

HYDROLOGICAL MODELING OF ALBERTA USING SWAT MODEL



A preliminary Report

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1. Summary

Water is Alberta's most important renewable natural resource. It is reported that it has a good supply of surface water. However, spatial and temporal variation of the climate and hydrologic cycle has caused regions of water scarcity in this province. Numerous factors contribute to the complexity of water management in Alberta. These include: conflict over water resources; inadequacy of knowledge about existing programs, water uses, and water availability; and the nature and extent of stakeholder participation.

An exact knowledge of internal renewable water resources of Alberta is needed to lay a strong basis for a systematic analysis of water use-water availability for its long-term planning of the water and food security. The main objective of this project is the quantification of Alberta's water resources including all components of the water balance at the subbasin spatial and monthly temporal scale. This includes blue water flow (river discharge plus deep aquifer recharge), green water flow (evapotranspiration), green water storage (soil moisture), and aquifer recharge.

In this study we used the program Soil and Water Assessment Tool (SWAT) in combination with the Sequential Uncertainty Fitting program (SUFI-2) to calibrate and validate a hydrologic model of Alberta based on river discharges. Uncertainty analyses were also performed to assess the model performance. The results were not very satisfactory by using the observed climate data, but more reasonable results were obtained through the use of CRU (Climate Research Unit, <http://www.cru.uea.ac.uk/>) gridded climate data. The study period modeled was 1985–2006 for calibration (1991–2006) and validation (1985–1990). We quantified all components of the water balance including blue water flow (water yield plus deep aquifer recharge),

green water flow (actual and potential evapotranspiration) and green water storage (soil moisture) at sub-basin level with monthly time-steps. The spatially aggregated water resources components were used to predict sub-provincial blue and green water resources availability. Using the 2.5 arcmin population map available from the Center for International Earth Science Information Network in 2005, 2005, and 2015 (CIESIN, <http://sedac.ciesin.columbia.edu/gpw>), the water scarcity indicator, was obtained and presented as per-capita blue water availability per year at subbasin level. The results show that the lack of information on the dam operation, water diversion, and consumptive water use causes a large uncertainty in the areas concerned, hence we do not show this graph until more accurate information is used. Pertaining to the staple food crops in the province, the vulnerable situation of water resources availability has serious implications for the province's food security, and the looming impact of climate change could only worsen the situation. This study provides a strong basis for further studies concerning the water and food security and the water resources management strategies in the province and a good basis for the analysis of impact of climate change on blue and green water resources in Alberta.

2. Introduction

2.1 Climate

Alberta, as the fourth largest province in Canada, has an area of 661,185 km². It is located between 45-65°N and 105-125 ° E. The altitude varies from 170 m in the Wood Buffalo National Park in the northeast to 3747 m in the Rocky Mountains along the southwestern border. This variation as well as the variation in sea surface temperature of the Pacific Ocean has a pronounced influence on the diversity of the climate. Although most parts of Alberta could be classified as semi-arid, it has a wide range of climatic

conditions. The average annual precipitation is 510 mm yr^{-1} . The leeward side of the Canadian Rocky Mountains, part of which is known as the Foothills, is relatively wet, with an average annual precipitation of 600 mm or more, while that of northern Alberta ranges from about 400 mm (northeast) to over 500 mm on the northwest, and that of southern Alberta from less than 350 mm (southeast) to about 450 mm [Mwale et al., 2009]. Arctic air masses in the winter produce extreme minimum temperatures varying from -54°C in northern Alberta to -46°C in southern Alberta. In the summer, continental air masses produce maximum temperatures from 32°C in the mountains to 40°C in southern Alberta.

2.2 Water availability

Although Alberta is abundant in terms of fresh water, but the spatial and temporal variation of this resource has caused regions of scarcity. Northern regions of Alberta are the wettest. The majority of Alberta's water is generated in the Peace River system and flows northward through the Slave River. In contrast, in the south, where water use is highest, the least amount is available. There are three main reasons of variation in stream flow: i) The size of drainage basin (e.g., the Peace River Basin encompasses nearly 44% of total area of Alberta); ii) The location of headwater systems (the mountains and foothills receive more precipitation than do the plains); iii) The variation in climate (temperature is higher and evaporation greater in southeastern Alberta than in northern and western regions). Based on the hydrologic deviation by Alberta Environment (<http://www.environment.alberta.ca/apps/basins/default.aspx?Basin=12>), there are ten River Basins (RB) or River Sub-basins (RSB) in Alberta (Figure 1). These include:

Hay River Basin: the Hay River is located in the northwest portion of the province and originates in British Columbia's Rocky Mountains. It flows from

the Hay River eventually meet Arctic Ocean. The basin has a drainage area of 47,900 km² at the Alberta-Northwest Territories border. The mean annual discharge at the border is 3,630 million m³.

Peace River Basin: the Peace River begins in the mountains of British Columbia, and flows to Alberta. The W.A.C. Bennett Dam is located

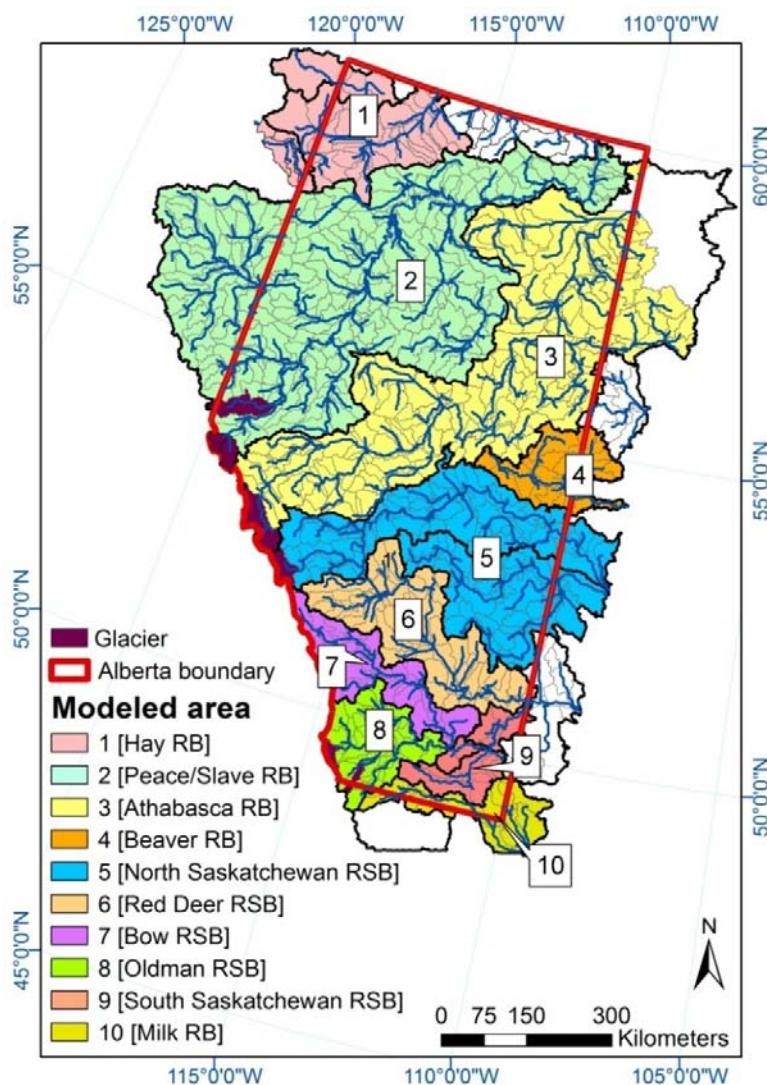


Figure 1. The modeled region of Alberta including main river basins/subbasins. The white area is the modeled subbasins which are not located within Alberta boundary.

on the Peace River in British and influences the stream flow in downstream.

The river flows northeast across the province, through the town of Peace River and empties into the Slave River. At Peace Point the Peace River has a mean annual discharge of 68,200 million m³ and a drainage area of 293,000 km². The Peace/Slave River Basin includes the Wapiti, Smoky, Little Smoky and Wabasca rivers.

Athabasca River Basin: the Athabasca River originates in the Rocky Mountains of Alberta. The river flows northeast through the province, past the urban centers of Jasper, Hinton, Whitecourt, Athabasca and Fort McMurray prior to emptying into Lake Athabasca. Flows from the basin eventually make their way to the Arctic Ocean. At Jasper, Athabasca and Fort McMurray the mean annual discharge is 2,790 million m³, 13,600 million m³ and 20,860 million m³, respectively. The drainage areas at Jasper, Athabasca and Fort McMurray are 3,880 km², 74,600 km² and 133,000 km² respectively. The Athabasca River Basin includes the McLeod, Pembina and Clearwater rivers.

Beaver River Basin: the Beaver River is one of the smaller basins within the province with a catchment area of about 14,500 km². The basin and river extend east, across the provinces of Saskatchewan and Manitoba, emptying into Hudson's Bay. The Beaver River begins at Beaver Lake, and then flows through urban centres of Bonnyville, Cold Lake and Grand Centre. The mean annual discharge of the Beaver River at the Alberta-Saskatchewan border is 653 million m³. The Cold Lake Area Weapons Range comprises the majority of the northern part of the basin. The basin is characterized by many meandering streams and rivers which drain such lakes as Cold, Moose, Muriel, Ethel and Wolf Lake.

North Saskatchewan River Basin: covers about 80,000 km² of the province.

The basin begins in the ice fields of Banff and Jasper National Parks and generally flows in an eastward direction to the Alberta-Saskatchewan border. The Brazeau, Nordegg, Ram, Clearwater, Sturgeon and Vermilion rivers flow into the North Saskatchewan River within Alberta. The Battle River also forms part of the North Saskatchewan Basin and joins with the North Saskatchewan River in Saskatchewan. There are two large dams located in the basin. The Big Horn Dam on the North Saskatchewan River creates Lake Abraham. The Brazeau Reservoir is created by the Brazeau Dam, located on the Brazeau River. Major centres within the basin include Drayton Valley, Edmonton, Fort Saskatchewan and the Saddle Lake Indian Reserve. The mean annual discharge from the basin in Alberta into Saskatchewan is over seven billion m³.

The Red Deer, Oldman and Bow River Subbasins: are part of South Saskatchewan River Basin; begin in the Rocky Mountains, generally flowing eastward through foothills and prairie. The combined watershed of the basins is 121,095 km², of which 41% is from the Red Deer sub-basin. The mean annual discharge from the combined basin into Saskatchewan is 9,280 million m³.

Milk River Basin: is the smallest of the province's major river basins encompassing an area of about 6,500 km². The river is a northern part of the Missouri-Mississippi River Basin. The Milk River enters Alberta from Montana, flows eastward through the southern portion of the province prior to looping back to Montana. Mean annual flows entering Alberta are 106 million m³ and leaving Alberta are 167 million m³.

The annual variation of water resources causes critical water supply licensing problems in the areas where water users have already been licensed to

withdraw a certain amount of the estimated mean annual flow volume. Total annual runoff from the high mountain regions varies little from year to year. The variation is large for Bow River from about 900 million m³ in 1949 to 160 million m³ in 1954. In contrast, total annual flow variation in the Battle River at Ponoka, a central plain stream, has ranged from 15 million m³ in 1976 to 260 million m³ in 1927. Located midway between these two, the Red Deer River, at Red Deer, which rises on the eastern slopes of the Rocky Mountains, has experienced a variation in total annual flow volume from less than 700 million m³ in 1949 to almost 4000 million m³ in 1915.

Seasonal variations also affect water supply. Spring melts and summer rains produce the great volumes of flow while drier fall weather and temporary storage of water in snow and ice during winter are reflected in low runoff patterns. This seasonal change in surface water flow varies across the province. Mountain-fed streams such as the Bow River generally experience greatest flows in June or July during the mountain snow melting period, while streams located in the plains usually peak in April. The Battle River is an example of the latter. The West Arrow wood and Sounding creeks respond almost entirely to an early spring melt.

2.3 Water use and water management

Aside from hydro power production (a very significant but non-consumptive use) there are five main water withdrawal (consumptive) uses in Alberta: agricultural, thermal power, municipal, industrial and water injection. In addition there are instream uses other than hydro, which include fisheries, recreation and effluent dilution. The total amount of water withdrawn by users is not fully consumed; some, such as sewage effluent, irrigation return flow and thermal cooling water is returned to the natural drainage system. For example, the total amount of surface water withdrawn by major water users in Alberta in 1989 was approximately 4700 million m³, while the total

volume consumed was 2600 million m³. The irrigation is the largest water user so far.

In addition to the sources of surface water, groundwater is an important component of Alberta's water resource. Practically every part of the province has groundwater, but aquifer depths, yields, and water potability vary. Aquifer discharge establishes the base flow of many rivers and streams, sustaining them during winter and other dry periods. Of all the water currently withdrawn in Alberta, only about 3% comes from the groundwater system. However, this relatively small volume is of vital importance, since a great many Albertans depend upon groundwater for their domestic water supply. Currently there are approximately 500,000 domestic wells in the province and about 7,000 are added each year. Figure 2 shows the percent of natural water flow which is allocated in each river basin. It is shown that in the central and southern part of Alberta water use is high and in some areas it is fully allocated for different sectors of uses.

Irrigation for agriculture is the largest user of water in Alberta, accounting for 60 to 65 per cent of all water consumed on average. In 2007, irrigation - including small, private irrigators - accounted for nearly 43% of allocated surface water, or more than 4.1 billion m³. It represents almost 73% of all water allocated in the South Saskatchewan River Basin. Thirteen organized irrigation districts collectively represent the largest amount of water allocated for a specific purpose in Alberta at over 3.5 billion m³ (Figure 3). The four largest districts account for 83% of total diversions.

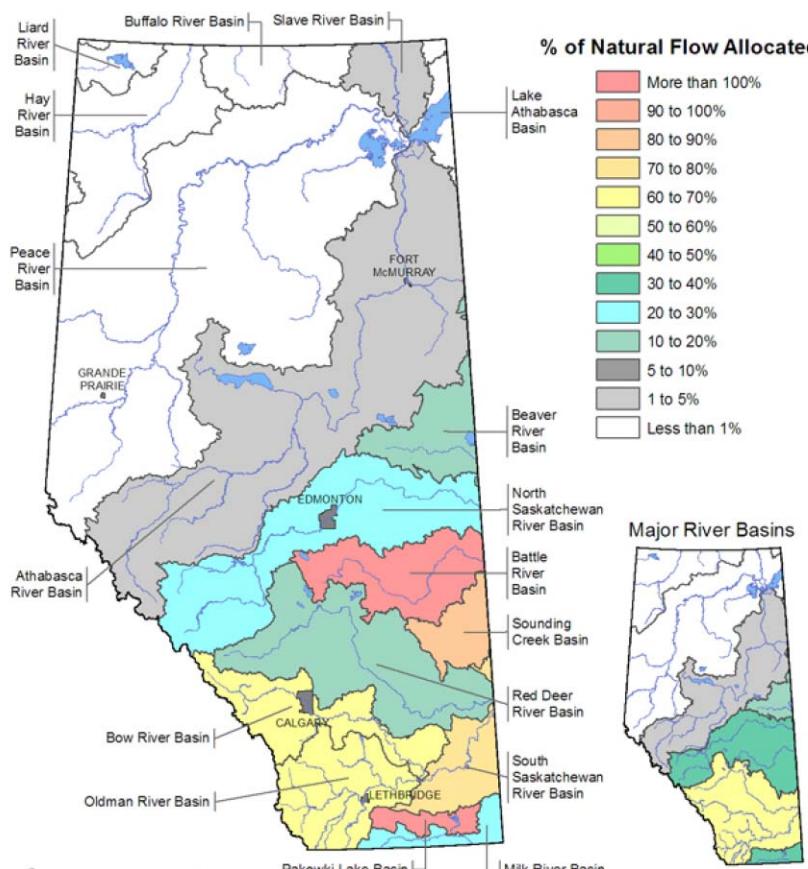


Figure 2. Water allocations in 2008 by river basins compared to average natural flow [Government of Alberta, Environment].

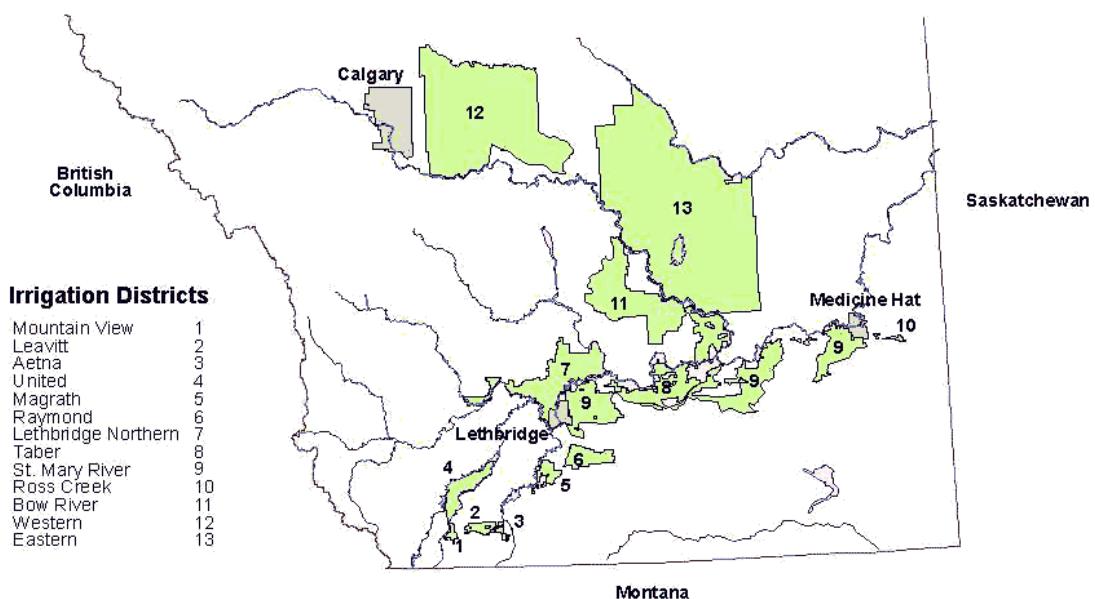


Figure 3. Thirteen organized irrigation districts in Alberta

Nearly all uses of water result in some water that is not returned back to the ecosystem from which it was derived. With irrigation, the majority of water applied to crops is taken up by plants for growth, or evapo-transpires into the atmosphere. Additionally, a small amount of water is never used for irrigation itself; however, it is required to maintain the minimum depth of water in canals and reservoirs in order to transport irrigation water through the system. Therefore, some of this water ends up as return flow back into other creeks and/or rivers, though seepage and evaporation losses in canals and reservoirs can occur.

In much of southern Alberta, there is not enough rainfall and moisture to naturally sustain agricultural crops. However, there is abundant sunshine and heat that can contribute to growing many different crops if water were not a limiting factor. Early in the settlement of Alberta, it was recognized that agriculture would not be successful in the southern region without an abundant and assured supply of water to irrigate fields. Irrigation Districts were organized and granted water licenses to divert large quantities of water from the tributaries of the South Saskatchewan River, primarily the Oldman (St. Mary, Waterton and Belly) and Bow Rivers [Alberta Water Portal, http://www.albertawater.com/index.php?option=com_content&view=article&id=84].

Numerous factors contribute to the complexity of water management, including conflict over water resources; adequacy of knowledge about existing programs, water uses, and water availability; and the nature and extent of stakeholder participation. The manmade changes on natural water systems have a significant impact, both spatially and temporally, on hydrological water balance of the region [Faramarzi et al., 2009]. Figure 4 shows the Alberta water management infrastructure and projects

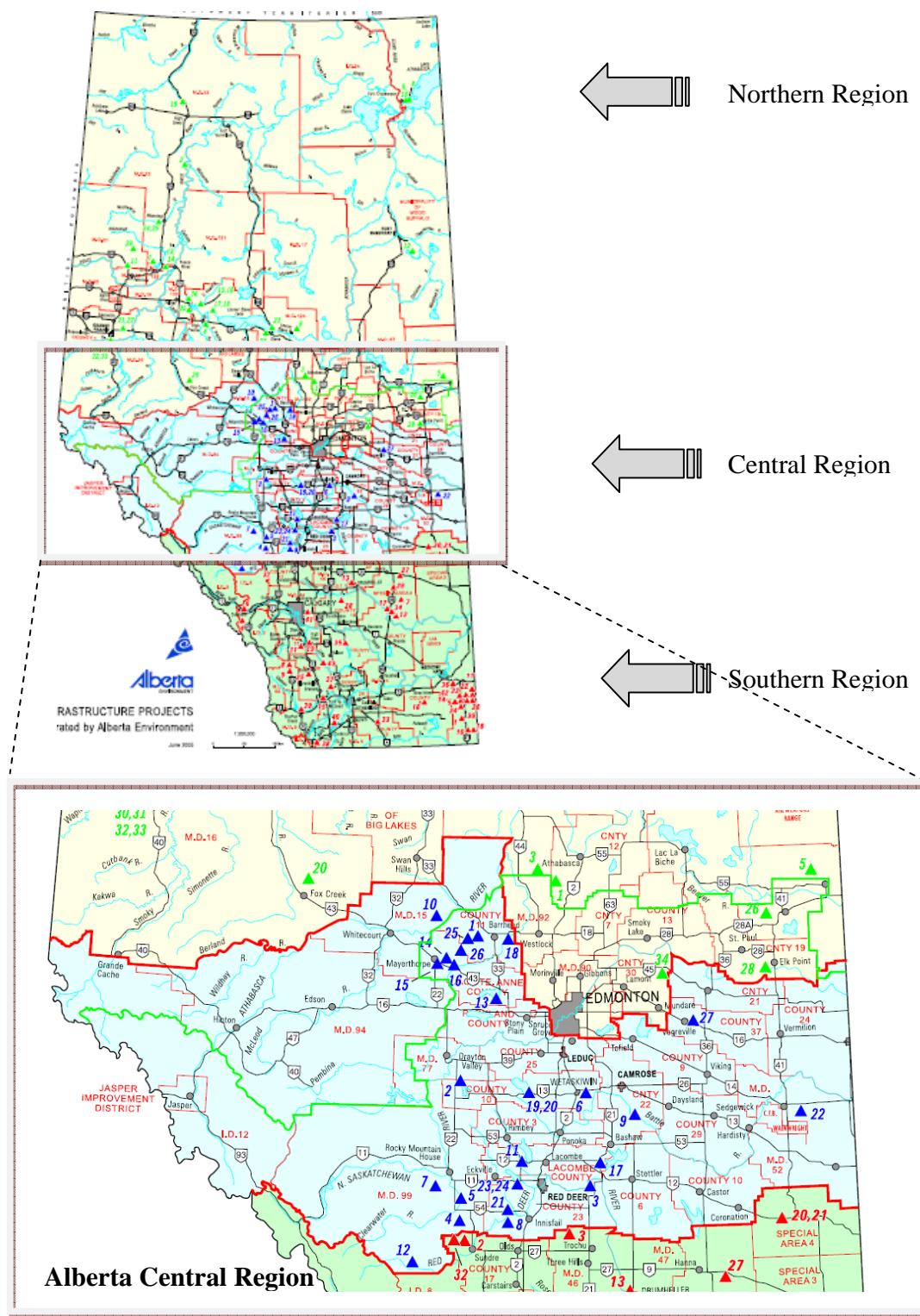


Figure 4. Major water management infrastructure projects in Alberta [owned and operated by Alberta Environment, 2005].

[<http://www3.gov.ab.ca/env/water/wmo/resources/maps.html>]. Table 1 shows the projects operating in Central Region of Alberta.

Table 1. List of the water projects which are operated by Alberta Environment within the Central Region

<http://www3.gov.ab.ca/env/water/wmo/resources/maps.html>

CENTRAL REGION		
LOCATION NUMBER	PROJECT NAME	TYPE OF STRUCTURE
1	Barrhead Water Supply	Weir
2	Buck Lake	Weir
3	Buffalo Lake Pumphouse / Pipeline	Pumphouse
4	Burntstick Lake	Weir
5	Clearwater River	Dykes
6	Coal Lake	Dam
7	Cow Lake Stabilization	Weir
8	Dickson Dam	Dam
9	Driedmeat Lake	Weir
10	Goose Lake	Weir
11	Gull Lake Pumphouse / Pipeline	Pumphouse
12	Klein Lake	Dam
13	Lac Ste. Anne	Weir
14	Little Paddle Dykes	Dykes
15	Paddle River Dam	Dam
16	Paddle River Dykes	Dykes
17	Parlby Cr. / Spotted L. / Alix L. Structure	Multiple
18	Pembina River Dykes	Dykes
19	Pigeon Lake - Creek	Ditch
20	Pigeon Lake - Weir	Weir
21	Red Deer River Erosion	Groynes
22	Ribstone Lake	Dam
23	Sylvan Lake Creek	Channel Improvement
24	Sylvan Lake Retaining Wall	Erosion Protection
25	Thunder Lake	Weir
26	Twin Lakes	3Backflood
27	Vermilion River – All Phases including Dam	Channel Improvement, Dam

2.4 Future climate change impact

It is reported that all dry regions of the world show an overall net negative impact of climate change on water resources and freshwater ecosystems. Decrease of runoff will likely result in reduction in the value of the services provided by water resources and the increase of annual runoff in other areas are likely to be tempered in some areas by negative effects of increased precipitation variability and seasonal runoff shifts on water supply, water quality and flood risks (IPCC, 2007). Increases in temperature can affect the amount and duration of snow cover which, in turn, can affect timing of streamflow. Glaciers are expected to continue retreating, and many small glaciers may disappear entirely. Peak streamflow may move from late spring to early spring/late winter in those areas where snowpack is important in determining water availability. Changes in streamflow have important implications for water and flood management, irrigation, and planning. If supplies are reduced, off-stream users of water such as irrigated agriculture and in-stream users such as hydropower, fisheries, recreation and navigation could be most directly affected. Canada, with a wide range of climate conditions is expected to face changes on both water quantity and quality. The earlier stream peak flow in spring [Whitefield and Cannon, 2000], Drought conditions in Prairie Provinces [Nyirfa and Harron, 2001], saltwater intrusion into estuarine groundwater [Forbes et al., 1997] are reported in Canada to be evidence of global climate change. It is of strategic importance for Canadian provinces to assess the impact of climate change on freshwater resources availability with a high spatial and temporal resolution model such as the one created here.

2.5 Project objectives

Numerous factors contribute to the complexity of water management, including conflict over water resources; inadequacy of knowledge about

existing programs, water uses, and water availability; and the nature and extent of stakeholder participation.

The main objective of this project is the quantification of Alberta's water resources including all components of the water balance at the subbasin spatial and monthly temporal scale. This includes blue water flow (river discharge plus deep aquifer recharge), green water flow (evapotranspiration), green water storage (soil moisture), and aquifer recharge as shown in Figure 5.

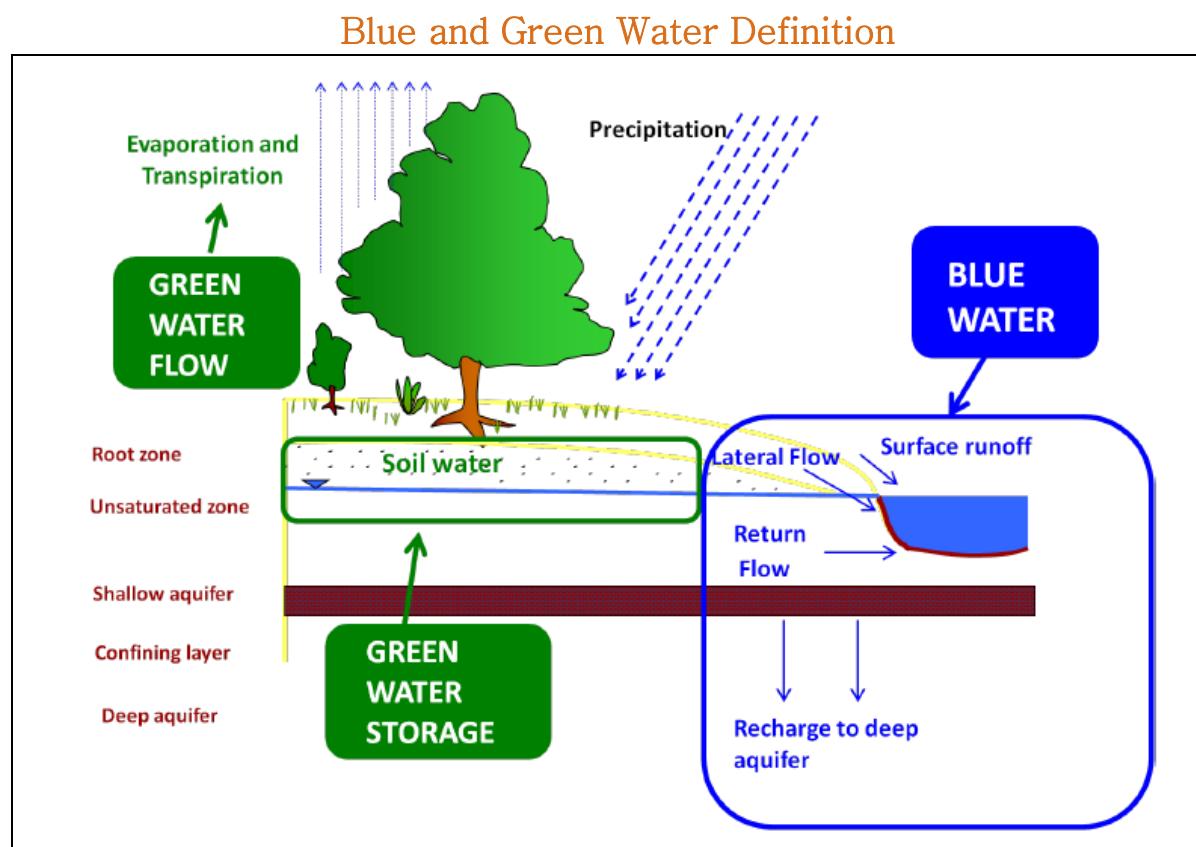


Figure 5. Definition of water balance components including blue water flow, green water flow, and green water storage.

3. Methodology

To model Alberta's water resources we used the hydrologic model Soil and Water Assessment Tool (SWAT) [Arnold et al., 1998] in combination with the Sequential Uncertainty Fitting program (SUFI-2) [Abbaspour 2007, Abbaspour et al., 2007] to calibrate, validate, and perform uncertainty analysis based on the available measured river discharge data. The modeled region of Alberta is shown in Figure 1.

3.1 The SWAT simulator

SWAT is a computationally efficient simulator of hydrology and water quality at various scales. It is a mechanistic time-continuous model that can handle very large watersheds in a data efficient manner. The model is already used in the "Hydrologic Unit Model for the United States" (HUMUS) [Arnold et al., 1999; Srinivasan et al., 1998], where the entire U.S. was simulated with good results for river discharges at around 6000 gauging stations. This study is now extended within the national assessment of the USDA Conservation Effects Assessment Project (CEAP, <http://www.nrcs.usda.gov/Technical/nri/ceap/ceapgeneralfact.pdf>). A more recent large scale SWAT application included the work of Gosain et al., [2006] where twelve large river basins in India were modelled with the purpose of quantifying the climate change impact on hydrology. SWAT is recognized by the U.S. Environmental Protection Agency (EPA) and has been incorporated into the EPA's BASINS (Better Assessment Science Integrating Point and Non-point Sources) [Di Luzio et al., 2002]. We used SWAT to model the whole of Africa [Schuel et al., 2008a,b], and the country of Iran [Faramarzi et al., 2009] as well as smaller watershed in Switzerland [Abbaspour et al., 2007] and China [Yang et al., 2008].

SWAT is developed to quantify the impact of land management practices on water, sediment and agricultural chemical yields in large complex watersheds with varying soils, land uses, and management conditions over long periods of time. The main components of SWAT are hydrology, climate, nutrient cycling, soil temperature, sediment movement, crop growth, agricultural management, and pesticide dynamics. In this study, we used Arc-SWAT [Olivera et al., 2006], where ArcGIS (ver. 9.3) environment is used for project development.

Spatial parameterization of the SWAT model is performed by dividing the watershed into subbasins based on topography. These are further subdivided into a series of hydrologic response units (HRU), based on unique elevation, soil, landuse, and slope characteristics. The responses of each HRU in terms of water and nutrient transformations and losses are determined individually, aggregated at the subbasin level and routed to the associated reach and catchment outlet through the channel network. SWAT represents the local water balance through four storage volumes: snow, soil profile (0–2 m), shallow aquifer (2–20 m) and deep aquifer (>20 m). The soil water balance equation is the basis of hydrological modeling. The simulated processes include surface runoff, infiltration, evaporation, plant water uptake, lateral flow, and percolation to shallow and deep aquifers. Surface runoff is estimated by SCS curve number equation using daily precipitation data based on soil hydrologic group, land use/land cover characteristics and antecedent soil moisture.

In this study, potential evapotranspiration (PET) was simulated using Hargreaves method (Hargreaves et al., 1985). Actual evapotranspiration (AET) was predicted based on the methodology developed by Ritchie [1972]. The daily value of the leaf area index (LAI) was used to partition the PET

into potential soil evaporation and potential plant transpiration. LAI and root development were simulated using the "crop growth" component of SWAT. This component represents the interrelation between vegetation and hydrologic balance. A more detailed description of the model is given by Neitsch et al. [2002].

3.2 The calibration program SUFI-2

The program SUFI-2 [Abbaspour 2007; Abbaspour et al., 2007; Abbaspour et al., 2004] was used for a combined calibration and uncertainty analysis. In any (hydrological) modeling work there are uncertainties in input (e.g., rainfall), in conceptual model (e.g., by process simplification or by ignoring important processes), in model parameters (non-uniqueness) and in the measured data (e.g., discharge used for calibration). SUFI-2 maps the aggregated uncertainties to the parameters and aims to obtain the smallest parameter uncertainty (ranges). The parameter uncertainty leads to uncertainty in the output which is quantified by the 95% prediction uncertainty (95PPU) calculated at the 2.5% (L95PPU) and the 97.5% (U95PPU) levels of the cumulative distribution obtained through Latin hypercube sampling. Starting with large but physically meaningful parameter ranges that bracket 'most' of the measured data within the 95PPU, SUFI-2 decreases the parameter uncertainties iteratively. After each iteration, new and narrower parameter uncertainties are calculated [see Abbaspour 2007] where the more sensitive parameters find a larger uncertainty reduction than the less sensitive parameters. In deterministic simulations, output (i.e., river discharge) is a signal and can be compared to a measured signal using indices such as R^2 , root mean square error, or Nash-Sutcliffe, NS . In stochastic simulations where predicted output is given by a prediction uncertainty band instead of a signal, we devised two different indices to compare measurement to simulation: the *P-factor* and the *R-factor*.

[Abbaspour 2007; Abbaspour et al., 2004]. These indices were used to gauge the strength of calibration and uncertainty measures. The *P-factor* is the percentage of measured data bracketed by the 95PPU. As all correct processes and model inputs are reflected in the observations, the degree to which they are bracketed in the 95PPU indicates the degree to which the model uncertainties are being accounted for. The maximum value for the *P-factor* is 100%, and ideally we would like to bracket all measured data, except the outliers, in the 95PPU band. The *R-factor* is calculated as the ratio between the average thickness of the 95PPU band and the standard deviation of the measured data. It represents the width of the uncertainty interval and should be as small as possible. *R-factor* indicates the strength of the calibration and should be close to or smaller than a practical value of 1. As a larger *P-factor* can be found at the expense of a larger *R-factor*, often a tradeoff between the two must be sought.

3.3 The calibration setup and analysis

Sensitivity, calibration, validation, and uncertainty analysis were performed for the hydrology using river discharge. As SWAT model involve a large number of parameters, a sensitivity analysis was essential to identify the key parameters across different hydrologic regions. For the sensitivity analysis, 22 parameters integrally related to stream flow [Liu et al., 2008; Levesque et al., 2008; Holvoet et al., 2005; White and Chaubey, 2005; Abbaspour et al., 2007a, Faramarzi et al., 2009] were initially selected (Table 2). We refer to these as the 'global' parameters. In a second step, these global parameters were further differentiated by main river basins in order to account for spatial variation in climate and management conditions (i.e., SCS curve number CN2 of agricultural areas was assigned differently in Beaver River Basin from that of Milk River Basin areas). This resulted in 102 scaled parameters.

As different calibration procedures produce different parameter sets (Abbaspour et al., 1999; Abbaspour et al., 2007a; Schuol et al., 2008b; Yang et al., 2008), we used two different approaches here for comparison of observed and simulated discharge data to provide more confidence in the results. These include: (i) the “global approach”, where all discharge gauges from all river basins were calibrated within a single calibration framework, (ii) the “regional approach”, where discharge gauges were separately calibrated for different water regions. Based on the deviation presented in Figure 1, we considered six major water regions for the regional calibration and did not consider the “River Sub Basins (RSB)” as a single water region.

The six calibrated water regions were:

- RB1 and RB2 (for RB 1 we did not have any discharge data)
- RB 3
- RB 4
- RB 5
- RB 6, 7, 8, and 9
- RB 10

4. Input data

SWAT can run on different ranges of data availability. Clearly, the more the input data the better will be the output results. Table 3 summarizes a list of essential and optional SWAT data requirement. The status of data availability is also indicated in Table 3. The preliminary results are based on the data indicated in the Table. Figures 6 to 10 show spatial distribution of the land use classes, soil types, climate stations, river discharge stations and CRU raster climate points used in this study.

Table 2. Sensitive input parameters in the calibration processes

Parameter Name	Definition
SURLAG.bsn	Surface runoff lag time (days)
SMTMP.bsn	Snow melt base temperature ($^{\circ}\text{C}$)
SFTMP.bsn	Snowfall temperature ($^{\circ}\text{C}$)
SMFMN.bsn	Minimum melt rate for snow during the year (mm/ $^{\circ}\text{C}$ -day)
TIMP.bsn	Snow pack temperature lag factor
CN2.mgt	SCS runoff curve number for moisture condition II
ALPHA_BF.gw	Base flow alpha factor (days)
REVAPMN.gw	Threshold depth of water in the shallow aquifer for 'revap' to occur (mm)
GW_DELAY.gw	Groundwater delay time (days)
GW_REVAP.gw	Groundwater revap. coefficient
GWQMN.gw	Threshold depth of water in the shallow aquifer required for return flow to occur (mm)
RCHRG_DP.gw	Deep aquifer percolation fraction
ESCO.hru	Soil evaporation compensation factor
SOL_AWC.sol	Soil available water storage capacity (mm H ₂ O/mm soil)
SOL_K.sol	Soil conductivity (mm/hr)
SOL_BD.sol	Soil bulk density (g/cm ³)
SMFMX.bsn	Maximum melt rate for snow during the year (mm/ $^{\circ}\text{C}$ -day)
EPCO.hru	Plant uptake compensation factor
OV_N.hrul	Manning's n value for overland flow
SOL_ALB.sol	Moist soil albedo
CH_N2.rte	Manning's n value for main channel
CH_K2.rte	Effective hydraulic conductivity in the main channel (mm/hr)

Table 3. Data requirement of SWAT

Data name	Required information
DEM	- we are using 90m x 90m resolution data from: ESRI Global Digital Elevation Model (SRTM)
Landuse	- we are using 250 m resolution data from: Natural Resources Canada - NRCAN's EOSD data - Earth Observation for Sustainable Development. This is augmented for areas surrounding Alberta with 1000 m resolution data from global database
Soil	- we are using the data from Agriculture Canada or CANSIS - Canadian Soils Inventory System and some data from Agriculture Canada found under the Canadian Geography Networks Arc Voyager's ArcIMS site. The spatial resolution is 1:250000. For the Alberta surrounding area we used the FAO global soil map. We have created an associated database containing the following variables needed for SWAT simulations: <ul style="list-style-type: none"> - Two soil layers (0-30 cm, 30-100 cm) - Soil Hydrologic group (A, B, C, or D) - Maximum rooting depth (mm) - Textural class of first soil layer - Depth from soil surface to bottom of each layer (mm) - Moist bulk density (g/cm^3) - Available water capacity (mm H₂O/mm soil) - Saturated hydraulic conductivity (mm/hr) - Organic carbon content (% soil weight) - Clay content (% soil weight) - Silt content (% soil weight) - Sand content (% soil weight) - Rock fragment content (% total weight) - Moist soil albedo - Soil erodibility factor, K, in USLE equation
Stream network map	- missing We would like to have a river map with river names
Climate data	1- we bought a CD from: http://climate.weatheroffice.ec.gc.ca/prods_servs/documentation_index_e.html The database is sparse in northern Alberta The data base includes: <ul style="list-style-type: none"> - Daily precipitation (mm) for the period of 1985 to 2007

	<ul style="list-style-type: none"> - Daily Max temperature (degree C.) for the period of 1985 to 2007 - Daily Min temperature (degree C.) for the period of 1985 to 2007 - Location (lat, long, elevation) of the climate stations <p>2. we downloaded the raster data from http://www.cru.uea.ac.uk/cru/data These are gridded climate database (0.5 degree) CRU TS3.0 and include:</p> <ul style="list-style-type: none"> - Daily precipitation (mm) for the period of 1985 to 2006 - Daily Max temperature (degree C.) for the period of 1985 to 2006 - Daily Min temperature (degree C.) for the period of 1985 to 2006 - Location (lat, long, elevation) of the climate stations
Reservoir operation information	<ul style="list-style-type: none"> - missing <p>We would need information on the location of dams and reservoirs and their operations as follows:</p> <ul style="list-style-type: none"> - Month the reservoir became operational (0-12) - Reservoir surface area when the reservoir is filled to the emergency spillway (ha) - Volume of water needed to fill the reservoir to the emergency spillway (10^4 m³) - Reservoir surface area when the reservoir is filled to the principal spillway (ha) - Volume of water needed to fill the reservoir to the principal spillway (10^4 m³) - Initial reservoir volume. - Initial sediment concentration in the reservoir (mg/L) - Equilibrium sediment concentration in the reservoir (mg/L) - Hydraulic conductivity of the reservoir bottom (mm/hr) - Daily reservoir outflow (m³/s).
Inlet	<ul style="list-style-type: none"> - missing - Lat and long for any inlet to the watershed is required - daily data for any inlet (optional)
Agricultural management data	<ul style="list-style-type: none"> - missing - Planting and harvest dates - Fertilization information (when, where, how much) - Tillage operation (method, date) - Irrigation (source, date, amount) - Grazing - Tile drains (exists or not, if yes, at what depth) - Pesticide application - Crop rotation

Water management	<ul style="list-style-type: none"> - missing - Water transfer information, water use from shallow and deep aquifer, river, and ponds
River discharge data at hydrometric stations	<ul style="list-style-type: none"> - have daily river discharge (m^3/s) data for 167 stations. However, some are given in terms of water height rather than discharge; some are controlled by dams and reservoirs, and some by glaciers. Need to know this information but we currently don't have them. Source: <p>http://www.wsc.ec.gc.ca/hydat/H2O/index_e.cfm</p>
Crop yield data	<ul style="list-style-type: none"> - missing Need: - Annual yield for major crops in the region
Water quality at hydrometric stations (if water quality is required)	<ul style="list-style-type: none"> - missing <p>This data would be needed for water quality studies. Needed data are some or all of the following depending on the objectives:</p> <ul style="list-style-type: none"> - Sediment load transported by the river (daily, or monthly) (tn), or - River sediment concentration (mg/l) - Nitrate load transported by the river (kg N) - Phosphorus load transported by the river (Kg P) - Dissolved oxygen transported by the river (kg O₂) - Algal biomass transported by river (kg) - Other chemicals such as: NH₄, NO₂, Mineral P, organic P, Organic N, CBOD are also considered by SWAT
Point sources	<ul style="list-style-type: none"> - missing - Input from water treatment plants (quantity and quality of water) - Lat-Lon location - Springs (quantity and quality, and also Lat-Long location)

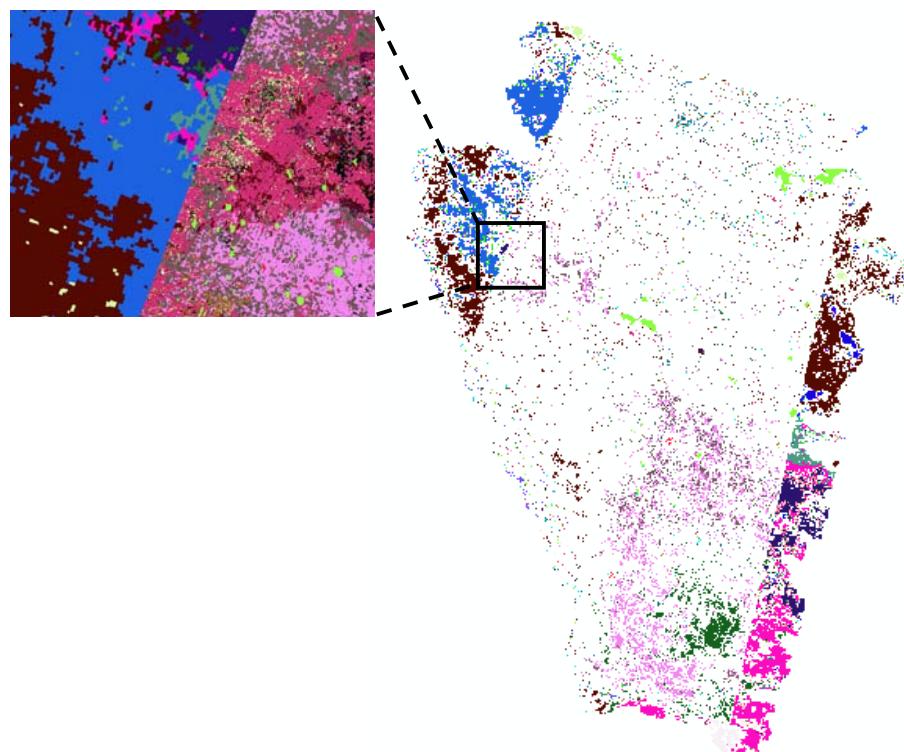


Figure 6. Landuse map of Alberta (250 m resolution) and surrounding areas (1000 m resolution).

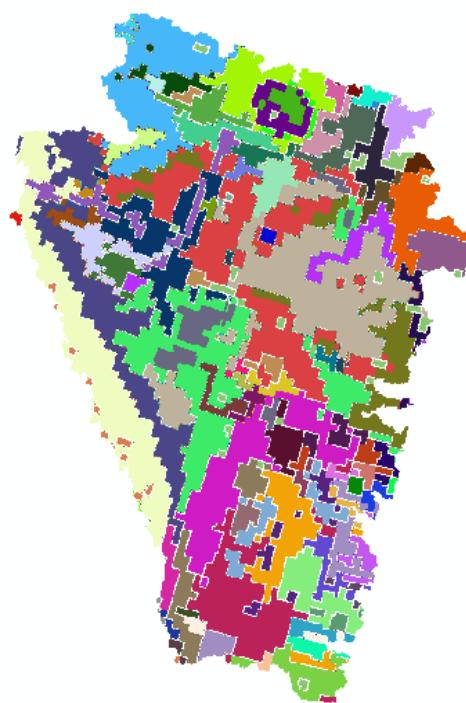


Figure 7. Soil map of Alberta (1000 m resolution).

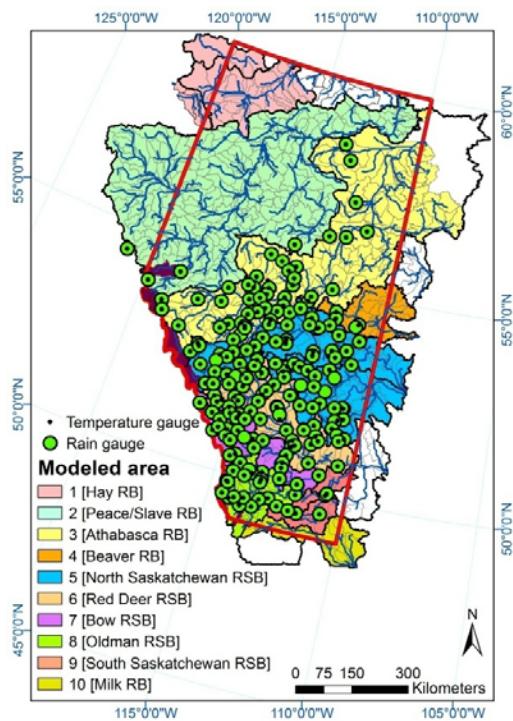


Figure 8. Distribution of observed temperature and precipitation stations.

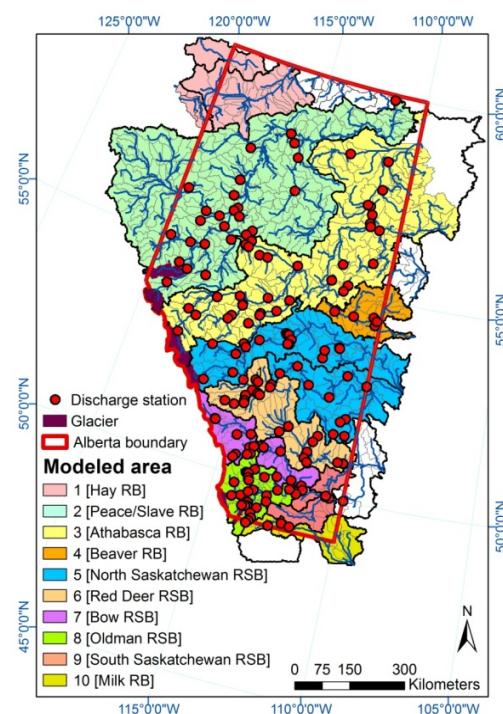


Figure 9. Distribution of the 167 outlets used in the initial run.

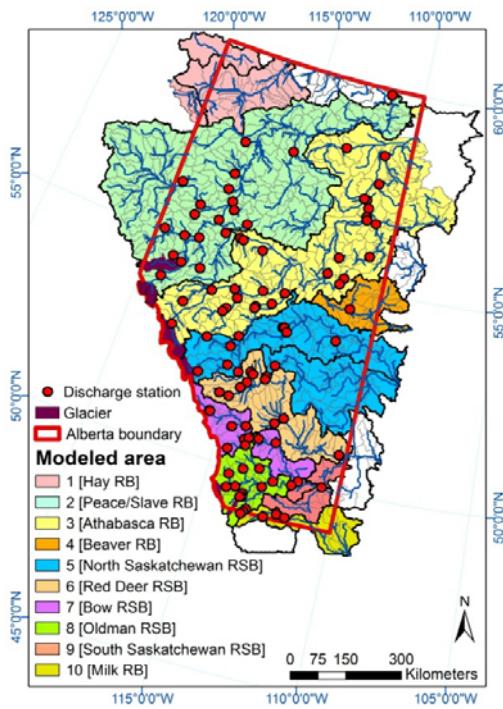


Figure 10. Distribution of the 101 outlets used in the initial run

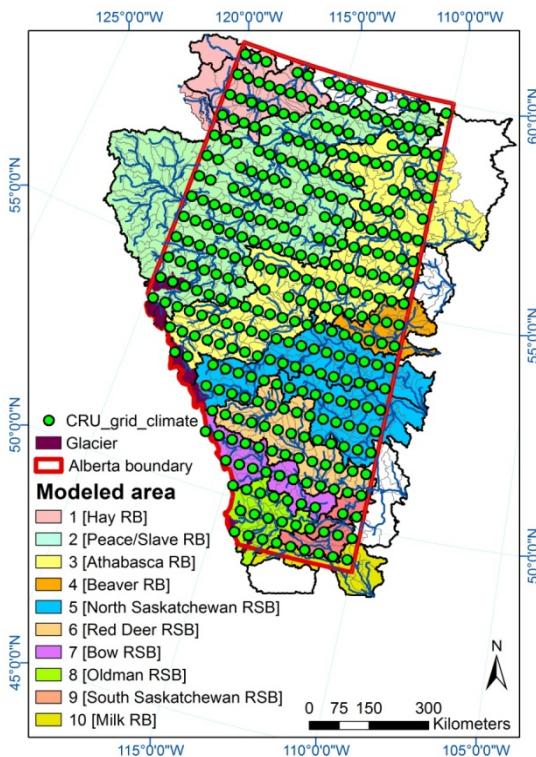


Figure 11. Distribution of the gridded climate points with 0.5 degree resolution from CRU providing daily precipitation and maximum and minimum daily temperature data for the entire Alberta.

5. Preliminary results

To calibrate and validate the hydrologic model, we started with one first run to get an indication of the model performance and observed discharge stations to be used for calibration. The results show that many stations are:

- small creeks
- under the influence of reservoirs, dams and glaciers,
- some stations are not properly placed on the correct river or stream (a river map with river names would be useful to identify these stations), and
- some have only reported water heights and no discharge numbers

After identifying and properly accounting for this, we calibrated in the next step using the discharge data of 101 stations (Figure 10) rather than 167 (Figure 9). Examples of discharge stations under the influence of dam, reservoir, Glacier, consumptive water use, water transfer, or wrong data (water height instead of discharge) are presented in Figures 12 to 14. Figure 15 shows a station located downstream of a dam, Figure 16 shows a station located in a small creek. To calibrate the former we need to know dam's operation while the data from the small creek is not reliable. Performance of these stations cannot be improved by calibration unless we know the exact nature of the observed discharge.

Figure 17 shows example of stations that can be improved by calibration. Because, the first run shows a rather good prediction in terms of BR^2 and P -factor but the R -factor (a measure of uncertainty) has to be decreased through parameter optimization in the next calibration iterations.

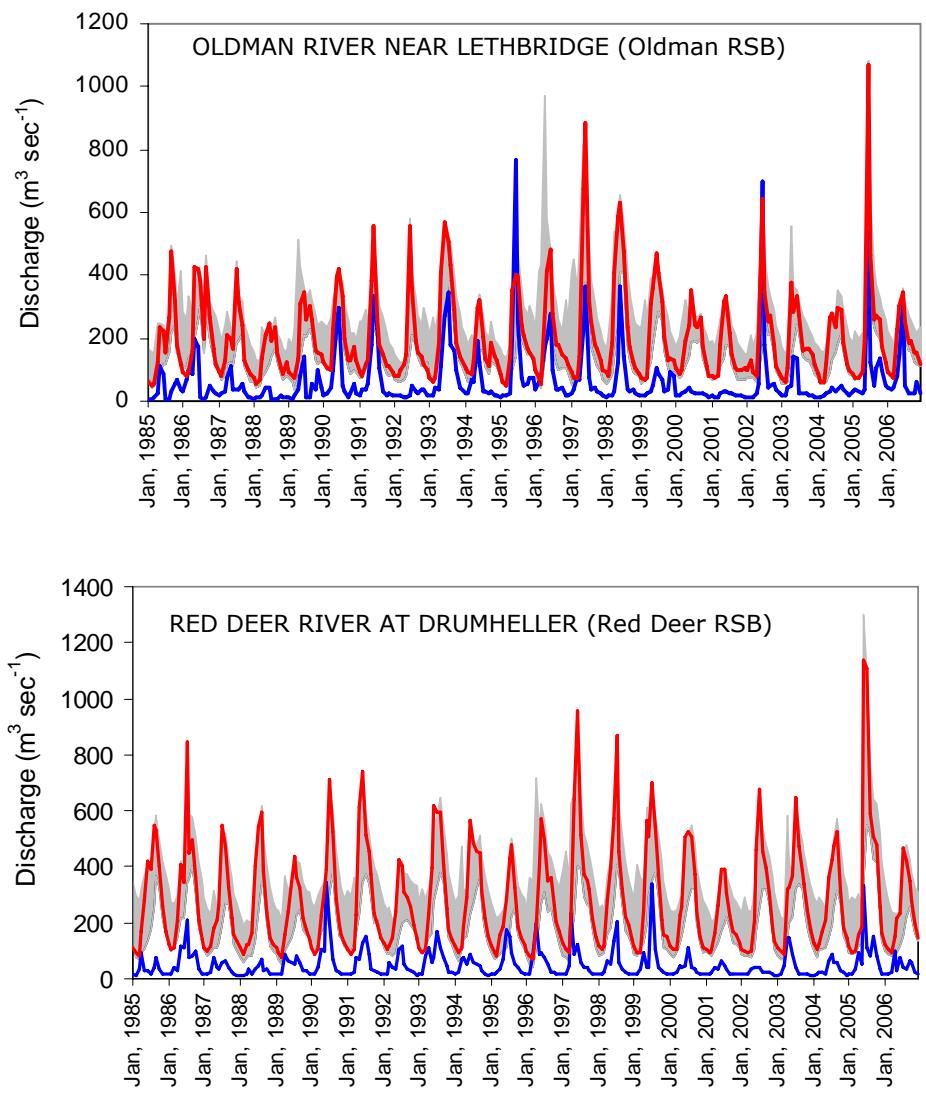


Figure 12. Example of stations that could not benefit from calibration and most likely is affected by a dam or reservoir or water extract from upstream.

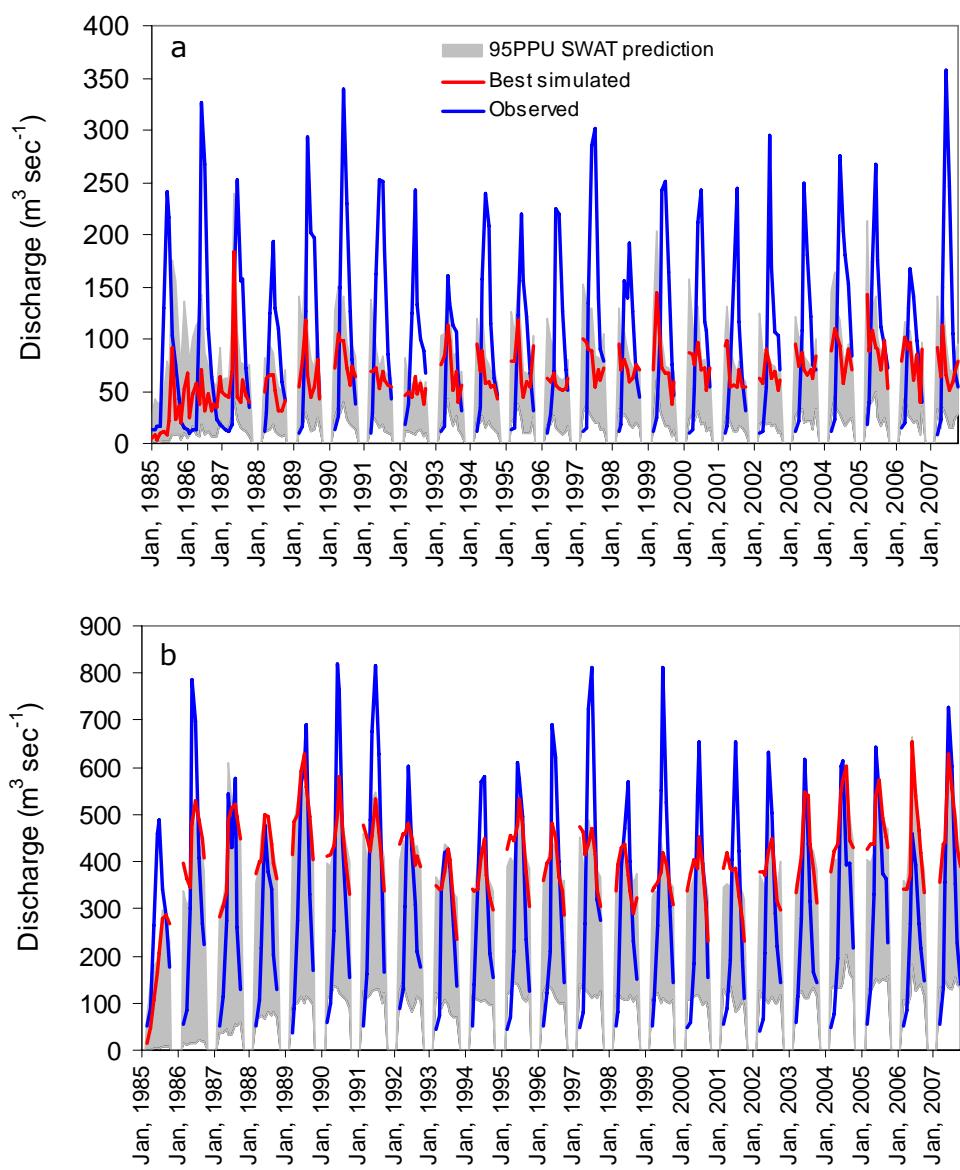


Figure 13. Example of stations that are affected by glaciers at upstream. The glaciers have additional input to the rivers. We modified this in SWAT model.

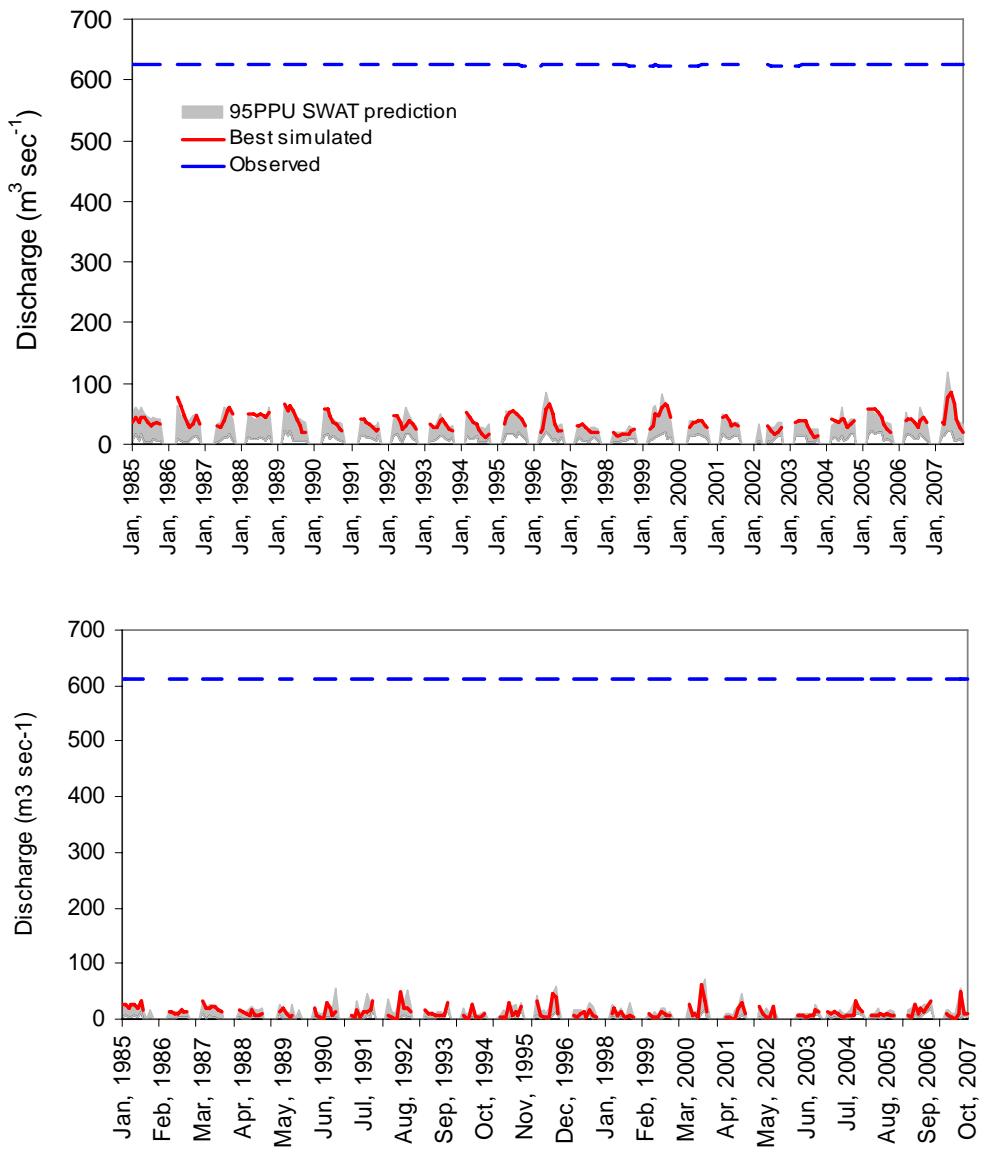


Figure 14. Example of stations where we have water heights instead of discharges. We need to obtain discharges, or remove them from calibration process.

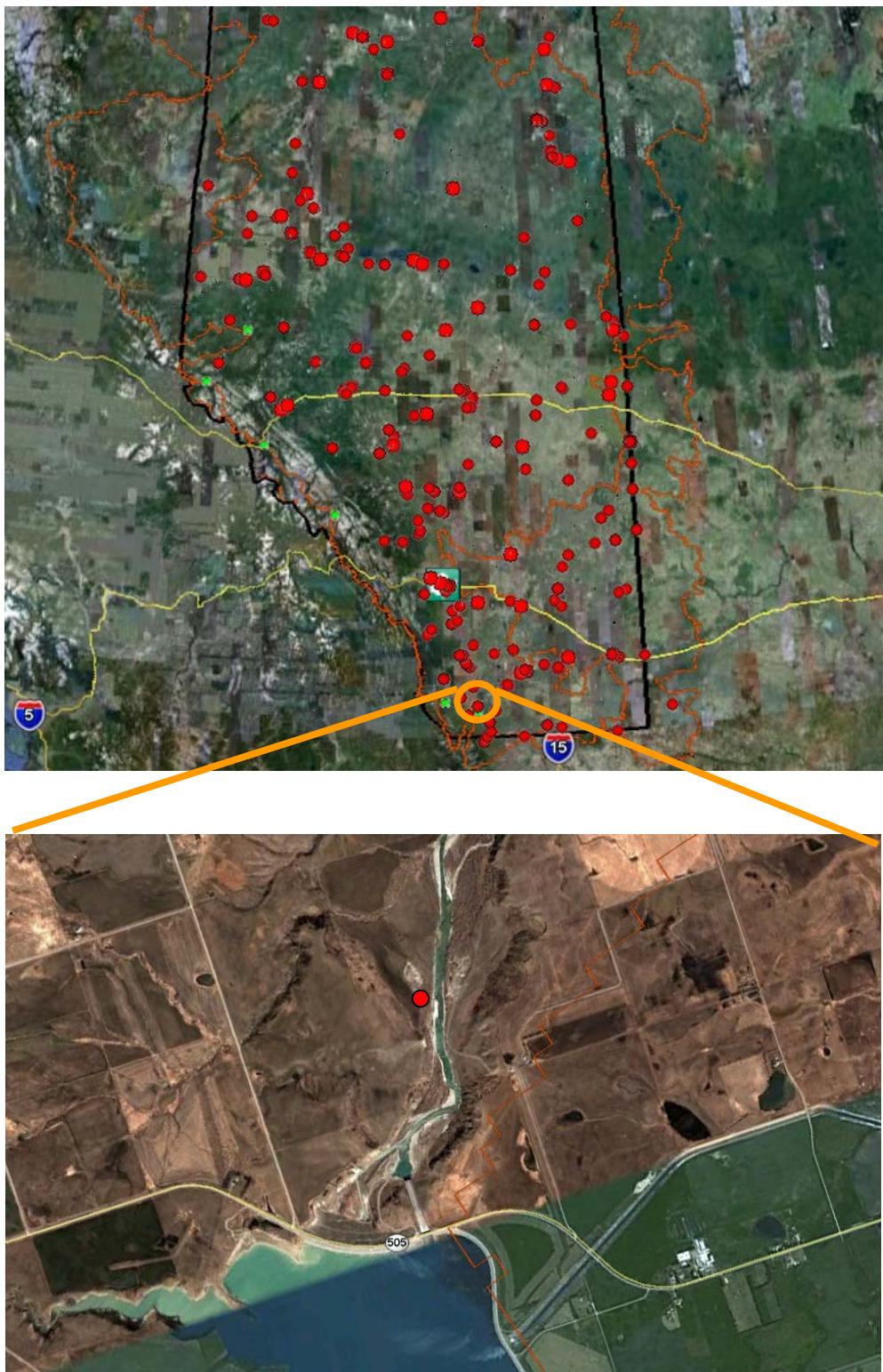


Figure 15. Example of stations located downstream of a dam. To calibrate this station we need to know the dam's operation



Figure 16. Example of a discharge station located in a small creek. The data from these stations are not reliable

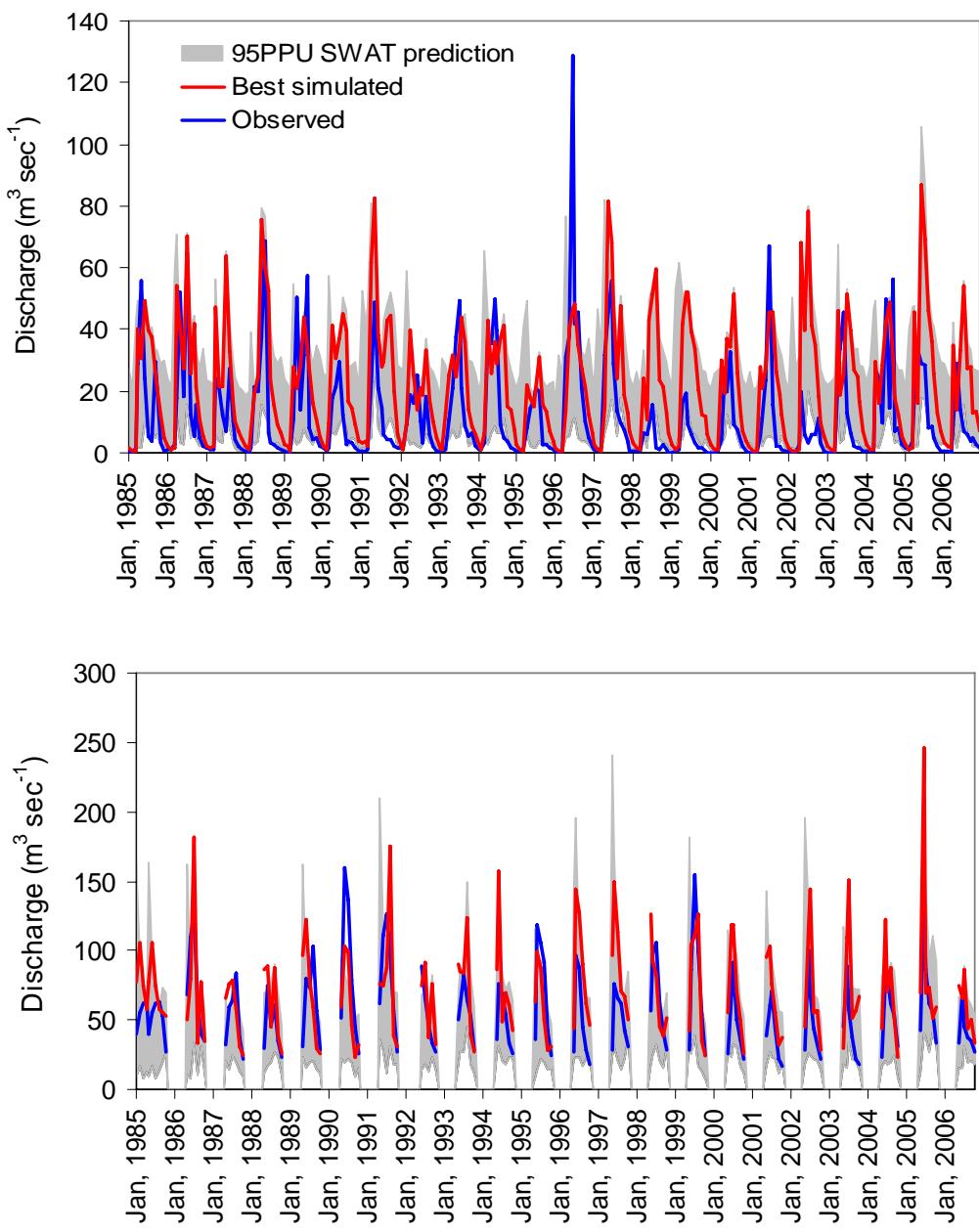


Figure 17. Example of a stations that could be improved with calibration.

6. Final results

6.1 Final results using the observed climate data as input to the SWAT model

Using the observed climate data of 194 rain gauge and 189 temperature gauges as input in the SWAT model (Figure 8), the calibration results for 101 discharge stations produced a poor performance as presented in Table 3. In general, we started with a rather wide initial range of parameter values for each water region and tried to narrow this uncertainty in the next calibration iterations. All water regions performed poor in terms of goal function and R^2 . The initial *P-factor* was in general satisfactory but attempt to narrow uncertainty band while improving goal function, resulted in quite small percentage of observed data bracketed within uncertainty band (i.e. in average for the whole Alberta the P-factor was 0.17, at final stage of calibration procedure). To improve the calibration performance in some stations which were likely affected by glaciers, we considered additional water inflow using “inlet” option in the model. Figure 18 shows how the calibration performance was improved in a downstream station of a glacier in the model (namely “Athabasca River near Windfall” station, Figure 19). In this station, the calibration performance was improved from 0.45 to 0.63 for *P-factor*, from 1.47 to 1.43 for *R-factor*, from 0.17 to 0.80 for R^2 and from 0.02 to 0.66 for goal function (bR^2).

Table 3. Calibration performance of different water regions while using observed climate data as input in the SWAT model.

River basin/subbasin	<i>P-factor</i>		<i>R-factor</i>		R^2		Goal function	
	initial	Final	initial	Final	initial	Final	initial	Final
Hay & Peace/Slave RB	0.46	0.16	4.40	1.70	0.09	0.08	0.07	0.08
Athabasca RB	0.61	0.27	4.46	2.56	0.04	0.06	0.02	0.03
Beaver RB	0.51	0.18	4.62	2.75	0.06	0.07	0.02	0.03
North Saskatchewan RSB	0.37	0.08	19.37	7.38	0.04	0.05	0.03	0.05
Red Deer, Bow, South Sas., Oldman RSB	0.48	0.23	4.93	2.95	0.07	0.11	0.04	0.05
Milk RB	0.20	0.11	79.04	56.73	0.11	0.14	0.09	0.12

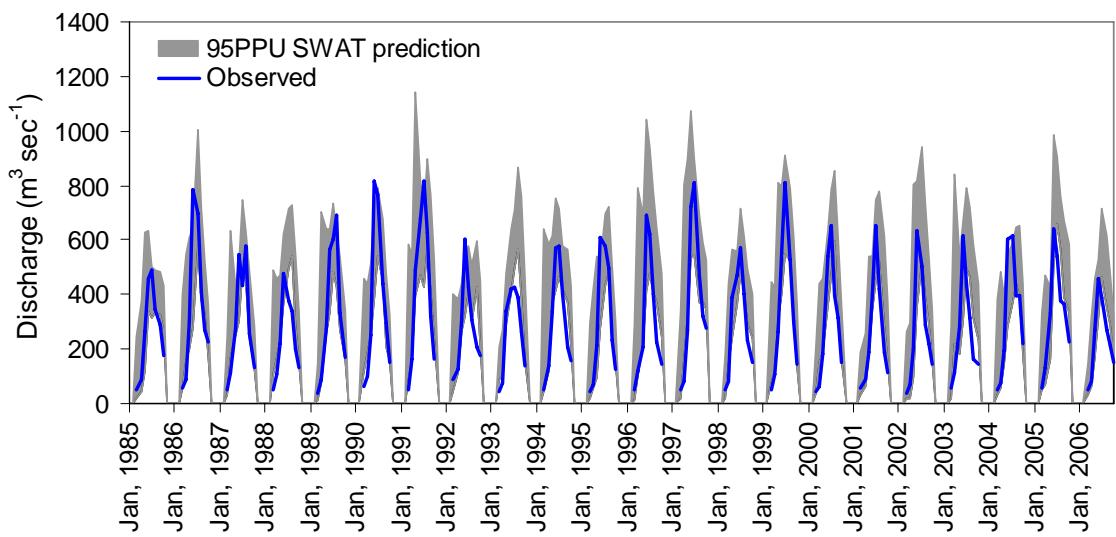


Figure 18. Calibration performance of the “Athabasca River near Windfall” station that was improved compare to its performance with the initial model setup where the effect of glacier did not considered (Figure 13b).

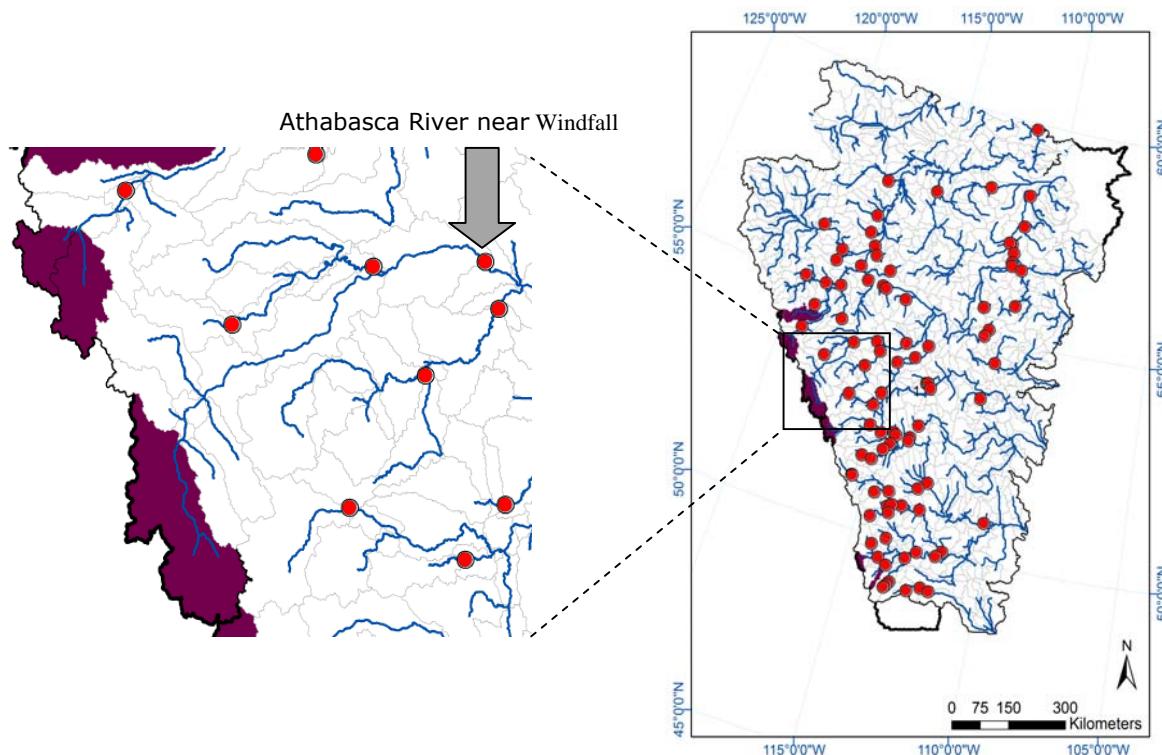


Figure 19. Athabasca River near Windfall station, located at downstream side of a glacier.

Using the optimized parameter ranges we further intended to calculate the long-term average hydrological components at subbasin level to be able to compare the results with improved input data in the next phase. Figures 20 to 24 show different hydrological components of Alberta resulted from this phase of the analysis.

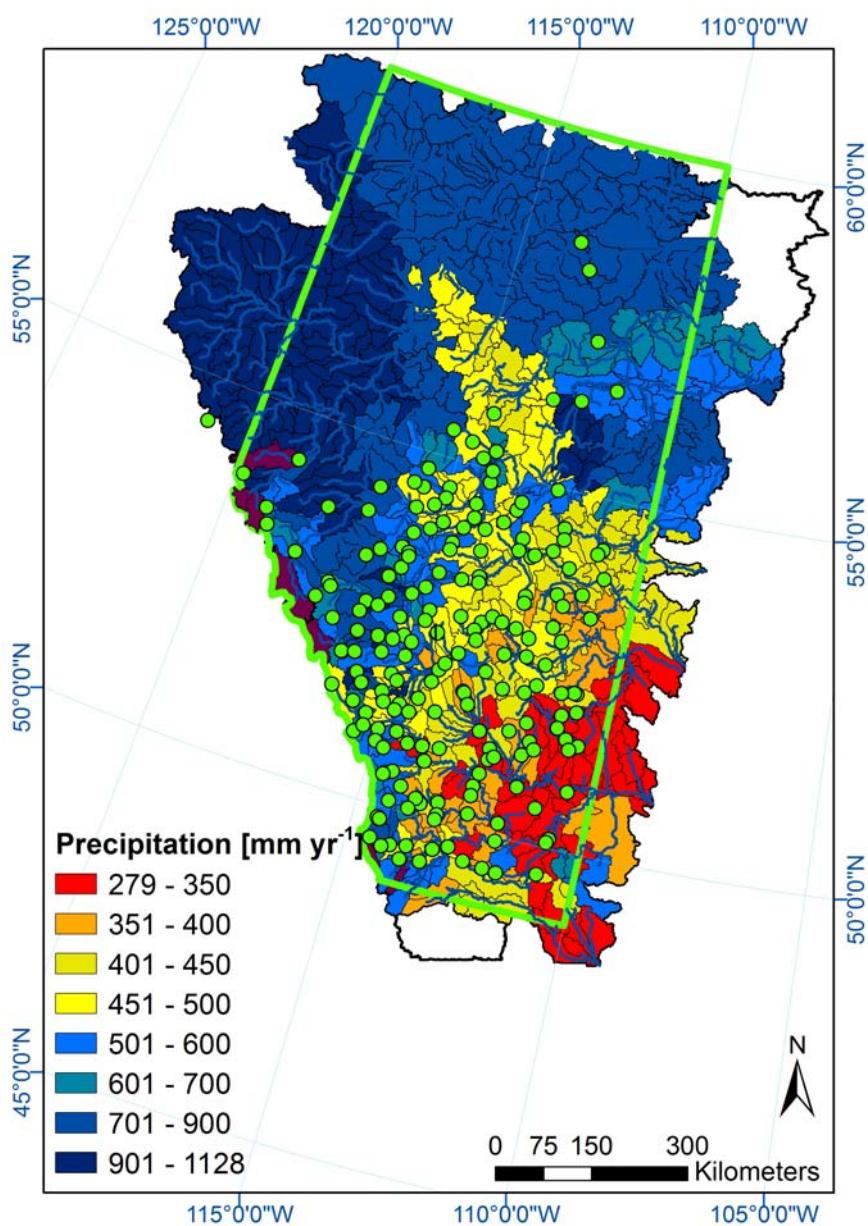


Figure 20. Long term (1985-2007) average distribution of precipitation.

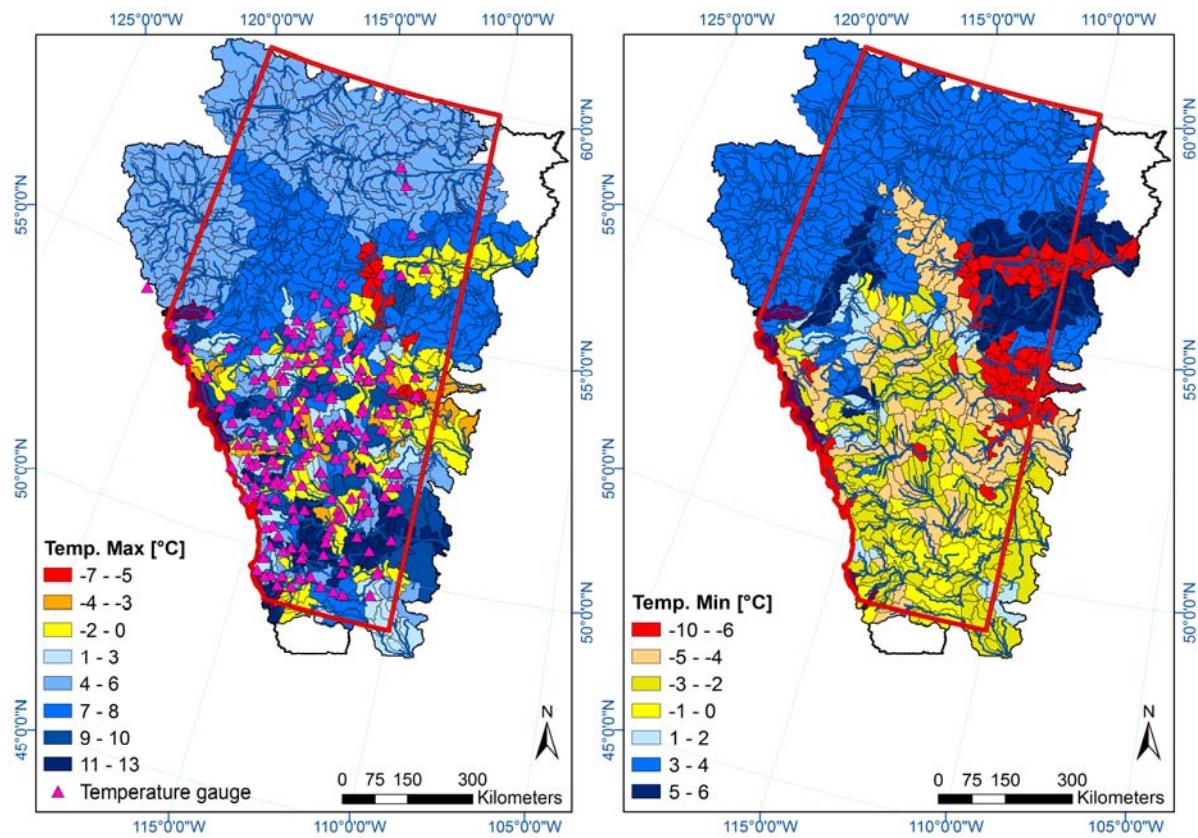


Figure 21. Long term (1985-2007) average distribution of maximum and minimum temperature.

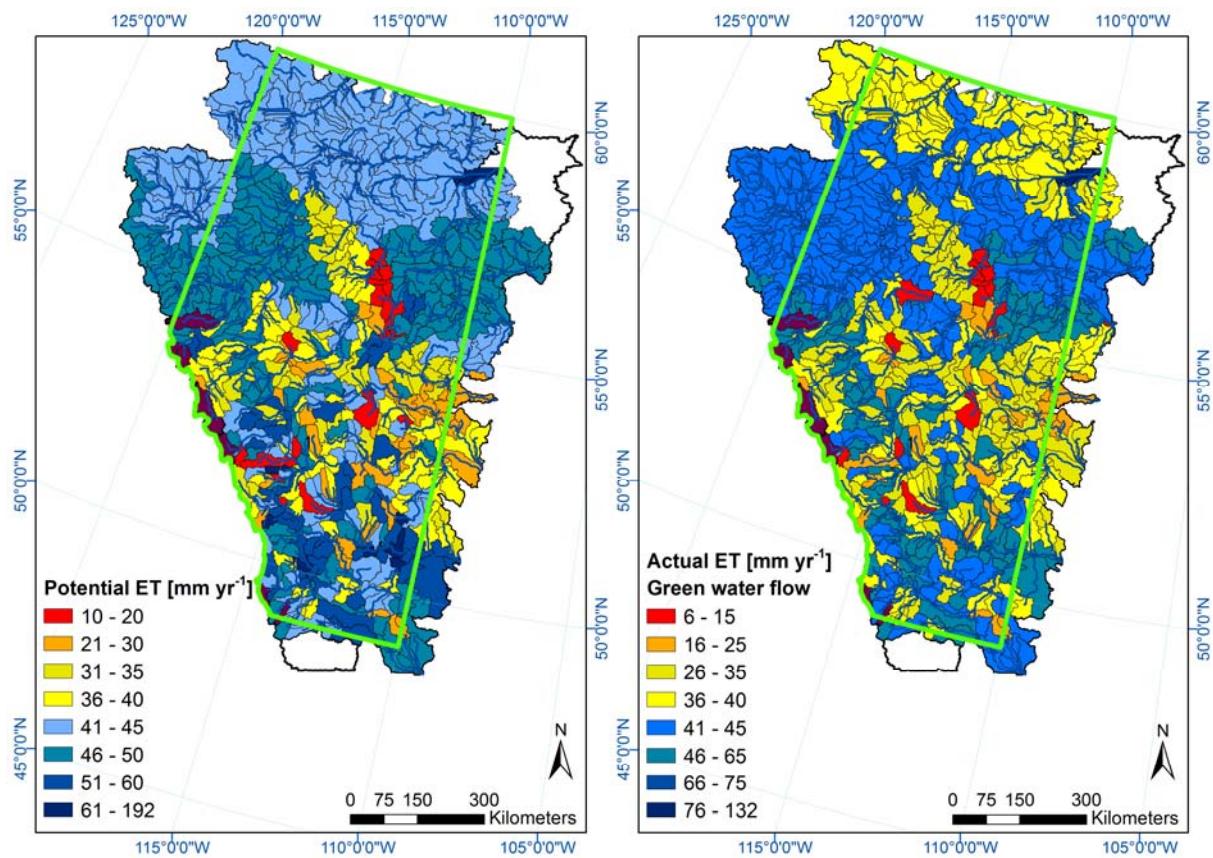


Figure 22. Long term (1985-2007) average distribution of green water flow (actual and potential evapotranspiration).

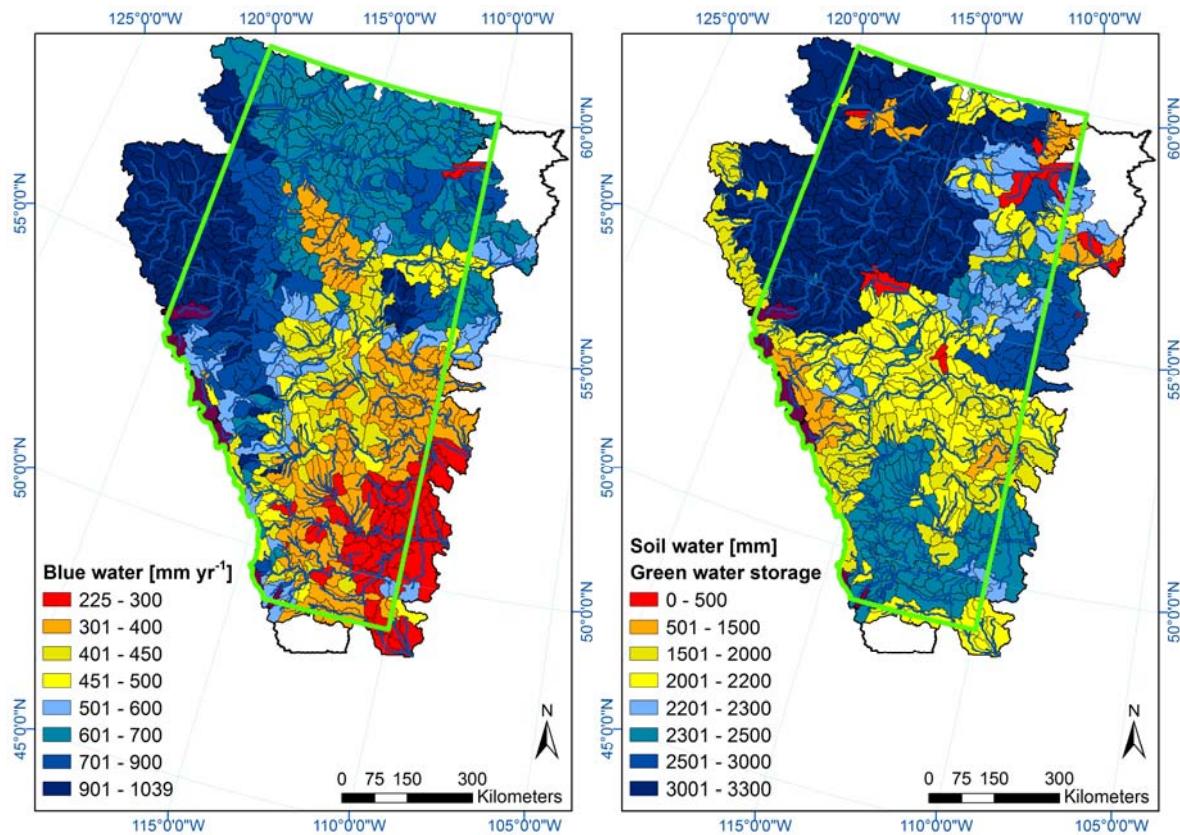


Figure 23. Long term (1985-2007) average distribution of blue water (water yield plus deep aquifer recharge) and green water storage (soil moisture).

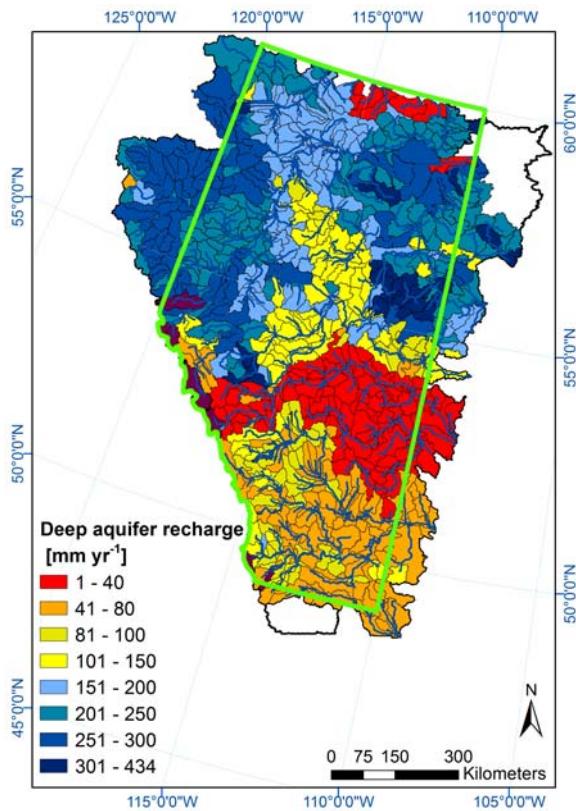


Figure 24. Long term (1985-2007) average distribution of deep aquifer recharge.

6.2 Final results using the CRU gridded climate data as input to the SWAT model

In general, a poor calibration result from previous section enforced the idea that i) climate data may have large errors associated with it, or ii) lack of stations in the northern part of Alberta (Figure 8) has a large impact on the overall model performance, or iii) the distribution of the observed stations is such that they are not assigned to the correct subbasins in the SWAT model.

To test some of these hypotheses, we obtained gridded climate data from Climate Research Unit, UK (CRU) to set up a new SWAT project for Alberta

taking the effect of glaciers in some subbasins as described in the previous section. The CRU provides 0.5 degree daily precipitation and temperature data. We performed calibration, validation, and uncertainty analysis using the discharge data of 101 stations (Figure 10). The calibration results were better in terms of *P-factor*, *R-factor* and goal function compared to the results using observed climate data. Table 4 shows calibration results aggregated at water region level. As shown in Table 4 the *R-factor*, R^2 and goal function were improved from their initial values while having a more satisfactory *P-factor* compare to the condition where we used the observed climate data for Alberta. Figures 25 to 27 show the calibration (1991-2006) and validation (1985-1990) results for some discharge stations. A high uncertainty (large *R-factor*) and small *p-factor* in some stations relates to insufficient accounting of agricultural and industrial water use, water diversion or water transfer projects and the construction or operation of dams/reservoirs in the province during the period of study. The water management maps of Alberta Environment (Figures 2, 3, and 4) show some of the man's activities influencing natural hydrology during the period of study. Regions with the highest activities have the worst calibration/validation results as well as the largest uncertainties. The construction of dams, reservoirs, roads, and tunnels can affect the local hydrology for many years. This is an important and often neglected source of uncertainty in large-scale hydrological modeling. As the extent of management in water resources development increases, hydrological modeling will become more and more difficult and will depend on the availability of detailed knowledge of the management operations.

Using the optimized parameter ranges, Figures 28 to 32 are shown as example of the type of maps that can be produced based on long-term averages. These variables are available at monthly resolution and could also

be tabulated with upper and lower uncertainty bonds for every one of 928 subbasins in the region of study.

Appendix I gives the long-term (1985-2006) average values of hydrological components for each of 928 subbasins. In Appendix II the location of the numbered subbasins is shown.

In Appendix III we aggregated the subbasin data into the major subbasins suggested in Figure 1. Also shown is the graphical representation of these data. We could not find much measured data to compare with our results. But water yield (net amount of water contributed to the river by the subbasin) estimated by SWAT was compared to the values give by Environment Alberta:

(<http://www.environment.alberta.ca/apps/basins/default.aspx?Basin=12>)

although we are not sure if both values are referring to the same things.

The water yield Figure shows large uncertainties in the water yield of water rich subbasins. The reported uncertainty contains natural year to year variation due to climate as well as water use and water abstraction. The later information was not available to us. Hence, our reported values could be taken as naturalized values.

Table 4. Calibration performance of different water regions while using CRU gridded climate data as input in the SWAT model.

River basin/subbasin	P_factor		R-factor		R ²		Goal function	
	initial	Final	initial	Final	initial	Final	initial	Final
Hay & Peac/Slave RB	0.45	0.47	3.36	2.87	0.27	0.28	0.21	0.21
Athabasca RB	0.67	0.39	3.94	3.01	0.30	0.33	0.23	0.24
Beaver RB	0.56	0.31	4.27	3.29	0.18	0.23	0.13	0.21
North Saskatchewan RSB	0.56	0.35	38.61	1.95	0.29	0.37	0.23	0.29
Red Deer, Bow, South Sas., Oldman RSB	0.48	0.30	6.58	4.47	0.37	0.39	0.26	0.27
Milk RB	0.28	0.55	108.78	3.89	0.22	0.34	0.17	0.33

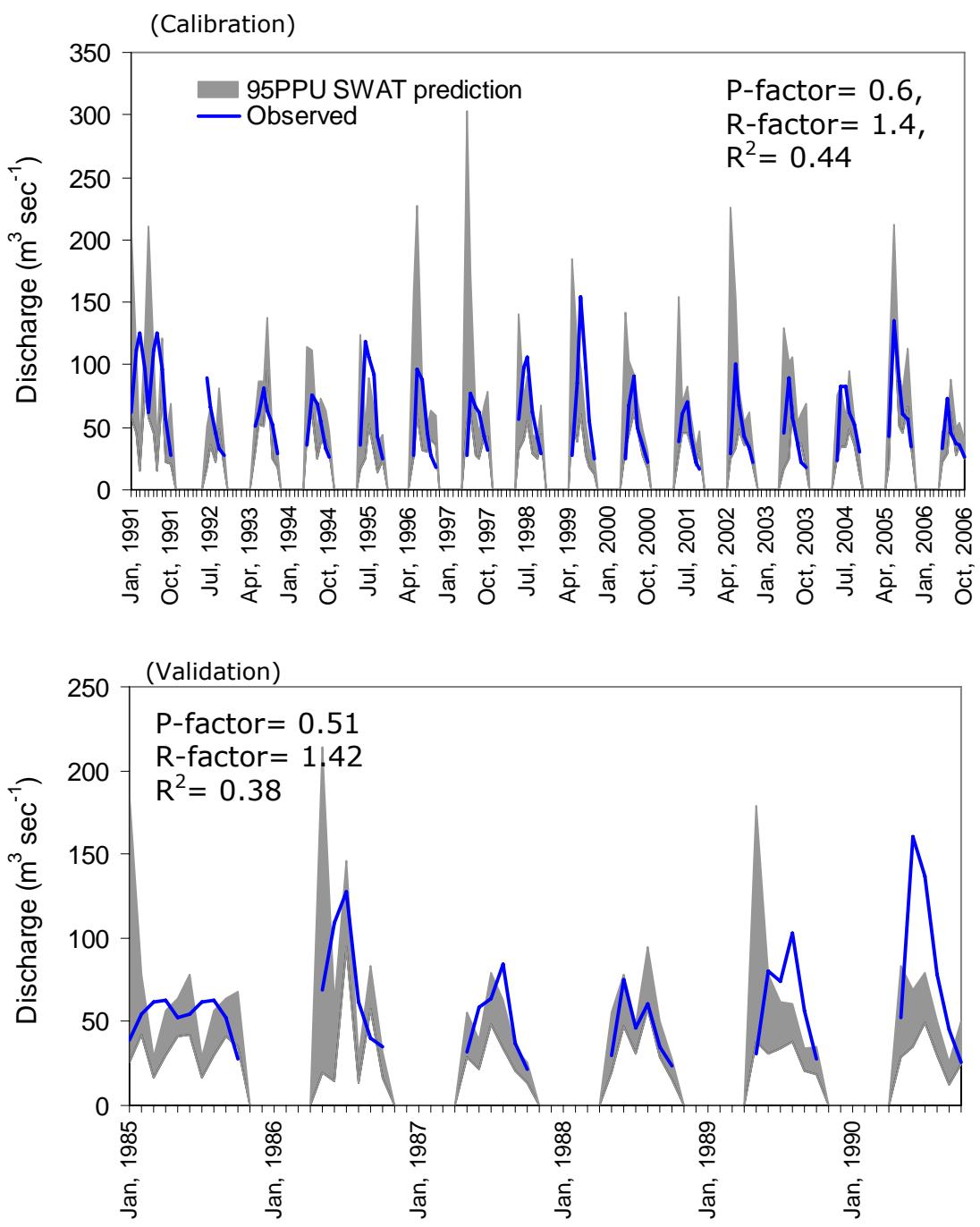


Figure 25. Comparison of the observed (blue line) and simulated (expressed as 95% prediction uncertainty band) discharges for “Nordegg River at Sunchild Road” station located in North Saskatchewan River Subbasin (subbasin number 645).

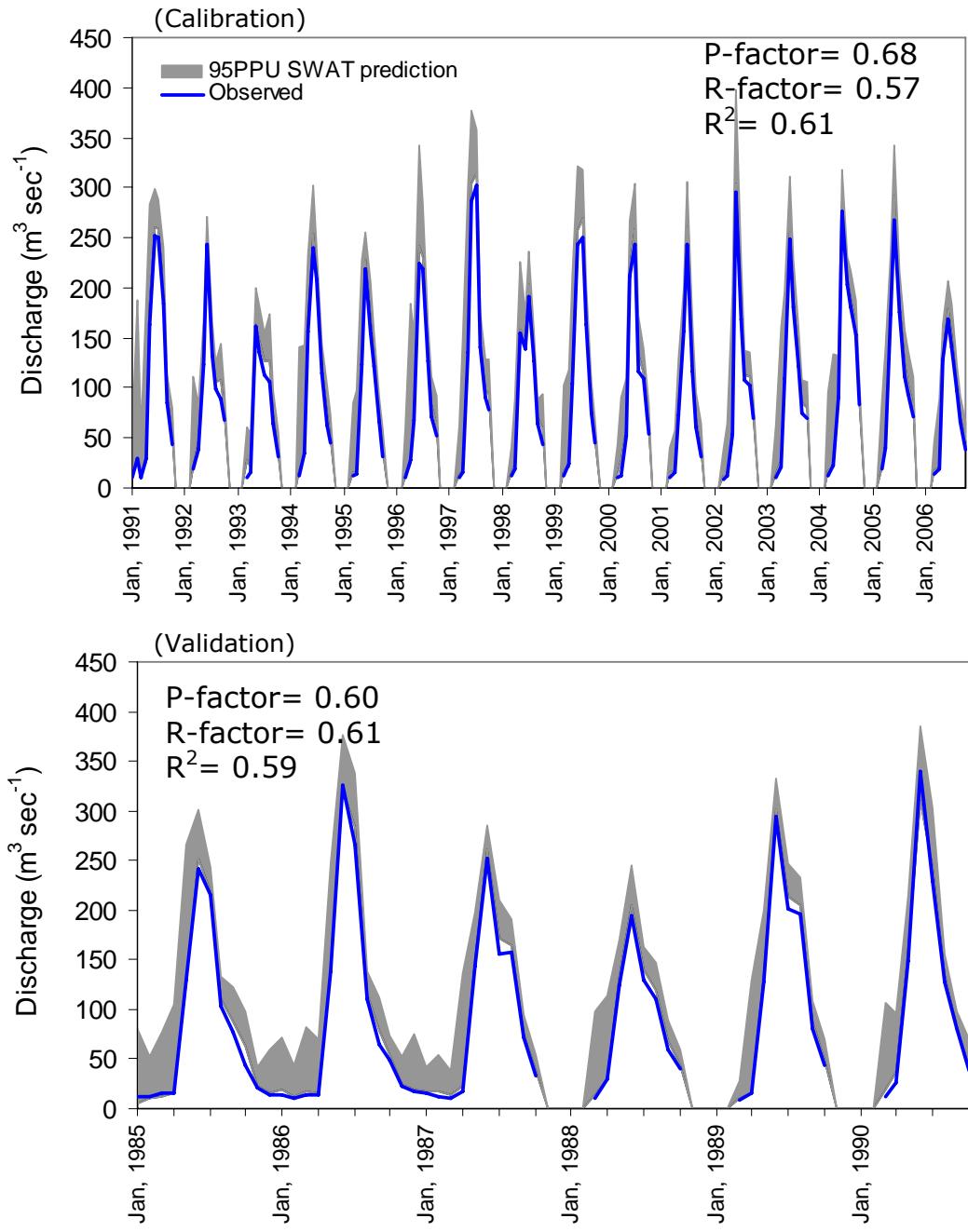


Figure 26. Comparison of the observed (blue line) and simulated (expressed as 95% prediction uncertainty band) discharges for "Smoky River Over Hells Creek" station located in Peace/Slave River Basin (subbasin number 496).

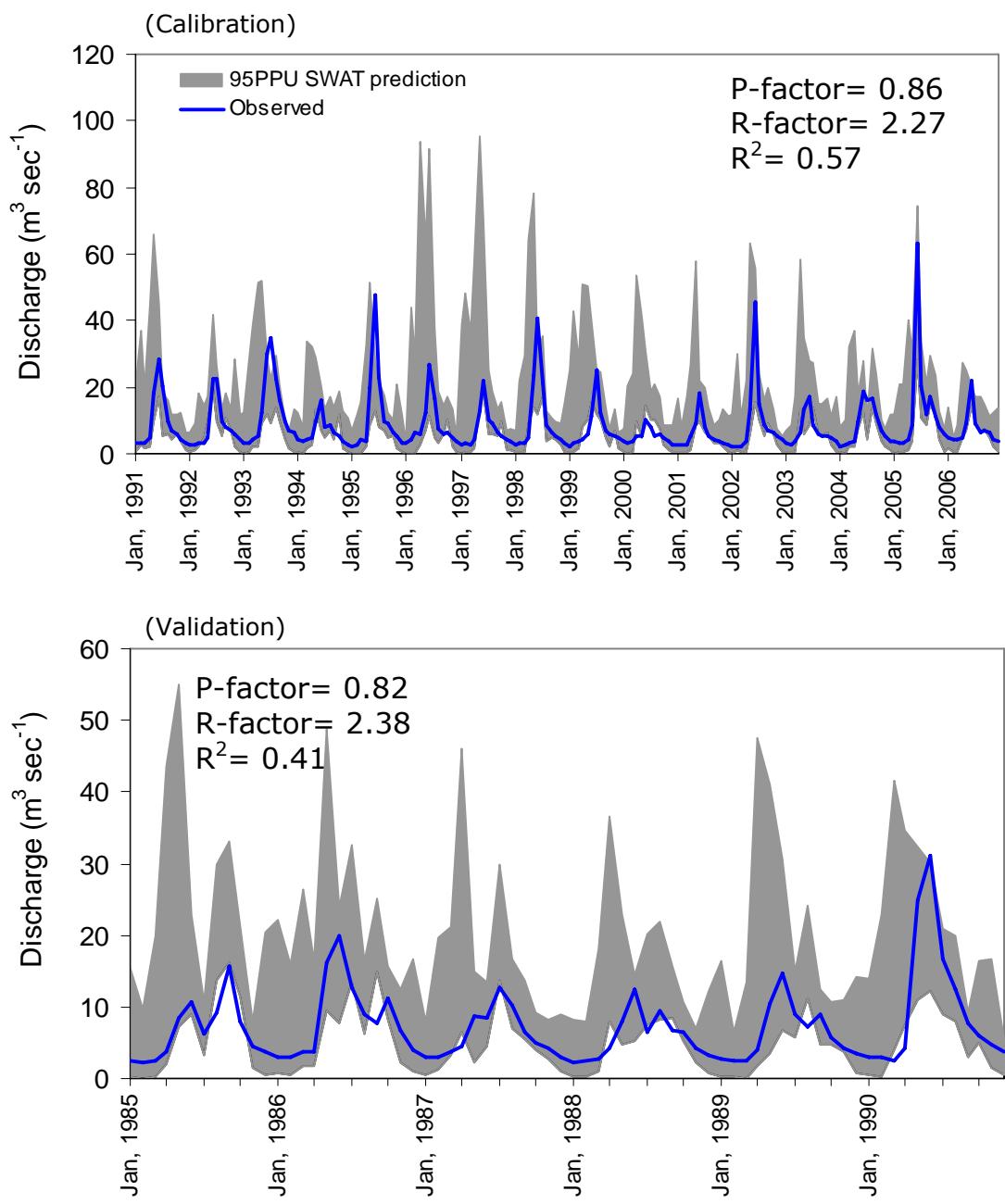


Figure 27. Comparison of the observed (blue line) and simulated (expressed as 95% prediction uncertainty band) discharges for "Elbow River at Bragg Creek" station located in Bow River Subbasin (subbasin number 780).

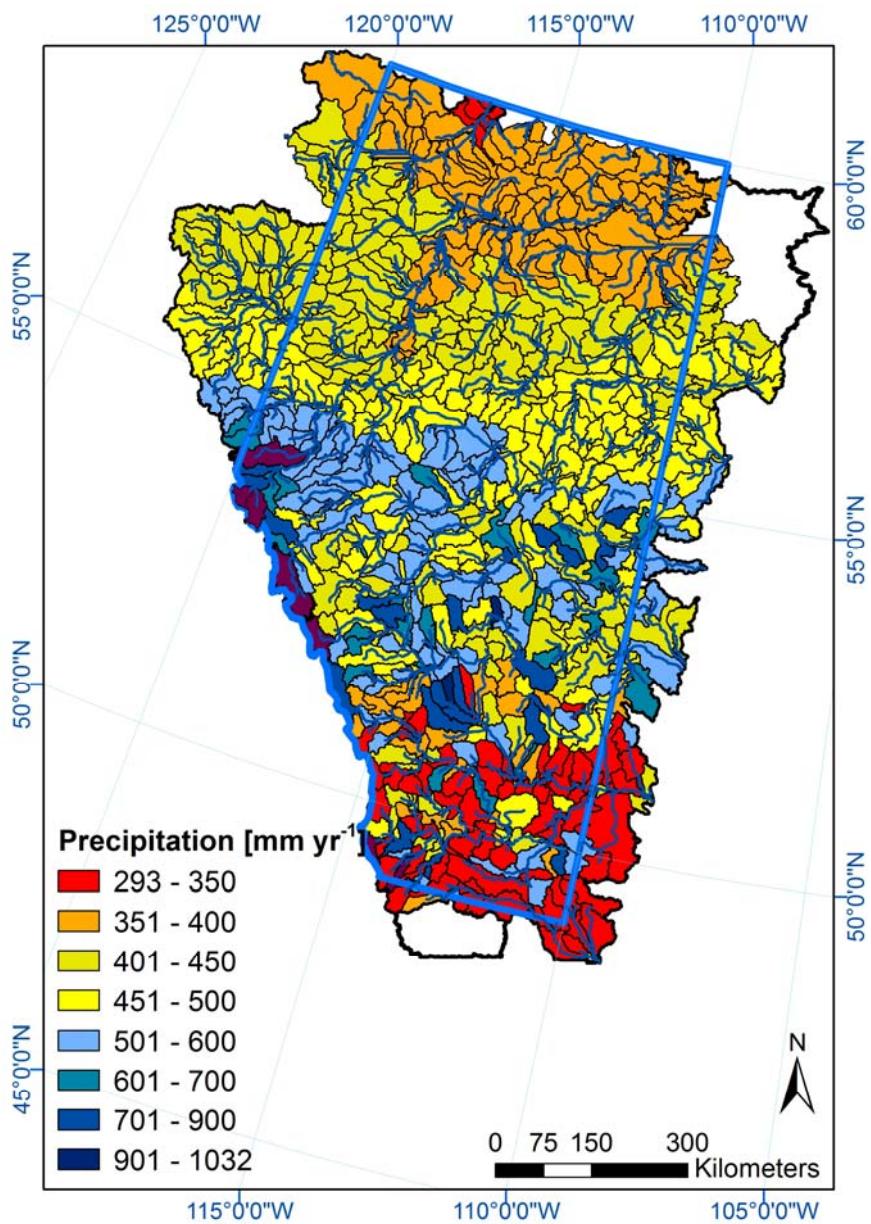


Figure 28. Long term (1985-2006) average distribution of precipitation using CRU gridded climate data.

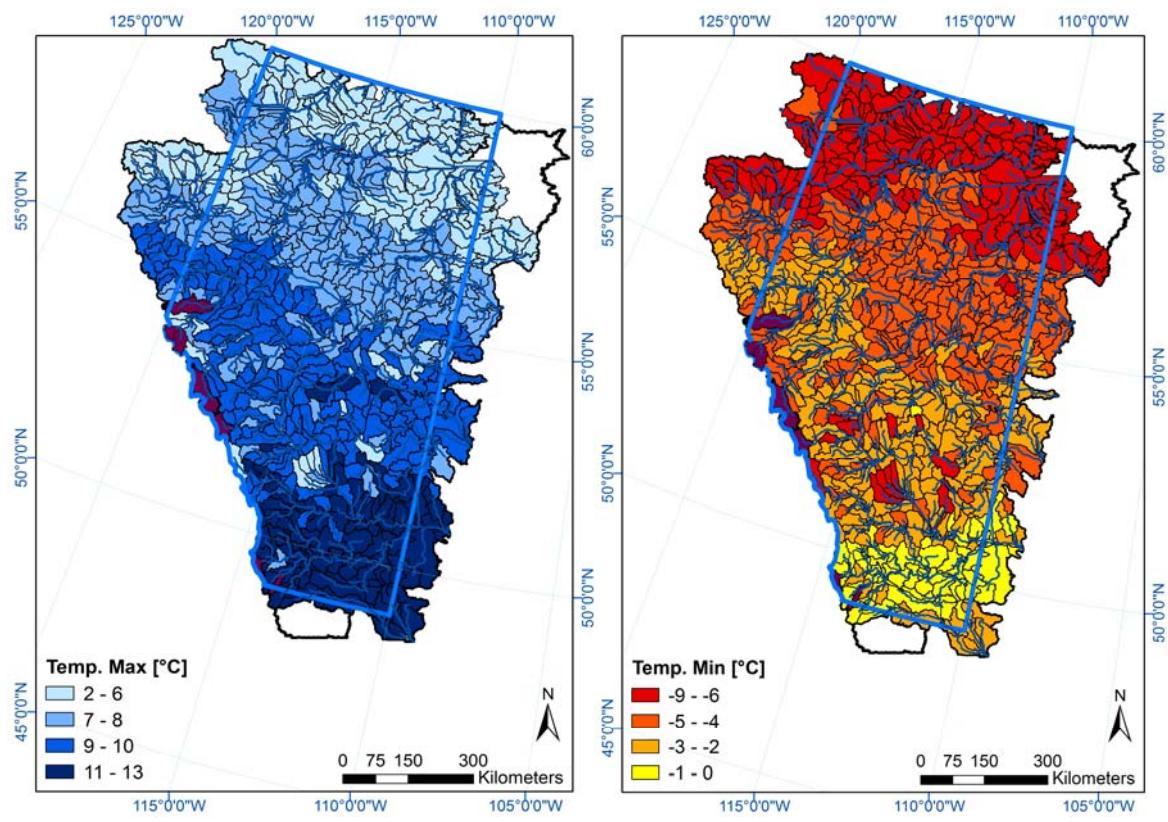


Figure 29. Long term (1985-2006) average distribution of maximum and minimum temperature using CRU gridded climate data.

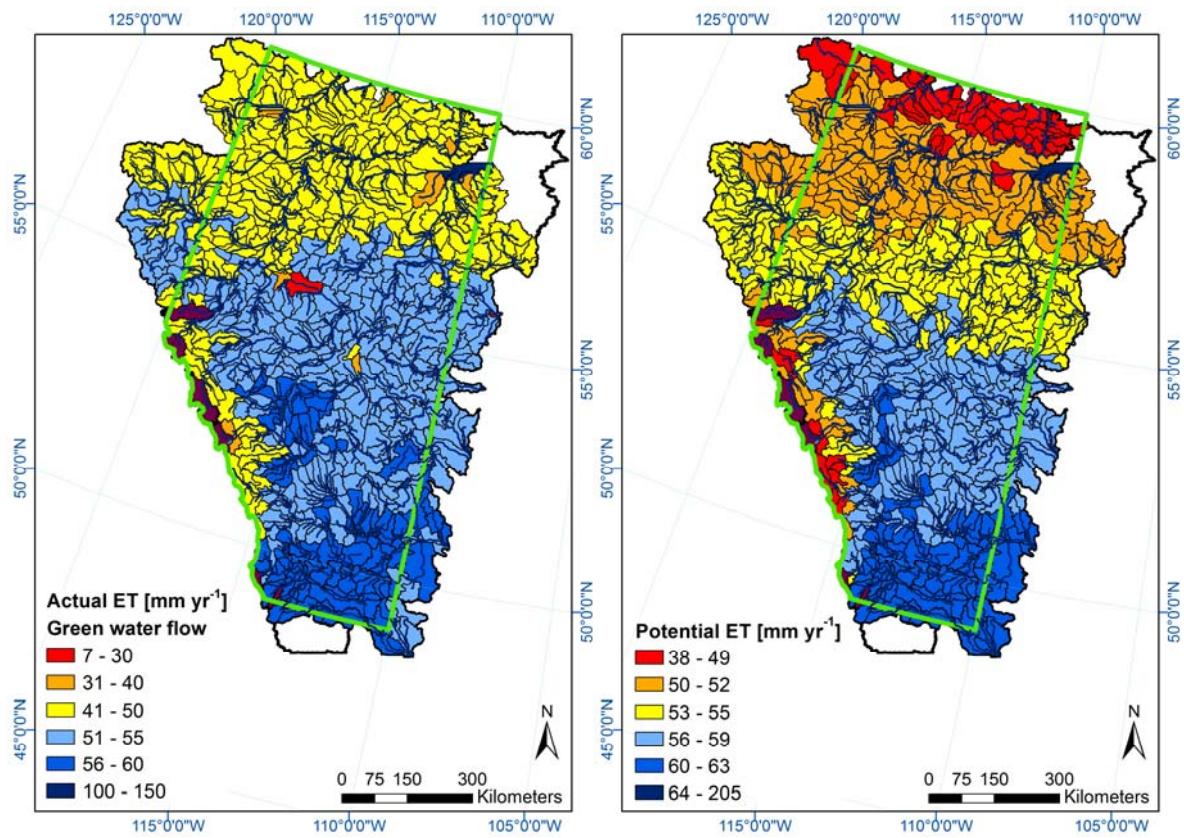


Figure 30. Long term (1985-2006) average distribution of green water flow (actual and potential evapotranspiration) using CRU gridded climate data.

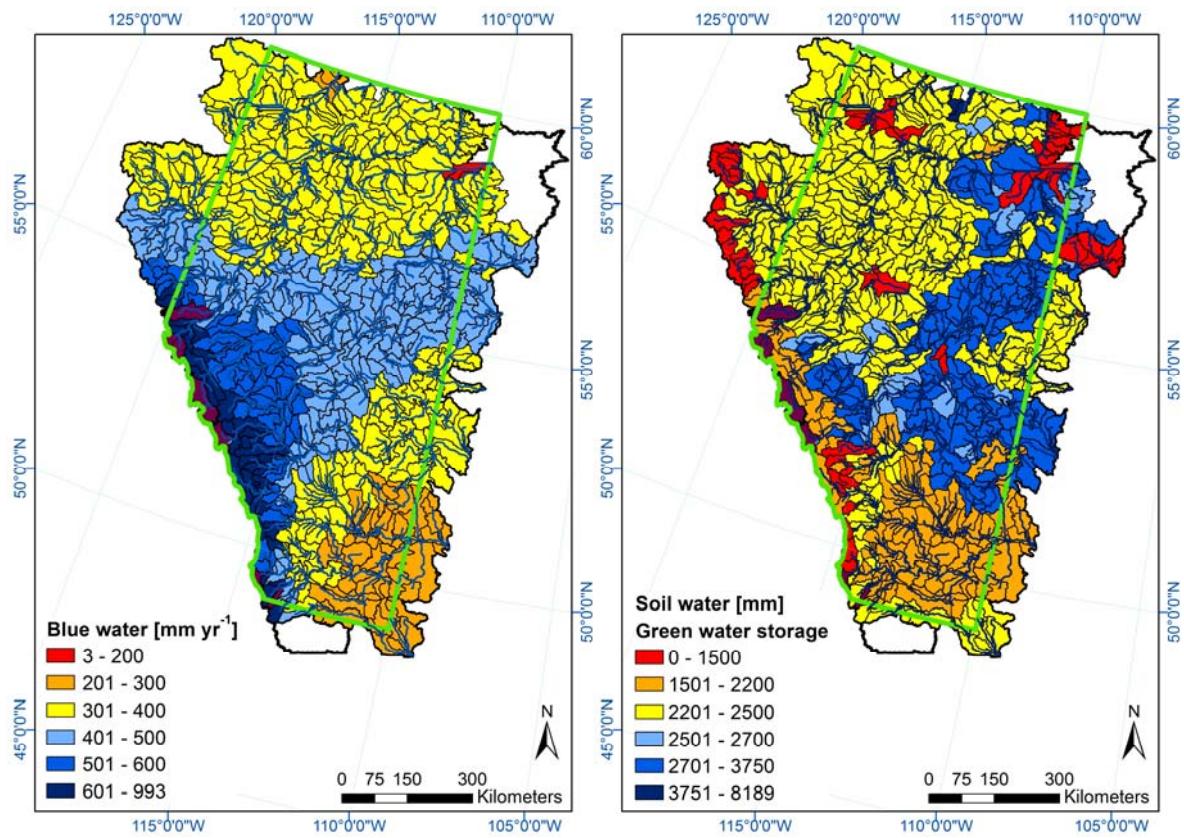


Figure 31. Long term (1985-2006) average distribution of blue water (water yield plus deep aquifer recharge) and green water storage (soil moisture) using CRU gridded climate data.

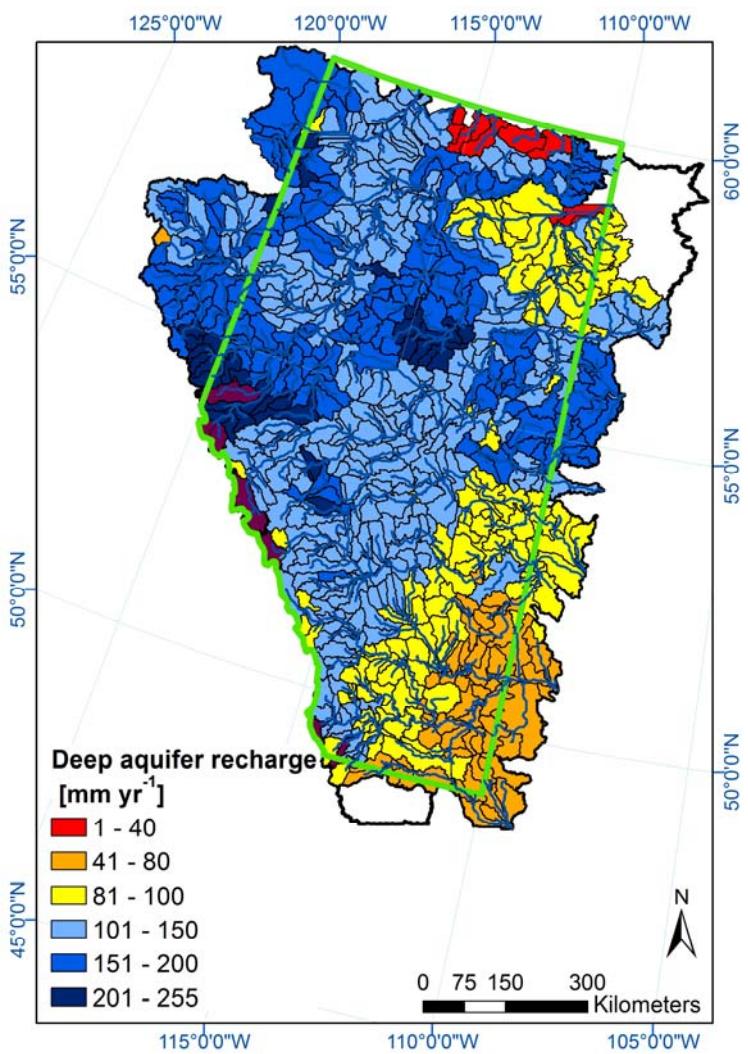


Figure 32. Long term (1985-2006) average distribution of deep aquifer recharge using CRU gridded climate data.

7. Data gap

What we have produced pertains to more or less natural conditions. More data regarding irrigation, cropping structure, water transfer, and dams and reservoirs are needed to produce a more real picture. In the following we identify some data gaps.

1. A precise water use data is needed to draw a more reliable picture of blue water resources availability with smaller uncertainty band. An application of blue water information could be to draw a water scarcity map of Alberta presenting per capita water availability per year. Drawing water scarcity map based only on naturalized blue water resources availability or blue water availability with a high uncertainty band might not present the real scarcity situation in the regions.
2. Calibration of a large-scale distributed hydrologic model against river discharge alone does not provide sufficient confidence for all components of the water balance. We suggest a multi-criteria calibration (Abbaspour et al. 2007) for a better characterization of different components and as a way of dealing with the non-uniqueness problem (narrowing of the prediction uncertainty). For example because of the direct relationship between crop yield and evapotranspiration, we can include yield as an additional target variable in the calibration process in order to improve the simulation of ET, soil moisture, and deep aquifer recharge. We assume that if yield is correct, then actual evapotranspiration and also soil moisture are simulated correctly. This in turn indicates that deep aquifer recharge is correct; hence, increasing our confidence on the calculated blue water, that is the sum of river discharge and deep aquifer recharge.

3. Water transfer between/in different river systems is another source of uncertainty in hydrological model results, as it can change the hydrologic regime from its natural condition. We need this data to use as another input in the model to improve the calibration results.
4. Agricultural management data is required for the reasons explained previously to model major crop yields.
5. Future climate change data are useful to use as input in our calibrated hydrological model to assess the impact of climate change on hydrological components and water resources availability as well as crop yield.

8. Suggestion for project continuation

The next phase of this project could combine the water availability (this project) and water use (the project by Liu et al.) to build a more integrated model of Alberta. Furthermore, a more refined input database could improve model calibration. Such a model could be used for analysis of various water balance component as well as water supply-water demand analysis similar to the study by Faramarzi et al. [2010a, b]. Using the improved calibrated model, climate change scenarios could be run for foreseen future management changes and their impacts on water resources quantified. With the use of a population map, hot spots of water scarcity could be identified.

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Appendix I

Long-term average (1985-2007) hydrological components at subbasin level obtained with M95ppu. The M95PPU is calculated at the 50% level of the cumulative distribution obtained through Latin hypercube sampling.

Subbasin	RB NAME	PCP	TMAX	TMIN	BLUE	DA	ET	PET	SW
1	Hay RB	377.54	4.1	-7.84	334.16	184.91	45.4	47.76	2493.64
2	Hay RB	369.34	4.16	-7.96	326.02	151.94	45.29	49.01	2409.11
3	Hay RB	367.95	4.05	-8.28	324.44	148.21	44.95	48.27	2427.85
4	Hay RB	384.69	5.08	-7.47	340.27	157.89	46.07	49.36	2382.78
5	Hay RB	333.11	4.44	-8.23	290.37	123.09	44.84	48.02	2438.35
6	Hay RB	333.11	4.44	-8.23	290.16	123	45.04	48.01	2438.1
7	Hay RB	339.34	4.5	-7.79	295.67	108.34	45.1	48.12	2402.7
8	N_Hay RB	358.7	3.49	-7.79	316.65	10.38	42.72	45.67	2275.6
9	N_Hay RB	366.14	2.75	-8.21	325.05	11.84	42.06	44.61	2374.67
10	N_Hay RB	358.7	3.49	-7.79	316.39	10.21	42.63	45.32	2272.51
11	Hay RB	339.34	4.5	-7.79	295.1	109.68	45.16	47.63	2402.58
12	Hay RB	333.11	4.44	-8.23	288.75	110.21	44.99	47.95	2411.43
13	N_Hay RB	358.7	3.49	-7.79	316.37	115.28	43.13	46.12	2429.68
14	Hay RB	354.77	5.14	-7.58	310.38	136.57	45.18	48.1	2399.29
15	N_Hay RB	362.3	3.01	-7.8	324.39	10.99	37.77	45.41	2303.77
16	Hay RB	412.06	6.31	-6.13	365.04	177.49	47.35	49.69	2353.65
17	Hay RB	365.57	5.23	-7.6	319.99	140.77	45.76	49.01	2410.04
18	N_Hay RB	366.14	2.75	-8.21	321.04	1.7	43.11	46.08	7801.62
19	Hay RB	371.49	3.62	-8.04	327.18	127.05	44.91	47.25	2433
20	Hay RB	402.93	6.5	-5.86	355.5	172.27	47.36	50.27	2338.61
21	Hay RB	402.93	6.5	-5.86	356.01	81.13	47.02	50.18	1573.03
22	Hay RB	390.94	5.05	-7.06	345.1	166.18	45.93	48.56	2386.28
23	Hay RB	358.71	4.45	-7.82	314.16	123.36	45.04	48.27	2407.72
24	Hay RB	354.77	5.14	-7.58	309.86	139.2	45.38	48.29	2398.84
25	Hay RB	354.77	5.14	-7.58	309.44	126.92	45.75	48.67	2377.47
26	Hay RB	391.15	5.24	-7.11	344.79	138.46	46.1	49	2356.22
27	Hay RB	391.15	5.24	-7.11	345.15	164.23	45.85	49.04	2376.9
28	Hay RB	399.15	6.12	-6.67	359.83	104.05	39.26	49.5	337.26
29	Hay RB	358.71	4.45	-7.82	314.25	122.74	45.09	48.02	2407.64
30	Hay RB	402.93	6.5	-5.86	356.31	95.24	46.68	49.81	1574.85
31	Hay RB	371.49	3.62	-8.04	327.49	143.5	44.66	47.49	2456.08
32	Hay RB	384.69	5.08	-7.47	338.65	132.12	45.95	48.82	2370.03
33	N_Hay RB	392.86	2.2	-8.8	336.77	2.41	41.99	45.01	8189.46
34	Hay RB	365.57	5.23	-7.6	320.27	125.06	45.44	48.13	1138.84
35	Hay RB	412.06	6.31	-6.13	364.94	178.23	47.27	50.26	2353.69
36	Hay RB	402.93	6.5	-5.86	355.34	204.9	47.73	50.92	2388.69
37	Hay RB	399.15	6.12	-6.67	353.13	143.32	46.29	50.11	2338.61
38	Hay RB	372.89	5.1	-7.62	327.38	128.12	45.66	48.85	2358.78
39	Hay RB	404.89	6.38	-6.15	365.15	147.94	39.34	49.68	271.04
40	Hay RB	412.06	6.31	-6.13	364.81	178.57	47.58	50.71	2353.41
41	Hay RB	412.06	6.31	-6.13	365.05	175.78	47.29	50.48	2353.6
42	Hay RB	393.16	5.87	-7.04	354.21	96.86	38.76	49.49	409.33
43	Peace RB	364.96	3.71	-7.32	322.31	104.62	43.68	46.54	3447.99

44	Hay RB	392.9	5.42	-7.52	347.43	141.59	45.48	48.09	1142.55
45	N_Hay RB	358.35	3.44	-7.39	317.13	10.71	42.38	45.73	2300.37
46	Hay RB	404.89	6.38	-6.15	365.32	123.69	39.22	49.07	251.38

Table 5. Continued.

Subbasin	RB NAME	PCP	TMAX	TMIN	BLUE	DA	ET	PET	SW
47	Hay RB	399.15	6.12	-6.67	360.19	104.62	39.05	49.64	350.19
48	Hay RB	393.16	5.87	-7.04	347.01	139.19	46.62	49.48	1111.6
49	N_Hay RB	353.84	3.41	-7.32	310.64	10.99	43.08	46.51	2298.13
50	Hay RB	412.06	6.31	-6.13	364.66	179.84	47.77	50.06	2353.37
51	Hay RB	388.85	5.23	-7.45	343.08	141.61	45.75	48.97	2374.42
52	Hay RB	399.15	6.12	-6.67	352.75	142.35	46.86	49.8	1104.85
53	Hay RB	412.65	6.08	-6.86	365.85	148.04	46.85	49.94	1104.5
54	N_Hay RB	361.89	3.76	-7.33	318.83	11.25	43.78	47	2818.53
55	Hay RB	412.65	6.08	-6.86	365.59	135.51	47	49.28	2366.81
56	Hay RB	393.16	5.87	-7.04	346.79	141.3	46.81	49.83	1111.43
57	Peace RB	364.96	3.71	-7.32	322.33	152.18	43.7	46.96	1119.9
58	Peace RB	360.54	3.43	-7.23	317.93	175.33	44.27	47.5	1204.23
59	Hay RB	412.06	6.31	-6.13	364.3	178.43	48.04	51.4	2353.19
60	Peace RB	394.08	2.59	-8.29	351.56	146.9	42.68	45.97	2542.64
61	Peace RB	368.1	4.14	-6.97	325.8	129.76	43.3	46.31	2395.27
62	Peace RB	360.54	3.43	-7.23	317.85	175.57	44.31	47.33	1204.6
63	Peace RB	364.96	3.71	-7.32	322	146.93	43.75	47.29	2431.28
64	Hay RB	415.38	6.29	-6.36	367.65	176.18	47.86	50.71	2361.12
65	Hay RB	412.06	6.31	-6.13	364.43	206.27	48.22	51.39	2404.29
66	Peace RB	367.93	4.08	-6.83	325.07	181.93	44.85	48.61	1168.75
67	Athabasca RB	368.38	2.77	-7.56	325.59	109.17	43.84	47.4	1458.77
68	Peace RB	368.91	4.33	-6.88	325.93	186.99	45.15	47.95	2484.56
69	Hay RB	412.06	6.31	-6.13	364.29	179.36	48.17	51.42	2353.15
70	Peace RB	389.84	4.01	-7.05	344.91	151.95	45.82	49.08	2414.15
71	Peace RB	392.52	2.33	-8.56	349.97	148.23	42.39	45.3	2527.35
72	Peace RB	366.44	4.37	-6.83	323.3	149.27	44.48	47.46	2411.63
73	Peace RB	368.41	4.36	-6.95	325.8	149.71	44.43	47.45	2412.02
74	Peace RB	368.41	4.36	-6.95	325.9	184.64	44.59	47.52	2479.85
75	Peace RB	366.44	4.37	-6.83	323.2	148.87	44.57	48	2411.55
76	Peace RB	367.93	4.08	-6.83	331.72	115.67	37.46	47.97	498.46
77	Peace RB	375.85	3.64	-7.04	333.07	184.8	44.79	47.75	1205.41
78	Peace RB	379.25	5.07	-7.12	333.87	139.17	45.85	49.24	1128.67
79	Peace RB	388.85	5.23	-7.45	342.98	140.57	45.8	48.89	1139.26
80	Peace RB	383.16	6.2	-6.1	336.15	134.43	47.28	50.34	2312.26
81	Peace RB	383.16	6.2	-6.1	336.1	139.74	47.38	50.25	2308.86
82	Peace RB	367.93	4.08	-6.83	331.56	136.08	37.59	48.05	542.48
83	Peace RB	406.59	6.07	-7.05	360.25	139.42	46.29	49.35	2368.83
84	Peace RB	375.85	3.64	-7.04	332.87	183.13	44.85	47.99	1205.21
85	Peace RB	367.93	4.08	-6.83	331.42	137.53	37.63	48.57	542.47
86	Hay RB	411.2	6.08	-6.99	364	140.03	47.24	50.31	2370.98
87	Peace RB	368.91	4.33	-6.88	332.98	140.28	37.52	48.48	524.74
88	Peace RB	382.73	4.01	-7.19	338.26	155.47	45.71	48.9	2428.23
89	Peace RB	376.69	6.24	-5.01	330.47	128.07	47.34	50.29	2322.14
90	Peace RB	382.73	4.01	-7.19	338.24	172.65	45.74	48.7	2434.65
91	Peace RB	383.16	6.2	-6.1	336.22	130.4	47.25	50.45	2343.15

92	Peace RB	376.69	6.24	-5.01	330.69	127.53	47.29	50.17	2322.16
93	Peace RB	376.69	6.24	-5.01	330.75	125.78	47.3	50.23	2320.92
94	Peace RB	382.73	4.01	-7.19	338.87	136.76	45.17	48.12	2392.13

Table 5. Continued.

Subbasin	RB NAME	PCP	TMAX	TMIN	BLUE	DA	ET	PET	SW
95	Peace RB	367.93	4.08	-6.83	324.92	180.8	45.13	48.19	1168.12
96	Peace RB	376.08	4.79	-6.37	330.69	151.63	45.91	49.34	2397.11
97	Peace RB	376.69	6.24	-5.01	330.6	129.15	47.35	50.25	2322.13
98	Peace RB	376.08	4.79	-6.37	331.09	188.08	46.07	49.08	2450.7
99	Peace RB	389.84	4.01	-7.05	345.66	187.41	45.45	48.82	2486.86
100	Peace RB	373.32	5.14	-6.29	328.66	161.74	46.06	49.44	1755.32
101	Peace RB	376.08	4.79	-6.37	330.5	135.84	45.97	48.99	2379.41
102	Peace RB	376.08	4.79	-6.37	330.48	138.18	45.93	48.82	1740.71
103	Peace RB	412.65	6.08	-6.86	365.5	172.5	47.29	50.25	2371.52
104	Peace RB	373	4.27	-7.05	329.95	191.6	44.58	47.78	2481.45
105	Peace RB	414.71	6.12	-6.89	367.75	174.17	47.26	50.56	2364.28
106	Peace RB	376.69	6.24	-5.01	332.23	124.71	45.72	50.63	2317.04
107	Peace RB	393.02	3.62	-7.45	350.06	130.27	43.39	46.35	2427.67
108	Peace RB	415.69	5.59	-7.11	368.74	171.45	47.37	50.25	2373.28
109	Peace RB	376.78	4.65	-6.49	332.4	184.8	45.71	48.98	1137.65
110	Peace RB	376.69	6.24	-5.01	330.14	140.67	47.8	51.17	2308.73
111	Peace RB	375.74	6.21	-5.07	329.9	130.78	47.08	50.02	2321.2
112	Peace RB	393.02	3.62	-7.45	349.29	175.16	44.42	47.35	2476.32
113	Peace RB	375.74	6.21	-5.07	329.81	129.86	47.14	50.28	2321.17
114	Peace RB	376.69	6.24	-5.01	330.46	140.51	47.5	50.41	2308.89
115	Peace RB	375.74	6.21	-5.07	329.9	129.59	47.13	50.07	2321.16
116	Peace RB	422.15	5.97	-6.38	373.9	151.85	48.63	51.57	2388.81
117	Peace RB	422.15	5.97	-6.38	374.49	139.27	48.25	51.32	2350
118	Peace RB	377.54	6.16	-5.15	331.39	145.66	46.93	49.98	2305.74
119	Peace RB	376.69	6.24	-5.01	330.56	139.3	47.44	50.36	2308.91
120	Peace RB	373.98	6.26	-5.26	328.15	127.67	46.49	50.86	2298.73
121	Peace RB	406.59	6.07	-7.05	360.02	143	46.55	49.48	2368.55
122	Peace RB	376.69	6.24	-5.01	330.31	140.69	47.69	50.69	2308.8
123	Peace RB	435.07	5.94	-6.05	386.28	155.98	49.25	52.28	1381.54
124	Peace RB	422.15	5.97	-6.38	373.18	138.98	49.57	52.65	1353.98
125	Peace RB	383.16	6.2	-6.1	336.18	147.64	47.49	50.58	2308.73
126	Peace RB	420.19	5.31	-7.05	372.46	138.64	47.4	50.62	2364.4
127	Peace RB	397.79	6.85	-6.3	351.25	144.7	46.95	49.97	2308.17
128	Peace RB	422.15	5.97	-6.38	374.23	207.75	48.25	51.2	2417.2
129	Athabasca RB	381.59	4.45	-6.45	337.66	88.19	46.01	49.66	3641.77
130	Peace RB	420.25	6.32	-6.96	372.68	148.31	47.63	50.18	2369.42
131	Peace RB	397.79	6.85	-6.3	351.33	143.57	46.86	49.89	2308.17
132	Peace RB	397.79	6.85	-6.3	351.16	134.7	46.94	49.96	2331.74
133	Athabasca RB	376.02	4.55	-6.43	3.15	1.65	130.42	188.84	0.13
134	Peace RB	435.07	5.94	-6.05	386.8	136.12	48.91	51.15	2374.12
135	Peace RB	435.07	5.94	-6.05	386.41	155.42	49.21	52.29	1381.4
136	Athabasca RB	373.64	6.17	-5.22	328.15	93.48	46.83	49.99	3017.71
137	Peace RB	375.74	6.21	-5.07	329.36	169.85	47.77	50.38	2303.6
138	Athabasca RB	375.51	5.08	-6.58	329.77	94.33	46.05	49.29	3087.57

139	Athabasca RB	376.78	4.65	-6.49	352.87	119.34	7.77	48.48	53.92
140	Athabasca RB	379.76	5.98	-5.51	333.53	79.79	46.74	49.69	3004.81
141	Athabasca RB	379.76	5.98	-5.51	333.51	80.4	46.74	49.4	3004.81

Table 5. Continued.

Subbasin	RB NAME	PCP	TMAX	TMIN	BLUE	DA	ET	PET	SW
142	Athabasca RB	375.95	5.02	-6.47	2.97	1.47	131.5	190.01	5.41
143	Peace RB	397.79	6.85	-6.3	350.79	134.15	47	49.38	2331.67
144	Athabasca RB	376.02	4.55	-6.43	2.92	1.41	130.66	189.22	0.13
145	Peace RB	422.15	5.97	-6.38	374.64	175.63	48.03	50.57	2359.05
146	Peace RB	414.71	6.12	-6.89	366.66	171.21	47.88	51.13	2363.86
147	Athabasca RB	387.21	5.64	-5.96	339.94	83.05	47.04	50.38	3017.97
148	Peace RB	385.79	6.68	-5.79	337.81	132.74	48.43	51.03	2314.12
149	Athabasca RB	376.02	4.55	-6.43	2.62	1.27	130.72	189.32	0.13
150	Athabasca RB	387.21	5.64	-5.96	340.9	82.95	46.63	48.98	2210
151	Athabasca RB	396.53	5.22	-6.5	350.69	97.12	45.46	48.24	3086.99
152	Athabasca RB	379.76	5.98	-5.51	333.43	94.28	46.69	49.44	3026.46
153	Peace RB	421.4	5.75	-6.93	372.97	172.29	47.93	50.59	2377.5
154	Athabasca RB	373.64	6.17	-5.22	327.01	81.8	47.07	50.5	2991.88
155	Peace RB	375.74	6.21	-5.07	328.74	144.56	47.66	50.3	2308.73
156	Athabasca RB	395.6	6.07	-5.4	348.79	105.07	47.15	50.38	3026.54
157	Peace RB	385.79	6.68	-5.79	338.02	139.84	48.21	50.88	2299.45
158	Athabasca RB	381.59	4.45	-6.45	336.9	94.68	46.17	49.19	3738.59
159	Peace RB	394.67	6.26	-5.14	347.56	172.72	47.54	50.11	2309.6
160	Peace RB	422.15	5.97	-6.38	373.63	139.17	48.42	51.5	2370.83
161	Peace RB	422.15	5.97	-6.38	373.72	140.17	48.4	51.51	2349.87
162	Peace RB	435.07	5.94	-6.05	385.81	162.73	49.23	52.42	1382.77
163	Athabasca RB	391.5	5.1	-6.29	2.6	1.23	131.88	191.12	5.78
164	Athabasca RB	391.5	5.1	-6.29	357.78	106.35	35.06	49.02	415.85
165	Peace RB	435.07	5.94	-6.05	386.6	150.16	48.55	51.34	2390.34
166	Peace RB	394.67	6.26	-5.14	347.8	175.77	47.3	50.58	2309.26
167	Peace RB	422.15	5.97	-6.38	373.83	175.21	48.59	51.65	2360.07
168	Peace RB	435.07	5.94	-6.05	386.67	150.06	48.58	51.82	2390.16
169	Peace RB	435.07	5.94	-6.05	386.56	150.32	48.71	51.8	2368.41
170	Athabasca RB	391.5	5.1	-6.29	345.97	95.97	46.88	49.98	3702.9
171	Peace RB	435.07	5.94	-6.05	385.9	148.27	49.46	52.1	1379.57
172	Athabasca RB	396.53	5.22	-6.5	349.25	86.56	46.85	49.95	2518.88
173	Peace RB	435.07	5.94	-6.05	387.1	139.12	48.54	51.1	2374.51
174	Peace RB	435.07	5.94	-6.05	387.34	135.24	48.36	51.39	2396.58
175	Athabasca RB	392.16	5.38	-6.25	357.17	105.95	34.81	49.81	385.1
176	Peace RB	414.81	5.96	-6.91	368.82	149.31	46.06	48.86	2378.56
177	Peace RB	414.81	5.96	-6.91	368.84	148.87	46.03	49.09	2378.59
178	Peace RB	393.1	6.32	-5.12	345.24	178.26	48.48	51.68	2318.37
179	Peace RB	426.92	5.84	-6.73	378.43	147.84	48.47	51.65	2383.56
180	Athabasca RB	401.78	4.76	-6.43	355.54	87.4	46.64	49.73	2653.76
181	Peace RB	394.02	7.04	-5.57	346.93	135.94	48.11	50.66	2355.05
182	Athabasca RB	395.6	6.07	-5.4	349.31	134.54	47.54	50.58	3057.51
183	Peace RB	441.91	7.48	-4.56	392.15	145.18	49.76	52.55	2344.51
184	Peace RB	435.07	5.94	-6.05	387.22	141.16	48.53	51.63	2374.29
185	Peace RB	408.17	5.25	-6.16	361.48	161.94	47.64	50.69	2361.59

186	Peace RB	397.79	6.85	-6.3	350.84	134.79	47.45	50.55	2370.08
187	Peace RB	397.41	5.56	-6.17	350.23	139.06	47.84	50.81	2338.79
188	Peace RB	426.92	5.84	-6.73	378.37	149.49	48.68	51.66	2383.37

Table 5. Continued.

Subbasin	RB NAME	PCP	TMAX	TMIN	BLUE	DA	ET	PET	SW
189	Peace RB	441.91	7.48	-4.56	390.96	78.59	51.29	54.27	2329.66
190	Peace RB	394.67	6.26	-5.14	348.01	177.07	47.79	50.63	2309.12
191	Peace RB	408.17	5.25	-6.16	361.64	139.24	47.36	50.63	2346.53
192	Peace RB	394.67	6.26	-5.14	348.17	187.65	47.84	50.88	2343.59
193	Peace RB	435.07	5.94	-6.05	387.38	183.64	48.31	51.65	2368.95
194	Peace RB	435.07	5.94	-6.05	387.33	151.76	48.5	51.73	2368.44
195	Peace RB	394.96	7.3	-5.91	349.25	133.72	46.28	50.86	2307.21
196	Peace RB	408.12	6.56	-6.51	361.57	149.15	47.56	50.62	2354.49
197	Athabasca RB	395.73	5.22	-6.62	361.3	82.73	34.87	49.75	396.37
198	Athabasca RB	401.78	4.76	-6.43	355.25	85.4	47.09	49.79	2646.27
199	Peace RB	435.07	5.94	-6.05	387.67	139.45	48.26	50.78	2374.5
200	Peace RB	441.91	7.48	-4.56	392.12	157.61	49.82	52.83	2315.37
201	Athabasca RB	401.78	4.76	-6.43	355.17	86.68	46.99	50.2	2647.26
202	Peace RB	465.47	7.61	-4.21	415.82	160.29	50.19	52.8	1361.99
203	Peace RB	414.81	5.96	-6.91	368.95	152.41	46.16	49.33	2378.44
204	Peace RB	408.12	6.56	-6.51	363.47	128.63	45.7	50.58	2381.16
205	Athabasca RB	392.16	5.38	-6.25	345.66	98.7	47.19	50.23	3693.37
206	Peace RB	441.91	7.48	-4.56	391.81	157.76	50.13	52.72	1333.15
207	Peace RB	441.91	7.48	-4.56	392.17	159.62	49.83	53.08	1333.21
208	Peace RB	441.91	7.48	-4.56	392.09	153.63	49.88	53.08	2315.32
209	Peace RB	441.91	7.48	-4.56	392.03	160.14	50.05	53.19	1333.19
210	Peace RB	441.91	7.48	-4.56	392.16	143.4	49.95	53.15	2344.39
211	Peace RB	408.14	6.38	-5.61	360.29	149.18	48.61	51.7	2318.97
212	Athabasca RB	424.41	4.81	-6.8	378.81	137.1	46.26	49.38	3149.2
213	Peace RB	404.44	7.1	-5.44	358.69	128.41	46.63	51.62	2358.46
214	Peace RB	441.91	7.48	-4.56	392.01	144.7	50.03	53.04	2344.49
215	Peace RB	441.91	7.48	-4.56	392.11	156.64	49.84	52.92	2315.35
216	Athabasca RB	401.78	4.76	-6.43	355.24	89.84	47.09	50.32	2645.7
217	Peace RB	417.78	6.62	-5.61	369.96	155.82	48.35	50.95	2338.21
218	Peace RB	441.91	7.48	-4.56	391.38	133.55	50.74	53.79	2314.97
219	Peace RB	441.91	7.48	-4.56	392.07	150.89	49.91	52.89	2315.3
220	Peace RB	394.96	7.3	-5.91	347.43	134.22	48.05	51.13	2366.44
221	Peace RB	404.44	7.1	-5.44	355.91	134.99	49.41	52.42	2364.49
222	Peace RB	391.35	7.68	-5.09	343.07	140.79	48.91	51.93	2301.73
223	Peace RB	411.48	5.54	-5.98	363.76	161.63	47.91	50.92	2357.24
224	Peace RB	441.91	7.48	-4.56	392.24	152.18	49.86	52.88	2315.32
225	Peace RB	435.07	5.94	-6.05	387.17	138.55	48.81	51.87	2353.52
226	Peace RB	426.92	5.84	-6.73	378.99	136.06	48.24	51.25	2404.36
227	Peace RB	441.91	7.48	-4.56	392.4	142.64	49.75	52.72	2364.04
228	Peace RB	410.21	6.97	-5.41	363.44	214.98	48.26	51.4	2366.47
229	Athabasca RB	392.16	5.38	-6.25	345.84	99.99	46.98	50.62	3694.03
230	Peace RB	402.78	6.92	-4.71	355.14	157.91	48.29	50.87	2316.9
231	Peace RB	465.47	7.61	-4.21	416.57	161.45	49.54	52.6	2356.18
232	Peace RB	441.91	7.48	-4.56	392.07	143.32	50.07	53.26	2344.36

233	Peace RB	441.91	7.48	-4.56	392.02	148.31	49.88	52.98	2314.04
234	Peace RB	425.21	5.92	-5.55	377.19	167.5	48.39	51.52	2337.07
235	Athabasca RB	413.83	5.86	-6.15	366.15	100.28	48.83	51.92	3707.56

Table 5. Continued.

Subbasin	RB NAME	PCP	TMAX	TMIN	BLUE	DA	ET	PET	SW
236	Peace RB	391.35	7.68	-5.09	343.03	147.52	49.14	51.68	2301.67
237	Athabasca RB	429.25	4.9	-6.56	383.19	92.58	47.03	50.15	2728.87
238	Peace RB	410.37	6.75	-4.76	362.29	186.49	48.52	51.07	2309.99
239	Peace RB	410.37	6.75	-4.76	362.43	211.76	48.47	51.67	2339.36
240	Peace RB	441.91	7.48	-4.56	392.24	146.26	49.81	53.38	2325.38
241	Peace RB	441.91	7.48	-4.56	392.23	148.4	49.88	53	2314.05
242	Athabasca RB	416.74	5.5	-6.25	368.28	89.36	48.82	51.95	2243.42
243	Peace RB	441.91	7.48	-4.56	392.66	144.27	49.47	52.03	2309.56
244	Peace RB	441.91	7.48	-4.56	392.12	150.66	49.91	52.98	2311.88
245	Peace RB	441.91	7.48	-4.56	392.41	142.41	49.66	52.74	2364.01
246	Peace RB	441.91	7.48	-4.56	392.17	151.26	49.88	52.97	2311.9
247	Peace RB	391.35	7.68	-5.09	342.78	141.54	49.22	52.31	2301.62
248	Athabasca RB	413.83	5.86	-6.15	366.13	99.78	48.88	51.87	3707.55
249	Athabasca RB	416.74	5.5	-6.25	368.73	89.58	48.33	50.91	2243.63
250	Peace RB	420.17	7.32	-4.47	371.03	154.69	49.46	52.02	2311.32
251	Peace RB	417.78	6.62	-5.61	369.23	143.53	48.89	52.02	2326.62
252	Athabasca RB	429.25	4.9	-6.56	383.07	94.67	47.11	50.26	2727.66
253	Peace RB	429.72	6.74	-5.15	381.89	155.84	48.5	51.07	2320.67
254	Peace RB	391.35	7.68	-5.09	342.63	144.84	49.45	52.57	2301.55
255	Peace RB	404.44	7.1	-5.44	355.82	134.38	49.45	52.43	2364.49
256	Peace RB	465.47	7.61	-4.21	416.24	157.74	49.87	52.87	2356.65
257	Peace RB	465.47	7.61	-4.21	415.39	176.62	50.69	53.92	1362.81
258	Peace RB	465.47	7.61	-4.21	416.84	151.24	49.42	52.62	2394.34
259	Peace RB	409.18	7.39	-4.1	359.99	140.12	49.95	53.05	2348.92
260	Athabasca RB	414.29	5.61	-6.55	365.75	86.58	48.41	51.53	2512.8
261	Peace RB	410.21	6.97	-5.41	363.12	144.39	48.46	51	2321.71
262	Peace RB	424.7	6.58	-5.51	376.17	158.91	49.1	52.2	2336.77
263	Peace RB	421.07	7.44	-4.95	371.3	139.73	50.04	53.08	2354.09
264	Athabasca RB	441.91	5.82	-6.38	392.85	98.02	48.4	51.54	2510.84
265	Peace RB	445.53	7.14	-4.93	397.37	157.2	48.63	51.26	2329.02
266	Athabasca RB	429.25	4.9	-6.56	382.99	87.83	47.2	50.44	2734.34
267	Peace RB	445.95	7.42	-3.96	396.71	149	49.53	52.07	2361.63
268	Athabasca RB	438	6.22	-6.04	389.35	92.54	49.27	52.52	2221.17
269	Athabasca RB	422.46	6.67	-5.93	372.83	89.17	49.66	52.3	2484.47
270	Athabasca RB	422.46	6.67	-5.93	373.27	88.61	49.52	52.15	2200.68
271	Athabasca RB	422.46	6.67	-5.93	373.17	87.57	49.62	52.27	2200.66
272	Peace RB	495.41	8.43	-3.73	445.58	175.24	49.93	52.56	2384.64
273	Peace RB	495.41	8.43	-3.73	444.75	172.21	50.85	54.12	1382.14
274	Peace RB	440.06	6.44	-5.06	390.33	171.48	49.97	53.19	2334.31
275	Peace RB	437.53	5.32	-6.18	390.21	166.8	47.92	51.08	2385.33
276	Athabasca RB	441.91	5.82	-6.38	394.39	104.48	48	51.19	3068.96
277	Peace RB	398.23	7.78	-4.29	349.12	139.5	49.79	52.44	2353.84
278	Peace RB	465.47	7.61	-4.21	416.25	154.18	49.92	52.97	2356.43
279	Athabasca RB	422.46	6.67	-5.93	373.3	87.55	49.53	52.71	2200.66

280	Peace RB	398.23	7.78	-4.29	348.8	137.76	50.13	52.94	2354.27
281	Athabasca RB	422.46	6.67	-5.93	373.24	88.83	49.61	52.7	2200.7
282	Peace RB	465.47	7.61	-4.21	417	151.01	49.28	51.88	2389.67

Table 5. Continued.

Subbasin	RB NAME	PCP	TMAX	TMIN	BLUE	DA	ET	PET	SW
283	Peace RB	420.17	7.32	-4.47	371.01	195.98	49.62	52.97	2319.16
284	Athabasca RB	429.25	4.9	-6.56	382.58	89.5	47.47	50.89	2726.4
285	Peace RB	420.17	7.32	-4.47	370.7	193.05	49.86	52.39	2321.34
286	Peace RB	429.72	6.74	-5.15	381.39	154.35	48.76	52.02	2320.58
287	Peace RB	420.17	7.32	-4.47	370.85	193.53	49.88	52.99	2321.33
288	Peace RB	438.89	7.9	-3.19	391.12	138.53	48.52	53.66	2301.79
289	Peace RB	398.23	7.78	-4.29	349.03	142.65	50.07	53.12	2304.88
290	Peace RB	465.47	7.61	-4.21	416.43	153.39	49.84	52.85	2394.41
291	Peace RB	438.89	7.9	-3.19	389.43	136.41	50.23	53.37	2343.06
292	Peace RB	420.88	7.33	-4.42	374.21	137.3	47.7	52.63	2344.84
293	Peace RB	398.23	7.78	-4.29	349.09	139.32	49.88	52.97	2353.79
294	Peace RB	448.24	7.45	-4.46	398.07	162.35	50.13	53.19	2318.76
295	Peace RB	448.24	7.45	-4.46	398.47	207.41	49.95	53.3	2326.29
296	Peace RB	438.89	7.9	-3.19	390.45	138.76	49.14	54.37	2339.88
297	Peace RB	445.95	7.42	-3.96	396.71	149.36	49.63	52.72	2361.55
298	Peace RB	433.33	6.57	-4.99	383.15	155.6	50.09	53.27	2318.56
299	Peace RB	495.41	8.43	-3.73	445.18	176.08	50.34	53.46	2384.39
300	Athabasca RB	455.08	5.11	-6.51	408.12	97.63	48.42	51.72	2771.81
301	Peace RB	435.58	6.52	-5.26	385.43	188.34	50.02	52.7	2319.5
302	Peace RB	465.47	7.61	-4.21	416.2	152.42	50.13	53.2	2394.19
303	Peace RB	495.41	8.43	-3.73	444.58	173.46	51.18	54.39	1382.01
304	Athabasca RB	422.46	6.67	-5.93	373.21	90.26	49.77	53.01	2200.61
305	Peace RB	449.91	8.28	-2.99	402.98	143.41	48.18	53.16	2337.97
306	Peace RB	430.3	7.2	-3.78	383.26	136.11	47.72	53.14	2346.96
307	Peace RB	449.91	8.28	-2.99	401.07	142.58	50.08	53.18	2343.06
308	Athabasca RB	438	6.22	-6.04	389.27	90.87	49.44	52.6	2221.06
309	Peace RB	448.97	7.46	-4.65	398.88	160.97	50.38	52.98	2323.5
310	Peace RB	449.91	8.28	-2.99	402.92	139.98	48.18	53.69	2337.9
311	Peace RB	409.18	7.39	-4.1	362.29	132.72	47.77	53.16	2342.41
312	Peace RB	398.23	7.78	-4.29	350.56	130.95	48.61	53.37	2346.73
313	Peace RB	465.47	7.61	-4.21	416.19	159.93	50.25	53.3	2394.01
314	Athabasca RB	442.83	5.53	-6.4	394.45	140.76	48.82	52.1	3121.08
315	Athabasca RB	444.68	6.55	-5.49	394.64	114.39	49.94	53.03	3027.24
316	Athabasca RB	450.96	6.61	-5.66	401.02	148.33	50.12	52.85	3066.1
317	Peace RB	426.37	7.22	-4.84	377.99	161.29	49.11	52.04	2334.03
318	Peace RB	434.11	8.06	-3.79	387.19	142.18	47.86	53.35	2310.33
319	Peace RB	495.41	8.43	-3.73	445.03	181.27	50.58	53.72	2385.29
320	Peace RB	449.91	8.28	-2.99	402.85	142.55	48.3	53.91	2337.93
321	Peace RB	438.89	7.9	-3.19	388.44	144.21	51.3	54.44	2361.63
322	Peace RB	495.41	8.43	-3.73	444.02	185.3	51.74	54.88	1382.73
323	Peace RB	495.41	8.43	-3.73	445.13	179.56	50.35	53.63	2385.31
324	Peace RB	433.33	6.57	-4.99	383.06	195.56	50.44	53.65	2321.42
325	Peace RB	452.88	7.6	-4.33	403.57	158.24	49.65	52.88	2327.84
326	Athabasca RB	454.41	6.87	-5.3	404.16	97.94	50.22	53.4	2205.84

327	Athabasca RB	452.8	6.33	-5.66	403.8	148.22	49.95	52.67	3070.98
328	Peace RB	495.41	8.43	-3.73	444.9	182.44	50.72	53.6	2385.31
329	Athabasca RB	454.41	6.87	-5.3	404.16	93.42	50.19	53.46	2205.74

Table 5. Continued.

Subbasin	RB NAME	PCP	TMAX	TMIN	BLUE	DA	ET	PET	SW
330	Athabasca RB	454.85	6.71	-5.6	404.61	95.82	50.11	52.81	2202.35
331	Peace RB	434.11	8.06	-3.79	387.26	143.2	47.9	52.9	2343.61
332	Athabasca RB	455.08	5.11	-6.51	407.94	143.2	48.17	51.57	879.87
333	Athabasca RB	455.08	5.11	-6.51	407.8	142.38	48.27	51.43	879.81
334	Athabasca RB	454.41	6.87	-5.3	403.99	139.93	50.38	53.29	3064.08
335	Athabasca RB	454.41	6.87	-5.3	404.37	101.25	50.07	53.07	3029.65
336	Peace RB	453.56	6.84	-5	403.48	206.58	50.63	53.54	2322.6
337	Peace RB	427.42	8.57	-3.33	376.87	159.75	50.98	54.28	2303.53
338	Peace RB	444.48	7.18	-4.37	393.81	202.64	51	54.39	2318.37
339	Peace RB	449.91	8.28	-2.99	399.89	149.02	51.13	54.46	2360.49
340	Athabasca RB	455.08	5.11	-6.51	407.8	139.76	48.33	51.7	879.49
341	Peace RB	444.48	7.18	-4.37	393.78	202.49	50.93	54.06	2318.38
342	Athabasca RB	488.21	5.93	-6.16	438.12	152.18	50.37	53.78	3104.33
343	Peace RB	440.06	6.44	-5.06	389.99	177.48	50.55	53.5	2334.06
344	Athabasca RB	455.08	5.11	-6.51	407.64	137.44	48.36	51.79	878.69
345	Athabasca RB	455.08	5.11	-6.51	407.79	143.95	48.36	51.5	879.73
346	Athabasca RB	448.36	5.98	-5.75	399.67	96.55	49.7	52.68	2219.79
347	Peace RB	554.28	8.48	-3.7	503.45	217.05	50.81	53.53	1407.22
348	Athabasca RB	454.41	6.87	-5.3	403.66	145	50.55	53.99	3064.04
349	Athabasca RB	452.8	6.33	-5.66	402.86	109.52	49.93	52.82	3035.33
350	Athabasca RB	452.8	6.33	-5.66	403.51	140.8	50.12	52.81	3070.88
351	Peace RB	449.91	8.28	-2.99	399.95	158.34	50.97	53.78	2307.48
352	Athabasca RB	455.08	5.11	-6.51	407.66	144.13	48.36	51.72	879.7
353	Peace RB	427.42	8.57	-3.33	376.48	157.16	51.41	54.28	2303.36
354	Peace RB	470.82	7.58	-4.59	420.67	166.14	50.2	53.32	2330.1
355	Athabasca RB	448.36	5.98	-5.75	400.19	146.79	49.26	52.69	784.74
356	Peace RB	427.42	8.57	-3.33	376.85	144.44	51.08	54.01	2342.49
357	Peace RB	452.97	7.16	-4.4	402.2	209.61	51.29	54.42	2324.88
358	Peace RB	477.34	8.6	-3.68	425.83	161.62	52.12	55.54	2360.04
359	Peace RB	554.28	8.48	-3.7	501.74	216.47	52.49	55.81	1406.83
360	Peace RB	444.48	7.18	-4.37	393.72	203.54	51.05	54.72	2318.35
361	Peace RB	479.2	7.77	-4.52	429.13	170.35	50.63	53.97	2329.1
362	Peace RB	448.24	7.45	-4.46	398.53	240.25	50.31	53.57	2364.03
363	Athabasca RB	448.36	5.98	-5.75	400.24	93.99	49.38	53.3	2600.52
364	Peace RB	554.28	8.48	-3.7	503.8	207.51	50.48	53.11	2410.08
365	Peace RB	470.82	7.58	-4.59	428.17	151.57	42.49	54.01	160.97
366	Athabasca RB	448.36	5.98	-5.75	400.26	140.28	49.39	52.6	3087.28
367	Athabasca RB	455.08	5.11	-6.51	407.67	143.37	48.64	51.75	879.42
368	Athabasca RB	450.96	6.61	-5.66	401.18	104.22	50.03	52.98	2204.48
369	Peace RB	452.88	7.6	-4.33	405.74	150.21	47.8	52.39	2359.71
370	Peace RB	483.61	7.36	-4.39	432.72	223.95	51.24	54.66	2329.6
371	Athabasca RB	451.86	7.02	-5.06	401.19	115.3	51.12	54.78	3028.96
372	Peace RB	554.28	8.48	-3.7	502.28	192.1	52.3	55.09	1405.38
373	Peace RB	487.17	7.72	-4.39	435.73	186.5	51.6	54.93	2339.57

374	Athabasca RB	448.36	5.98	-5.75	399.9	104.66	49.75	53	2710.09
375	Peace RB	434.11	8.06	-3.79	387.44	140.2	48.13	53.16	2343.5
376	Peace RB	444.48	7.18	-4.37	393.61	205.32	51.25	54.6	2318.31

Table 5. Continued.

Subbasin	RB NAME	PCP	TMAX	TMIN	BLUE	DA	ET	PET	SW
377	Peace RB	474.19	8.76	-3.16	422.33	160.63	52.06	55.42	2359.99
378	Athabasca RB	452.8	6.33	-5.66	403.77	143	50.16	53.44	3070.88
379	Peace RB	495.41	8.43	-3.73	447.72	159.59	48.17	53.16	2399.76
380	Peace RB	495.41	8.43	-3.73	447.55	161.17	48.24	53.63	2399.76
381	Peace RB	483.14	7.18	-4.68	432.95	223.45	50.75	54.24	2335.74
382	Peace RB	462.07	8.27	-3.42	411.33	154.29	51.38	54.87	2387.15
383	Peace RB	474.19	8.76	-3.16	423.07	159.47	51.46	54.56	2360.19
384	Peace RB	519.95	8.66	-3.86	470.32	176.38	50.29	53.51	2418.67
385	Athabasca RB	451.86	7.02	-5.06	401.75	96.52	50.87	54.14	2205.61
386	Athabasca RB	467.47	6.91	-5.24	417.56	97.05	50.89	53.58	2206.03
387	Athabasca RB	474.18	6.54	-5.63	423.57	156.54	50.53	53.26	3073.09
388	Peace RB	471.45	7.15	-4.67	420.6	210.8	51.38	54.34	2336.07
389	Peace RB	462.07	8.27	-3.42	413.33	159.11	49.45	54.78	2333.98
390	Athabasca RB	467.47	6.91	-5.24	417.49	117.49	50.87	54.29	3033.36
391	Peace RB	519.95	8.66	-3.86	470.26	180.95	50.56	53.29	2377.53
392	Peace RB	554.28	8.48	-3.7	504.38	191.07	49.92	53.18	2391.57
393	Peace RB	465.72	8.83	-3.58	416.41	159.07	49.85	55.1	2325.16
394	Athabasca RB	488.21	5.93	-6.16	437.2	101.55	49.8	53.1	3030.07
395	Peace RB	462.07	8.27	-3.42	413.42	162.01	49.43	53.98	2334.01
396	Athabasca RB	470.82	7.58	-4.59	433.64	101.4	37.55	53.56	131.57
397	Athabasca RB	485.77	8.27	-3.7	448.63	106.35	38.01	53.61	131.78
398	Peace RB	455.81	8.22	-3.62	405.37	167.04	51.42	54.19	2333.41
399	Peace RB	465.72	8.83	-3.58	414.81	157.52	51.48	54.67	1696.34
400	Peace RB	465.72	8.83	-3.58	417.23	151.9	49.08	55.03	1694.34
401	Athabasca RB	499.02	8.11	-4.22	467.72	110.26	31.47	53.94	136.9
402	Peace RB	483.14	7.18	-4.68	432.68	218.76	51.2	53.99	2337.31
403	Peace RB	455.81	8.22	-3.62	405.69	156.71	50.9	54.55	1693.64
404	Peace RB	514.11	8.83	-4	462.98	174.69	51.52	54.75	2409.62
405	Athabasca RB	454.53	6.64	-5.4	405.66	145.14	50.67	53.99	3067.27
406	Athabasca RB	448.36	5.98	-5.75	400.04	145.71	49.89	52.83	3087.24
407	Peace RB	554.28	8.48	-3.7	503.37	217.74	51.11	54.04	1407.09
408	Peace RB	554.28	8.48	-3.7	503.45	211.19	51.11	54.63	1406.68
409	Peace RB	554.28	8.48	-3.7	503.94	204	50.48	53.93	2409.91
410	Athabasca RB	499.02	8.11	-4.22	467.86	108.04	31.5	54.12	136.89
411	Peace RB	554.28	8.48	-3.7	503.81	197.05	50.71	53.53	2408.83
412	Peace RB	554.28	8.48	-3.7	503.52	203.63	50.98	54.37	2409.74
413	Athabasca RB	499.02	8.11	-4.22	467.81	108.18	31.52	54.15	136.88
414	Peace RB	502.36	8.88	-3.75	451.44	176.14	51.5	54.27	2362.53
415	Peace RB	554.28	8.48	-3.7	502.71	205.16	51.73	55.06	2409.48
416	Peace RB	674.66	6.02	-4.8	629.41	227.68	46.19	49.71	1521.72
417	Peace RB	477.34	8.6	-3.68	426.92	160.24	51.79	55.23	2385.59
418	Peace RB	474.19	8.76	-3.16	422.58	162.75	52.22	55.42	2359.89
419	Peace RB	485.77	8.27	-3.7	434.55	166.78	51.8	55.06	2363.37
420	Athabasca RB	499.02	8.11	-4.22	447.51	105.96	51.5	54.72	2486.34

421	Athabasca RB	453.56	6.84	-5	403.74	119.42	50.8	53.76	3028.44
422	Athabasca RB	466.53	7.06	-4.88	416.86	117.76	50.97	53.96	3030.92
423	N_Beaver	451.31	6.49	-5.36	400.1	158.6	50.85	53.66	2466.82

Table 5. Continued.

Subbasin	RB NAME	PCP	TMAX	TMIN	BLUE	DA	ET	PET	SW
424	N_Beaver	451.31	6.49	-5.36	400.74	169.46	50.49	53.69	2469.27
425	Athabasca RB	510.92	8.23	-4.42	459.44	111.74	51.9	55.11	2486.25
426	Athabasca RB	479.2	7.77	-4.52	454.52	155.71	7.41	53.64	51.2
427	Athabasca RB	451.31	6.49	-5.36	402.41	144.97	50.55	53.69	3062.59
428	Athabasca RB	454.53	6.64	-5.4	405.7	145.81	50.9	53.83	3067.21
429	Athabasca RB	517.56	8.1	-4.42	4.02	1.81	140.98	203.84	387.4
430	N_Beaver	451.31	6.49	-5.36	400.25	168.08	50.59	52.94	2469.14
431	N_Beaver	451.31	6.49	-5.36	400.42	169.03	50.35	53.66	2469.38
432	Athabasca RB	465.81	7.28	-4.82	415.17	120.15	50.96	54.45	3023.31
433	Athabasca RB	454.53	6.64	-5.4	405.1	110.97	50.8	53.6	3032.03
434	Athabasca RB	465.81	7.28	-4.82	414.52	119.55	51.6	54.53	3023.15
435	Athabasca RB	517.56	8.1	-4.42	465.21	108.67	51.9	54.68	2490.32
436	Athabasca RB	510.92	8.23	-4.42	458.07	108.01	52.57	55.39	2492.35
437	Peace RB	514.11	8.83	-4	462.49	193.62	51.85	54.59	2347.98
438	Athabasca RB	471.24	6.35	-5.7	420.09	94.92	50.26	53.64	3014.92
439	Athabasca RB	451.31	6.49	-5.36	401.68	148.27	50.73	53.44	3062.49
440	Peace RB	474.19	8.76	-3.16	422.12	159.18	52.17	55.1	2386.21
441	Peace RB	674.66	6.02	-4.8	628.03	243.6	46.85	50.2	1523.19
442	Peace RB	514.11	8.83	-4	462.11	178.43	52.08	55.61	2362.01
443	Peace RB	502.36	8.88	-3.75	450.44	174.48	51.93	55.26	2362.31
444	Peace RB	502.36	8.88	-3.75	450.47	172.5	51.86	55.15	2362.28
445	Peace RB	591.97	7.36	-3.94	542.65	213.92	49.64	53	2446.89
446	Athabasca RB	464.27	6.22	-5.56	414.23	98.35	50.37	53.89	3015.54
447	Athabasca RB	464.27	6.22	-5.56	415.18	148.31	50.59	53.38	3074.07
448	Athabasca RB	471.24	6.35	-5.7	421.13	149.79	50.55	53.52	3074.95
449	Athabasca RB	499.02	8.11	-4.22	447.2	106.46	51.45	54.44	2489.29
450	Athabasca RB	485.94	6.69	-5.39	435.21	155.16	51.41	54.18	3071.38
451	Athabasca RB	487.75	6.48	-5.66	437.36	157.93	50.86	53.94	3073.68
452	Athabasca RB	506.77	7.89	-4.81	454.54	108.94	51.64	54.67	3019.04
453	Peace RB	528.59	9.36	-2.83	474.91	181.33	53.63	56.32	2368.08
454	Athabasca RB	506.77	7.89	-4.81	454.53	105.97	51.76	55.14	3016.4
455	Athabasca RB	487.75	6.48	-5.66	437.6	158.77	50.79	53.58	3073.71
456	Peace RB	528.59	9.36	-2.83	474.97	178.69	53.64	56.61	2368.03
457	Athabasca RB	497.01	7.77	-4.69	445.21	106.83	52.04	55.44	3016.3
458	Athabasca RB	511.79	7.56	-4.38	461.23	107.73	51.5	54.19	2489.1
459	Athabasca RB	506.77	7.89	-4.81	455.12	105.93	51.45	54.44	3012.64
460	Athabasca RB	482.89	6.51	-5.66	432.98	153.03	50.97	53.71	3077.92
461	Athabasca RB	471.24	6.35	-5.7	421.39	148.72	50.67	53.65	3074.9
462	Athabasca RB	506.77	7.89	-4.81	454.45	104.64	51.82	54.73	3016.35
463	Peace RB	533.04	8.86	-3.3	480.97	204.11	52.11	54.85	2393.96
464	Peace RB	540.65	9.04	-3.51	487.61	185.93	53.15	56.49	2409.24
465	Athabasca RB	506.77	7.89	-4.81	454.24	104.34	51.77	55.18	3016.35
466	Athabasca RB	487.75	6.48	-5.66	437.34	158.07	51.02	53.81	3073.61
467	Peace RB	528.59	9.36	-2.83	474.54	198.49	54.1	57.14	2407.93

468	Athabasca RB	471.24	6.35	-5.7	420.98	149.11	50.96	54.38	3074.81
469	Peace RB	535.82	8.93	-3.19	482.2	199.43	53.75	56.67	2411.61
470	Peace RB	563.25	8.39	-3.88	511.47	213.38	51.7	55.1	2398.41

Table 5. Continued.

Subbasin	RB NAME	PCP	TMAX	TMIN	BLUE	DA	ET	PET	SW
471	Athabasca RB	517.56	8.1	-4.42	464.38	110.62	52.94	56.38	2493.7
472	N_Beaver	451.31	6.49	-5.36	400.45	165.98	50.57	53.36	2207.62
473	N_Beaver	464.27	6.22	-5.56	412.77	162.77	50.24	53.58	2480.66
474	Peace RB	596.53	8.75	-3.57	544.8	223.54	51.58	54.8	2396.89
475	N_Beaver	464.27	6.22	-5.56	431.72	149.45	8.07	53.86	60.32
476	N_Beaver	464.27	6.22	-5.56	412.33	170.69	50.4	53.8	2222.91
477	Peace RB	535.82	8.93	-3.19	482.27	196.57	53.85	57.12	2381.57
478	Peace RB	596.53	8.75	-3.57	544.01	224.49	52.49	55.89	2396.59
479	Athabasca RB	471.24	6.35	-5.7	421.33	152.92	50.99	54.49	3074.79
480	N_Beaver	464.27	6.22	-5.56	412.33	163.17	50.76	53.82	2480.49
481	Athabasca RB	486.36	7.11	-5	435.21	159.45	51.52	54.74	3073.52
482	Peace RB	533.04	8.86	-3.3	480.05	205.16	53.06	56.13	2393.08
483	Peace RB	591.97	7.36	-3.94	543.5	185.63	49.54	52.9	1397.68
484	Athabasca RB	518.29	8.42	-4.67	465.71	109.09	52.87	56.28	2489.76
485	Peace RB	782.76	4.79	-5.24	740.63	254.75	44.11	46.99	1677.67
486	Athabasca RB	518.29	8.42	-4.67	466.12	129.57	52.97	56.58	3044.74
487	Athabasca RB	508.69	8.69	-4.31	456.35	105.15	52.77	55.57	2483.15
488	Athabasca RB	506.77	7.89	-4.81	454.94	109.26	51.98	54.71	2490.97
489	Peace RB	688.43	6.12	-4.36	643.01	195.59	46.73	49.46	1460.38
490	Athabasca RB	473.72	7.55	-4.41	421.96	102.31	51.92	55.56	3001.73
491	Athabasca RB	465.81	7.28	-4.82	415.11	151.06	51.68	54.42	3064.61
492	Athabasca RB	518.29	8.42	-4.67	466.02	106.84	52.73	55.71	2488.42
493	Athabasca RB	483.02	7.34	-4.68	433.49	100.51	50.25	54.6	3033.21
494	N_Beaver	464.27	6.22	-5.56	412.17	162.82	50.87	53.68	2480.43
495	Athabasca RB	479.41	6.83	-5.28	428.44	153.42	51.48	54.68	3066.21
496	Peace RB	688.43	6.12	-4.36	642.48	202.71	47.23	50.19	1461
497	Athabasca RB	483.02	7.34	-4.68	431.05	100.25	51.97	55.4	3007.29
498	Athabasca RB	483.02	7.34	-4.68	431.56	99.89	51.68	54.62	3003.6
499	Athabasca RB	508.69	8.69	-4.31	455.93	107.72	52.85	55.52	3012.33
500	Peace RB	670.16	5.84	-5.18	621.95	250.37	47.79	50.62	1538.46
501	Athabasca RB	486.36	7.11	-5	434.36	100.84	51.76	55.28	3008.22
502	Peace RB	584.1	9.24	-3.16	530.21	233.92	54.52	57.24	2431.26
503	Peace RB	782.76	4.79	-5.24	739.39	229.92	45.18	48.99	1672.1
504	Peace RB	688.43	6.12	-4.36	642.19	223.27	47.76	51.36	1522.15
505	Athabasca RB	485.67	6.99	-5.08	434.37	103.24	51.64	55.13	3010.01
506	Athabasca RB	497.01	7.77	-4.69	445.38	107.89	52.38	55.07	3014.75
507	Athabasca RB	478.06	7.53	-4.37	426.06	96.06	52.21	54.91	3002.82
508	Athabasca RB	512.85	8.22	-3.91	459.61	105.55	53.01	55.69	3007.47
509	Athabasca RB	478.06	7.53	-4.37	425.98	101.16	52.15	54.95	3003.52
510	Athabasca RB	485.78	7.9	-3.19	433.05	100.37	53.19	55.92	3002.12
511	Athabasca RB	485.78	7.9	-3.19	433.34	102.62	52.92	55.61	3001.25
512	Athabasca RB	477.22	7.65	-4.19	425.13	101.41	52.23	54.94	3001.67
513	Athabasca RB	478.06	7.53	-4.37	426.54	97.03	52.15	54.85	2472.79
514	Athabasca RB	518.29	8.42	-4.67	465.41	108.24	53.11	55.79	2488.32

515	Athabasca RB	508.69	8.69	-4.31	456.33	129.76	52.8	55.78	3033.76
516	Athabasca RB	478.06	7.53	-4.37	426.1	98.59	52.39	55.15	2472.67
517	Athabasca RB	478.97	7.74	-4	426.87	103.46	52.5	55.26	3006.02

Table 5. Continued.

Subbasin	RB NAME	PCP	TMAX	TMIN	BLUE	DA	ET	PET	SW
518	Athabasca RB	583.83	9.31	-3.77	531.09	125.12	52.85	55.63	2497.72
519	N_Beaver	456.65	6.5	-5.33	403.56	158.67	51.13	54.04	2468.73
520	Athabasca RB	577.74	7.05	-5.6	524.96	118.69	50.46	53.69	2523.04
521	Athabasca RB	604.2	7.16	-4.81	548.8	127.81	48.58	51.44	2559.51
522	Athabasca RB	580.47	9.35	-2.85	525.77	119.25	54.89	57.74	2485
523	Athabasca RB	580.47	9.35	-2.85	525.97	122.46	54.58	57.45	2485.08
524	Athabasca RB	481.64	8.36	-3	442.04	109.33	40.5	56.42	120.65
525	Athabasca RB	581.91	8.48	-4.26	528.05	120.03	51.25	54.12	2838.9
526	Athabasca RB	583.83	9.31	-3.77	530.28	123.12	53.28	56.17	2497.6
527	Athabasca RB	568.77	8.51	-4.89	515.41	115.69	53.09	55.99	2506.14
528	Athabasca RB	490.67	9.27	-4.27	437.46	96.59	53.65	56.42	2474.35
529	Athabasca RB	572.76	8.96	-3.88	518.44	119.44	54.25	57.05	2496.76
530	Athabasca RB	568.77	8.51	-4.89	3.78	1.19	141.96	205.18	447.08
531	Athabasca RB	508.69	8.69	-4.31	455.16	112.49	53.01	55.31	3013.47
532	Athabasca RB	490.67	9.27	-4.27	437.23	103.2	53.77	56.53	2474.3
533	Beaver RB	456.65	6.5	-5.33	401.33	168.15	51.57	54.4	2469.23
534	Beaver RB	456.65	6.5	-5.33	402.8	157.55	51.5	54.84	2468.59
535	Athabasca RB	501.28	8.79	-2.98	449.34	104.75	52.14	56.97	3007.11
536	Athabasca RB	540.7	9.11	-4.61	487.52	111.56	53.67	56.39	2491.68
537	Athabasca RB	568.77	8.51	-4.89	515.95	111.11	52.95	55.72	2502.24
538	Athabasca RB	575.15	9.47	-4.77	521.49	113.9	53.91	56.68	2498.2
539	Athabasca RB	503.73	9.22	-3.44	452.3	107.48	51.96	56.56	3032.62
540	Beaver RB	461.74	6.67	-5.37	407.29	168.56	51.43	54.23	2476.24
541	Beaver RB	444.49	7.14	-4.95	390.46	154.32	52.37	55.69	2455.6
542	Athabasca RB	581.91	8.48	-4.26	527.76	120.16	51.2	54.42	2838.82
543	Athabasca RB	738.66	5.38	-5.91	688.58	109.25	45.69	48.66	1907.46
544	Beaver RB	437.9	7.08	-4.69	382.64	161.69	52.15	55.04	2462.75
545	Beaver RB	477.22	7.65	-4.19	421.27	164.68	52.66	55.87	2443.01
546	Beaver RB	461.41	8.16	-3.71	405.57	160.94	53.02	56.33	2431.61
547	Beaver RB	437.9	7.08	-4.69	382.75	153.25	52.25	55.58	2455.26
548	Athabasca RB	501.28	8.79	-2.98	450.05	104.31	51.62	57.15	2474.51
549	Athabasca RB	503.73	9.22	-3.44	452.01	104.52	52.13	56.68	3032.55
550	Beaver RB	437.9	7.08	-4.69	382.77	153.15	52.36	55.13	2455.24
551	Beaver RB	437.9	7.08	-4.69	382.3	152.96	52.61	55.82	2455.12
552	Athabasca RB	490.67	9.27	-4.27	437.07	100.2	53.88	57.07	2474.33
553	Athabasca RB	583.83	9.31	-3.77	530.48	124.85	53.25	56.05	2497.5
554	Athabasca RB	564.5	9.79	-3.98	510.45	114.22	54.24	57.1	2929.11
555	Athabasca RB	564.5	9.79	-3.98	510.18	112.42	54.37	57.17	2487.55
556	Athabasca RB	610.71	9.04	-4.1	555.84	127.33	54.08	56.91	2508.05
557	Athabasca RB	587.97	9.14	-4.54	534.44	193.21	54.28	57.25	3100.74
558	Athabasca RB	587.97	9.14	-4.54	533.67	123.63	54.15	57.39	2501.5
559	Athabasca RB	587.97	9.14	-4.54	534.62	189.91	54.22	57.15	3100.75
560	Beaver RB	469.9	7.36	-4.76	412.93	152.74	52.44	55.69	2456.02
561	Athabasca RB	587.97	9.14	-4.54	534.36	190.77	54.37	57.66	3100.72

562	Beaver RB	437.9	7.08	-4.69	382.86	152.94	52.43	55.73	2455.17
563	Beaver RB	463.48	8.13	-3.83	408.11	161.19	53.04	56.18	2437.19
564	Beaver RB	460.26	7.86	-4.31	403.65	150.36	53.13	56.37	2455.73

Table 5. Continued.

Subbasin	RB NAME	PCP	TMAX	TMIN	BLUE	DA	ET	PET	SW
565	Athabasca RB	610.71	9.04	-4.1	557.28	200.35	54.13	57.31	3106.54
566	Beaver RB	460.26	7.86	-4.31	403.25	150.56	53.55	56.9	2453.98
567	Beaver RB	460.26	7.86	-4.31	403.7	150.31	53.12	56.26	2455.71
568	Beaver RB	437.9	7.08	-4.69	382.81	153.24	52.43	55.64	2455.16
569	Athabasca RB	800.45	4.74	-5.75	749.39	109.81	45.12	48.39	1943.08
570	Athabasca RB	637.21	7.54	-4.93	584.69	103.02	51.94	54.87	1806.38
571	Athabasca RB	738.66	5.38	-5.91	689.75	125.29	44.92	47.82	1910.55
572	Athabasca RB	575.15	9.47	-4.77	521.38	120.95	54.26	57.18	2499.93
573	Beaver RB	431	7.83	-4.46	375.8	139.95	52.66	55.53	2437.24
574	Beaver RB	425.81	7.73	-3.99	371.26	137.86	53.12	56.19	2437.85
575	Beaver RB	437.9	7.08	-4.69	383.12	149.24	52.51	55.52	2445.8
576	Athabasca RB	609.56	9.68	-4.28	555.82	201.68	54.57	57.73	3111.8
577	Beaver RB	425.81	7.73	-3.99	371.04	137.38	53.13	56.45	2438.04
578	Athabasca RB	609.56	9.68	-4.28	553.18	129.68	54.79	57.85	2834.04
579	North Sas. RSB	481.64	8.36	-3	441.97	113.64	39.61	56.51	118.87
580	Beaver RB	431	7.83	-4.46	375.57	139.39	52.72	55.56	2437.22
581	Beaver RB	431	7.83	-4.46	375.12	138.98	53.2	56.33	2436.97
582	Beaver RB	425.81	7.73	-3.99	370.35	138.25	53.73	56.8	2437.63
583	Athabasca RB	738.66	5.38	-5.91	689.7	103.19	44.89	48.02	1906.56
584	North Sas. RSB	461.41	8.16	-3.71	407.96	100.57	53.45	56.24	2867.55
585	Beaver RB	431	7.83	-4.46	375.08	139.06	53.32	56	2436.92
586	Athabasca RB	738.66	5.38	-5.91	688.45	92.38	47.24	50.29	1869.77
587	Athabasca RB	564.5	9.79	-3.98	510.22	114.29	54.62	57.37	2487.46
588	Athabasca RB	609.56	9.68	-4.28	552.93	129.79	54.98	57.82	2834.02
589	Athabasca RB	533.82	9.69	-2.99	480.42	110.67	53.75	56.59	2480.75
590	North Sas. RSB	478.94	8.66	-2.87	426.34	105.01	52.97	56.67	2868.26
591	North Sas. RSB	479.66	8.04	-3.73	427.04	107.74	52.5	56.18	2871.01
592	North Sas. RSB	481.64	8.36	-3	426.73	112.17	53.68	56.35	2873.11
593	North Sas. RSB	478.94	8.66	-2.87	425.49	119.71	53.87	56.56	2868.48
594	Athabasca RB	635.32	8.65	-4.62	577.8	129.21	53.07	55.8	2854.38
595	Athabasca RB	879.03	5.19	-5.55	828.33	117.39	43.66	46.65	1937.21
596	Beaver RB	425.81	7.73	-3.99	370.92	138.45	53.43	56.3	2437.73
597	Athabasca RB	879.03	5.19	-5.55	828.04	155.75	43.76	46.89	1943.16
598	North Sas. RSB	454.13	9.01	-2.44	400.33	102.65	54.79	57.79	2867.22
599	North Sas. RSB	530.63	9.44	-2.16	476.23	113.84	54.98	57.68	2592.93
600	Athabasca RB	845.49	5.65	-5.65	793.7	101.78	46.48	49.15	1886.77
601	North Sas. RSB	494.91	9.39	-2.09	440.45	108.6	54.35	58.15	2871.6
602	North Sas. RSB	494.91	9.39	-2.09	440.45	110.39	54.28	57.97	2871.61
603	North Sas. RSB	494.91	9.39	-2.09	440.7	108.17	54.42	58.09	2870.98
604	North Sas. RSB	437.59	8.63	-3.42	385.81	97.02	52.67	56.47	2863.23
605	North Sas. RSB	463.48	8.13	-3.83	410.99	99.36	53.36	56.03	2869.58
606	Beaver RB	425.81	7.73	-3.99	373.61	147.7	51.26	55.88	2421.79
607	Athabasca RB	845.49	5.65	-5.65	793.61	106.7	46.73	49.76	1887.16
608	North Sas. RSB	530.63	9.44	-2.16	476.33	109.7	55.2	58.07	2592.85

609	Athabasca RB	594.06	9.54	-4.83	540.35	189.91	55.38	58.11	3105.42
610	North Sas. RSB	454.13	9.01	-2.44	400.37	104.41	55	58.21	2867.35
611	North Sas. RSB	494.91	9.39	-2.09	438.83	92.28	55.47	58.11	2874.86

Table 5. Continued.

Subbasin	RB NAME	PCP	TMAX	TMIN	BLUE	DA	ET	PET	SW
612	North Sas. RSB	570.06	10.09	-2	516.27	119.49	55.57	58.11	2871.31
613	North Sas. RSB	570.06	10.09	-2	515.8	121.16	55.79	58.57	2587.14
614	North Sas. RSB	482.25	9.17	-2.97	427.56	90.78	54.53	57.27	2876.01
615	Athabasca RB	591.53	9.7	-4.69	538.8	195.79	54.61	57.19	3096.8
616	Athabasca RB	591.53	9.7	-4.69	538.28	193.06	55.13	58.48	3096.68
617	Athabasca RB	585.13	9.89	-3.46	530.85	120.24	55.04	58.29	2485.12
618	Athabasca RB	585.13	9.89	-3.46	530.6	145.13	55.33	58.17	3043.37
619	North Sas. RSB	504.32	9.63	-2.75	450.8	106.98	54.01	57.95	2874.23
620	North Sas. RSB	482.25	9.17	-2.97	428.27	104.5	53.63	57.23	2872.32
621	North Sas. RSB	482.25	9.17	-2.97	427.58	107.04	54.75	57.39	2874.05
622	North Sas. RSB	435.13	8.15	-3.93	383.25	98.52	53.56	56.2	2864.87
623	North Sas. RSB	544.71	9.72	-1.77	489.33	120.98	55.59	58.21	2872.88
624	North Sas. RSB	435.13	8.15	-3.93	384.01	93.8	52.84	56.69	2867.49
625	North Sas. RSB	570.06	10.09	-2	515.53	119.03	55.96	58.61	2587.07
626	North Sas. RSB	504.32	9.63	-2.75	449.6	112.92	55.54	58.29	2876.16
627	North Sas. RSB	434.24	8.42	-3.58	382.87	96.52	53.08	56.93	2869.57
628	North Sas. RSB	585.13	9.89	-3.46	530.86	152.83	55.16	57.77	2889.79
629	North Sas. RSB	570.06	10.09	-2	515.64	121.25	55.73	58.61	2587.15
630	North Sas. RSB	435.13	8.15	-3.93	383.14	92.16	53.72	56.5	2864.78
631	North Sas. RSB	426.97	8.02	-4.21	374.44	88.54	53.31	55.95	2580.18
632	North Sas. RSB	429.43	8.06	-4	376.54	86.66	53.71	56.3	2864.53
633	North Sas. RSB	621.12	8.45	-5.57	563.94	130.36	50.97	53.64	2910.54
634	North Sas. RSB	477.22	8.91	-2.63	422.56	109.34	54.94	57.71	2581.71
635	North Sas. RSB	436.06	8.94	-3.13	382.92	100.75	53.54	57.42	2857.57
636	North Sas. RSB	429.15	8.75	-3.12	377.46	94.27	53.2	56.9	2864.23
637	North Sas. RSB	608.55	9.58	-2.93	553.96	135.35	55.49	58.16	2604.51
638	North Sas. RSB	589.92	9.88	-3.89	535.39	155.5	55.18	57.92	2895.28
639	North Sas. RSB	592.08	9.49	-5.1	538.83	204.36	54.12	57.04	2956.41
640	North Sas. RSB	589.92	9.88	-3.89	533.64	128.06	55.12	58.3	2855.68
641	North Sas. RSB	429.43	8.06	-4	377.78	88.22	52.79	56.6	2866.34
642	North Sas. RSB	589.92	9.88	-3.89	533.55	129.19	55.2	57.84	2855.66
643	North Sas. RSB	592.08	9.49	-5.1	535.96	129.53	54.64	57.49	2869.35
644	North Sas. RSB	621.12	8.45	-5.57	569.21	136.33	51.76	54.64	1705.28
645	North Sas. RSB	746.57	6.4	-6.23	696.31	111.62	48.51	51.3	1772.12
646	North Sas. RSB	429.43	8.06	-4	376.66	86.65	53.76	56.45	2866.21
647	North Sas. RSB	436.06	8.94	-3.13	383.33	94.96	53.28	57.03	2857.65
648	North Sas. RSB	429.15	8.75	-3.12	376.84	97.68	53.56	57.3	2858.61
649	North Sas. RSB	425.76	8.58	-3.37	373.04	92.67	54.19	56.82	2863.44
650	North Sas. RSB	429.15	8.75	-3.12	377.41	95.5	53.46	57.13	2864.15
651	North Sas. RSB	416.7	8.58	-3.72	363.74	91.23	53.37	56.96	2864.1
652	North Sas. RSB	589.92	9.88	-3.89	533.74	129.94	55.19	57.87	2855.65
653	North Sas. RSB	429.43	8.06	-4	379.15	88.02	51.4	56.77	2866.65
654	North Sas. RSB	429.43	8.06	-4	378.64	90.56	51.68	56.43	2862.49
655	North Sas. RSB	502.91	9.44	-2.69	449.6	111.01	54.38	57.91	2881.73

656	North Sas. RSB	589.92	9.88	-3.89	533.06	132.71	55.77	58.52	2855.5
657	North Sas. RSB	482.25	9.17	-2.97	428.22	105.86	54.08	57.75	2875.9
658	North Sas. RSB	750.1	6.04	-6.74	702.9	139.76	46.59	49.39	1818.97

Table 5. Continued.

Subbasin	RB NAME	PCP	TMAX	TMIN	BLUE	DA	ET	PET	SW
659	North Sas. RSB	1031.92	2.47	-8.46	992.97	97.99	35.36	38.2	2152.99
660	North Sas. RSB	477.22	8.91	-2.63	423.95	104.65	54.17	57.72	2872.57
661	North Sas. RSB	433.01	9.48	-2.21	380.2	92.51	53.66	57.36	2854.31
662	North Sas. RSB	502.91	9.44	-2.69	449.36	114.15	54.72	58.3	2881.62
663	North Sas. RSB	502.91	9.44	-2.69	448.41	110.66	55.53	58.26	2590.12
664	North Sas. RSB	416.7	8.58	-3.72	363.6	88.31	53.68	57.36	2863.92
665	North Sas. RSB	750.1	6.04	-6.74	677.39	115.04	47.32	50.08	3007.46
666	North Sas. RSB	622.55	8.97	-5.83	567.98	128.59	52.71	55.4	2638.76
667	North Sas. RSB	694.06	6.88	-6.96	630.25	125.47	48.08	50.95	2972.88
668	North Sas. RSB	622.55	8.97	-5.83	567.53	128.9	53.1	55.88	2638.59
669	North Sas. RSB	425.76	8.58	-3.37	373.68	92.29	53.63	57.39	2864.39
670	North Sas. RSB	416.7	8.58	-3.72	363.59	86.11	53.73	57.32	2863.89
671	North Sas. RSB	416.7	8.58	-3.72	363.55	87.38	53.75	57.31	2863.88
672	North Sas. RSB	1018.43	2.72	-8.52	977.91	104.5	36.07	38.73	2090.72
673	North Sas. RSB	592.67	9.81	-3.53	537.29	121.98	55.68	58.26	2605.56
674	Red Deer RSB	592.67	9.81	-3.53	538.85	139.87	55.55	58.27	2190.51
675	North Sas. RSB	694.06	6.88	-6.96	645.4	119.94	49.02	52.09	1768.53
676	Red Deer RSB	551.85	9.45	-3.24	499.53	130.66	54.44	58.38	2184.81
677	Red Deer RSB	608.55	9.58	-2.93	555.26	147.87	55.75	58.62	2186.82
678	Red Deer RSB	551.85	9.45	-3.24	499.46	131.69	54.48	58.71	2184.81
679	North Sas. RSB	622.55	8.97	-5.83	565.98	128.09	53.52	56.48	2886.37
680	Red Deer RSB	537.12	9.44	-2.63	484.49	135.25	55.05	57.74	2175.33
681	Red Deer RSB	501.71	9.54	-3.16	447.95	124.02	55.73	58.68	2207.8
682	North Sas. RSB	460.09	9.29	-2.51	407.79	100.72	53.53	57.46	2873.01
683	North Sas. RSB	460.09	9.29	-2.51	407.7	99.66	53.49	57.21	2872.99
684	North Sas. RSB	447.83	9.28	-2.65	394.78	98	54.14	57.8	2858.5
685	North Sas. RSB	433.01	9.48	-2.21	380.02	89.1	54.09	57.79	2860.25
686	North Sas. RSB	433.01	9.48	-2.21	379.19	88.78	54.94	57.59	2859.61
687	North Sas. RSB	428.32	8.47	-3.61	375.06	91.31	53.79	57.25	2867.7
688	North Sas. RSB	420.66	9.08	-3.09	367.29	84.61	54.14	56.75	2863.11
689	North Sas. RSB	428.32	8.47	-3.61	374.69	90.64	54.03	57.52	2867.58
690	North Sas. RSB	428.16	9.19	-2.98	375.82	80.75	53.19	57.08	2666.58
691	North Sas. RSB	428.16	9.19	-2.98	375.1	93.21	53.65	57.28	2864.34
692	Red Deer RSB	489.92	9.41	-2.9	435.94	123.2	55.78	58.4	2206.65
693	Red Deer RSB	460.09	9.29	-2.51	406.33	112.95	55.06	57.89	2196.59
694	North Sas. RSB	420.66	9.08	-3.09	367.84	85.69	53.36	57.12	2862.89
695	North Sas. RSB	420.66	9.08	-3.09	367.09	91.35	54.2	56.84	2081.24
696	Red Deer RSB	501.71	9.54	-3.16	447.99	123.76	54.83	58.46	2209.23
697	North Sas. RSB	447.83	9.28	-2.65	394.35	87.04	54.22	58.36	2668.49
698	Red Deer RSB	462	9.71	-2.98	408.15	112.89	54.81	57.43	2195.84
699	Red Deer RSB	669.89	7.79	-5.95	609.7	149.72	49.58	52.53	1340.04
700	North Sas. RSB	420.66	9.08	-3.09	366.71	94.22	54.37	57.34	2081.16
701	Red Deer RSB	462	9.71	-2.98	407.98	110.75	54.83	57.46	2195.81
702	North Sas. RSB	428.32	8.47	-3.61	373.35	95.5	54.45	57.27	2863.95

703	North Sas. RSB	428.32	8.47	-3.61	373.07	95.65	54.37	57.05	2866.71
704	Red Deer RSB	431.23	9.43	-2.76	378.32	104.51	54.04	56.65	2189.69
705	North Sas. RSB	420.66	9.08	-3.09	369.6	86.76	51.06	57.31	2078.78

Table 5. Continued.

Subbasin	RB NAME	PCP	TMAX	TMIN	BLUE	DA	ET	PET	SW
706	North Sas. RSB	420.66	9.08	-3.09	366.51	84.04	54.09	56.74	2863.15
707	Red Deer RSB	462	9.71	-2.98	408.79	113.78	53.9	57.72	2198.9
708	Red Deer RSB	551.85	9.45	-3.24	496.87	133.47	56	58.83	2216.68
709	Red Deer RSB	551.85	9.45	-3.24	497.98	134.92	54.88	58.88	2219.87
710	Red Deer RSB	551.85	9.45	-3.24	498.06	131.03	54.77	58.78	2219.9
711	Red Deer RSB	551.85	9.45	-3.24	498.26	134.47	54.71	58.69	2219.95
712	Red Deer RSB	501.71	9.54	-3.16	447.5	125.24	55.02	58.95	2209.18
713	Red Deer RSB	551.85	9.45	-3.24	496.81	132.74	56.07	58.97	2183.37
714	Red Deer RSB	551.85	9.45	-3.24	497.16	133.4	55.95	58.85	2216.67
715	Red Deer RSB	669.89	7.79	-5.95	608.33	151.25	49.81	52.84	2277.79
716	North Sas. RSB	420.66	9.08	-3.09	366.49	89.21	54.37	57.31	2863.12
717	Red Deer RSB	490.23	10.31	-2.55	436.52	123.28	54.85	58.62	2206.64
718	Red Deer RSB	558.69	9.95	-4.19	503.59	131.66	55.26	58.1	2185.83
719	Red Deer RSB	558.69	9.95	-4.19	505.09	133.34	53.75	58.01	2188.15
720	Red Deer RSB	490.23	10.31	-2.55	436.65	124.07	54.81	58.83	2206.65
721	North Sas. RSB	413.08	9.32	-3.23	360.45	79.1	53.14	57.47	2655.01
722	North Sas. RSB	420.66	9.08	-3.09	369.66	86.53	51.25	57.35	2078.71
723	North Sas. RSB	414.8	9.65	-2.13	361.29	89.19	54.58	57.22	2850.95
724	North Sas. RSB	425.5	9.38	-2.7	373.76	89.02	52.45	56.25	2857.79
725	North Sas. RSB	390.43	9.35	-3.04	337.59	80.34	53.82	57.57	2858.6
726	Red Deer RSB	837.23	4.32	-8.19	771.71	104.12	44.25	46.87	1476.97
727	Red Deer RSB	558.69	9.95	-4.19	503.72	138.7	55.47	58.11	2188.42
728	Red Deer RSB	669.89	7.79	-5.95	608.84	147.61	50.62	53.65	1339.93
729	Red Deer RSB	558.69	9.95	-4.19	502.71	139.33	56.45	59.42	2187.99
730	Red Deer RSB	837.23	4.32	-8.19	771.75	106.62	42.95	46.03	1511.01
731	North Sas. RSB	390.43	9.35	-3.04	337.11	83.7	54.64	57.27	2858.02
732	Red Deer RSB	558.69	9.95	-4.19	502.08	138.46	56.23	58.86	2200.05
733	Red Deer RSB	669.89	7.79	-5.95	609.03	139.96	50.63	53.66	1339.5
734	North Sas. RSB	416.95	9.29	-3.14	362.39	110.76	55.01	57.9	2082.19
735	Red Deer RSB	558.69	9.95	-4.19	503.16	141.33	56.07	58.79	2188.07
736	North Sas. RSB	414.8	9.65	-2.13	363.03	87.22	53.22	57.57	2852.82
737	North Sas. RSB	390.43	9.35	-3.04	336.3	83.46	55.14	57.77	2856.8
738	Red Deer RSB	490.23	10.31	-2.55	435.92	126.93	55.64	59.42	2206.34
739	North Sas. RSB	398.65	9.39	-3.13	344.39	79.6	54.31	57.19	2860.86
740	North Sas. RSB	390.43	9.35	-3.04	338.15	79.37	53.59	57.72	2076.6
741	Red Deer RSB	468.66	9.98	-2.86	415.5	114.91	54.39	58.13	2204.24
742	Red Deer RSB	468.66	9.98	-2.86	415.37	114.88	54.49	58.46	2204.2
743	Bow RSB	969.29	4.36	-6.81	896.12	120.62	43.66	46.63	1509.28
744	Bow RSB	881.11	3.97	-7.74	812.87	96.8	42.41	45.12	1489.73
745	Bow RSB	881.11	3.97	-7.74	812.15	106.85	41.03	43.74	1529.54
746	North Sas. RSB	389.79	10.09	-2.69	337.87	82.69	53.5	57.71	2856.27
747	North Sas. RSB	342.91	9.71	-3.16	290.59	69.42	53.36	55.98	2850.86
748	North Sas. RSB	390.43	9.35	-3.04	336.42	78.73	55.36	57.87	2856.94
749	Red Deer RSB	417.55	10.16	-3.07	365.92	101.14	53.42	57.21	2199.23

750	Red Deer RSB	417.55	10.16	-3.07	366.01	100.06	53.33	57.28	2199.3
751	Bow RSB	841.01	3.81	-7.87	772.09	93.43	41.93	44.81	1516.49
752	North Sas. RSB	342.91	9.71	-3.16	291.37	69.14	52.45	56.22	2851.19

Table 5. Continued.

Subbasin	RB NAME	PCP	TMAX	TMIN	BLUE	DA	ET	PET	SW
753	North Sas. RSB	377.56	9.56	-3.2	324.9	78.66	53.22	55.73	2850.82
754	North Sas. RSB	342.42	9.41	-3.92	290.2	71.92	53.24	55.8	2848.92
755	Bow RSB	726.73	6.01	-6.92	662.08	127.68	46.96	49.65	1406.12
756	Red Deer RSB	386.32	10.6	-2.43	333.75	89.3	54.52	58.51	2180.29
757	Red Deer RSB	386.32	10.6	-2.43	333.26	93.68	54.34	58.24	2184.32
758	North Sas. RSB	342.91	9.71	-3.16	289.73	69.07	53.72	56.4	2845.02
759	Red Deer RSB	386.32	10.6	-2.43	333.45	87.99	54.48	58.25	2180.26
760	Bow RSB	585.69	9.62	-4.45	529.8	134.19	53.5	56.17	2211.34
761	Red Deer RSB	415.56	10.6	-2.73	362.64	98.76	53.66	57.96	2199.77
762	Bow RSB	585.69	9.62	-4.45	531.34	135.71	53.27	55.94	2234.66
763	Bow RSB	726.73	6.01	-6.92	662.08	103.36	47.51	50.55	1401.73
764	Red Deer RSB	386.32	10.6	-2.43	333.47	90.12	54.66	58.53	2180.24
765	Bow RSB	585.69	9.62	-4.45	529.5	141.07	53.65	56.42	2215.73
766	Red Deer RSB	386.32	10.6	-2.43	333.23	91.89	54.68	58.82	2180.29
767	Red Deer RSB	377.97	10.94	-2.49	323.96	88.46	54.83	58.66	2188.31
768	Red Deer RSB	434.77	10.72	-2.35	380.51	111.74	54.56	58.4	2197.7
769	Red Deer RSB	377.97	10.94	-2.49	323.93	91.92	55.03	59.01	2182.36
770	Bow RSB	841.01	3.81	-7.87	770.95	96.75	42.52	45.35	1516.77
771	Bow RSB	499.78	10.07	-3.29	445.84	126.01	54.29	56.87	2210.79
772	NN	335.39	9.84	-3.02	281.78	80.37	54.98	57.85	2177.32
773	North Sas. RSB	342.42	9.41	-3.92	289.46	71.08	53.59	56.26	2848.69
774	Bow RSB	499.78	10.07	-3.29	445.52	105.24	54.26	56.81	2216.67
775	Bow RSB	499.78	10.07	-3.29	446.82	122.31	53.06	57.03	2214.01
776	Red Deer RSB	434.77	10.72	-2.35	380.45	108.6	54.84	58.83	2197.67
777	North Sas. RSB	342.91	9.71	-3.16	289.28	68.5	53.87	56.66	2845.59
778	Red Deer RSB	377.56	9.56	-3.2	325.18	89.6	53.63	56.21	2170.6
779	Bow RSB	499.78	10.07	-3.29	445.32	122.56	54.56	57.3	2210.68
780	Bow RSB	709.99	6.37	-6.92	643.48	100.4	48.12	51.11	1398.45
781	North Sas. RSB	335.39	9.84	-3.02	282.34	71.22	54.08	57.89	2847.68
782	Bow RSB	561.13	9.91	-4	505.79	107.23	53.72	56.29	2232.82
783	Bow RSB	499.78	10.07	-3.29	445.78	105.03	54.23	56.93	2216.68
784	NN	335.39	9.84	-3.02	281.69	78.85	55.23	57.91	2177.23
785	NN	335.39	9.84	-3.02	284.8	81.03	51.91	57.78	2160.78
786	Red Deer RSB	342.8	10.51	-3.26	289.23	79.55	55.06	57.77	2168.72
787	Bow RSB	561.13	9.91	-4	506.84	124.81	52.82	56.71	2227.79
788	Bow RSB	418.16	11.28	-2.12	364.13	93.33	54.29	58.76	2189.53
789	Red Deer RSB	370.3	10.74	-2.68	316.94	87.78	54.59	57.28	2190.01
790	Red Deer RSB	342.8	10.51	-3.26	289.02	84.93	55.22	57.92	2168.68
791	Bow RSB	561.13	9.91	-4	503.54	124.41	54.42	57.17	2223.12
792	Bow RSB	418.16	11.28	-2.12	364.2	95.42	54.2	58.65	2189.59
793	Bow RSB	418.16	11.28	-2.12	364.03	93.79	54.37	58.7	2189.49
794	Bow RSB	418.16	11.28	-2.12	363.87	94.22	54.46	58.79	2189.44
795	Bow RSB	395.5	11.14	-2.1	341.7	92.51	54.35	58.47	2189.21
796	Bow RSB	377.97	10.94	-2.49	323.17	92.51	55.46	59.26	2188.02

797	Red Deer RSB	342.8	10.51	-3.26	288.92	80.5	55.23	57.91	2168.59
798	Bow RSB	561.13	9.91	-4	506.38	124.23	53.06	56.98	2227.61
799	Bow RSB	392.77	11.29	-2.02	339.08	91.91	54.4	58.37	2193.52

Table 5. Continued.

Subbasin	RB NAME	PCP	TMAX	TMIN	BLUE	DA	ET	PET	SW
800	Bow RSB	418.16	11.28	-2.12	363.61	95.01	54.65	59.01	2189.35
801	Bow RSB	395.5	11.14	-2.1	341.63	93.04	54.3	58.42	2189.17
802	Bow RSB	392.77	11.29	-2.02	337.75	92.7	55.69	58.38	2192.27
803	Bow RSB	395.5	11.14	-2.1	341.02	92.43	54.8	58.97	2188.94
804	Red Deer RSB	370.3	10.74	-2.68	317.74	88.5	53.53	57.47	2190.32
805	Bow RSB	678.3	9.05	-4.61	616.27	118.57	52.75	55.44	2252.14
806	Red Deer RSB	342.8	10.51	-3.26	288.76	84.67	55.3	58.13	2168.49
807	Red Deer RSB	308.77	10.37	-3.25	253.9	73.91	56.29	58.95	2161.93
808	Bow RSB	678.3	9.05	-4.61	616.11	128.89	52.99	55.62	2250.91
809	Red Deer RSB	366.9	11.4	-2.2	313.51	88.79	54.72	58.53	2167.55
810	Bow RSB	753.88	5.24	-6.26	685.06	100.87	46.99	49.84	1417.09
811	Red Deer RSB	333.97	11.45	-2.15	279.83	93.41	55.49	58.1	1591.71
812	Red Deer RSB	333.97	11.45	-2.15	279.62	92.84	55.63	58.35	1591.61
813	Red Deer RSB	333.97	11.45	-2.15	279.75	85.95	55.48	58.19	1591.54
814	Red Deer RSB	333.97	11.45	-2.15	279.36	77.02	55.58	58.26	2161.51
815	Red Deer RSB	309.49	10.51	-2.49	254.34	74.87	56.54	59.19	2180.1
816	Red Deer RSB	333.97	11.45	-2.15	279.32	78.25	55.56	58.19	2161.54
817	Red Deer RSB	308.77	10.37	-3.25	254.13	74.21	56.05	58.7	2162.05
818	Red Deer RSB	295.84	11.36	-1.68	239.92	68.98	56.99	59.65	2170.67
819	Red Deer RSB	294.16	11.49	-1.97	239.84	69.98	55.77	58.36	2174.46
820	Red Deer RSB	333.97	11.45	-2.15	279.23	76.85	55.54	58.11	2161.52
821	Red Deer RSB	294.16	11.49	-1.97	239.54	71.39	55.96	58.62	2174.38
822	Red Deer RSB	333.97	11.45	-2.15	279.02	77.29	55.71	58.29	2161.44
823	Red Deer RSB	333.97	11.45	-2.15	280.18	79.74	54.55	58.52	2161.14
824	Bow RSB	392.77	11.29	-2.02	338.39	93.55	54.79	58.62	2193.27
825	Red Deer RSB	294.16	11.49	-1.97	239.58	72.14	55.7	58.42	2155.56
826	Red Deer RSB	306.93	10.62	-2.46	252.84	71.48	55.17	59.12	2179.1
827	NN	306.93	10.62	-2.46	251.05	74.47	56.72	59.36	2177.26
828	Red Deer RSB	292.66	11.61	-1.61	236.13	68.94	57.09	59.76	2172.22
829	Red Deer RSB	292.66	11.61	-1.61	235.99	68.61	57.3	59.87	2172.12
830	Red Deer RSB	295.84	11.36	-1.68	239.63	71.59	56.87	59.44	2170.72
831	Red Deer RSB	306.93	10.62	-2.46	254.44	72.34	53.08	59.15	2179.62
832	NN	292.66	11.61	-1.61	239.04	69.13	53.89	59.68	2172.1
833	NN	292.66	11.61	-1.61	238.85	68.24	54.02	59.75	2172.07
834	Oldman RSB	445.88	11.55	-1.92	389.4	98.67	55.18	59.38	2194.48
835	NN	306.93	10.62	-2.46	254.31	74.76	53.08	59.23	2179.63
836	NN	306.93	10.62	-2.46	251.21	73.4	56.23	58.88	2176.47
837	NN	306.93	10.62	-2.46	251.03	71.74	56.45	59.1	2176.31
838	NN	292.66	11.61	-1.61	238.83	69.35	54.1	59.96	2170.85
839	Oldman RSB	418.16	11.28	-2.12	362.82	97.75	54.51	58.75	2189.39
840	Oldman RSB	445.88	11.55	-1.92	389.55	98.79	55.13	59.44	2194.5
841	NN	292.66	11.61	-1.61	239.04	67.86	53.92	59.74	2172.1
842	Oldman RSB	678.3	9.05	-4.61	614.72	116.85	53.65	56.22	2251.81
843	Oldman RSB	445.88	11.55	-1.92	386.5	94.25	57.65	60.49	2190.39

844	Oldman RSB	445.88	11.55	-1.92	387.58	96.9	57.09	59.78	2193.58
845	Oldman RSB	403.93	12.03	-1.26	346.44	92.46	56.51	60.29	2182.71
846	Oldman RSB	403.93	12.03	-1.26	346.57	91.31	56.43	60.23	2182.73

Table 5. Continued.

Subbasin	RB NAME	PCP	TMAX	TMIN	BLUE	DA	ET	PET	SW
847	Oldman RSB	445.88	11.55	-1.92	387.62	99.04	57.06	59.77	2193.61
848	Oldman RSB	403.93	12.03	-1.26	346.42	92.14	56.67	60.47	2182.63
849	Oldman RSB	445.88	11.55	-1.92	387.74	97.85	56.99	59.71	2193.62
850	NN	312.27	11.72	-1.6	257.38	75.35	55.5	61.4	2174.5
851	South Sas. RSB	295.84	11.36	-1.68	239.23	69.69	57.31	59.95	2170.46
852	South Sas. RSB	313.4	11.93	-0.98	258.06	73.46	56.27	58.88	2174.98
853	Oldman RSB	498.8	11.53	-1.49	438.65	92.92	57.79	60.51	2197.66
854	Oldman RSB	422.29	12.53	-0.65	364.3	100.17	57.23	60.85	2181
855	Bow RSB	351.81	12.14	-1.65	296.21	90.85	56.57	59.31	2183.42
856	Bow RSB	351.81	12.14	-1.65	296.56	84.61	56.2	59.9	2183.1
857	Oldman RSB	650.71	8.74	-3.74	583.54	113.33	55.02	57.9	1309.85
858	South Sas. RSB	292.66	11.61	-1.61	235.91	71.97	57.73	60.5	2171.88
859	South Sas. RSB	313.4	11.93	-0.98	257.97	75.99	56.68	59.29	2174.73
860	Bow RSB	325.23	12.19	-1.36	269.82	81.24	56.45	59.14	2158.5
861	Bow RSB	325.23	12.19	-1.36	270.39	79.84	55.88	59.36	2176.41
862	Oldman RSB	498.8	11.53	-1.49	439.54	106.71	57.72	60.43	2201.8
863	Oldman RSB	390.33	11.95	-1.37	334.44	90.98	56.14	59.94	2188.11
864	Bow RSB	325.23	12.19	-1.36	269.55	77.32	56.69	59.39	2158.33
865	Oldman RSB	356.83	12.77	-0.74	300.51	82.04	56.86	60.32	2180.74
866	Oldman RSB	650.71	8.74	-3.74	583.05	120.53	55.28	58.13	1309.97
867	Oldman RSB	650.71	8.74	-3.74	586.77	124.67	54.03	56.82	2253.32
868	Oldman RSB	498.8	11.53	-1.49	439.64	107.42	57.65	60.52	2201.81
869	Oldman RSB	422.29	12.53	-0.65	364.43	98.14	57.31	60.96	2180.94
870	Oldman RSB	650.71	8.74	-3.74	587.13	125.08	53.86	56.55	2253.32
871	Bow RSB	325.23	12.19	-1.36	269.52	78.79	56.84	59.67	2176.44
872	Oldman RSB	356.83	12.77	-0.74	301.08	85.3	56.38	60.52	2179.25
873	Oldman RSB	498.8	11.53	-1.49	438.34	101.29	58.43	61.16	2197.6
874	Oldman RSB	334.39	12.84	-0.66	277.38	78.87	57.85	60.58	2176.69
875	Oldman RSB	498.8	11.53	-1.49	438.89	105.95	58.28	60.99	2189.1
876	Oldman RSB	381.43	12.57	-0.7	323.85	91.38	57.33	60.78	2179.3
877	Oldman RSB	809.26	7.71	-3.38	737.41	147.95	52.33	55.12	2297.57
878	Oldman RSB	356.83	12.77	-0.74	300.48	87.07	57.25	60.98	2180.59
879	South Sas. RSB	313.4	11.93	-0.98	258.03	61	56.85	59.51	2174.4
880	South Sas. RSB	313.4	11.93	-0.98	258.09	77.07	56.76	59.34	2174.6
881	South Sas. RSB	313.4	11.93	-0.98	258.1	71.94	56.78	59.49	2172.58
882	South Sas. RSB	334.39	12.84	-0.66	277.74	77.18	57.8	60.46	2176.6
883	South Sas. RSB	313.4	11.93	-0.98	257.93	61.28	56.94	59.57	2174.35
884	South Sas. RSB	334.8	12.6	-0.33	279.5	79.73	56.3	60.26	2171.9
885	South Sas. RSB	335.1	11.81	-1.08	278.45	77.68	57.89	60.62	2178.14
886	Oldman RSB	422.29	12.53	-0.65	364.39	96.72	57.51	61.13	2180.8
887	Oldman RSB	381.43	12.57	-0.7	323.56	90.44	57.72	61.13	2179.09
888	Oldman RSB	422.29	12.53	-0.65	364.45	97.83	57.51	61.1	2180.8
889	South Sas. RSB	334.39	12.84	-0.66	278.63	78.74	56.71	60.9	2175.08
890	Oldman RSB	422.29	12.53	-0.65	364.18	97.45	57.71	61.3	2180.71

891	NN	312.27	11.72	-1.6	258.97	72.79	54.33	60.09	2175.24
892	Oldman RSB	405.95	11.82	-1.23	347.48	91.08	58.24	62.17	2188.17
893	Oldman RSB	523.48	12.24	-0.76	465.22	112.69	57.37	61.22	2195.07

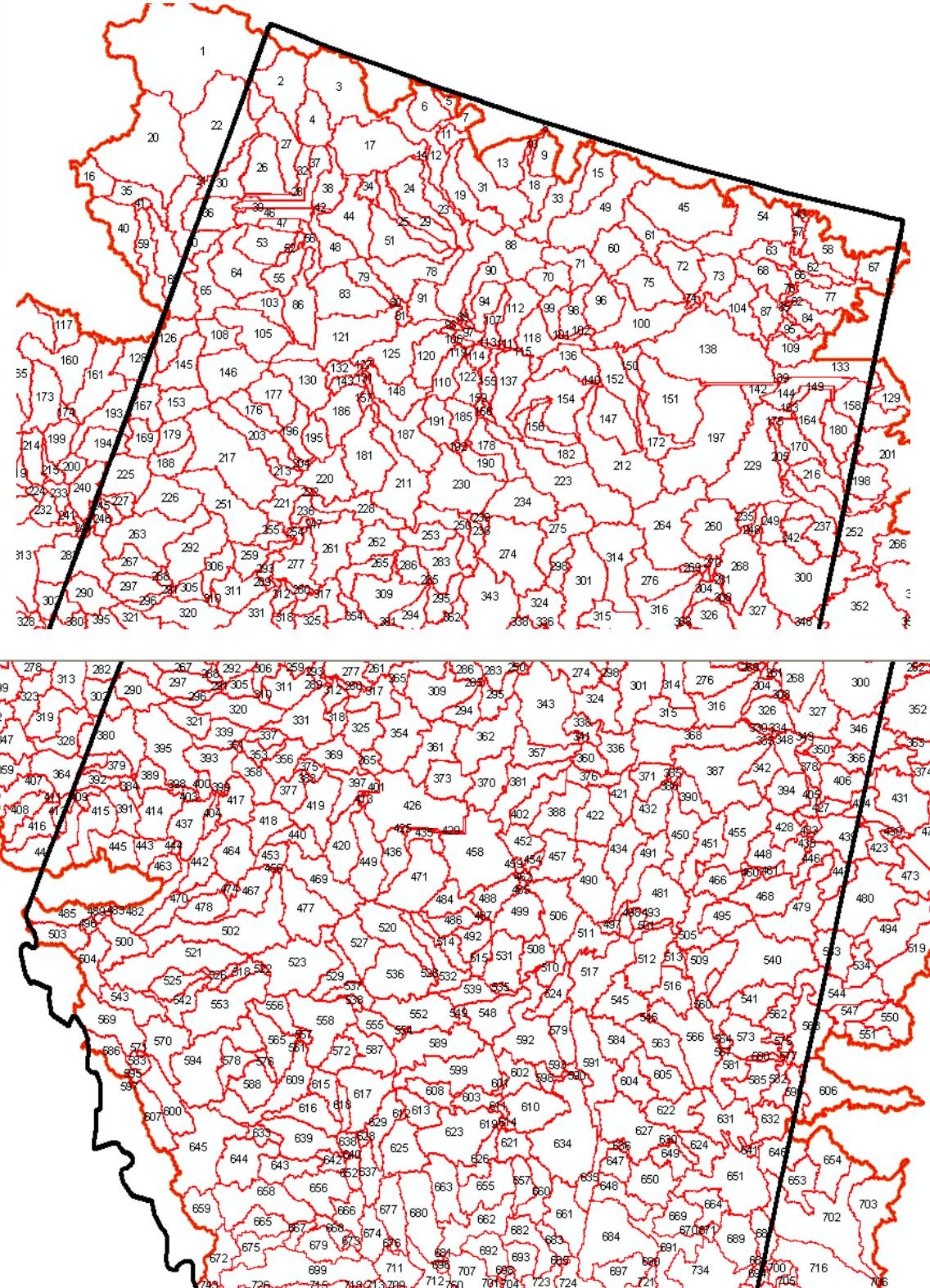
Table 5. Continued.

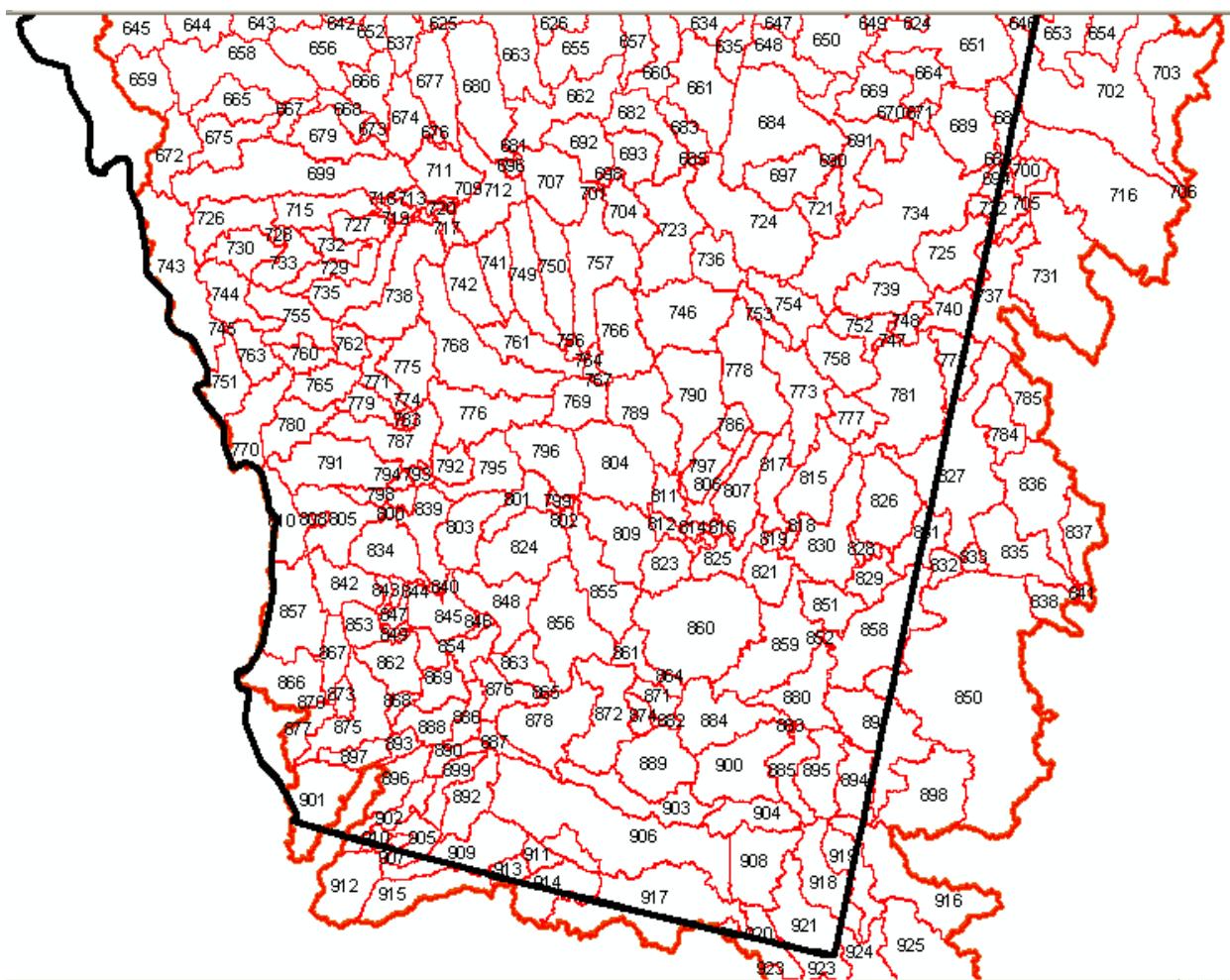
Subbasin	RB NAME	PCP	TMAX	TMIN	BLUE	DA	ET	PET	SW
894	NN	337.57	10.92	-2.65	280.74	72.09	57.28	60.06	2186.29
895	South Sas. RSB	337.57	10.92	-2.65	280.51	73.3	57.31	59.96	2186.26
896	Oldman RSB	523.48	12.24	-0.76	464.75	113.33	57.49	61.32	2190.13
897	Oldman RSB	757.25	10.43	-1.42	694.02	148.9	56.91	59.69	2220.95
898	NN	337.57	10.92	-2.65	284.49	73.88	53.55	60.14	2188.9
899	Oldman RSB	523.48	12.24	-0.76	465.47	116.37	57.22	61.02	2195.08
900	South Sas. RSB	335.1	11.81	-1.08	279.88	77.27	56.03	60.18	2178.74
901	Oldman RSB	757.25	10.43	-1.42	693.23	86.93	58.22	60.97	2219.66
902	Oldman RSB	523.48	12.24	-0.76	463.15	113.01	59.29	62.04	2190.12
903	South Sas. RSB	334.39	12.84	-0.66	278.14	82.84	57.1	61.39	2174.82
904	South Sas. RSB	335.1	11.81	-1.08	278.26	76.5	57.85	60.56	2177.62
905	Oldman RSB	523.48	12.24	-0.76	464.73	111.82	58.02	61.91	2195.12
906	South Sas. RSB	322.66	12.69	-0.42	265.53	80.8	58.19	62.34	2162.55
907	Oldman RSB	523.48	12.24	-0.76	463.3	109.33	59.23	61.94	2190.11
908	South Sas. RSB	346.77	12.48	-0.85	288.82	80.37	58.68	61.45	2179.47
909	Milk RB	405.95	11.82	-1.23	344.69	58.67	59.79	62.52	2350.49
910	Oldman RSB	523.48	12.24	-0.76	463.09	110.57	59.59	62.12	2189.98
911	Milk RB	349.81	12.28	-0.77	293.61	50.53	55.33	62.3	2332.47
912	Oldman RSB	757.25	10.43	-1.42	693.03	95.36	58.79	61.34	2219.96
913	Milk RB	349.81	12.28	-0.77	293.47	50.55	55.7	62.66	2332.29
914	Milk RB	349.81	12.28	-0.77	293.59	51.08	55.43	62.09	2331.11
915	Milk RB	523.48	12.24	-0.76	462.23	73.81	59.64	62.16	2360.73
916	Milk RB	323.59	11.77	-2.48	269.45	44.78	53.71	60.75	2345.4
917	Milk RB	353.61	12.94	-0.18	293.55	53.38	59.45	61.91	2327.32
918	Milk RB	323.59	11.77	-2.48	264.85	44.78	58.37	60.9	2345.2
919	Milk RB	323.59	11.77	-2.48	269.17	45.06	53.82	60.82	2345.28
920	Milk RB	346.77	12.48	-0.85	287.23	55.69	58.79	61.26	2342.91
921	Milk RB	323.59	11.77	-2.48	264.7	44.8	58.27	60.82	2345.51
922	Milk RB	323.59	11.77	-2.48	264.21	48.83	58.46	60.97	2351.8
923	Milk RB	323.59	11.77	-2.48	264.24	49.69	58.55	61.08	2351.69
924	Milk RB	323.59	11.77	-2.48	268.82	45.63	53.85	60.85	2345.32
925	Milk RB	323.59	11.77	-2.48	268.57	45.16	54.04	61.04	2345.05
926	Milk RB	323.59	11.77	-2.48	266.77	44.94	55.72	60.93	2345.21
927	Milk RB	323.59	11.77	-2.48	268.72	43.73	53.95	60.93	2344.97
928	Milk RB	323.59	11.77	-2.48	268.67	43.61	53.99	60.96	2344.9

RB: river basin, **RSB:** river subbasin, **N_Hay RB:** the modeled subbasins located nearby Hay River basin which are not part of Alberta main river basins. **N_Beaver:** the modeled subbasins located nearby Beaver River basin which are not part of Alberta main river basins, **PCP:** precipitation (mm), **TMAX:** maximum temperature ($^{\circ}\text{C}$), **TMIN:** minimum temperature ($^{\circ}\text{C}$), **Blue:** blue water and is total water yield plus deep aquifer recharge (mm yr^{-1}), **DA:** deep aquifer recharge (mm yr^{-1}), **SW:** green water storage (soil water, mm), **ET:** green water flow (actual evapotranspiration, (mm yr^{-1})), **PET:** potential evapotranspiration (mm yr^{-1}).

Appendix II

Subbasin number





Appendix III

Water balance components aggregated for major subbasins

River basin/sub basin	Blue		ET		SW		PET		DA		WYLD	
	L95PPU	U95PPU										
Hay	6.20	14.86	1.28	1.47	59.79	73.21	1.32	2.56	1.56	7.78	1.14	10.88
Peace	45.88	94.55	7.91	8.98	370.54	448.11	8.10	15.58	11.26	51.75	8.85	68.20
Athabasca	50.72	90.02	7.34	8.45	332.81	506.16	7.84	14.68	6.78	31.39	28.30	75.29
Beaver	4.15	8.39	0.77	0.86	33.42	44.06	0.78	1.45	0.99	4.11	1.74	6.14
North Sask.	30.73	49.01	4.32	4.95	200.05	277.09	4.45	7.90	4.59	13.88	19.11	40.97
Red Deer	15.06	23.80	2.41	2.74	91.70	113.81	2.48	4.31	2.35	7.90	8.92	19.40
Bow	8.92	18.56	1.13	1.51	47.94	61.11	1.16	2.36	1.10	4.57	5.68	15.89
Oldman	7.40	12.13	1.15	1.32	42.20	52.82	1.19	2.03	1.01	3.52	4.65	10.15
South Sask.	3.62	5.69	0.95	1.03	33.94	42.30	0.99	1.59	0.63	2.05	2.00	4.54
Milk	1.33	2.55	0.37	0.40	12.59	18.69	0.39	0.61	0.01	0.78	0.82	2.32

