creek	0.214	0.204	0.197	0.239	0.243	0.251	0.264	0.272	0.259	0.314	0.465	0.579	0.659
17	Residual Area W-6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.006	0.016	0.027	0.032	0.038	0.082
18	Lambly Creek	0.183	0.171	0.163	0.211	0.216	0.225	0.239	0.248	0.234	0.296	0.467	0.595	0.686
19	Residual Area W-7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.007	0.011	0.013	0.016	0.034
20	Mill Creek	0.503	0.483	0.431	0.539	0.465	0.524	0.489	0.500	0.549	0.553	0.552	0.625	0.694
21	Residual Area E-3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.002	0.002	0.004
22	Mission Creek	1.23	1.52	1.80	1.83	1.46	1.33	1.43	1.52	1.56	1.67	2.08	2.50	2.98
23	Residual Area E-4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.002	0.004
24	Bellevue Creek	0.012	0.013	0.011	0.010	0.010	0.011	0.012	0.014	0.017	0.020	0.027	0.044	0.057
25	Residual Area E-5	0.015	0.015	0.014	0.013	0.013	0.014	0.015	0.016	0.017	0.019	0.023	0.032	0.040
26	McDougall Creek	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.010	0.023
27	Residual Area W-8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.006	0.010	0.011	0.014	0.029
28	Powers Creek	0.168	0.164	0.162	0.176	0.174	0.174	0.177	0.182	0.177	0.197	0.263	0.315	0.359
29	Residual Area W-9	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.003	0.003	0.004	0.005	0.005	0.011
30	Trepanier Creek	0.184	0.181	0.182	0.183	0.171	0.161	0.155	0.167	0.161	0.169	0.226	0.281	0.344
31	Residual Area W-10	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.004	0.006	0.006	0.007	0.015
32	Peachland Creek	0.124	0.123	0.120	0.119	0.117	0.116	0.113	0.115	0.118	0.125	0.150	0.180	0.202
33	Residual Area W-11	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.003	0.003	0.004	0.005	0.006	0.011
34	Chute Creek	0.021	0.021	0.020	0.019	0.019	0.020	0.021	0.023	0.024	0.027	0.033	0.046	0.057
35	Residual Area E-6	0.002	0.002	0.002	0.003	0.003	0.003	0.004	0.004	0.006	0.007	0.008	0.009	0.019
36	Eneas Creek	0.008	0.008	0.008	0.008	0.008	0.008	0.006	0.005	0.007	0.009	0.015	0.018	0.021
37	Residual Area W-12	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.004	0.007	0.008	0.009	0.018

Table I.1 cont'd.

		Normal Weekly Discharge (m^3/s)												
Node	**Description**	**Week 14**	**Week 15**	**Week 16**	**Week 17**	**Week 18**	**Week 19**	**Week 20**	**Week 21**	**Week 22**	**Week 23**	**Week 24**	**Week 25**	**Week 26**
00	Inflows to Kalamalka Lake	2.63	4.86	6.25	7.81	7.84	6.69	5.94	5.32	5.11	4.08	3.02	2.00	1.58
1	Vernon Cr. at outlet of Kalamalka Lk.	0.330	0.458	0.849	1.405	2.219	2.994	3.511	3.810	4.031	4.153	4.089	3.780	3.374
3	Deep Creek	1.06	1.63	1.82	1.87	1.26	0.92	1.12	1.23	1.08	0.970	0.811	0.801	0.781
4	Residual Area W-1	0.029	0.037	0.037	0.050	0.064	0.079	0.081	0.076	0.064	0.052	0.045	0.044	0.034
5	Irish Creek	0.022	0.080	0.115	0.269	0.293	0.238	0.319	0.321	0.254	0.138	0.084	0.059	0.038
6	Residual Area W-2	0.040	0.097	0.132	0.284	0.307	0.253	0.333	0.335	0.269	0.156	0.102	0.078	0.057
7	Residual Area E-1	0.054	0.071	0.071	0.094	0.121	0.149	0.153	0.143	0.120	0.098	0.085	0.082	0.064
8	Equesis Creek	0.520	1.25	1.71	3.68	3.98	3.28	4.31	4.34	3.48	2.02	1.32	1.01	0.744
9	Residual Area W-3	0.003	0.004	0.004	0.005	0.006	0.007	0.008	0.007	0.006	0.005	0.004	0.004	0.003
10	Nashwito Creek	0.224	0.557	0.757	1.67	1.83	1.54	2.14	2.23	1.79	1.04	0.679	0.511	0.372
11	Residual Area W-4	0.032	0.042	0.042	0.056	0.072	0.088	0.090	0.084	0.071	0.058	0.050	0.049	0.038
12	Vernon Creek (at mouth)	1.37	2.06	2.65	3.26	3.46	3.90	4.61	5.02	5.10	5.11	4.89	4.57	4.15
13	Residual Area E-2	0.175	0.227	0.227	0.302	0.389	0.477	0.489	0.458	0.386	0.314	0.272	0.264	0.207
14	Whiteman Creek	0.726	1.58	2.07	4.47	4.98	4.39	6.45	6.96	5.69	3.38	2.27	1.74	1.30
15	Residual Area W-5	0.071	0.092	0.092	0.122	0.157	0.193	0.198	0.185	0.156	0.127	0.110	0.107	0.084
16	Shorts Creek	0.884	1.94	2.54	5.50	6.13	5.40	7.93	8.57	7.00	4.15	2.79	2.13	1.59
17	Residual Area W-6	0.127	0.164	0.164	0.219	0.282	0.346	0.355	0.332	0.280	0.227	0.197	0.191	0.150
18	Lambly Creek	0.940	2.132	2.808	6.156	6.866	6.045	8.902	9.620	7.852	4.630	3.092	2.348	1.733
19	Residual Area W-7	0.052	0.068	0.068	0.091	0.117	0.143	0.147	0.138	0.116	0.094	0.082	0.079	0.062
20	Mill Creek	1.16	1.96	2.45	3.01	3.02	2.61	2.34	2.12	2.05	1.68	1.30	0.935	0.785
21	Residual Area E-3	0.007	0.009	0.009	0.012	0.015	0.018	0.019	0.018	0.015	0.012	0.010	0.010	0.008
22	Mission Creek	4.95	8.87	12.2	20.0	23.3	22.4	29.9	35.7	37.3	33.0	31.5	25.8	18.8
23	Residual Area E-4	0.005	0.007	0.007	0.009	0.012	0.015	0.015	0.014	0.012	0.010	0.008	0.008	0.006
24	Bellevue Creek	0.088	0.281	0.464	1.04	1.38	1.42	2.08	2.52	2.30	1.59	1.19	0.833	0.599
25	Residual Area E-5	0.057	0.166	0.269	0.594	0.784	0.808	1.176	1.424	1.303	0.901	0.677	0.476	0.345
26	McDougall Creek	0.057	0.145	0.262	0.557	0.738	0.652	0.578	0.412	0.299	0.188	0.121	0.112	0.107
27	Residual Area W-8	0.045	0.058	0.058	0.078	0.100	0.123	0.126	0.118	0.099	0.081	0.070	0.068	0.053
28	Powers Creek	0.470	0.941	1.32	2.89	3.73	3.41	4.83	5.04	4.14	2.61	1.84	1.40	1.04
29	Residual Area W-9	0.016	0.021	0.021	0.030	0.041	0.053	0.054	0.051	0.045	0.038	0.034	0.033	0.025
30	Trepanier Creek	0.475	0.925	1.57	3.75	6.03	5.76	7.88	7.88	6.50	4.33	3.18	2.35	1.72
31	Residual Area W-10	0.022	0.028	0.028	0.042	0.057	0.072	0.075	0.071	0.061	0.052	0.047	0.045	0.035
32	Peachland Creek	0.240	0.366	0.569	1.145	1.675	1.918	2.490	2.308	1.933	1.324	0.961	0.787	0.684
33	Residual Area W-11	0.017	0.022	0.022	0.032	0.043	0.055	0.056	0.053	0.047	0.040	0.036	0.034	0.026
34	Chute Creek	0.081	0.235	0.380	0.841	1.11	1.14	1.67	2.02	1.85	1.28	0.959	0.674	0.488
35	Residual Area E-6	0.028	0.036	0.036	0.053	0.072	0.091	0.094	0.089	0.077	0.066	0.059	0.057	0.044
36	Eneas Creek	0.033	0.093	0.136	0.275	0.374	0.370	0.503	0.484	0.422	0.295	0.193	0.142	0.113
37	Residual Area W-12	0.027	0.034	0.034	0.047	0.061	0.076	0.078	0.073	0.062	0.050	0.044	0.042	0.033

Table I.1 cont'd.

Node	Description	Normal Weekly Discharge (m^3/s)												
		Week 27	**Week 28**	**Week 29**	**Week 30**	**Week 31**	**Week 32**	**Week 33**	**Week 34**	**Week 35**	**Week 36**	**Week 37**	**Week 38**	**Week 39**
00	Inflows to Kalamalka Lake	1.04	1.23	1.08	1.06	0.738	0.718	0.616	0.489	0.509	0.562	0.457	0.554	0.340
1	Vernon Cr. at outlet of Kalamalka Lk.	2.96	2.62	2.37	2.21	2.01	1.82	1.64	1.48	1.32	1.23	1.12	1.04	0.964
3	Deep Creek	0.729	0.585	0.515	0.477	0.371	0.425	0.340	0.287	0.287	0.330	0.301	0.314	0.276
4	Residual Area W-1	0.025	0.017	0.017	0.015	0.013	0.011	0.010	0.010	0.009	0.008	0.007	0.007	0.007
5	Irish Creek	0.027	0.018	0.009	0.007	0.003	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
6	Residual Area W-2	0.046	0.034	0.025	0.020	0.014	0.012	0.009	0.008	0.007	0.008	0.006	0.007	0.006
7	Residual Area E-1	0.047	0.031	0.031	0.028	0.025	0.021	0.020	0.019	0.017	0.015	0.014	0.014	0.013
8	Equesis Creek	0.592	0.444	0.317	0.257	0.185	0.156	0.123	0.102	0.091	0.098	0.081	0.090	0.082
9	Residual Area W-3	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
10	Nashwito Creek	0.291	0.205	0.134	0.098	0.062	0.046	0.030	0.020	0.017	0.022	0.016	0.018	0.015
11	Residual Area W-4	0.028	0.018	0.018	0.017	0.015	0.012	0.012	0.011	0.010	0.009	0.008	0.008	0.008
12	Vernon Creek (at mouth)	3.68	3.20	2.88	2.68	2.38	2.24	1.97	1.76	1.61	1.55	1.42	1.35	1.24
13	Residual Area E-2	0.150	0.100	0.100	0.091	0.079	0.066	0.063	0.061	0.055	0.050	0.045	0.045	0.041
14	Whiteman Creek	1.04	0.742	0.500	0.371	0.252	0.201	0.152	0.123	0.112	0.123	0.109	0.128	0.120
15	Residual Area W-5	0.060	0.041	0.041	0.037	0.032	0.027	0.025	0.025	0.022	0.020	0.018	0.018	0.016
16	Shorts Creek	1.27	0.904	0.607	0.448	0.300	0.238	0.178	0.142	0.128	0.142	0.125	0.147	0.138
17	Residual Area W-6	0.108	0.073	0.073	0.066	0.057	0.048	0.045	0.044	0.040	0.036	0.033	0.033	0.030
18	Lambly Creek	1.376	0.963	0.627	0.447	0.282	0.212	0.145	0.106	0.090	0.108	0.087	0.110	0.099
19	Residual Area W-7	0.045	0.030	0.030	0.027	0.024	0.020	0.019	0.018	0.017	0.015	0.014	0.014	0.012
20	Mill Creek	0.593	0.658	0.607	0.597	0.483	0.476	0.440	0.395	0.401	0.420	0.383	0.418	0.341
21	Residual Area E-3	0.006	0.004	0.004	0.004	0.003	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.002
22	Mission Creek	12.2	10.7	6.72	5.22	3.23	2.37	1.72	1.69	1.20	1.67	1.72	2.60	1.75
23	Residual Area E-4	0.005	0.003	0.003	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.001	0.001	0.001
24	Bellevue Creek	0.409	0.227	0.131	0.061	0.036	0.022	0.017	0.010	0.009	0.010	0.015	0.036	0.027
25	Residual Area E-5	0.238	0.136	0.082	0.042	0.028	0.020	0.017	0.013	0.012	0.013	0.016	0.028	0.023
26	McDougall Creek	0.085	0.064	0.046	0.028	0.016	0.009	0.006	0.005	0.006	0.010	0.013	0.015	0.012
27	Residual Area W-8	0.038	0.026	0.026	0.024	0.020	0.017	0.016	0.016	0.014	0.013	0.012	0.012	0.010
28	Powers Creek	0.816	0.600	0.435	0.342	0.256	0.214	0.174	0.151	0.143	0.156	0.158	0.168	0.166
29	Residual Area W-9	0.017	0.010	0.010	0.009	0.008	0.006	0.006	0.006	0.005	0.004	0.003	0.003	0.003
30	Trepanier Creek	1.27	0.926	0.681	0.534	0.404	0.324	0.255	0.212	0.202	0.228	0.254	0.261	0.266
31	Residual Area W-10	0.024	0.014	0.014	0.013	0.011	0.009	0.008	0.008	0.007	0.005	0.005	0.005	0.005
32	Peachland Creek	0.546	0.452	0.385	0.318	0.253	0.213	0.176	0.155	0.137	0.139	0.140	0.149	0.137
33	Residual Area W-11	0.018	0.011	0.011	0.010	0.008	0.007	0.006	0.006	0.005	0.004	0.004	0.004	0.003
34	Chute Creek	0.337	0.192	0.116	0.060	0.040	0.029	0.024	0.018	0.018	0.018	0.023	0.040	0.033
35	Residual Area E-6	0.030	0.018	0.018	0.016	0.014	0.011	0.010	0.010	0.008	0.007	0.006	0.006	0.006
36	Eneas Creek	0.086	0.067	0.052	0.039	0.027	0.020	0.016	0.012	0.010	0.012	0.011	0.012	0.010
37	Residual Area W-12	0.023	0.015	0.015	0.013	0.011	0.008	0.008	0.007	0.004	0.002	0.000	0.000	0.000

Table I.1 cont'd.

Node	Description	Normal Weekly Discharge (m^3/s)												
		Week 40	Week 41	Week 42	Week 43	Week 44	Week 45	Week 46	Week 47	Week 48	Week 49	Week 50	Week 51	Week 52
00	Inflows to Kalamalka Lake	0.319	0.298	0.377	0.440	0.526	0.469	0.535	0.551	0.509	0.664	0.488	0.709	0.457
1	Vernon Cr. at outlet of Kalamalka Lk.	0.859	0.764	0.669	0.599	0.554	0.502	0.447	0.422	0.386	0.351	0.318	0.298	0.241
3	Deep Creek	0.295	0.339	0.509	0.415	0.384	0.395	0.526	0.563	0.651	0.559	0.528	0.538	0.567
4	Residual Area W-1	0.006	0.005	0.005	0.004	0.002	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5	Irish Creek	0.000	0.000	0.000	0.001	0.001	0.001	0.004	0.002	0.002	0.000	0.000	0.000	0.000
6	Residual Area W-2	0.006	0.007	0.011	0.012	0.013	0.014	0.016	0.013	0.013	0.011	0.010	0.010	0.010
7	Residual Area E-1	0.011	0.010	0.010	0.008	0.005	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
8	Equesis Creek	0.081	0.094	0.142	0.153	0.165	0.178	0.209	0.173	0.166	0.141	0.136	0.128	0.126
9	Residual Area W-3	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
10	Nashwito Creek	0.014	0.019	0.038	0.042	0.048	0.054	0.069	0.053	0.051	0.038	0.035	0.031	0.030
11	Residual Area W-4	0.007	0.006	0.006	0.005	0.003	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
12	Vernon Creek (at mouth)	1.15	1.10	1.17	1.01	0.934	0.892	0.966	0.978	1.028	0.903	0.839	0.829	0.801
13	Residual Area E-2	0.036	0.031	0.031	0.025	0.015	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000
14	Whiteman Creek	0.116	0.132	0.183	0.192	0.207	0.227	0.272	0.228	0.219	0.185	0.176	0.165	0.165
15	Residual Area W-5	0.015	0.013	0.013	0.010	0.006	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000
16	Shorts Creek	0.134	0.152	0.216	0.226	0.245	0.270	0.326	0.271	0.260	0.218	0.207	0.193	0.193
17	Residual Area W-6	0.026	0.023	0.023	0.018	0.011	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000
18	Lambly Creek	0.094	0.113	0.185	0.197	0.220	0.246	0.309	0.248	0.236	0.188	0.175	0.159	0.159
19	Residual Area W-7	0.011	0.009	0.009	0.008	0.004	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
20	Mill Creek	0.333	0.326	0.354	0.377	0.408	0.387	0.411	0.417	0.402	0.457	0.394	0.473	0.383
21	Residual Area E-3	0.001	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
22	Mission Creek	1.89	1.96	2.52	2.03	2.24	2.40	2.87	2.17	2.15	1.92	1.81	1.63	1.49
23	Residual Area E-4	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
24	Bellevue Creek	0.026	0.039	0.054	0.044	0.044	0.049	0.042	0.029	0.024	0.020	0.016	0.015	0.012
25	Residual Area E-5	0.023	0.030	0.038	0.032	0.033	0.035	0.031	0.024	0.021	0.019	0.017	0.016	0.015
26	McDougall Creek	0.009	0.004	0.003	0.003	0.003	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
27	Residual Area W-8	0.009	0.008	0.008	0.007	0.004	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
28	Powers Creek	0.166	0.169	0.190	0.183	0.187	0.198	0.214	0.195	0.189	0.174	0.171	0.160	0.165
29	Residual Area W-9	0.003	0.003	0.003	0.003	0.003	0.002	0.002	0.002	0.002	0.001	0.001	0.001	0.001
30	Trepanier Creek	0.270	0.262	0.260	0.221	0.213	0.229	0.217	0.216	0.206	0.202	0.205	0.182	0.200
31	Residual Area W-10	0.005	0.004	0.004	0.004	0.004	0.003	0.003	0.003	0.002	0.002	0.002	0.002	0.002
32	Peachland Creek	0.130	0.127	0.137	0.125	0.126	0.142	0.140	0.137	0.129	0.126	0.127	0.115	0.115
33	Residual Area W-11	0.003	0.003	0.003	0.003	0.003	0.002	0.002	0.002	0.002	0.002	0.001	0.001	0.001
34	Chute Creek	0.032	0.042	0.054	0.046	0.046	0.050	0.045	0.035	0.030	0.027	0.024	0.023	0.021
35	Residual Area E-6	0.006	0.006	0.006	0.005	0.005	0.004	0.004	0.003	0.003	0.003	0.002	0.002	0.002
36	Eneas Creek	0.008	0.008	0.007	0.007	0.008	0.011	0.010	0.010	0.009	0.008	0.008	0.006	0.006
37	Residual Area W-12	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table I.1 cont'd.

Node	Description	Normal Weekly Discharge (m^3/s)												
		Week 1	**Week 2**	**Week 3**	**Week 4**	**Week 5**	**Week 6**	**Week 7**	**Week 8**	**Week 9**	**Week 10**	**Week 11**	**Week 12**	**Week 13**
38	Robinson Creek	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.002
39	Residual Area E-7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.001
40	Naramata Creek	0.002	0.002	0.001	0.001	0.001	0.002	0.002	0.002	0.003	0.004	0.006	0.013	0.018
41	Residual Area E-8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.003	0.005	0.006	0.007	0.014
42	Trout Creek	0.411	0.421	0.425	0.430	0.436	0.411	0.378	0.338	0.381	0.433	0.540	0.550	0.555
43	Residual Area W-13	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.005	0.008	0.010	0.011	0.022
44	Turnbull Creek	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.003	0.005
45	Residual Area E-9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.005	0.008	0.010	0.011	0.022
46	Penticton Creek	0.013	0.014	0.011	0.010	0.010	0.011	0.013	0.016	0.019	0.023	0.034	0.060	0.081
49	Residual Area W-14	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.002	0.002	0.004
50	Residual Area E-10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.001
51	Shingle Creek	0.101	0.102	0.107	0.111	0.109	0.105	0.097	0.092	0.093	0.100	0.115	0.124	0.131
52	Ellis Creek	0.070	0.077	0.072	0.067	0.064	0.067	0.070	0.076	0.081	0.091	0.110	0.166	0.210
53	Residual Area W-15	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.007	0.012	0.014	0.017	0.033
54	Residual Area E-11	0.044	0.048	0.046	0.044	0.042	0.043	0.044	0.046	0.048	0.052	0.058	0.081	0.099
55	Marron River	0.023	0.024	0.025	0.025	0.027	0.027	0.027	0.027	0.033	0.039	0.050	0.054	0.057
56	Residual Area W-16	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
57	Residual Area W-17	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.007	0.011	0.013	0.015	0.031
60	Shuttleworth Creek	0.041	0.047	0.044	0.040	0.037	0.039	0.041	0.044	0.047	0.053	0.064	0.101	0.130
61	Residual Area W-18	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.003	0.004	0.004	0.008
62	Residual Area W-19	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.003	0.004	0.005	0.009
63	Residual Area E-12	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.006	0.010	0.012	0.014	0.027
65	Residual Area E-13	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001
66	Vaseux Creek	0.262	0.284	0.272	0.258	0.246	0.251	0.258	0.271	0.283	0.308	0.350	0.498	0.613
67	Residual Area W-20	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.002	0.003	0.005
68	Residual Area E-14	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.003	0.003	0.004	0.008
69	Park Rill	0.012	0.013	0.014	0.015	0.016	0.017	0.017	0.016	0.026	0.036	0.054	0.061	0.066
70	Residual Area W-21	0.014	0.014	0.014	0.015	0.015	0.016	0.016	0.016	0.019	0.022	0.029	0.031	0.033
71	Wolfcub Creek	0.007	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.012	0.017	0.025	0.033	0.039
72	Residual Area E-15	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.003	0.006	0.007	0.008	0.016
73	Testalinden Creek	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.003	0.004	0.007	0.008	0.008
74	Residual Area W-22	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
76	Residual Area E-16	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.002	0.003	0.005
77	Residual Area W-23	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.007	0.011	0.013	0.016	0.031
78	Inkaneep Creek	0.083	0.089	0.088	0.088	0.089	0.091	0.093	0.094	0.112	0.135	0.177	0.215	0.242
79	Residual Area E-17	0.067	0.070	0.070	0.070	0.071	0.072	0.073	0.074	0.085	0.098	0.121	0.142	0.158

Table I.1 cont'd.

Node	Description	Normal Weekly Discharge (m^3/s)												
		Week 14	**Week 15**	**Week 16**	**Week 17**	**Week 18**	**Week 19**	**Week 20**	**Week 21**	**Week 22**	**Week 23**	**Week 24**	**Week 25**	**Week 26**
38	Robinson Creek	0.006	0.035	0.062	0.148	0.199	0.206	0.304	0.370	0.338	0.231	0.171	0.117	0.082
39	Residual Area E-7	0.002	0.003	0.003	0.004	0.005	0.006	0.006	0.006	0.005	0.004	0.004	0.003	0.003
40	Naramata Creek	0.030	0.106	0.178	0.406	0.539	0.556	0.814	0.988	0.903	0.621	0.464	0.324	0.231
41	Residual Area E-8	0.020	0.026	0.026	0.036	0.047	0.058	0.060	0.056	0.047	0.038	0.033	0.032	0.025
42	Trout Creek	0.738	1.73	2.30	4.66	6.84	6.91	10.7	12.2	12.5	10.1	6.78	4.89	3.79
43	Residual Area W-13	0.034	0.043	0.043	0.059	0.078	0.097	0.099	0.093	0.078	0.064	0.055	0.053	0.041
44	Turnbull Creek	0.010	0.046	0.081	0.192	0.257	0.264	0.390	0.474	0.433	0.296	0.220	0.152	0.107
45	Residual Area E-9	0.034	0.043	0.043	0.059	0.078	0.096	0.099	0.093	0.078	0.063	0.055	0.053	0.041
46	Penticton Creek	0.130	0.431	0.717	1.62	2.15	2.22	3.24	3.93	3.59	2.48	1.85	1.29	0.929
49	Residual Area W-14	0.006	0.008	0.008	0.010	0.014	0.017	0.017	0.016	0.014	0.011	0.010	0.009	0.007
50	Residual Area E-10	0.002	0.003	0.003	0.004	0.005	0.006	0.006	0.006	0.005	0.004	0.003	0.003	0.003
51	Shingle Creek	0.154	0.258	0.374	0.790	1.40	1.70	2.62	3.72	4.28	3.63	3.19	2.33	1.73
52	Ellis Creek	0.290	0.845	1.24	2.54	3.16	3.12	4.33	5.06	4.59	3.19	2.41	1.70	1.25
53	Residual Area W-15	0.050	0.064	0.064	0.088	0.115	0.143	0.147	0.138	0.116	0.094	0.082	0.079	0.061
54	Residual Area E-11	0.127	0.338	0.453	0.862	1.010	0.955	1.25	1.40	1.26	0.883	0.676	0.487	0.368
55	Marron River	0.076	0.191	0.224	0.327	0.338	0.297	0.414	0.363	0.341	0.251	0.160	0.119	0.093
56	Residual Area W-16	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001
57	Residual Area W-17	0.046	0.059	0.059	0.081	0.107	0.133	0.136	0.128	0.107	0.087	0.076	0.073	0.057
60	Shuttleworth Creek	0.176	0.516	0.701	1.36	1.60	1.51	1.99	2.23	2.00	1.40	1.06	0.757	0.565
61	Residual Area W-18	0.012	0.016	0.016	0.022	0.028	0.035	0.036	0.034	0.029	0.023	0.020	0.020	0.015
62	Residual Area W-19	0.014	0.017	0.017	0.024	0.031	0.039	0.040	0.037	0.031	0.026	0.022	0.022	0.017
63	Residual Area E-12	0.041	0.053	0.053	0.072	0.095	0.118	0.121	0.113	0.095	0.077	0.067	0.065	0.050
65	Residual Area E-13	0.002	0.002	0.002	0.003	0.004	0.005	0.005	0.005	0.004	0.003	0.003	0.003	0.002
66	Vaseux Creek	0.792	2.13	2.86	5.48	6.42	6.13	7.94	8.91	7.99	5.61	4.35	3.28	2.47
67	Residual Area W-20	0.008	0.011	0.011	0.014	0.019	0.024	0.024	0.023	0.019	0.016	0.013	0.013	0.010
68	Residual Area E-14	0.012	0.015	0.015	0.021	0.027	0.033	0.034	0.032	0.027	0.022	0.019	0.019	0.014
69	Park Rill	0.097	0.292	0.348	0.521	0.540	0.470	0.668	0.581	0.545	0.393	0.239	0.171	0.126
70	Residual Area W-21	0.044	0.111	0.130	0.190	0.196	0.172	0.240	0.210	0.198	0.145	0.093	0.069	0.054
71	Wolfcub Creek	0.058	0.180	0.227	0.386	0.426	0.387	0.530	0.531	0.484	0.341	0.236	0.167	0.123
72	Residual Area E-15	0.024	0.030	0.030	0.042	0.055	0.068	0.070	0.065	0.055	0.045	0.039	0.038	0.029
73	Testalinden Creek	0.014	0.049	0.059	0.091	0.094	0.081	0.117	0.102	0.095	0.067	0.039	0.027	0.019
74	Residual Area W-22	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
76	Residual Area E-16	0.008	0.010	0.010	0.014	0.019	0.023	0.024	0.022	0.019	0.015	0.013	0.013	0.010
77	Residual Area W-23	0.047	0.060	0.060	0.082	0.108	0.134	0.137	0.129	0.108	0.088	0.076	0.074	0.057
78	Inkaneep Creek	0.345	0.944	1.15	1.88	1.99	1.85	2.32	2.56	2.31	1.65	1.23	0.899	0.697
79	Residual Area E-17	0.207	0.533	0.659	1.08	1.19	1.09	1.47	1.47	1.35	0.965	0.683	0.499	0.382

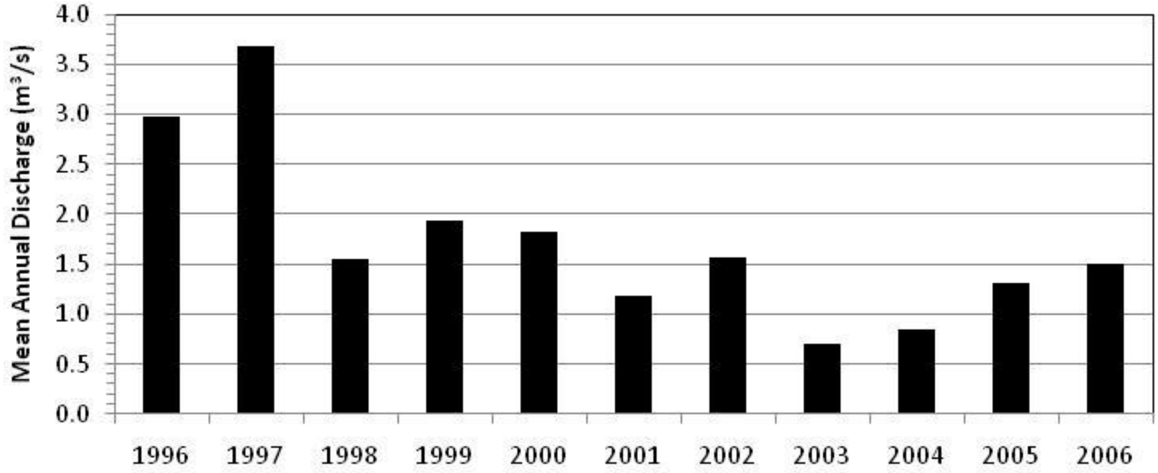
Table I.1 cont'd.

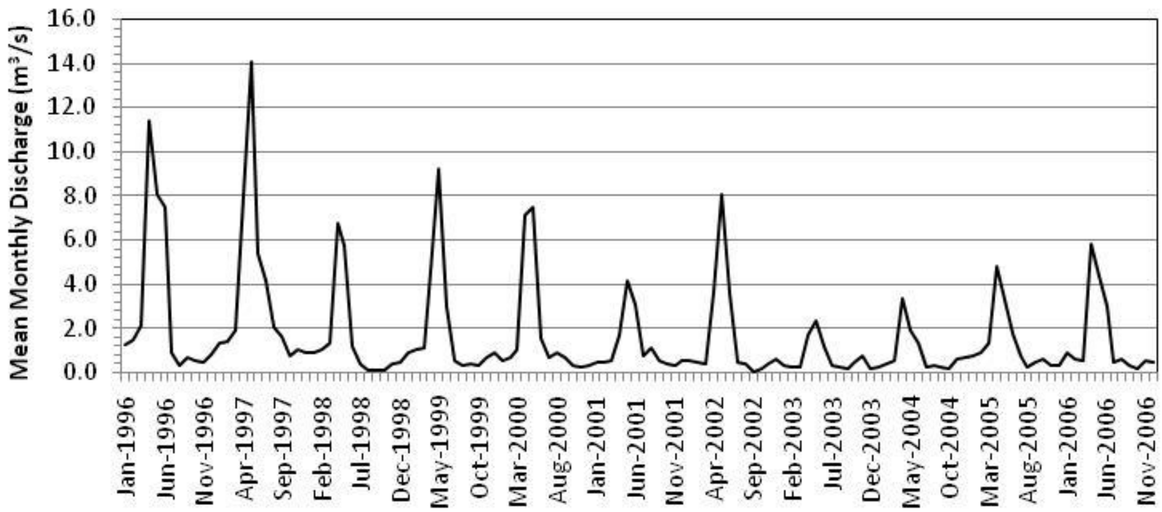
Node	Description	Normal Weekly Discharge (m^3/s)												
		Week 27	Week 28	Week 29	Week 30	Week 31	Week 32	Week 33	Week 34	Week 35	Week 36	Week 37	Week 38	Week 39
38	Robinson Creek	0.054	0.026	0.012	0.003	0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.002	0.001
39	Residual Area E-7	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000
40	Naramata Creek	0.157	0.085	0.047	0.019	0.010	0.005	0.005	0.002	0.002	0.001	0.003	0.011	0.007
41	Residual Area E-8	0.017	0.011	0.011	0.010	0.008	0.006	0.006	0.005	0.003	0.001	0.000	0.000	0.000
42	Trout Creek	2.99	2.29	1.68	1.21	0.853	0.684	0.545	0.468	0.420	0.429	0.413	0.439	0.400
43	Residual Area W-13	0.029	0.019	0.019	0.016	0.013	0.010	0.010	0.009	0.005	0.002	0.000	0.000	0.000
44	Turnbull Creek	0.071	0.036	0.018	0.005	0.002	0.001	0.002	0.000	0.000	0.000	0.000	0.004	0.002
45	Residual Area E-9	0.029	0.019	0.019	0.016	0.013	0.010	0.010	0.009	0.005	0.002	0.000	0.000	0.000
46	Penticton Creek	0.632	0.347	0.197	0.087	0.049	0.028	0.023	0.010	0.009	0.011	0.019	0.049	0.035
49	Residual Area W-14	0.005	0.003	0.003	0.003	0.002	0.002	0.002	0.002	0.001	0.000	0.000	0.000	0.000
50	Residual Area E-10	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000
51	Shingle Creek	1.16	0.838	0.634	0.444	0.346	0.283	0.185	0.160	0.141	0.142	0.146	0.163	0.122
52	Ellis Creek	0.903	0.539	0.340	0.171	0.121	0.087	0.088	0.058	0.057	0.058	0.074	0.130	0.098
53	Residual Area W-15	0.043	0.028	0.028	0.024	0.020	0.015	0.014	0.013	0.008	0.003	0.000	0.000	0.000
54	Residual Area E-11	0.285	0.185	0.128	0.073	0.059	0.048	0.052	0.039	0.039	0.039	0.044	0.065	0.051
55	Marron River	0.078	0.066	0.054	0.044	0.035	0.032	0.028	0.024	0.022	0.022	0.020	0.021	0.020
56	Residual Area W-16	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
57	Residual Area W-17	0.040	0.026	0.026	0.023	0.018	0.014	0.013	0.012	0.008	0.003	0.000	0.000	0.000
60	Shuttleworth Creek	0.430	0.269	0.177	0.088	0.065	0.047	0.054	0.034	0.033	0.033	0.041	0.075	0.052
61	Residual Area W-18	0.011	0.007	0.007	0.006	0.005	0.004	0.003	0.003	0.002	0.001	0.000	0.000	0.000
62	Residual Area W-19	0.012	0.007	0.007	0.007	0.005	0.004	0.004	0.003	0.002	0.001	0.000	0.000	0.000
63	Residual Area E-12	0.035	0.023	0.023	0.020	0.016	0.013	0.012	0.011	0.007	0.003	0.000	0.000	0.000
65	Residual Area E-13	0.002	0.001	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
66	Vaseux Creek	1.89	1.22	0.803	0.444	0.355	0.284	0.311	0.229	0.228	0.227	0.261	0.391	0.304
67	Residual Area W-20	0.007	0.005	0.005	0.004	0.003	0.003	0.002	0.002	0.001	0.001	0.000	0.000	0.000
68	Residual Area E-14	0.010	0.006	0.006	0.006	0.005	0.004	0.003	0.003	0.002	0.001	0.000	0.000	0.000
69	Park Rill	0.101	0.082	0.062	0.046	0.030	0.024	0.018	0.013	0.009	0.009	0.007	0.008	0.006
70	Residual Area W-21	0.045	0.038	0.031	0.026	0.020	0.018	0.016	0.014	0.013	0.013	0.012	0.012	0.011
71	Wolfcub Creek	0.095	0.064	0.044	0.026	0.017	0.012	0.011	0.006	0.005	0.005	0.006	0.011	0.007
72	Residual Area E-15	0.020	0.013	0.013	0.012	0.009	0.007	0.007	0.006	0.004	0.002	0.000	0.000	0.000
73	Testalinden Creek	0.014	0.011	0.007	0.004	0.002	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000
74	Residual Area W-22	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
76	Residual Area E-16	0.007	0.004	0.004	0.004	0.003	0.003	0.002	0.002	0.001	0.001	0.000	0.000	0.000
77	Residual Area W-23	0.040	0.026	0.026	0.023	0.019	0.014	0.013	0.012	0.008	0.003	0.000	0.000	0.000
78	Inkaneep Creek	0.545	0.399	0.315	0.204	0.154	0.131	0.123	0.101	0.092	0.080	0.083	0.106	0.084
79	Residual Area E-17	0.306	0.226	0.171	0.120	0.096	0.083	0.079	0.065	0.061	0.061	0.062	0.075	0.065

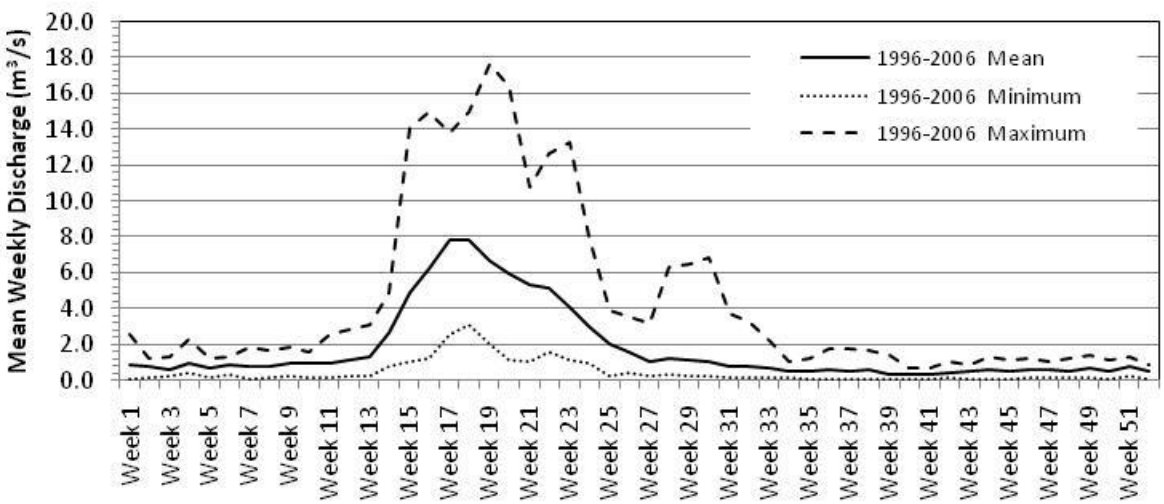
Table I.1 cont'd.

Node	Description	Normal Weekly Discharge (m^3/s)												
		Week 40	Week 41	Week 42	Week 43	Week 44	Week 45	Week 46	Week 47	Week 48	Week 49	Week 50	Week 51	Week 52
38	Robinson Creek	0.001	0.002	0.003	0.002	0.002	0.002	0.001	0.000	0.000	0.000	0.000	0.000	0.000
39	Residual Area E-7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
40	Naramata Creek	0.007	0.011	0.017	0.013	0.013	0.015	0.013	0.008	0.006	0.005	0.003	0.003	0.002
41	Residual Area E-8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
42	Trout Creek	0.391	0.409	0.461	0.467	0.468	0.493	0.472	0.446	0.417	0.405	0.407	0.404	0.388
43	Residual Area W-13	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
44	Turnbull Creek	0.001	0.003	0.005	0.003	0.003	0.004	0.003	0.001	0.001	0.000	0.000	0.000	0.000
45	Residual Area E-9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
46	Penticton Creek	0.033	0.053	0.077	0.060	0.060	0.069	0.058	0.039	0.031	0.025	0.019	0.017	0.013
49	Residual Area W-14	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
50	Residual Area E-10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
51	Shingle Creek	0.124	0.128	0.164	0.138	0.126	0.169	0.161	0.137	0.126	0.109	0.114	0.107	0.099
52	Ellis Creek	0.090	0.130	0.169	0.132	0.134	0.155	0.137	0.105	0.091	0.083	0.072	0.070	0.062
53	Residual Area W-15	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
54	Residual Area E-11	0.046	0.062	0.076	0.060	0.061	0.071	0.065	0.054	0.049	0.047	0.042	0.042	0.039
55	Marron River	0.019	0.019	0.021	0.021	0.022	0.024	0.024	0.024	0.023	0.022	0.022	0.022	0.021
56	Residual Area W-16	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
57	Residual Area W-17	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
60	Shuttleworth Creek	0.045	0.070	0.093	0.067	0.069	0.085	0.074	0.057	0.050	0.046	0.040	0.039	0.033
61	Residual Area W-18	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
62	Residual Area W-19	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
63	Residual Area E-12	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
65	Residual Area E-13	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
66	Vaseux Creek	0.275	0.375	0.463	0.363	0.371	0.432	0.392	0.322	0.291	0.277	0.250	0.249	0.227
67	Residual Area W-20	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
68	Residual Area E-14	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
69	Park Rill	0.005	0.005	0.007	0.007	0.008	0.013	0.012	0.011	0.009	0.008	0.008	0.008	0.008
70	Residual Area W-21	0.011	0.011	0.012	0.012	0.013	0.014	0.014	0.014	0.013	0.013	0.013	0.013	0.012
71	Wolfcub Creek	0.005	0.009	0.012	0.008	0.009	0.013	0.012	0.009	0.007	0.006	0.005	0.005	0.005
72	Residual Area E-15	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
73	Testalinden Creek	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000
74	Residual Area W-22	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
76	Residual Area E-16	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
77	Residual Area W-23	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
78	Inkaneep Creek	0.072	0.089	0.107	0.093	0.098	0.118	0.116	0.104	0.087	0.079	0.075	0.075	0.072
79	Residual Area E-17	0.061	0.071	0.082	0.073	0.075	0.085	0.081	0.073	0.068	0.066	0.063	0.063	0.060

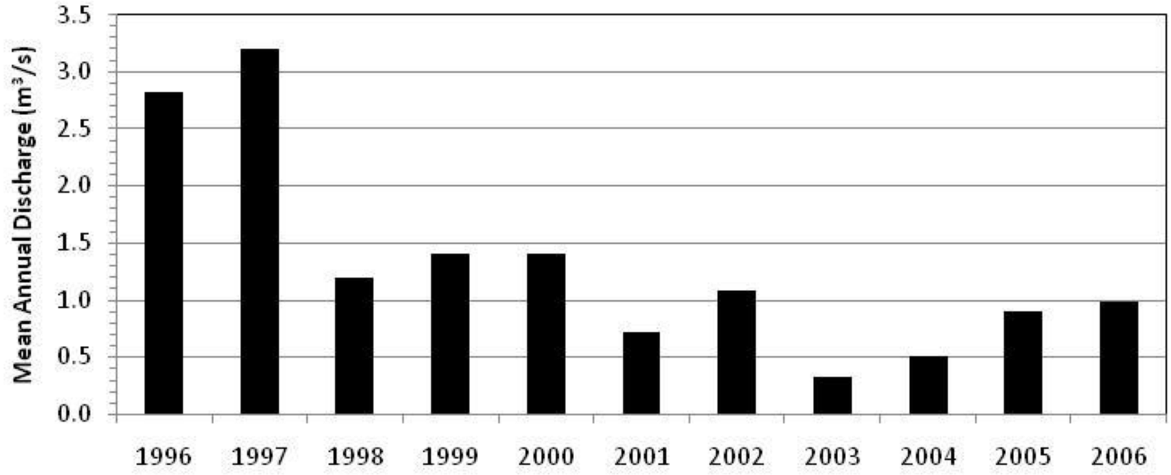
Node 00: Inflows to Kalamalka / Wood Lake

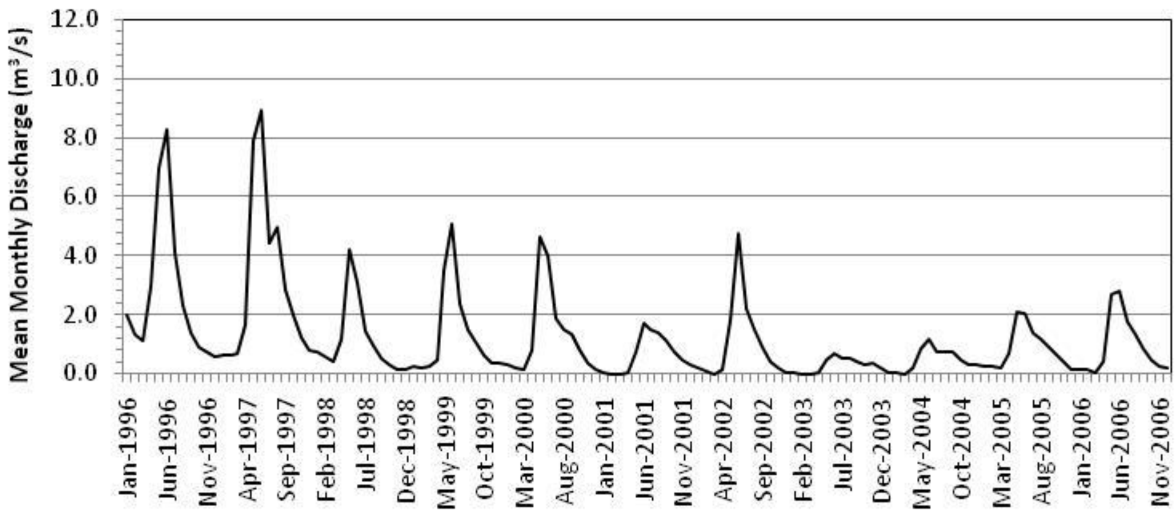


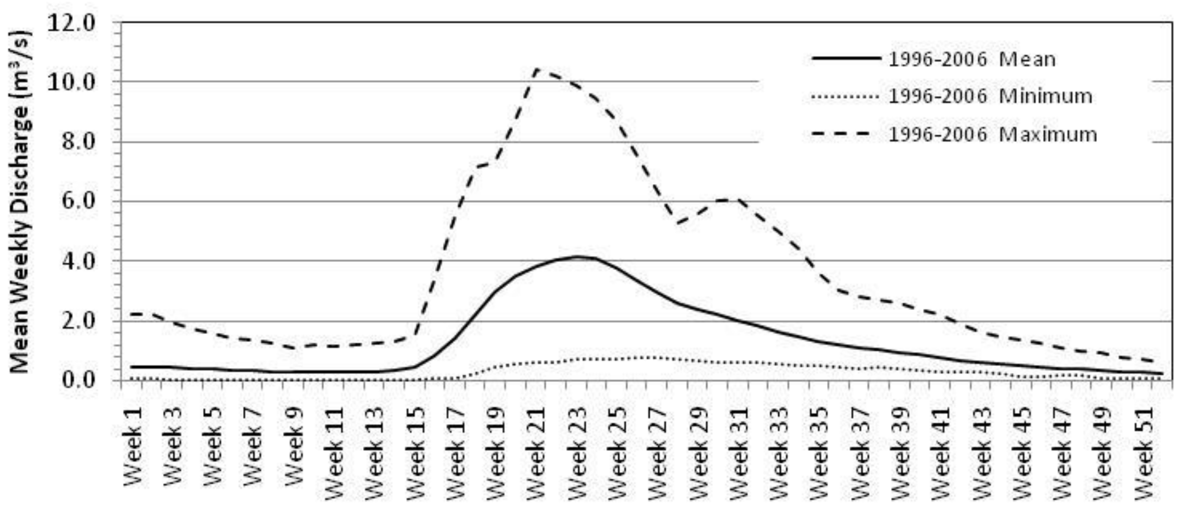




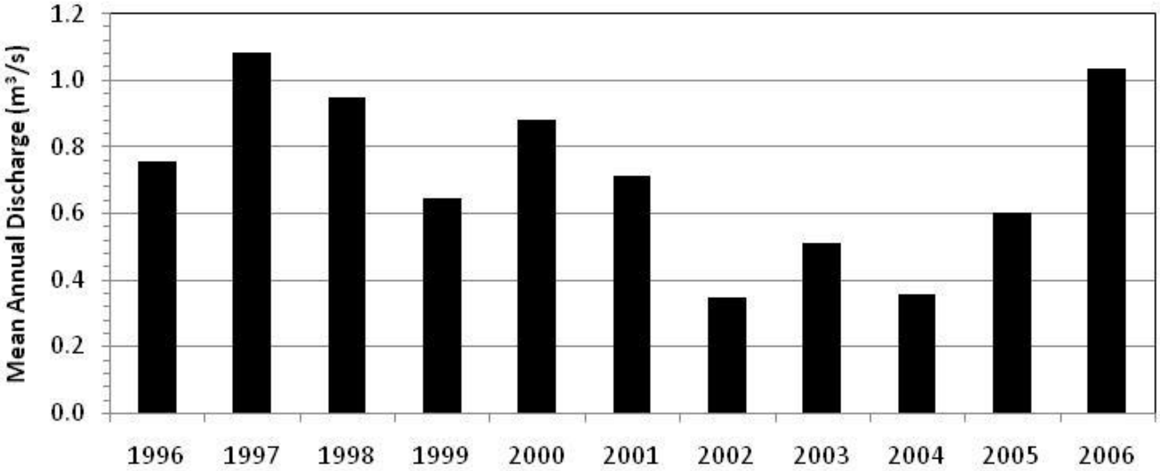
Node 1: Vernon Cr. at outlet of Kalamalka Lake

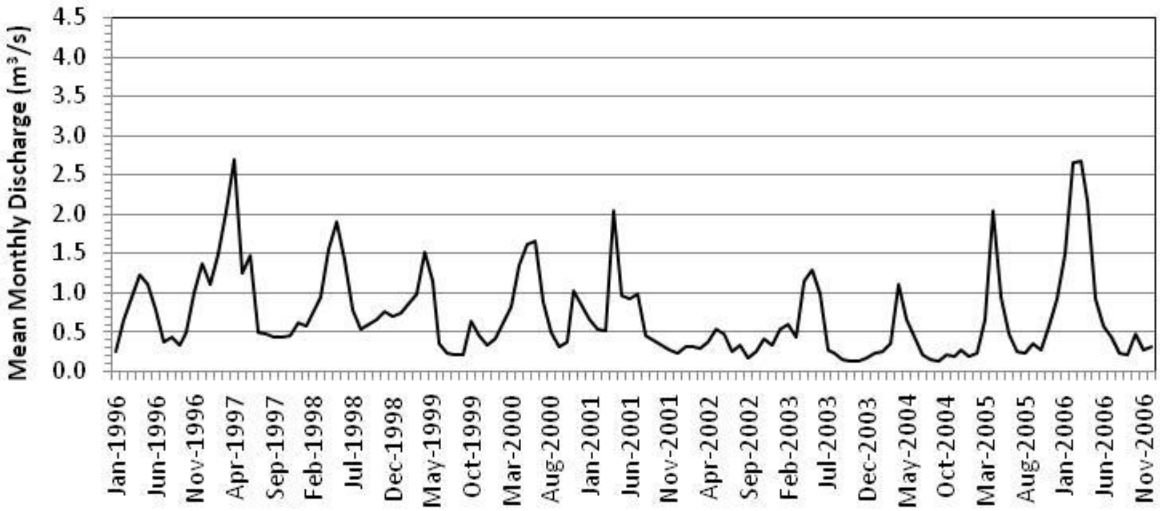


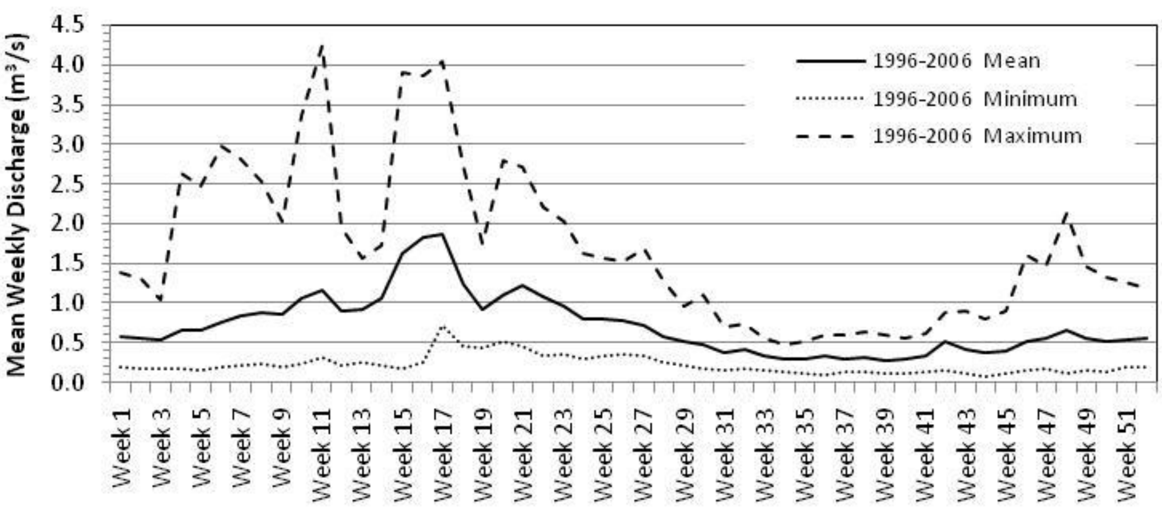




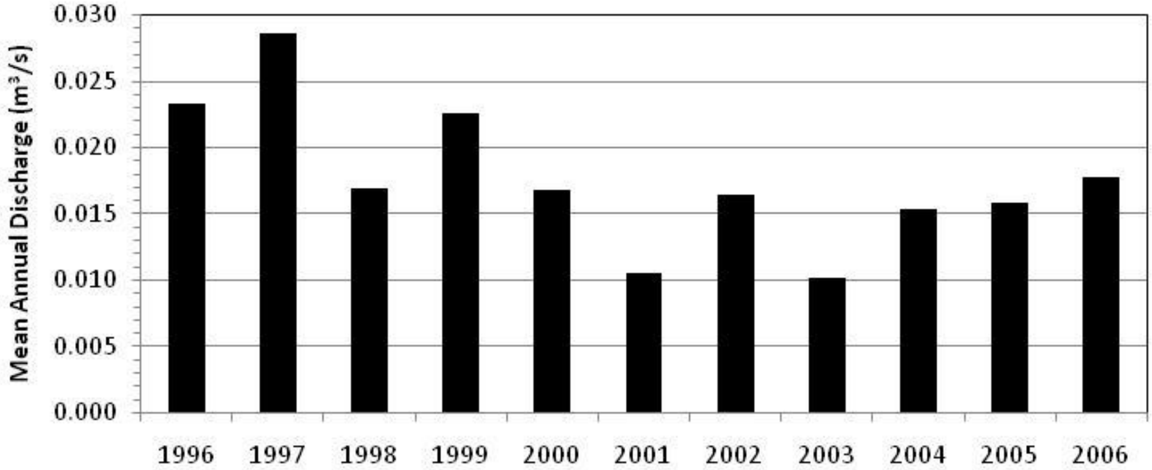
Node 3: Deep Cr.

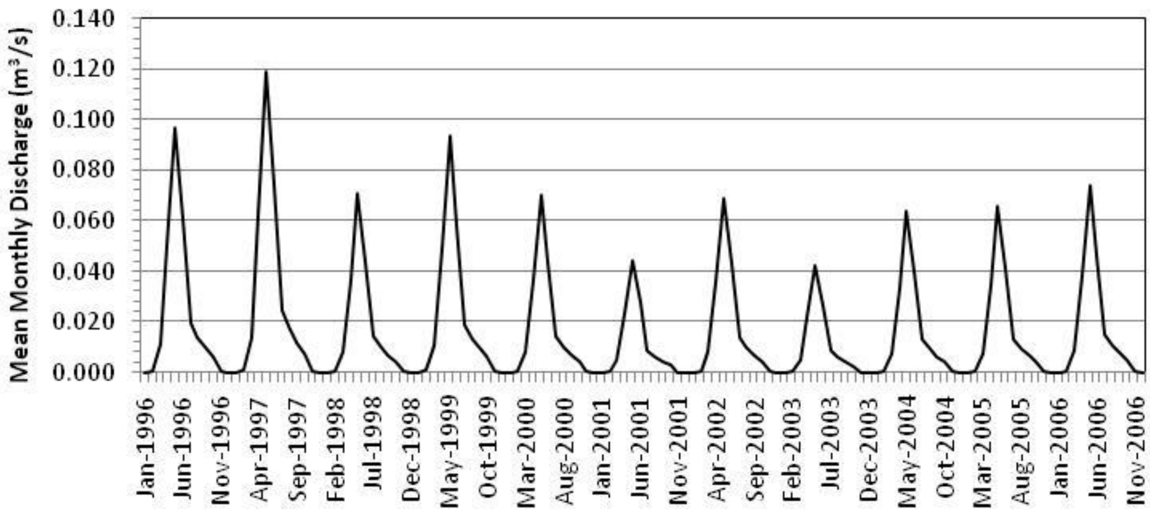


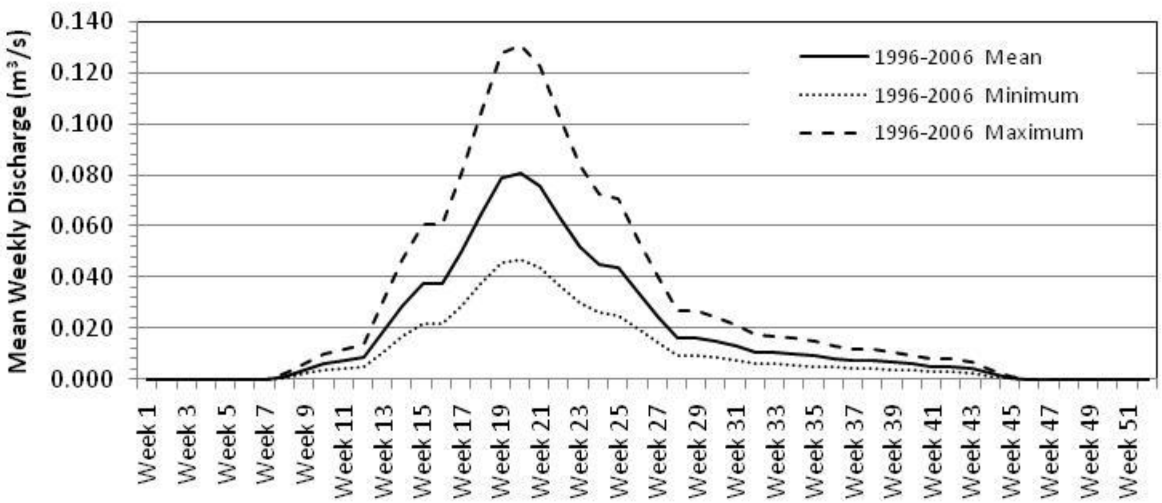




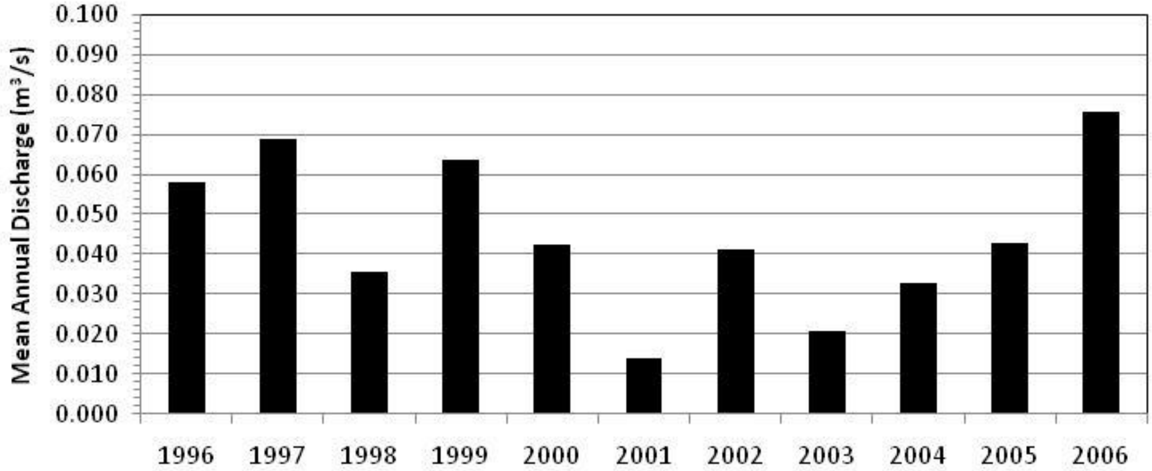
Node 4: Residual Area W-1

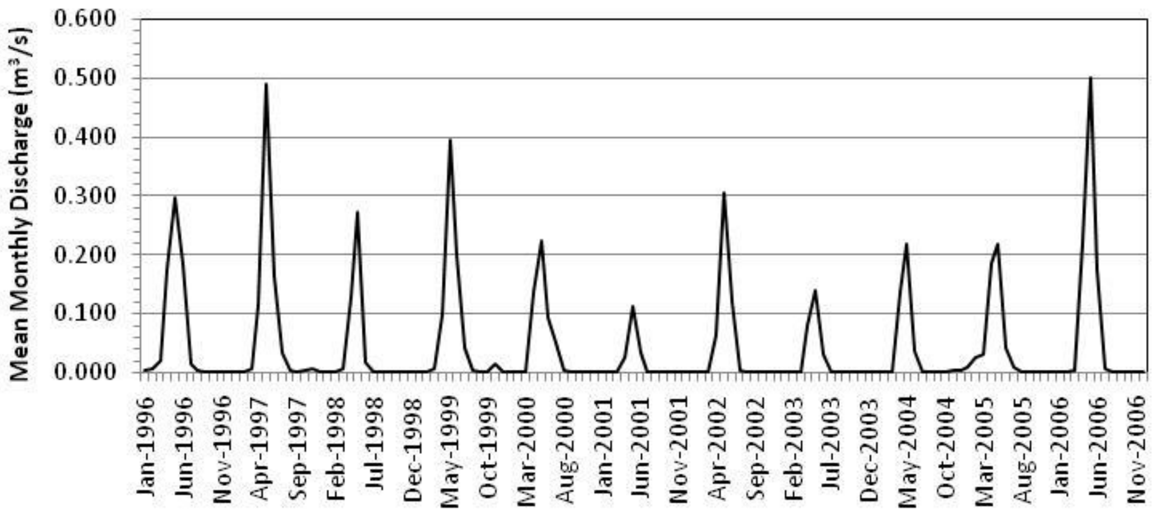


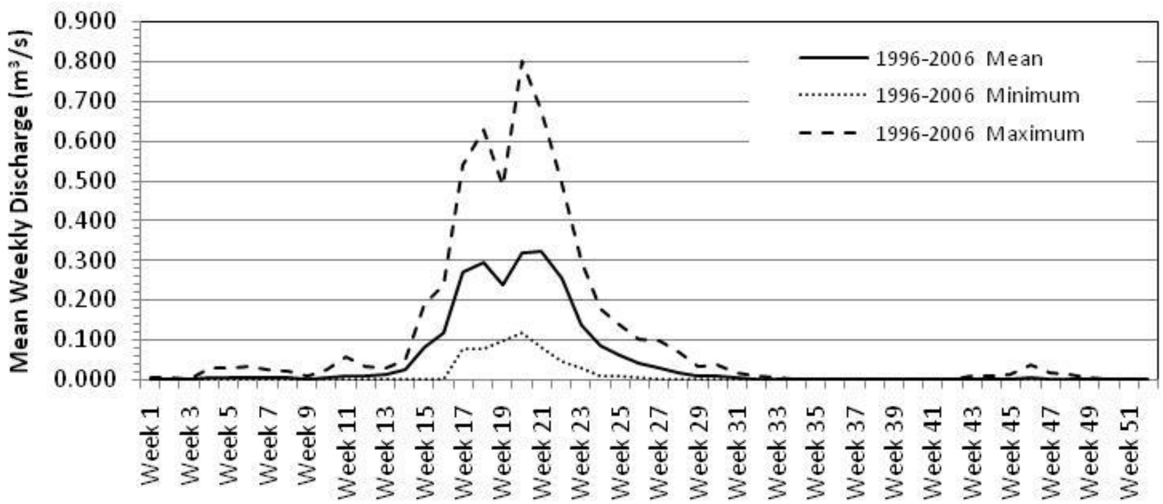




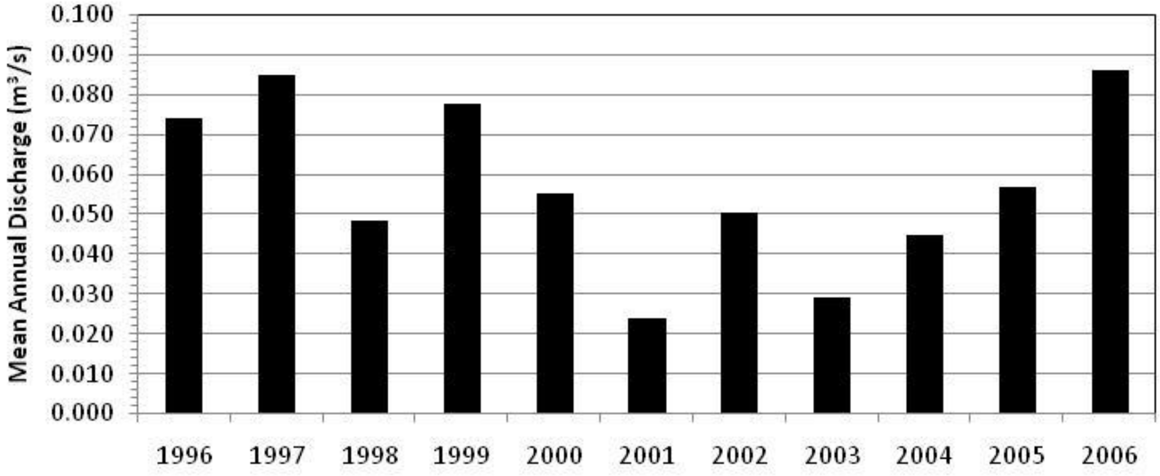
Node 5: Irish Cr.

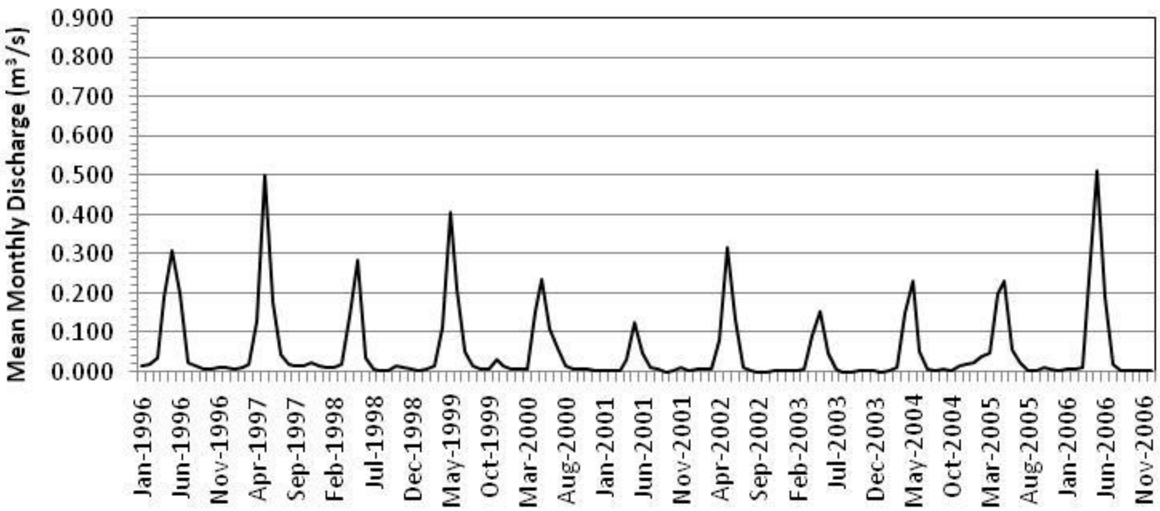


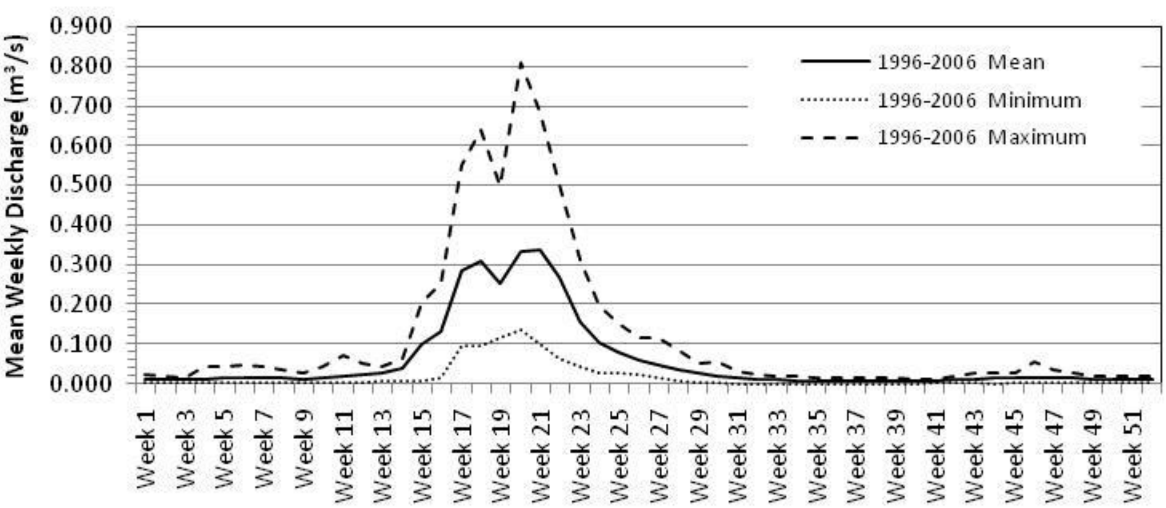




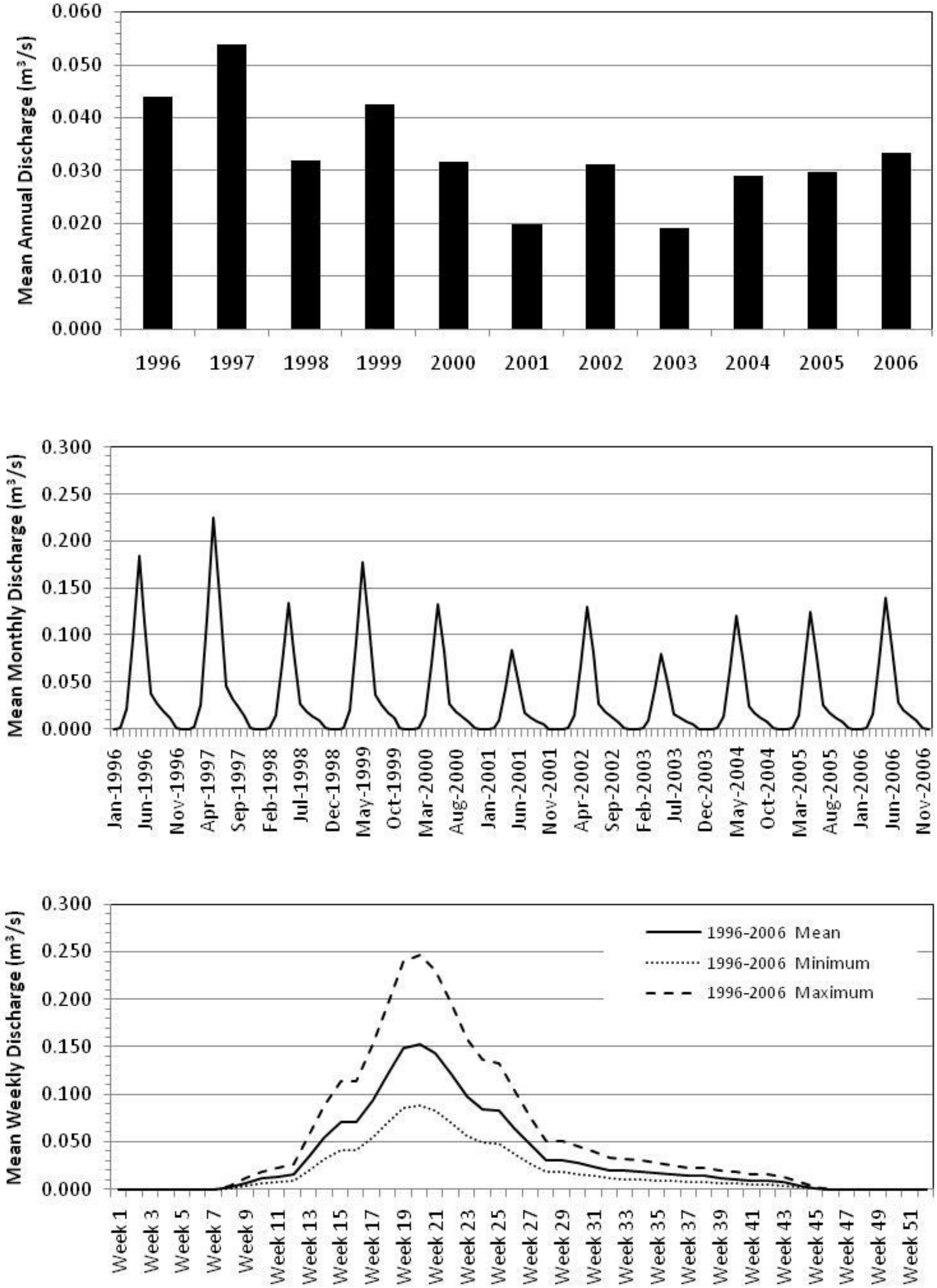
Node 6: Residual Area W-2



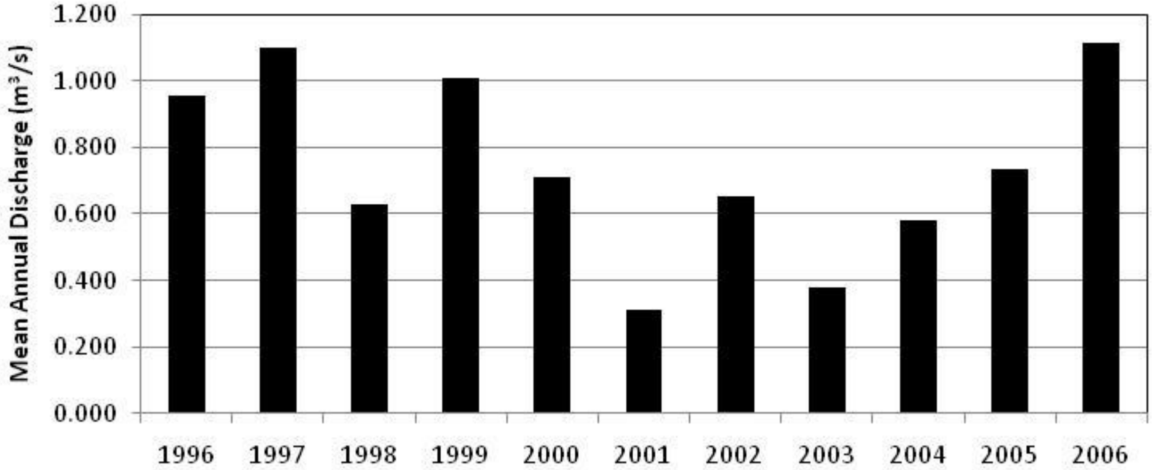


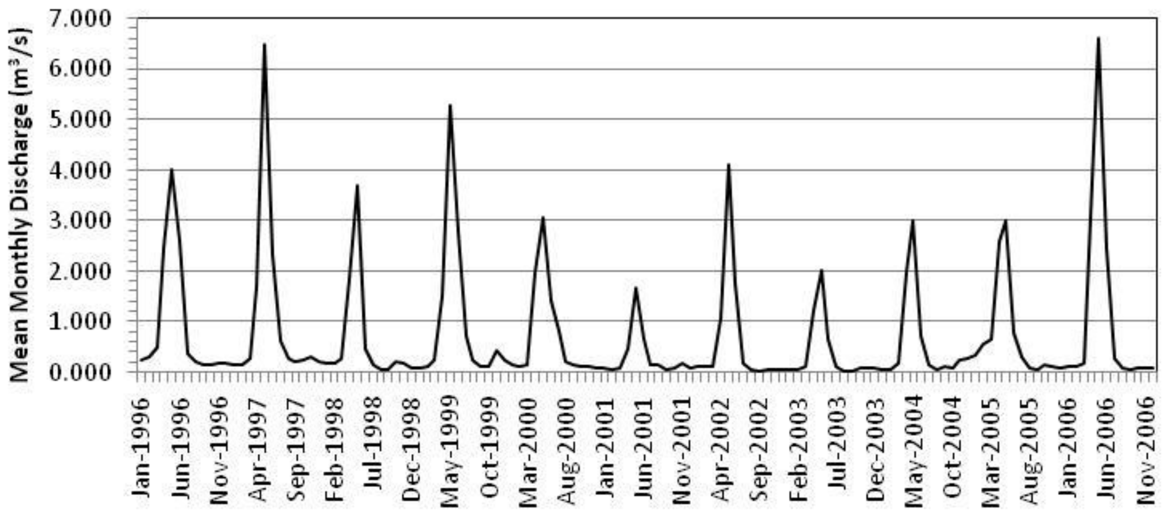


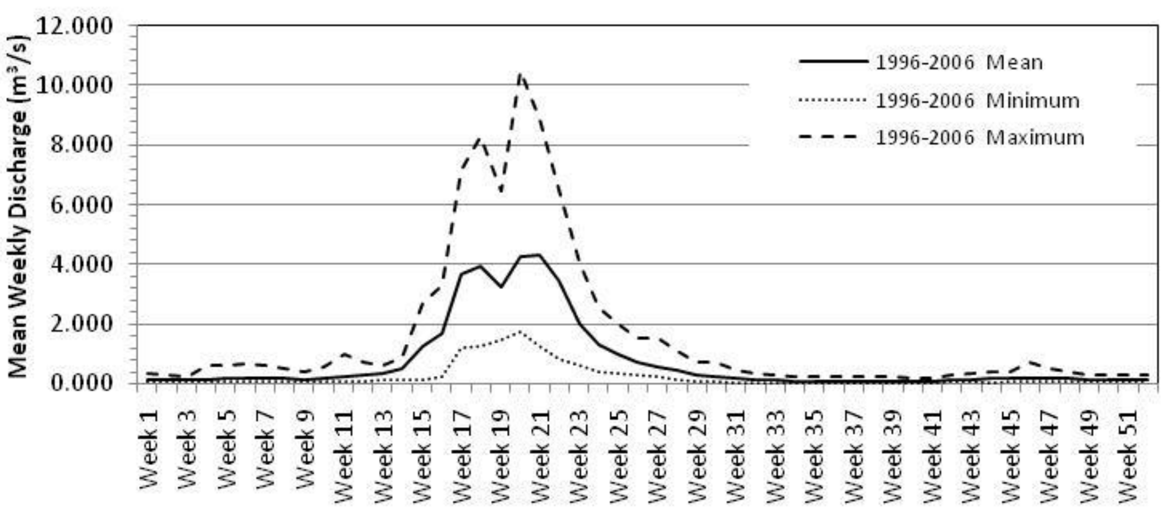
Node 7: Residual Area E-1



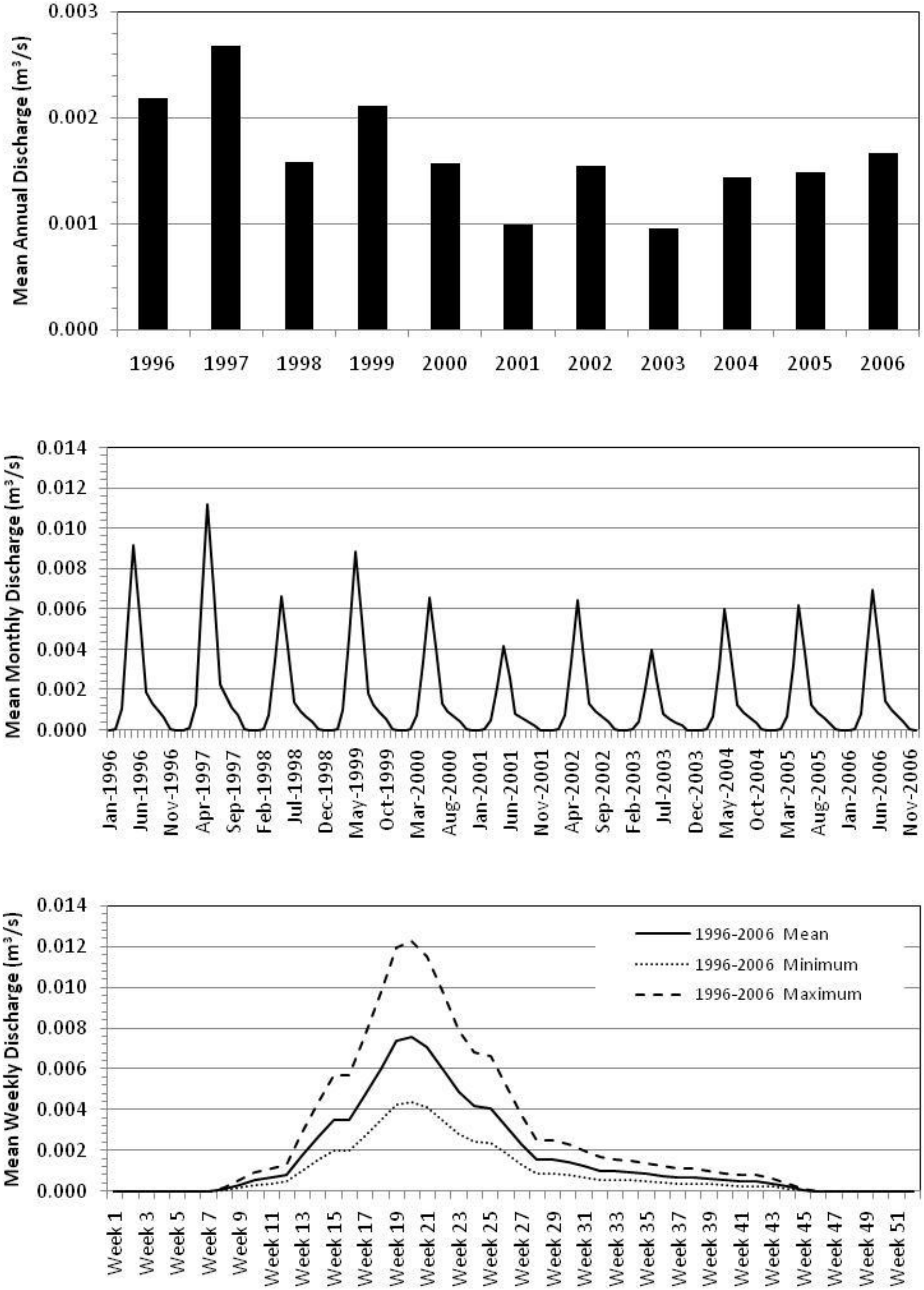
Node 8: Equesis Cr.



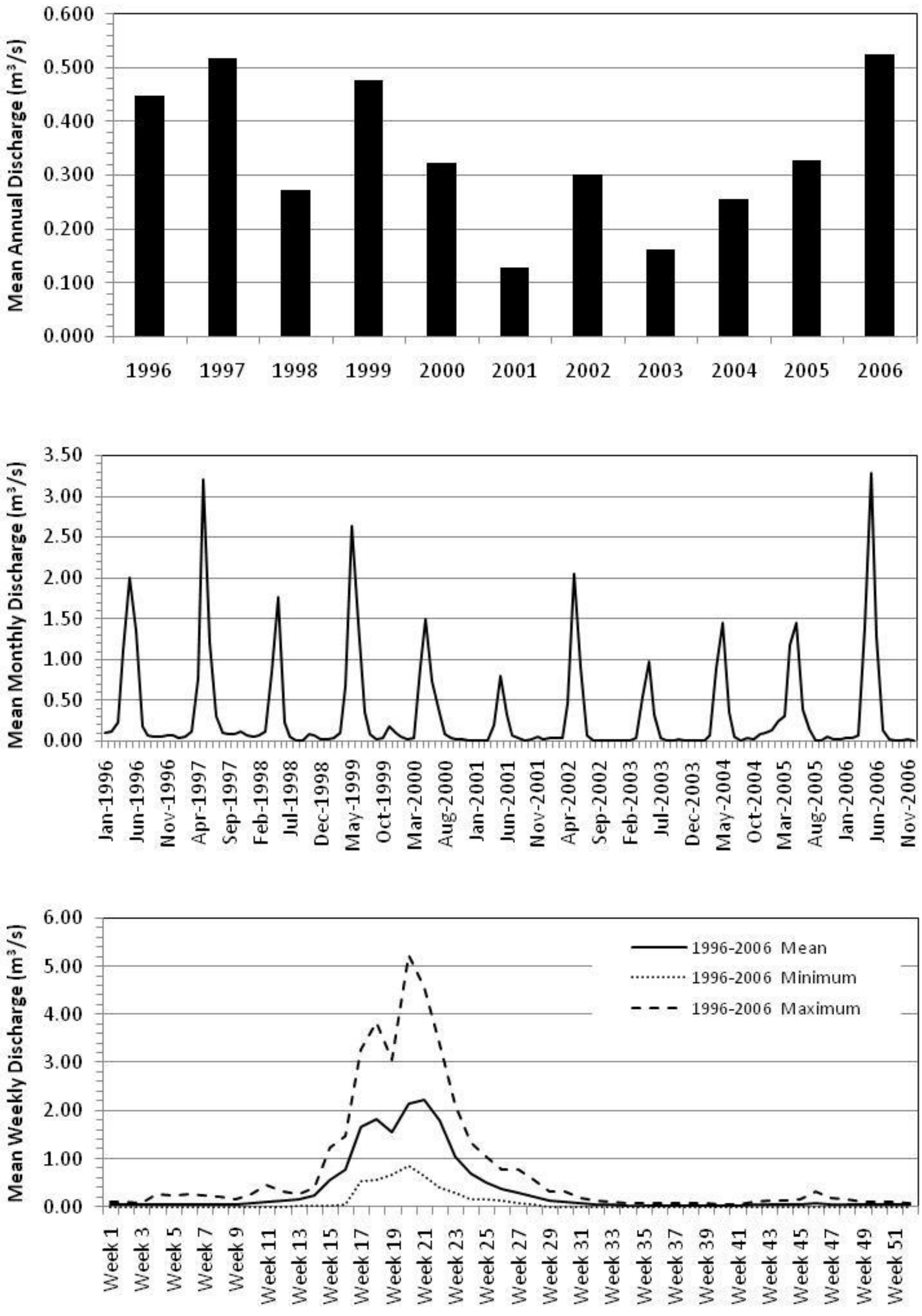




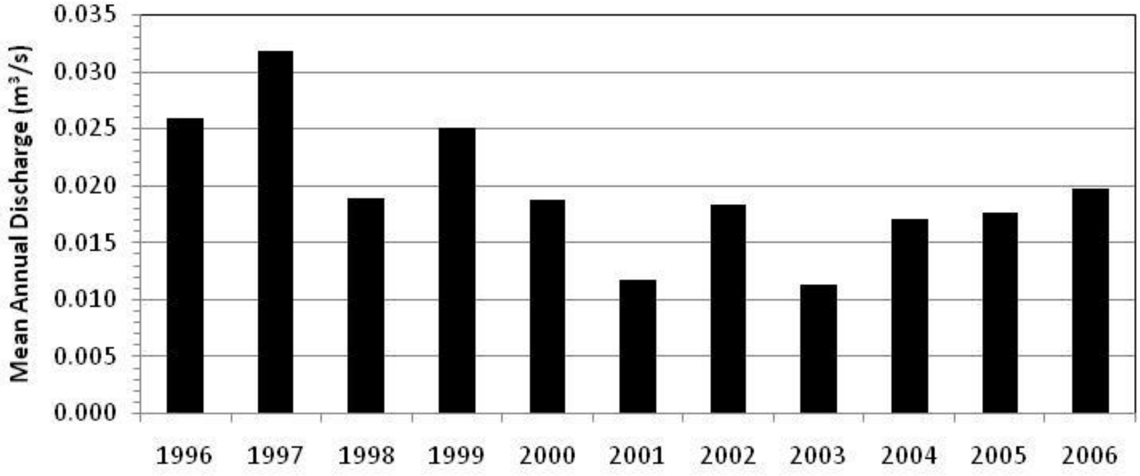
Node 9: Residual Area W-3

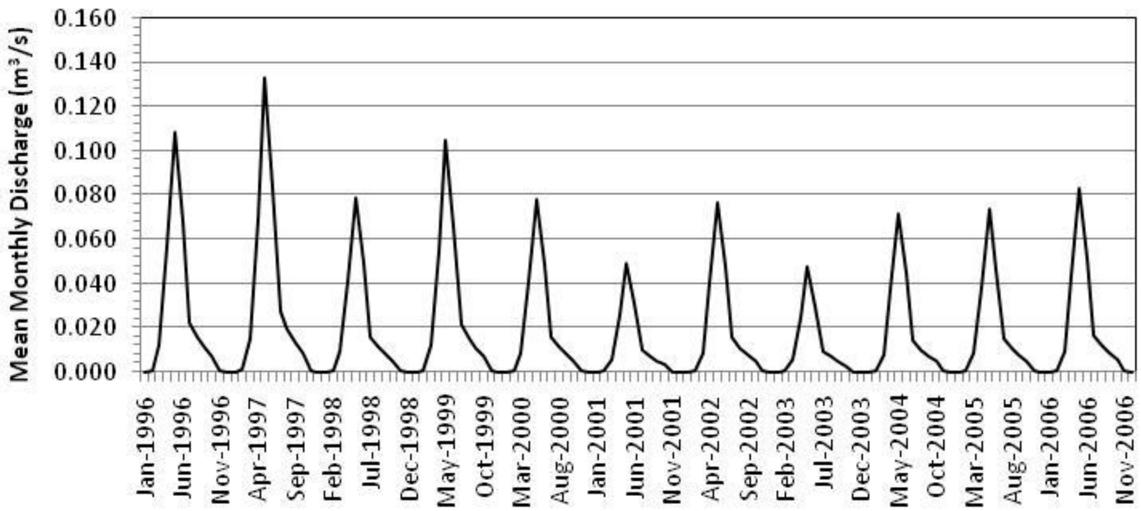


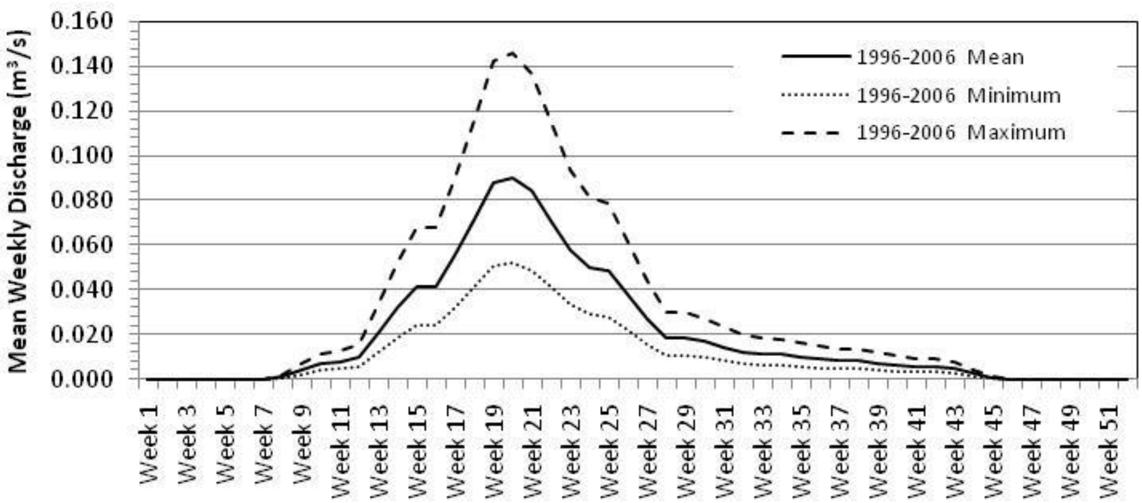
Node 10: Nashwhito Cr.



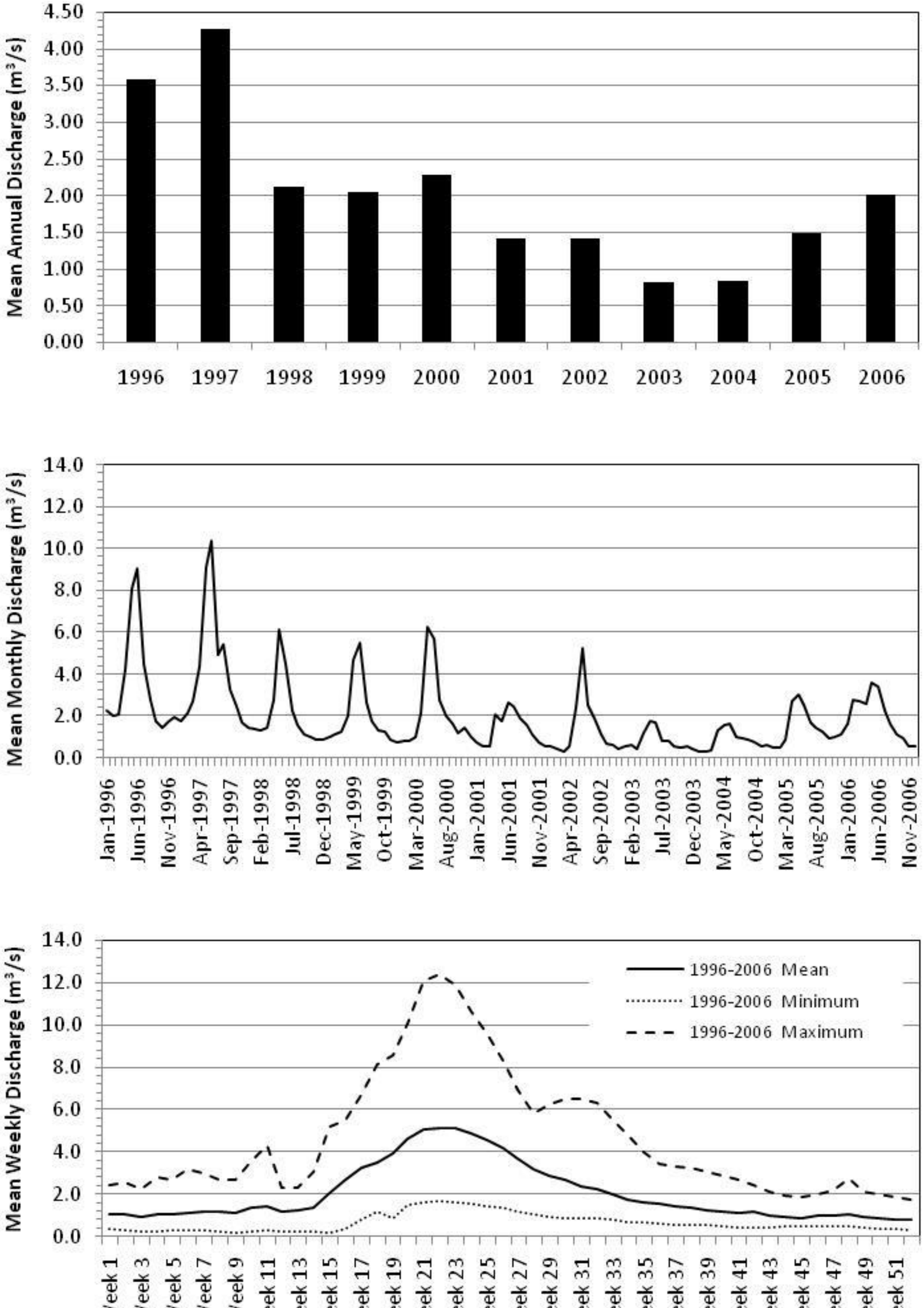
Node 11: Residual Area W-4



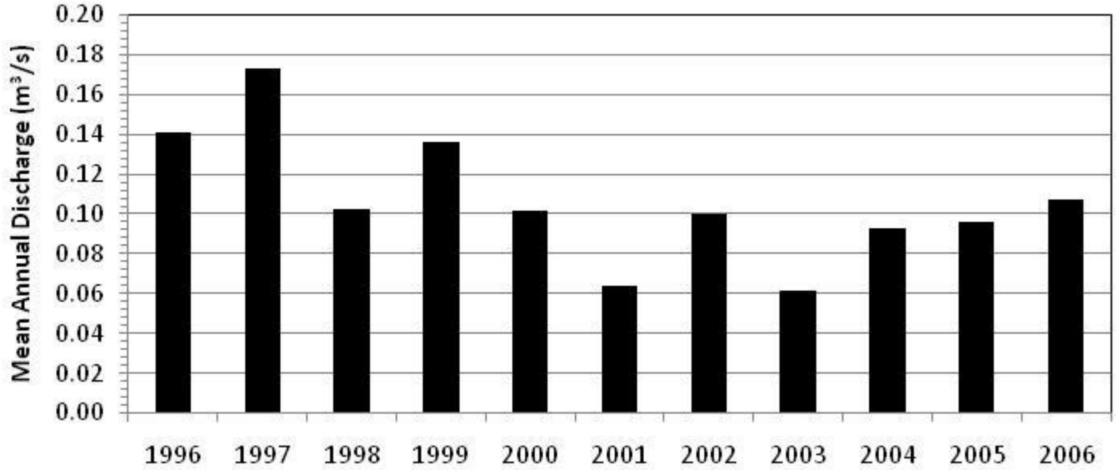


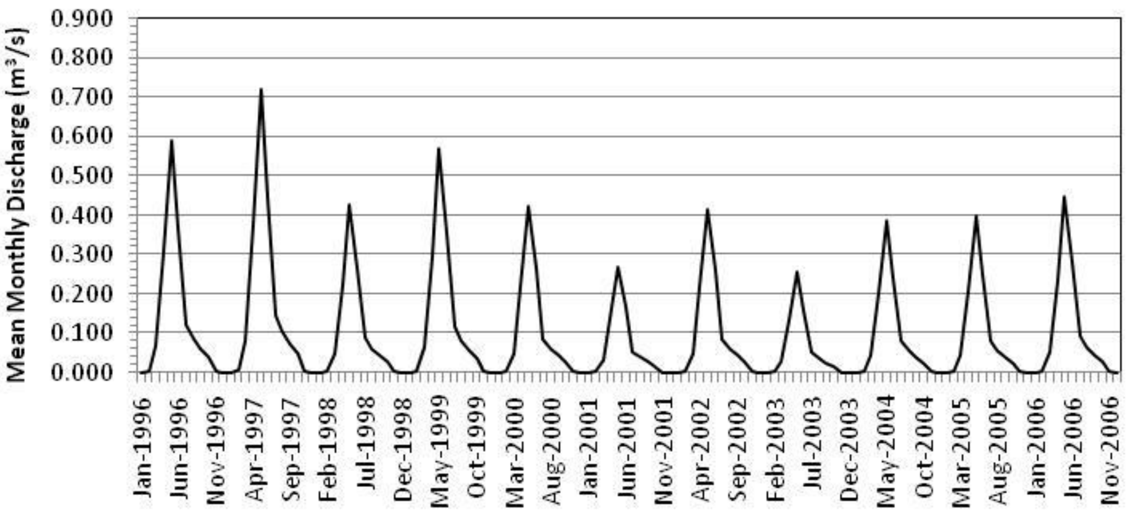


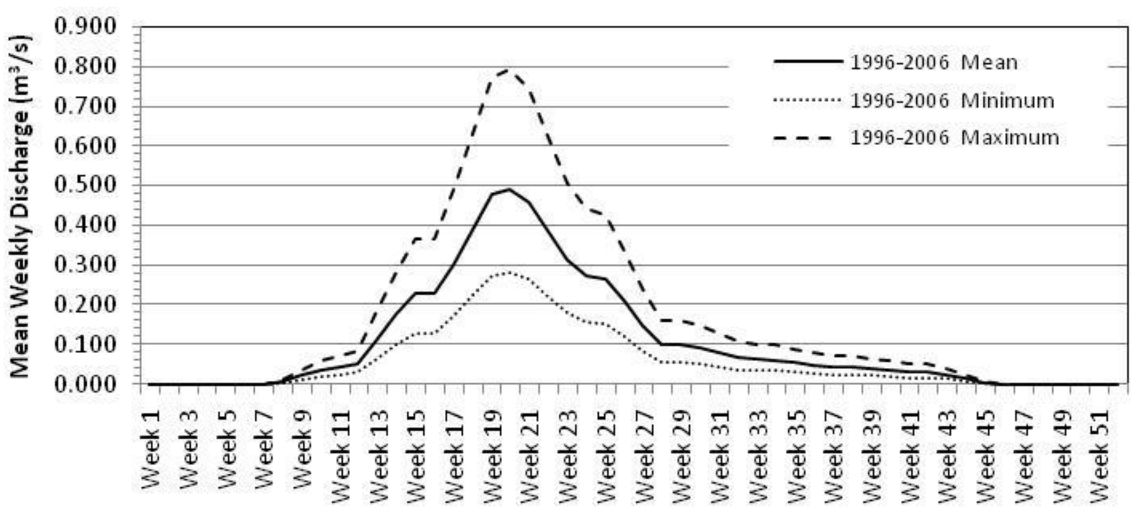
Node 12: Vernon Cr at Mouth



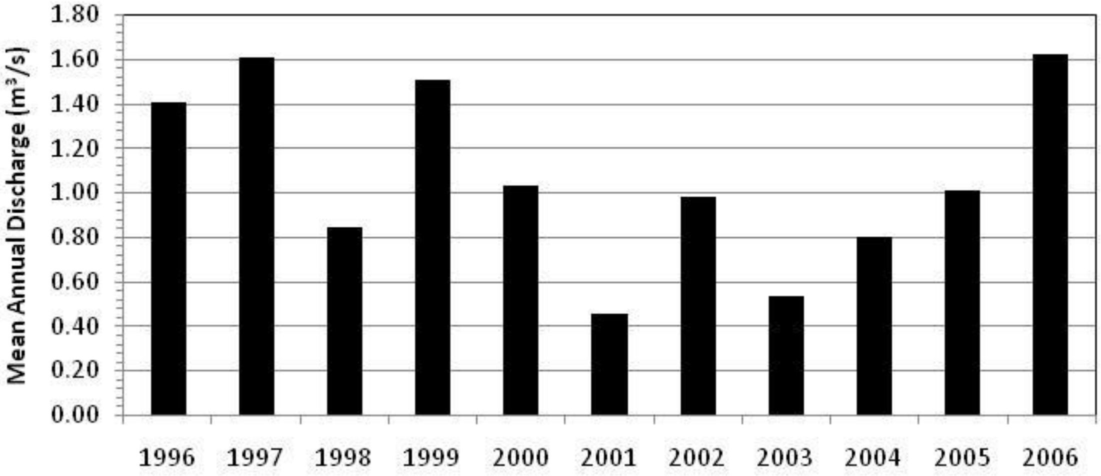
Node 13: Residual Area E-2

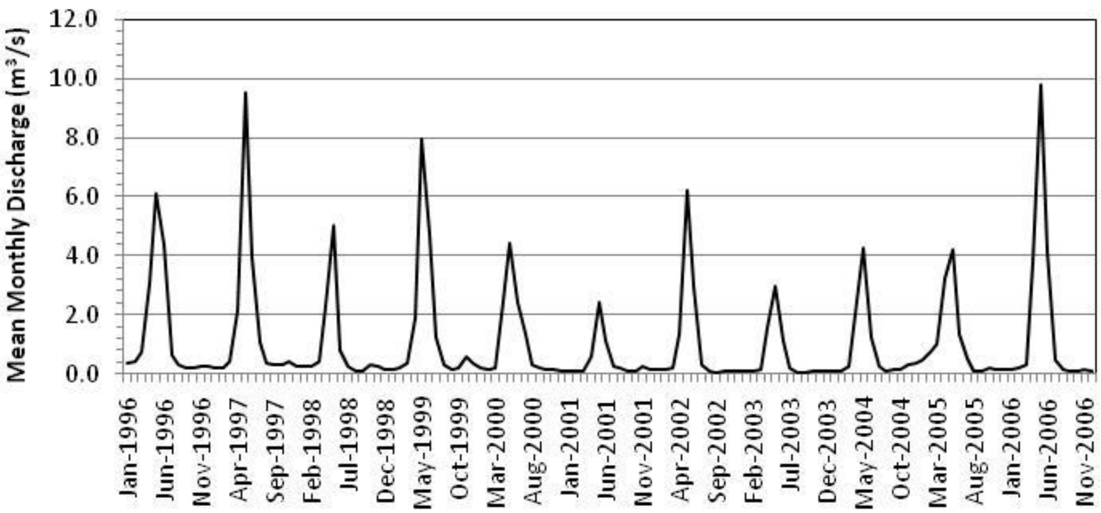


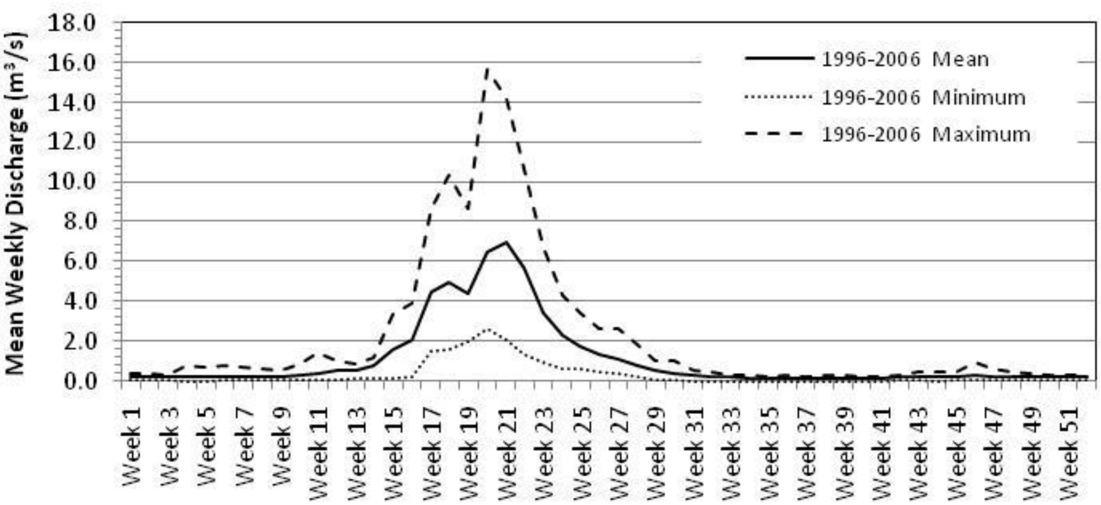




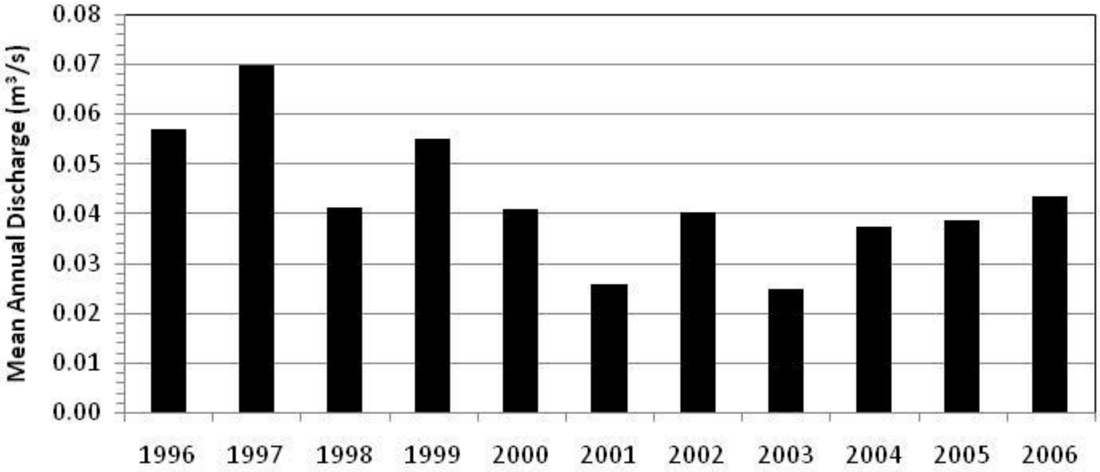
Node 14: Whiteman Cr.

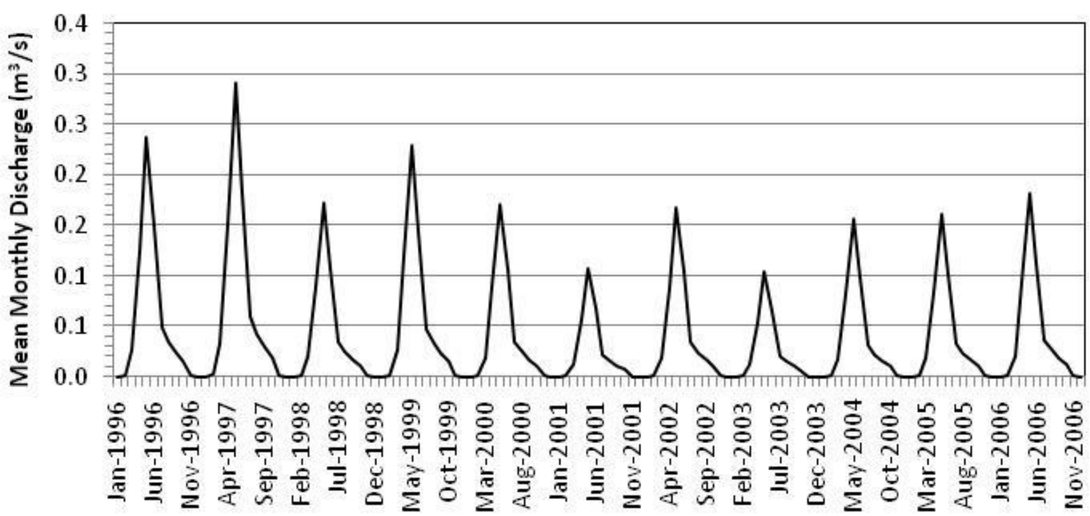


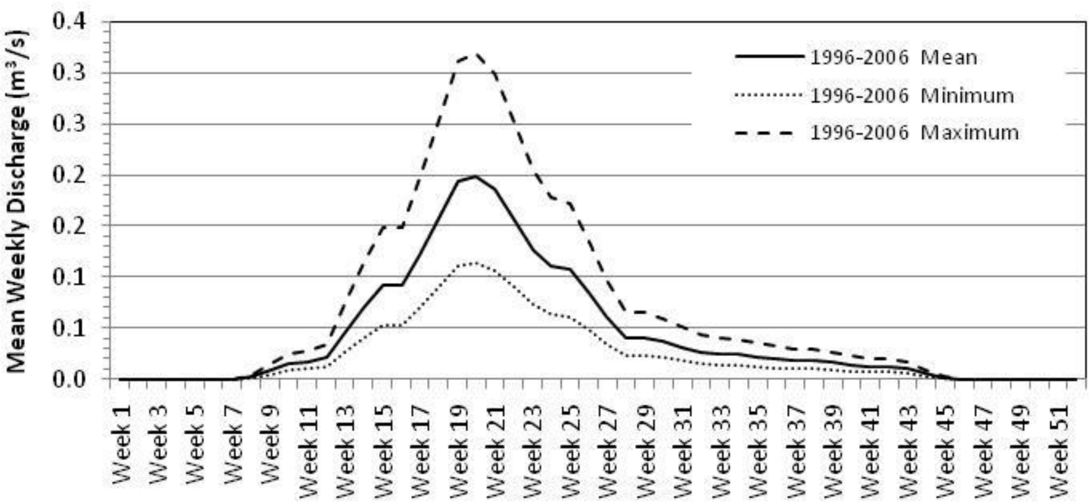




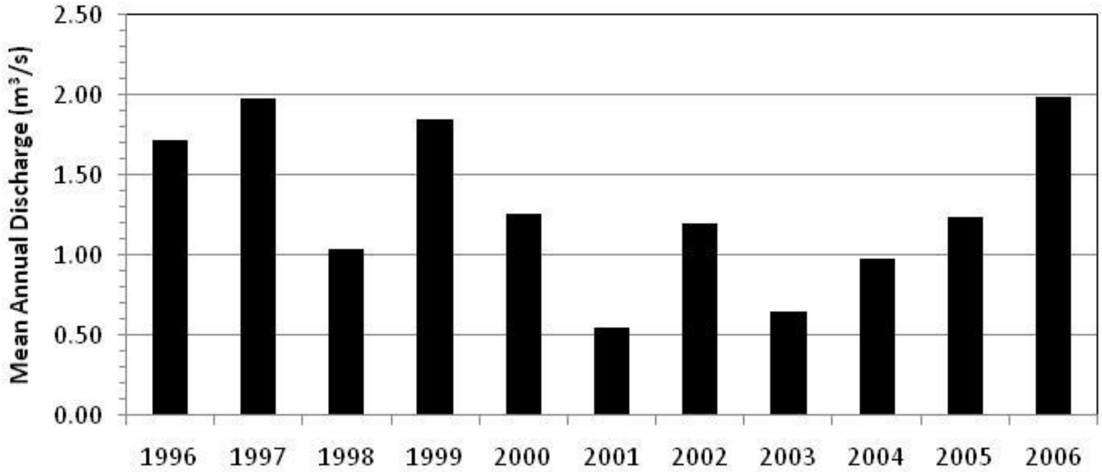
Node 15: Residual Area W-5

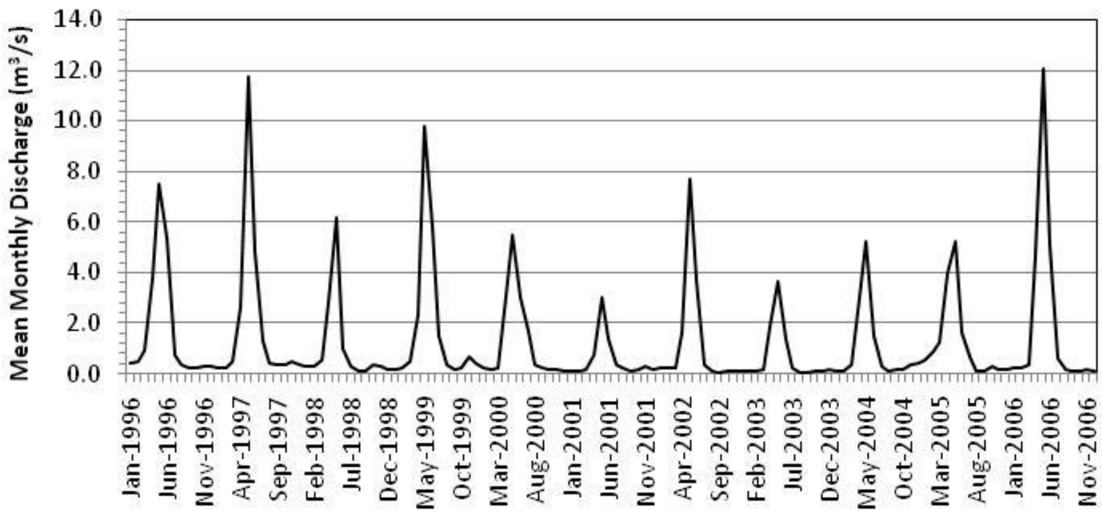


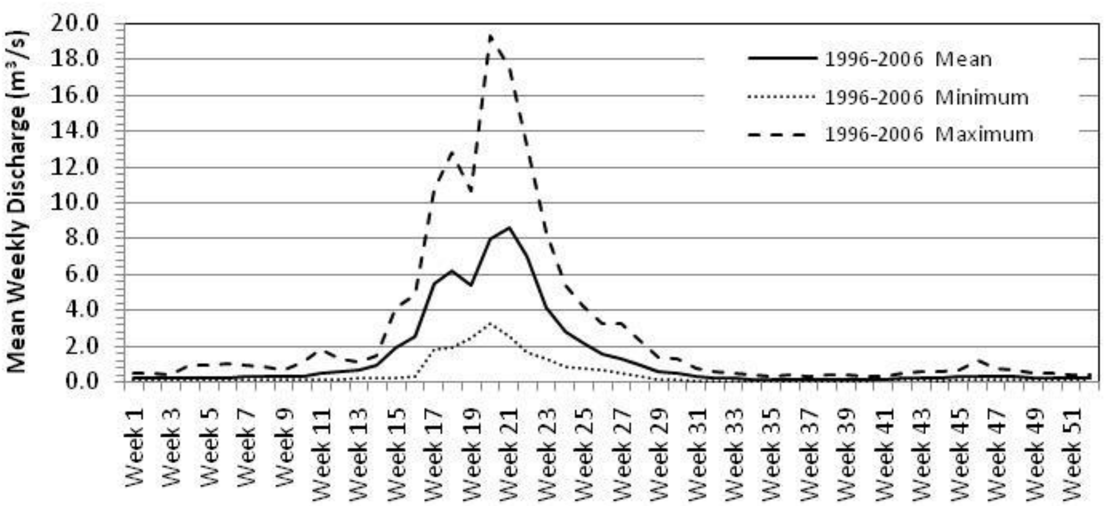




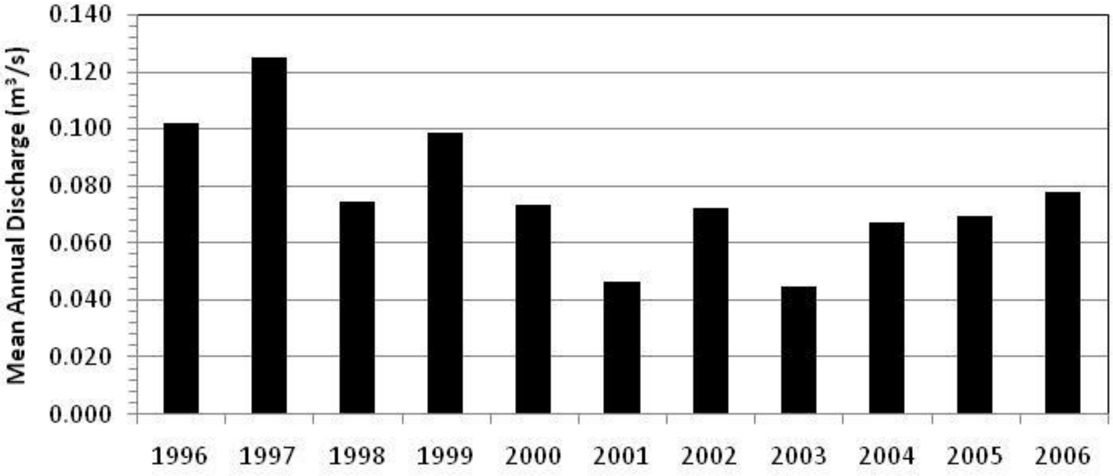
Node 16: Shorts Cr.

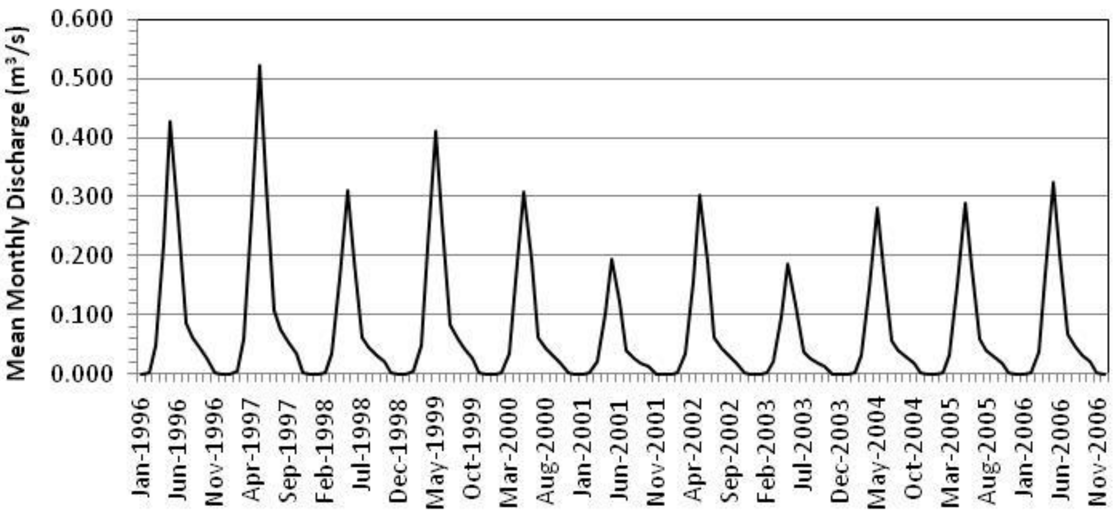


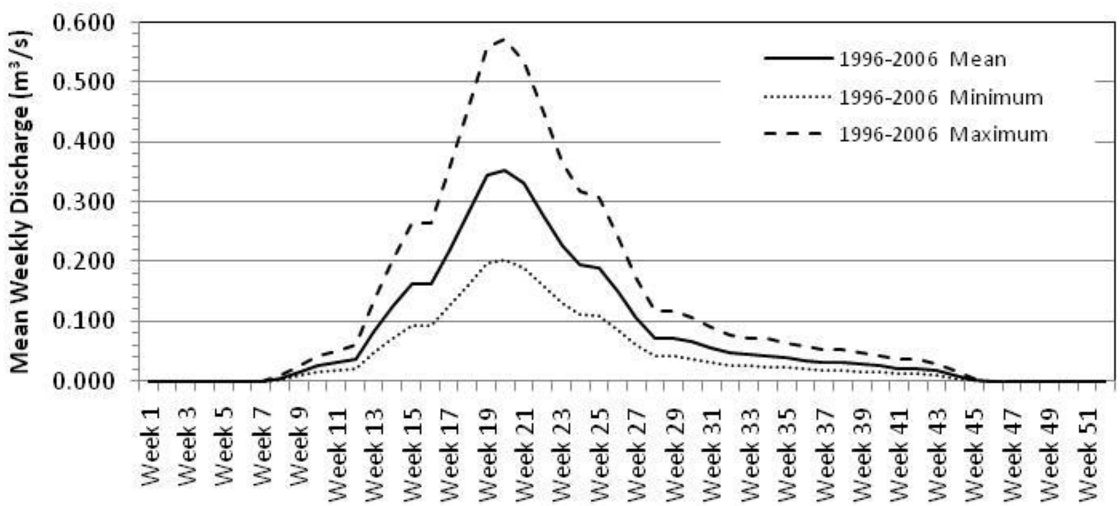




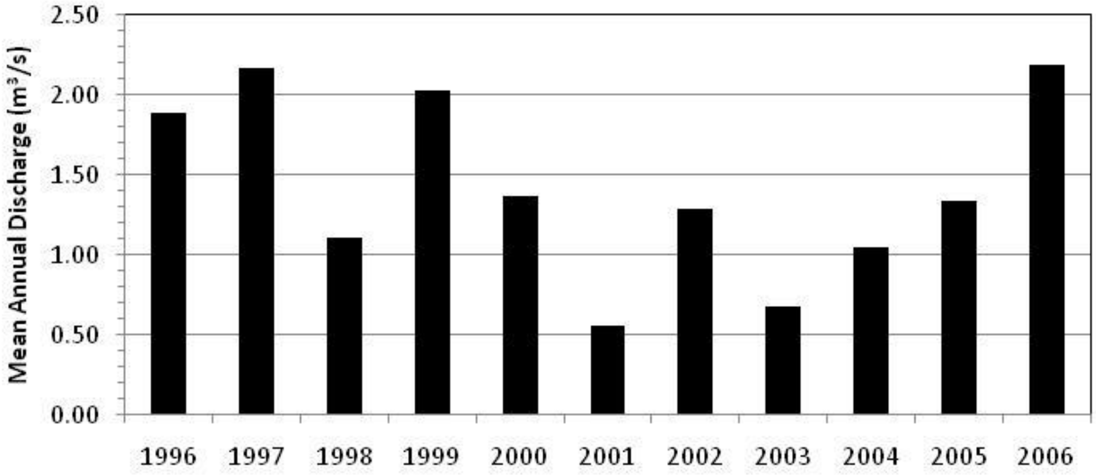
Node 17: Residual Area W-6

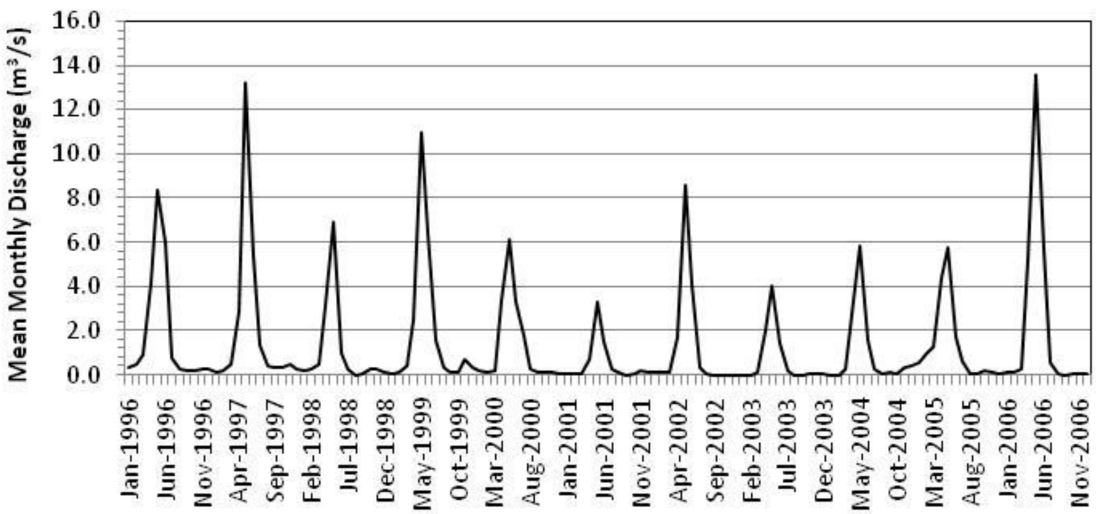


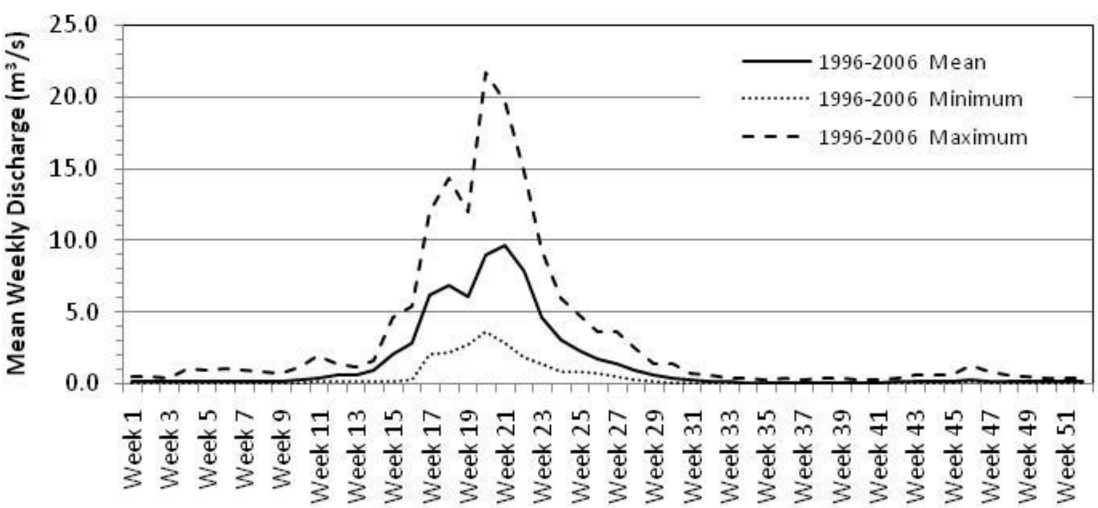




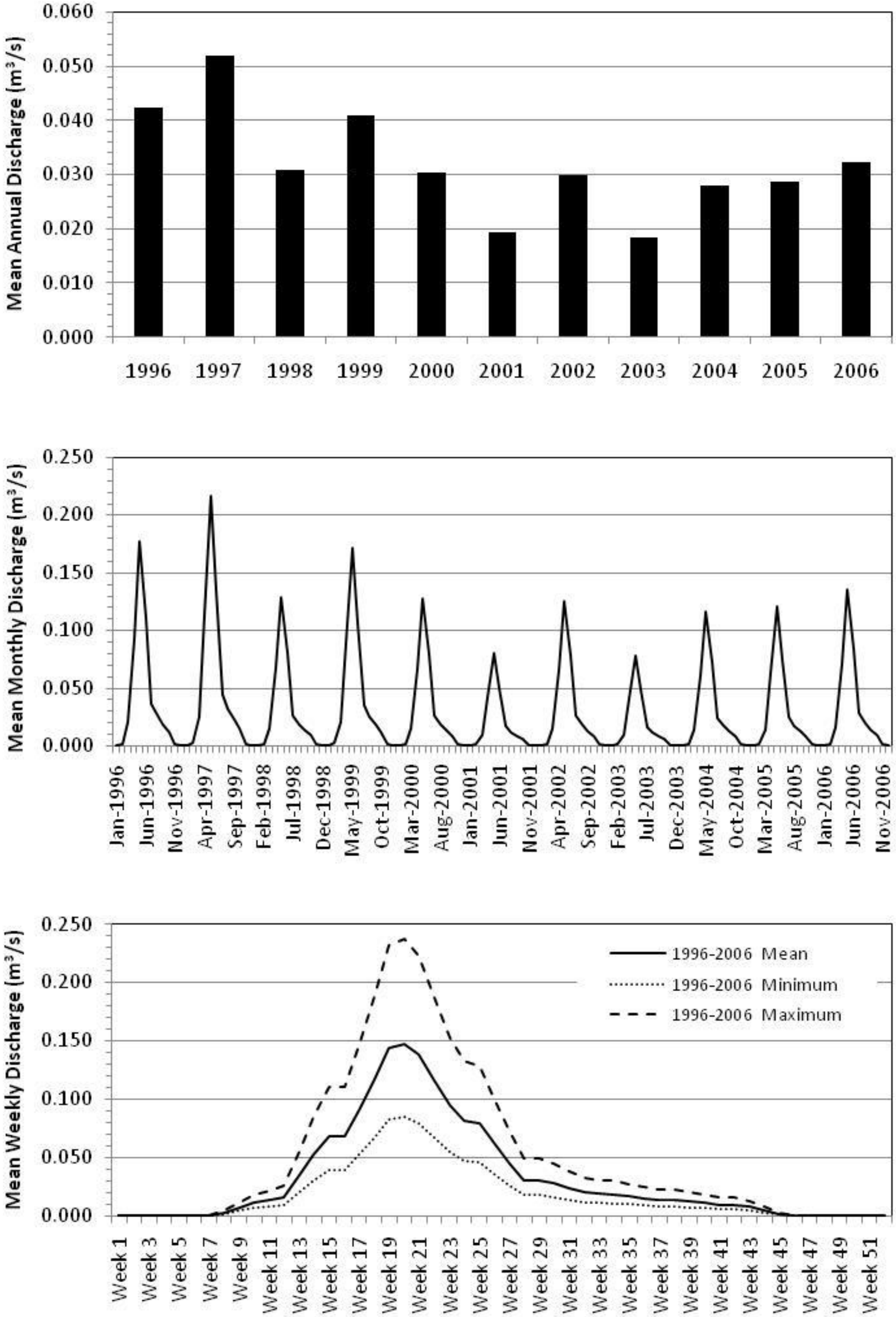
Node 18: Lambly Cr.



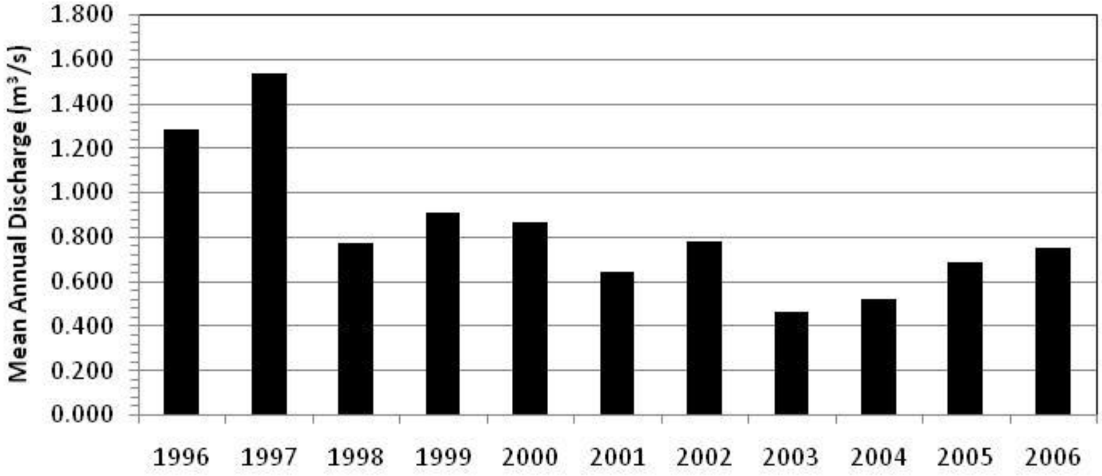


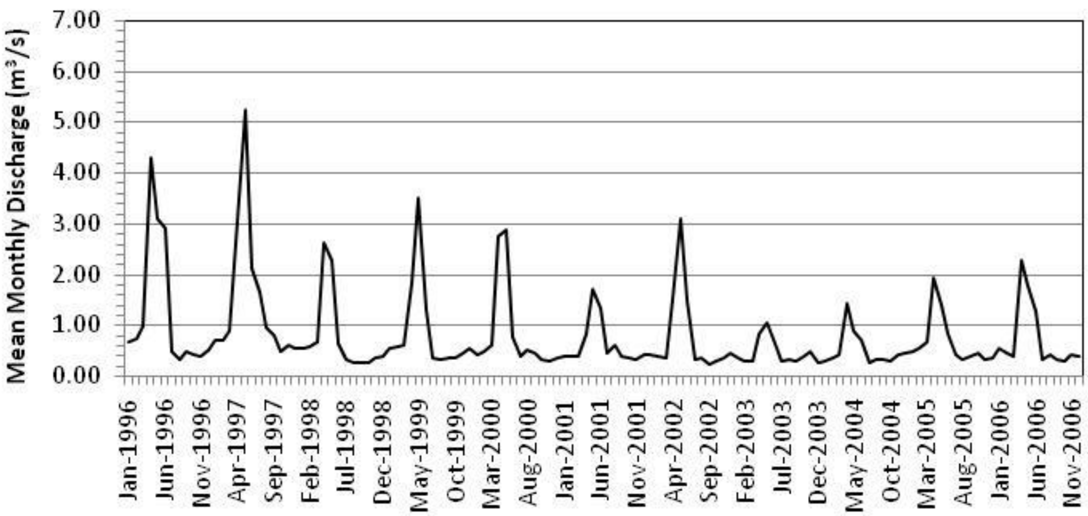


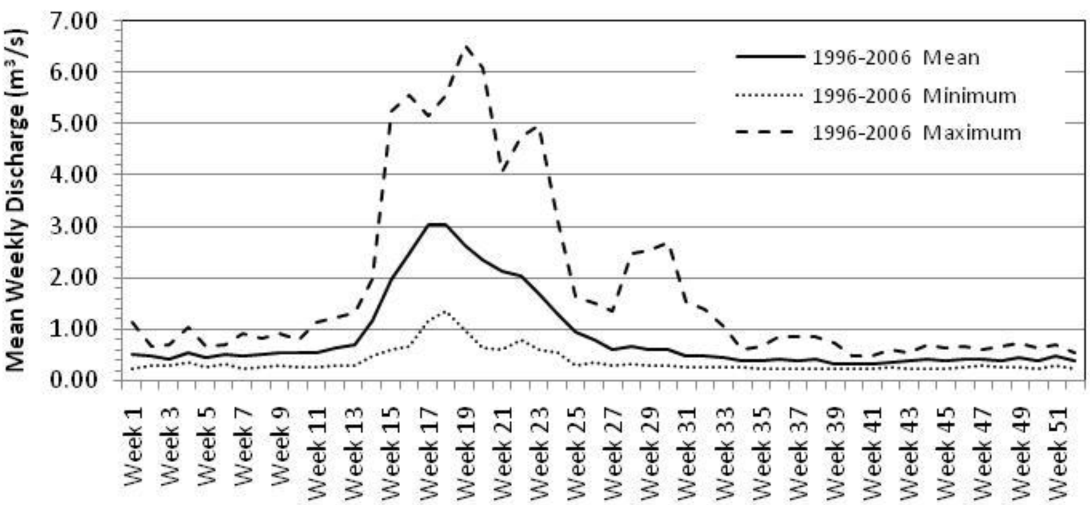
Node 19: Residual Area W-7



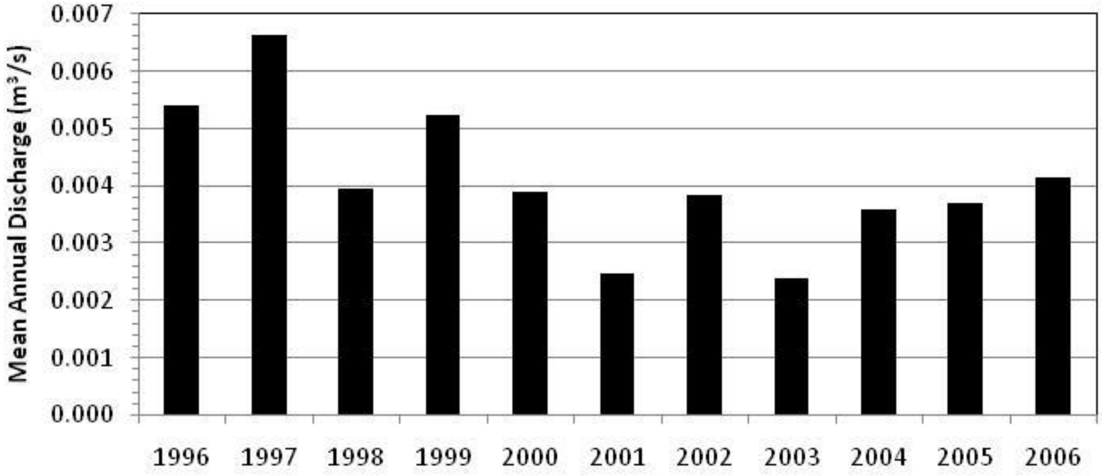
Node 20: Mill (Kelowna) Cr.

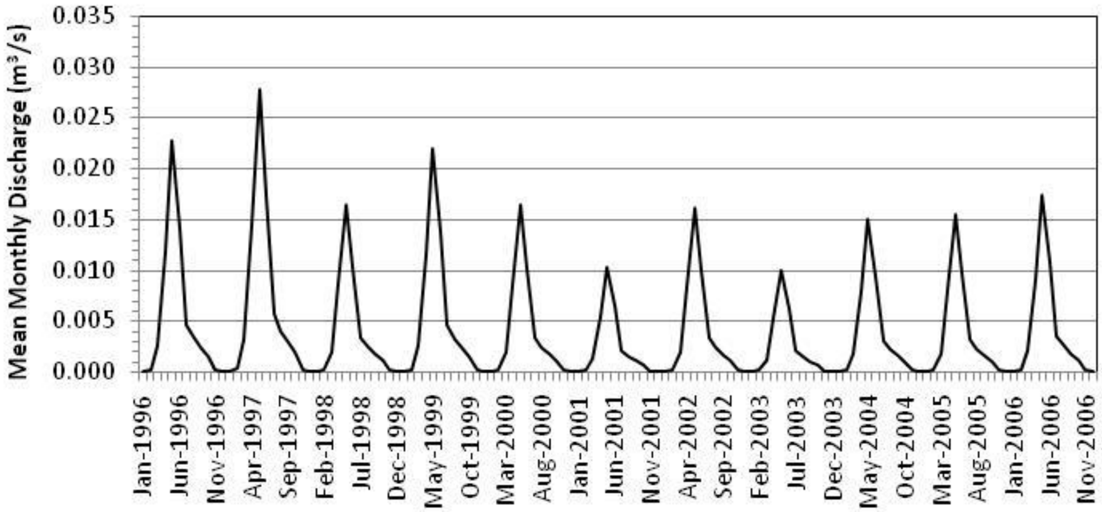


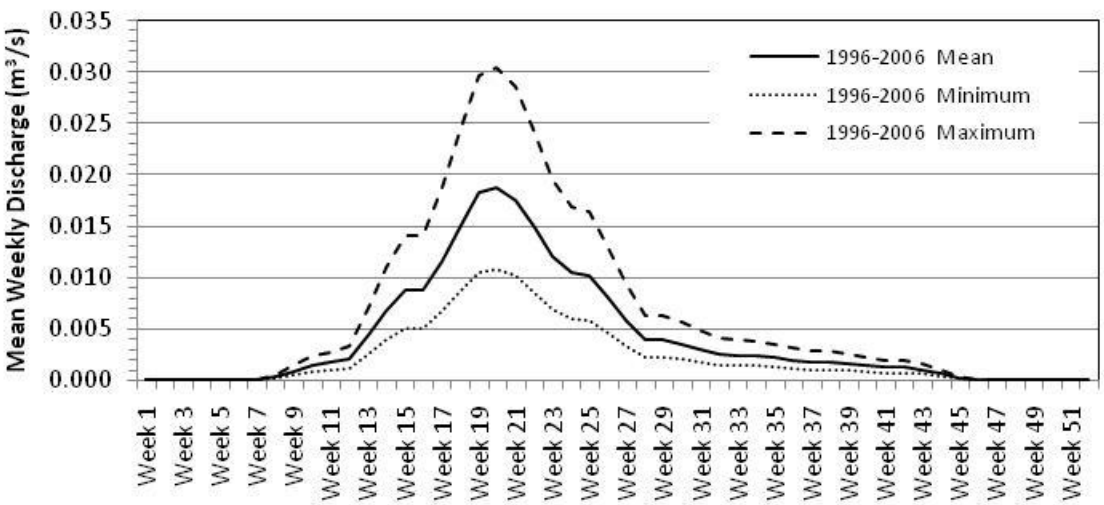




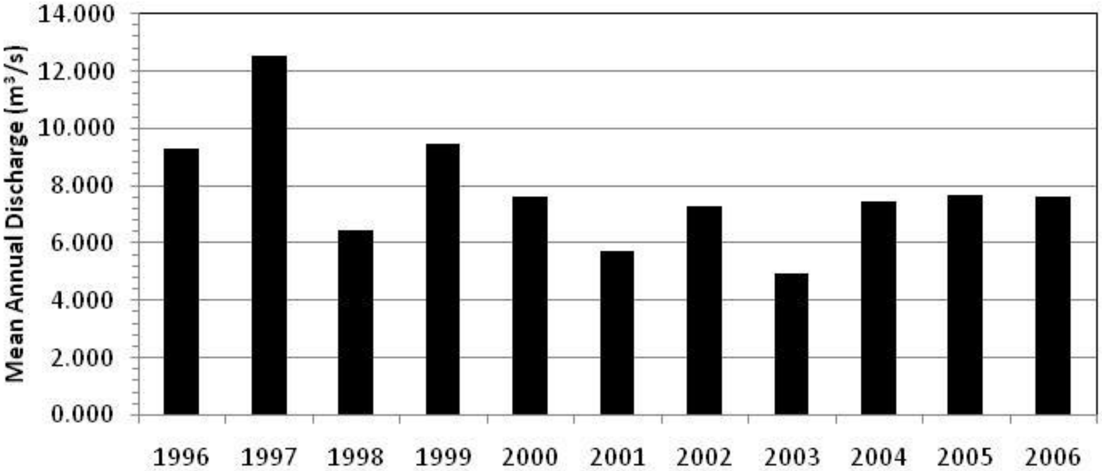
Node 21: Residual Area E-3

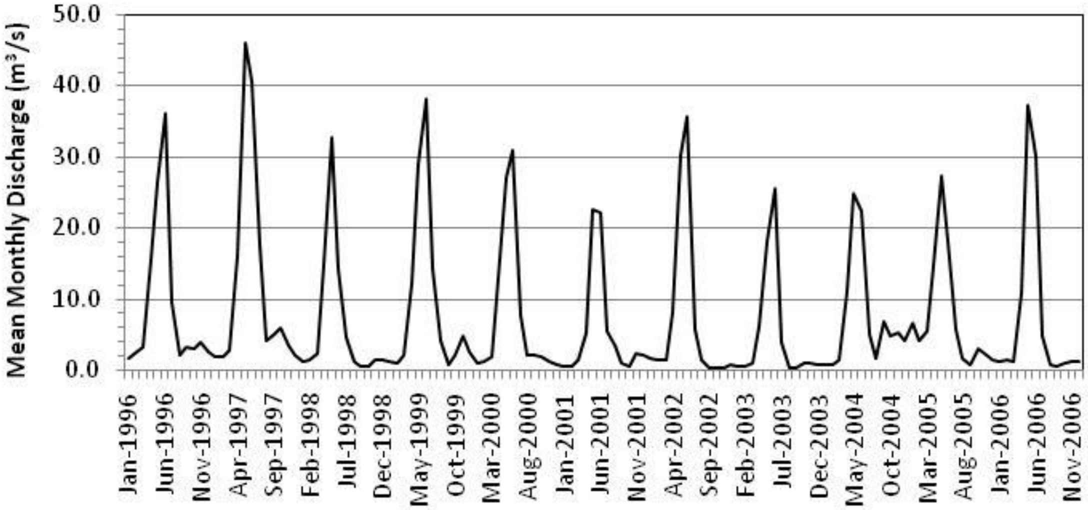


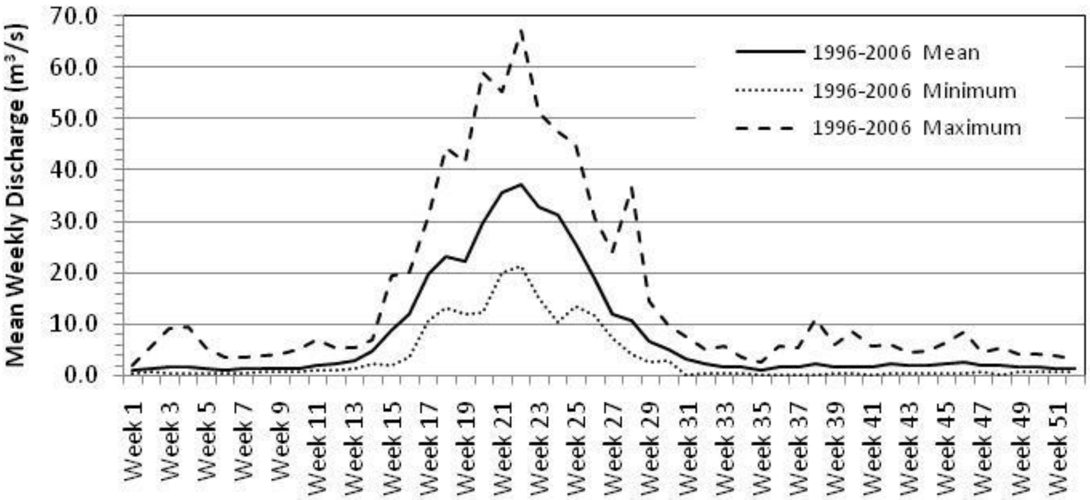




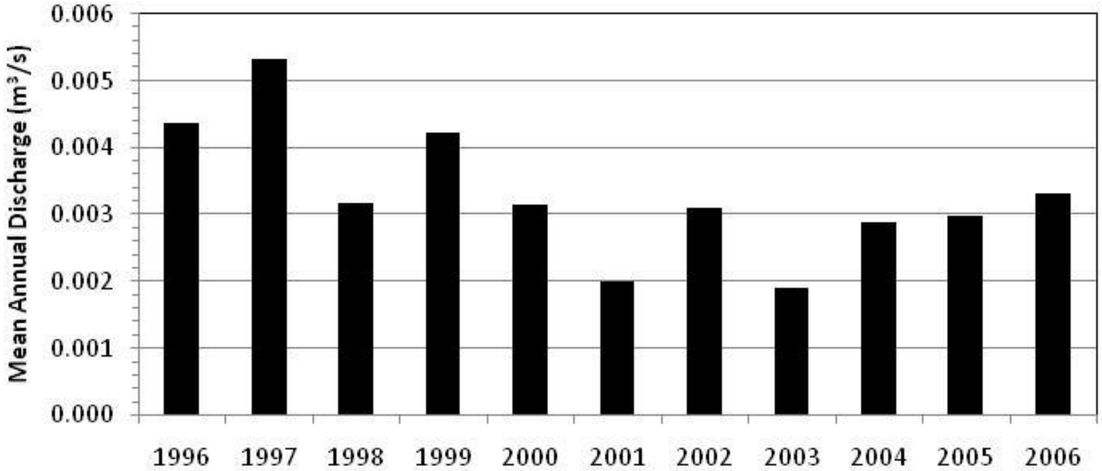
Node 22: Mission Cr.

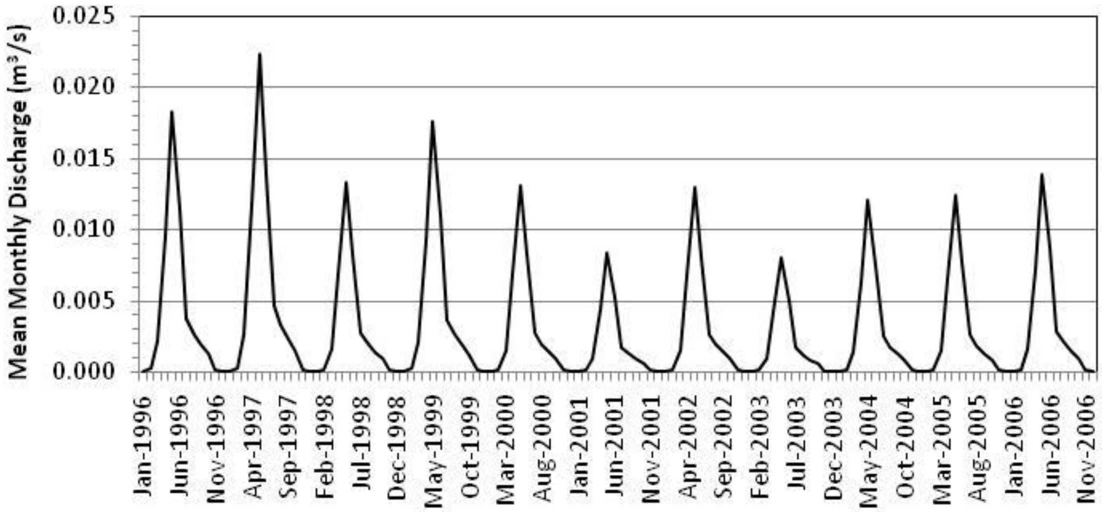


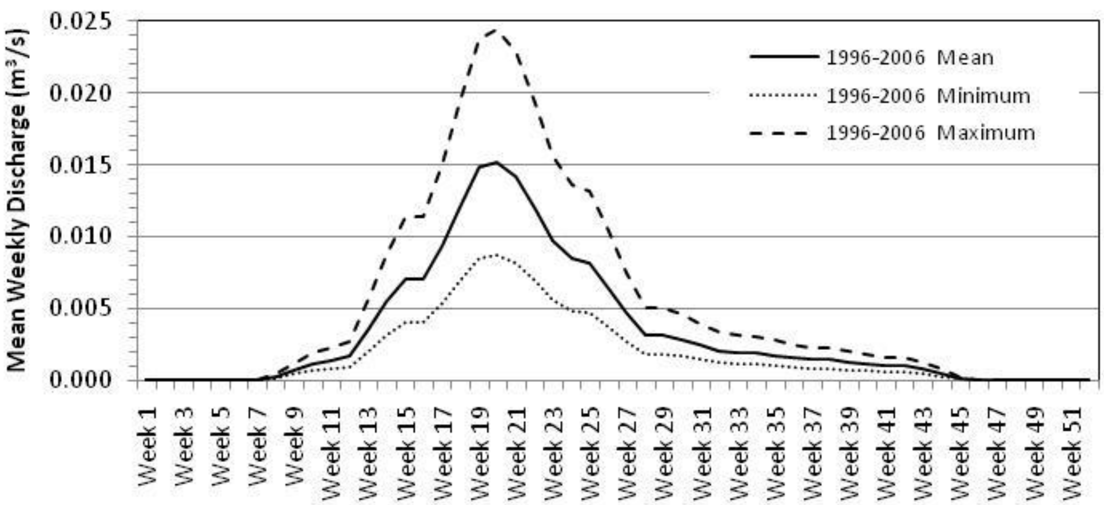




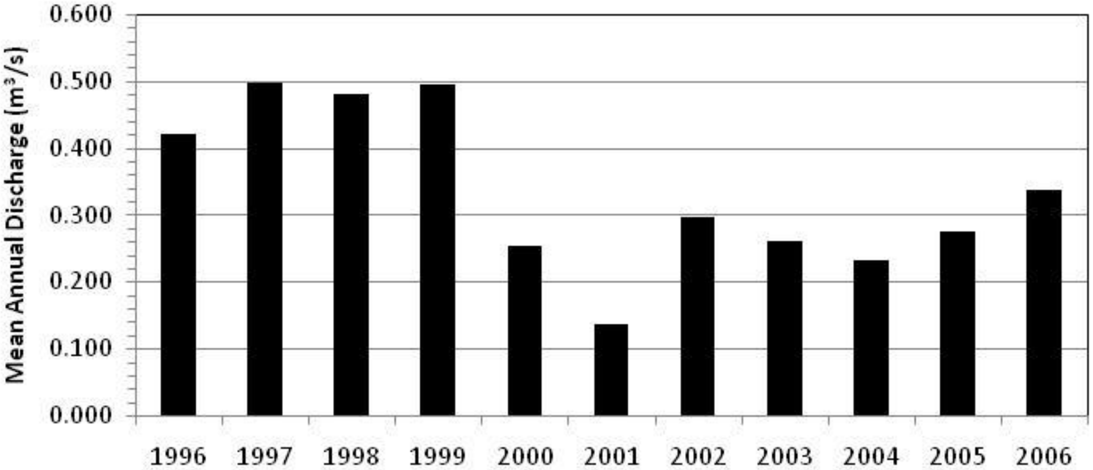
Node 23: Residual Area E-4

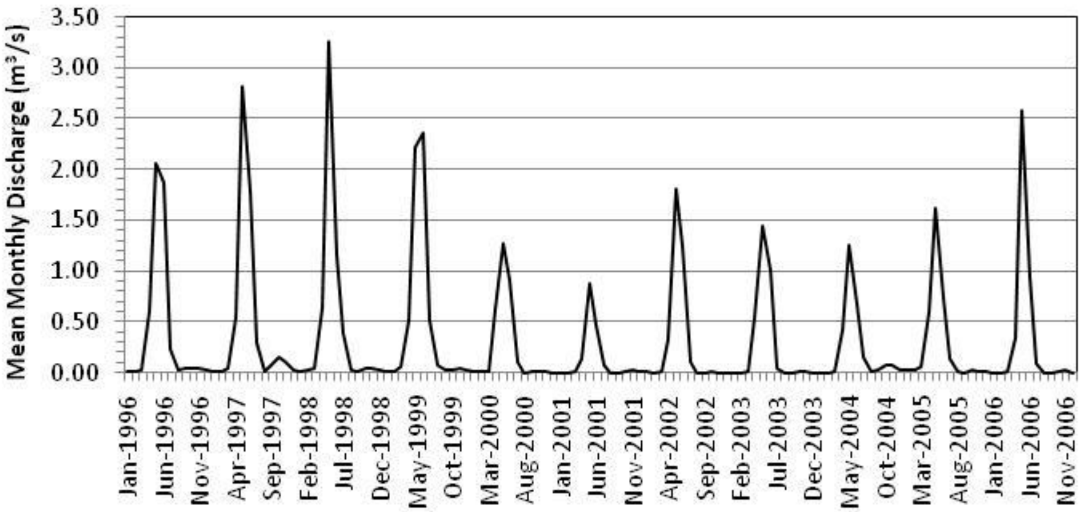


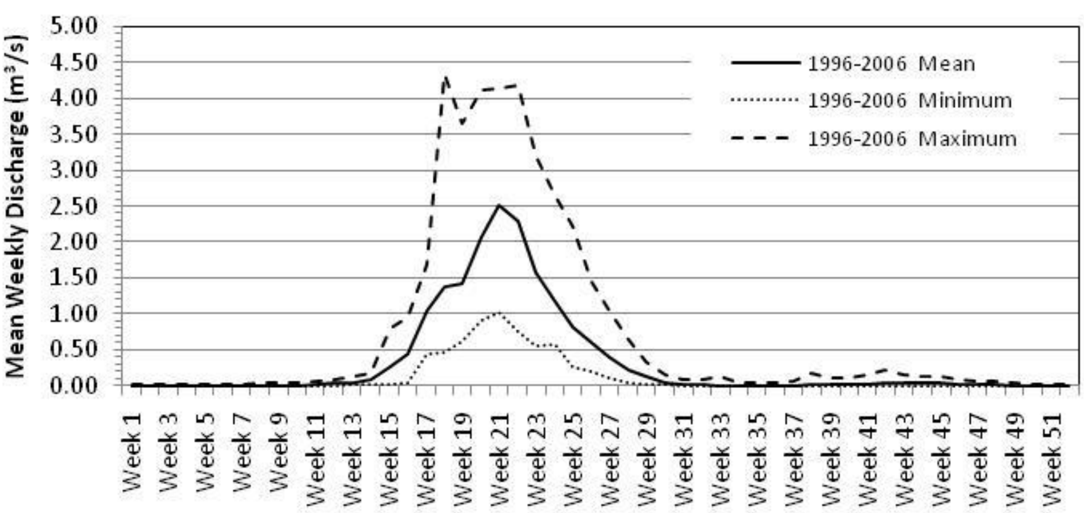




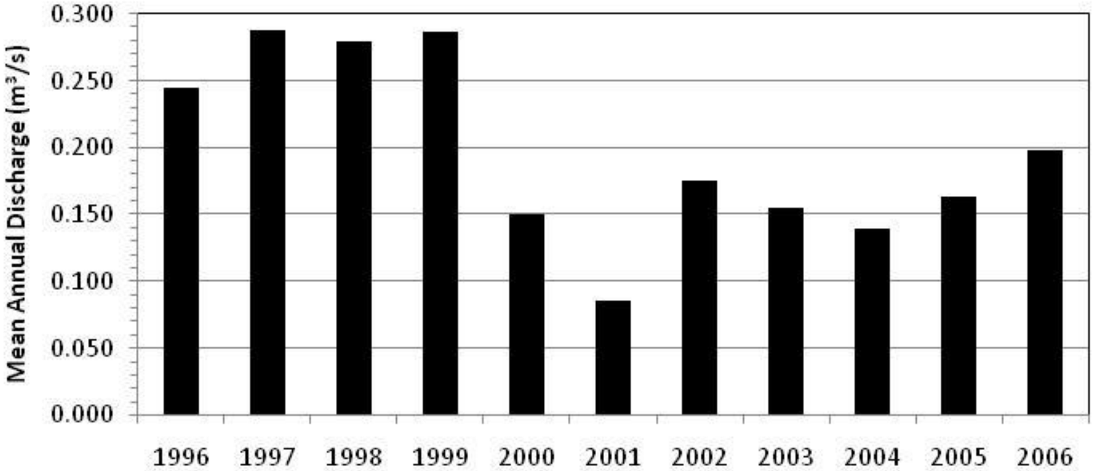
Node 24: Bellevue Cr.

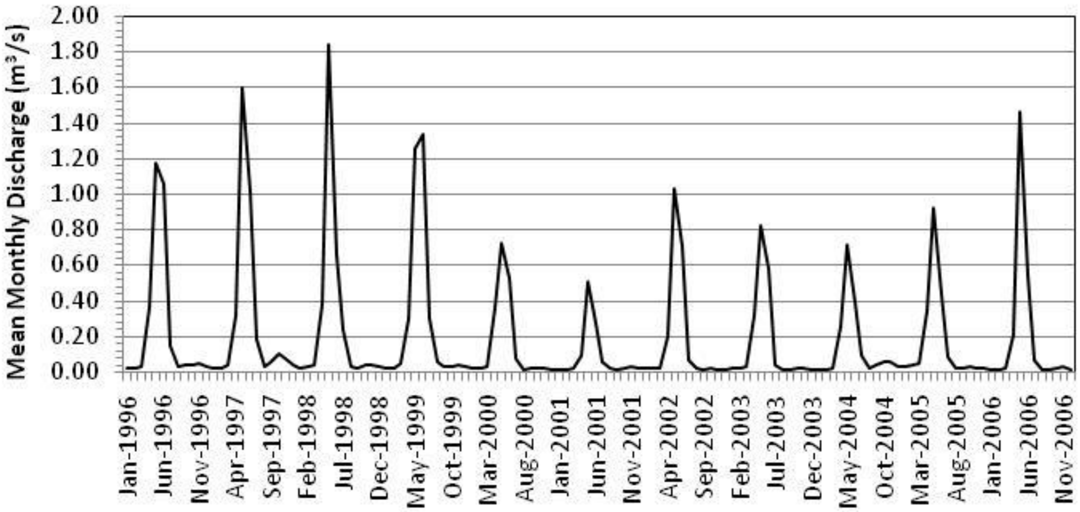


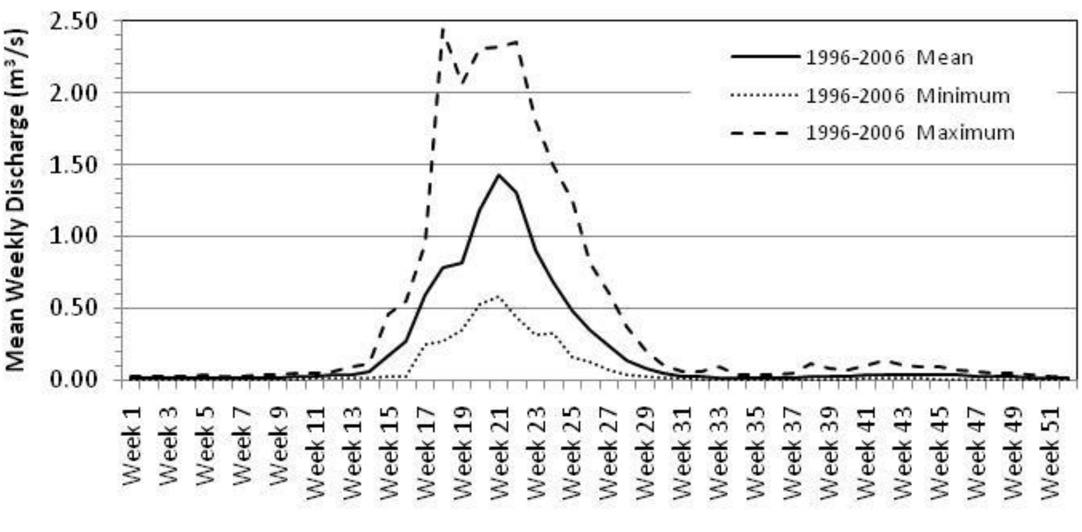




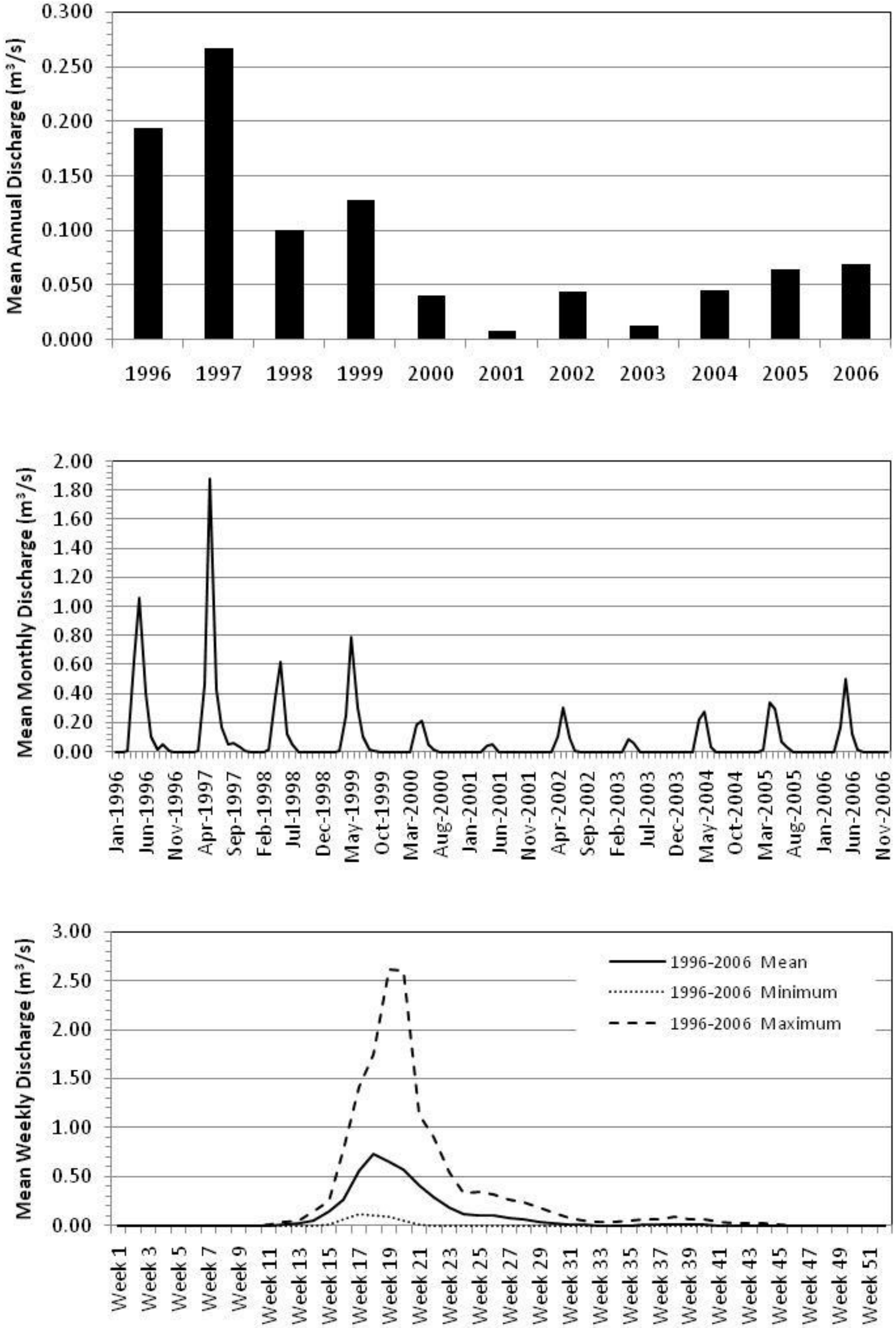
Node 25: Residual Area E-5



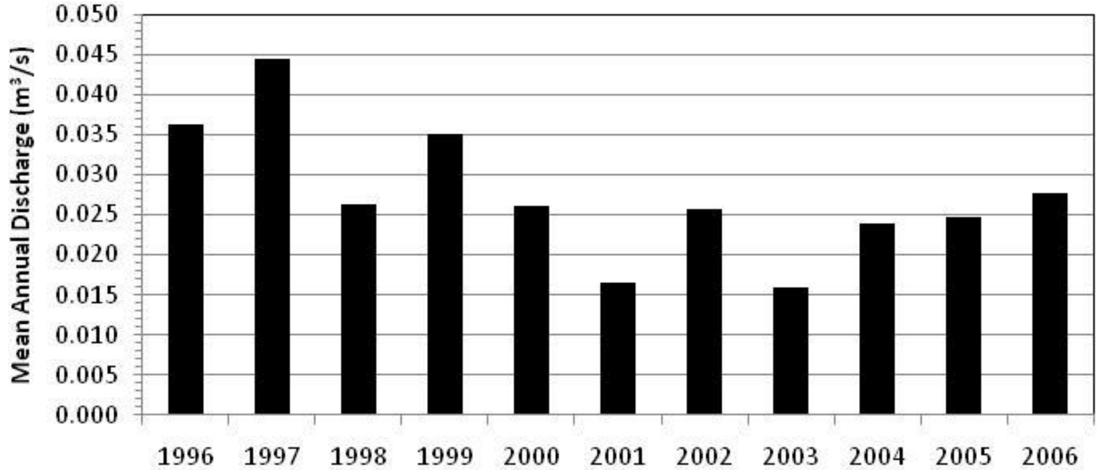


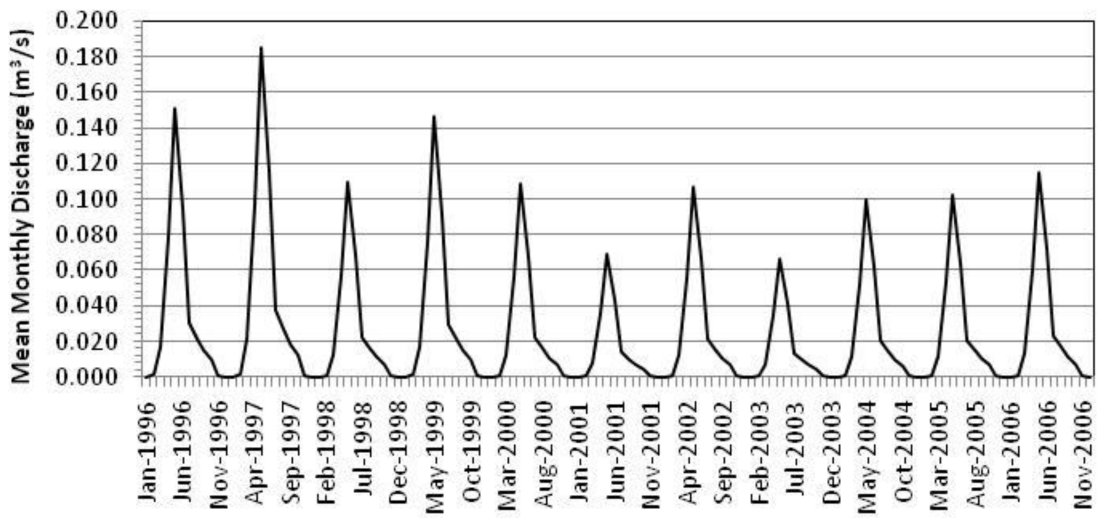


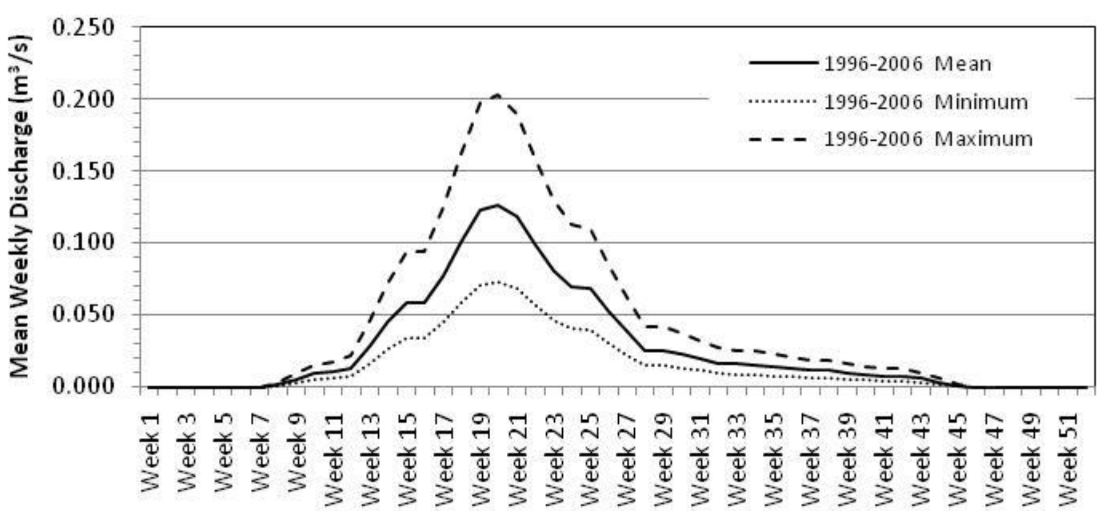
Node 26: McDougall Cr.



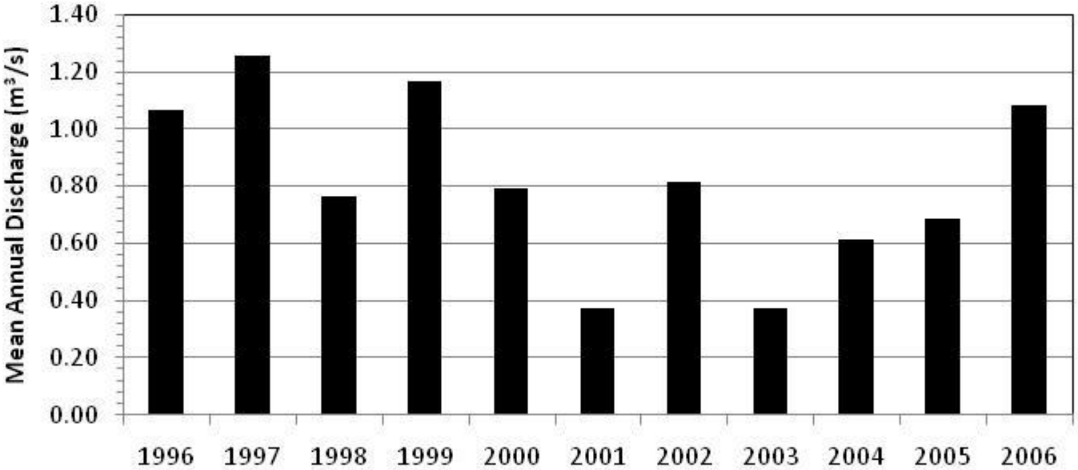
Node 27: Residual Area W-8

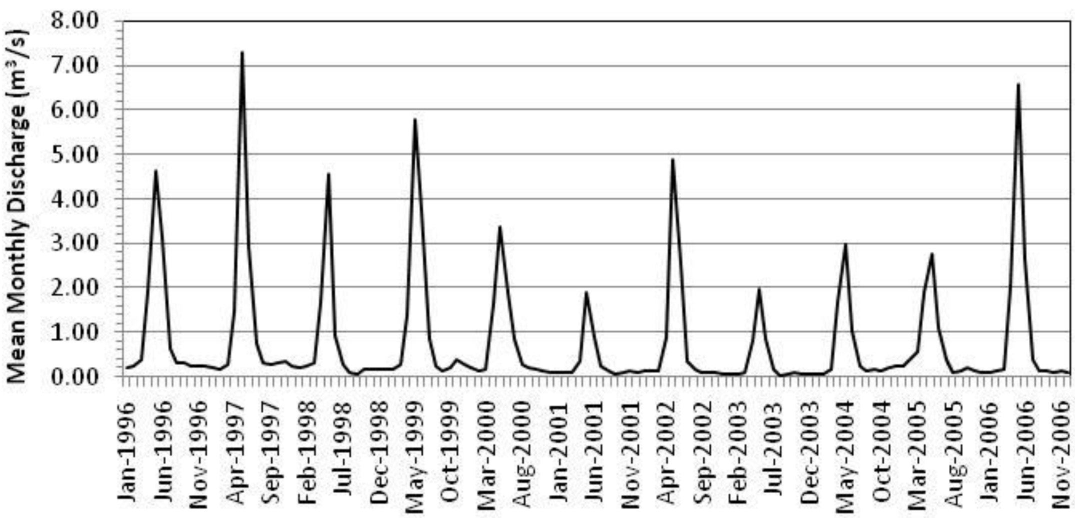


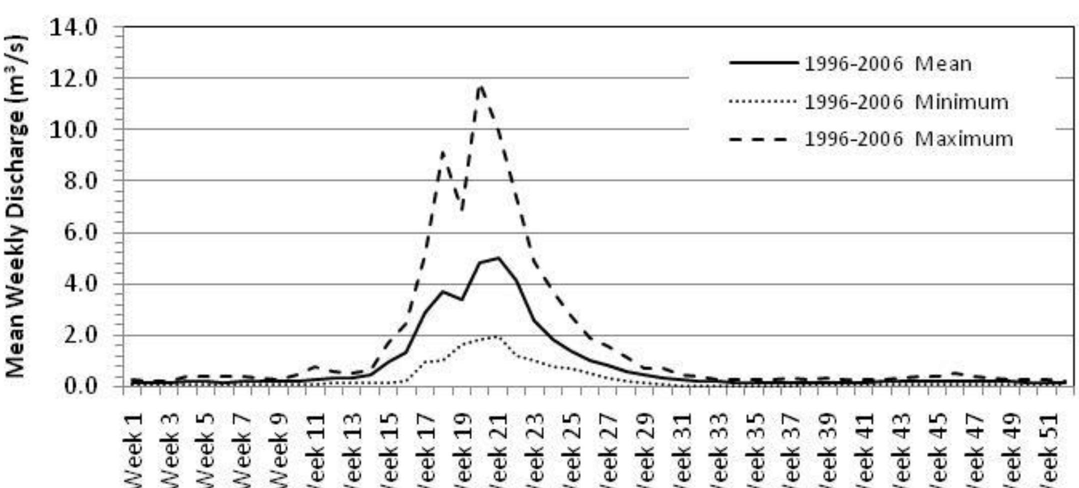




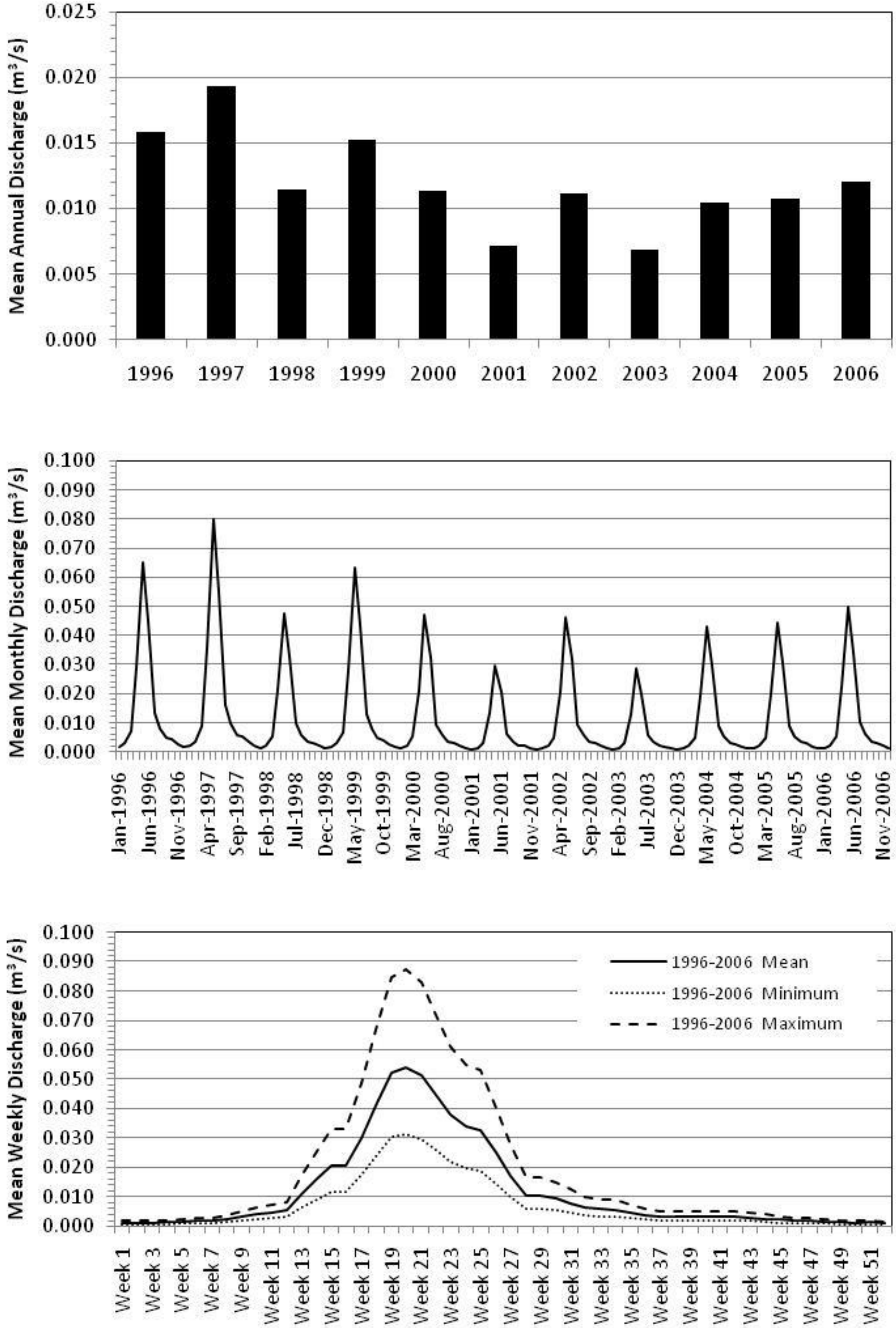
Node 28: Powers Cr.



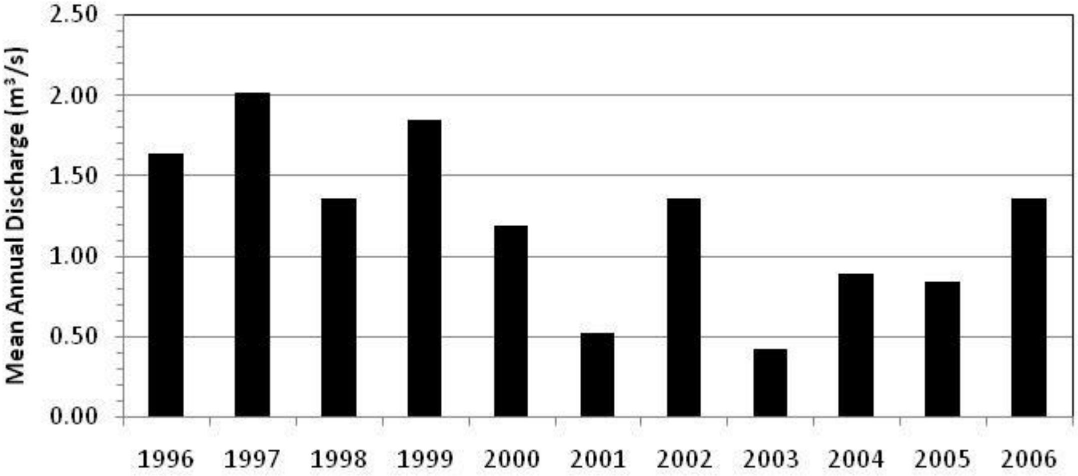


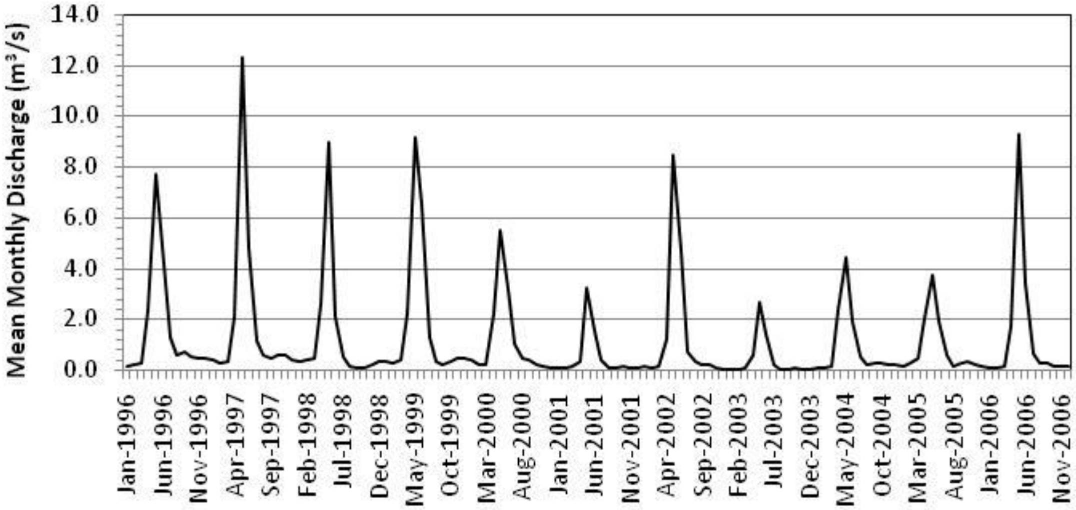


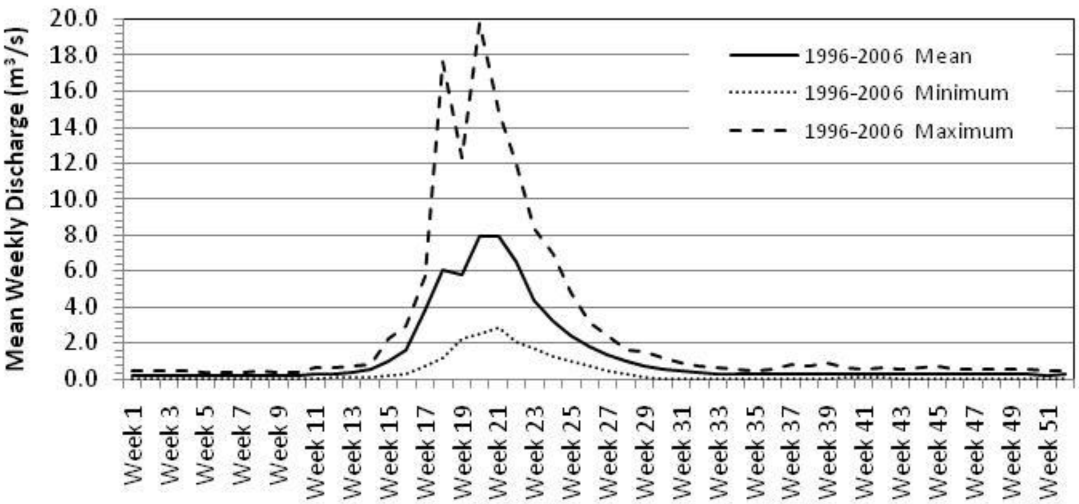
Node 29: Residual Area W-9



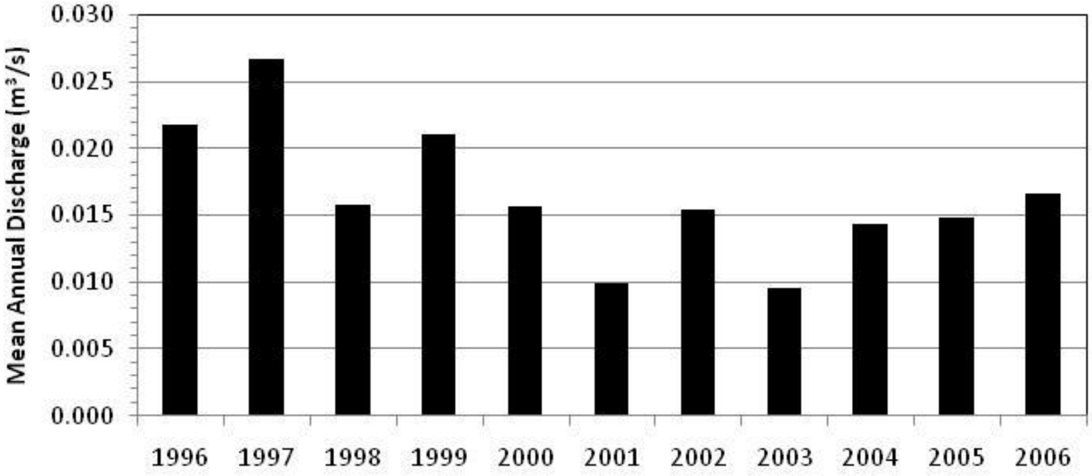
Node 30: Trepanier Cr.

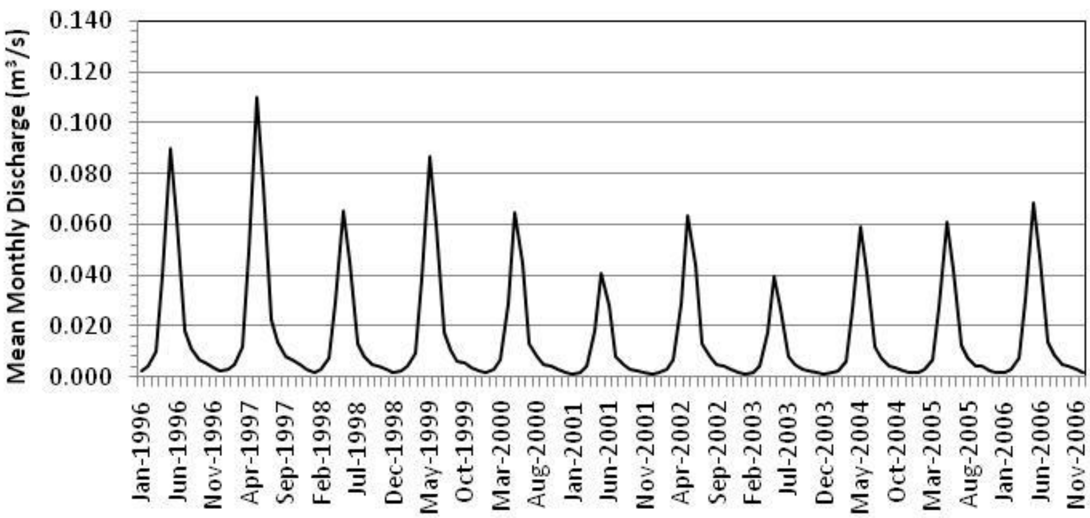


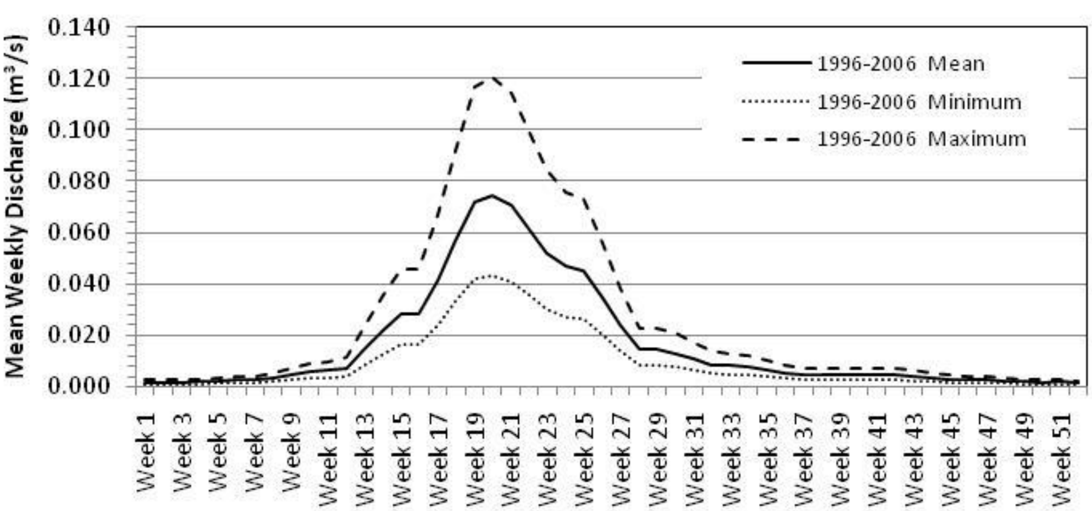




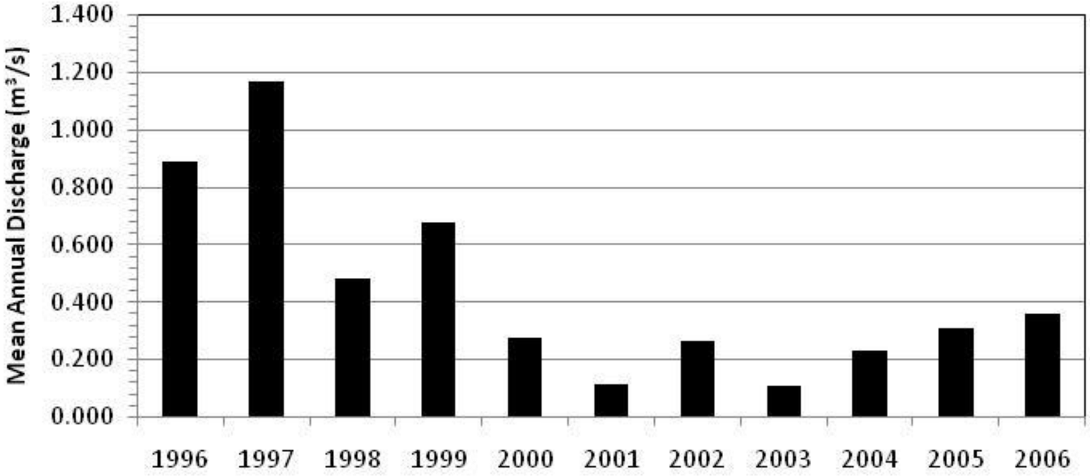
Node 31: Residual Area W-10

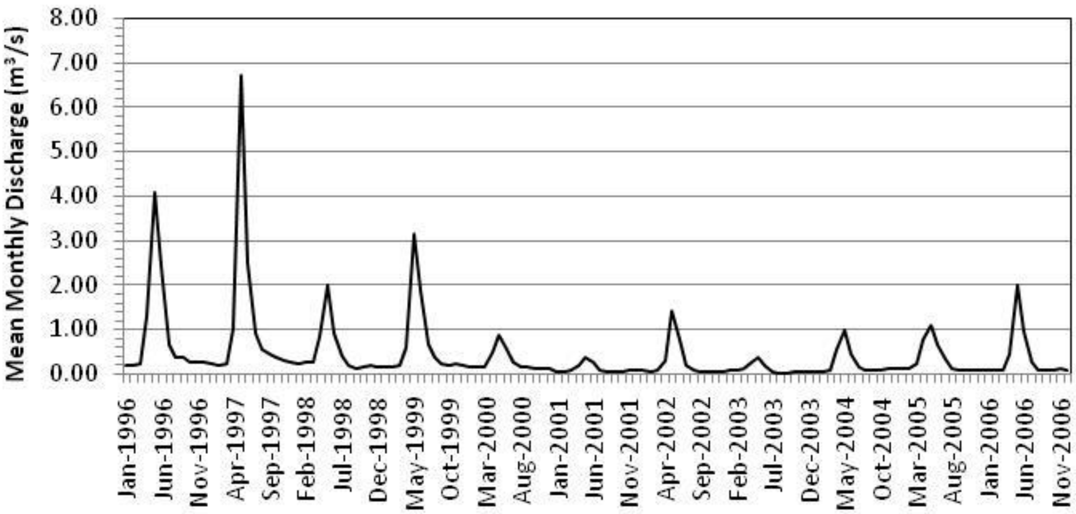


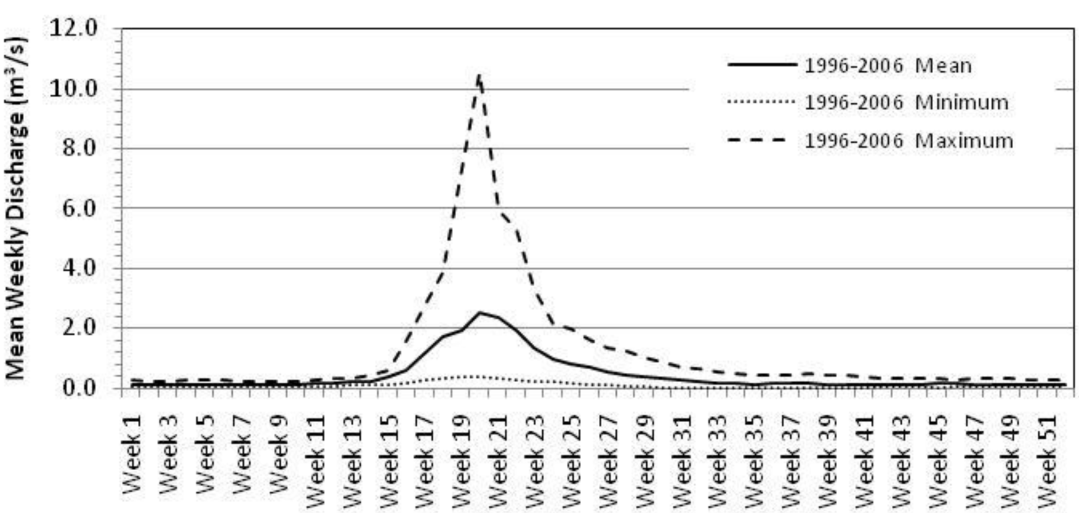




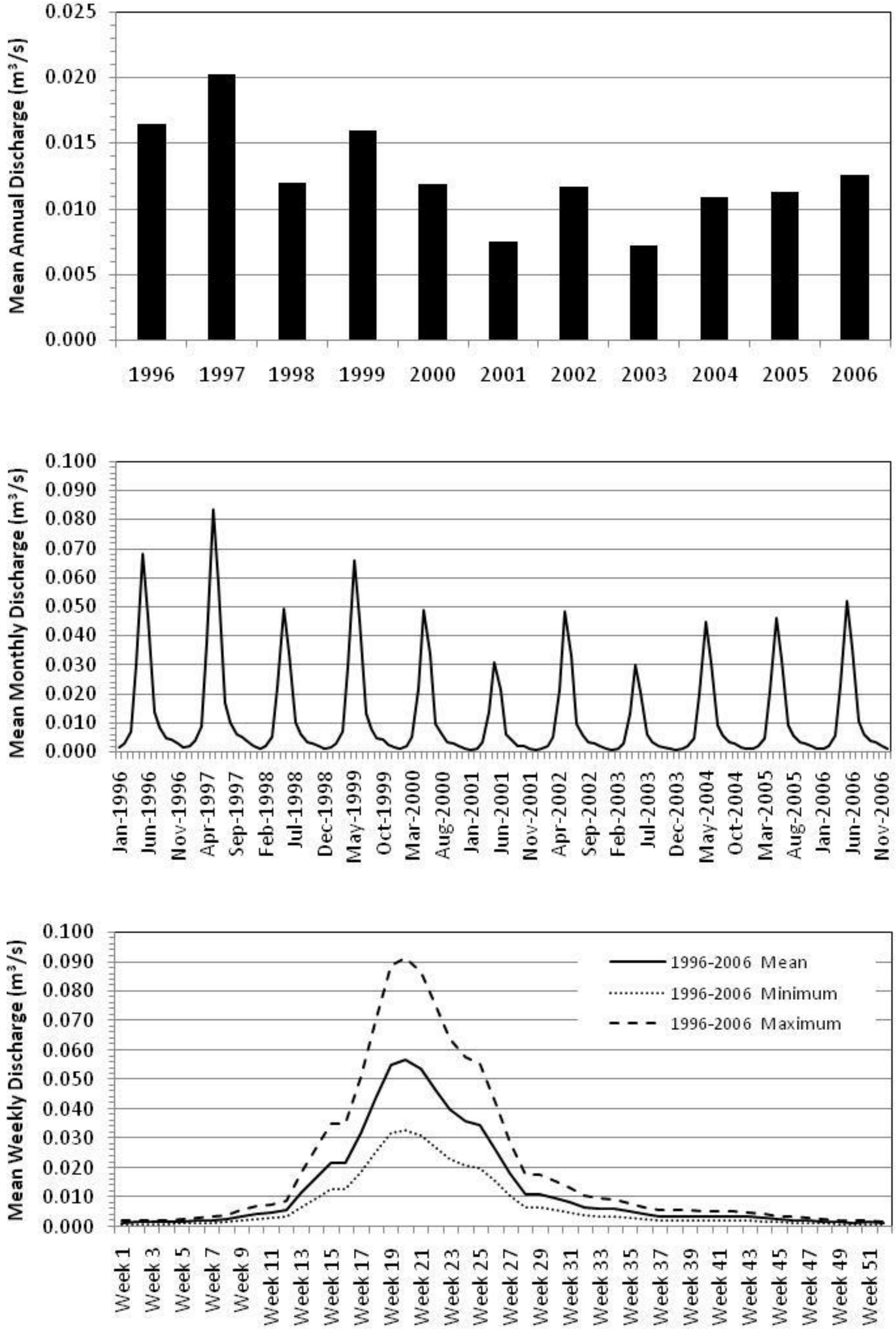
Node 32: Peachland Cr.



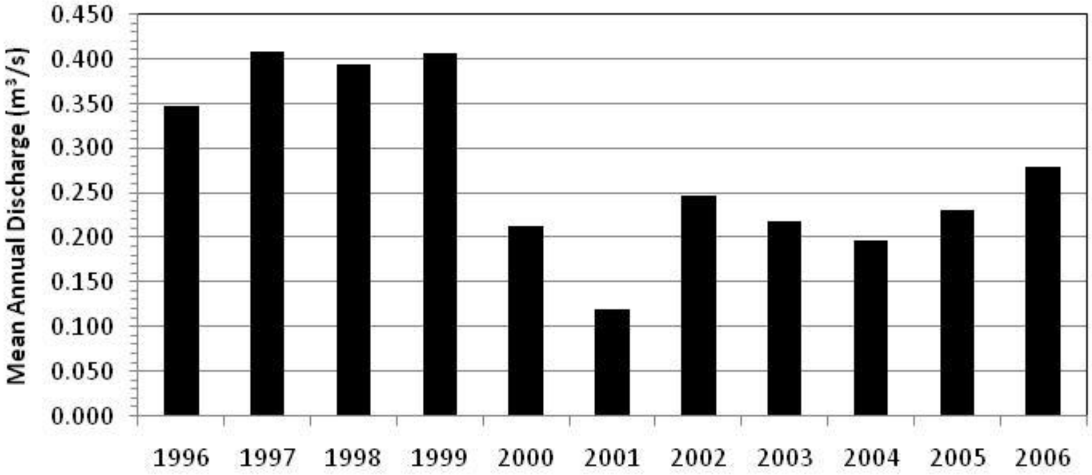


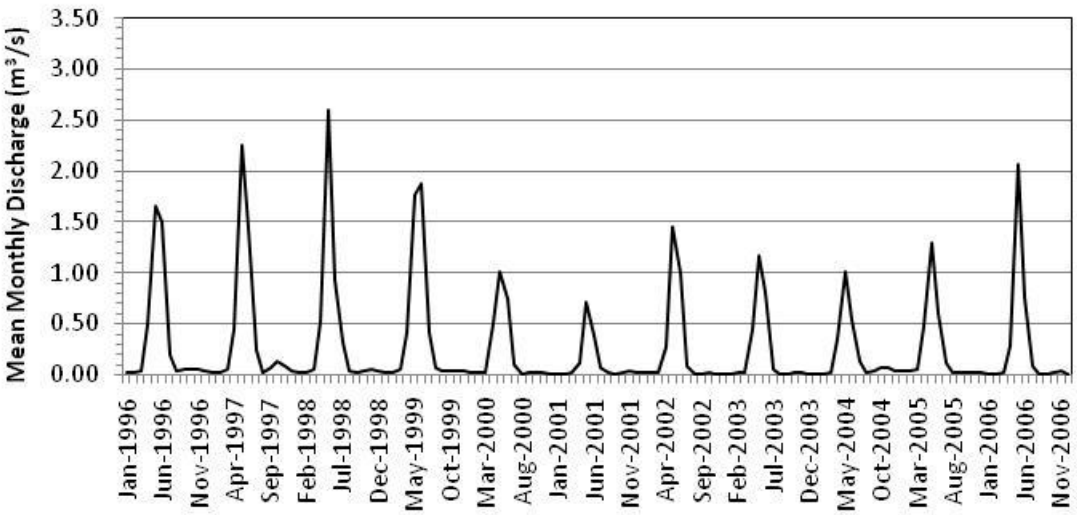


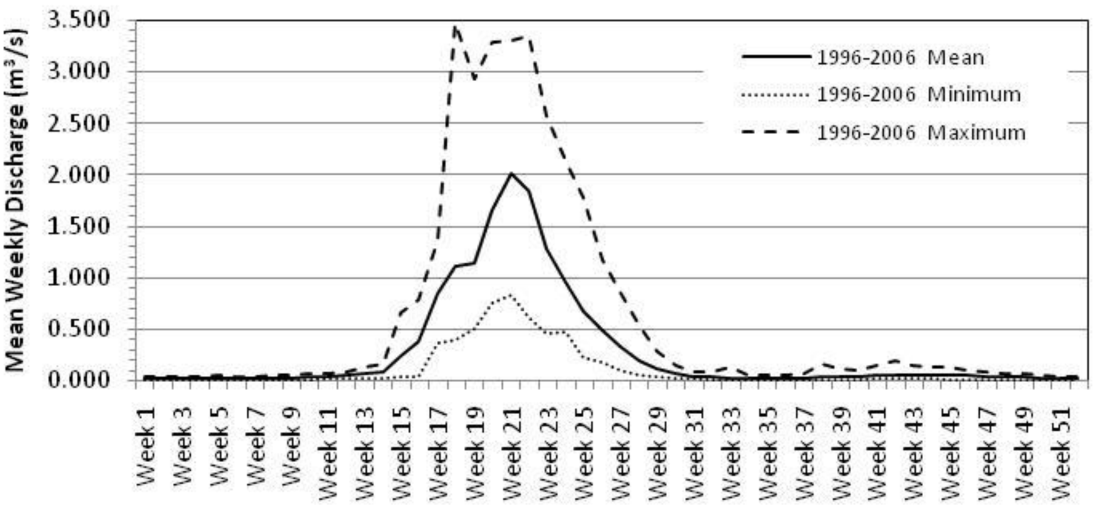
Node 33: Residual Area W-11



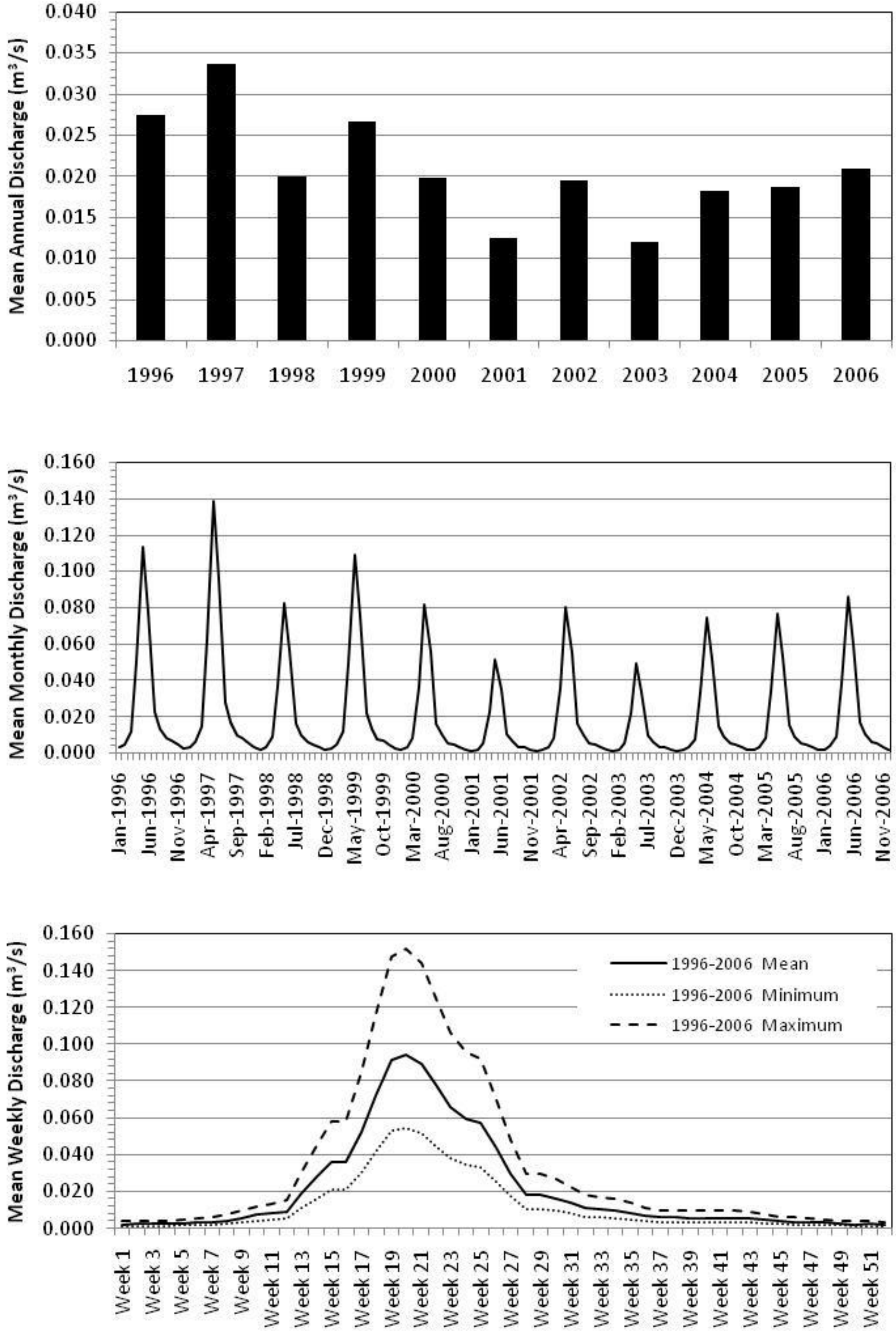
Node 34: Chute Cr.



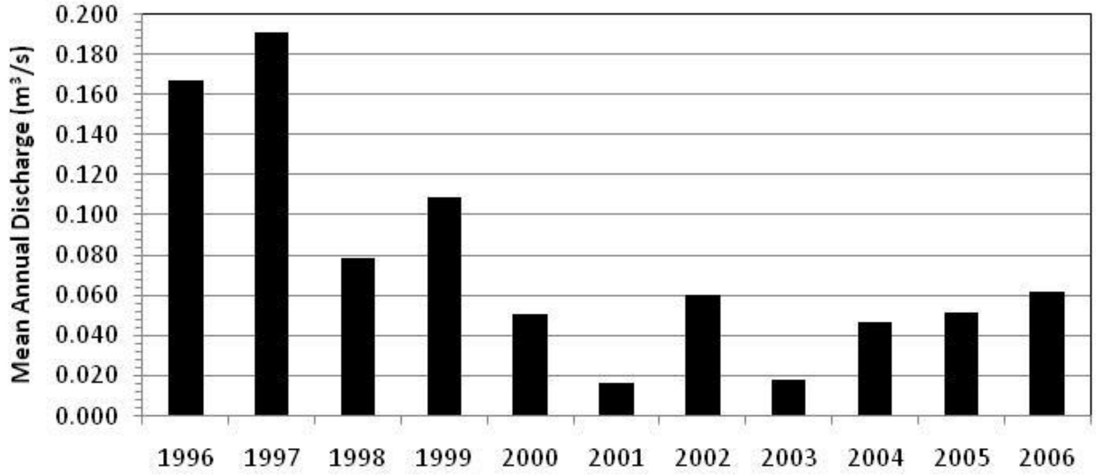


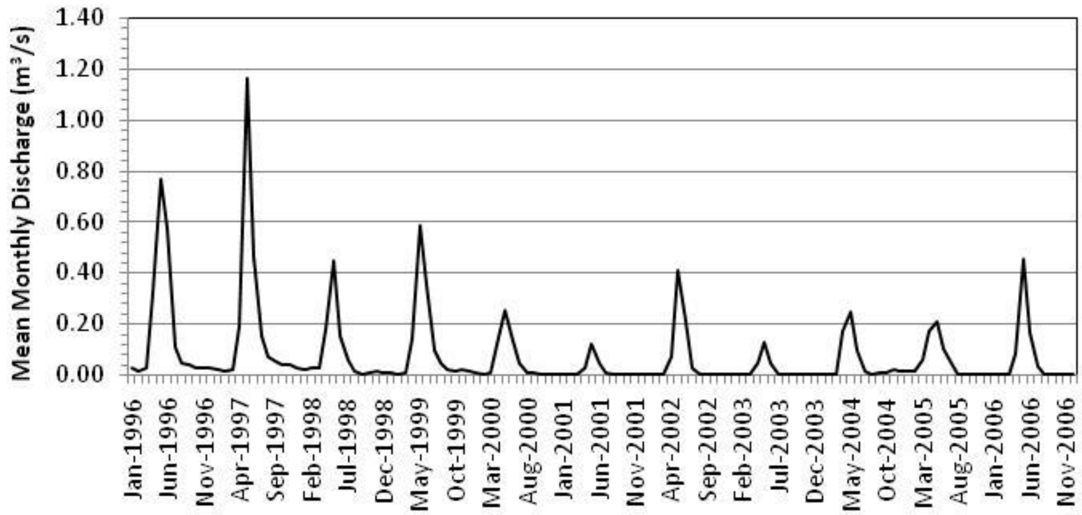


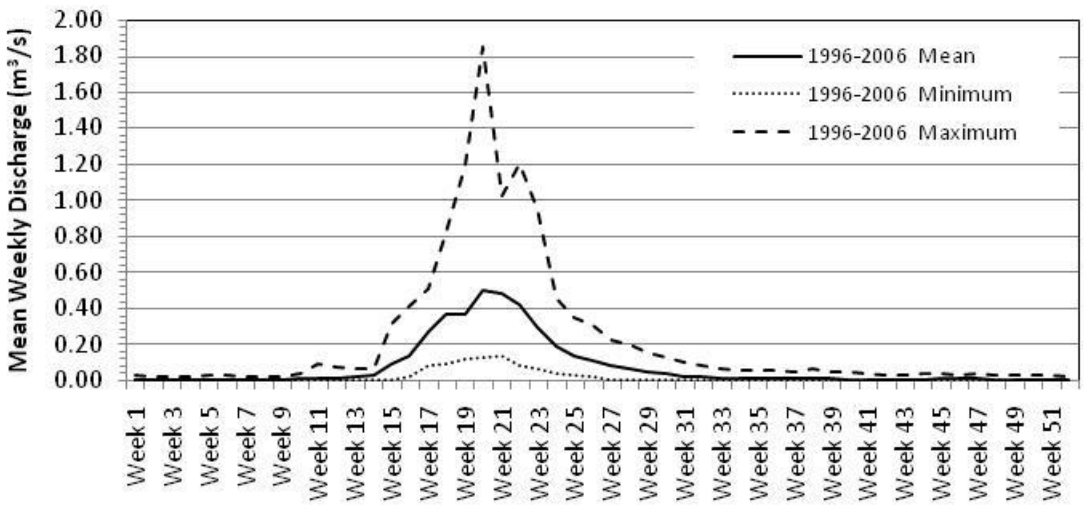
Node 35: Residual Area E-6



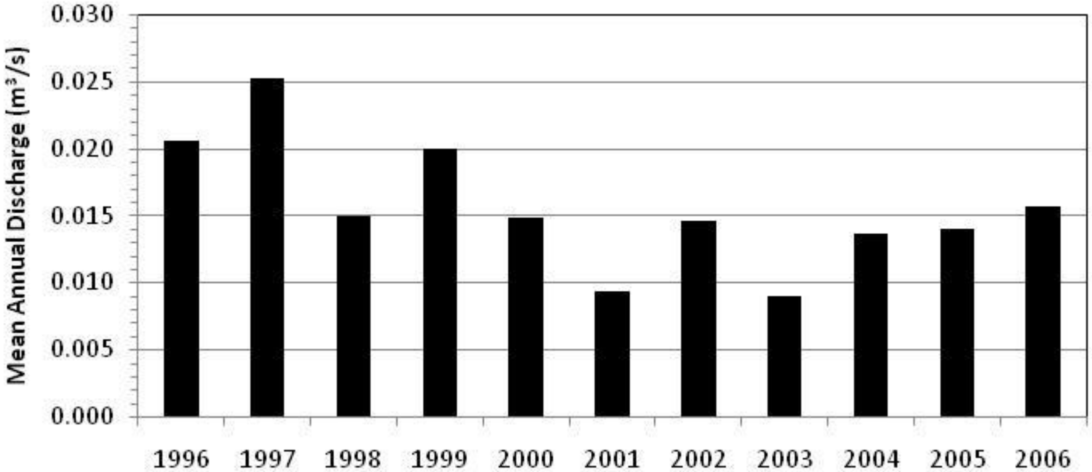
Node 36: Eneas Cr.

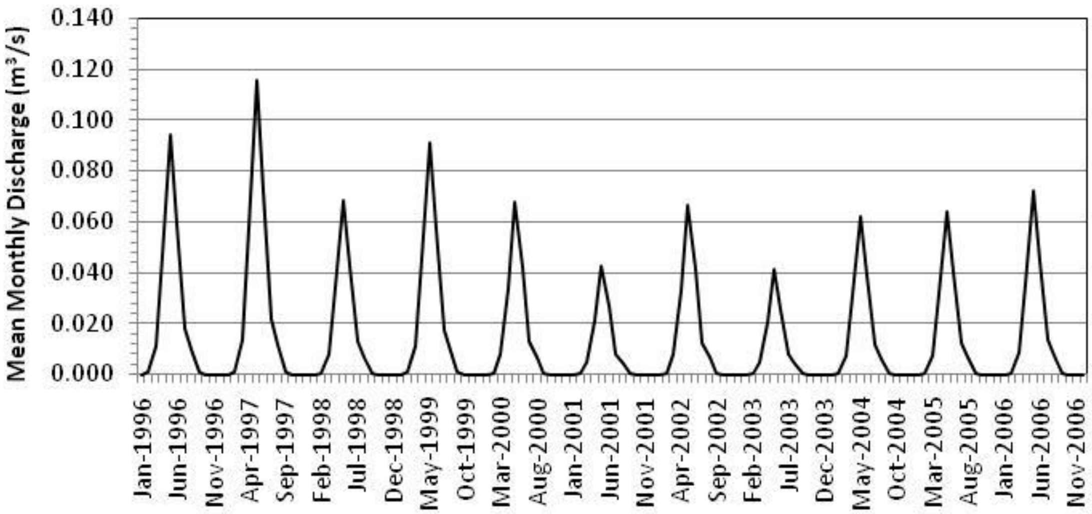


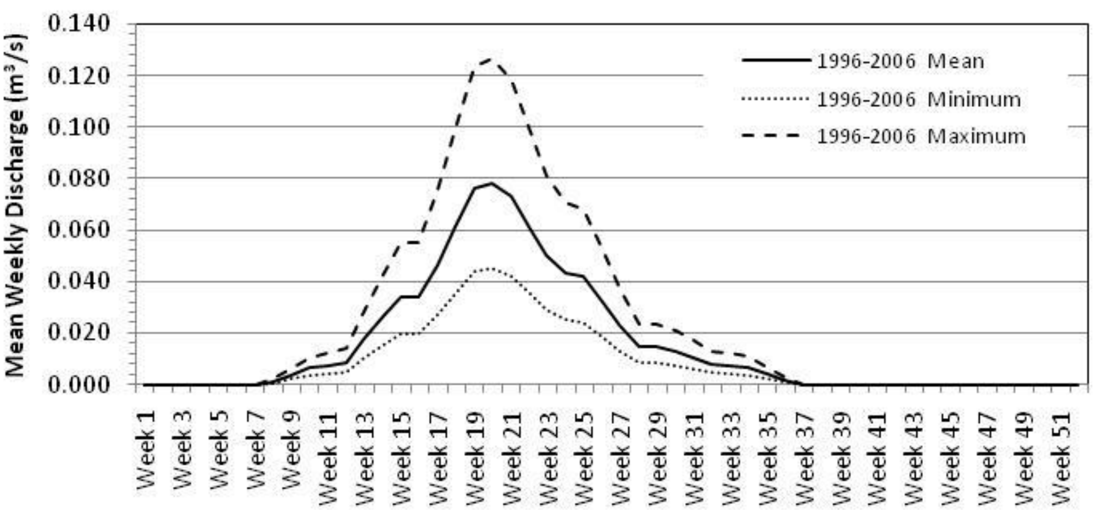




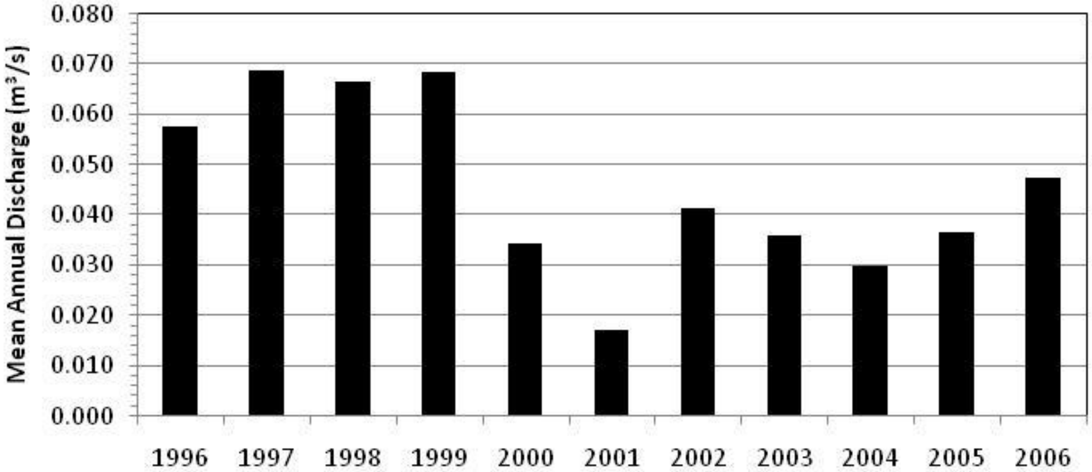
Node 37: Residual Area W-12

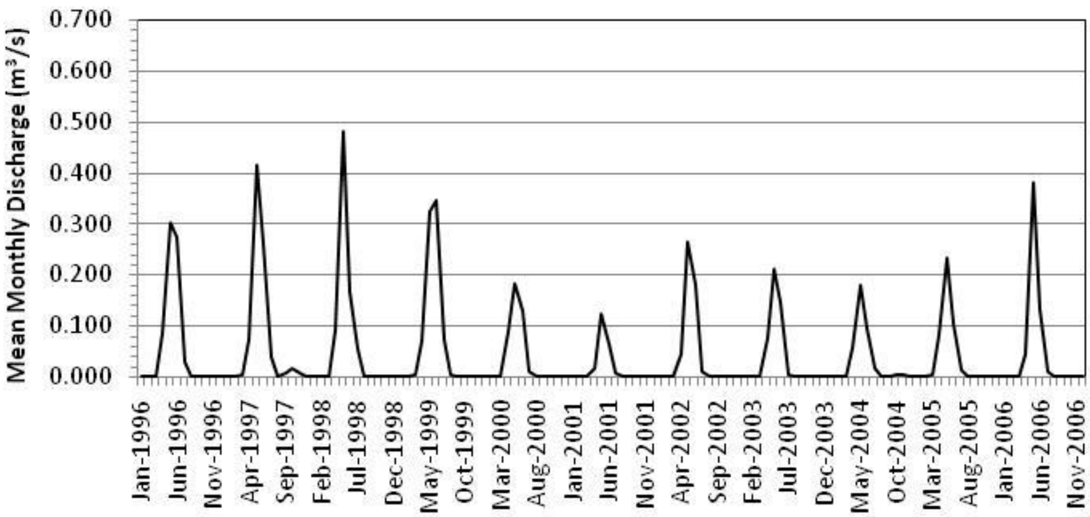


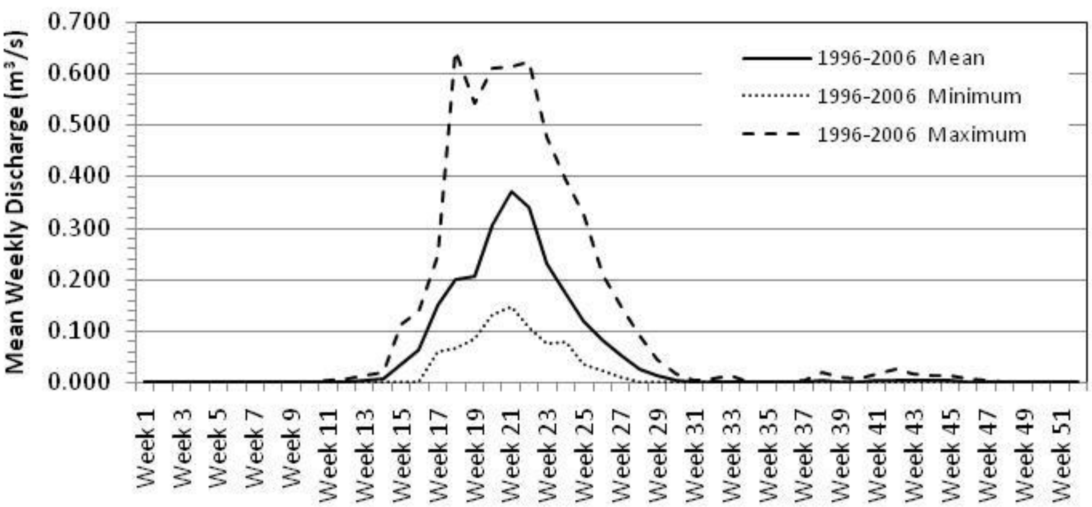




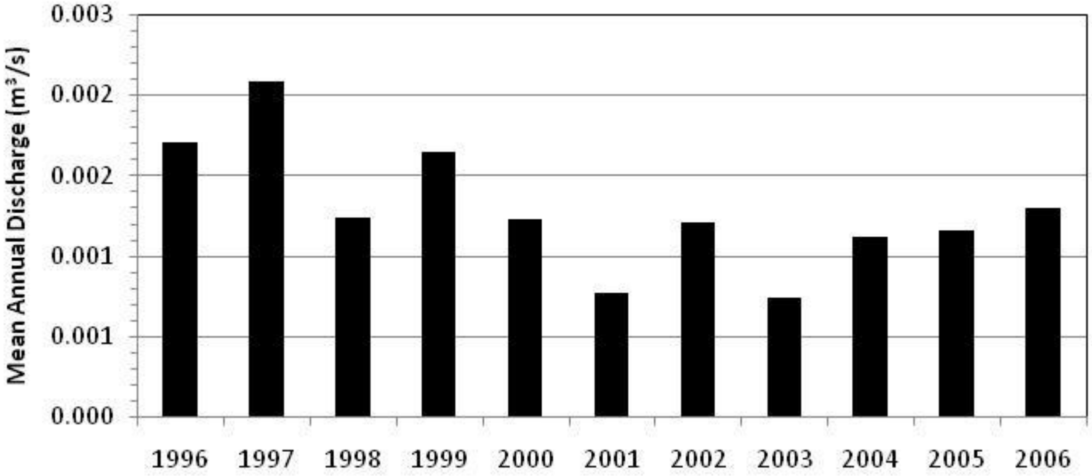
Node 38: Robinson Cr.

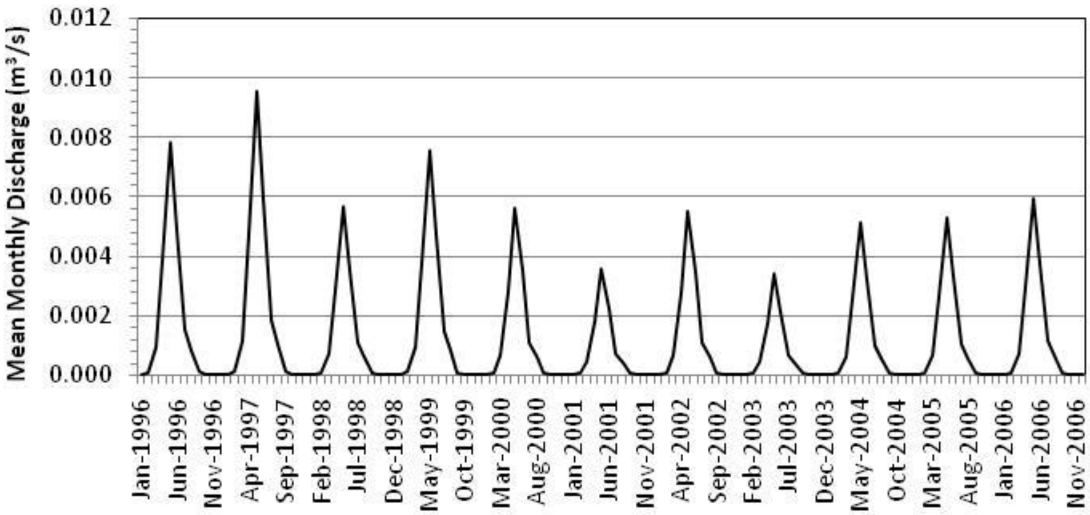


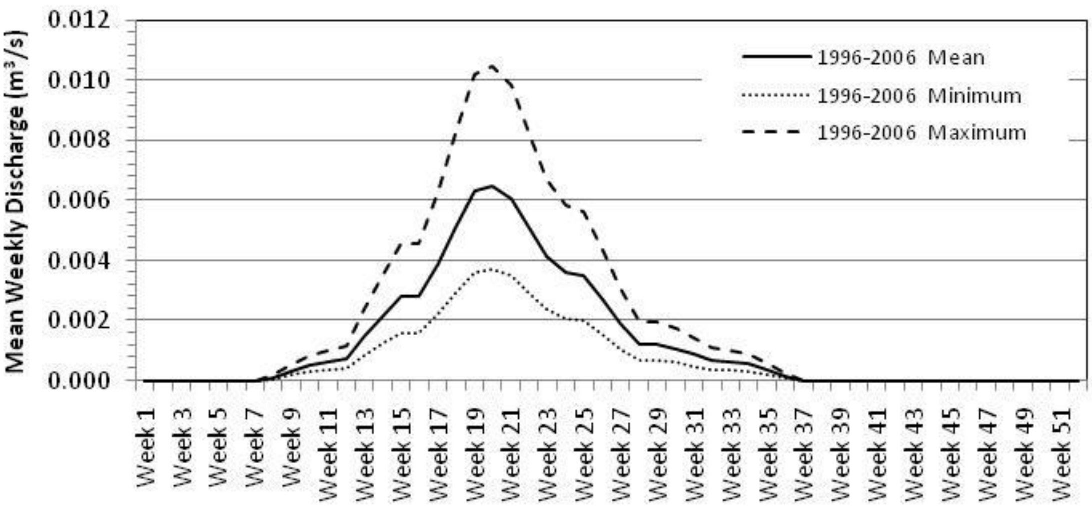




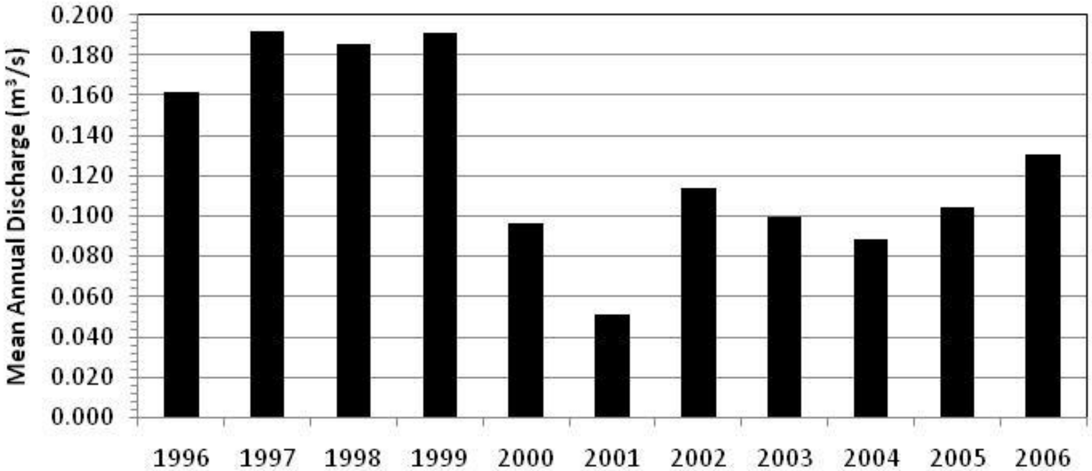
Node 39: Residual Area E-7

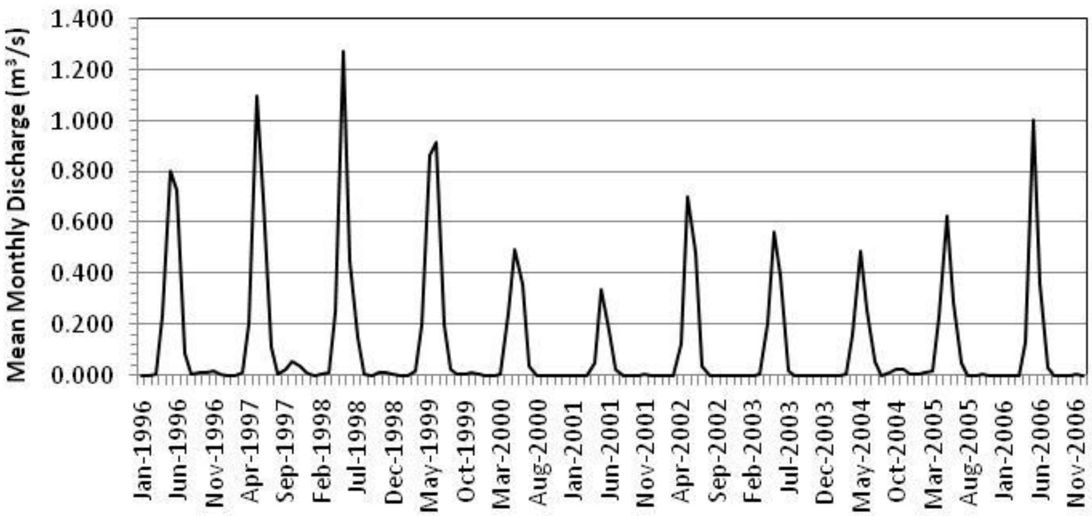


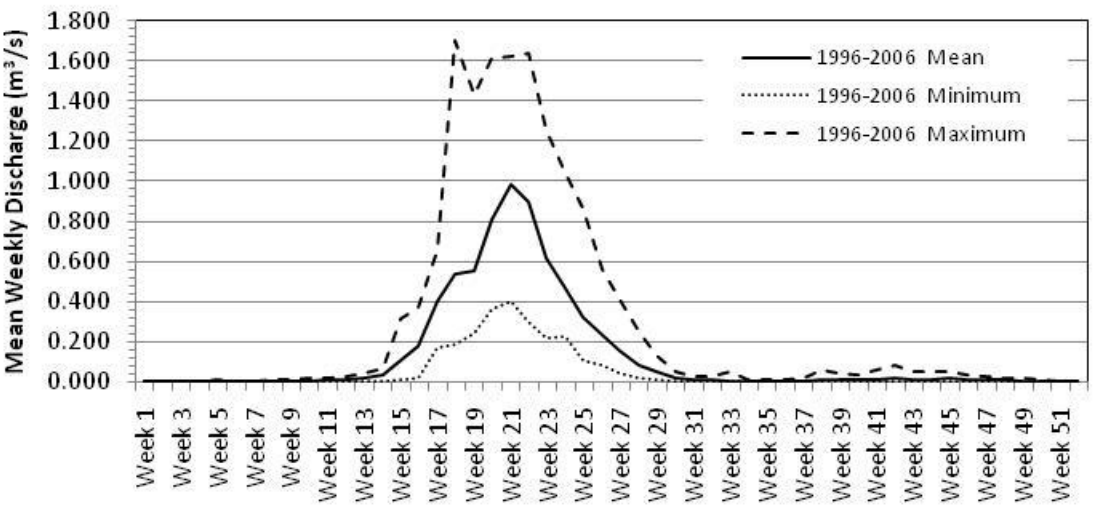




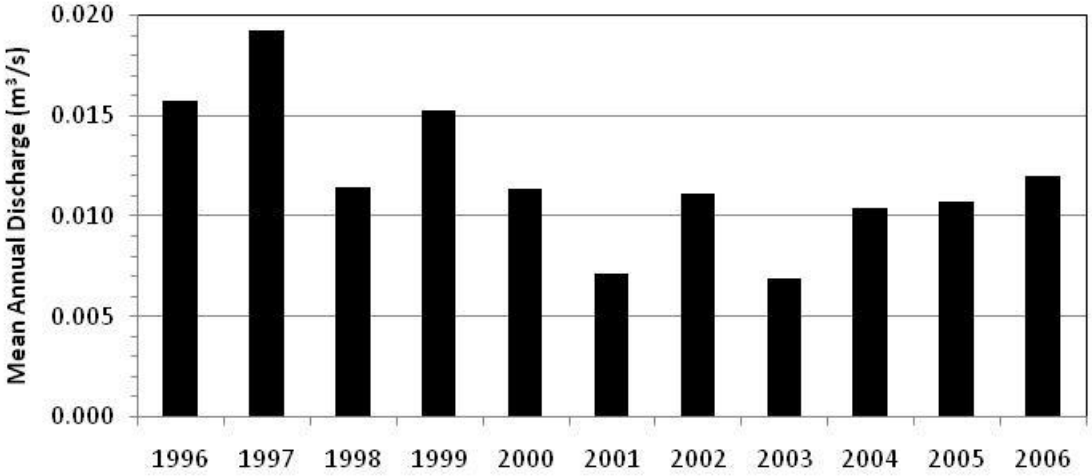
Node 40: Naramata Cr.

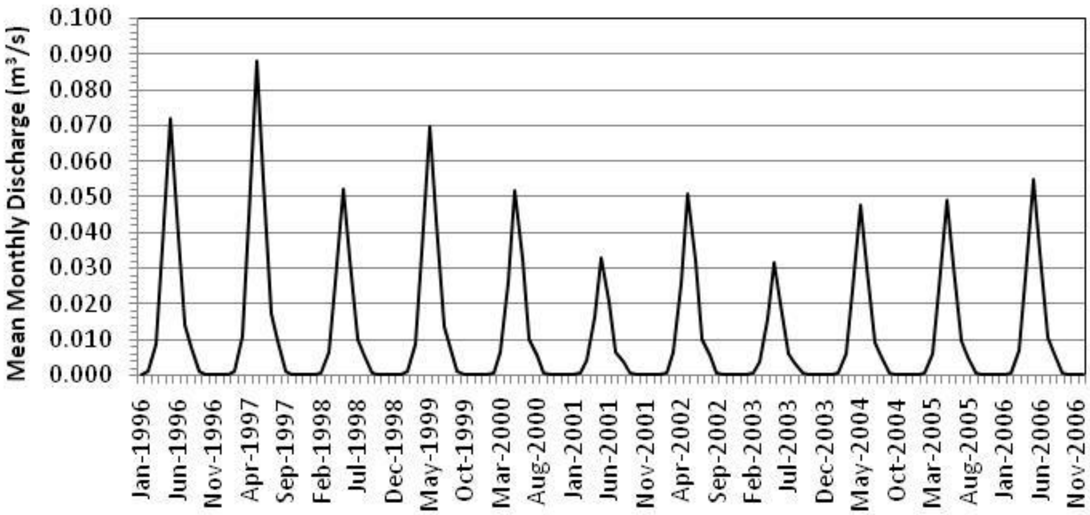


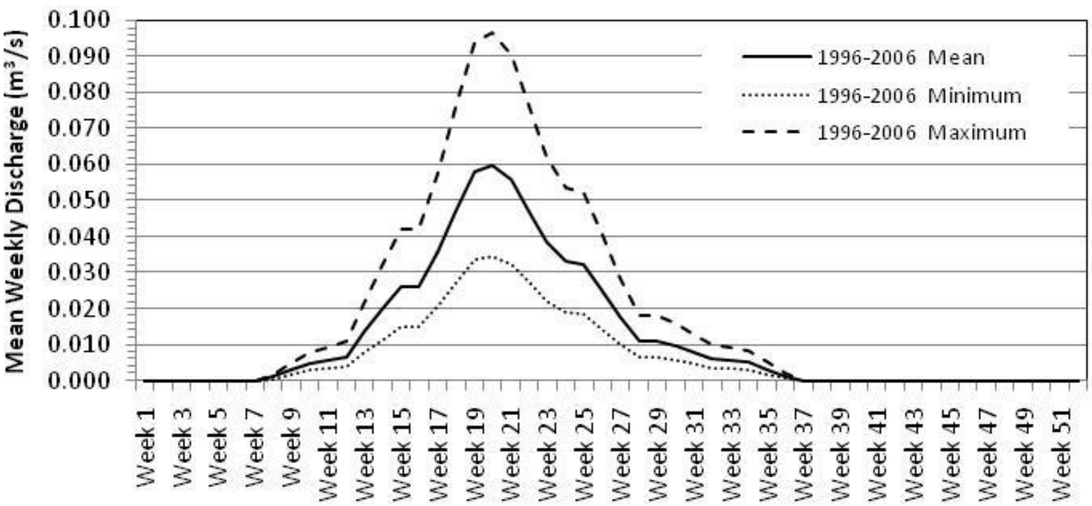




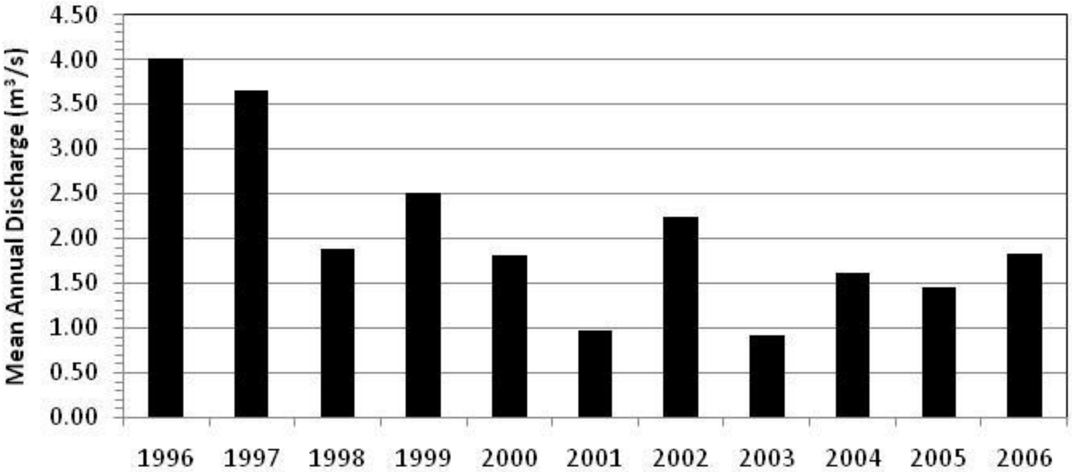
Node 41: Residual Area E-8

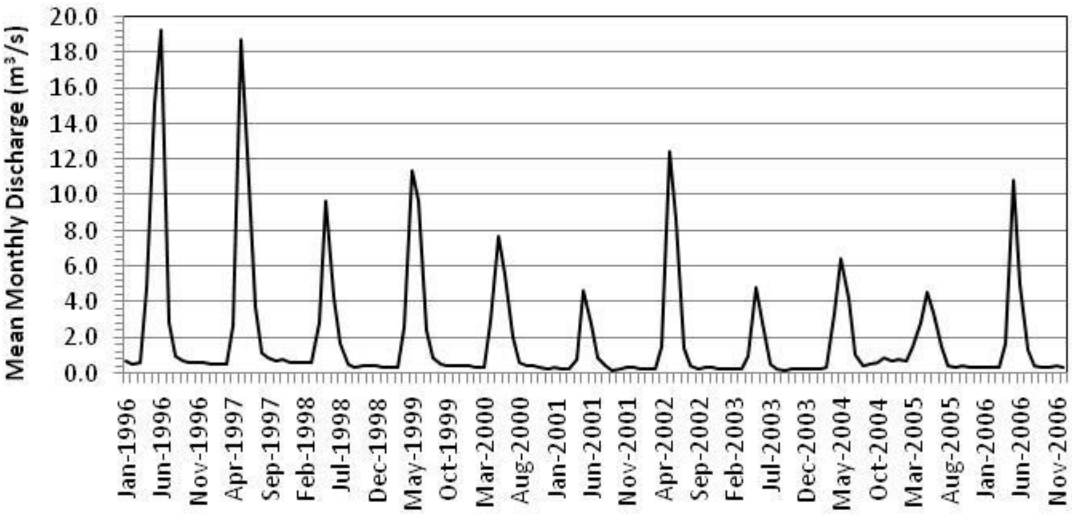


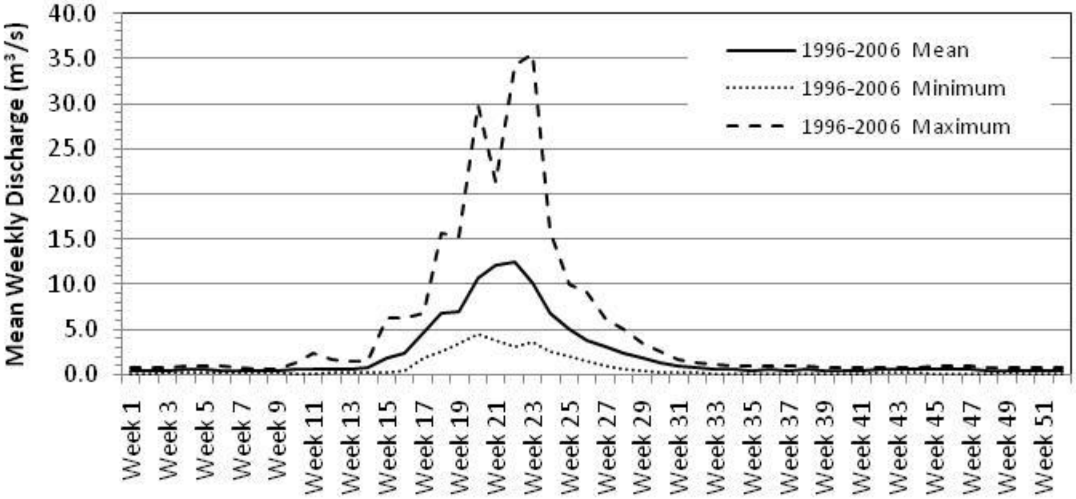




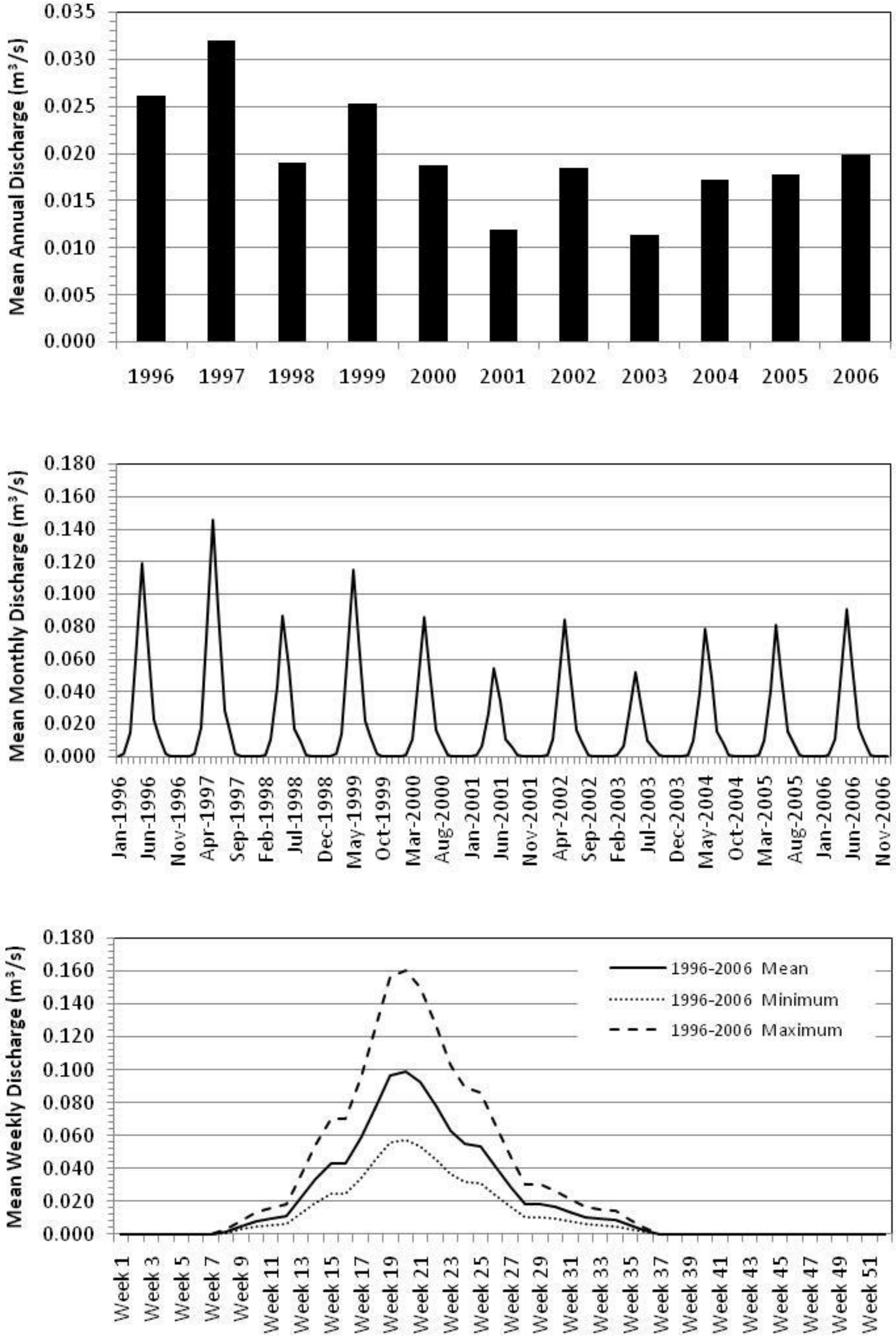
Node 42: Trout Cr.



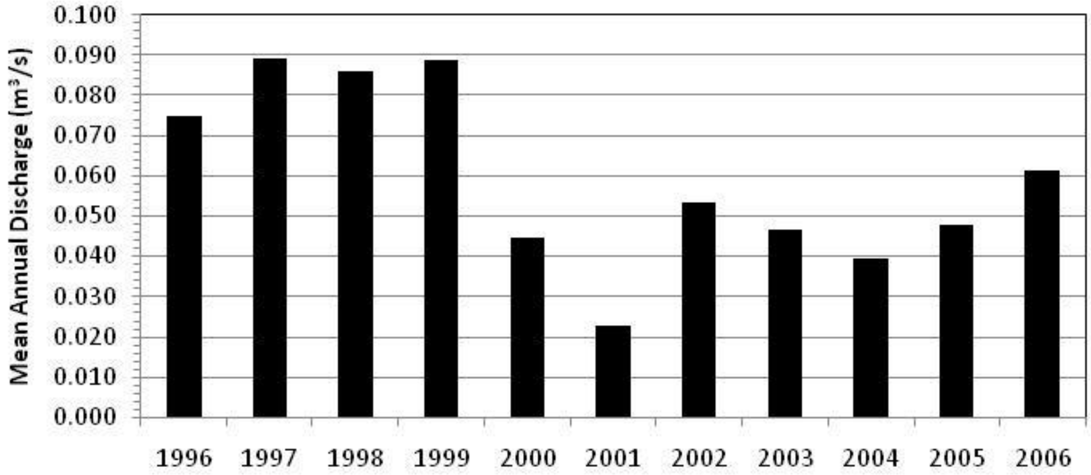


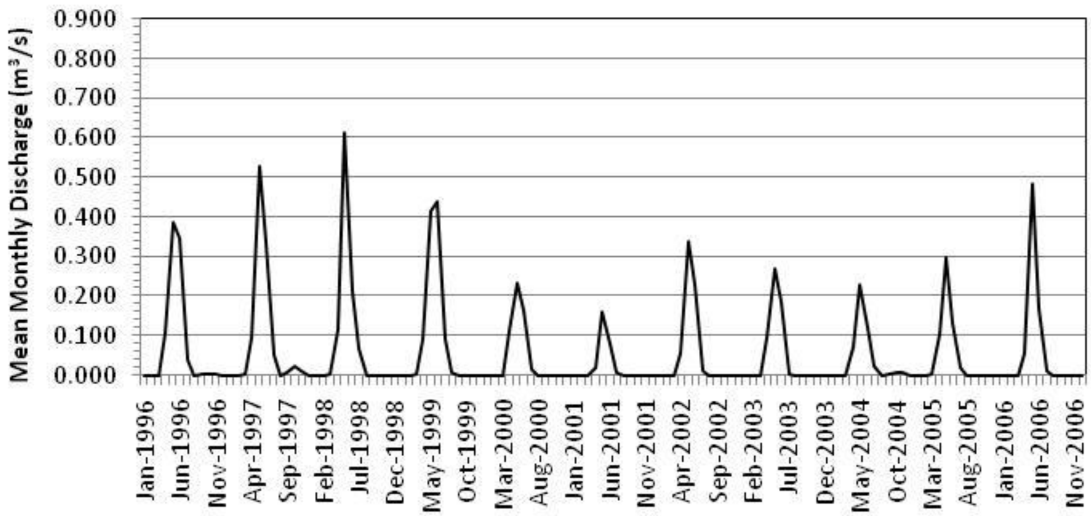


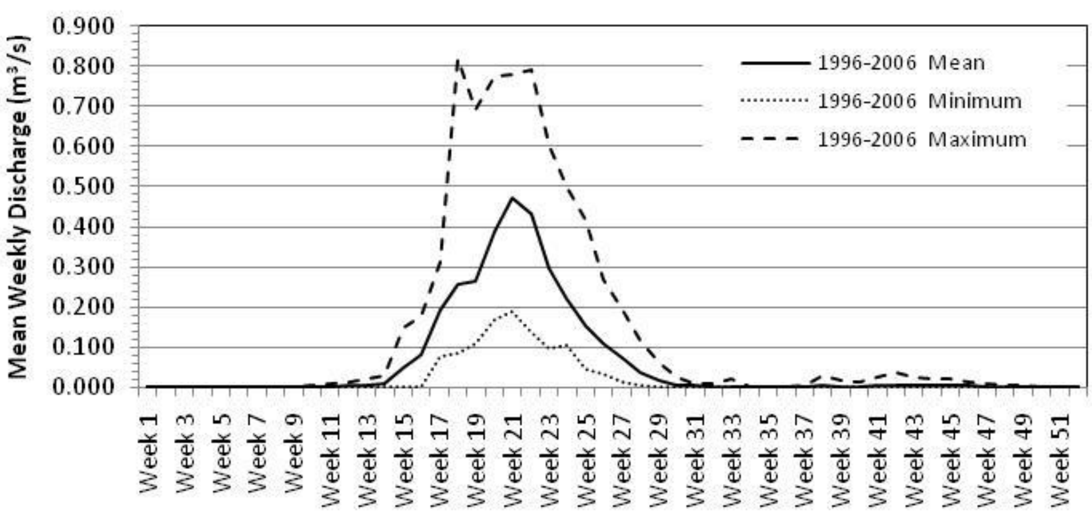
Node 43: Residual Area W-13



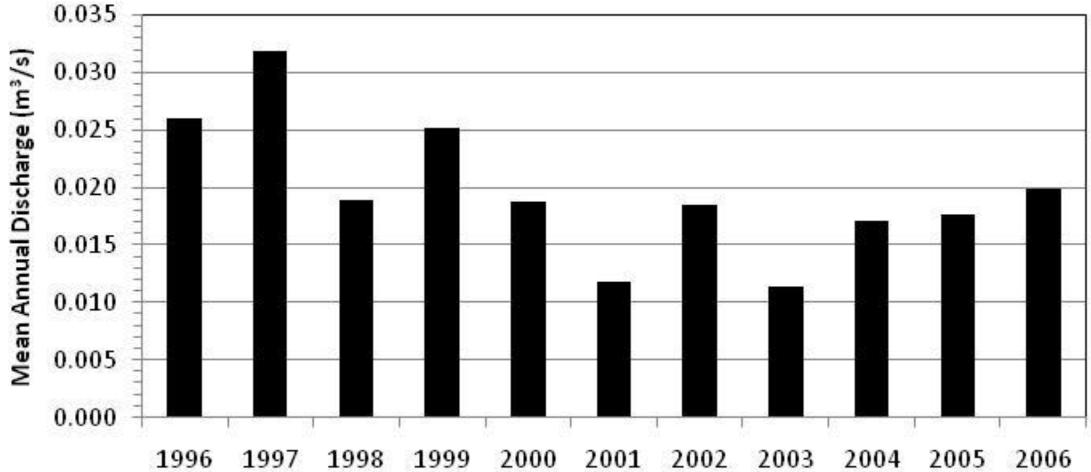
Node 44: Turnbull Cr.

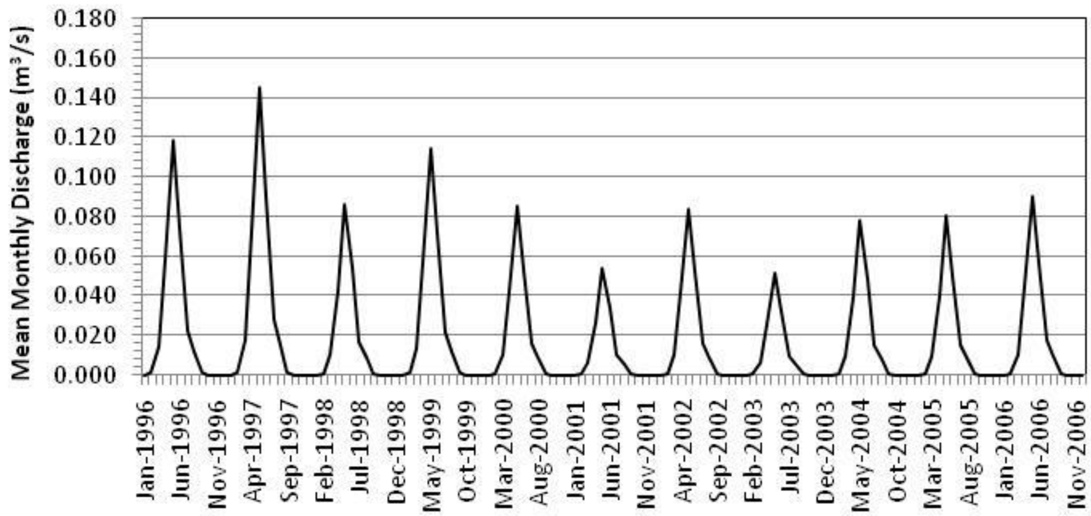


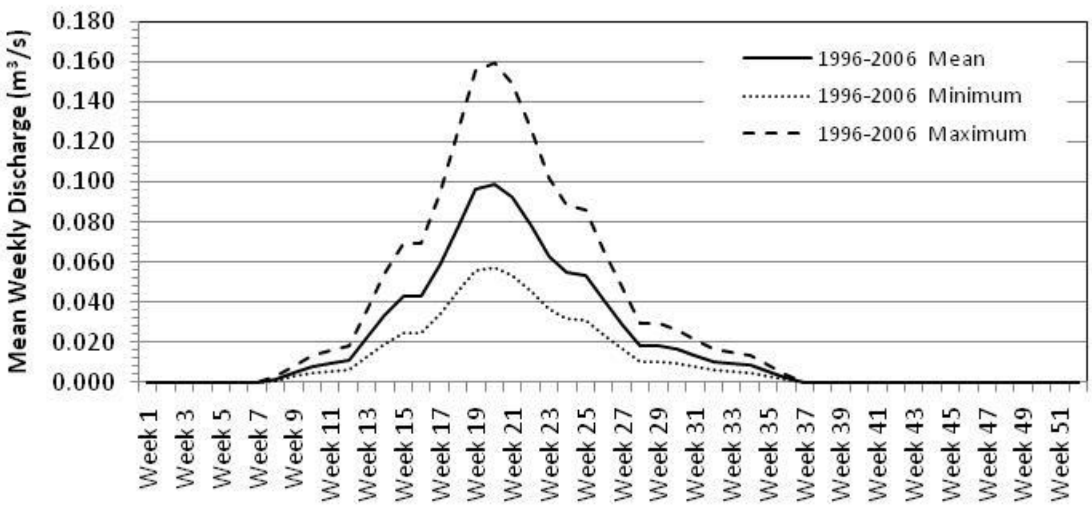




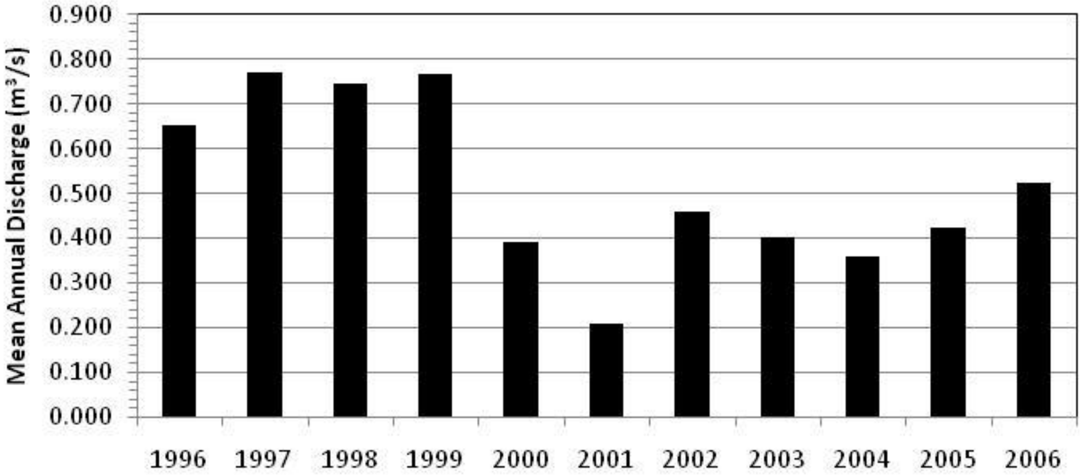
Node 45: Residual Area E-9

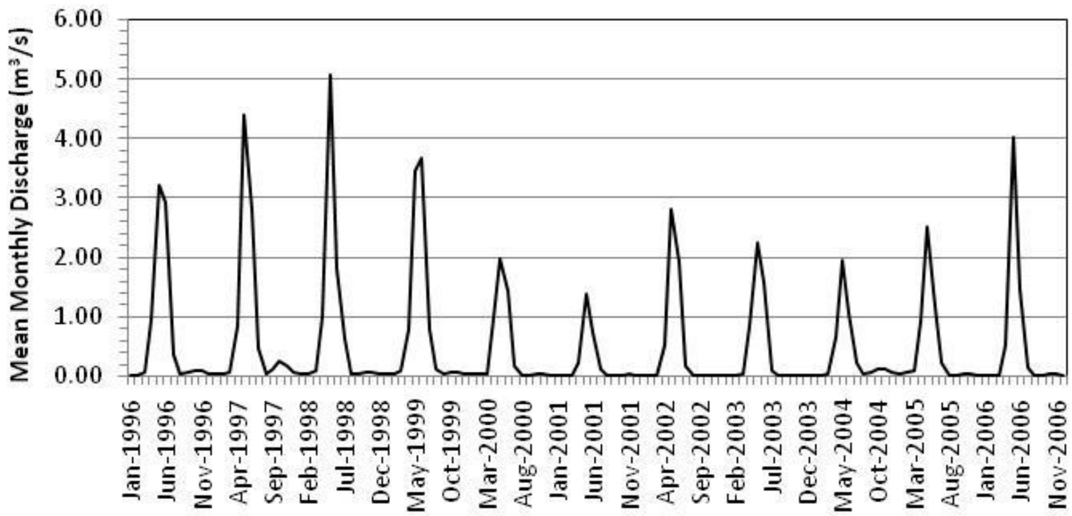


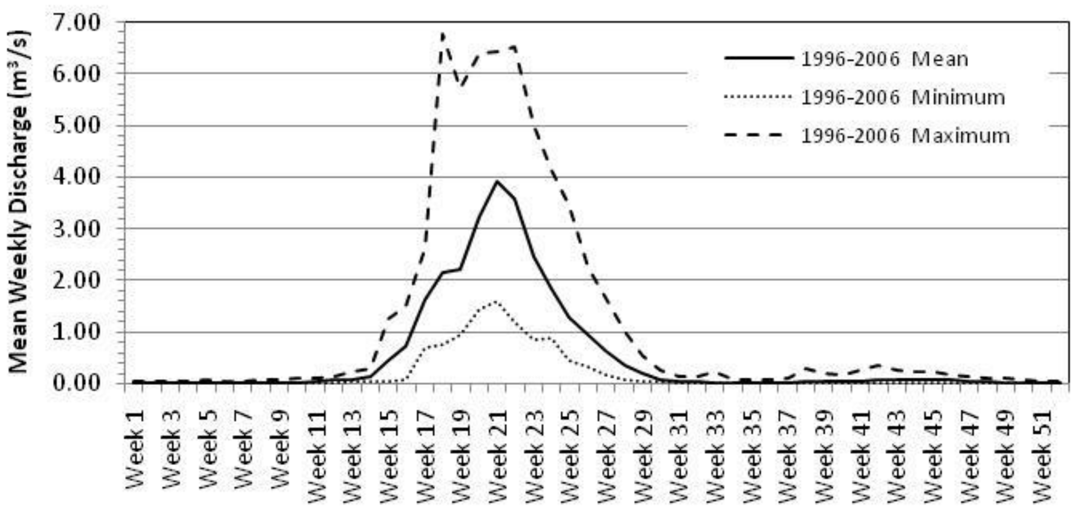




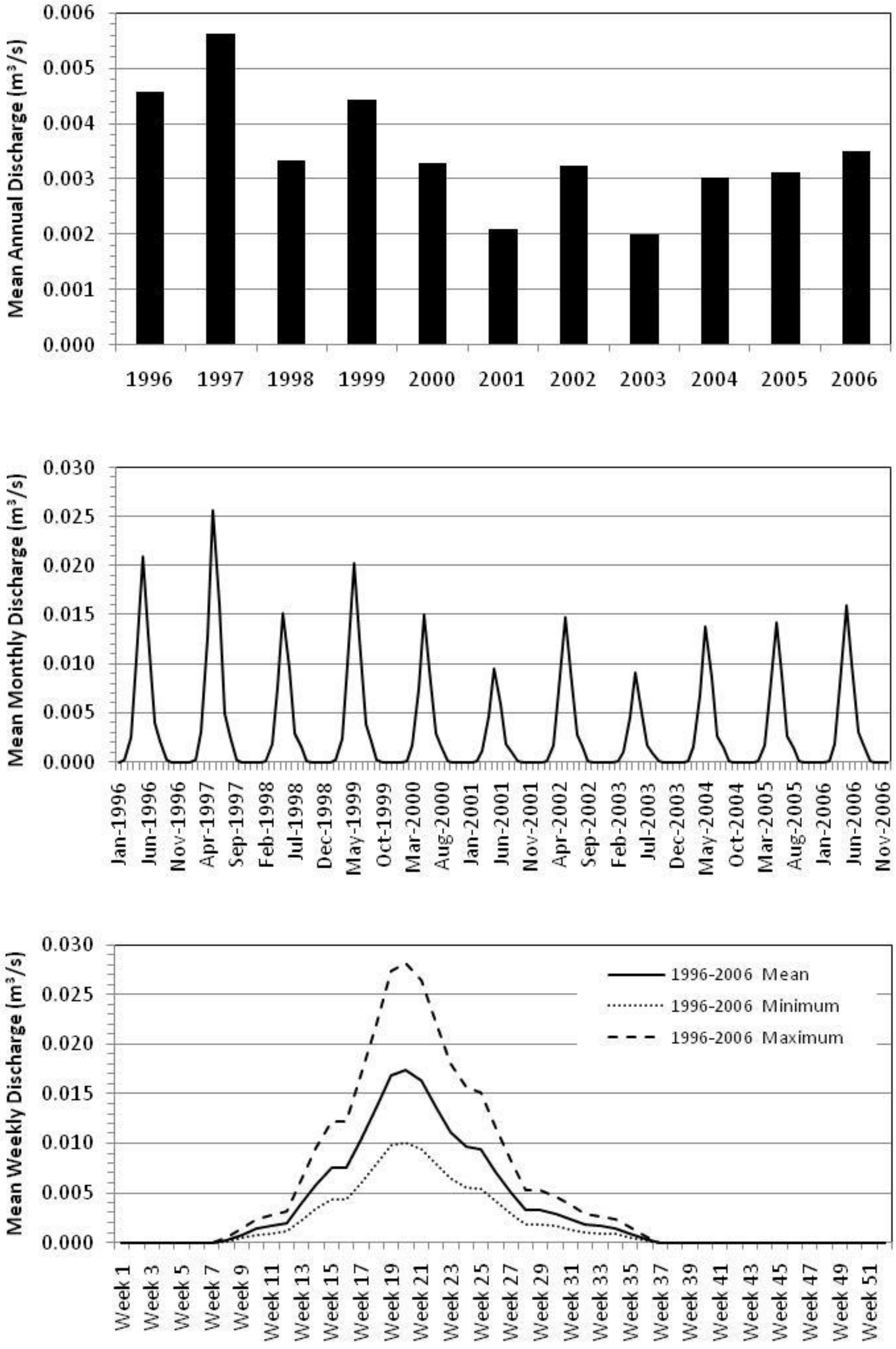
Node 46: Penticton Cr.



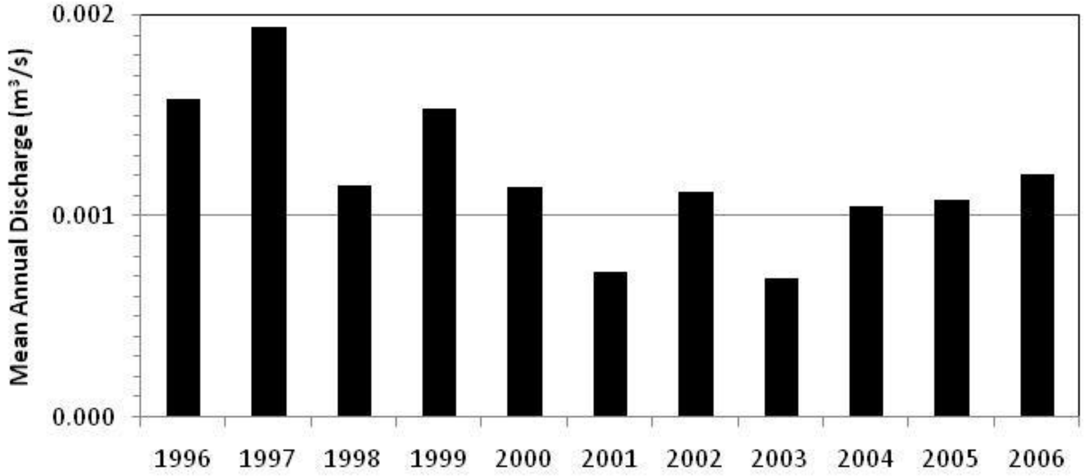


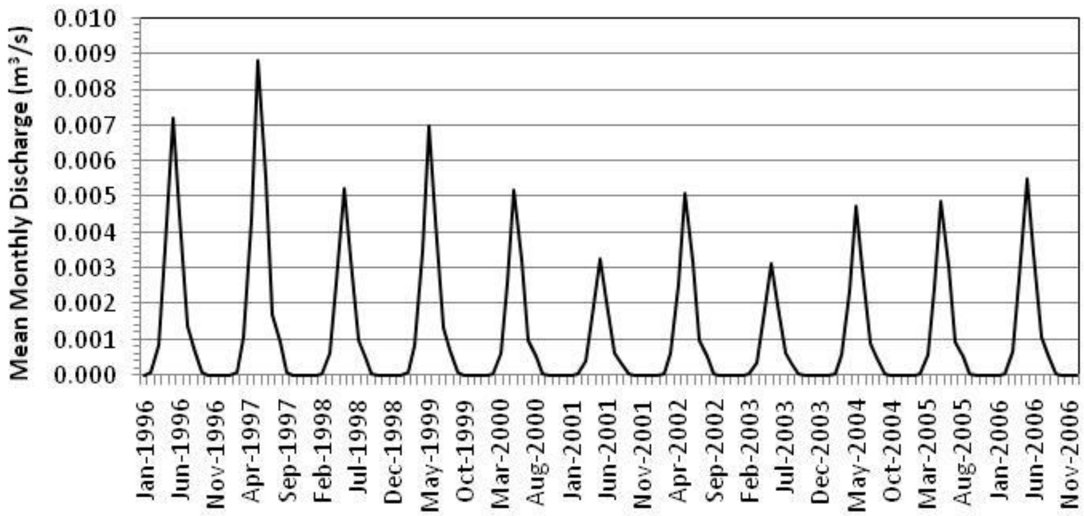


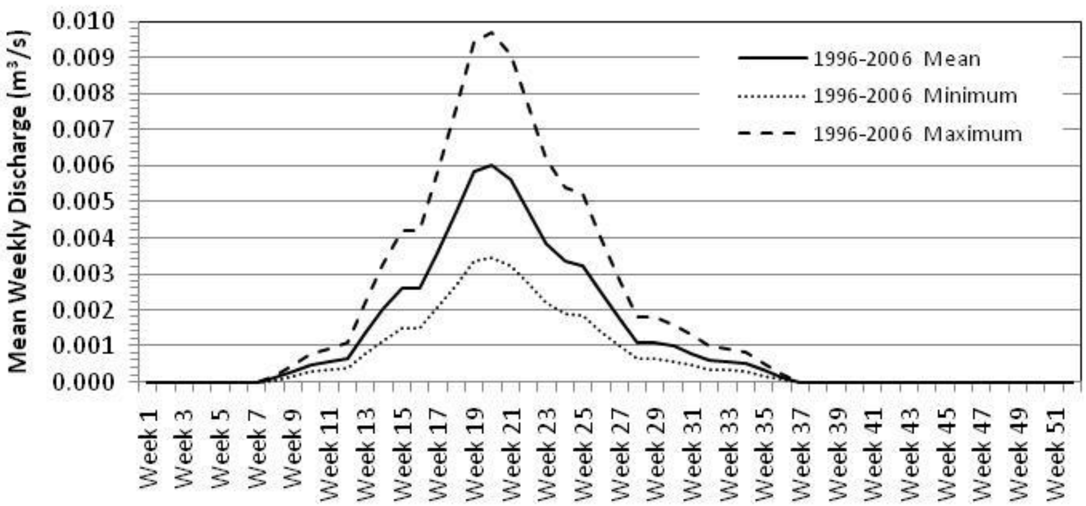
Node 49: Residual Area W-14



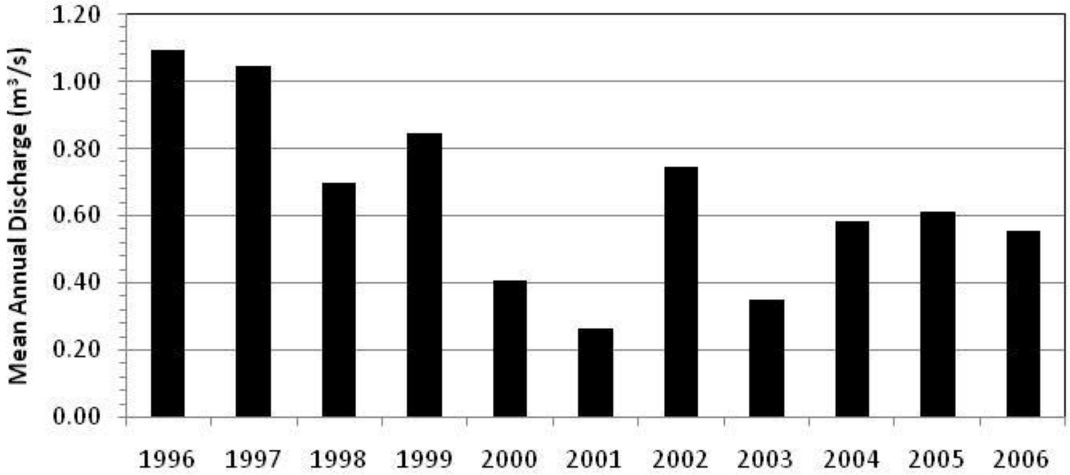
Node 50: Residual Area E-10

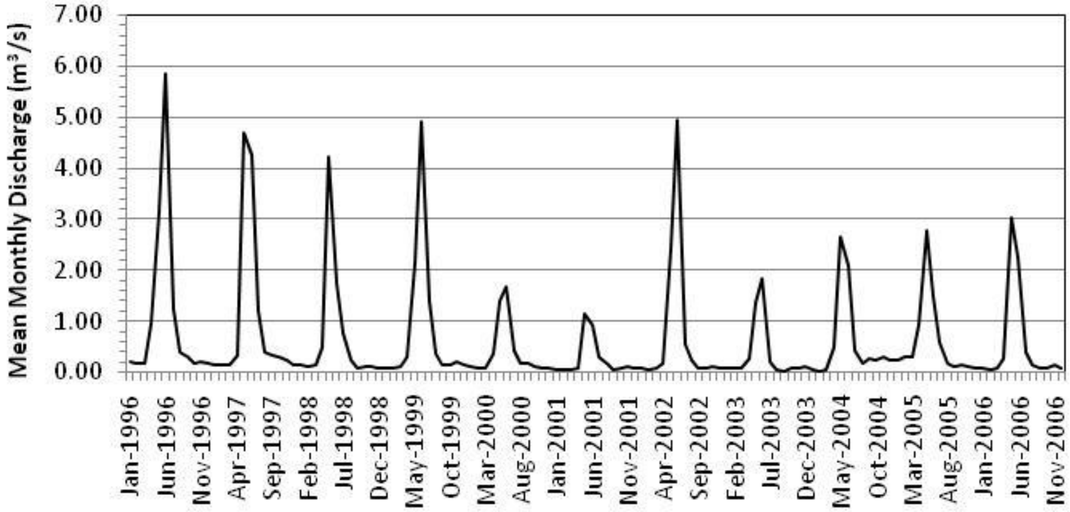


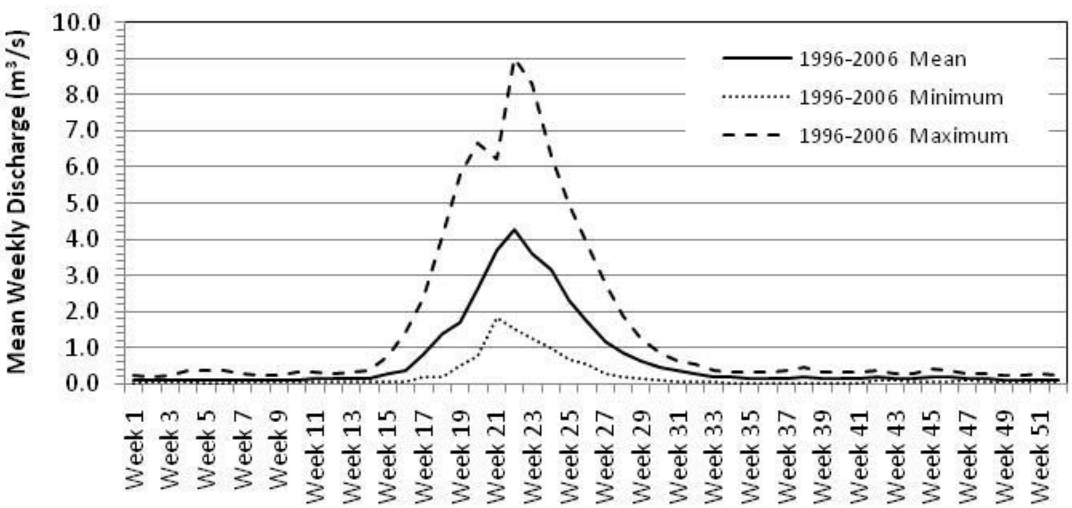




Node 51: Shingle Cr.







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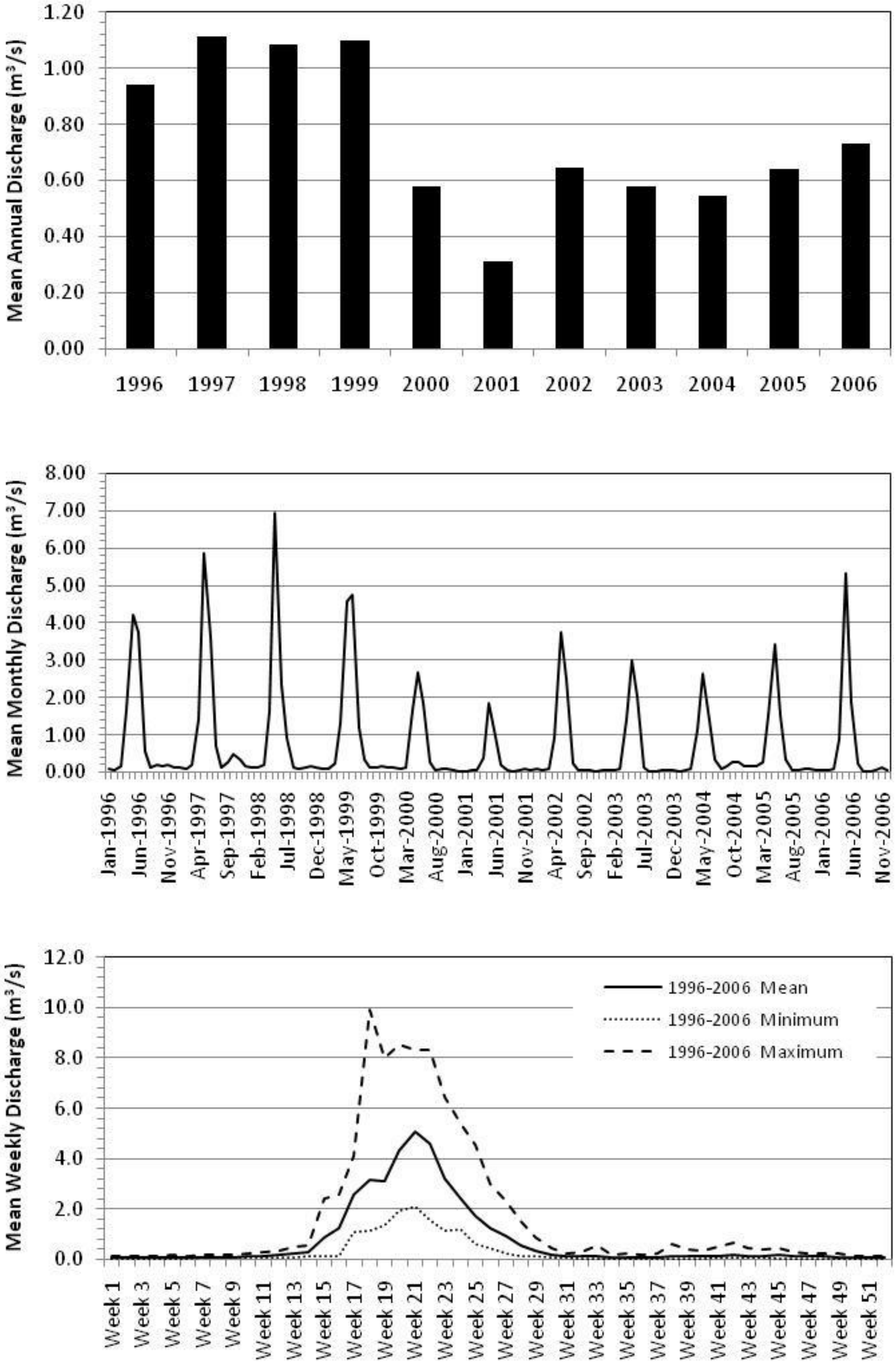
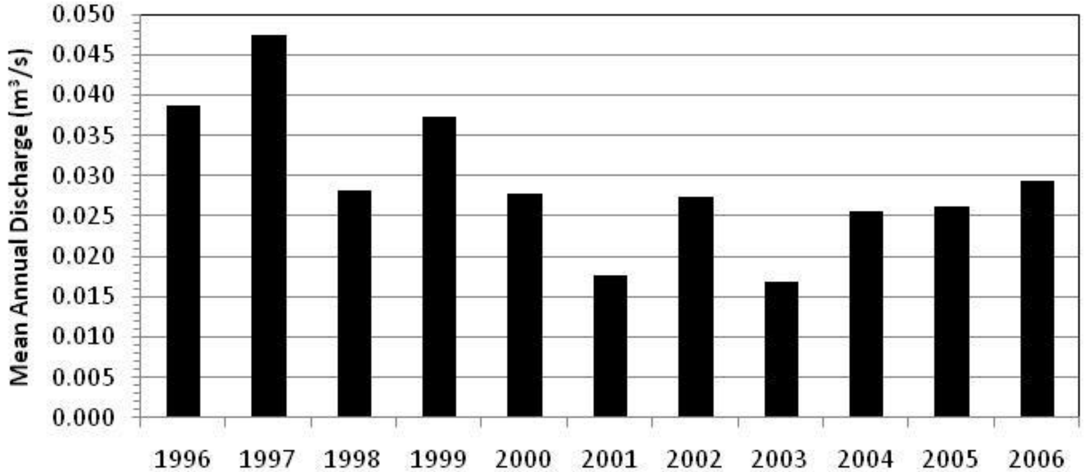
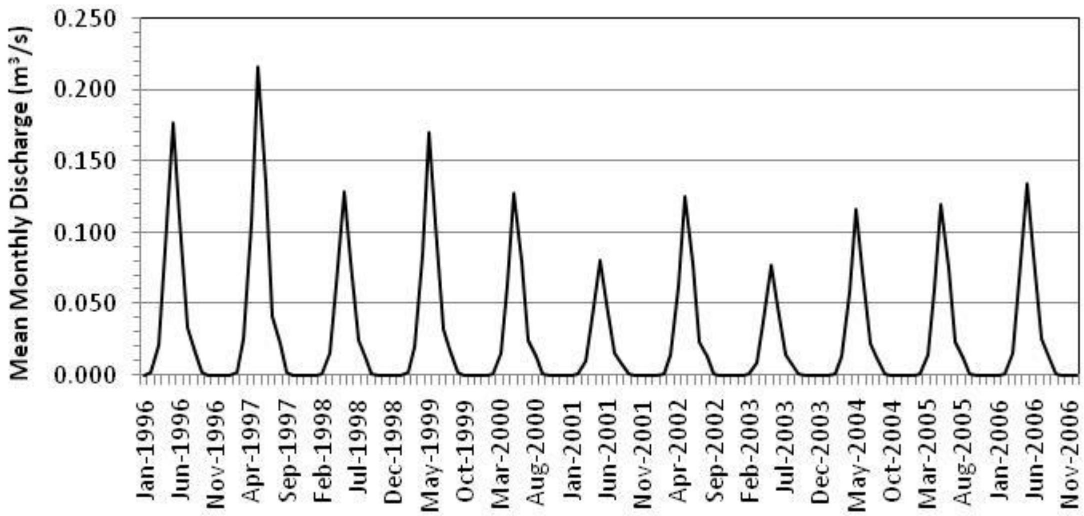
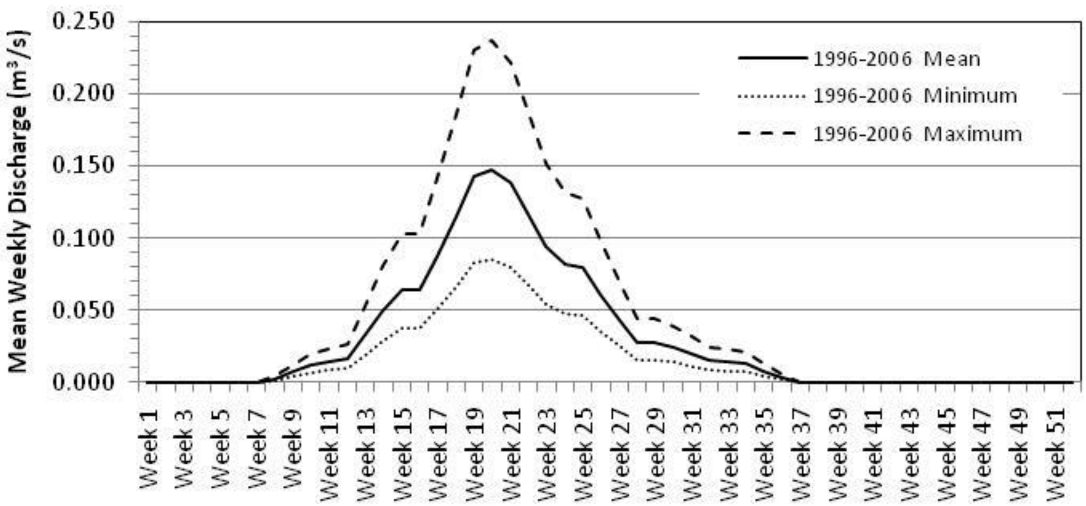


Node 53: Residual Area W-15







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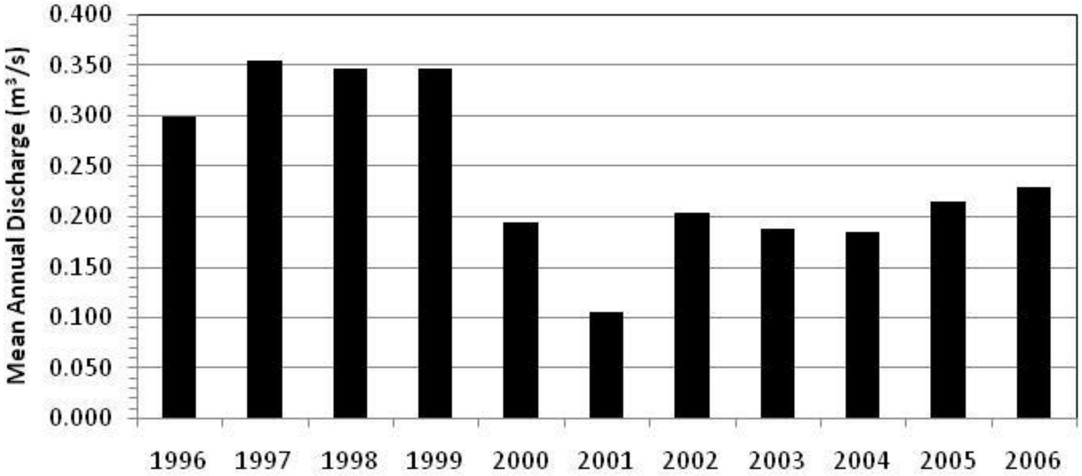
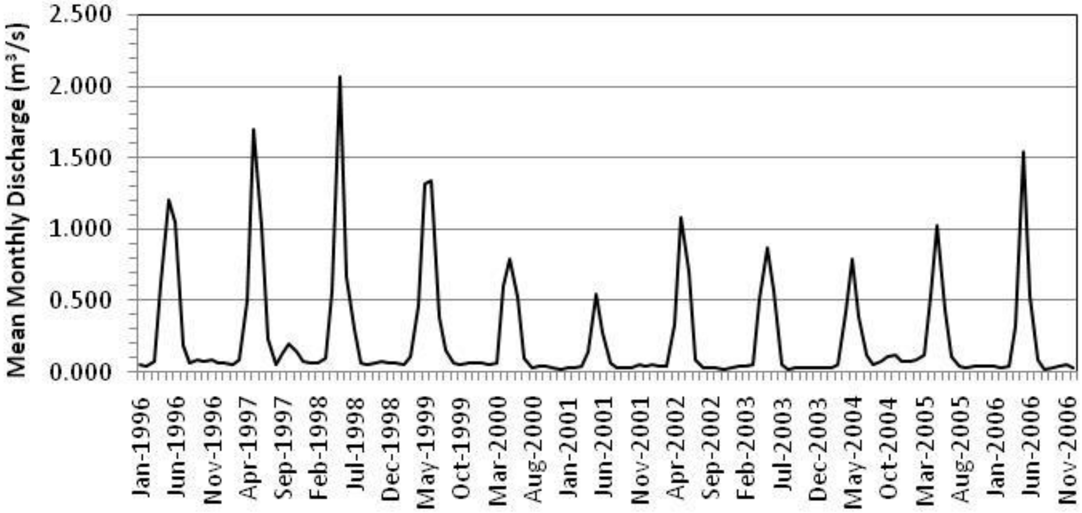
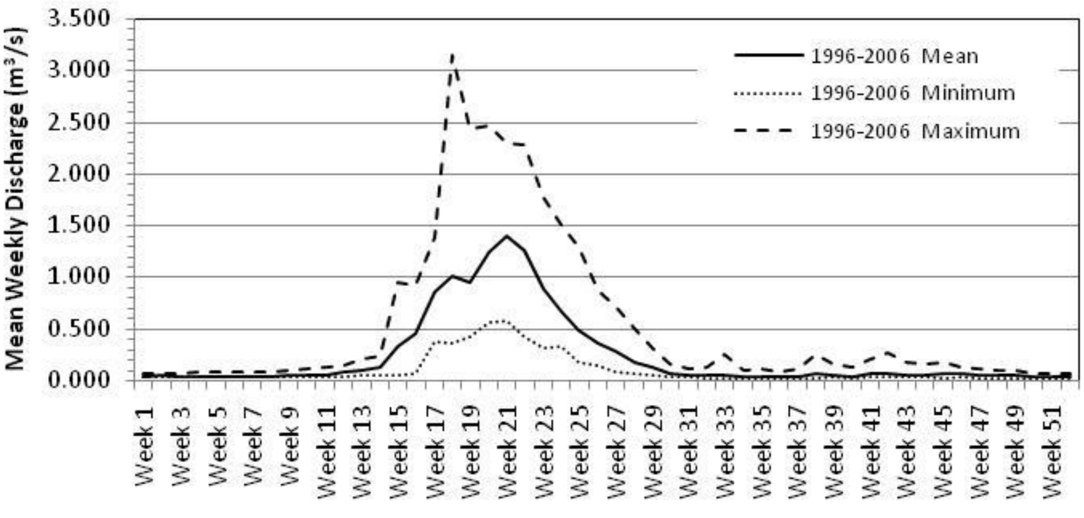
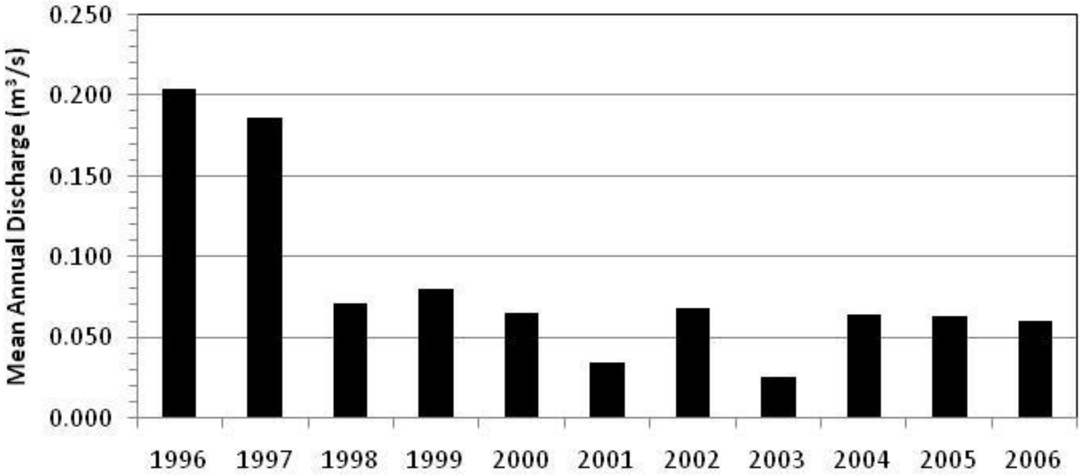
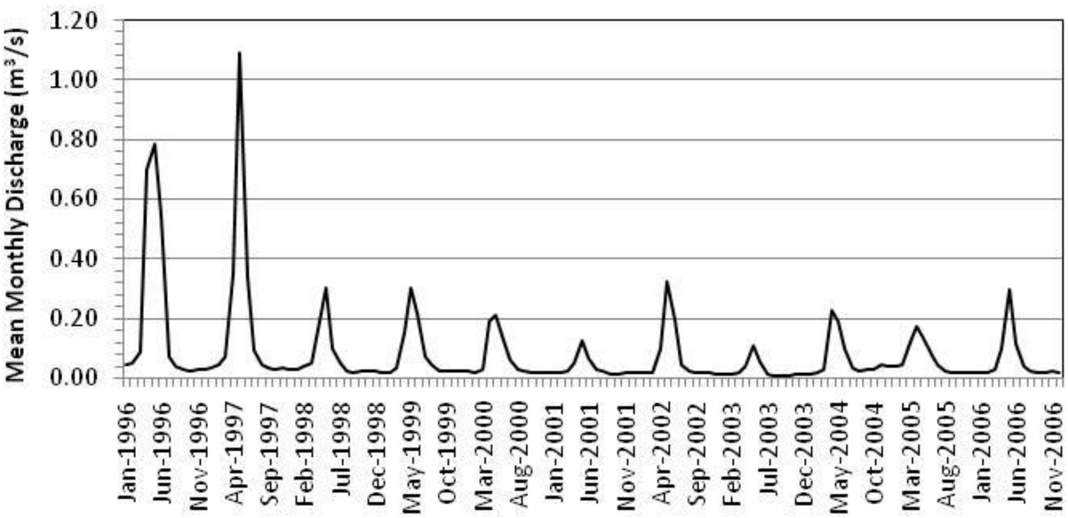


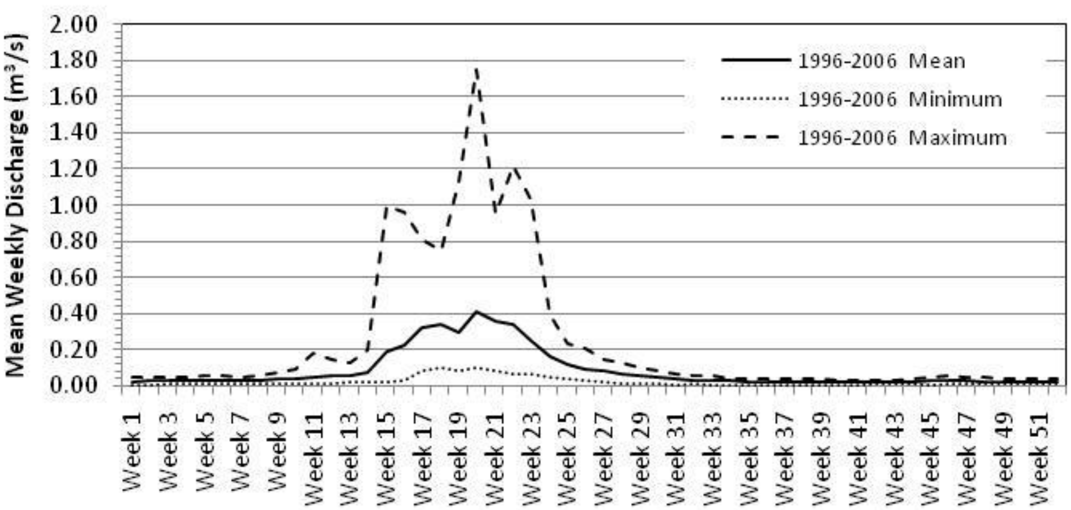




Node 55: Marron River







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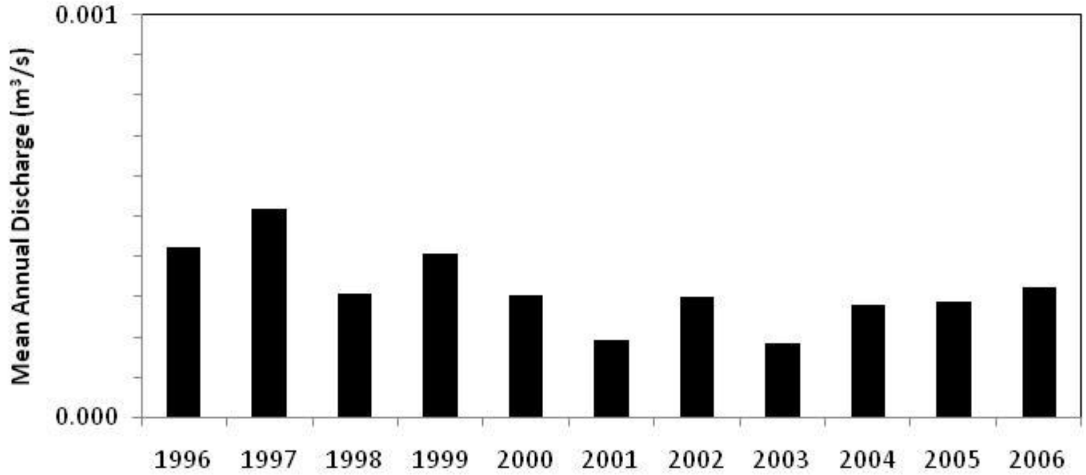

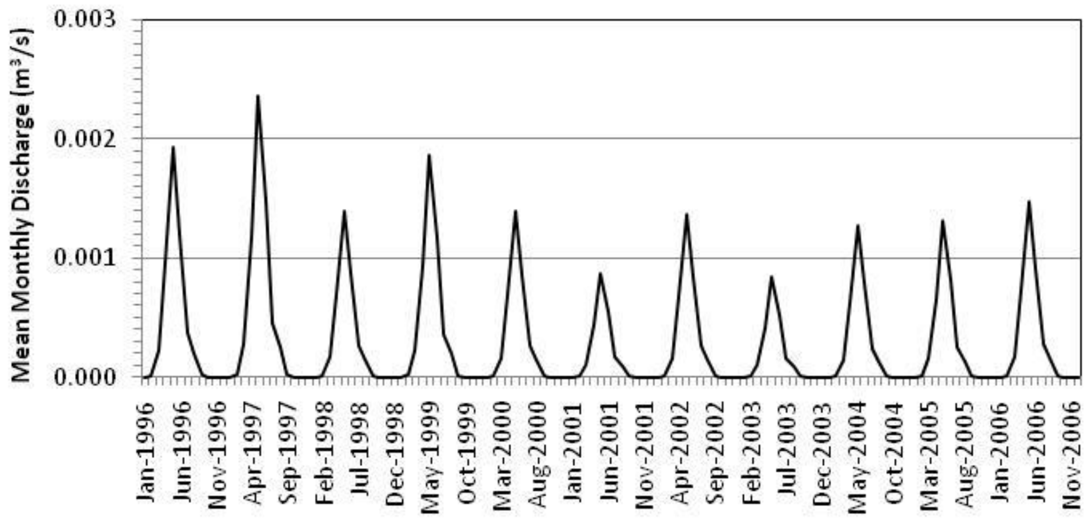

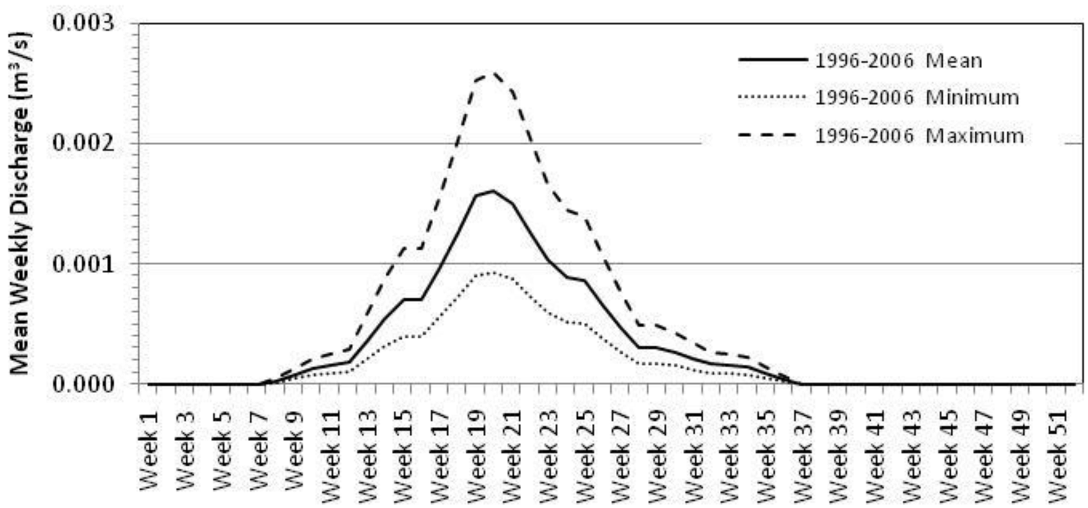

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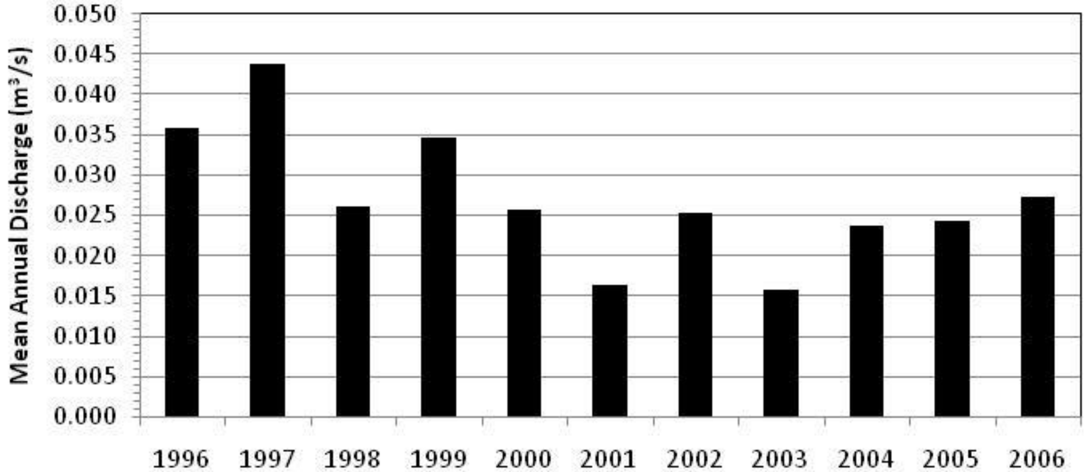
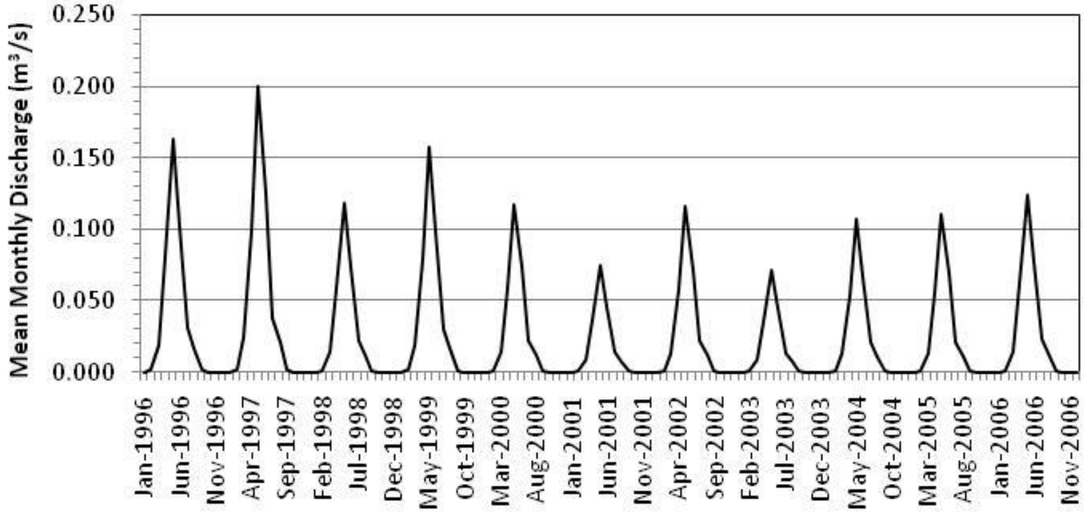
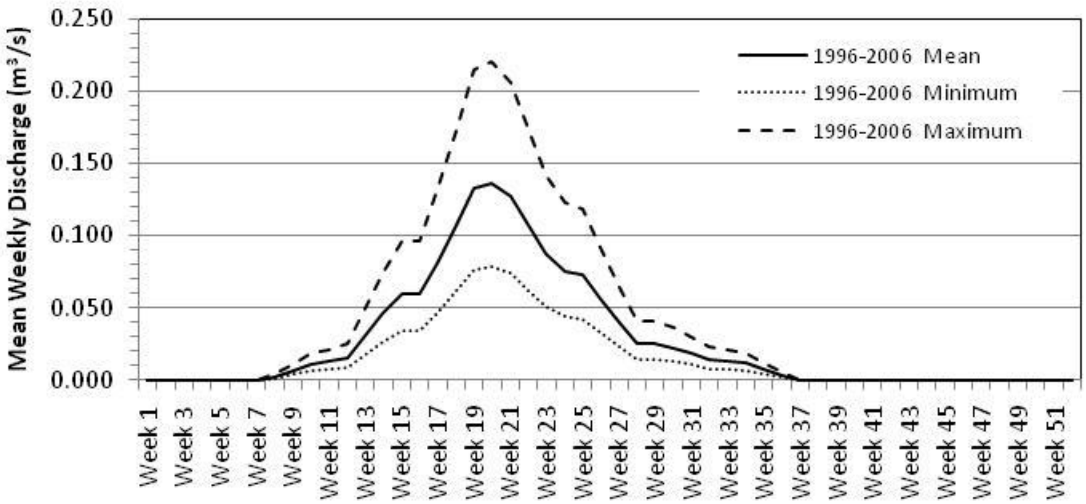
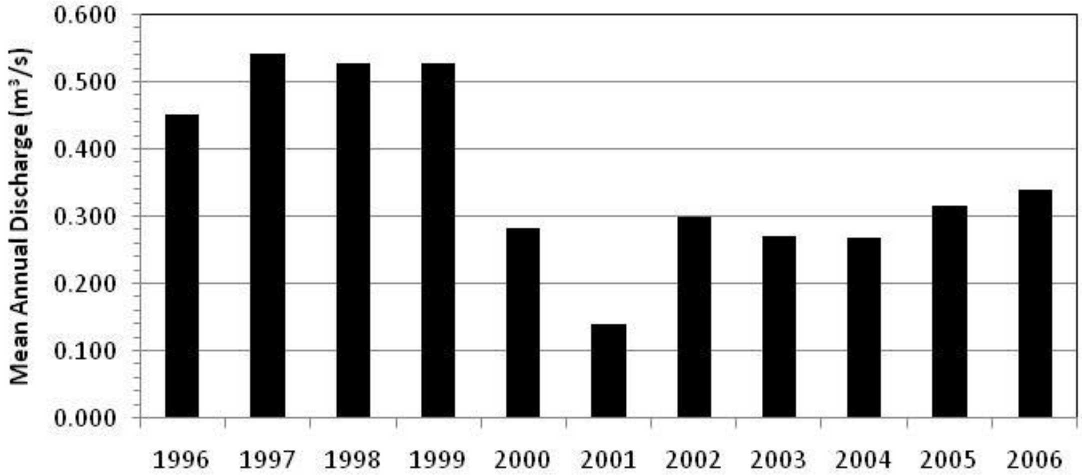
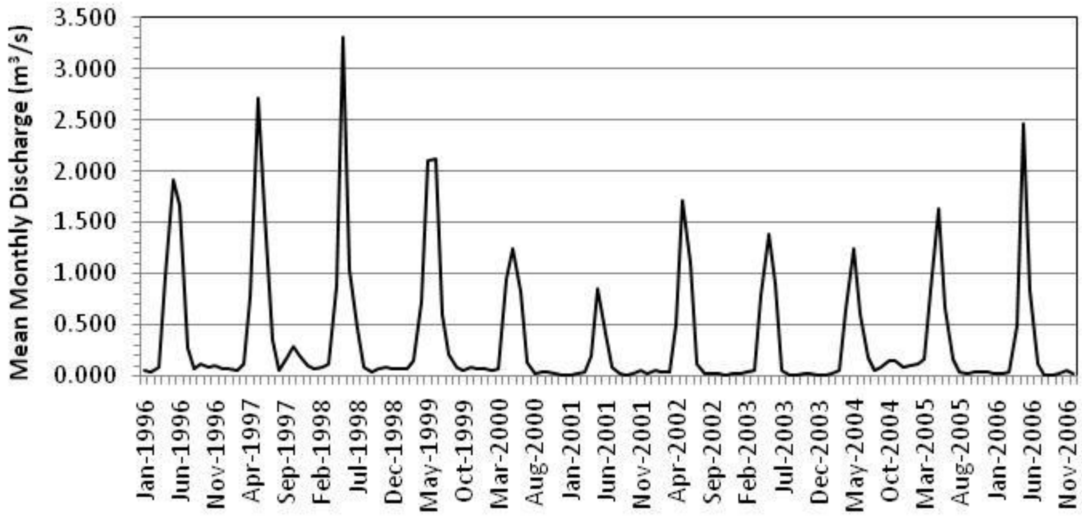


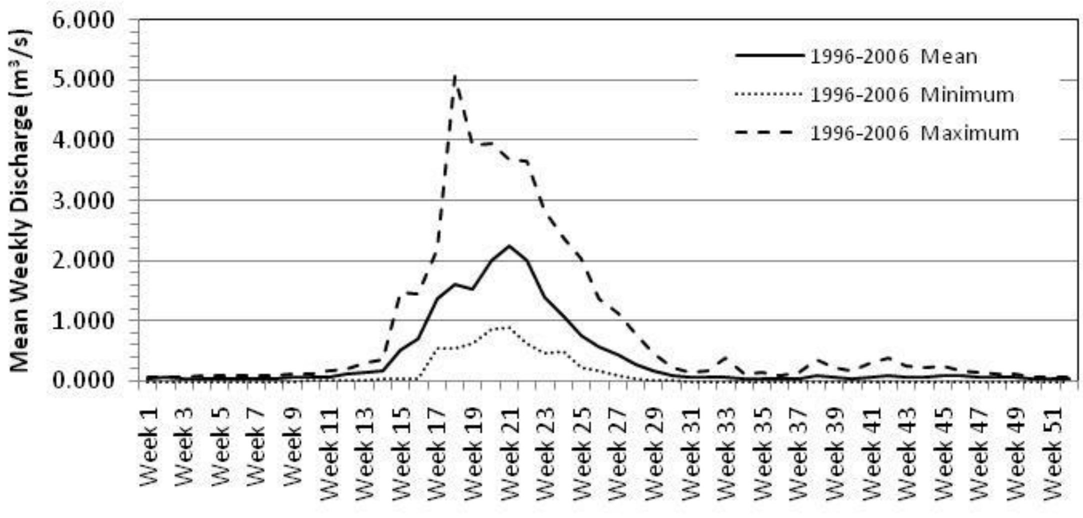




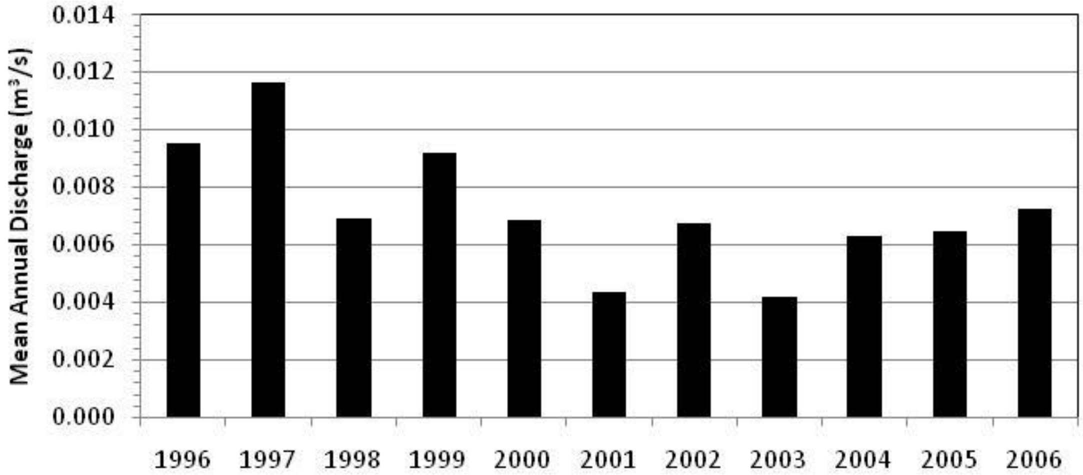
Node 60: Shuttleworth Cr.

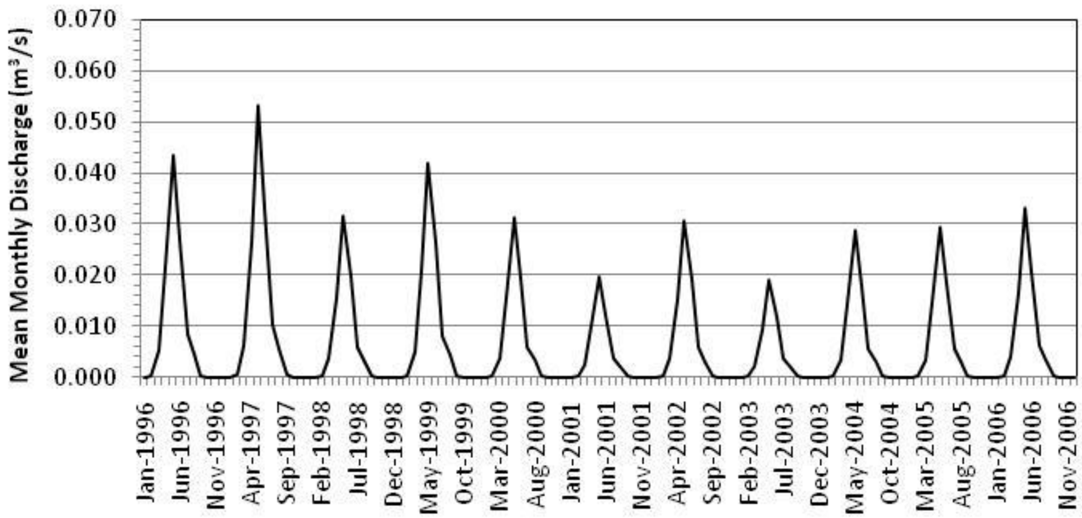


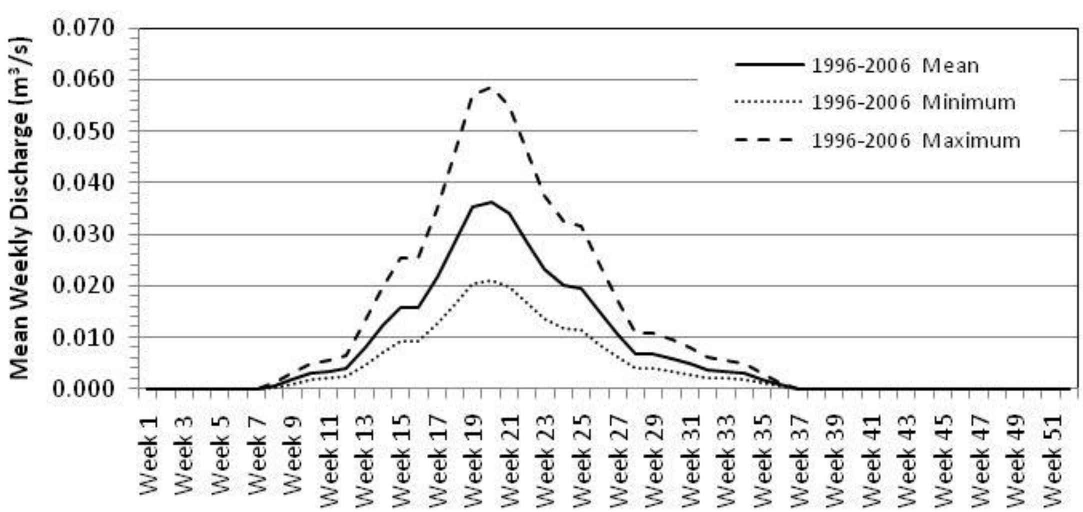




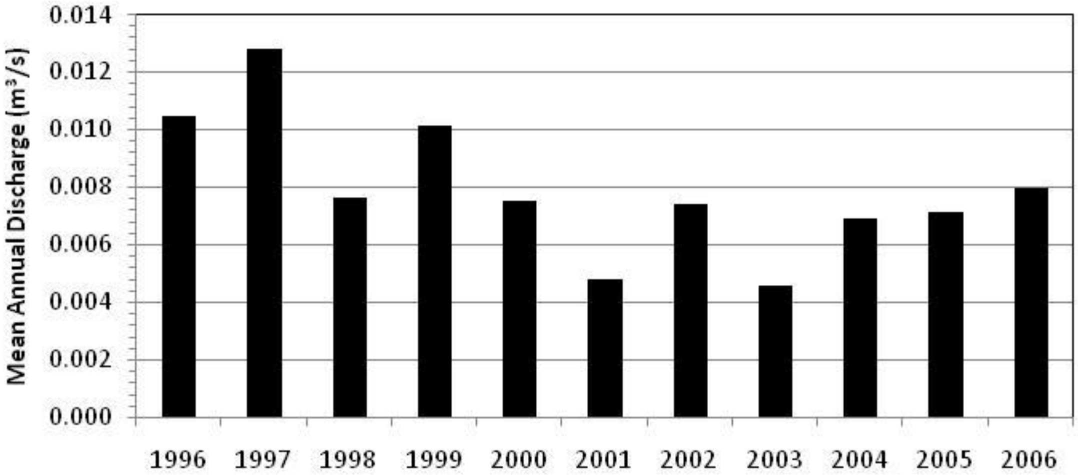
Node 61: Residual Area W-18

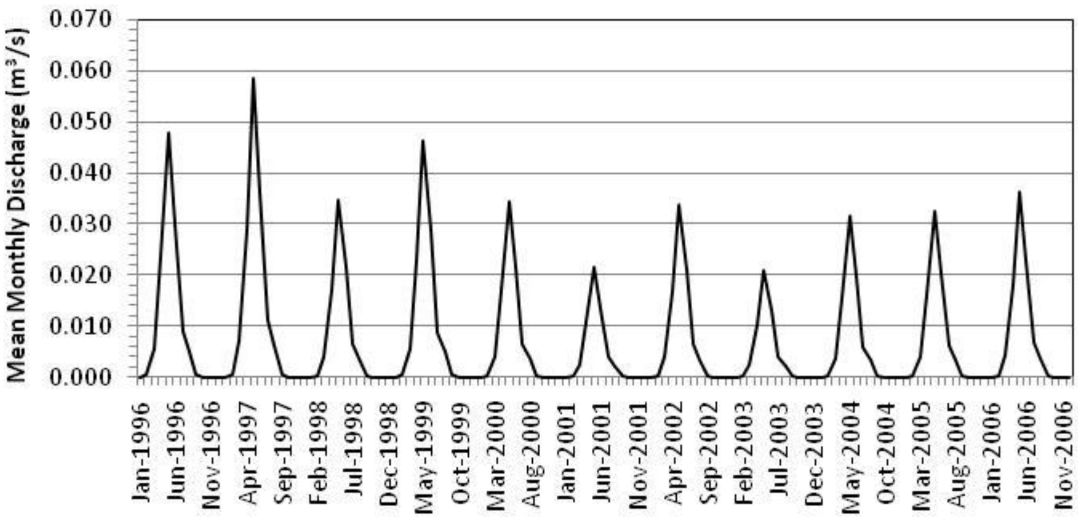


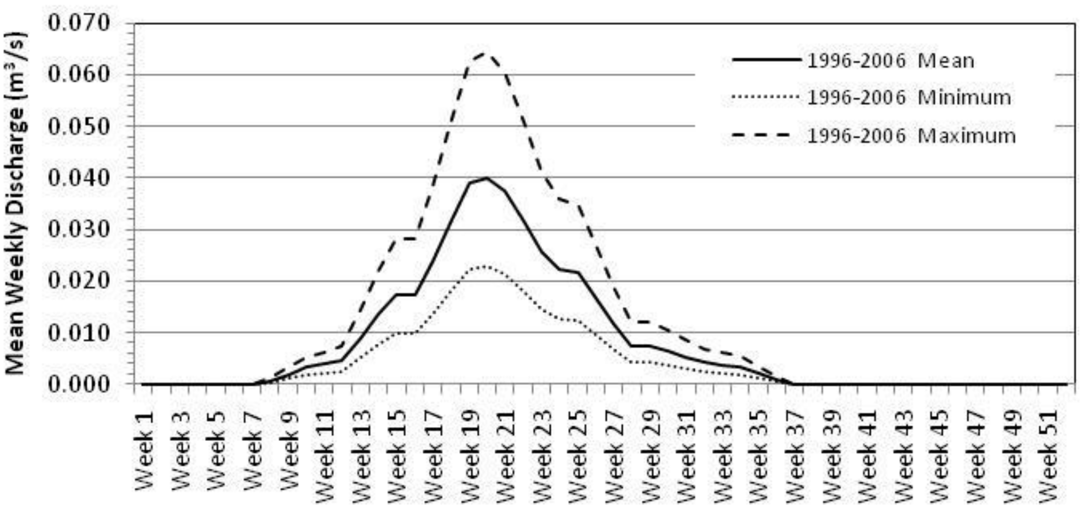




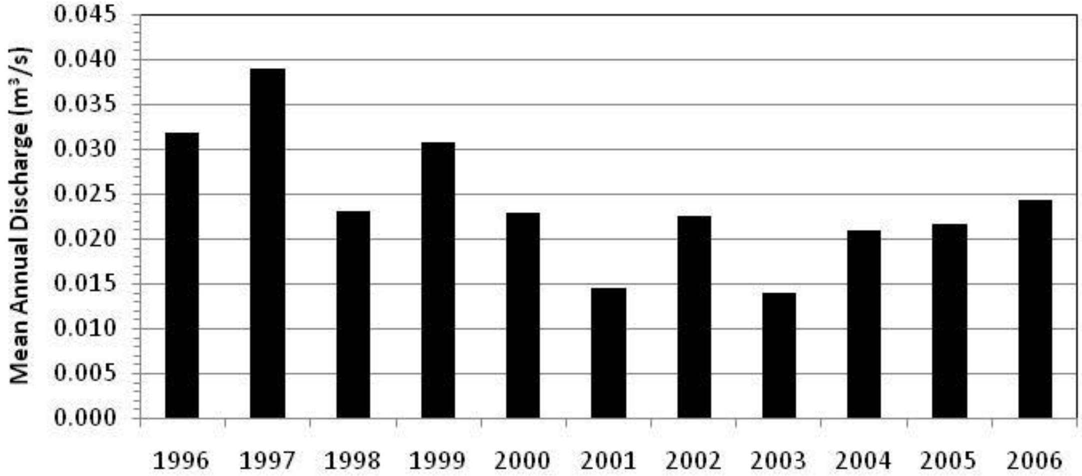
Node 62: Residual Area W-19

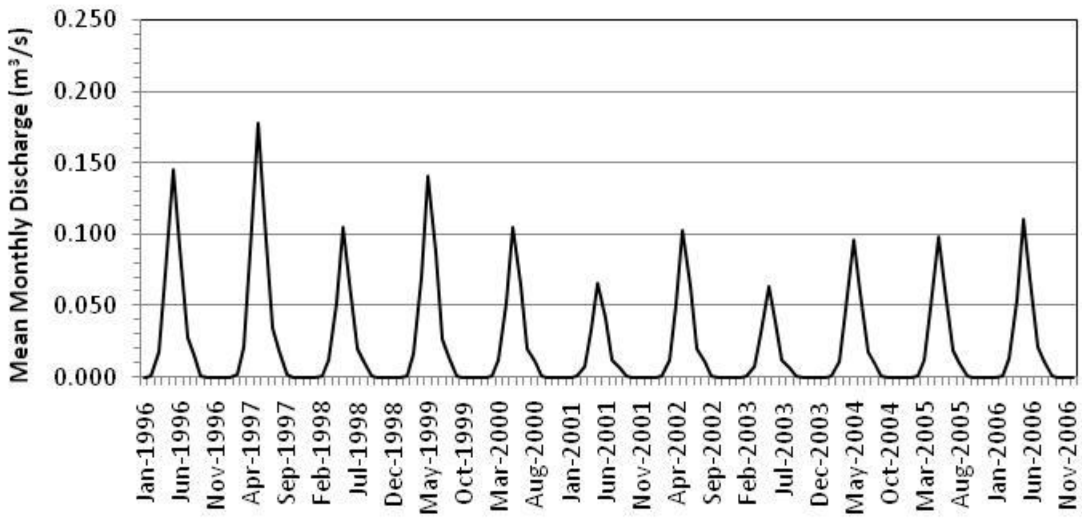


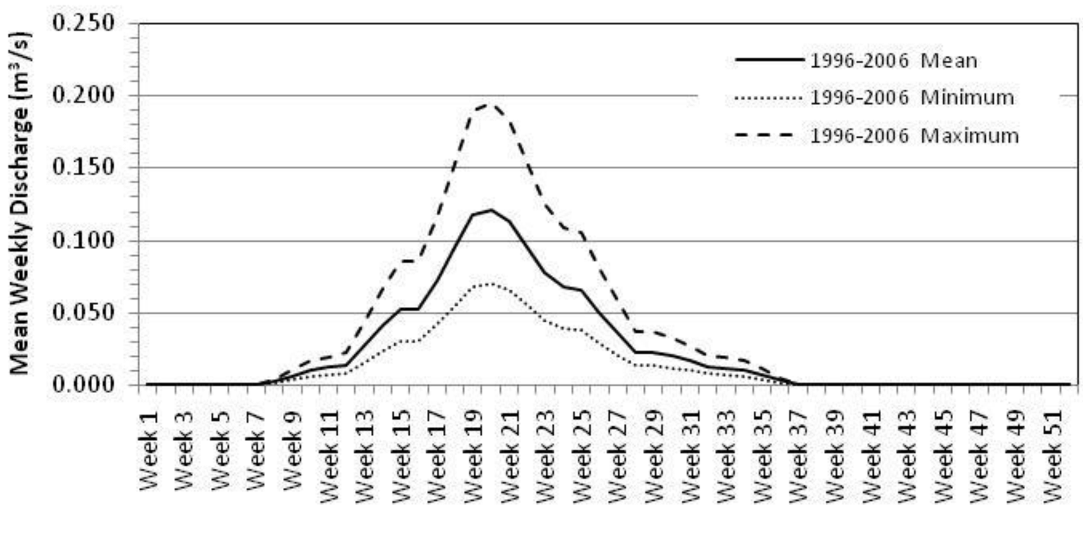




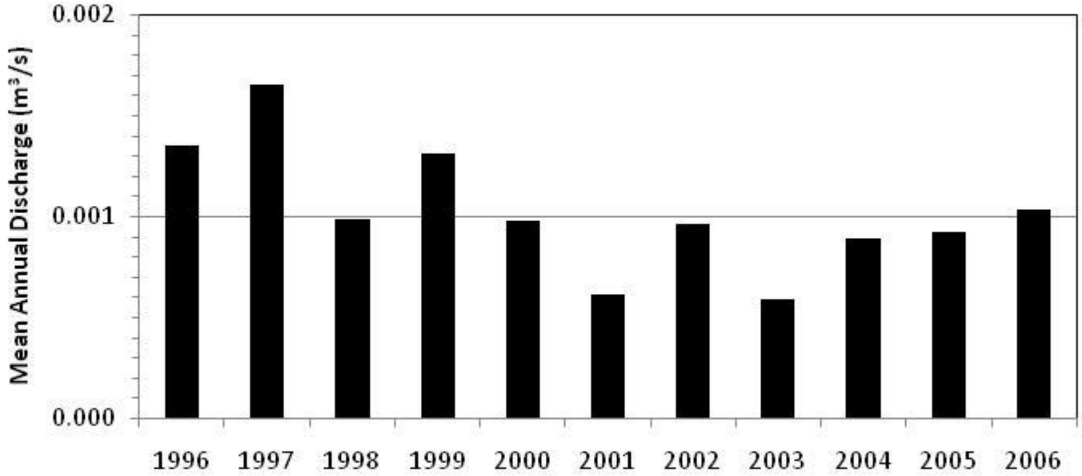
Node 63: Residual Area E-12

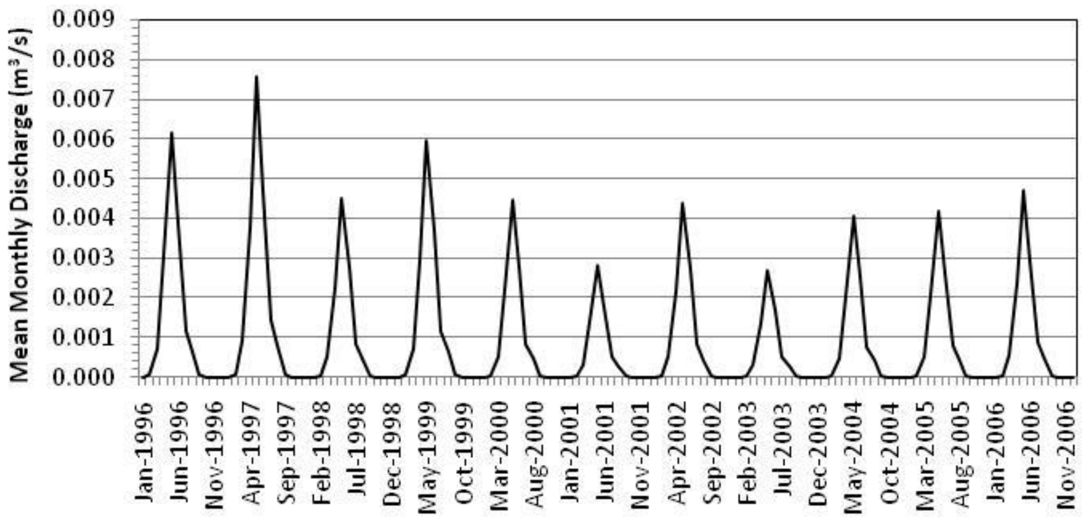


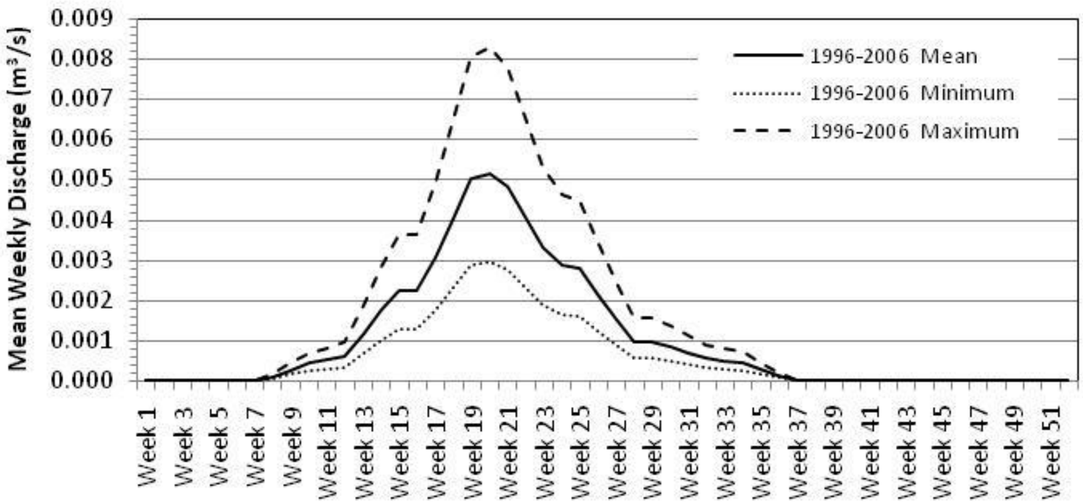




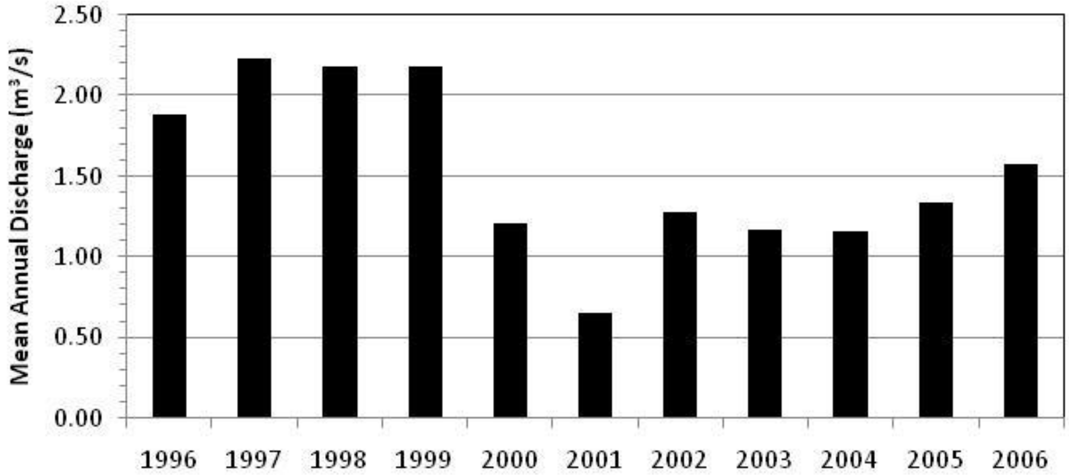
Node 65: Residual Area E-13

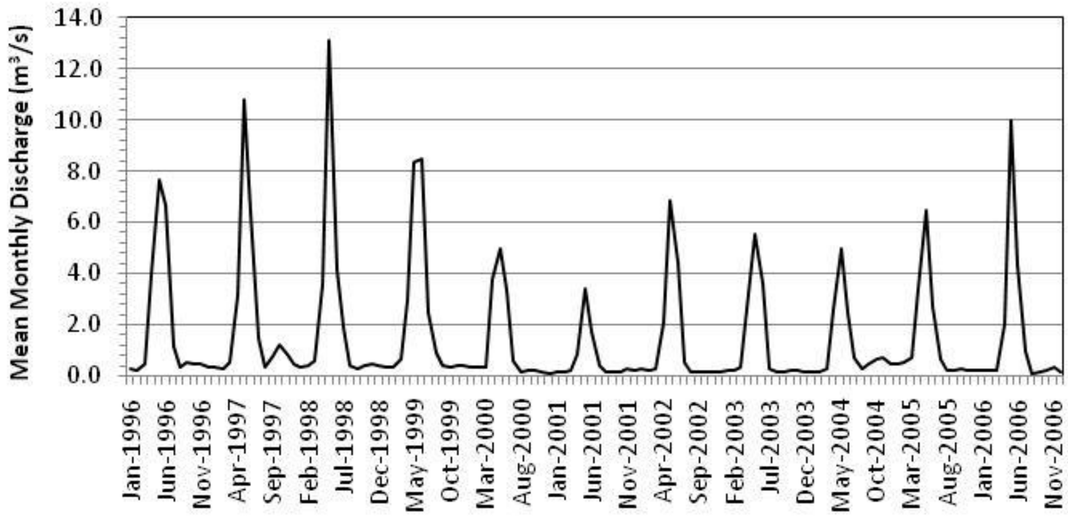


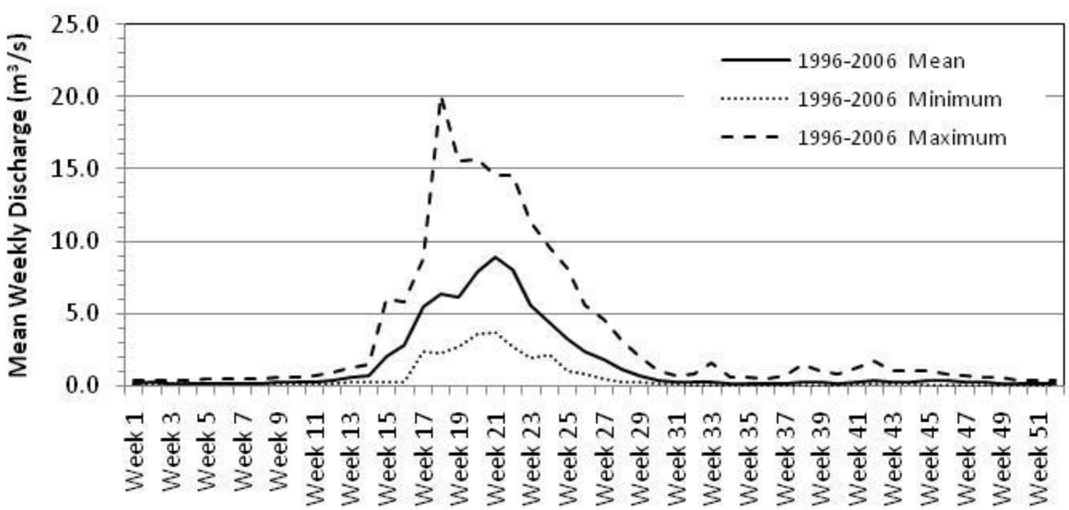




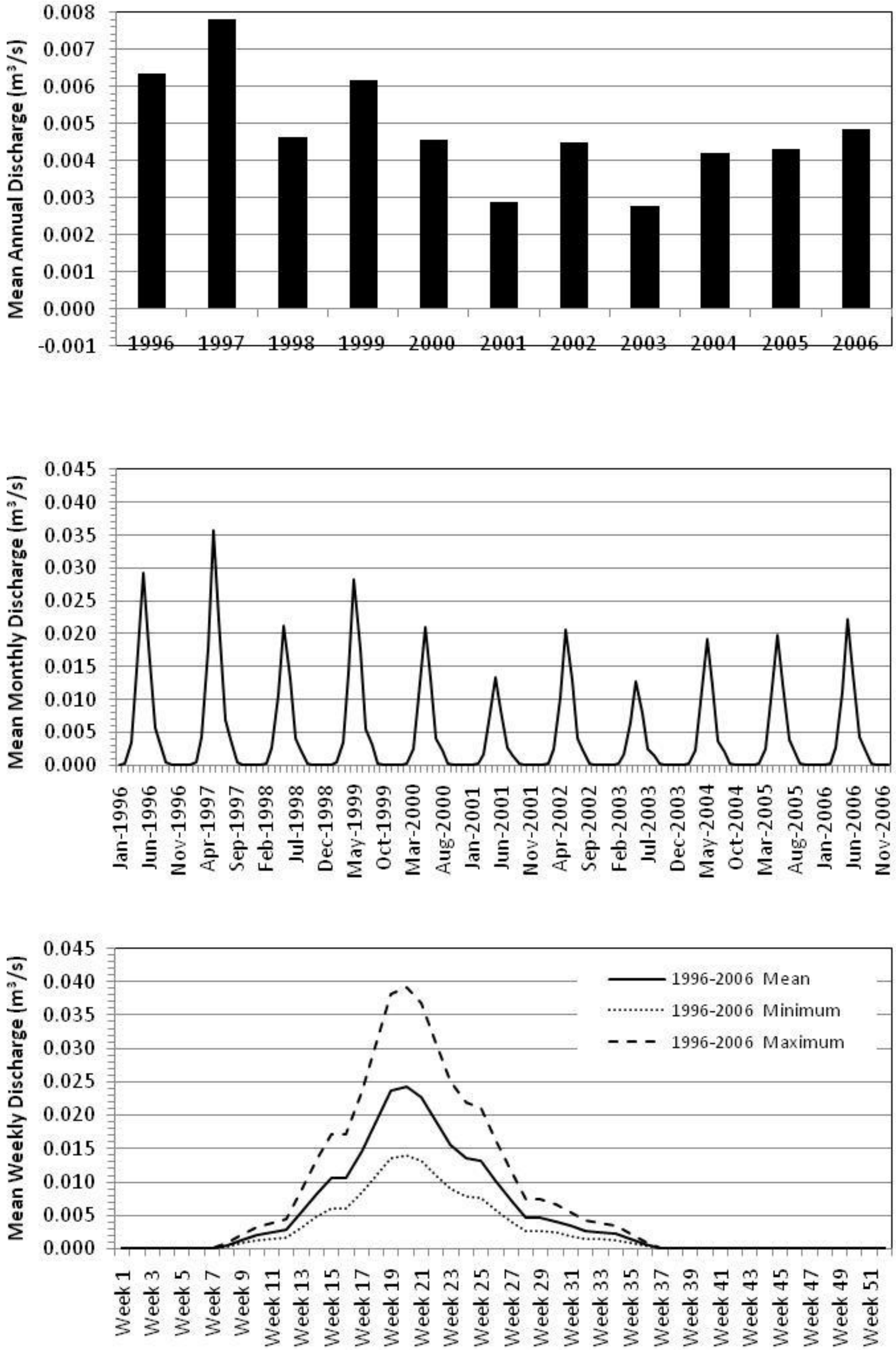
Node 66: Vaseux Cr.



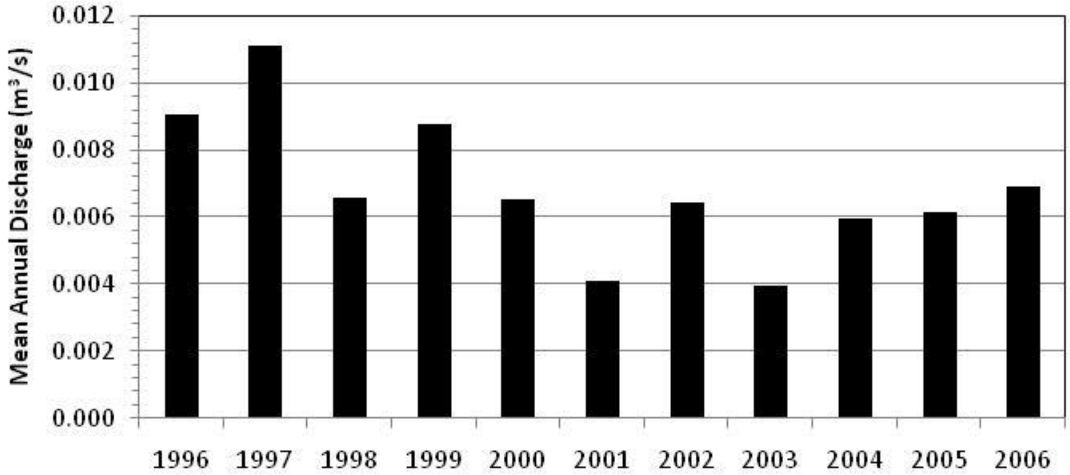


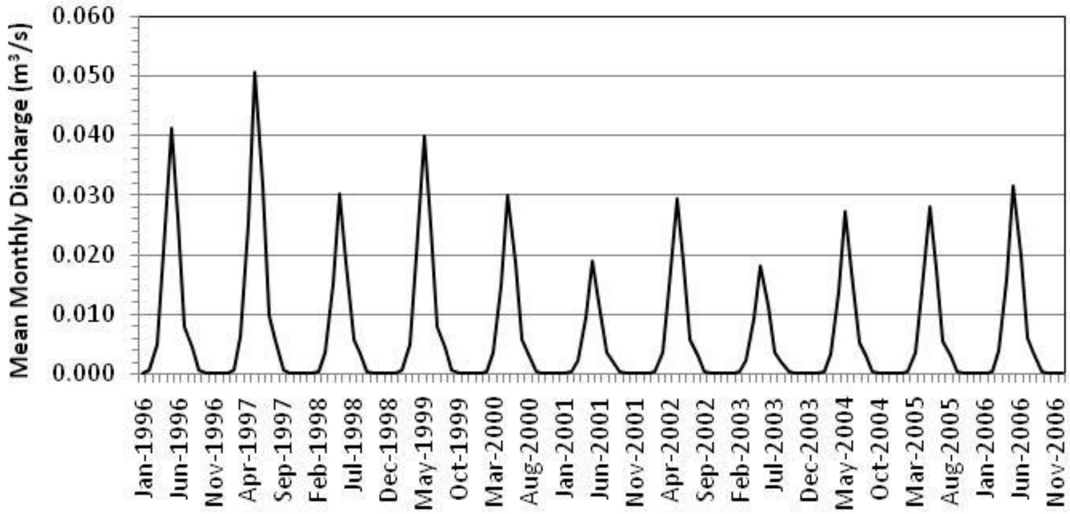


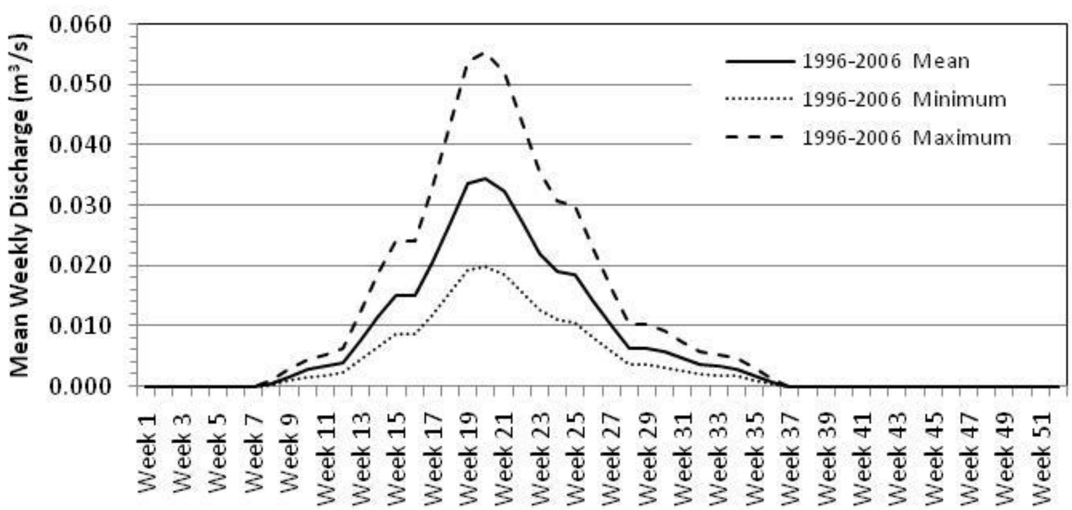
Node 67: Residual Area W-20



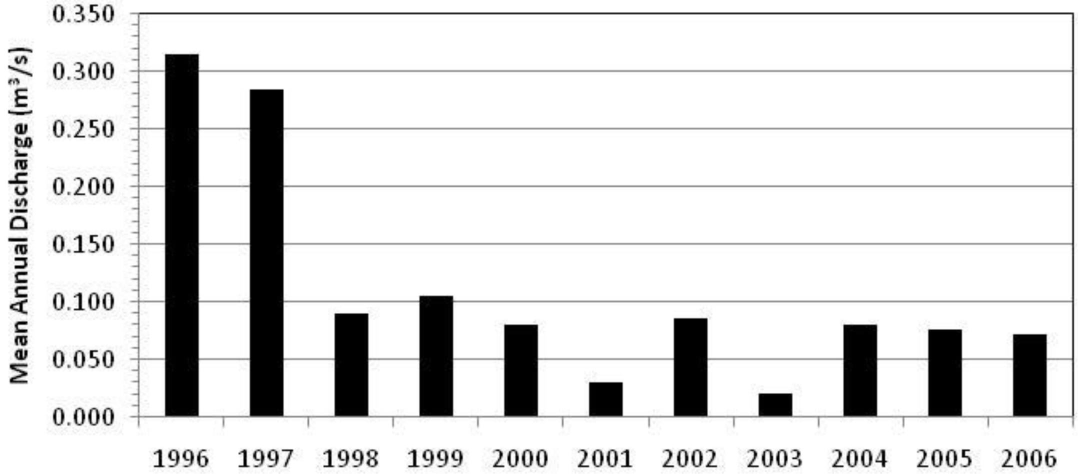
Node 68: Residual Area E-14

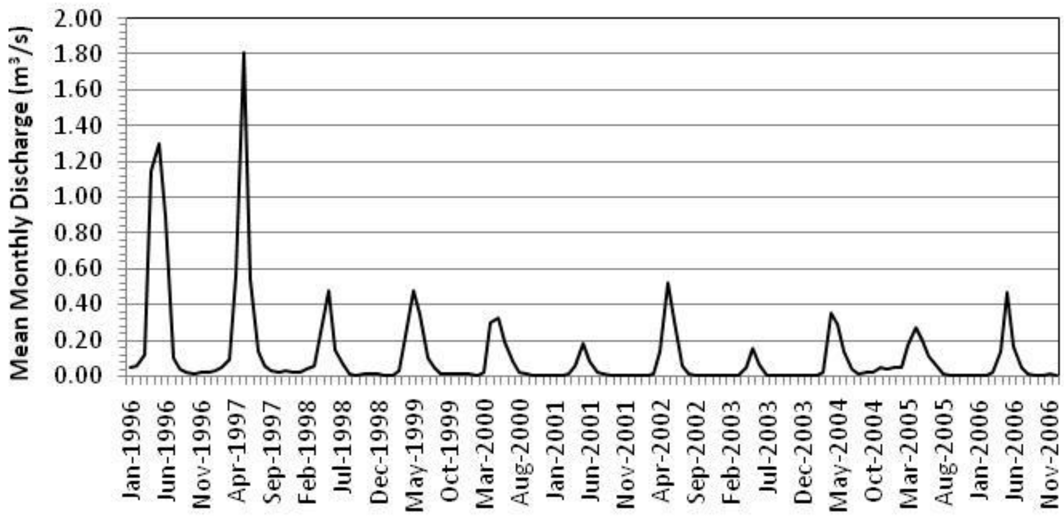


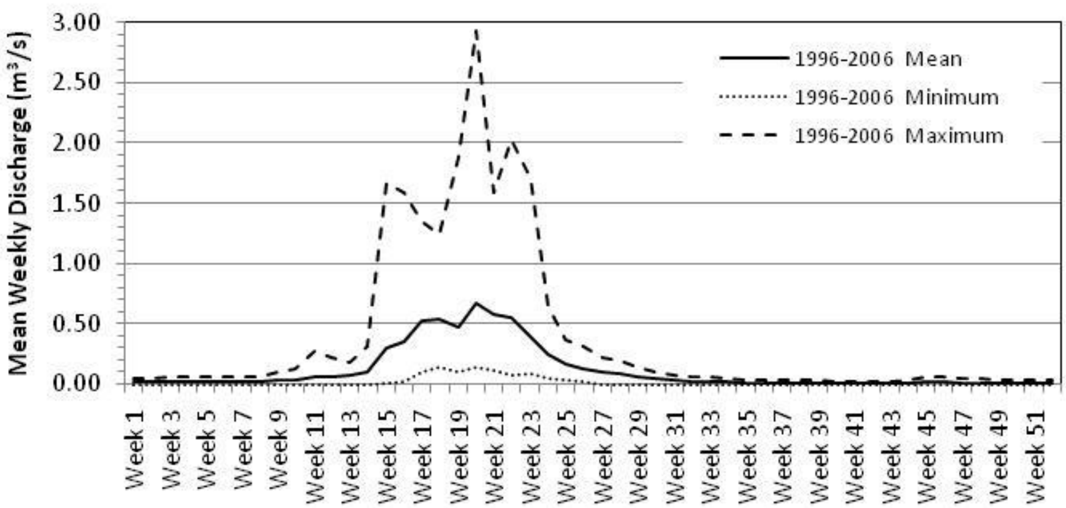




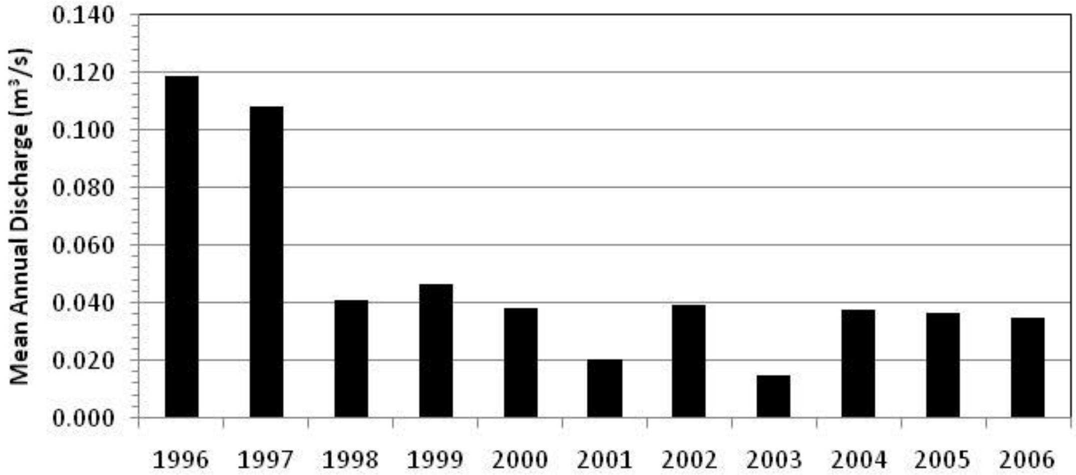
Node 69: Park Rill

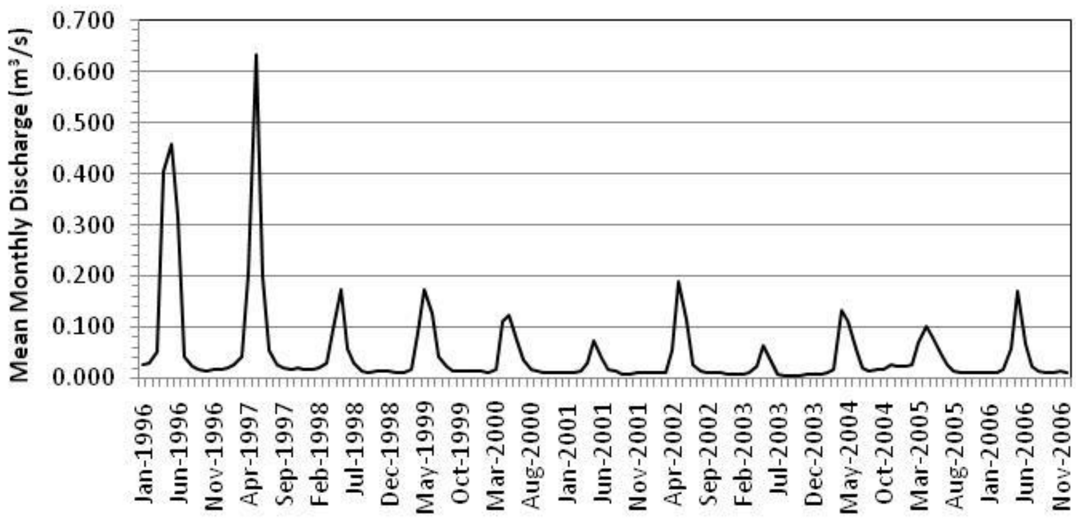


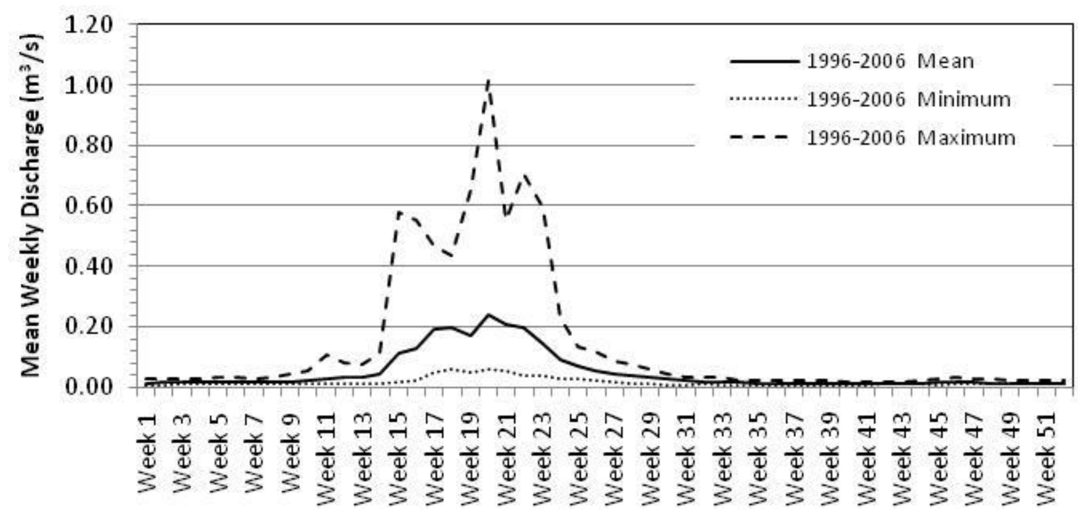




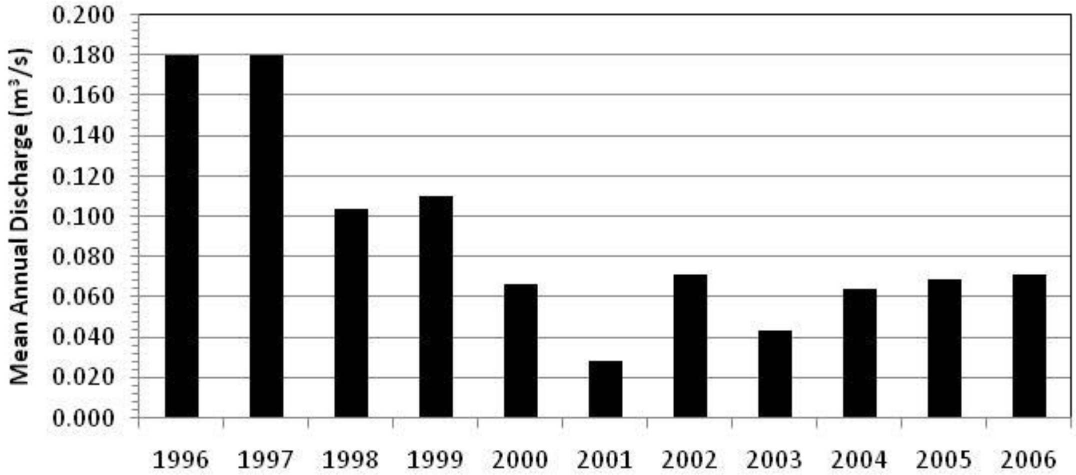
Node 70: Residual Area W-21

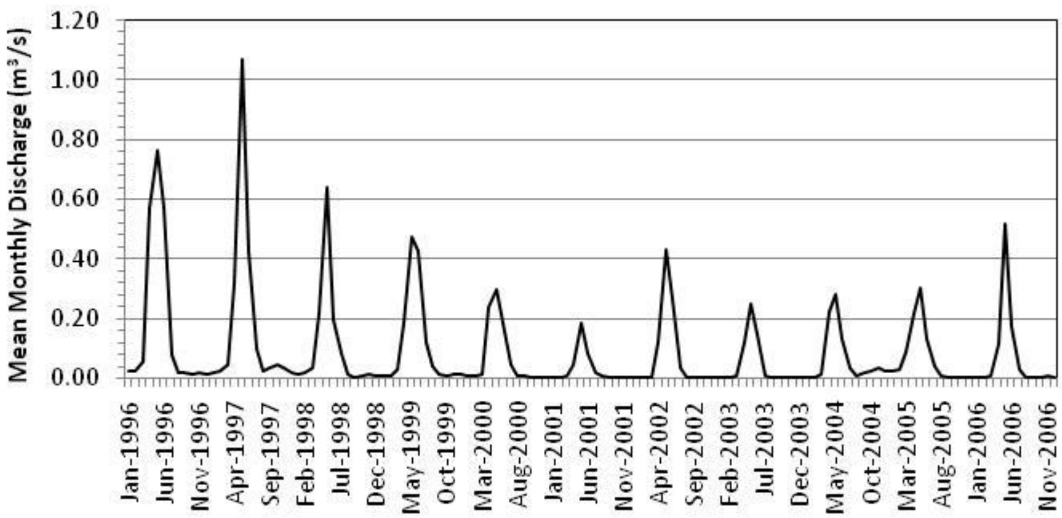


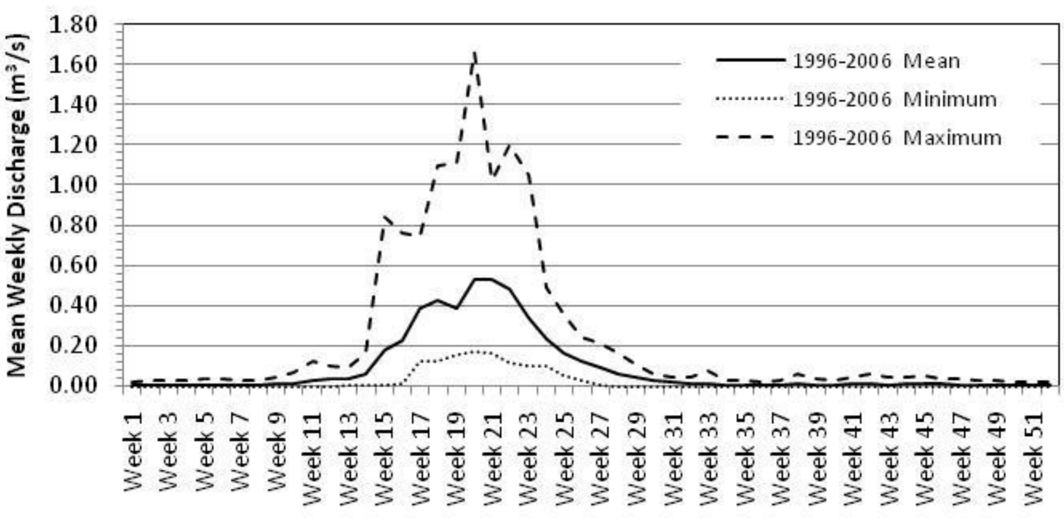




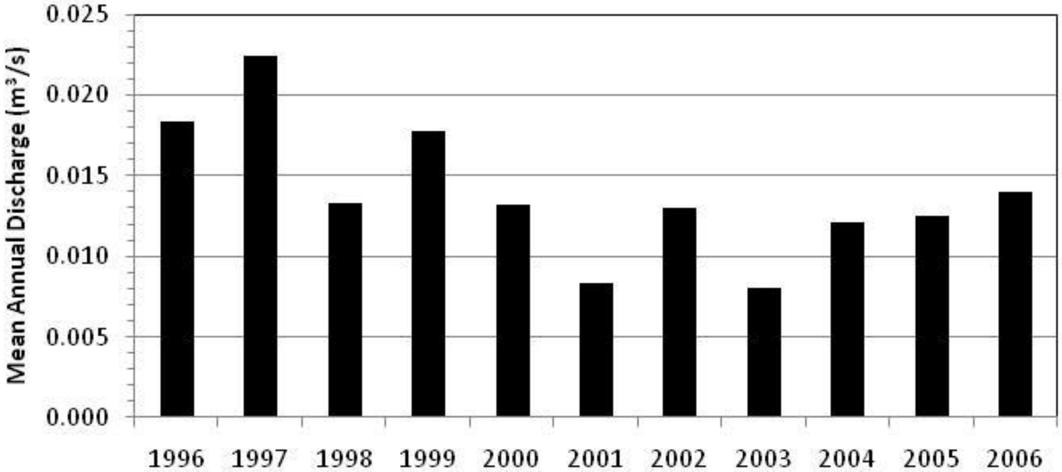
Node 71: Wolfcub Cr.

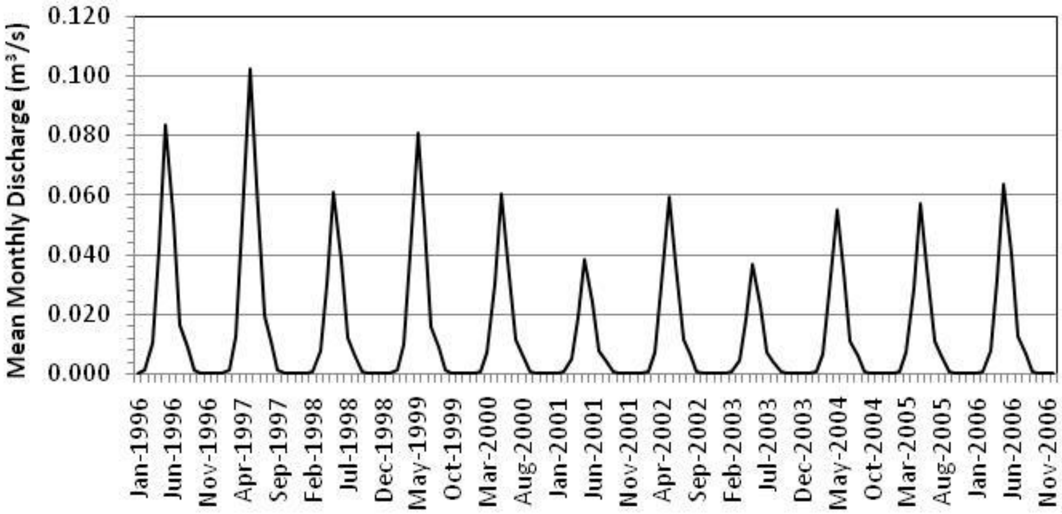


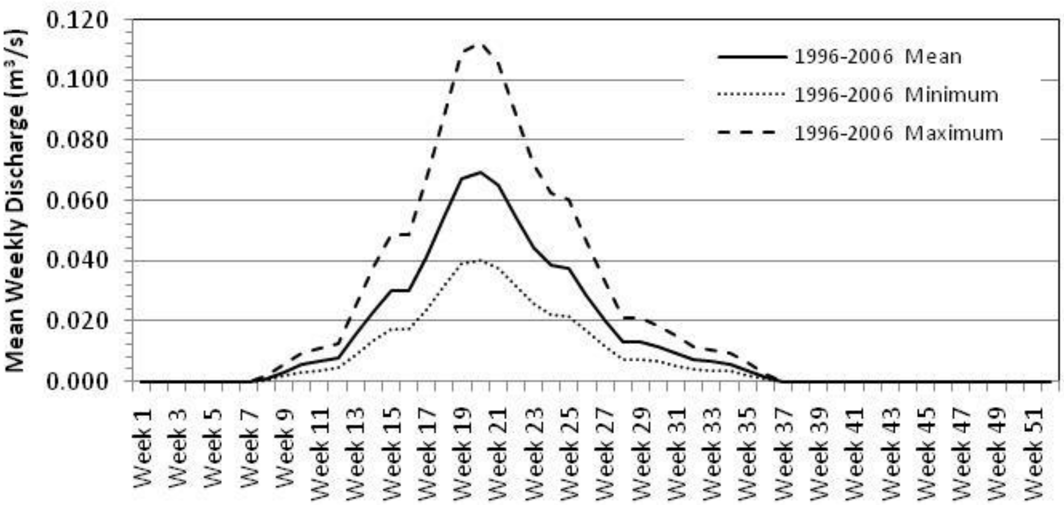




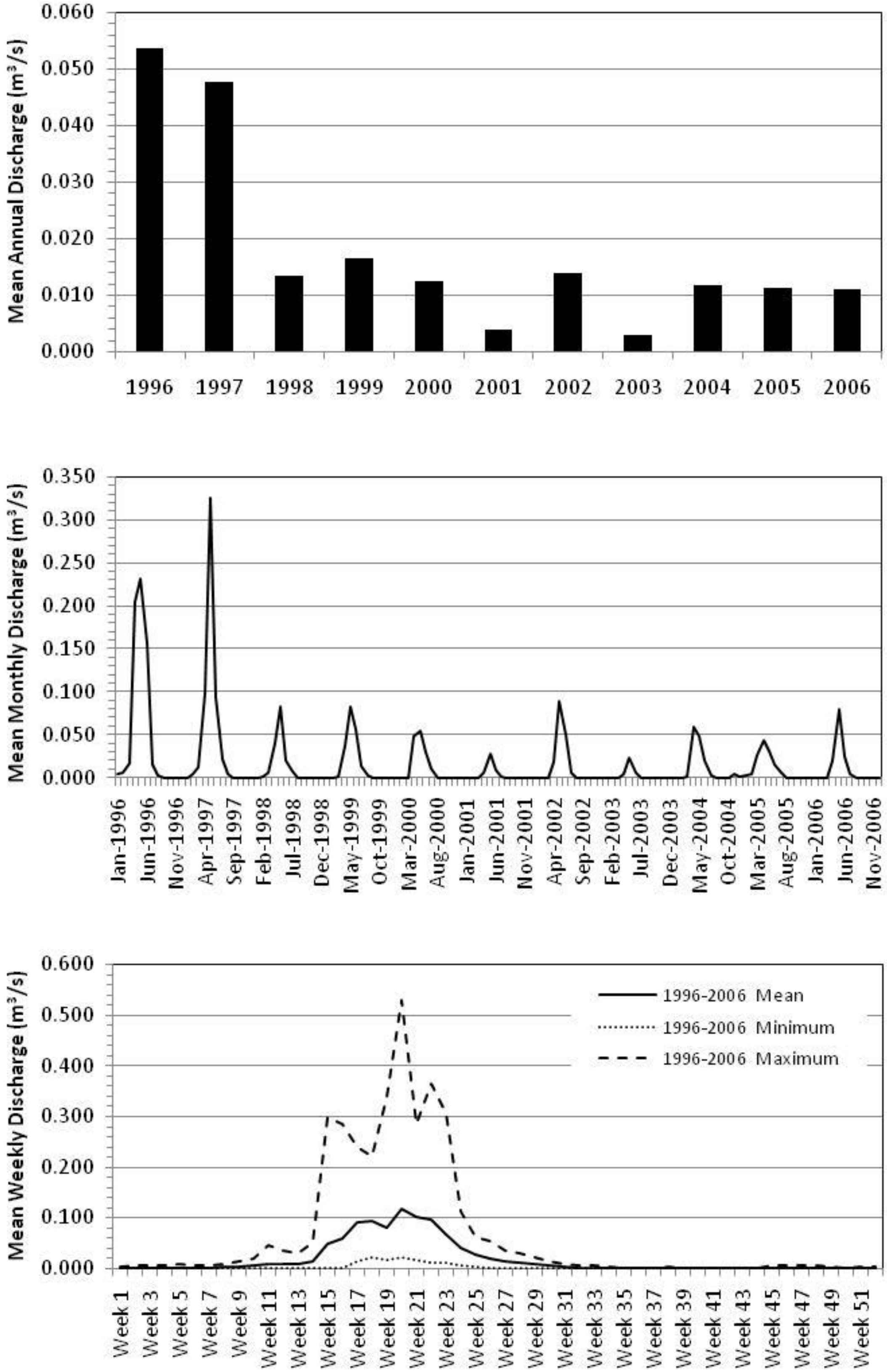
Node 72: Residual Area E-15



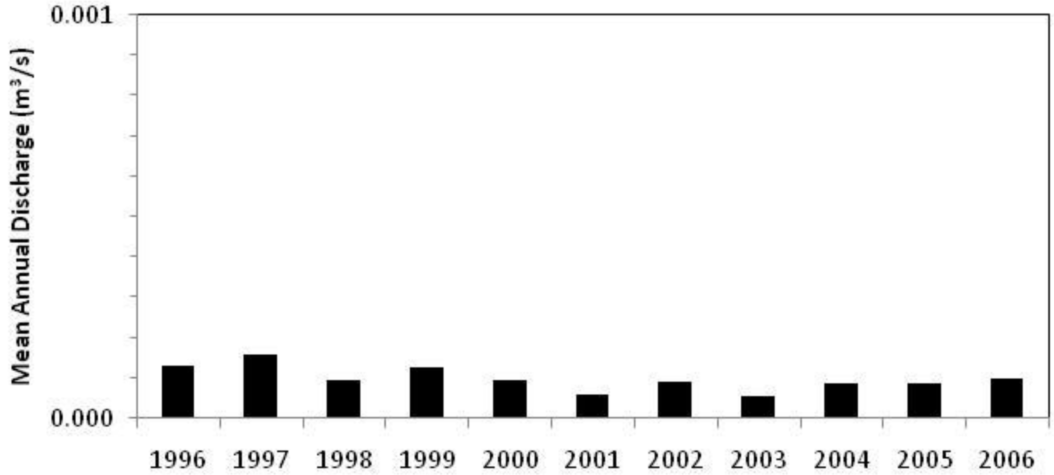


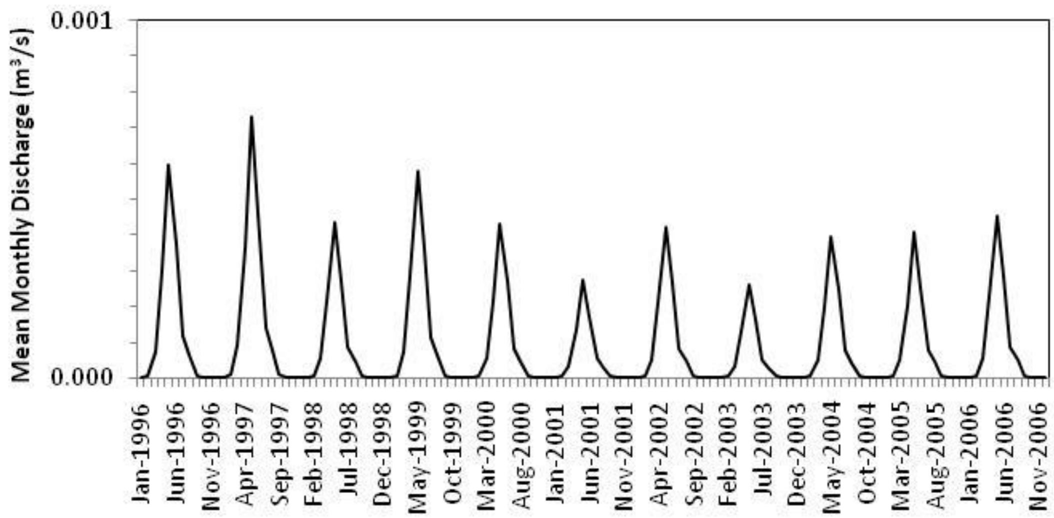


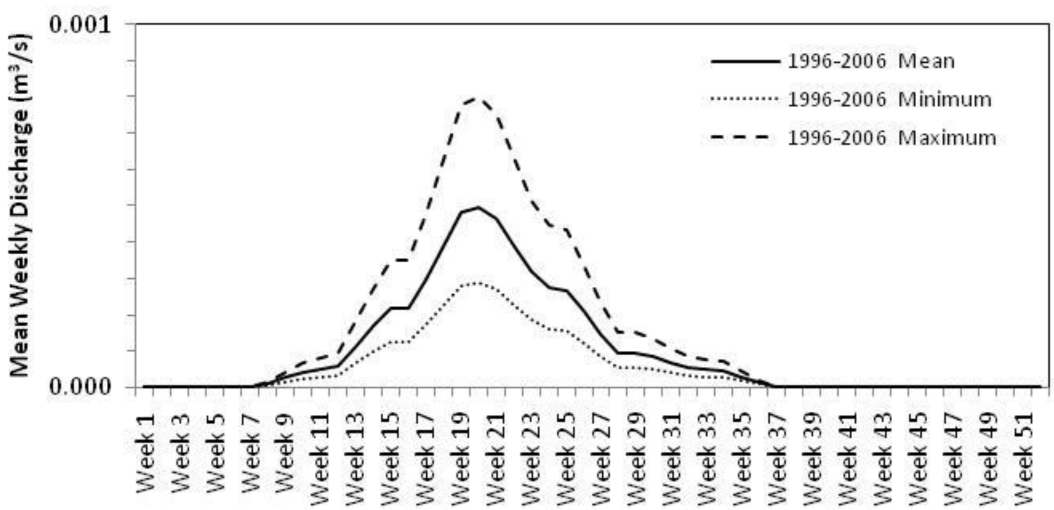
Node 73: Testalinden Cr.



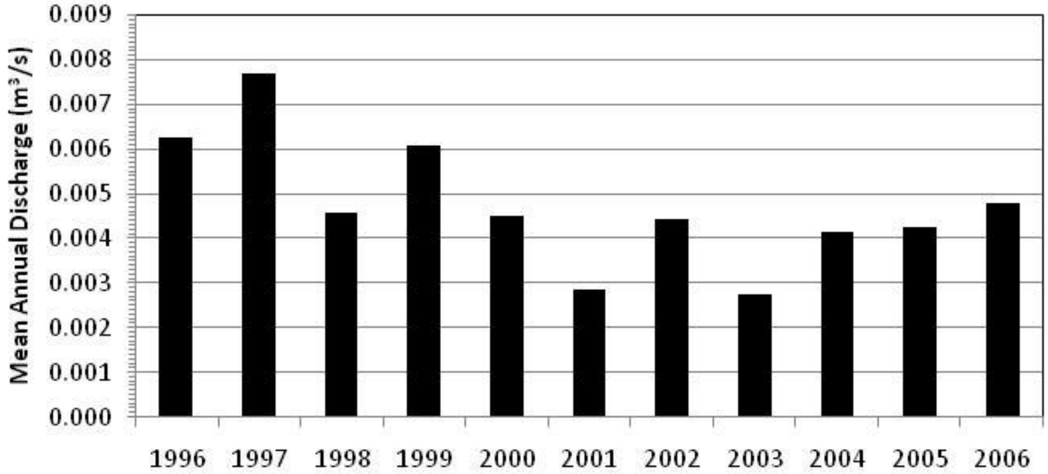
Node 74: Residual Area W-22

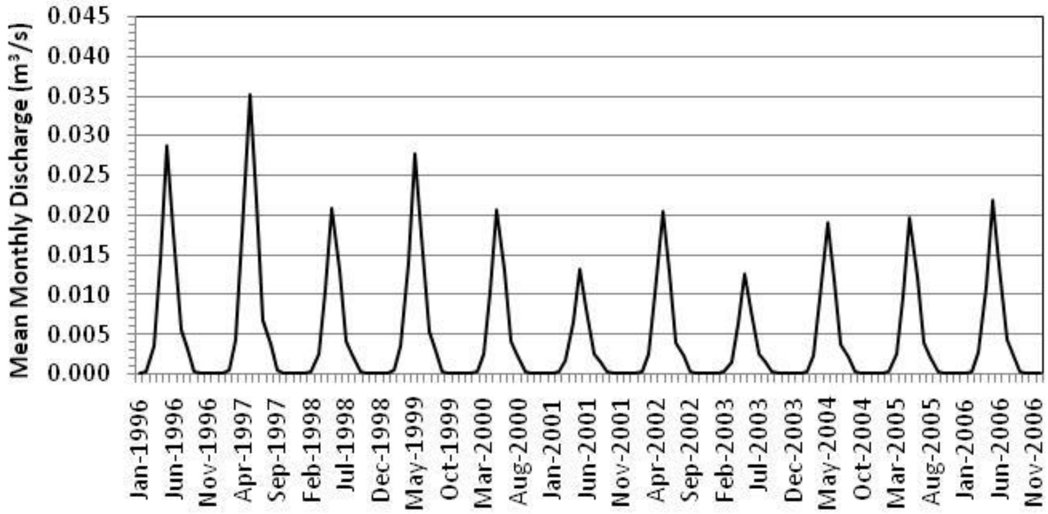


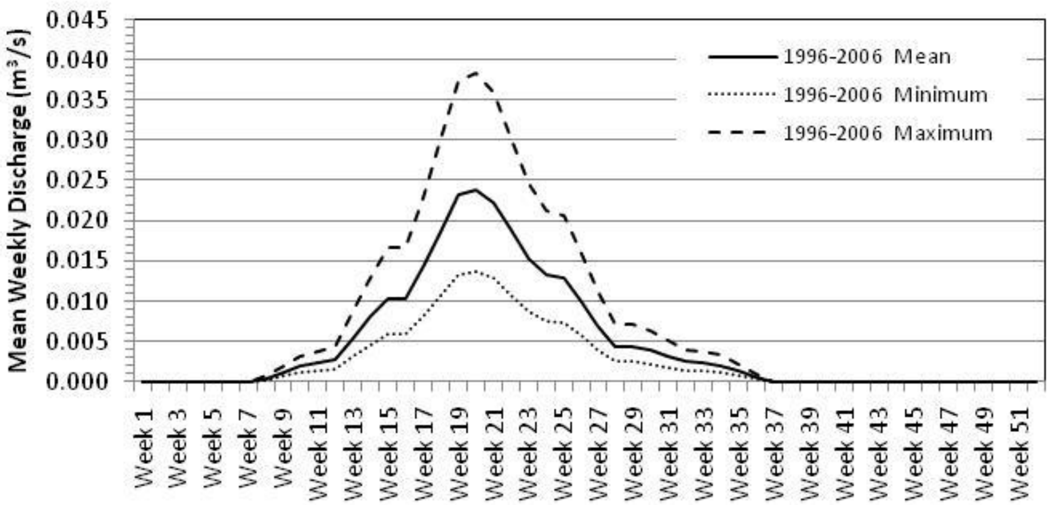




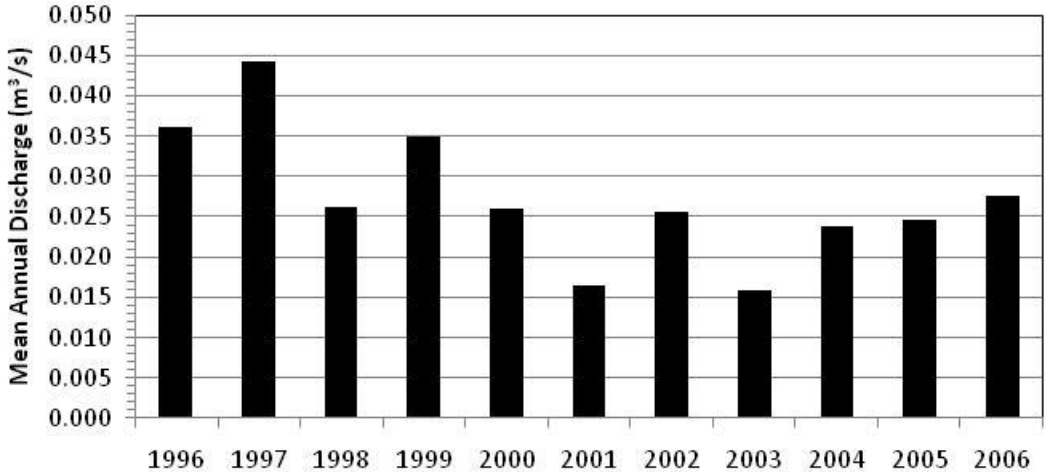
Node 76: Residual Area E-16

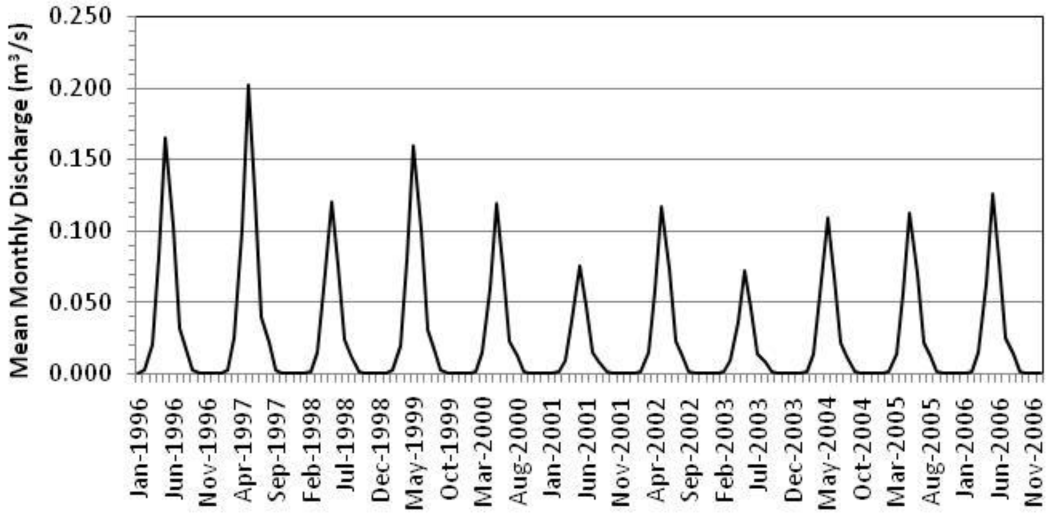


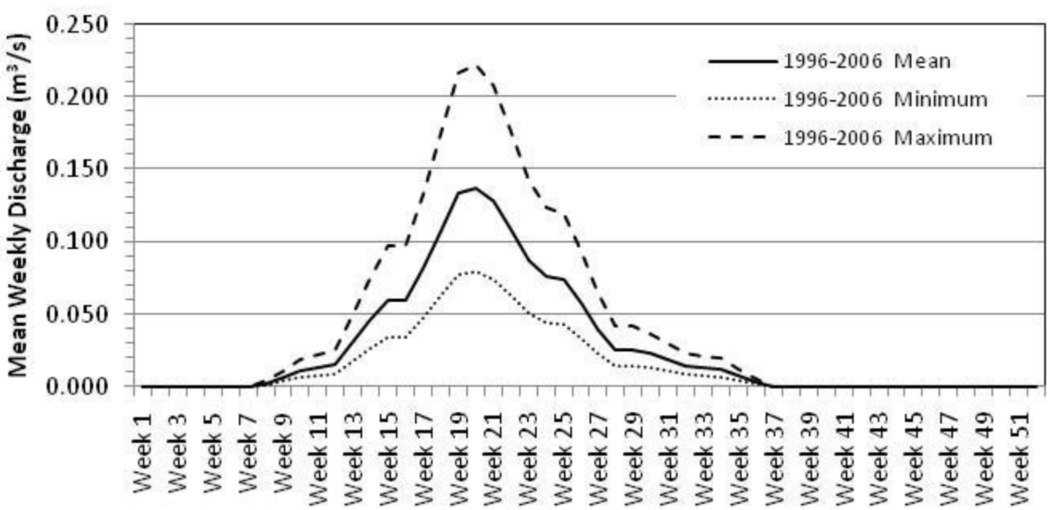




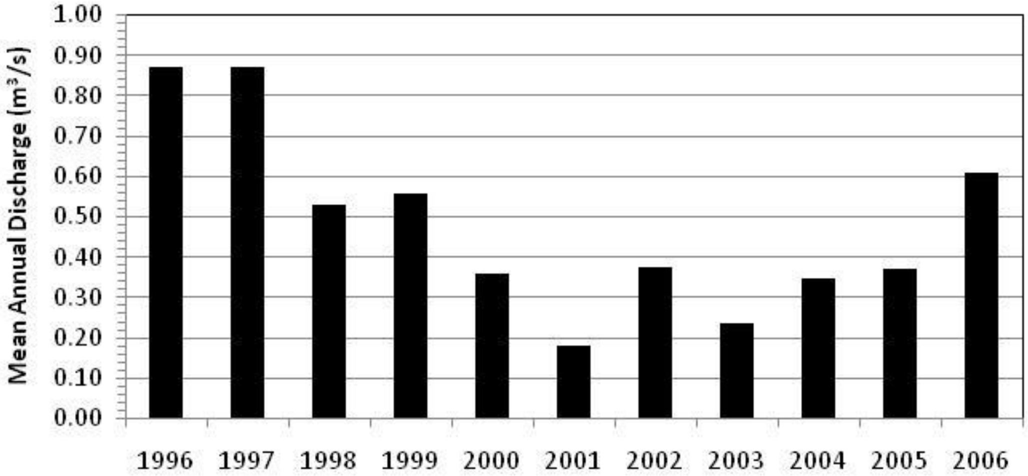
Node 77: Residual Area W-23

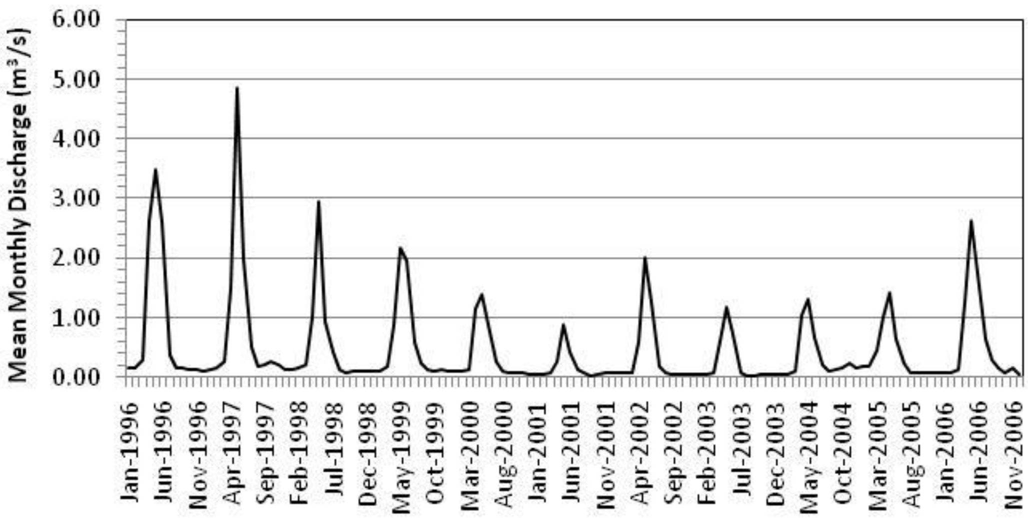


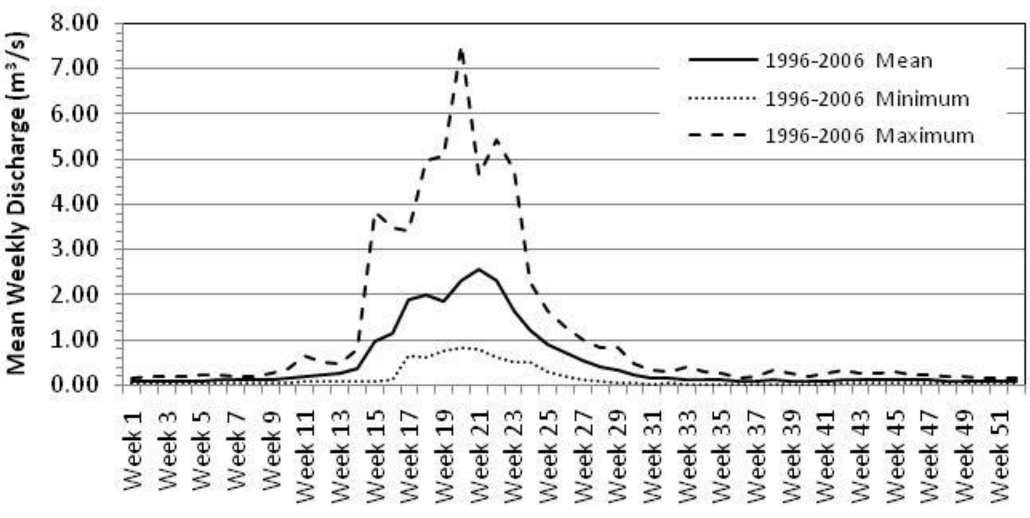




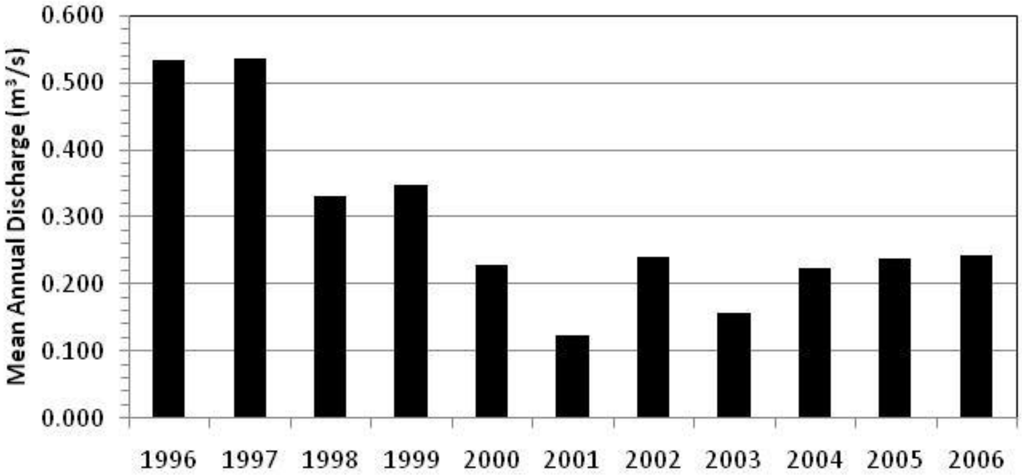
Node 78: Inkaneep Cr.

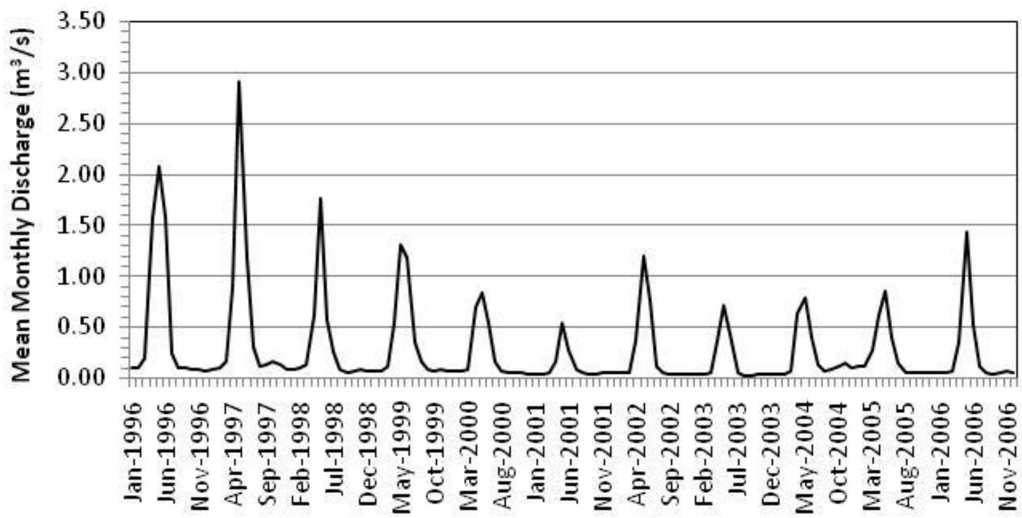


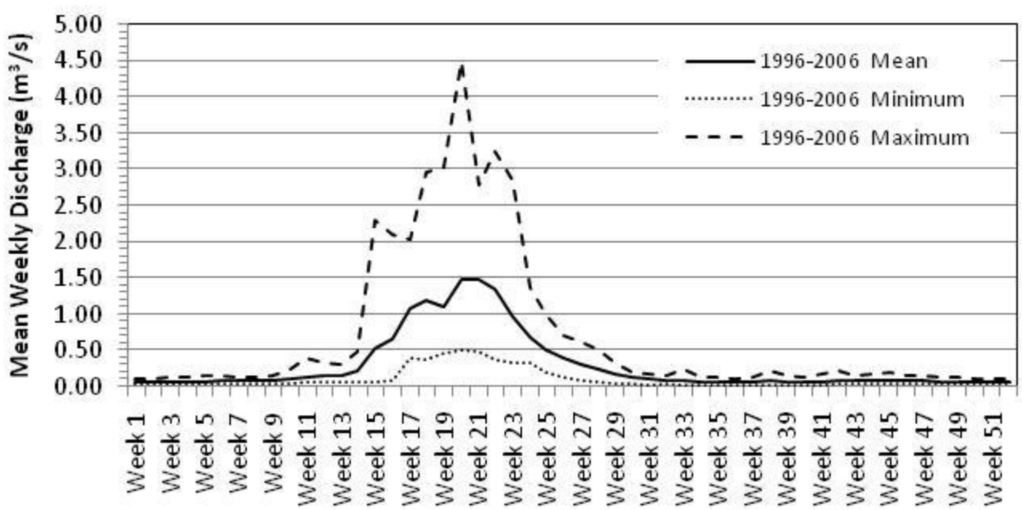




Node 79: Residual Area E-17







APPENDIX J

Tributary Streamflow Details

APPENDIX J – TRIBUTARY STREAMFLOW DETAILS

J.1 INTRODUCTION

Detailed information and discussion of the streamflows in the 32 nodes on streams are provided here in **Appendix J**, while information and discussion on flows in the 40 residual areas is presented in **Appendix K.** The term "**normal**", when referring to streamflow in these appendices, refers to the average over the 1996-2006 standard period.

J.2 NODES 1 AND 12: VERNON CREEK

Overview

The Vernon Creek sub-basin is located on the east side of the northern portion of the Basin (Map 1). The main stem and its tributaries, including Oyama Creek, Coldstream Creek and BX Creek drain a large area of plateau at elevations above 1,200 m. Vernon Creek has three (3) main reaches, as follows:

1. Upper Vernon Creek between Swalwell Lake and Ellison (Duck) Lake;
2. Middle Vernon Creek between Ellison (Duck) and Wood Lakes; and
3. Lower Vernon Creek between Kalamalka and Okanagan Lakes.

Vernon Creek is strongly influenced by the presence of storage reservoirs both in the uplands and along the valley bottom. In the uplands, the District of Lake Country operates storage reservoirs at Crooked, Swalwell, Oyama, and Dammer Lakes and Greater Vernon Water operates a reservoir at King Edward Lake. MOE manages the water levels in Kalamalka and Wood Lakes by a dam at the outlet of Kalamalka Lake. The two lakes are connected by a canal at Oyama and can be considered a single water body under normal water levels. The principal tributaries to Kalamalka / Wood Lake include:

- Middle Vernon Creek,
- Oyama Creek, and
- Coldstream Creek.

From the outlet of Kalamalka Lake, Lower Vernon Creek flows through the City of Vernon before it flows into Okanagan Lake. BX Creek, which drains the northern portion of the sub-basin and flows through Swan Lake, is the principal tributary to Lower Vernon Creek.

Land use in the basin includes forest harvesting in the mid and upper elevations. The eastern slope of Kalamalka Lake is a combination of Provincial Park, Protected area and Ecological Reserve. The valley bottom supports agriculture, industry and urban and recreational development.

Available Hydrometric Data

In total, 31 hydrometric stations have been operated by the Water Survey of Canada and five hydrometric stations have been managed by others in the Vernon Creek sub-basin (Appendix B). Among these, only three currently operate, and of these only one records natural streamflows [*Coldstream Creek above municipal intake* (08NM142)].

In order to develop natural streamflow estimates for Nodes 1 and 12, and to estimate inflows to Kalamalka / Wood Lake (defined as Node 00), the following hydrometric stations were used:

- *Kalamalka Lake at Vernon Pumphouse* (08NM143);
- *Vernon Creek at the outlet of Kalamalka Lake* (08NM065); and
- *Vernon Creek near the mouth* (08NM160).

Since all three of the above-noted stations are regulated, it was necessary to identify the water use and management patterns in the sub-basin in order to estimate natural streamflows. This information was identified during Task 7 (Appendix A.7). Details of the methods used to estimate the water use and management data are provided in Appendix E. The methods followed to develop the natural streamflow estimates are provided below.

Methods Used to Estimate Natural Streamflows

Natural streamflows in the Vernon Creek sub-basin were estimated for the following three points and areas of interest:

1. Inflows to Kalamalka / Wood Lake (Node 00),
2. Vernon Creek at the outlet of Kalamalka Lake (Node 1), and
3. Vernon Creek at the mouth (Node 12).

<u>Inflows to Kalamalka / Wood Lake (Node 00)</u>

In order to estimate the natural inflows to Kalamalka / Wood Lake, the water balance for Kalamalka / Wood Lake was analyzed on a weekly basis. Similar to the general water balance in Appendix B.13, the water balance for Kalamalka / Wood Lake takes the form:

Volume of water in – Volume of water out = Volumetric change in storage ...[Eq J.1]

Using the water balance parameters adopted by the OWSDP, the general annual water balance used to estimate natural inflows to Kalamalka / Wood Lake is as follows:

$$[(QS + \sum DSN)\,\Delta t + PL + RFS + DL\,\Delta t + QT\,\Delta t + QR]\,\Delta t - [Q_{out}\,\Delta t + EL + ES] = \Delta SL$$

... [Eq J.2]

where,

$(QS + \sum DSN)\,\Delta t$ = Natural volumetric inflow to Kalamalka / Wood Lake (ML)

Δt = one year

PL = Volume of precipitation directly onto lake surfaces (ML). This term is based on the precipitation estimates developed by Duke et al. (2008a). Precipitation in mm was converted to volumes based on lake surface areas identified in this study (Appendix G).

RFS = Volume of surface return flows due to human activity (e.g. wastewater treatment plant outflows) (ML). Since no significant wastewater outflows were identified in Dobson Engineering Ltd. (2008) for Node 1, this was assigned a value of zero.

$DL\,\Delta t$ = Volume of groundwater discharged as underflow to lakes (ML). This value is unknown and is a topic currently being investigated by the groundwater study for the OWSDP. For the purposes of our calculations, this was assumed to account for 7% of the total inflow to the lake. This value was estimated from the annual water balance to Kalamalka Lake, discussed in Section 6.2 and presented in Appendix G.

$QT\,\Delta t$ = Volume of water imported from outside the natural contributing area (ML). According to information provided by Dobson Engineering Ltd. (2008) as well as several major water suppliers, the only water attributed to this term was associated with the District of Lake Country water imports from Okanagan Lake. On a weekly basis, these imports were not considered to be significant. Annual values are however presented in Appendix E.

QR Δt = Volume of water stored in or released from upland reservoirs (ML). Volumes of water stored were assigned positive values while those released were assigned negative values. On an annual basis this term can generally be ignored, however, on a weekly basis this term is significant. This term is based on estimates by Polar Geoscience Ltd. (2009) and is described in Appendix E.

Q_{out} Δt = Residual or outgoing outflow from Kalamalka Lake (ML). This term is based directly on the Water Survey of Canada streamflow records on *Vernon Creek at the outlet of Kalamalka Lake* (08NM065).

EL = Volume of water lost to evaporation from lake surface (ML). This term is based on lake evaporation estimates developed by Schertzer and Taylor (2008). It is our understanding that this data is subject to revision and that the method may underestimate actual values (Guy pers. comm. 2008).

ES = Volume of water extracted from surface sources for human use (ML). This term is based on the estimates of water use developed by Polar Geoscience Ltd. (2009), which are described in Appendix D.

ΔSL = Volumetric change in lake storage (ML). This is based directly on the lake level records on Kalamalka Lake. The conversion of lake level changes to volumetric changes was based on the lake storage tables developed in this study (Appendix G).

Rearranging Equation J.2 to solve for $(QS + \sum DSN)$,

$$(QS + \sum DSN)\,\Delta t = \Delta SL + [Q_{out}\,\Delta t + EL + ES] - [PL + RFS + DL\,\Delta t + QT\,\Delta t + QR\,\Delta t] \quad \text{... [Eq J.2]}$$

Since *RFS* = 0, and *QT is* assumed to be 0,

$$(QS + \sum DSN)\ \Delta t = \Delta SL + [Q_{out}\ \Delta t + EL + ES] - [PL + DL\ \Delta t + QR\ \Delta t] \quad ..[\text{Eq J.3}]$$

Equation J.3 was solved for each week of the standard period (1996-2006). The results are presented in Appendix I. When information on the proportion of total lake inflow attributed to groundwater becomes available from the groundwater study, surface inflows to Kalamalka / Wood Lake can be refined.

Vernon Creek at the outlet of Kalamalka Lake (Node 1)

In order to estimate the natural outflows from Kalamalka Lake, a water balance approach was used. Since the outlet is currently regulated and since lake and outflow records reflect regulated conditions, a number of assumptions and hydraulic calculations based on assumed natural condition were necessary. The process was as follows:

1. Based on a field review of the outlet of Kalamalka Lake, the elevation of the outlet under natural (non-regulated) conditions was estimated to be 390.6 m.

2. Based on a review of the historic Kalamalka Lake level records and experience in modelling other mainstem lakes in the Basin, a starting lake level in the first week of the standard period was assigned an elevation of 391.0 m.

3. The total lake storage volume at the beginning of the week was estimated based on the storage tables for Kalamalka and Wood Lakes (Appendix G).

4. The depth above the assumed natural outlet of the lake was calculated by subtracting the elevation of the estimated natural lake outlet from the estimated natural lake elevation.

5. The natural weekly outflow from Kalamalka Lake was modelled using Haestad Flow Master software, which was used to automate the calculation of the Manning's Equation. From observations and measurements at the outlet, the natural outlet of the lake was assumed to be a rectangular channel 4 m wide with a 1% gradient and gravel-bed (Manning's $n = 0.035$).

6. The weekly change in storage under natural conditions was calculated using the following equation:

   $$\Delta SL = [(QS + \sum DSN)\,\Delta t + PL] - [Q_{out\_nat}\,\Delta t + EL] \quad \text{... [Eq. J.4]}$$

   where,

   $Q_{out\_nat}\,\Delta t$ = Natural outflow from Kalamalka Lake (ML) as determined in Step 5.

7. Based on the volume of water in Kalamalka / Wood Lake at the start of the week and the change in lake storage over the week, the volume of water in the lake at the end of the lake was calculated. This volume was converted to a lake level at the end of the week according to the storage tables in Appendix G.

8. Steps 4 to 7 were repeated by replacing the lake level at the start of the week with the lake level at the end of the preceding week.

Since the assumed configuration of the lake outlet can affect natural outflows, a number of configurations were assessed to determine the sensitivity of the calculations. In general however, the results were not particularly sensitive to the choice of configuration assuming the parameters of width, stream gradient, and channel morphology were reasonably consistent with actual measured conditions.

The results for Node 1 – Vernon Creek at the outlet of Kalamalka Lake are presented in Appendix I.

Vernon Creek at the mouth (Node 12)

Weekly natural streamflows at the mouth of Vernon Creek were estimated according to the following equation:

$$(QS + \sum DSN)\,\Delta t_{Node\ 12} = (QS + \sum DSN)\,\Delta t_{Node\ 1} + (QS + \sum DSN)\,\Delta t_{Lower\ Vernon\ Creek} \quad ..\text{[Eq J.5]}$$

where,

$(QS + \sum DSN)\,\Delta t_{Node\ 12} =$	Natural volumetric runoff of Vernon Creek at the mouth (ML);
$(QS + \sum DSN)\,\Delta t_{Node\ 1} =$	Natural volumetric runoff of Vernon Creek at the outlet of Kalamalka Lake (ML);
$(QS + \sum DSN)\,\Delta t_{Lower\ Vernon\ Creek} =$	Natural volumetric inflow to Lower Vernon Creek (ML) (between Kalamalka and Okanagan Lakes).

Since $(QS + \sum DSN)_{Node\ 1}$ was determined above, the main task was to identify the inflows to Lower Vernon Creek. This was accomplished by reviewing the overlapping WSC records of *Vernon Creek at the mouth* (08NM160) and *Vernon Creek at the outlet of Kalamalka Lake* (08NM065). Unfortunately, the overlapping record is only complete for 1970-1982[1]. Based on this data, a 1970-1982 average weekly inflow to lower Vernon Creek was determined. In order to estimate the inflow for each year of the standard period (1996 – 2006), the 1970-1982 average inflows were scaled according to the ratio of weekly streamflows in *Whiteman Creek above Bouleau Creek* (08NM174) in a given year to its 1970-1982 weekly averages. The Whiteman Creek record was chosen for its proximity, completeness, and reasonably similar hydrologic regime.

The inflows to Lower Vernon Creek were then naturalized by accounting for the estimated surface water use from Lower Vernon Creek and its tributaries (Polar Geoscience Ltd. 2009). In order to account for the actual position of the WSC gauge 08NM160 upstream of the

[1] There are also some overlapping seasonal records (for winter and early spring) between 1985 and 1999.

mouth, naturalized flows were scaled slightly higher (+2%) to account for actual contributing area between the gauge and the mouth.

While a considerable area of the Vernon Creek sub-basin is underlain by alluvial aquifers (Figure 2.3), there is no solid information on streamflow losses or gains known to the authors. Based on conversations with the groundwater study team (R. Allard pers. comm. 2008) , it is possible that shallow groundwater flow beneath hydrometric stations such as *BX Creek above Vernon Intake* (08NM020) may go unnoticed. In the event such flow enters the stream network downslope, actual streamflows at the lower position may be underestimated based on gauge records.

Confirmation / Validation

The following reports were reviewed to confirm and/or validate the streamflow estimates for Vernon Creek:

- Associated Engineering (2004),
- Coulson (1972),
- District of Lake Country (2005),
- Greater Vernon Services (2007),
- Letvak (1992),
- McNeil (1991),
- Reksten (1971a), and
- Reksten (1991).

J.3 NODE 3: DEEP CREEK

Overview

Deep Creek drains the northernmost sub-basin in the Okanagan Basin and flows in a southerly direction through the City of Armstrong and Township of Spallumcheen before reaching Okanagan Lake at the north arm of the lake. Approximately half of the basin is characterized by a broad valley bottom with agricultural, rural and urban residential, and some industrial areas. The remainder of the sub-basin has moderately steep valley slopes that support forest harvesting, recreation, and other uses. The City of Armstrong is the major water supplier in the node; however, a large portion of its water is sourced from Fortune Creek, which flows into Shuswap River. There are several other smaller water suppliers in the node that obtain water largely from alluvial aquifer(s) in the area (Dobson Engineering Ltd. 2008). Given the unique physiography and sub-surface conditions of the Deep Creek sub-basin, streamflows in Deep Creek are strongly affected by groundwater. Overall, Deep Creek is considered an influent stream – one that is fed by groundwater. This results in baseflows that tend to be higher and sustained longer than other comparably-sized streams in the north Okanagan. In addition, given the relatively low elevations, unit peak flows in Deep Creek tend to be somewhat muted with respect to other streams in the region.

Available Hydrometric Data

A total of four hydrometric stations have operated in the Deep Creek sub-basin, but none are currently active (Appendix B). Only one station has records of natural streamflows [*Deep Creek at Young Road* (08NM177)], however, this station has only six years of record between 1970 and 1975. Records from Deep Creek were reviewed to determine the timing and magnitude of base flows and peak flows, but given the constraints they were not directly used to estimate the natural streamflows in Deep Creek. The actual methods used are described below.

Methods Used to Estimate Natural Streamflows

According to NHC (2001), regional relations are not reliable for estimating streamflows in Deep Creek. In order to confirm this, we reviewed the available regulated hydrometric records from *Deep Creek at the mouth* (08NM153), water use data presented in Dobson Engineering Ltd. (2008) and the regional relations developed for this study (Appendix C).

According to the hydrometric records for 1970-1975, Deep Creek at the mouth had a regulated runoff of 72 mm. According to the region-wide variability in runoff (Figure 2.1), the 1996-2006 period is estimated to be 6% wetter than the 1970-1975 period, therefore the regulated runoff for the standard period at the mouth of Deep Creek is estimated at 76 mm. Using information presented in Dobson Engineering Ltd. (2008), water extractions from Deep Creek were estimated to be about 6,000 ML per year (or 28 mm). Assuming the water use patterns have remained roughly the same over time, the naturalized runoff is estimated to be 76 mm + 28 mm = 104 mm. According to the regional runoff relations for the area, Deep Creek should have a natural runoff of only about 40 mm. The difference of 64 mm is likely to be the result of considerable groundwater inflow along Deep Creek. The presence of such large groundwater inflows to the creek make the estimate of natural streamflows particularly challenging, given the limited amount of data available.

Ideally, natural streamflows of Deep Creek at the mouth would be estimated using streamflow records at the mouth along with estimates of water extractions from the creek. Unfortunately, neither is available. In order to determine the natural streamflows for the standard period, we began by searching for a surrogate streamflow record – preferably a station nearby that has a similar hydrologic regime. Unfortunately, no single hydrometric record could be found in the Basin that had similar characteristics to the six year record on Deep Creek. The elevated baseflows and the timing and magnitude of peak flows was unlike most other nodes assessed in the study, with the possible exception of Mill (Kelowna) Creek.

Inflows to Lower Vernon Creek, as calculated by the difference between the flows of *Vernon Creek at the mouth* (08NM160) and *Vernon Creek at the outlet of Kalamalka Lake* (08NM065), were found to be the most similar to Deep Creek at the mouth (Figure J.1) among all records reviewed. Upon review of the physiography of the two catchments, it is not surprising the two are reasonably similar. Both catchments drain similar sized areas with similar elevations, and both flow across considerable lengths of low gradient valley bottom underlain by alluvial aquifers (Figure 2.3).

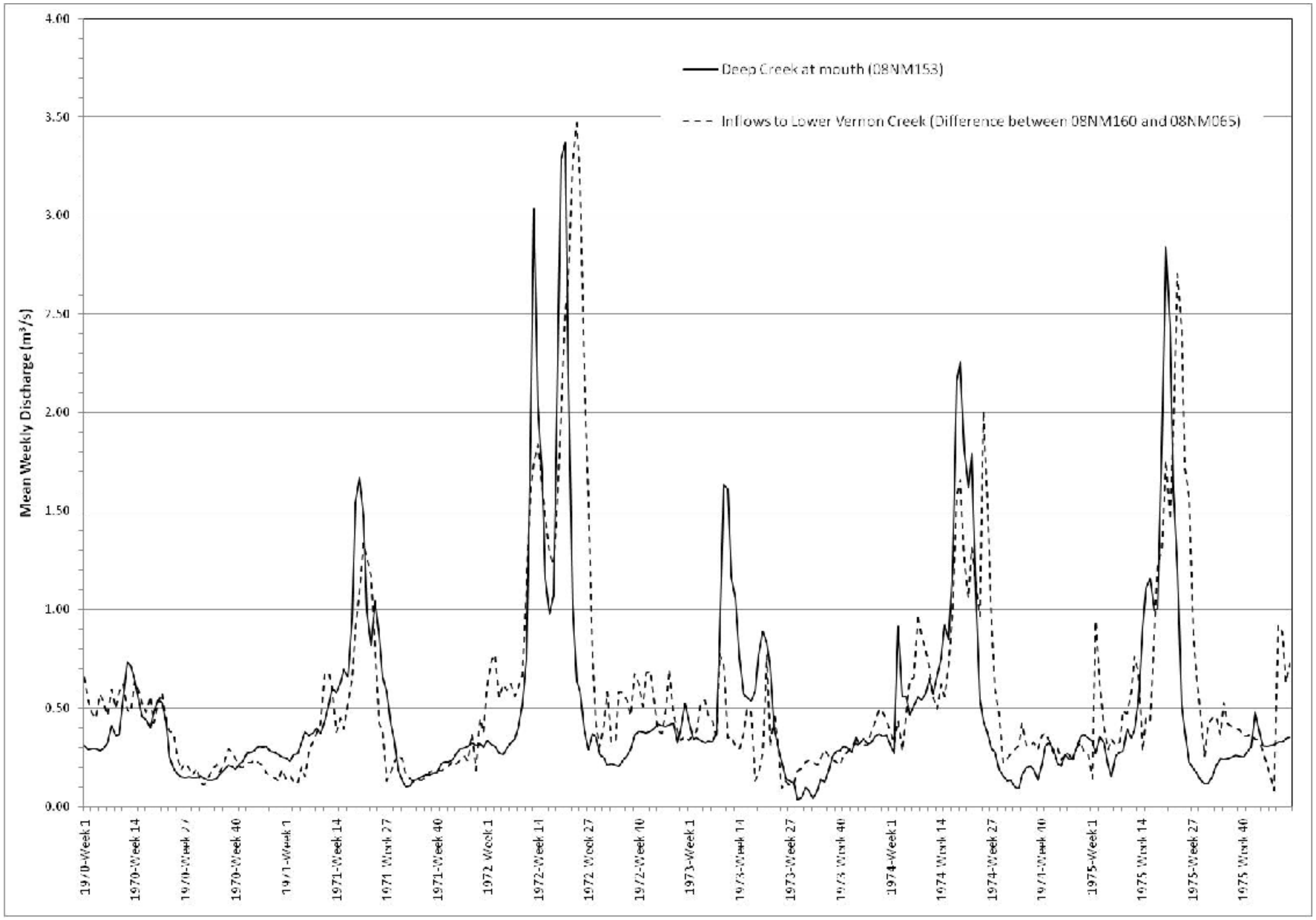


Figure J.1 Comparison of streamflows between Deep Creek at the mouth (08NM153) and recorded inflows to Lower Vernon Creek.

As a result, the estimated inflows to Lower Vernon Creek (described in Section J.2) were deemed a suitable surrogate for Deep Creek. However, given that the normal annual runoff for Deep Creek under natural conditions is estimated to be 104 mm, all weekly data was scaled uniformly to reconcile with this value.

Confirmation / Validation

The following reports were reviewed to confirm and/or validate the streamflow estimates for Deep Creek:

- NHC (2001), and
- Rekshten (1991).

J.4 NODE 5: IRISH CREEK

Overview

Irish Creek has a small catchment on the west side of the valley near the north end of Okanagan Lake. The upper portion of the sub-basin drains moderately steep, east-facing slopes. Where Irish Creek meets the valley bottom, it makes an abrupt bend and flows southwards over broad, gently sloping valley bottom and through Okanagan I.R. No. 1, which is the primary residential reserve of the Okanagan Indian Band. Land use is primarily agricultural along the lower gentle reaches of the basin. Two water suppliers divert water from the creek: Grandview Waterworks District (GWD) and the Okanagan Indian Band (Dobson Engineering Ltd. 2008). With no developed storage, natural stream flows tend to be low or zero during summer.

Available Hydrometric Data

Only one hydrometric station has operated on Irish Creek, however, records were only collected for about 9 weeks in 1922.

Methods Used to Estimate Natural Streamflows

Given the proximity of Irish Creek to Ewer Creek, the streamflows at *Ewer Creek near the mouth* (08NM176) were used as a surrogate for Irish Creek. However, since Ewer Creek has streamflow records only for 1971 to 1986, it was necessary to extend the Ewer Creek record to cover the 1996-2006 standard period. This was done by identifying the weekly relation of streamflows between Ewer and Whiteman Creeks, the latter of which has recorded streamflows for the standard period. Estimated Ewer Creek streamflows were then scaled uniformly by a factor of 0.26 to account for the lower median catchment elevation and annual runoff expected in Irish Creek relative to Ewer Creek (Appendix C). The lowermost portion of Irish Creek flows across an alluvial fan and aquifer (Figure 2.3). Streamflow losses were therefore taken into account as described in Section 3.6.

Confirmation / Validation

No information specific to Irish Creek was identified during the study.

J.5 NODE 8: EQUESIS CREEK

Overview

Equesis Creek is located on the west side of Okanagan Lake near the northern end of the Basin. The upper portion of the sub-basin drains gently sloping plateau and includes Pinaus Lake. Land use on the plateau consists primarily of forest harvesting, but also includes outdoor recreation (e.g. fishing). Below about an elevation of 1,300 m, the basin drains moderately steep eastward-facing slopes. Approximately half way down from the plateau, the large tributary of Ewer Creek enters from the southwest. At about an elevation of 500 m, Equesis Creek crosses a terrace consisting of thick unconsolidated deposits that supports an alluvial aquifer (Figure 2.3). Near Okanagan Lake, Equesis Creek flows across the Okanagan I.R. No. 1 and a large alluvial fan that has merged with one near the mouth of Nashwhito Creek. Agriculture is the principal land use activity downstream of Ewer Creek; however, according to Dobson Engineering Ltd. (2008) no water from Equesis Creek is used for irrigation. The Okanagan Indian Band however, does extract water from Equesis Creek and distributes primarily to areas outside of the sub-basin (Dobson Engineering Ltd. 2008).

The Okanagan Indian Band and Ministry of Environment jointly manage Pinaus Lake in order to supplement natural streamflows when needed (Dobson Engineering Ltd. 2008).

Available Hydrometric Data

Three hydrometric stations have operated in the Equesis Creek sub-basin. Only one station however [*Ewer Creek near the mouth* (08NM176)] has records of natural streamflows. Unfortunately, this station operated only until 1986.

Methods Used to Estimate Natural Streamflows

As indicated in Section J.4, in order to extend the record of Ewer Creek to the standard period, weekly relations were identified between Ewer Creek and Whiteman Creek, and those relations were used to adjust the Whiteman Creek streamflows in order to represent Ewer Creek streamflows. Given the high correlation between the unit discharge of the two streams for the overlapping period of 1972 to 1986, the adjustments were relatively modest. The estimated Ewer Creek unit discharge for the standard period was then scaled down according to the ratio of estimated normal annual discharge at Ewer Creek near the mouth to Equesis Creek at the mouth (Appendix C). A ratio of 0.52 was identified, which reflects the fact the annual unit discharge at the mouth of Equesis Creek is on average 52% of that at Ewer Creek.

As indicated in Section 3.6, there is potential that Equesis Creek is fed by groundwater along its lower reaches (NHC 2001). However, since we have no solid information on groundwater gains, we have conservatively assumed that zero streamflow gain occurs.

Confirmation / Validation

As a check, the natural streamflow estimates at the mouth of Equesis Creek were compared against the measured regulated streamflows at *Equesis Creek near the mouth* (08NM161). The regulated mean annual runoff over the period of record (1969-1982) was found to be 85% of the natural mean annual runoff for the standard period. This would suggest that about 15% of the mean annual runoff is used for off-stream purposes. Unfortunately, the available records, summarized in Dobson Engineering Ltd. (2008), do not permit the confirmation of such water use.

The following reports were reviewed to confirm and/or validate the streamflow estimates for Deep Creek:

- Letvak (1994), and
- Reksten (1991).

J.6 NODE 10: NASHWITO CREEK

Overview

Nashwhito Creek is located on the west side of Okanagan Lake between Equesis Creek to the north and Whiteman Creek to the south. Nashwhito Creek drains a relatively small area of gently sloping plateau above 1,200 m elevation. Below that elevation, the sub-basin is characterized by moderately steep slopes. A considerable area of forest in the sub-basin has been harvested. Near an elevation of 500 m, the creek flows over a large terrace of thick unconsolidated sediments, which supports an aquifer (Figure 2.3). Near the mouth, a large alluvial fan has developed, which has merged with the fan from Equesis Creek to the north. Limited agricultural activities occur on the terrace and alluvial fan. The Okanagan Indian Band extracts water from Nashwhito Creek for use largely outside the sub-basin (Dobson Engineering Ltd. 2008).

Available Hydrometric Data

Only one hydrometric station has operated on Nashwhito Creek; but only a few weeks of streamflow data were recorded in 1921.

Methods Used to Estimate Natural Streamflows

Given there are limited records in the sub-basin, streamflow estimates at the mouth of Nashwhito Creek were derived by assuming the pattern of streamflows in Nashwito Creek can be approximated by the average of *Whiteman Creek above Bouleau Creek* (08NM174) and Ewer Creek at the mouth (synthesized according to Section J.5). Given the difference in median catchment elevation and therefore normal annual runoff between Whiteman, Ewer Creeks, and Nashwhito Creek at the mouth, all streamflows were scaled down in order to reconcile with the regionally-based normal annual runoff of Nashwhito Creek.

The lowermost portion of Nashwhito Creek flows across an alluvial fan and aquifer (Figure 2.3). Streamflow losses were thus accounted for in the streamflow estimates, as described in Section 3.6.

Confirmation / Validation

No information specific to Nashwhito Creek was identified during the study.

J.7 NODE 14: WHITEMAN CREEK

Overview

Whiteman Creek is located on the west side of Okanagan Lake in the northern portion of the Basin. It is located between Nashwhito Creek to the north and Shorts Creek to the south. Whiteman Creek drains gently sloping plateau above an elevation of about 1,400 m. Considerable areas on the plateau have been logged. Below an elevation of about 1,400 m, hillslopes are relatively steep. The principal tributary to Whiteman Creek is Bouleau Creek which drains the northern half of the sub-basin. Bouleau Creek is fed by Bouleau Lake situated at an elevation of about 1,375 m. Near an elevation of about 550 m, Whiteman Creek flows past a large terrace of unconsolidated sediments before reaching a large alluvial fan at Okanagan Lake. Agricultural and residential development is present on the terrace and alluvial fan. The primary user of water from Whiteman Creek is the Okanagan Indian Band, which diverts water principally for use in nearby areas. No storage is developed in the sub-basin (Dobson Engineering Ltd. 2008).

Available Hydrometric Data

Three hydrometric stations have operated on Whiteman Creek; however, only *Whiteman Creek above Bouleau Creek* (08NM174) is currently active. In addition, this station reflects natural streamflow conditions and has a 36-year, nearly complete[2] record. As a result, this station is one of the principal reference stations for natural streamflows in the Okanagan. The other stations in the Whiteman Creek sub-basin, which gauged regulated flows near the mouth of Whiteman Creek, have records up to 1972 only.

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[2] No streamflows were recorded between mid-May and mid-October 1997 on *Whiteman Creek above Bouleau Creek* (08NM174).

Methods Used to Estimate Natural Streamflows

The record of natural streamflows for *Whiteman Creek above Bouleau Creek* (08NM174) was the primary basis on which natural streamflows at the mouth of Whiteman Creek were estimated. The first step was to fill the gap in the record during spring and summer 1997. This was done by inspecting natural streamflow records from all stations that had overlapping records and had records for the missing period in 1997. The record at *Camp Creek at mouth near Thirsk* (08NM134) was identified as most suitable given its similar pattern of streamflows. For the missing weeks, the ratios of 1997 weekly streamflows to the 1971-2006 average weekly streamflows were determined for Camp Creek. These ratios were then applied to Whiteman Creek to fill the missing records.

The complete weekly record of natural streamflows at the hydrometric station (08NM174) was then scaled to reflect the lower unit discharge at the mouth. According to the regional runoff relations (Appendix C), normal annual runoff at the mouth is about 81% of the value at the hydrometric station (08NM174).

As indicated in Section 3.6, there is potential that Whiteman Creek is fed by groundwater along its lower reaches (NHC 2001). However, since there is no solid information on groundwater gains, it has been conservatively assumed that no streamflow gain occurs.

Confirmation / Validation

The estimated natural streamflows at the mouth were compared with the available record of regulated streamflows at the hydrometric stations *Whiteman Creek near Vernon* (08NM046) and *Whiteman Creek at the mouth* (08NM180). The values were reasonably comparable; however, direct validation of the estimates is limited by the period of record at the mouth (pre-1972) and the unknown volume of water actually withdrawn from the creek during the period of streamflow record.

J.8 NODE 16: SHORTS CREEK

Overview

Shorts Creek is located on the west side of Okanagan Lake between Whiteman Creek to the north and Lambly Creek to the south. The sub-basin drains gently sloping plateau at elevations of about 1,400 m. Below this, the creek flows over a series of waterfalls through a relatively steep-sided canyon, which makes a relatively abrupt s-shaped bend as it approaches Okanagan Lake. The mouth of Shorts Creek is characterized by a large alluvial fan, which is the site of some residences and Fintry Provincial Park. Like many parts of the Okanagan, forest harvesting occurs in the uplands. According to Dobson Engineering Ltd. (2008), the Okanagan Indian Band diverts some water from Shorts Creek for use in nearby areas. In addition, there are future plans by Lakeview Irrigation District to divert water from Dunwaters Creek (a tributary to Shorts Creek) to Lambly Creek. There is no developed storage in the Shorts Creek sub-basin.

Available Hydrometric Data

One hydrometric station, which recorded regulated streamflows, operated near the mouth of Shorts Creek between 1969 and 1982. Although this station is considered regulated by the Water Survey of Canada, the degree of regulation is likely modest. According to Dobson Engineering Ltd. (2008), annual water use from Shorts Creek is 38 ML, which we estimate to be about 0.09% of the annual runoff of Shorts Creek. As a result, the hydrometric record on Shorts Creek is close to natural.

Methods Used to Estimate Natural Streamflows

Since the Shorts Creek record does not include the standard period, it was necessary to identify a representative station(s) in order to estimate natural streamflows. Both *Terrace Creek near Kelowna* (08NM138) and *Whiteman Creek above Bouleau Creek* (08NM174) were reviewed. The former station is regulated, and since we have no information to confidently naturalize this record, this station was not used. The record from Whiteman Creek is however natural and has a remarkably similar unit discharge as Shorts Creek (Figure J.2). The only exception to this likeness was during the fall and winter baseflow period, when streamflows in Whiteman Creek were consistently above those in Shorts Creek. While the extraction of water from Shorts Creek may explain some of the discrepancy, it is more likely that relative groundwater contributions to Whiteman Creek are greater. This is consistent with NHC (2001), and provides further evidence that Whiteman Creek is likely an influent stream, while Shorts Creek may or may not be effluent.

Despite these differences, natural streamflows at the mouth of Shorts Creek were based on the natural streamflow record at Whiteman Creek above Bouleau Creek (08NM174). In order reconcile the weekly discharge with the normal annual discharge identified in the regional analysis (Appendix C); the weekly record was scaled accordingly.

As indicated above, Shorts Creek possibly losses water along the lowermost portion of the creek as it flows across an alluvial fan and aquifer (Figure 2.3). Streamflow losses were therefore applied to the gross streamflow estimates as described in Section 3.6.

Confirmation / Validation

No additional information specific to Shorts Creek was identified during the study.

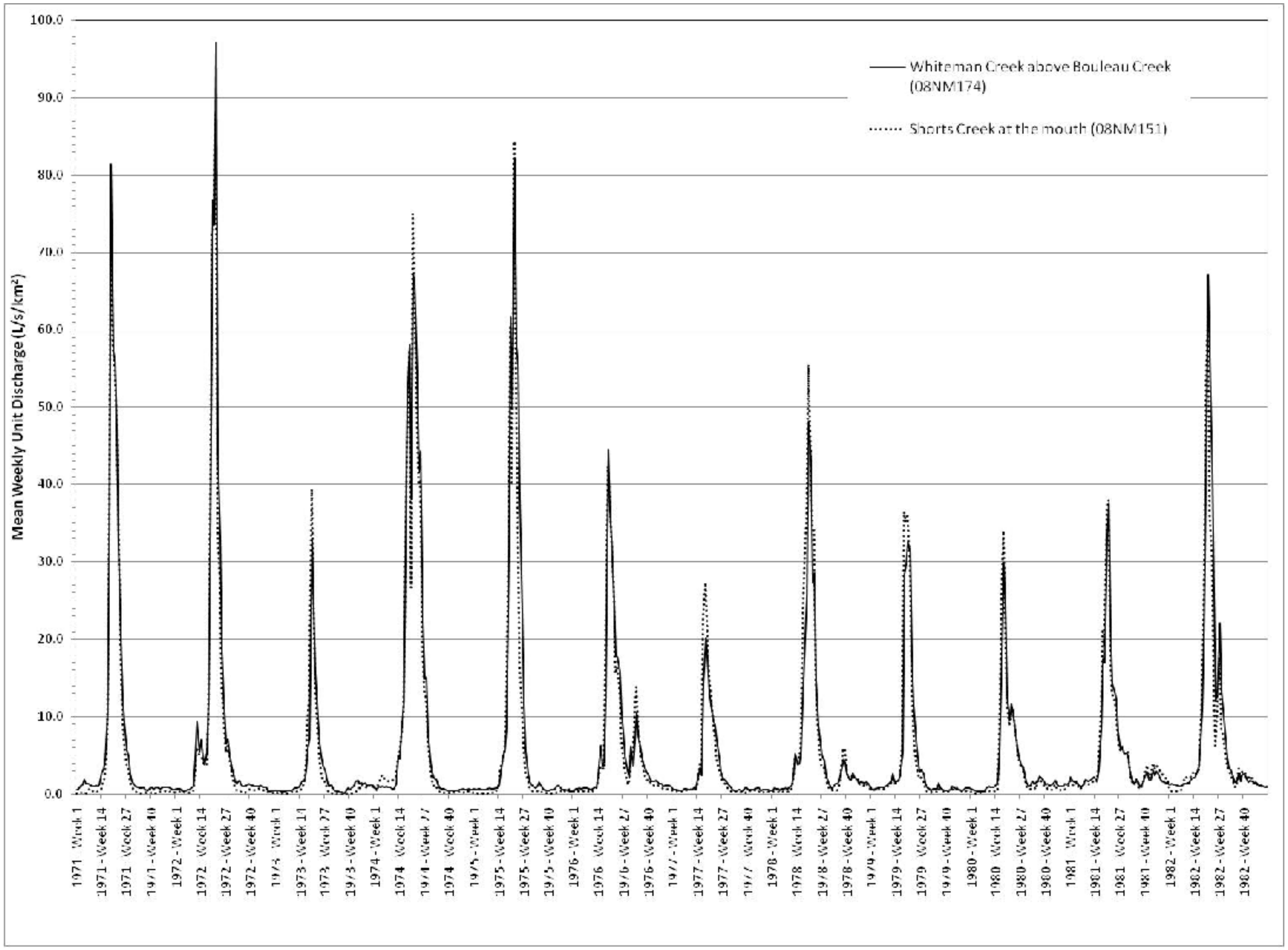

Figure J. 2 Comparison of recorded unit discharge for Whiteman Creek above Bouleau Creek and Shorts Creek at the mouth.

J.9 NODE 18: LAMBLY CREEK

Overview

Lambly Creek is located on the west side of Okanagan Lake, south of Shorts Creek and north of Powers Creek. The upper half of the watershed consists of gently sloping terrain. Along the lower half of the sub-basin, Lambly Creek and Bald Range Creek are deeply incised forming moderately steep slopes. Terrace Creek, a major tributary to Lambly Creek, drains the northern portion of the sub-basin. Forest harvesting has occurred throughout the sub-basin but is most concentrated at higher elevations. A small alluvial fan is located near the mouth of Lambly Creek. Residential development has occurred on this fan.

Although there is little water use within the sub-basin, Lambly Creek is designated a Community Watershed as it supplies water to customers in the Westbank area. Two water suppliers operate in the watershed: Lakeview Irrigation District (LID) and Westbank Irrigation District (WID).

LID manages the Big Horn and Esperon Reservoirs in the upper portion of the sub-basin. As required, water is released from the reservoirs and diverted at a lower elevation intake on Lambly Creek where it is piped to Rose Valley Lake (reservoir) from which water is distributed to its customers in the Westbank area (Dobson Engineering Ltd. 2008).

Around 1945, WID was granted a licence to store water in Lambly Lake and divert water retained in this lake to the Powers Creek watershed. As a result, Lambly Lake and its catchment have been part of the Powers Creek sub-basin for over 60 years. Given that this configuration has been in place for such a long period and since there are no known plans to change this, we have assumed that the present configuration (i.e. Lambly Lake catchment is part of the Powers Creek sub-basin) remains in place under simulated natural conditions. WID also holds water licences to store water in Tadpole Reservoir in Lambly Creek sub-basin and to divert water into Powers Creek via the Alocin Creek diversion (which passes through a small area of the Nicola River watershed).

Available Hydrometric Data

Seven Water Survey of Canada and three independently operated hydrometric stations have operated in the Lambly Creek sub-basin (Appendix B). Only one of these *[Lambly Creek near Kelowna* (08NM058)] recorded natural streamflows, however only for a short period until 1927. Of the stations recording regulated flows, only *Lambly Creek above Terrace Creek* (08NM165) has some record of streamflows during the standard period. The three independent hydrometric stations in the sub-basin have been recently established to support water management by LID and WID and have short records.

Methods Used to Estimate Natural Streamflows

In order to develop natural streamflow estimates for Lambly Creek at the mouth, the first step was to identify a representative stream with a similar hydrologic regime and complete record over the standard period. *Whiteman Creek above Bouleau Creek* (08NM174) was identified as the nearest one with a similar physiography and hydrologic regime. As a check, available regulated unit streamflows from *Lambly Creek above Terrace Creek* (08NM165) were compared with the Whiteman Creek record (Figure J.3). In general, the timing and pattern of streamflows from the two streams correlated well, although there appeared to be a tendency for slightly higher baseflows and higher peak flows in Lambly Creek. This is consistent with the differences noted between streams in Group 3 versus Group 4 in the regional hydrologic relations (Appendix C).

The estimated discharge record at Whiteman Creek was then scaled uniformly in order to reconcile with the normal annual runoff estimated for Lambly Creek at the mouth (Appendix C). As a last step, the streamflow losses identified by Obedkoff (1990) for Lambly Creek were applied throughout the year (Section 3.6).

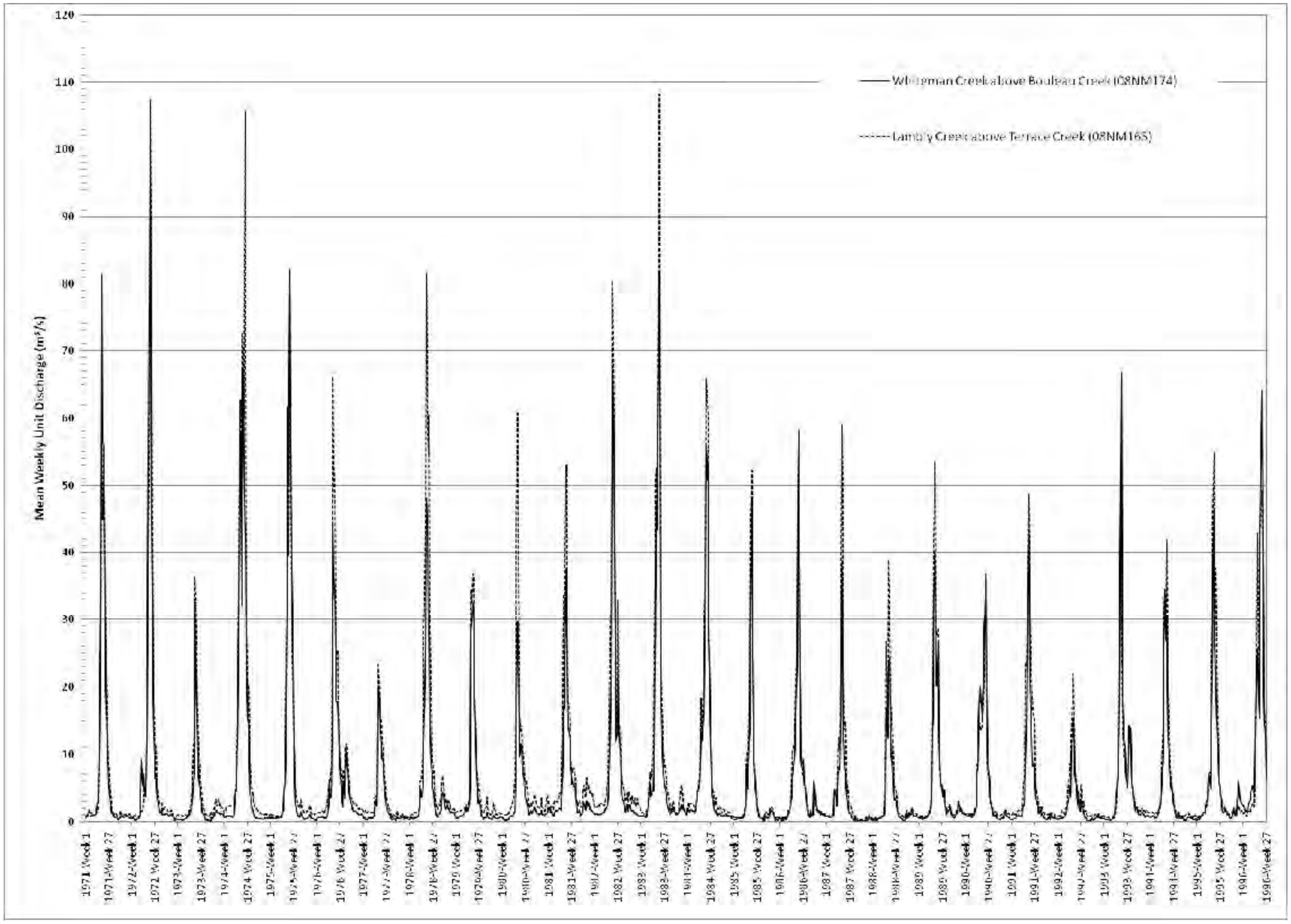

Figure J.3 Comparison of recorded unit discharge for Whiteman Creek above Bouleau Creek (08NM174) and Terrace Creek near Kelowna (08NM138).

Confirmation / Validation

The following reports were reviewed to confirm and/or validate the streamflow estimates for Lambly Creek:

- Dobson Engineering Ltd. (2001a),
- Dobson Engineering Ltd. (2002a),
- Letvak (1989)
- Reksten (1970), and
- Summit Environmental Consultants Ltd (2004b).

J.10 NODE 20: MILL (KELOWNA) CREEK

Overview

Mill (Kelowna) Creek is located in the central Okanagan, east of Okanagan Lake near Kelowna. The sub-basin includes the main tributaries Scotty, Whelan and Dilworth Creeks. The headwaters of the sub-basin are located on gently rolling plateau at elevations of about 1,200 m. Hillslopes are moderately steep from the edge of the plateau to the broad valley bottom. The creek flows westward off the plateau, and then southwards through the broad valley bottom of Ellison and Rutland before curving westwards until it flows into Okanagan Lake in downtown Kelowna. The lower slopes include residential development, agriculture and industry, an airport and golf courses. Forest harvesting is common on the mid slopes and plateau.

Black Mountain Irrigation District (BMID) and Glenmore-Ellison Irrigation District (GEID) use a large portion of the water diverted from Mill Creek. Within the sub-basin, BMID manages the James Lake reservoir. Water released from James Lake reservoir flows into Scotty Creek which then enters a closed pipe distribution system near the Sunset Ranch Golf Course (Dobson Engineering Ltd. 2008). Within the sub-basin, GEID operates the Posthill, South, and Bulman Reservoirs and an intake on Mill Creek. Water from Mill Creek is diverted to the McKinley (balancing) Reservoir outside of the sub-basin. Water from McKinley Reservoir enters a closed distribution system. Mill Creek also supplies the Ellison area separately from the McKinley system. Since 2005, the Kelowna airport has been supplied water from GEID (Dobson Engineering Ltd. 2008).

In a similar manner as Deep Creek, Mill (Kelowna) Creek has been identified by NHC (2001) as likely to be significantly influenced by groundwater. As shown on Figure 2.3, the creek flows across a broad low-gradient valley underlain by an extensive aquifer system.

Available Hydrometric Data

Seven Water Survey of Canada hydrometric stations have operated in the Mill (Kelowna) Creek sub-basin (Appendix B). Four more have recently been established to assist with management of the water supply. Only *Scotty Creek near Rutland* (08NM036) has a record of natural streamflows in the sub-basin. Two stations have records of regulated streamflows during a part of the standard period:

- *Bulman Creek near the mouth* (08NM225), and
- *Kelowna Creek near Kelowna – Lower Station* (08NM053).

Methods Used to Estimate Natural Streamflows

As indicated in Section 3.6.1, field observations of Mill (Kelowna) Creek indicate that it loses water on the alluvial fan upstream of the Kelowna International Airport, is frequently dry or has very low flows through the airport, and then begins to pick up flow just downstream (Summit 2007). Given these observations, the lack of streamflow records at the mouth, and limited reliable estimates of water extraction from the creek, estimation of natural streamflows at the mouth is challenging.

Since NHC (2001) suggest that regional relations are unreliable for estimating normal annual runoff for Mill (Kelowna) Creek, we assessed the available record at *Kelowna Creek near Kelowna – Lower Station* (08NM053). Based on this regulated record, the 1968-1995 mean annual runoff was estimated to be 79 mm. After adjusting the 1968-1995 period runoff to reflect the 1996-2006 standard period, the estimated mean annual runoff was 74 mm. Using the information presented in Dobson Engineering Ltd. (2008), our best estimate of 2006 water use extracted upstream of the gauge on Mill Creek is 10,000 ML or 45 mm on a unit area basis. Assuming that water use has not changed significantly over time, the naturalized runoff at the gauge site is 74 mm + 45 mm = 119 mm. By comparison, the regionally-based normal annual runoff of Mill Creek is 80 mm (Appendix C). We suggest the difference of 39 mm can be explained largely by groundwater contributions along lower Mission Creek, which is consistent with the findings of NHC (2001).

After consideration of several nearby hydrometric stations, given the proximity and similar physiography, the estimated inflows to Kalamalka and Wood Lakes (Node 00) were used as a basis for developing estimates for Mill (Kelowna) Creek at the mouth. The lake inflow records were scaled uniformly to reconcile with the expected normal annual runoff of Mill Creek at the mouth. In this case, rather than rely on the regionally-based estimate of 80 mm, the naturalized runoff estimate of 119 mm was used. However, following a comparison of the estimates based on the Kalamalka / Wood Lake inflows with the streamflow records at station 08NM053, it was evident that baseflows in Mill Creek were consistently about 0.2 m^3/s higher than baseflows into Kalamalka and Wood Lakes. To account for this, a baseflow of 0.2 m^3/s was added to the streamflow estimates for Mill (Kelowna) Creek at the mouth.

Confirmation / Validation

The following reports were reviewed to confirm and/or validate the streamflow estimates for Mill (Kelowna) Creek:

- Coulson (1983), and
- Reksten (1973a).

J.11 NODE 22: MISSION CREEK

Overview

Mission Creek is the largest watershed in the Okanagan, and it flows from the eastern side of the Basin to Kelowna. It includes several large tributaries including: Pearson, Joe Rich, Belgo, Hydraulic, and KLO Creeks. These drain gently sloping plateau above elevations of about 1200 m. Mid slopes are moderately steep to steep. Mission Creek flows through a steep canyon in the vicinity of the Hydraulic Creek, and then flows onto a large alluvial fan in the Kelowna area. This fan coalesces with the fans of Mill and Bellevue Creeks to form a large area of relatively flat land. Forest harvesting has occurred throughout the uplands. Terraces and gentle portions along mid elevations support agriculture and rural residential land use. The lower elevations of the sub-basin are a mix of urban and rural residential, agriculture, recreational (parks and golf course), and commercial uses.

The largest water suppliers in the sub-basin include Black Mountain Irrigation District (BMID) and the South East Kelowna Irrigation District (SEKID). Smaller suppliers include Falconridge Water Utility (administered by the Regional District of Central Okanagan), Benvoulin Water Users, Mission Creek Water Users Community and South Kelowna Water Users Community. There are several private intakes on Mission Creek and its tributaries. BMID and SEKID manage several reservoirs in the sub-basin including: Fish Hawk, Greystoke and Ideal reservoirs (BMID) and McCulloch, Fish, Browne and Long Meadow reservoirs (SEKID).

The Rutland Waterworks District obtains water from 14 wells in the Mill and Mission sub-basins, including 4 wells located in the Mission Creek sub-basin. In low and average run-off years, the South East Kelowna Irrigation District diverts water from Stirling Creek in the West Kettle Basin into the Mission Creek sub-basin. When McCulloch Reservoir is full, water is discharged to Idabel Creek, a tributary to the West Kettle Basin. During low run-off years, flow from Browne and Long Meadow Reservoirs are diverted from the Grouse Creek tributary to Hydraulic Creek below McCulloch Reservoir. The Black Mountain Irrigation District in co-operation with MOE release water from storage to maintain instream flows for Mission Creek for conservation purposes.

Available Hydrometric Data

In total 30 WSC and 13 independently managed hydrometric stations have operated in the Mission Creek sub-basin (Appendix B). Of these, only six stations have recorded natural streamflows, unfortunately only one of these six stations has any record within the standard period. Although they do not currently operate, nor do they have records within the standard period, the following two stations have natural flows and lengthy records, and are useful reference stations to understand the streamflow patterns in the sub-basin:

- *Daves Creek near Rutland (08NM137)*, and

- *Pearson Creek near the mouth (08NM172)*[3].

Amongst the several stations in the sub-basin, the most useful record of streamflow for the purpose of this study was available from the actively operating station *Mission Creek near East Kelowna* (08NM116). A continuous record of streamflow at this station is available back to 1967. Given the location of this station near the fan of Mission Creek, streamflows from all major tributaries to Mission Creek are accounted for, and only a minor amount of adjustment to the data is necessary to reflect conditions at the mouth of the creek. However, before doing so, the regulated record must be naturalized, as discussed below.

Methods Used to Estimate Natural Streamflows

As described in Appendix A.7, a detailed review of water use and management information within the Mission Creek sub-basin was performed by the study team. The details of the review are provided in Appendix F. In summary, weekly estimates of the volume of water extracted above and below the hydrometric station *Mission Creek near East Kelowna* (08NM116) were developed using records obtained from South East Kelowna Irrigation District (SEKID), Black Mountain Irrigation District (BMID), and the provincial water licence information system (WLIS). In addition, the influence of reservoir operations was determined by reviewing operational data provided by SEKID and BMID. Lastly, water imported to the sub-basin from outside the natural contributing area was accounted for.

Given the complete record of streamflows in Mission Creek at station 08NM116, streamflows were naturalized by accounting for water use, storage, and imports in the sub-basin upstream of the station. To account for the relatively small contributing area between the station and the mouth, all data was then scaled up by 4%, which is the percentage of the total sub-basin between the hydrometric station and the mouth.

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[3] We are aware that an independently operated station has been re-established at this location in 2006. However, we were unable to obtain this data prior to reporting.

Confirmation / Validation

The following reports were reviewed to confirm and/or validate the streamflow estimates for Mission Creek:

- Coulson (1971),
- Hunter (1971),
- Lowen and Letvak (1981),
- Obedkoff (1978),
- Reksten (1972a),
- Reksten (1973b), and
- Reksten (1977)

J.12 NODE 24: BELLEVUE CREEK

Overview

Bellevue Creek is a small sub-basin located on the east side Okanagan Lake. On the mid and upper slopes, the watershed consists of moderately steep to steep terrain in which the creek has carved a steep rocky canyon down the center. At lower elevations, Bellevue Creek flows through the Okanagan Mission of the City of Kelowna. The 2003 Okanagan Mountain Park wildfire burned the periphery of the mid slopes and much of the lower end of the sub-basin. Logging is common within mid and upper slopes and residential development covers the lower slopes.

Bellevue Creek has no storage reservoirs where flow may be regulated. Residential areas are supplied by the City of Kelowna using water from Okanagan Lake (Node 47).

Available Hydrometric Data

Two hydrometric stations have operated on Bellevue Creek, one reflecting natural conditions and the other reflecting "regulated" conditions (there are a few water intakes upstream). *Bellevue Creek near Okanagan Mission* (08NM035) recorded natural flows continuously between 1969 and 1986 and provides a solid foundation from which to characterize the natural streamflows in the sub-basin.

Methods Used to Estimate Natural Streamflows

In order to adjust the Bellevue Creek record so that it reflected the 1996-2006 standard period, it was necessary to develop relations with records from one or more stations that have overlapping data and have data for the standard period. Several streams (e.g. Coldstream, Whiteman, Greata, Camp, Shatford, and Vaseux Creeks) were investigated to identify the degree of correlation with Bellevue Creek. On a weekly basis over a 15 year period from 1971-1985, *Vaseux Creek above Solco Creek* (08NM171) had the highest correlation with *Bellevue Creek near Okanagan Mission* (08NM035) (r=0.96).

For each week of the year, the (15-year) average ratio of unit discharge of Bellevue Creek to Vaseux Creek was calculated and statistically smoothed to avoid unrealistic steps from one week to the next. This ratio was then used to predict Bellevue Creek streamflows based on the Vaseux Creek record. This was followed by a minor adjustment to all data in order to reconcile the weekly discharges with the normal annual discharge as predicted by the regionally-based estimates (Appendix C).

The lowermost portion of Bellevue Creek flows across an alluvial fan and aquifer (Figure 2.3). Streamflow losses were therefore applied to all data as described in Section 3.6.

Confirmation / Validation

No additional information specific to Bellevue Creek was identified during the study.

J.13 NODE 26: MCDOUGALL CREEK

Overview

This is a small sub-basin located on the east side of Okanagan Lake in the central portion of the Basin. The creek drains a small area of plateau above 1,200 m. Below this elevation, the creek has downcut into the valley side creating steep-sided slopes. The lower reach crosses a gently sloped terrace in Westbank and on Westbank First Nation land. Land-use on the upper slopes is primarily forest harvesting, and the lower elevations include a mix of urban development and agriculture. Lakeview Irrigation District (LID) diverts water from Lambly Creek via Rose Valley reservoir into the sub-basin.

Available Hydrometric Data

Only one hydrometric station has operated in the McDougall Creek sub-basin (Appendix B); however it is of little value to this study as it recorded regulated conditions for a few years between 1920 and 1929.

Methods Used to Estimate Natural Streamflows

In order to develop streamflow estimates for McDougall Creek, it was necessary to determine the most representative station available. After reviewing several stations, *Greata Creek near the mouth* (08NM134) was chosen given its proximity, physiography and similar hydrology. However, given the slightly lower normal annual runoff at Greata Creek, unit discharge data from Greata Creek were scaled up by approximately 16% to estimate McDougall Creek flows. Given the relatively limited information available, monthly runoff data were compared with estimates developed by Summit Environmental Consultants Ltd. (2004b). While the estimates reflected slightly different periods, the comparison was favourable. The lowermost portion of McDougall Creek flows across an alluvial fan and aquifer (Figure 2.3). Streamflow losses were therefore applied to streamflow estimates as described in Section 3.6.

Confirmation / Validation

The following reports were reviewed to confirm and/or validate the streamflow estimates for McDougall Creek:

- Summit Environmental Consultants Ltd. (2004b).

J.14 NODE 28: POWERS CREEK

Overview

The Powers Creek sub-basin is a Community Watershed located between Lambly Creek to the north, MacDougall Creek to the east and Trepanier Creek to the south. The creek drains a small area of plateau above 1,100 m, and then flows through a deeply incised canyon until reaching the benchlands in Westbank. Powers Creek has downcut through a terrace of thick glacial sediments near the 600 m elevation to form Glen Canyon. The creek forms a large alluvial fan at Gellatly. Forestry activity is common on the plateau portions of the sub-basin. The benchlands support residential, agricultural, industrial and commercial development.

The Westbank Irrigation District (WID) is the major water supplier in the sub-basin, and obtains its water from two other watersheds in addition to Powers Creek, including, Alocin Creek (a tributary to the Nicola River) and Lambly Creek. WID has five reservoirs for storage in the sub-basin, including Horseshoe/Dobbin, Paynter, Jackpine, Lambly, and Tadpole (Tadpole is located in the Lambly Creek sub-basin) reservoirs. In 1945, WID was granted the right to build a saddle dam on Lambly Lake to permanently divert outflow into Powers Creek. As noted in Section J.9, given that flows in the Lambly Lake catchment have been diverted for over 60 years, and since there are no plans to change this, we have assumed that the present configuration (i.e. Lambly Lake catchment is part of the Powers Creek sub-basin) remains in place under simulated natural conditions.

Available Hydrometric Data

In total, five Water Survey of Canada and three independently operated hydrometric stations have been established in the Powers Creek sub-basin (Appendix B). Only the three independent stations remain active, however, their relatively short records limit their usefulness for this study. The station *Powers Creek above Westbank Diversion* (08NM033) is the only WSC station that recorded natural streamflows. However, it operated between 1965 and 1974 on a seasonal basis only. Two WSC stations, although regulated, provide some insight to the inflows along the lower portion of the creek (Section 3.6.2). These include:

- *Powers Creek below Westbank Diversion* (08NM059), and
- *Powers Creek at the mouth* (08NM157).

Methods Used to Estimate Natural Streamflows

Several methods to estimate natural streamflows in Powers Creek were considered. It was considered using the natural records from *Powers Creek above Westbank Diversion* (08NM033); however the record is seasonal, incomplete and would have required adjusting the data to represent the standard period. Naturalization of the independently collected streamflow data at *Powers Creek at Gelatly Road was also considered*. However, this data was not obtained prior to reporting, and the quality of the data is unknown. It was therefore decided to estimate the unit discharge of Powers Creek by averaging the synthesized unit discharge for Lambly Creek to the north (Section J.9), and Trepanier Creek to the south (Section J.15). The information used to develop the estimated streamflows at each of these streams was considered more reliable than the data available for Powers Creek. In order to reconcile the weekly streamflow estimates with the normal annual runoff based on the regional analysis (Appendix C), all data were adjusted slightly. Section 3.6 describes the potential for surface water – groundwater interaction along lower Powers Creek. In summary, losses near the top of the fan are likely offset by gains on the bottom of the fan. It has therefore been assumed that no net loss to groundwater occurs in estimating streamflows at the mouth of Powers Creek.

Previous Hydrologic Studies

The following reports were reviewed to confirm and/or validate the streamflow estimates for Powers Creek:

- Dobson Engineering Ltd. (2001b),
- Dobson Engineering Ltd. (2002b),
- Summit Environmental Consultants Ltd. (2004b)

J.15 NODE 30: TREPANIER CREEK

Overview

Trepanier Creek is located on the west side of Okanagan Lake near Peachland and is located between Powers Creek to the north and Peachland Creek to the south. The sub-basin drains gently sloping plateau located to about 1,200 m and includes the tributaries MacDonald and Lacoma Creeks. Trepanier Creek is deeply entrenched into the plateau and forms a gently sloping, narrow valley bottom from about 800 m elevation down to Okanagan Lake. At about an elevation of 450 m, the creek incises through the benchlands above Peachland and forms a medium-size alluvial fan at Okanagan Lake. The plateau supports forest harvesting and is used extensively for outdoor recreation. The Brenda Mine is located on the uplands, but has not been operational since 1990 and the site is being reclaimed. The Coquihalla Highway - Okanagan Connector (Highway 97) traverses the length of the valley. Residential and farm land is located below 600 m elevation.

The District of Peachland (DoP) is the major water supplier in the basin. The DoP obtains water from Trepanier Creek as well as Peachland Creek, Okanagan Lake and three groundwater wells. DoP operates the Silver Lake reservoir for storage in the sub-basin. Water can be diverted from the Trepanier Creek sub-basin to the Peachland Creek sub-basin via the McDonald Creek diversion at the Brenda Mine.

Available Hydrometric Data

A total of six hydrometric stations, all recording regulated streamflows, have operated in the Trepanier Creek sub-basin, three of which were operated by the Water Survey of Canada. The single most useful station for this study is *Trepanier Creek near Peachland* (08NM041). This station has a continuous record between 1973 and 1979, and between 1983 and 2006.

Methods Used to Estimate Natural Streamflows

Since the record at station 08NM041 is available and reflects the lower part of the watershed (thus capturing all major tributaries) it is a suitable for streamflow naturalization. Fortunately, the gauge is just upstream of the major water intake operated by the District of Peachland. As a result, given the relatively low number of water users/licensees upstream of this station, we decided to conduct a detailed analysis of water use. Since actual water use information was not available for the specific area of interest, we assumed the active water licences reflect actual water use. Because of the relatively low number of water users located upstream of hydrometric station 08NM041 any potential error from this assumption was not considered to be significant.

Based on the detailed map of Trepanier Creek developed by Summit (2004b), all points of diversion (PODs) upstream of station 08NM041 were identified and the water licence information was compiled (Table J.1). In order to estimate weekly water use patterns based on annually based water licences, it was necessary to make a number of assumptions regarding the distribution of water use by type. For domestic and irrigation water use, we adopted the distributions presented in Summit Environmental Consultants Ltd. (2004b) and reproduced in Table J.9. For the summer camp located on Silver Lake, we assumed licensed water use was split evenly between July and August. Two types of storage licences were identified, one that supports the District of Peachland waterworks and the other that supports irrigation. We assumed that all licensed storage is captured in spring according to the following distribution, which approximates the natural inflows in the area:

- April: 10.6%
- May: 59.3%
- June: 30.1%

Table J.1 Summary of active water licences and points of diversion upstream of the hydrometric station *Trepanier Creek near Peachland* (08NM041).

Point of Diversion	Source	Licence	**Type of use and licensed quantity** (metric conversion in brackets)
PD58765 PD58766 PD58767	Venner Creek	F007169	Domestic: 500 gallons/day (829 m^3/year) Irrigation: 17.5 acre-feet/year (21,586 m^3/year)
PD58770	Silver Lake	C049770	Camp: 3,000 gallons/day (13.6 m^3/day, assuming camp is open between July 1 and August 31)
PD58768	Silver Lake	C048445 & C058522	Domestic: 1,000 gallons/day (1,659 m^3/year)
PD58771	Silver Lake	Eight (8) licences held by District of Peachland	Storage (in support of waterworks): 456.06 acre-feet/year (562,545 m^3/year)
PD58593	Lacoma Creek	C105414, C105415, C106676, C106677	Storage (in support of irrigation): 69 acre-feet (85,110 m^3/year)
			Total *Domestic: 2,488 m^3/year* *Irrigation: 21,586 m^3/year* *Camp: 13.6 m^3/day between July 1 and August 31* *Storage: 647,655 m^3/year*

Table J.2 Assumed monthly distribution of water use by type, District of Peachland.

Month	Domestic (%)	Irrigation (%)	Waterworks (%)
January	3.6	0	3.2
February	3.6	0	2.9
March	3.9	0.5	3.2
April	5.9	4.0	5.5
May	11.4	13.7	4.1
June	12.1	15.0	12.0
July	17.6	24.6	20.0
August	17.8	25.0	20.7
September	11.2	13.4	12.1
October	5.7	3.8	7.6
November	3.6	0	4.5
December	3.6	0	4.2
Total	*100*	*100*	*100*

Notes: Individual domestic and irrigation water licence distributions are based on Summit Environmental Consultants Ltd. (2004b). The distribution of water use for waterworks purposes is based on actual water use records for the District of Peachland between 1999 and 2001.

Releases from storage in support of waterworks were assumed to follow the actual distribution of water use by the District of Peachland (Table J.2). Releases in support of irrigation were assumed to follow the irrigation distribution (Table J.2). The monthly distributions were then partitioned into weekly distribution and estimates of water use and storage filling and release were made (Table J.3). The net values in m^3/s (Table J.3) were then used to naturalize the streamflow record at *Trepanier Creek near Peachland* (08NM041), which assumes water use patterns are similar from year to year.

In order to fill missing data for a portion of 1996 and 1997 in the Trepanier Creek record, weekly relations between Trepanier Creek and *Greata Creek near the mouth* (08NM173) were identified and used to estimate Trepanier Creek flows. Given the difference in median catchment elevation between the Trepanier Creek station (08NM041) and the mouth, it was necessary to scale the unit discharge down according to the regional runoff relations (Appendix C). As a result, unit discharges at the station were reduced about 8% to reflect conditions at the mouth. As noted in Section 3.6, Obedkoff (1990) identified Trepanier Creek as an effluent stream. Streamflows at the mouth were therefore reduced accordingly.

Table J.3 Estimated weekly volume of water extracted and captured/released from storage upstream of the hydrometric station Trepanier Creek near Peachland (08NM041).

	Total off-stream water extraction (m^3)	**Storage**		**NET (m^3/wk)**	**NET (m^3/s)**
		Volume of water captured in reservoirs (m^3)	**Volume of water released from reservoirs (m^3)**		
Week 1	20	0	4,065	-4,045	-0.007
Week 2	20	0	4,065	-4,045	-0.007
Week 3	20	0	4,065	-4,045	-0.007
Week 4	20	0	4,065	-4,045	-0.007
Week 5	21	0	4,052	-4,031	-0.007
Week 6	22	0	4,042	-4,020	-0.007
Week 7	22	0	4,042	-4,020	-0.007
Week 8	22	0	4,042	-4,020	-0.007
Week 9	37	0	4,247	-4,210	-0.007
Week 10	46	0	4,147	-4,101	-0.007
Week 11	46	0	4,147	-4,101	-0.007
Week 12	46	0	4,147	-4,101	-0.007

Table J.3 cont'd.

	Total off-stream water extraction (m^3)	Storage		NET (m^3/wk)	NET (m^3/s)
		Volume of water captured in reservoirs (m^3)	Volume of water released from reservoirs (m^3)		
Week 13	73	2,246	4,683	-2,365	-0.004
Week 14	236	15,719	7,901	8,054	0.013
Week 15	236	15,719	7,901	8,054	0.013
Week 16	236	15,719	7,901	8,054	0.013
Week 17	236	15,719	7,901	8,054	0.013
Week 18	661	75,191	7,529	68,323	0.113
Week 19	732	85,103	7,467	78,368	0.130
Week 20	732	85,103	7,467	78,368	0.130
Week 21	732	85,103	7,467	78,368	0.130
Week 22	772	67,760	12,112	56,420	0.093
Week 23	826	44,637	18,307	27,156	0.045
Week 24	826	44,637	18,307	27,156	0.045
Week 25	826	44,637	18,307	27,156	0.045
Week 26	907	38,260	19,900	19,267	0.032
Week 27	1,393	0	29,461	-28,067	-0.046
Week 28	1,393	0	29,461	-28,067	-0.046
Week 29	1,393	0	29,461	-28,067	-0.046
Week 30	1,393	0	29,461	-28,067	-0.046
Week 31	1,408	0	30,143	-28,735	-0.048
Week 32	1,414	0	30,416	-29,002	-0.048
Week 33	1,414	0	30,416	-29,002	-0.048
Week 34	1,414	0	30,416	-29,002	-0.048
Week 35	1,221	0	26,916	-25,694	-0.042
Week 36	740	0	18,165	-17,425	-0.029
Week 37	740	0	18,165	-17,425	-0.029
Week 38	740	0	18,165	-17,425	-0.029
Week 39	740	0	18,165	-17,425	-0.029
Week 40	217	0	10,280	-10,063	-0.017
Week 41	217	0	10,280	-10,063	-0.017
Week 42	217	0	10,280	-10,063	-0.017
Week 43	217	0	10,280	-10,063	-0.017
Week 44	105	0	7,781	-7,676	-0.013
Week 45	21	0	5,907	-5,886	-0.010
Week 46	21	0	5,907	-5,886	-0.010
Week 47	21	0	5,907	-5,886	-0.010
Week 48	21	0	5,743	-5,723	-0.009
Week 49	20	0	5,335	-5,315	-0.009
Week 50	20	0	5,335	-5,315	-0.009
Week 51	20	0	5,335	-5,315	-0.009
Week 52	23	0	6,097	-6,074	-0.009

Confirmation / Validation

The following reports were reviewed to confirm and/or validate the streamflow estimates for Trepanier Creek:

- Cairns (1992),
- Dobson Engineering Ltd. (1998)
- Hunter (1978),
- Reksten (1973c), and
- Summit Environmental Consultants Ltd. (2004b).

J.16 NODE 32: PEACHLAND CREEK

Overview

Peachland Creek is located near Peachland south of Powers Creek and north of Trout Creek. The sub-basin and its major tributary, Greata Creek, drain gently sloping uplands above about 1,200 m elevation. Below this elevation, the creek is deeply incised and has formed a canyon. Greata Creek is deeply entrenched but the valley bottom is wide and gently sloping until the confluence with Peachland Creek. At the lower end of the valley (below about 600 m) the Peachland Creek cuts through a bench before crossing a small alluvial fan at Okanagan Lake. Forestry is largely concentrated in the uplands. Industrial, agricultural and residential land uses are common at lower elevations.

The District of Peachland (DoP) is the major water supplier that extracts water from the sub-basin. DoP stores water in Peachland Lake and Glen Lake. Water extracted from Peachland Creek by DoP is distributed within and outside of the sub-basin. Water can be diverted from Trepanier Creek to Peachland Creek via the McDonald Creek diversion at the Brenda Mine. Several private landowners hold water licences and extract water directly from the creek.

Available Hydrometric Data

Streamflows have been gauged at 10 hydrometric stations in the Peachland Creek sub-basin (Appendix B). Only *Greata Creek near the mouth* (08NM173) records natural streamflows. This station has operated continuously since 1970 and is one of the key reference stations in the Basin. All other stations that have recorded regulated flows have been discontinued.

Methods Used to Estimate Natural Streamflows

Streamflows at the mouth of Peachland Creek were estimated by scaling the excellent record available from Greata Creek. Based on regional hydrologic relations (Appendix C), all Greata Creek unit discharge data were scaled down approximately 10% to reflect the lower median catchment elevation above the mouth of Peachland Creek. Streamflow losses as identified by Obedkoff (1990) were then applied to all data (Section 3.6).

Confirmation / Validation

The following reports were reviewed to confirm and/or validate the streamflow estimates for Peachland Creek:

- Dobson Engineering Ltd. (1999), and
- Summit Environmental Consultants Ltd. (2004b).

J.17 NODE 34: CHUTE CREEK

Overview

The Chute Creek sub-basin is located on the east side of Okanagan Lake, south of Okanagan Mountain Provincial Park. It is bordered by the headwaters of Bellevue Creek to the east and the headwaters of Robinson, Naramata and Penticton Creeks to the south. Most of the sub-basin consists of moderately steep terrain and rounded ridge tops. Chute Creek and its tributaries, Lebanon and Ratnip Creeks, flow across a small benched area between elevations about 1,100 m and 1,300 m. The northern portion of the watershed was subjected to wildfire in 2003. The mid and upper slopes in the sub-basin support forestry activities. A fishing lodge is located on Chute Lake, and there is agriculture on the terrace adjacent to Okanagan Lake. Water is diverted from Chute Creek into Robinson Creek by the Naramata Water Utility (Regional District of Okanagan-Similkameen).

Available Hydrometric Data

Only one hydrometric station has operated on Chute Creek (Appendix B). However, it is of little value since only summer flows were recorded between 1920 and 1922.

Methods Used to Estimate Natural Streamflows

Streamflows at Chute Creek were estimated by scaling the Bellevue Creek synthesized record (Section J.12) according to the ratio of their respective normal annual runoff values. As a result, the unit discharge for Chute Creek is generally about 7% lower than Bellevue Creek.

Confirmation / Validation

No additional information specific to Chute Creek was identified during the study.

J.18 NODE 36: ENEAS CREEK

Overview

Eneas Creek is a long narrow valley that is oriented parallel to Okanagan Lake and was carved out by a meltwater channel in the late stages of the most recent glaciation. The headwaters are bordered by Peachland Creek and the west side of the Eneas Creek is bordered by Trout Creek. The valley bottom generally follows a gentle grade. Based on Church et al. (1991), streamflow losses to groundwater likely occur along Eneas Creek where the creek flows across thick fluvial and glacial deposits. The west side of the valley tends to have steep slopes, whereas the east side of the valley consists of moderately steep slopes. There is very little logging activity in the sub-basin, and it is home to Eneas Lake Provincial Park. Residential and agricultural lands exist in the valley bottom below an elevation of about 600 m where the valley becomes wider. The District of Summerland stores water in two reservoirs: Eneas and Garnet Lakes.

Available Hydrometric Data

Within the Eneas Creek sub-basin, only two hydrometric stations reflecting regulated conditions have operated. The only one measuring streamflows was *Eneas Creek near Summerland* (08NM228), which operated between 1974 and 1975. The other station (08NM227) recorded water levels on Garnet Lake between 1973 and 1981.

Methods Used to Estimate Natural Streamflows

Streamflows in Eneas Creek were estimated based on averaging the unit discharge from *Greata Creek near the mouth* (08NM173) and *Camp Creek at mouth near Thirsk* (08NM134). The resulting unit discharge values were then scaled to reconcile with the regionally-based normal annual runoff estimate (Appendix C). Streamflow losses were accounted for as described in Section 3.6. There is however considerable uncertainty in stream losses near the lower end of the creek. Church et al. (1991) suggest that the creek "disappears into the glacial overburden". However, since there they do not indicate the timing or location of zero flows in the creek, it was necessary to follow our original assumption noted in Section 3.6.

Confirmation / Validation

The following reports were reviewed to confirm and/or validate the streamflow estimates for Eneas Creek:

- Reksten (1973d).

J.19 NODE 38: ROBINSON CREEK

Overview

The Robinson Creek sub-basin is a small watershed on the east side of Okanagan Lake located between Chute Creek and Naramata Creek. The slopes above about 1,100 m are gently sloping, the mid slopes are moderately steep and adjacent to Okanagan Lake is a glaciolacustrine terrace. There is a small amount of logging on the upper slopes of the watershed. The terrace adjacent to the lake supports agriculture.

The major water supplier, the Regional District of Okanagan-Similkameen (RDOS), stores water in two reservoirs, Elinor and Naramata Lakes. Water from these reservoirs can be diverted to the Chute Creek sub-basin. RDOS has an intake lower on Robinson Creek and diverts water to other nodes.

Available Hydrometric Data

No hydrometric stations have operated in the Robinson Creek sub-basin.

Methods Used to Estimate Natural Streamflows

Streamflows in Robinson Creek were estimated by scaling the Bellevue Creek synthesized record (Section J.12) according to the ratio of their respective normal annual runoff values. As a result, the unit discharge for Robinson Creek is generally about 30% lower than Bellevue Creek.

Confirmation / Validation

No additional information specific to Robinson Creek was identified during the study.

J.20 NODE 40: NARAMATA CREEK

Overview

The Naramata Creek sub-basin is a small watershed located south of the Robinson Creek sub-basin. The creek drains a gently sloping plateau above 1,200 m elevation. Below this elevation, the creek has carved a steep canyon into the hillside. Between 500 m elevation and Okanagan Lake, Naramata Creek has incised through two terraces, one comprised of glaciofluvial sediments and the other glaciolacustrine sediments. Logging occurs on the plateau and the terraces near the lake support agriculture and residential land uses.

The Naramata Water Utility, which is operated by the Regional District of the Okanagan-Similkameen, diverts water from the Robinson and Chute Creek sub-basins into the Naramata Creek sub-basin.

Available Hydrometric Data

No known hydrometric stations have operated in the Naramata Creek sub-basin.

Methods Used to Estimate Natural Streamflows

Streamflows in Naramata Creek were estimated by scaling the Bellevue Creek synthesized record (Section 5.12) according to the ratio of their respective normal annual runoff values. As a result, the unit discharge for Naramata Creek is generally about 11% lower than Bellevue Creek.

Confirmation / Validation

The following reports were reviewed to confirm and/or validate the streamflow estimates for Naramata Creek:

- Obedkoff (1982), and
- Obedkoff (1987).

J.21 NODE 42: TROUT CREEK

Overview

Trout Creek is the third largest watershed within the Okanagan Basin and has several tributaries including North Trout, Camp, Bull, Isintok, and Darke Creeks. The watershed consists of moderately steep slopes with rounded mountains and ridge-tops. Trout Creek and its larger tributaries have incised deeply into the surrounding terrain. There are scattered, short reaches where Trout Creek flows across wider sections of gentle floodplain. Between the confluence of Darke Creek and 620 m elevation (upstream from the Prairie Valley neighbourhood of Summerland), there is a large glaciofluvial outwash plain (thick deposit of sands and gravels) that was deposited near the end of the most recent glaciation. During this time, the creek flowed eastwards through Prairie Valley (Nasmith 1962). During post-glacial times, the creek has downcut into the outwash gravels and has diverted southwards to follow a pre-existing meltwater channel located on the east side of Mount Conkle (Nasmith 1962). Elevations below about 600 m consist of terraces of thick glacial sediments. Trout Creek has formed a large modern fan at Okanagan Lake. A broad valley along Darke Creek supports agriculture. The mid and upper slopes have logging activity and below the confluence of

Darke Creek, there are agricultural, recreational (golf courses), commercial and urban land uses.

There are several reservoirs operated by the District of Summerland in the Trout Creek sub-basin including: Crescent, Headwaters 1, 2, 3, and 4, Tsuh, Whitehead, Thirsk, Canyon Lakes, Darke and Munro. Water is also diverted from Eneas Creek into the headwaters of Darke Creek.

Available Hydrometric Data

The Water Survey of Canada has established hydrometric stations at 10 locations in the Trout Creek sub-basin since 1920 (Appendix B). However, only three stations recorded natural streamflows, and among these only one remains active - *Camp Creek at Mouth near Thirsk* (08NM134). It has operated continuously since 1965 and is one of the primary reference stations for natural streamflows in the Okanagan Basin. *Bull Creek near Crump* (08NM133) is another station that has a lengthy record of natural streamflows; however, it was discontinued in 1986.

Two stations that have recorded regulated streamflows near the mouth include:

- *Trout Creek at the mouth* (08NM158), and
- *Trout Creek at canyon mouth* (Ministry of Environment).

The first station operated between 1969 and 1982, while the second station, operated independently by MOE has run seasonally since 2004. Unfortunately, there are some concerns with the quality of this second station's record (Epp, pers. comm. 2008) that limits our confidence in using the data.

Methods Used to Estimate Natural Streamflows

Streamflow naturalization was the original method planned to be used to estimate natural streamflows at the mouth of Trout Creek. To support this, a detailed review of water use and management data was conducted (Appendix A.7 and Appendix E). We anticipated using the streamflow records from the MOE hydrometric station near the mouth. Unfortunately, this data was made available late in this study (after the water use data had been revised), and with major caveats attached. Furthermore, there were substantial gaps in the record. Therefore this information could only be used as a supplementary data source.

It was therefore necessary to identify stream(s) most representative of the conditions in Trout Creek at the mouth. The hydrographs of the following stations were analyzed and compared with the available (albeit regulated) records on Trout Creek:

- *Shatford Creek near Penticton*[4] (08NM037),
- *Camp Creek at mouth near Thirsk* (08NM134),
- *Greata Creek near the mouth* (08NM173), and
- *Bull Creek near Crump* (08NM133).

Each of the four above-noted stations is within reasonable proximity, and has similar physiography and elevations. Despite this, some hydrologic differences were noted for the period of overlapping record, which may reflect small-scale climatic differences, vegetation differences or different levels of surface water to groundwater interaction. Among the group, unit streamflows in *Bull Creek near Crump* (08NM133) were considered to be most representative of Trout Creek. Peak flows were not as high as Camp Creek, yet baseflows were comparable to the other stations. Since the Bull Creek hydrometric station was discontinued in 1986, we identified weekly unit streamflow ratios between Camp Creek and Bull Creek for 1965-1986, and used these to estimate Bull Creek unit streamflows for 1996-2006 based on the available Camp Creek record. The estimated unit discharge for Bull Creek and the recorded values for the other three stations for the standard period are provided in Figure J.12.

The unit discharge hydrograph for Bull Creek was then assumed representative of the unit discharge for Trout Creek at the mouth. An adjustment was made to all data in order to reconcile the weekly values with the regionally-based normal annual runoff for Trout Creek (Appendix C). Lastly, to account for the potential streamflow losses across the alluvial fan,

[4] See Section J.24 for discussion of records at *Shatford Creek near Penticton* (08NM037)

we have assumed a similar rate of loss as reported by the Trout Creek Water Use Plan Consultative Committee (2005) (Section 3.6).

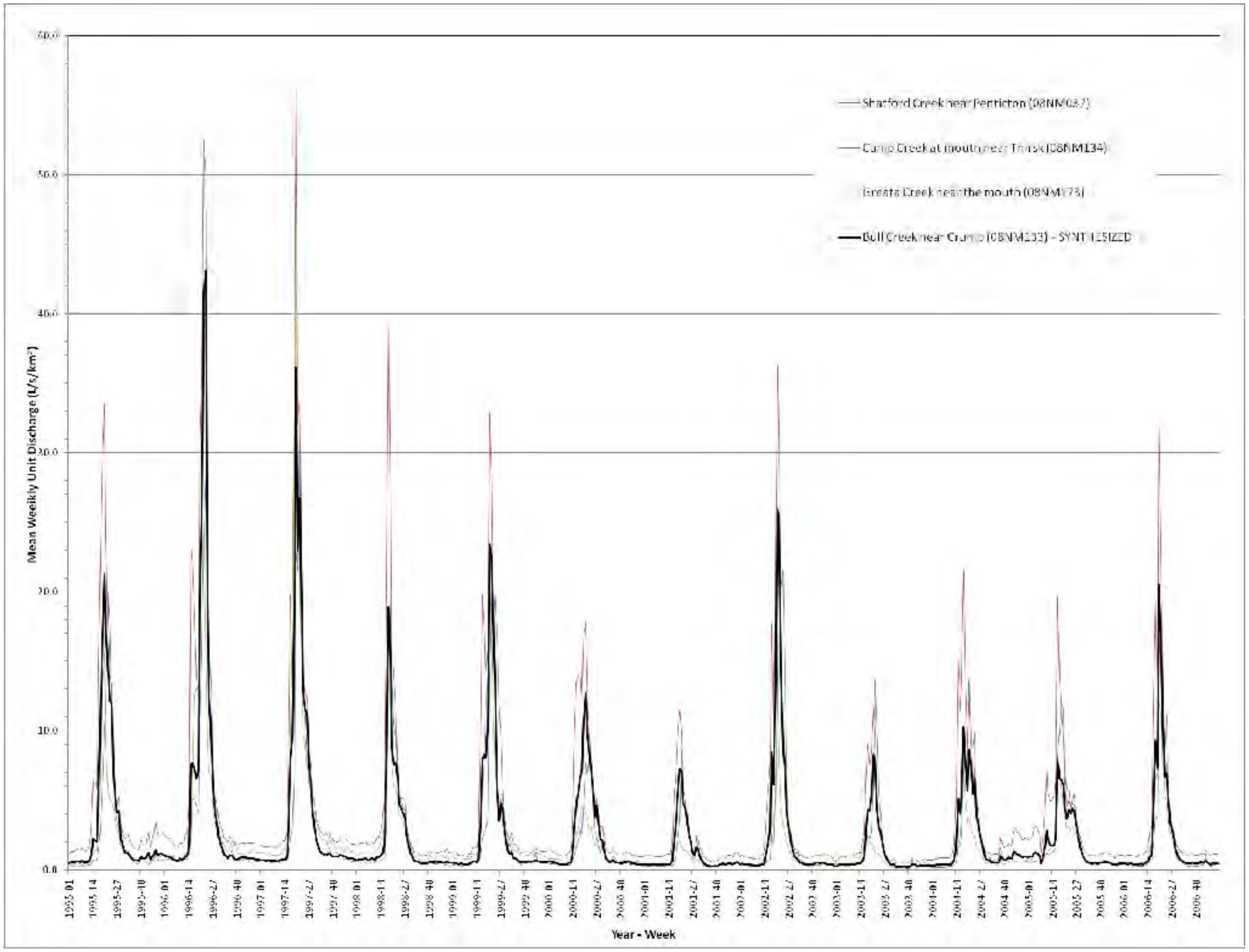

Figure J.4 Comparison of unit discharge recorded at Shatford, Camp, and Greata Creeks with estimated unit discharge for Bull Creek.

Confirmation / Validation

The following reports were reviewed to confirm and/or validate the streamflow estimates for Trout Creek:

- Agua Consulting Inc. (2008)
- Associated Engineering (1997),
- Cheng (1981),
- Fitzpatrick (2004),
- Letvak (1989),
- NHC (2005),
- Reksten (1971b),
- Reksten (1972b),
- Riordan (1986),
- Trout Creek Water Use Plan Consultative Committee (2005),
- Water Management Consultants (2003),
- Water Management Consultants (2008b), and
- Weiss (1981).

J.22 NODE 44: TURNBULL CREEK

Overview

Turnbull Creek is a small watershed draining the eastern side of Okanagan Lake between Naramata and Penticton Creeks. Above 1,100 m elevation, the sub-basin consists of gently sloping plateau. The bedrock-dominated middle elevations are moderately steep and at about 500 m elevation, the creek crosses a thick glaciolacustrine terrace before draining into Okanagan Lake. Logging activity occurs on the plateau and agricultural activities are present on the terraces.

No major water suppliers divert water from Turnbull Creek. However, there are a small number of water licensees who obtain water from the creek.

Available Hydrometric Data

No known hydrometric stations have operated in the Turnbull Creek sub-basin.

Methods Used to Estimate Natural Streamflows

Streamflows in Turnbull Creek were estimated by scaling the Bellevue Creek synthesized record (Section J.12) according to the ratio of their respective normal annual runoff values. As a result, the unit discharge for Robinson Creek is generally about 20% lower than Bellevue Creek.

Confirmation / Validation

No additional information specific to Turnbull Creek was identified during the study.

J.23 NODE 46: PENTICTON CREEK

Overview

The Penticton Creek sub-basin is located on the east side of Okanagan Lake and flows into the south end of the lake at Penticton. The Penticton Creek fan coalesces with the fans of Ellis and Shingle Creeks to form the broad valley bottom on which the City of Penticton is located. The headwaters of the sub-basin border the headwaters of Bellevue, Chute and Naramata Creeks. The western edge of the watershed partially borders Turnbull Creek. Above about 1300 m, the watershed consists of gently sloping terrain and rounded ridge tops. Below this elevation, Penticton Creek carves a deep canyon into the surrounding bedrock-dominated mid slopes. Below about 800 m elevation, the creek is incised in a thick outwash terrace comprised of sands and gravels. The creek makes a sharp bend to the south then west to flow around Mount Campbell and onto an alluvial fan. The upper slopes have logging activity and the fan and terraces support residential and farm land.

The City of Penticton is the main water user. Penticton Creek is one of their sources along with Okanagan Lake, Ellis Creek and groundwater.

Available Hydrometric Data

As shown in Appendix B, 13 hydrometric stations have been established by the Water Survey of Canada in the Penticton Creek sub-basin. Only four stations have records of natural streamflows and only three of these are active. The three stations, however, are located in the uplands and were established as part of the instrumentation in the Ministry of Forests and Range Upper Penticton Creek Experimental Watershed. These catchments are small (5.0 km^2 or less) because they were established for research purposes (specifically to document hydrologic effects of different levels of forest harvest).

None of the WSC stations that have records of regulated streamflows are currently operating and none of the WSC stations near the valley bottom have records during the standard period. As of 2007, the City of Penticton funded the installation of a hydrometric station at Van Horne. Data from this station may prove useful in future.

Methods Used to Estimate Natural Streamflows

Given the limited amount of natural streamflow information available for Penticton Creek, streamflows were estimated by scaling the Bellevue Creek synthesized record (Section J.12) according to the ratio of their respective normal annual runoff values. As a result, the unit discharge for Penticton Creek is generally about 20% lower than Bellevue Creek.

As shown in Figure 2.3, Penticton Creek flows across an alluvial fan and aquifer. Streamflow losses were therefore assumed as noted in Section 3.6.

Confirmation / Validation

The following reports were reviewed to confirm and/or validate the streamflow estimates for Penticton Creek:

- City of Penticton (2005),
- Schnorbus et al. (2004),
- Thyer et al. (2004)
- Winkler et al. (2003)

J.24 NODE 51: SHINGLE CREEK

Overview

Shingle Creek and its large tributary, Shatford Creek are located on the east side of the Okanagan Basin upslope from the City of Penticton. The watershed is located between Trout Creek to the north and the Marron River to the south. In the Shatford Creek catchment, slopes above 1300 m are gentle to moderately steep with rounded mountain and ridge-tops. Shatford creek has carved deeply into the upland surface to form a steep-sided valley. Shingle Creek drains a gently sloping plateau with steep-sided hills. From the confluence of Shatford Creek to about 540 m elevation. Shingle Creek is deeply entrenched and has steep valley sides. Below 540 m elevation, the valley opens up and the Shingle Creek crosses a series of kame and outwash terraces then crosses a large alluvial fan near the City of Penticton. The headwaters have a small amount of forestry activity. The eastern side of the sub-basin is home to Penticton Band I.R. No. 1. Land-use on the Penticton Band lands include agriculture, commercial, industrial (wood processing), and rural residential along the valley bottom, however most of the residential development is located on the fan near the Okanagan River channel.

Reservoirs in the sub-basin include Brent and Farleigh Lake. The Penticton Indian Band extracts water from three wells in the sub-basin. They divert some of the water from the sub-basin for use in other areas.

Available Hydrometric Data

WSC has operated four hydrometric stations in the Shingle Creek sub-basin (Appendix B), but only one remains active. This station is Shatford Creek near Penticton (08NM037). Although it is designated as having a regulated record, total water use and storage upstream of the station is relatively low with respect to the streamflow in the creek. Table J.10 lists the active water licences, points of diversion and volumes licensed upstream of the station. Assuming all licensees actually use their allocated volumes of water, water use on average would account for about 0.005 m^3/s on an annual basis. This represents about 1% of the estimated normal annual discharge Shatford Creek. Furthermore, a review of the unit discharge records for *Shatford Creek near Penticton* (08NM037) against the natural *Shingle*

Creek above Kaleden Diversion (08NM038) record (1979-1987) suggests the two streams have nearly identical unit hydrographs, suggesting that the Shatford Creek record reasonably reflects "natural" conditions.

Methods Used to Estimate Natural Streamflows

Streamflows in Shingle Creek at the mouth were estimated by scaling the *Shatford Creek near Penticton* (08NM037) unit discharge record according to the ratio of their respective normal annual runoff values. As a result, the unit discharge for Shingle Creek at the mouth is generally about 38% lower than Shatford Creek at the hydrometric station.

As shown in Figure 2.3, Shingle Creek flows across a broad alluvial fan and aquifer. Streamflow losses were therefore assumed as noted in Section 3.6.

Confirmation / Validation

No additional information specific to Shingle Creek was identified during the study.

Table J.10 Summary of active water licences upstream of the hydrometric station Shatford Creek near Penticton (08NM037).

Water Licence	Point of Diversion	Stream	Purpose	Quantity	Units		
C030919	PD54847	Shatford Creek	Domestic	500	gallons/day		
			Irrigation	6.5	acre-feet/year		
C031052			Domestic	1000	gallons/day		
			Irrigation	25	acre-feet/year		
C061920	PD54851	Palgrave Spring	Stockwatering	2000	gallons/day		
C106490	PD67922	Moose Creek	Stockwatering	500	gallons/day		
C108119	PD54849	Shatford Creek	Domestic	500	gallons/day		
C108120			Irrigation	10.83	acre-feet/year		
C108121	PD54856	Laking Brook	Domestic	500	gallons/day		
C108138			Irrigation	10	acre-feet/year		
C119206	PD54857 PD54858 PD54859	Clark Creek	Storage Storage Storage	3	acre-feet/year		
C119207	PD54857, PD54858	Clark Creek	Domestic	500	gallons/day		
			Irrigation	23.8	acre-feet/year		
C119871	PD64614	Shatford Creek	Domestic	500	gallons/day		
C119872	PD78651	Shatford Creek	Domestic	500	gallons/day		
C120439	PD54843	Shatford Creek	Irrigation	10	acre-feet/year		
C120440			Irrigation	12.5	acre-feet/year		
C120441			Irrigation	21.25	acre-feet/year		
			TOTALS:			Metric equivalent	
			Domestic	4000	gallons/day	18	m^3/day
			Irrigation	119.88	acre-feet/year	147,870	m^3/year
			Stockwatering	2500	gallons/day	0.4	m^3/day
			Total licences for off-stream use:			***154,530***	***m^3/year***
						0.005	***m^3/s***
			Storage	3	acre-feet/year	3700	m^3/year

J.25 NODE 52: ELLIS CREEK

Overview

Ellis Creek is directly across the Okanagan Valley from the Shingle Creek sub-basin and drains into the Okanagan River at Penticton. The sub-basin, including South Ellis Creek, drains gently sloping uplands above about 1,200 m elevation. Below this elevation, the creek flows through a deeply incised, bedrock-dominated canyon. At the mouth of the canyon, the creek flows across a terrace before flowing onto the alluvial fan. The alluvial fan coalesces with the Penticton and Shingle Creek fans to form a large gently-sloping area on which the City of Penticton is built. Logging occurs on the uplands and the valley bottom is home to urban, commercial, and industrial development.

The City of Penticton (CoP) is the major water supplier in the sub-basin and operates one upland reservoir (Ellis Reservoir). CoP diverts most of the water from the Ellis Creek for irrigation in other areas.

Available Hydrometric Data

Four Water Survey of Canada hydrometric stations have operated in the Ellis Creek sub-basin, however all but one, *Ellis Creek near Penticton* (08NM074), recorded regulated streamflows (Appendix B). This station was however only operated during the summer of 1922.

All WSC stations in the sub-basin were discontinued well prior to the standard period 1996-2006. Only the following two independent stations currently operate:

- *Ellis Creek near the mouth* (managed by Dobson Engineering Ltd.), and
- *Ellis Creek at Atkinson Street* (managed by the Ministry of Environment).

Both the above-noted stations were established only recently and have limited data available at this time.

Methods Used to Estimate Natural Streamflows

Given the relatively limited natural streamflow information available in the sub-basin, the unit discharge values of Ellis Creek were based on averaging the unit discharge from Bellevue Creek and Vaseux Creek, both of which have similar physiography, and are located on the east side of the Basin. All streamflow estimates for Ellis Creek were slightly adjusted in order to reconcile with the regionally-basin normal annual runoff (Appendix C). Since the lower portion of Ellis Creek flows across a broad alluvial fan and aquifer, assumed streamflow losses as noted in Section 3.6 were applied.

Confirmation / Validation

No additional information specific to Ellis Creek was identified during the study.

J.26 NODE 55: MARRON RIVER

Overview

The Marron River sub-basin is a low runoff creek rather than a river. Its small catchment, which includes the tributary Marama Creek, is located on the east side of Skaha Lake between Shingle Creek and Park Rill. Marron River occupies a steep-sided, former meltwater channel that was carved out during the most recent glaciation (Nasmith 1962). At the lower end of the basin, the topography consists of low-lying bedrock-dominated hills with thick deposits of glacial sediments in the depressions. Along this reach, it is believed that the surface flow from the Marron River is lost to groundwater in the thick outwash terraces (sand and gravels). There is little logging activity in this watershed. The Penticton Indian Band I.R. No. 1 is located in the north-eastern portion of the sub-basin. Agriculture is dispersed along the valley bottom and is more abundant at lower elevations.

The Kaleden Irrigation District's service area extends into the Marron River's sub-basin, but they do not divert any water from the creek. A small number of private landowners extract water from the creek.

Available Hydrometric Data

Horn Creek near Kaleden (08NM049) was the only hydrometric station established in the Marron River sub-basin. However, it recorded streamflows only during 1920.

Methods Used to Estimate Natural Streamflows

Given the similar watershed characteristics, Marron River was represented by the synthesized streamflows in Testalinden Creek (Section J.31). However, given the estimated normal annual runoff for Marron River is 52% of that in Testalinden Creek (Appendix C), all discharge estimates for Marron River were scaled accordingly. We have assumed streamflow losses occur near the mouth of Marron River according to Section 3.6. As noted above, there is considerable uncertainty as to whether Marron River streamflows reach Skaha Lake at all. In the future, this should be determined by field observation and/or communication with local residents.

Confirmation / Validation

No additional information specific to Marron River was identified during the study.

J.27 NODE 60: SHUTTLEWORTH CREEK

Overview

Shuttleworth Creek is a small sub-basin located on the east side of the valley that drains into the Okanagan River at Okanagan Falls. Above an elevation of 1,200 m, the creek drains gently sloping plateau. Below the plateau, the creek incised through thick glacial deposits and there have been several landslides along the gully walls. Below this elevation, the creek downcuts into the adjacent moderately steep, bedrock-dominated valley sides to create a steep canyon. When Shuttleworth Creek reaches the broad valley bottom at Okanagan Falls, it incises through remnants of glaciofluvial terraces and fans before flowing over a short reach of modern floodplain and fan. The mid and upper slopes of the sub-basin support logging activity. The valley bottom has residential development and agriculture.

Only private landowners draw water from this catchment and there is no developed storage. Okanagan Falls Irrigation District supplies water to the sub-basin from groundwater sources.

Available Hydrometric Data

Only two hydrometric stations have operated in the Shuttleworth Creek sub-basin, both of which recorded regulated flows. *Shuttleworth Creek near Okanagan Falls* (08NM006) operated between 1921 and 1964 on a seasonal basis. *Shuttleworth Creek at the mouth* (08NM149) operated between 1969 and 1971, and was then re-established in spring 2006 and remains active.

Methods Used to Estimate Natural Streamflows

The relatively short record at the mouth of Shuttleworth Creek and the questionable water use information available prevent streamflow estimation by naturalization. As a result, estimates for Shuttleworth Creek were based on the adjacent Vaseux Creek, which is similar in physiography. The pattern of streamflows at Shuttleworth Creek at the mouth was assumed to be similar to *Vaseux Creek above Solco Creek* (08NM171). The magnitude of streamflows was however reduced to account for the difference in median catchment elevation and thus normal annual runoff (Appendix C). Streamflow losses were assumed near the mouth of Shuttleworth Creek as noted in Section 3.6.

The estimated streamflows compared well throughout most of 2006 against the record of regulated streamflows at *Shuttleworth Creek at the mouth* (08NM149). A notable difference was that the estimated peak flow under natural conditions was higher than the actual regulated peak flow. Given the uncertain amount of water extraction from the creek, we have assumed this difference can be explained at least partly by water extractions from the creek.

Confirmation / Validation

No additional information specific to Shuttleworth Creek was identified during the study.

J.28 NODE 66: VASEUX CREEK

Overview

The Vaseux Creek sub-basin is located on the east side of Vaseux Lake and Okanagan River between Shuttleworth Creek to the north and Wolfcub and Inkaneep Creek to the south. Vaseux Creek and its tributary, Solco Creek, drain a gently sloping plateau above 1,500 m elevation. The creek has incised deeply into the surrounding plateau to form a steep-sided canyon. The mid elevation area of the creek has a narrow floodplain. The lower third of Vaseux Creek has downcut into bedrock forming a narrow steep canyon before crossing a large alluvial fan at the valley bottom. The plateau has been extensively logged. The Vaseux Bighorn National Wildlife Area is located at the lower end of the creek. The south end of the alluvial fan has industrial and residential development.

There is no known water supplier in the sub-basin and there is little developed storage in this sub-basin. Water extracted from the creek is used in-basin for irrigation by independent water licensees.

Available Hydrometric Data

Three hydrometric stations have been established on Vaseux Creek (Appendix B). These include:

- *Vaseux Creek above Solco Creek* (08NM171),
- *Vaseux Creek above Dutton Creek* (08NM246), and
- *Vaseux Creek near the mouth* (08NM246).

All three stations are classified by the WSC as natural; and an updated search of water licenses found no points of diversion above the Dutton Creek confluence.

The station near the mouth has only been in operation since 2006, so therefore it is of limited use in this study. *Vaseux Creek above Solco Creek* (08NM171) has a continuous record since fall 1970 and is a principal reference station in the Okanagan for natural streamflows, in a relatively high elevation catchment. The station *Vaseux Creek above Dutton Creek* (08NM246) operated for many years since 1919; however, it was discontinued in 1982. Nevertheless it provides a solid basis to understand the pattern of streamflows lower in the sub-basin.

Methods Used to Estimate Natural Streamflows

Unit discharge values for both Vaseux Creek above Solco and Vaseux Creek above Dutton Creeks were plotted and the overlapping records compared (Figure J.13). The latter station better reflects streamflow patterns at the mouth of Vaseux Creek, but unfortunately records for the standard period are not available. In order to estimate what the streamflows at Dutton Creek were likely to be in 1996-2006, weekly ratios were identified between the two hydrometric station records over the 1971 to 1982 period. These ratios provided the basis for estimating Vaseux Creek above Dutton Creek streamflow from the record of Vaseux Creek above Solco Creek record.

In order to reflect conditions at the mouth of Vaseux Creek, it was necessary to scale the record at Dutton Creek down to reflect the slightly lower unit discharge at the lower location. According to the regional runoff relations (Appendix C), Vaseux Creek unit discharge values were approximately 8% lower at the mouth than at above Dutton Creek. Furthermore, since the lower portion of Vaseux Creek flows across an alluvial fan and aquifer, the assumed streamflow losses were applied as noted in Section 3.6.

The estimated streamflows at the mouth were then compared with the actual streamflow records at Vaseux Creek at the mouth (08NM246) (Figure J.14). The natural streamflow estimates through most of 2006, with the exception of the spring period, were higher than the recorded flows. This difference may be explained by water extractions or possibly greater losses to groundwater than anticipated. Although refinements to the estimated natural flows are not warranted at this time, this could be completed in future with additional hydrometric measurements at the mouth, along with more accurate estimates of water extraction from surface sources.

Confirmation / Validation

The following reports were reviewed to confirm and/or validate the streamflow estimates for Vaseux Creek:

- Coulson (1978).

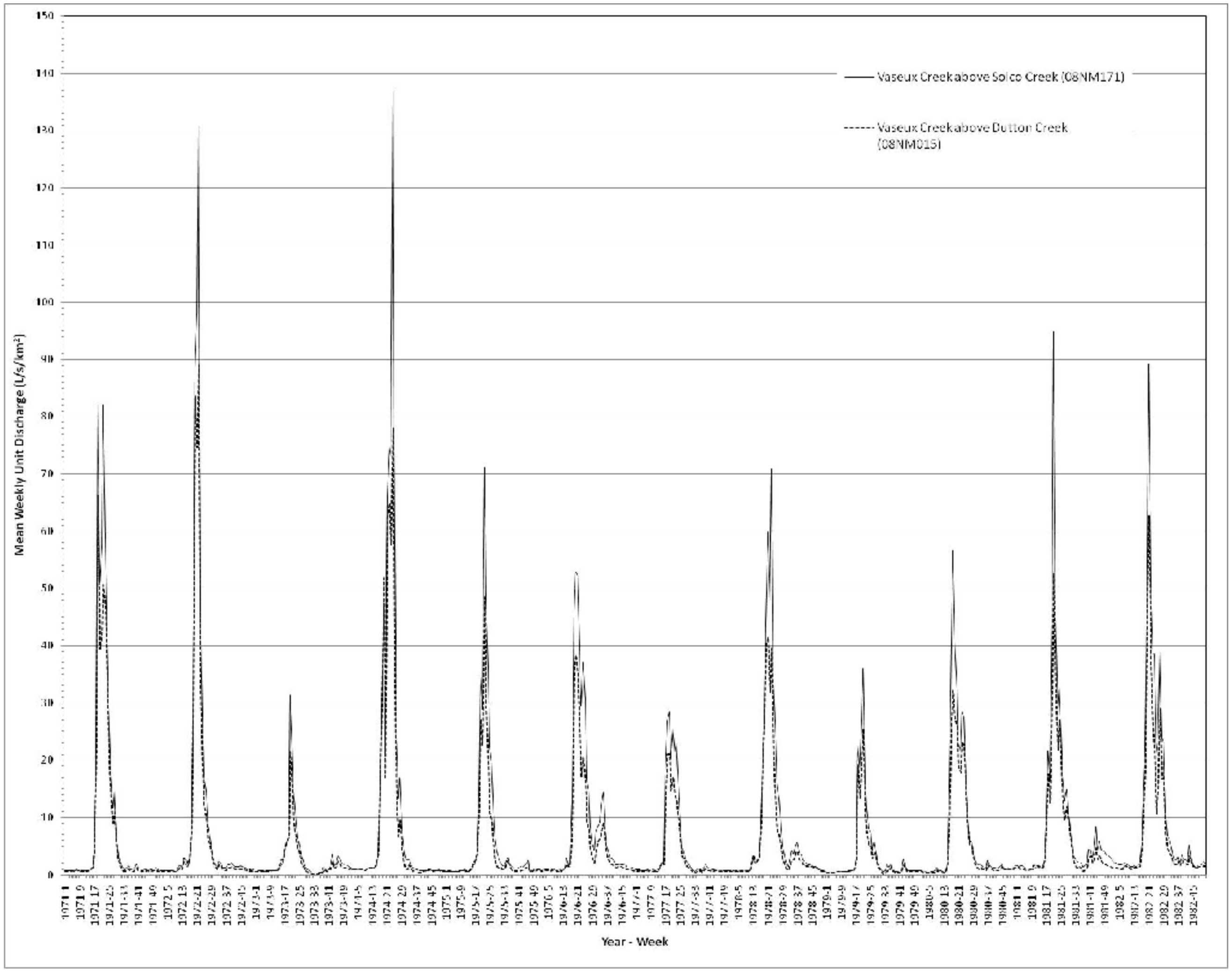

Figure J.5 Comparison of unit discharge at Vaseux Creek above Solco Creek (08NM171) and Vaseux Creek above Dutton Creek (08NM015).

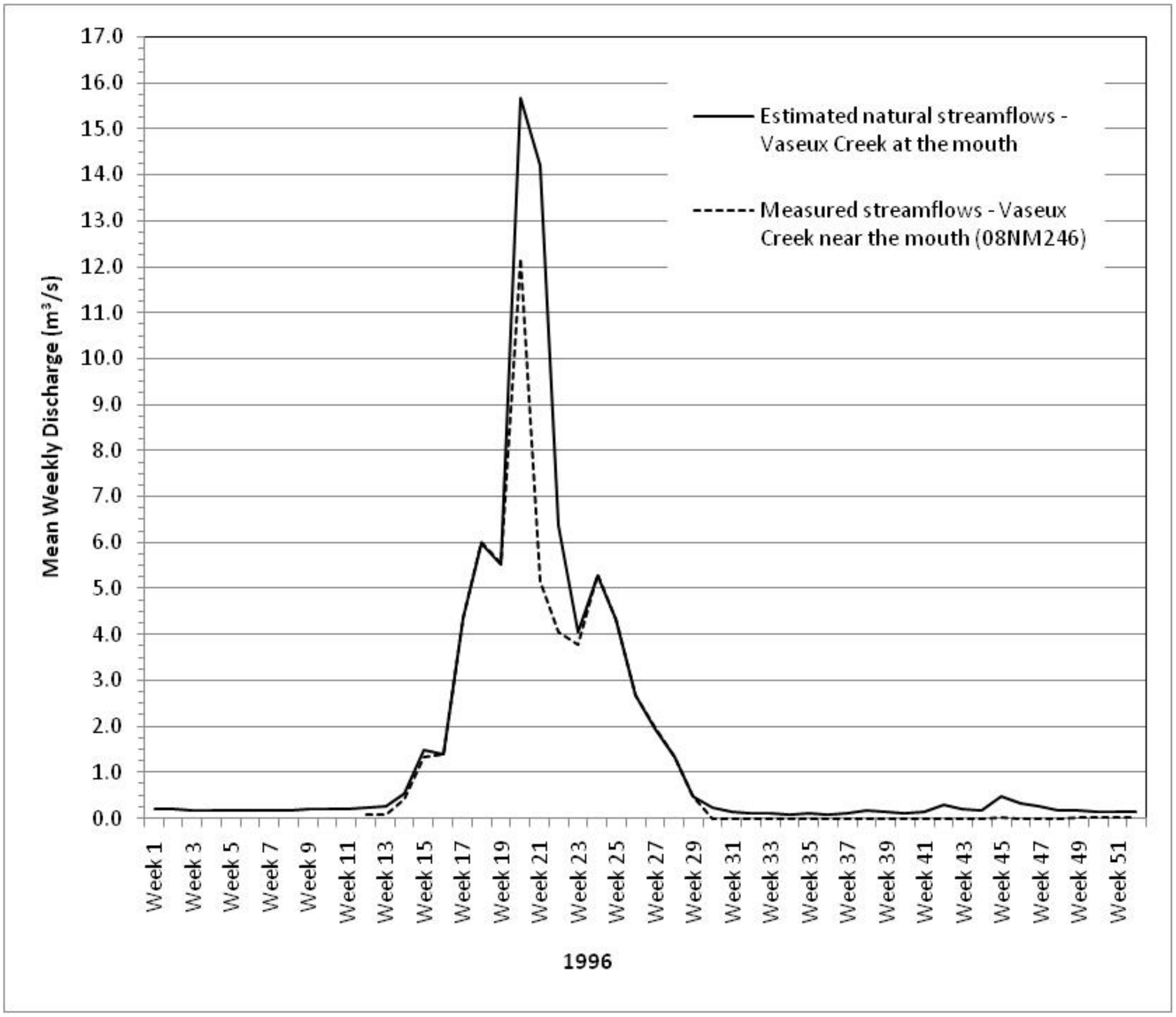

Figure J.6 Comparison of estimated natural streamflows and measured streamflows at Vaseux Creek at the mouth.

Note: The measured streamflows are likely influenced by water use and possibly greater groundwater losses than suggested by the available literature (see Section 3.6).

J.29 NODE 69: PARK RILL

Overview

The Park Rill sub-basin is located west of Vaseux Lake and drains into the Okanagan River north of Oliver. Kearns Creek is the main tributary to Park Rill. The watershed consists of moderately steep to steep, bedrock-dominated slopes with rounded mountain tops of 900 m to 1,200 m elevation. There are two areas in the middle of the sub-basin where the valley is wide and flat. The upper broad valley bottom surrounds White Lake and consists of thick glacial sediments. The second area is downstream in an area called Willowbrook. The Willowbrook area consists of modern fan deposits and thick outwash sediments. Downstream at about 420 m elevation, Park Rill has downcut through a glaciofluvial terrace that is located along the Okanagan River valley bottom. Park Rill then flows over an alluvial floodplain to the Okanagan River. There is very little forestry activity at the higher elevations. Agriculture is sparsely scattered throughout the valley bottom upstream of Willowbrook. Agriculture covers most gentle areas of thick surficial materials from Willowbrook downstream.

Private water users extract water from the creek. MOE owns and operates three reservoirs for fish rearing only; these include: Madden, Burnell and Ripley Lakes. The Willowbrook Water Utility, which extracts water from a well, is a private supplier of water to about 40 Willowbrook residents. The major water supplier for the eastern edge of the basin is the Town of Oliver. In the summer, water is diverted to the Park Rill sub-basin from the Oliver Rural Canal and in the winter, the water is taken from a well in residual area W-21.

Available Hydrometric Data

Park Rill near Oliver (08NM120) is the only hydrometric station that has operated in the Park Rill sub-basin. This station recorded regulated flows between April and October from 1951 to 1970. The hydrometric record on Park Rill suggests an annual runoff of about 10 mm. The regionally-based normal annual runoff for the sub-basin suggests it is 28 mm. This suggests that the extraction of water from the creek, losses to groundwater, or other loss (e.g. evaporation) strongly affects streamflows. Without actual estimates of water use during the period of record, the available hydrometric data is of little value to this study.

Methods Used to Estimate Natural Streamflows

In order to identify a representative station, the synthesized Vaseux Creek (Section J.28) and synthesized Testalinden Creek (Section J.31) records were compared with the available Park Rill near Oliver (08NM12) record. Based on this comparison, the timing of the peak flow in Testalinden Creek more closely matched the timing of the Park Rill record, probably because of their similar catchment median elevations. Given the similar physiography and elevations, the Testalinden unit discharge record was assumed to be representative of Park Rill. However, in order to reconcile with the expected normal annual runoff for Park Rill, all discharge values were scaled down by about 54%. Furthermore, since the lower portion of Park Rill flows across an alluvial fan and aquifer, assumed streamflow losses as noted in Section 3.6 were applied.

Confirmation / Validation

No additional information specific to Park Rill was identified during the study.

J.30 NODE 71: WOLFCUB CREEK

Overview

The Wolfcub Creek sub-basin is a small watershed located on the east side of the Town of Oliver. The north-western portion of the sub-basin consists of steep, bedrock-dominated slopes that are dissected by several steep gullies. The northeast corner of the catchment is gentle to moderately steep slopes largely blanketed with till. The lower slopes are covered with thick glacial sediments and are gullied. There are reaches of modern floodplain in the low-lying areas. The south edge of the study area generally is a low-lying, hummocky bedrock ridge. There is logging in the north east corner of the watershed. The western half of the sub-basin includes part of Osoyoos Indian Band I.R. No. 1. There is some agricultural and residential land use, and a golf course, in the low-lying areas on the west side of the sub-basin.

Wolfcub Creek typically dries up in the summer. Water for the small number of residents and small area of farmland is supplied by the Town of Oliver. The Town of Oliver obtains their water from the Oliver Rural Canal that stretches from Vaseux Lake to Osoyoos Lake, and from 12 groundwater wells. The Osoyoos Indian Band has a licence to draw water from the creek for irrigation.

Available Hydrometric Data

Wolfcub Creek near Oliver (08NM121) was the only hydrometric station established in the Wolfcub Creek sub-basin. It recorded regulated flows in 1952 only.

Methods Used to Estimate Natural Streamflows

Unit streamflows in Wolfcub Creek were estimated by averaging the synthesized unit discharge of Vaseux Creek at the mouth (Section J.28) and the synthesized unit discharge of Testalinden Creek at the mouth (Section J.31). The resulting streamflows were then uniformly scaled to reconcile with the expected normal annual runoff at Wolfcub Creek (Appendix C). Since the lower portion of Wolfcub Creek flows across an alluvial fan and aquifer, assumed streamflow losses as noted in Section 3.6 were then applied.

Confirmation / Validation

No additional information specific to Wolfcub Creek was identified during the study.

J.31 NODE 73: TESTALINDEN CREEK

Overview

Testalinden Creek, the smallest sub-basin identified in this study, is located on the west side of the Okanagan River near the south end of the Okanagan Basin. Most of the watershed consists of steep-sided slopes. There are areas of thick surficial materials within the sub-basin, especially along the mid and lower slopes. Testalinden Creek crosses and undercuts a thick deposit of glacial sediments at mid elevations. The south facing slopes tend be grasslands and the north facing slopes are forested. A large fan exists at the mouth of the creek. There appears to be little development in the sub-basin, other than agriculture on the fan.

Water for a small area of farmland is diverted from the Oliver Rural Canal by the Town of Oliver. The few residents receive domestic water, supplied by the Town of Oliver, from wells located in residual area E-16. There are some private licences for water extraction from Testalinden Creek for off-stream use.

Available Hydrometric Data

Two hydrometric stations have operated in the Testalinden Creek sub-basin. *Testalinden Creek near Oliver* (08NM130) recorded regulated flows between 1965 and 1968, while *Testalinden Creek in canyon* (08NM164) recorded natural flows (throughout the year) between 1969 and 1979, and only seasonally from 1980 to 1986.

Methods Used to Estimate Natural Streamflows

Since Testalinden Creek has a record of natural streamflows of reasonable length, but not during the standard period, we reviewed the potential of several hydrometric stations to provide a solid basis to estimate Testalinden Creek flows in 1996-2006. Among six stations reviewed, *Camp Creek at mouth near Thirsk* (08NM134) was best correlated to the Testalinden Creek record over 1970-1979. Ratios between the unit discharge at Testalinden Creek and Camp Creek were calculated and stratified according to the low, normal, and high runoff years[5]. These ratios were then used to estimate the 1996-2006 period streamflows for Testalinden Creek at the canyon. In order to reconcile with regionally-based normal annual runoff, all values were then scaled accordingly. Since the lower portion of Testalinden Creek flows across an alluvial fan and aquifer, assumed streamflow losses as noted in Section 3.6 were then applied.

Confirmation / Validation

No additional information specific to Testalinden Creek was identified during the study.

[5] Low, normal and high runoff years were based on the record of *Camp Creek at mouth near Thirsk* (08NM134). Low runoff years were defined as those with annual runoff less than 1 standard deviation below the normal annual runoff; high runoff years were defined as those with annual runoff greater than 1 standard deviation above normal annual runoff. Normal runoff years were defined as those with runoff within 1 standard deviation of the normal annual runoff.

J.32 NODE 78: INKANEEP CREEK

Overview

The Inkaneep Creek sub-basin is located on the east side of the Okanagan River near the southern end of the Basin and drains into Osoyoos Lake. Inkaneep Creek and its tributaries drain gently sloping plateau above 1,000 m elevation. Below this elevation, the creek has eroded a steep canyon into the bedrock-dominated slopes. At about 460 m elevation, Inkaneep Creek flows onto a large relict fan, then cuts through glaciofluvial terraces before draining onto the alluvial fan at Osoyoos Lake. There is logging on the plateau and a small area of agriculture at the headwaters of McCuddy Creek. The lower end of the catchment lies within Osoyoos Indian Band I.R. No. 1. The lower elevations of the reserve are used for agriculture, including production of some of Canada's best wine grapes.

Water from Inkaneep Creek is diverted into and stored at Waterdog Lake. There is no outlet to this lake and the Osoyoos Indian Band uses the lake water to irrigate the surrounding farm land. Most of the other farmland in the catchment area is irrigated by the Band using water from Osoyoos Lake.

Available Hydrometric Data

Hydrometric data has been collected at three stations in the Inkaneep Creek sub-basin. *Inkaneep Creek near Oliver* (Lower Station) (08NM012) recorded natural streamflows seasonally for a number of years between 1919 and 1929 and between 1941 and 1950. *Inkaneep Creek near Oliver* (Upper Station) (08NM082) recorded natural flows seasonally from 1940 to 1950. *Inkaneep Creek near the mouth* (08NM200) was established in spring 2006 and remains active. The streamflows at this station are regulated. Given the limited data within the sub-basin, the station records are useful as a check, but not as a primary basis for the estimation of natural streamflows.

Methods Used to Estimate Natural Streamflows

Since Inkaneep Creek is adjacent to and has very similar physiography to Wolfcub Creek, unit streamflows in Inkaneep Creek were estimated in a similar manner as Wolfcub Creek (Section J.30). Since the lower portion of Inkaneep Creek flows across an alluvial fan and aquifer, assumed streamflow losses as noted in Section 3.6 were also applied. Actual records of streamflows in Inkaneep Creek near the mouth (08NM082) were available for 2006 from mid-March until the end of the year. These data were naturalized by estimating the actual surface water extractions that occur in the sub-basin above the station. According to information presented by Dobson Engineering Ltd. (2008), it is estimated that about 4,400 ML of water are extracted from surface sources, primarily for irrigation between May and September. This amounts to an average extraction of 0.3 m^3/s during the summer months. Irrigation demands follow a distribution similar to that presented in Table J.8. Therefore, extractions were distributed so that they both reflected actual irrigation demands and totalled the estimated volume extracted. Estimated streamflows for 2006 from mid March to the end of the year were then substituted with naturalized streamflows based on the actual record.

Confirmation / Validation

The following reports were reviewed to confirm and/or validate the streamflow estimates for Inkaneep Creek:

- Obedkoff (1986).

APPENDIX K

Residual Area

Streamflow Estimates

APPENDIX K – RESIDUAL AREA STREAMFLOW ESTIMATES

K.1 Methods Used to Estimate Natural Streamflows

Within the Okanagan Basin, residual areas cover a total of 1,340 km^2 or 17% of the total area of the Basin. These areas consist of all land areas outside of the identified sub-basins (shaded yellow on Map 1). While the residual areas may include streams, most are considerably smaller than the principal tributaries in the Okanagan and often flow only during part of the year. Streamflows may occur during snowmelt in spring or during rainstorms, particularly if groundwater levels are near the surface or soils are frozen. Because residual areas occupy the lower, warmer and drier elevations in the watershed (Figure 3.1), there is typically a moisture deficit on an annual basis – i.e. evapotranspiration exceeds precipitation (Figure 3.3). Due to these moisture deficits, most hydrologic studies in the Basin disregard runoff from residual areas. While the total runoff from all residual areas is estimated to be relatively small (representing about 5% of all runoff in the Basin), for completeness, we have addressed it in this study.

Since there are essentially no useful hydrometric station records to estimate residual area runoff, a regionally-based approach was taken. Each residual area was classified into one of the 12 hydrologic groups identified in Appendix C, and 1996-2006 normal (i.e. averaged over 1996-2006) annual runoff was determined for each residual area based on the median elevation of the residual area. These values were then converted to discharge according to the size of the residual area. In order to estimate annual runoff for each of the 11 years of the standard period, the normal annual runoff data were scaled according to annual scaling factors developed from region-wide runoff data (Figure 2.1). These factors are listed in Table K.1.

Table K.1 Region-wide scaling factor used to adjust normal annual runoff estimates to annual runoff estimates - 1995 to 2006.

Year	Scaling factor (annual runoff ÷ 1996-2006 normal annual runoff)[1]
1995	0.98
1996	1.32
1997	1.62
1998	0.96
1999	1.28
2000	0.95
2001	0.60
2002	0.93
2003	0.58
2004	0.87
2005	0.90
2006	1.01

Notes: Values are based on the average of 14 hydrometric stations listed in Table 2.1

In order to distribute the annual runoff on a weekly time step, weekly distributions were assumed for each residual area. For a small number of relatively large residual areas with significant areas above about 1,391 m (the average elevation above which the precipitation typically exceeds evapotranspiration), the pattern of runoff for adjacent sub-basins was adopted. For the other residual areas, the weekly distribution was estimated based on the data presented in Consultative Board (1974b). Within that document, average monthly discharge estimates were provided for groups of "low lying areas" in the Okanagan Basin, which are effectively equivalent to residual areas identified in this study.

Based on this information, three typical monthly runoff patterns were identified. These were then partitioned into weekly distributions, and to minimize unrealistic step changes resulting from the conversion of monthly to weekly data, the data was smoothed by calculating 3-week running means. These distributions are presented in Figure K.1.

Residual areas were then assigned to a distribution pattern (either A, B, C[1]) according to their location with respect to the Consultative Committee's (1974) "low lying areas". In the case of large, higher elevation residual areas, a distribution was based on an adjacent stream. Although estimated annual runoff values vary, in cases where distribution A, B or C were used, we assumed the same weekly distribution for all years in the standard period. Given the relatively low runoff from these residual areas, this simplifying assumption was not considered to significantly affect the overall results. Table K.2 identifies the weekly runoff distributions assumed for each of the residual areas in the Basin.

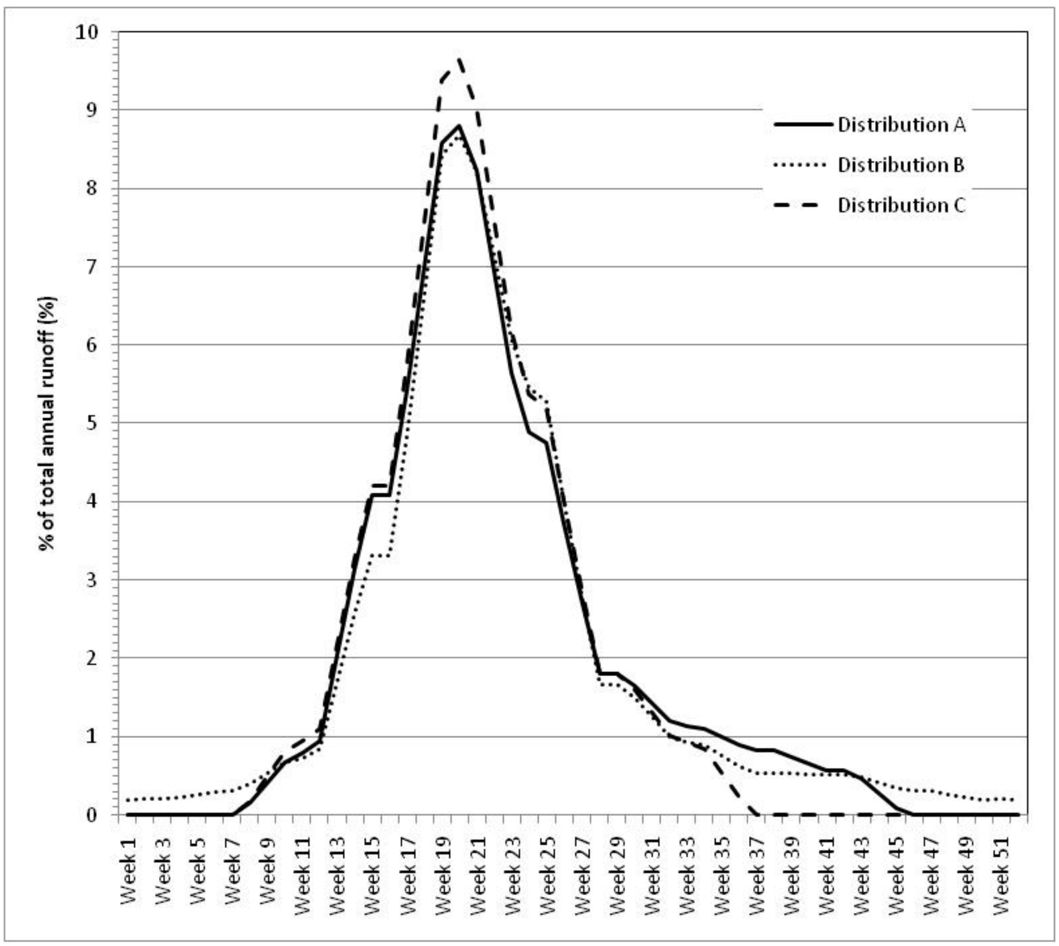

Figure K.1 Assumed distributions used to estimate weekly runoff from residual areas.

[1] Distribution "A" is based on Consultative Board's (1974b) "low lying areas 7, 8 and 9". Distribution "B" is based on "low lying area 6" and distribution "C" is based on "low lying areas 2, 3, 4, and 5".

Table K.2 Assumed runoff distributions used to estimate weekly runoff from residual areas.

Hydrologic Group	Residual area	Drainage area (km^2)	Median elevation (m)	Assumed runoff distribution
Group 2	W-1	19	586	A
	W-2	36.2	827	Irish Creek
	W-3	2.71	394	A
	W-4	17	685	A
	W-5	32.8	744	A
	W-6	56.6	761	A
	E-1	38.2	556	A
	E-2	124.4	550	A
Group 5	W-7	37	605	A
	W-8	25.1	711	A
	W-9	13.5	616	B
	W-10	16.3	676	B
Group 6	E-3	10.4	357	A
	E-4	6.88	446	A
	E-5	155.3	888	Chute Creek
	E-6	19.3	814	B
	E-7	2.32	513	C
	E-8	13.1	736	C
	E-9	22.2	725	C
	E-10	3.05	355	C
Group 9	W-11	23	590	B
	W-12	26.4	628	C
	W-13	27.5	717	C
	W-14	7.33	527	C
	W-15	40.9	715	C
Group 10	E-11	122.1	1019	Shuttleworth Creek
	E-12	27.9	640	C
	E-13	2.27	345	C
Group 11	W-16	0.84	451	C
	W-17	23.8	950	C
	W-18	9.25	778	C
	W-19	15.5	587	C
	W-20	11.5	496	C
	W-21	70.3	725	Testalinden Creek
	W-22	0.37	291	C
	W-23	62.4	516	C
Group 12	E-14	15.8	403	C
	E-15	28.7	453	C
	E-16	12.2	354	C
	E-17	160.4	1054	Inkaneep Creek

As shown in Figure K.1, in the majority of residuals, no runoff occurs during the winter, and for many areas this may also be true for late summer and fall.

K.2 Overall Results

Natural annual, monthly, and weekly streamflow estimates for all residual areas are provided in Appendix I. Tables K.3 and K.4 summarize normal annual runoff by quadrant and zone in the Basin. On average, we estimate about 5% of the total annual runoff in the Basin originates from residual areas. However, this proportion varies within the Basin, and increases generally in a southerly direction.

Table K.3 Normal (1996-2006) annual total streamflow from residual areas in the four (4) quadrants of the Okanagan Basin.

Quadrant[1]	**1996-2006 normal annual total flow from residual areas only (ML)**	**1996-2006 normal annual total flow from all areas (ML)**	**% of total flow from residual areas**
NW	11,131	338,878	3.3
NE	12,553	392,750	3.2
SW	4,939	32,365	15
SE	18,446	119,927	15
TOTAL	**47,069**	**883,921**	**5.3**
North Sub-total:	*23,684*	*731,628*	*3.2*
South Sub-total:	*23,385*	*152,293*	*15*
TOTAL	**47,069**	**883,921**	**5.3**
West sub-total:	*16,070*	*371,244*	*4.3*
East sub-total:	*30,999*	*512,677*	*6.0*
TOTAL	**47,069**	**883,921**	**5.3**

Notes:

1. Refer to Figure 5.1 in the main body of the report for locations of the four quadrants.

Table K.4 Normal (1996-2006) annual total streamflow from the residual areas in the five zones of the Okanagan Basin.

Zone[1]	1996-2006 normal annual total flow from residual areas only (ML)	1996-2006 normal annual total flow from all areas (ML)	% of total flow from residual areas
A	0	41,698	0.0
B	23,684	689,930	3.4
C	9,568	56,572	17
D	3,622	70,349	5.1
E	10,196	25,372	40
TOTAL	**47,069**	**883,921**	**5.3**

Notes:

1. Refer to Figure 5.2 in the main body of the report for locations of the five zones.

APPENDIX L

Water Balance Summaries for Skaha, Kalamalka and Okanagan Lakes

Kalamalka - Wood Lake Annual Water Balance				*Independently derived components of Net Inflow*										
				Expected values assumed for each parameter.										
Column ID	A	B	C=A+B	D	E	F	G	H	I	J	K	L = D+E+F+G+H-I-J-K	M=L-C	
Parameter:	Kalamalka Lake Outflow	Change in Kalamalka - Wood Lake Storage	Net Inflow to Kalamalka-Wood Lake (ver 1)	Natural Surface Inflow to Kalamalka-Wood Lake	Groundwater Inflow to Kalamalka-Wood Lake	Precipitation onto Kalamalka-Wood Lake	Surface Return Flows from WTPs to Kalamalka/Wood Lake	Imported Water to areas upstream of outlet of Kalamalka Lake	Evaporation from Kalamalka/Wood Lake surface	Water use from surface sources	Outflow from Kalamalka Lake via groundwater	Calculated net inflow based on summing the independently derived components (ver 2)	Difference between net inflows (ver 2 - ver 1)	
Source:	WSC hydrometric station 08NM065 "Vernon Creek at outlet of Kalamalka Lake"	WSC hydrometric station 08NM143 "Kalamalka Lake at Vernon Pumphouse"; storage curve for Kalamalka-Wood Lake as determined by Summit	Calculated as the sum of the recorded outflow and change in lake storage	Summit (2009) draft data for Node 00	Based on aquifer discharge estimates by Summit and Golder (2009)	Data from DHI; assumed lake surface area of 34,265,000 m2	Based on Summit letter report dated Jun 22, 2009	Estimated District of Lake Country withdrawals from Okanagan Lake based on DLC records for 2003. Other years scaled according to estimated total DLC water extractions (from all sources)	Data from DHI; assumed lake surface area of 34,265,000 m2	Based on water extractions from all surface sources upstream of outlet of Kalamalka Lake; Data based on Okanagan Water Demand Model and Water Use Area information. Date of data: 20 Jul 2009	Assume 15% of surface water ouflows from lake			
Units:	ML/year	ML/year	ML/year	ML/year	ML/year	ML/year	ML/year	ML/year	ML/year	ML/year	ML/year	ML/year	ML/year	%
				Gain	*Gain*	*Gain*	*Gain*	*Gain*	*Loss*	*Loss*	*Loss*			
Year														
1996	81,853	-191	*81,661*	94,019	40,040	20,696	0	916	30,029	22,247	12,278	*91,118*	*9,457*	*11.6%*
1997	112,167	-6,191	*105,976*	116,087	40,330	18,118	0	624	29,326	20,989	16,825	*108,019*	*2,043*	*1.9%*
1998	29,831	1,285	*31,116*	49,054	40,250	12,926	0	1,091	33,407	27,935	4,475	*37,505*	*6,389*	*20.5%*
1999	46,670	-2,953	*43,717*	60,993	40,146	13,684	0	761	30,388	23,299	7,000	*54,897*	*11,180*	*25.6%*
2000	39,062	-655	*38,407*	57,322	40,415	13,156	0	836	30,374	23,294	5,859	*52,201*	*13,794*	*35.9%*
2001	9,500	5,706	*15,205*	37,490	39,786	12,622	0	904	31,374	24,674	1,425	*33,329*	*18,124*	*119.2%*
2002	26,023	-2,749	*23,275*	49,657	39,422	8,539	0	1,075	31,686	24,524	3,904	*38,579*	*15,304*	*65.8%*
2003	3,674	-10,088	*-6,414*	22,047	39,095	9,969	0	998	32,976	27,925	551	*10,656*	*17,070*	*-266.1%*
2004	3,348	4,817	*8,164*	26,538	39,148	15,631	0	794	32,613	25,543	502	*23,453*	*15,288*	*187.3%*
2005	9,765	8,182	*17,947*	41,223	39,148	11,896	0	876	31,416	25,399	1,465	*34,863*	*16,916*	*94.3%*
2006	24,756	-430	*24,326*	47,266	39,385	11,741	0	951	32,569	26,509	3,713	*36,552*	*12,226*	*50.3%*
Mean:	*35,150*	*-297*	*34,853*	*54,699*	*39,742*	*13,543*	*0*	*893*	*31,469*	*24,758*	*5,272*	*47,379*	*12,526*	*35.9%*

Okanagan Lake Annual Water Balance					*Independently derived components of Net Inflow*											
					Expected values assumed for each parameter.											
Column ID	A	B	C=A+B		D	E	F	G	H	I	J	K	L = D+E+F+G+H-I-J-K		M=L-C	
Parameter:	Okanagan Lake Outflow	Change in Okanagan Lake Storage	Net Inflow to Okanagan Lake (ver 1)		Natural Surface Inflow to Okanagan Lake	Groundwater Inflow to Okanagan Lake	Precipitation onto Okanagan Lake	Surface Return Flows from WTPs to Okanagan Lake	Imported Water to the Okanagan Basin upstream of the outlet of Okanagan Lake	Evaporation from Okanagan Lake	Water use from surface sources	Outflow from Okanagan Lake via groundwater	Calculated net inflow based on summing the independently determined components(ver 2)		Difference between net inflows (ver 2 - ver 1)	
Source:	WSC hydrometric station 08NM050 "Okanagan River at Penticton"	WSC hydrometric station 08NM083 "Okanagan Lake at Kelowna"; storage curve for Okanagan Lake as determined by Summit	Calculated as the sum of the recorded outflow and change in lake storage		Sum of natural or naturallized inflows for Nodes 3-46 (Summit 2009 draft data)	Based on aquifer discharge estimates by Golder and Summit (2009)	Data from DHI; assumed lake area of 344,910,400 m2	Based on Summit estimates identified in letter report dated Jun 22, 2009	Estimated water imports from Stirling Creek (by South East Kelowna Irrigation District), Alocin Creek (Westbank Irrigation District) based on Dobson Engineering Ltd. (2008). Note that water from Duteau Cr and Fortune Creek are imported directly into distribution system. Some of this water may enter Okanagan Lake through groundwater or return flow.	Data from DHI; assumed lake area of 344,910,400 m2	Based on water extractions from all surface sources upstream of outlet of Okanagan Lake; Data based on Okanagan Water Demand Model and Water Use Area information. Data dated 20 Jul 2009	Assume 15% of surface water ouflows from lake				
Units:	ML/year	ML/year	ML/year		ML/year	ML/year	ML/year	ML/year	ML/year	ML/year	ML/year	ML/year	ML/year		ML/year	%
					Gain	*Gain*	*Gain*	*Gain*	*Gain*	*Loss*	*Loss*	*Loss*				
Year																
1996	992,262	14792	*1,007,054*		1,010,113	301,707	163,341	10,029	4,304	302,233	115,028	148,839	*923,394*		*-83,660*	*-8.3%*
1997	1,389,493	-59856	*1,329,637*		1,218,879	302,972	141,984	10,545	6,456	296,287	109,552	208,424	*1,066,573*		*-263,064*	*-19.8%*
1998	580,907	-22704	*558,203*		682,377	300,301	122,904	11,088	4,421	329,944	139,522	87,136	*564,489*		*6,286*	*1.1%*
1999	834,234	3784	*838,018*		929,718	299,218	112,920	11,673	4,870	304,909	117,483	125,135	*810,871*		*-27,147*	*-3.2%*
2000	607,727	-19264	*588,463*		702,503	300,383	110,777	11,899	3,459	305,117	119,177	91,159	*613,569*		*25,105*	*4.3%*
2001	247,166	5848	*253,014*		424,402	294,397	106,291	12,036	3,575	309,870	124,234	37,075	*369,523*		*116,508*	*46.0%*
2002	523,839	-31304	*492,535*		662,281	292,446	68,178	12,609	4,327	313,784	124,065	78,576	*523,416*		*30,881*	*6.3%*
2003	227,842	-104232	*123,610*		396,026	290,136	81,995	14,253	2,811	323,681	138,793	34,176	*288,571*		*164,961*	*133.5%*
2004	264,468	168216	*432,684*		563,832	291,365	137,453	15,121	2,361	320,447	125,440	39,670	*524,575*		*91,891*	*21.2%*
2005	521,508	-31304	*490,204*		641,070	291,613	99,792	15,625	3,880	308,794	128,800	78,226	*536,161*		*45,957*	*9.4%*
2006	599,231	-14104	*585,127*		816,710	293,712	114,542	17,064	4,752	319,704	132,380	89,885	*704,812*		*119,685*	*20.5%*
Mean:	*617,152*	*-8,193*	*608,959*		*731,628*	*296,205*	*114,562*	*12,904*	*4,111*	*312,252*	*124,952*	*92,573*	*629,632*		*20,673*	*3.4%*

Skaha Lake Annual Water Balance				*Independently derived components of Net Inflow*										
				Expected values assumed for each parameter.										
Column ID	A	B	C=A+B	D	E	F	G	H	I	J	K	L = D+E+F+G+H-I-J-K	M=L-C	
Parameter:	Skaha Lake Outflow	Change in Skaha Lake Storage	Net Inflow to Skaha Lake (ver 1)	Total Surface Inflow to Skaha Lake	Groundwater Inflow to Okanagan River between Okanagan and Skaha Lakes and inflow to Skaha Lake	Precipitation onto Skaha Lake	Surface Return Flows from WTPs to Okanagan River between outlets of Okanagan Lake and Skaha Lake	Imported Water to Okanagan River between outlets of Okanagan Lake and Skaha Lake	Evaporation from Skaha Lake	Water use from surface sources	Outflow from Skaha Lake via groundwater	Calculated net inflow based on summing the independently derived components(ver 2)	Difference between net inflows (ver 2 - ver 1)	
Source:	Water Survey of Canada hydrometric station 08NM002 "Okanagan River at Okanagan Falls"	Water Survey of Canada hydrometric station 08NM084 "Skaha Lake at Okanagan Falls"; lake storage curve for Skaha Lake from Summit	Calculated as the sum of the recorded outflow and change in lake storage	Sum of runoff of Okanagan River at Penticton (WSC station 08NM050) and estimated natural inflows for Nodes 49-56 (Summit 2009 draft data)	Based on aquifer discharge estimates by Golder and Summit (2009)	Data from DHI; assumed lake area of 18,773,900 m2	Based on Summit estimates identified in letter report dated Jun 22, 2009	Based on Summit letter report dated June 22, 2009	Data from DHI; assumed lake area of 18,773,900 m2	Based on water extractions from all surface sources between outlets of Okanagan and Skaha Lakes; Data based on Okanagan Water Demand Model and Water Use Area information.	Assume 15% of surface water ouflows from lake			
Units:	ML/year	ML/year	ML/year	ML/year	ML/year	ML/year	ML/year	ML/year	ML/year	ML/year	ML/year	ML/year	ML/year	%
				Gain	*Gain*	*Gain*	*Gain*	*Gain*	*Loss*	*Loss*	*Loss*			
Year														
1996	1,022,598	635	*1,023,233*	1,073,797	56,286	7,445	4,084	0	17,275	3,070	153,390	*967,877*	*-55,356*	*-5.4%*
1997	1,418,945	2,205	*1,421,150*	1,476,454	56,422	7,617	4,009	0	17,100	2,997	212,842	*1,311,563*	*-109,587*	*-7.7%*
1998	641,855	-1,159	*640,697*	651,254	56,531	6,819	3,804	0	18,824	3,973	96,278	*599,332*	*-41,364*	*-6.5%*
1999	862,971	-1,794	*861,177*	910,373	56,506	5,439	4,362	0	17,642	3,081	129,446	*826,512*	*-34,665*	*-4.0%*
2000	621,670	804	*622,474*	647,990	56,745	4,721	4,250	0	17,805	3,463	93,251	*599,188*	*-23,286*	*-3.7%*
2001	270,165	1,607	*271,772*	270,228	56,456	5,488	4,279	0	17,885	3,572	40,525	*274,470*	*2,697*	*1.0%*
2002	567,676	542	*568,218*	577,374	56,231	3,549	4,557	0	18,093	3,563	85,151	*534,903*	*-33,314*	*-5.9%*
2003	247,795	-2,224	*245,571*	264,435	56,064	4,806	4,384	0	18,795	3,963	37,169	*269,761*	*24,190*	*9.9%*
2004	296,952	953	*297,905*	308,939	56,119	7,626	4,404	0	18,648	3,600	44,543	*310,297*	*12,392*	*4.2%*
2005	566,264	1,159	*567,422*	570,637	55,971	5,336	4,410	0	18,228	3,605	84,940	*529,581*	*-37,842*	*-6.7%*
2006	643,373	-448	*642,925*	650,073	56,045	8,259	3,998	0	18,509	3,687	96,506	*599,673*	*-43,252*	*-6.7%*
Mean:	*650,933*	*207*	*651,140*	*672,869*	*56,307*	*6,100*	*4,231*	*0*	*18,073*	*3,507*	*97,640*	*620,287*	*-30,853*	*-4.7%*