COOKS-DEVILS CREEK INTEGRATED WATERSHED MANAGEMENT PLAN STATE OF THE WATERSHED REPORT CONTRIBUTION

SURFACE WATER HYDROLOGY REPORT

Planning Area Boundary:

The Cooks-Devils Creek planning area (CDCPA) is south of Lake Winnipeg in the Interlake Region. The area extends from north of Marchand to Sandy Point on Lake Winnipeg and from Winnipeg to east of Beausejour. THE CDCPA covers an area of 1,826 km^2. The Cooks-Devils Creek planning area is shown in Figure 1.

The planning area is made up of a number of individual watersheds. By definition, a watershed is the land area that contributes surface water runoff to a common point. It is separated from adjacent watersheds by a land ridge or divide. Watersheds can vary in size from a few hectares to thousands of square kilometres. A larger watershed can contain many smaller sub-watersheds. On a larger scale, a basin is defined as a collection of watersheds that feed into a common main tributary or large body of water (e.g. the Red River Basin). A sub-basin is a division of a basin and will be made up of multiple watersheds.

Watershed and basin boundaries form a prime ecological unit for:

- Information and knowledge management and analysis, and
- Water and land use planning and management.

Watershed and basin boundaries are defined through the application of the best available science and modified with documented and verifiable local input. Agriculture and Agri-Food Canada through the efforts of the Prairie Farm Rehabilitation Administration (AAFC-PFRA) and Manitoba Conservation and Water Stewardship have delineated a system of watershed and basin boundaries for Manitoba. These boundaries have been designed to extend to the mouths of some rivers and streams and along large bodies of water. The CDCPA boundaries were established using this system of watersheds.

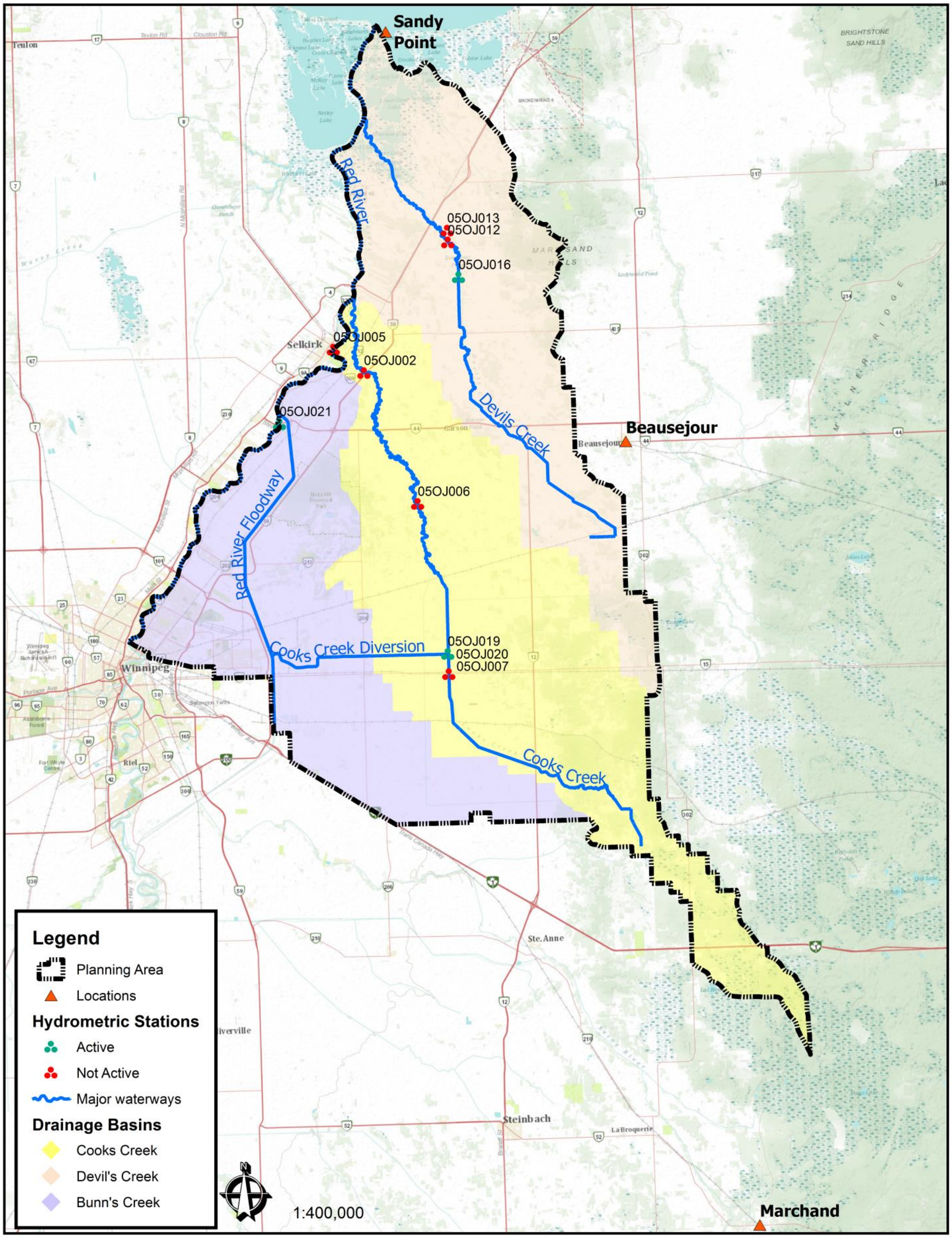

Figure 1: Cooks-Devil's Creek Planning Area

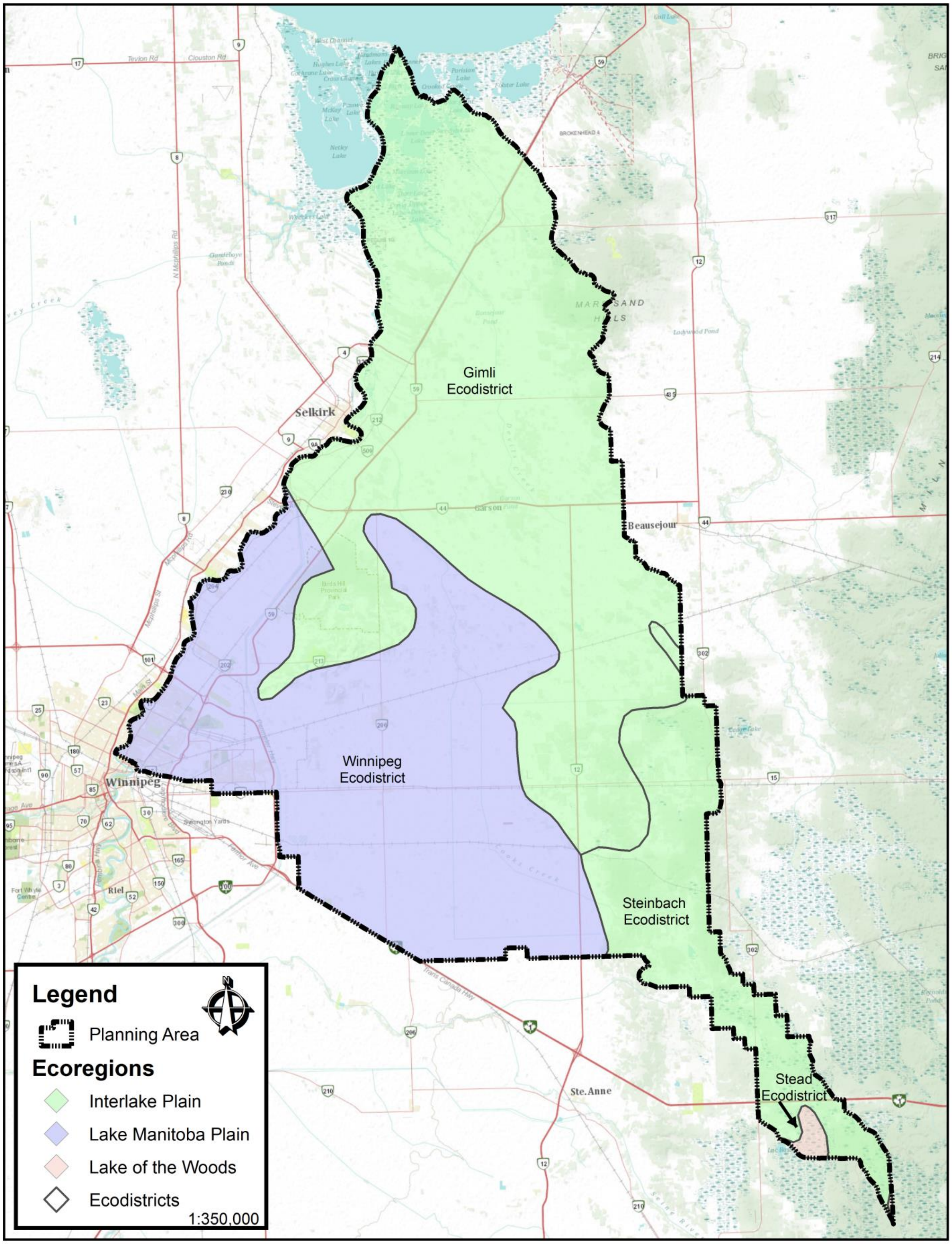

Figure 2: Cooks-Devil's Creek Planning Area - Ecoregions and Ecodistricts

Climate and Physiography:

The CDCPA stretches across three ecozones, three ecoregions and four ecodistricts as shown in Table 1 and Figure 2.

ECOZONE	ECOREGION	ECODISTRICT
Boreal Shield	Lake of the Woods	Stead
Boreal Plains	Interlake Plain	Gimli
		Steinbach
Prairies	Lake Manitoba Plain	Winnipeg

Table 1: Terrestrial Ecozones, Ecoregions, and Ecodistricts for Cooks-Devil's Creek Planning Area

Ecozones consist of a distinctive assemblage of physical and biological characteristics and possess environmental characteristics that tend to cohere and endure over the long term. Ecoregions form part of an ecozone and are characterized by a unique combination of landscape physiography and ecoclimate. Ecoregion boundaries are guided by distinctive features of both climate and physiographic. Ecodistricts are subdivisions of an ecoregion and are characterized by relatively homogenous physical landscape and climatic conditions[1].

Boreal Shield Ecozone

This ecozone has a strong continental climate which is characterized by long, cold winters and short, cool summers. The soil climate ranges from humid, cold Cryoboreal in the northwestern half to perhumid, moderately cool Boreal in the eastern section[2].

Lake of the Woods Ecoregion

This ecoregion is closely identified with the warmer, more humid southeastern mixed forest region than the colder, drier, closed mixed Boreal forest to the north. The Manitoba portion of this ecoregion has a climate marked by short, warm summers and long, cold winters[3].

Stead Ecodistrict

This ecodistrict lies in a more humid and cooler subdivision of the Subhumid Low Boreal Ecoclimatic Region in southern Manitoba[4].

The mean annual temperature is 2.8°C. The mean annual precipitation is approximately 578.3 mm, of which one-fifth falls as snow. Selected climate variables for the Stead Ecodistrict are shown in Table 2.

[1] Terrestrial Ecozones, Ecoregions, and Ecodistricts of Manitoba, page 11.
[2] Terrestrial Ecozones, Ecoregions, and Ecodistricts of Manitoba, page 59.
[3] Terrestrial Ecozones, Ecoregions, and Ecodistricts of Manitoba, page 126.
[4] Terrestrial Ecozones, Ecoregions, and Ecodistricts of Manitoba, page 127.

	Year	June-Aug	May-Sept	July	Jan
Temperature (°C)	2.8	18.0	15.5	19.3	-16.6
Precip. mm (equiv)	578.3	253.1	381.6	89.1	21.7
Rain/Snow (mm/cm)	464.3/114.0	253.1/0.0	379.0/2.6		

Table 2: Selected Climate Data[5] for Pinawa

The physiography varies from a level to depressional glaciolacustrine plain dominated by peatlands, to a smooth, level to gently undulating water-worked glacial till and fluvioglacial outwash plain, to irregular hummockly morainal uplands near Lake Winnipeg in the northern section. Elevations range from about 290 to 221 masl. The ecodistrict slopes approximately 1.0 m per km northwestward from its eastern edge toward Lake Winnipeg. Strong local relief of approximately 5 m to 30 m occurs along a series of sandy and gravelly ridges and uplands near Lake Winnipeg[6]. In this portion of the ecodistrict, slopes vary from five to ten per cent along sloping upland faces, to locally much steeper slopes in the Grand Beach area.

This ecodistrict has few lakes and the major rivers are the Winnipeg and Brokenhead, which drain into Lake Winnipeg[7].

Boreal Plains Ecozone

The climate of this ecozone is strongly influenced by continental climatic conditions and is typified by cold winters and moderately warm summers. The ecozone has a submid, moderately cold Cryoboreal soil climate[8].

Interlake Plain Ecoregion

This ecoregion is marked by short, warm summers and fairly long cold winters. Precipitation is highest during the growing season and is characterized by a subhumid, moderately cold to cold, Cryoboreal soil climate[9].

Gimli Ecodistrict

This ecodistrict is a generally north-south elongated area extending from north of Fisher Bay to southeast of Birds Hill. The mean annual temperature is 1.6 °C and the mean annual precipitation is 499.4 mm, of which less than one-fifth falls as snow. Selected climate variables for the Gimli Ecodistrict are shown in Table 3.

[5] Canadian Climate Normals, 1981-2010. Atmospheric Environment Service, Environment Canada.
[6] Terrestrial Ecozones, Ecoregions, and Ecodistricts of Manitoba, page 127.
[7] Terrestrial Ecozones, Ecoregions, and Ecodistricts of Manitoba, page 128.
[8] Terrestrial Ecozones, Ecoregions, and Ecodistricts of Manitoba, page 139.
[9] Terrestrial Ecozones, Ecoregions, and Ecodistricts of Manitoba, page 190.

	Year	June-Aug	May-Sept	July	Jan
Temperature (°C)	1.6	17.3	14.7	18.6	-18.3
Precip. mm (equiv)	499.4	220.1	328.9	70.3	16.9
Rain/Snow (mm/cm)	403.8/95.6	220.1/0.0	327.2/1.7		

Table 3: Selected Climate Data[10] for Arborg

This ecodistrict is a level to depressional glaciolacustrine lowland and a gently undulating lake terrace, characterized by fluvioglacial, shallow glaciolacustrine deposits and water-worked glacial till. Slopes range from long and nearly level in the lowlands to short and less than two per cent in the lake terrace area. The area south of Lake Winnipeg slopes very gently northward to Lake Winnipeg at a rate of less than 0.5 m per km. Netley Marsh on the south shore of Lake Winnipeg is a delta formed by the Red River. It has little relief and many channels and small water bodies that are enclosed by levees[11].

Steinbach Ecodistrict

The Steinbach Ecodistrict is a north-south elongated area extending from the USA border to east of Winnipeg. The mean annual temperature is 2.8 °C and the mean annual precipitation is 580.5 mm, of which approximately one-fifth falls as snow. Selected climate variables for the Steinbach Ecodistrict are shown in Table 3.

	Year	June-Aug	May-Sept	July	Jan
Temperature ℃	2.8	17.9	15.5	19.0	-16.6
Precip. mm (equiv)	580.5	267.1	393.3	93.2	22.2
Rain/Snow (mm/cm)	473.4/107.1	267.1/0.0	391.5/1.8		

Table 3: Selected Climate Data[12] for Steinbach

This ecodistrict's mean elevation is approximately 297 masl and its landforms range from a smooth, level glaciolacustrine plain to a gently undulating, water worked glacial till and glaciofluvial, terraced plain. Slopes range from level to less than five per cent and range in length from about 50 m to more than 150 m. The ecodistrict slopes gently at about 1.0 m per km northwestward from its eastern edge toward the Red River in the Central lowland area. Major drainage ways are the Roseau River and some creek drainaing towards the Red River[13].

[10] Canadian Climate Normals, 1981-2010. Atmospheric Environment Service, Environment Canada.
[11] Terrestrial Ecozones, Ecoregions, and Ecodistricts of Manitoba, page 201.
[12] Canadian Climate Normals, 1981-2010. Atmospheric Environment Service, Environment Canada
[13] Terrestrial Ecozones, Ecoregions, and Ecodistricts of Manitoba, page 202.

Surface Water Management Section

Prairies Ecozone

This ecozone comprises the northern extension of the former open grasslands of the Great Plains of North America. Topographic relief is generally subdued, and besides the large expanses of undulating and hummocky terrain, large river valleys are the most striking landscape feature. This ecozone has a continental climate, subhumid to semiarid, with short, warm summers and long, cold winters, low levels of precipitation and high evaporation. Winds are frequent and often strong in this ecozone, and precipitation in summertime is often in the form of localized heavy storms.[14].

Lake Manitoba Plain Ecoregion

This ecoregion is one of the warmest and most humid ecoregions on the Prairies. Short, warm summers and long, cold winters are characteristic of the regional climate.[15].

Winnipeg Ecodistrict

This ecodistrict is in the most humid subdivision of the Grassland Transition Ecoclimatic Region in southern Manitoba[16]. The mean annual temperature is 3.0 °C. The mean annual precipitation is approximately 532.6 mm, of which one-fifth falls as snow. Selected climate variables for the Winnipeg Ecodistrict are shown in Table 4.

	Year	June-Aug	May-Sept	July	Jan
Temperature °C	3.0	18.5	15.9	19.7	-16.4
Precip. mm (equiv)	532.6	246.5	349.0	79.5	19.9
Rain/Snow (mm/cm)	418.9/113.7	246.6/0	346.1/2.9		

Table 4: Selected Climate Data[17] for Winnipeg Richardson International Airport

The Winnipeg Ecodistrict lies in the central lowland of the Red River Plain. It is a smooth, level to very gently sloping, clayey glaciolacustrine plain. The Red River meanders northward through the centre of the plain and empties into Lake Winnipeg. Slopes range from level to less than two percent and are smooth and long (exceeding 150 m). Some stronger relief of about five to ten metres occurs along the Red and its major tributaries. These are the Morris, La Salle and Assiniboine rivers flowing from the west and the Roseau, Rat and Seine Rivers flowing from the east.

[14] Terrestrial Ecozones, Ecoregions, and Ecodistricts of Manitoba, page 205.
[15] Terrestrial Ecozones, Ecoregions, and Ecodistricts of Manitoba, page 244.
[16] Terrestrial Ecozones, Ecoregions, and Ecodistricts of Manitoba, page 260.
[17] Canadian Climate Normals, 1981-2010. Atmospheric Environment Service, Environment Canada.

Water Courses:

The CDCPA has three main waterways; the Cooks Creek (83.5 km in length), the Devil's Creek (56.4 km in length) and the Red River Floodway (30.4 km in length). Numerous drains act as tributaries and empty into these three waterways. These three waterways all flow in a north-westerly direction and empty into the Red River (71.5 km in length) which flows along the west boundary of the CDCPA.

The CDCPA also has ten waterways that have been designated as a provincial waterway. A waterway is designated as provincial if it is an artificial or man-made waterway and is a 3rd order drain or higher. Waterways are designated as provincial by an Order-In-Council.

The Cooks Creek basin has a gross drainage area of approximately 750 km^2. All tributaries and drains flow east or west into the centrally located Cooks Creek. Cooks Creek flows in a north-westerly direction, from west of Ross, to where it joins the Red River north of Selkirk.

The Devil's Creek basin has a gross drainage area of approximately 557 km^2. The majority of the drains flow east or west into the Devils Creek. Devil's Creek flows in a north-westerly direction through the Netley-Libau Marsh where it enters the Red River at Netley Lake. The north-easterly portion of the basin that does not contribute to Devil's Creek flows into the Libau Drain, which flows north-westerly into the Netley-Libau Marsh.

The Bunn's Creek basin has a gross drainage area of approximately 520 km^2 and drains in a westerly direction towards the Red River Floodway and the Red River, which flows north-easterly towards the Netley-Libau Marsh and Lake Winnipeg.

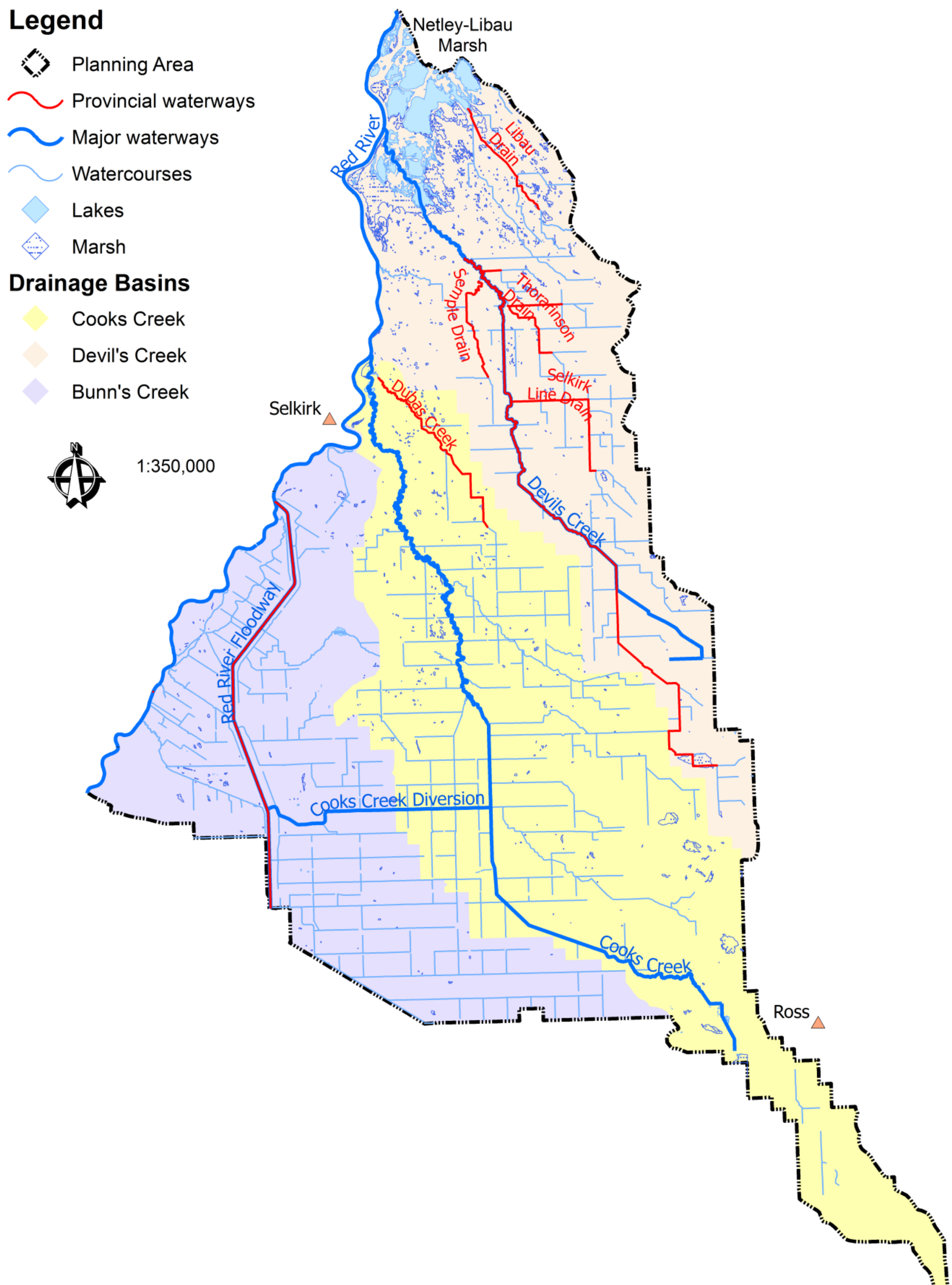

Figure 3: Cooks-Devil's Creek Planning Area - Major Waterways

Hydrometric Data:

The collection of hydrometric data is critical to the understanding of the availability, variability and distribution of water resources and provides the basis for responsible decision making on the management of this resource. Historic hydrometric data provides the basis for understanding the potential extent and limitation of the resource.

Water level and stream flow data collected under the Canada-Manitoba Hydrometric Agreement supports activities such as policy development, operation of water control works, flow forecasting, water rights licensing, water management investigations, hydrologic studies, water quality modeling, ecosystem protection and scientific studies.

Stream flow and lake level data has been recorded at twelve locations within the CDCPA for varying time periods since the late 1950s. The locations of the ten stations are shown in Figure 1. Table 5 provides information related to these ten stations.

Archived hydrometric data can be found at:

http://www.wsc.ec.gc.ca/applications/H2O/index-eng.cfm

Real time hydrometric data can be found at:

http://www.wateroffice.ec.gc.ca/index_e.html

Table 5: CDCPA Hydrometric Gauging Station Data

Station Number	Station Name	Years of Operation	Operational Schedule	Type of Data	Gross Drainage Area in km^2	Real Time Data Available
05OJ002	Cooks Creek near East Selkirk	1922-1929	Miscellaneous	Flow	666	No
		1930-1930	Seasonal	Level		
		1957-1971	Seasonal	Flow		
		1972-1991	Seasonal	Flow		
05OJ005	Red River at Selkirk	1950-1950	Seasonal	Level	287,000	Yes
		1957-1964	Seasonal	Level		
		1966-1966	Seasonal	Level		
		1969-1969	Seasonal	Level		
		2008-2013	Continuous	Flow & Level		
05OJ006	Cooks Creek at Cooks Creek	1960-1970	Seasonal	Flow	523	No
		1971-1994	Seasonal	Flow		
05OJ007	Cooks Creek near Glass	1960-1969	Seasonal	Flow	192	No
		1970-1991	Seasonal	Flow		
05OJ012	Devil's Creek near Semple	1965-1966	Miscellaneous	Flow	290	No
		1967-1970	Seasonal	Flow		
05OJ013	Township Line Drain near Libau	1967-1977	Seasonal	Flow	12.8	No
05OJ016	Devil's Creek near Libau	1971-1972	Seasonal	Flow	240	Yes
		1973-1974	Seasonal	Flow		
		1975-2001	Seasonal	Flow		
		2002-2013	Continuous	Flow & Level		
05OJ019	Cooks Creek below Cooks Creek Diversion	1990-2001	Seasonal	Flow	276	Yes
		2002-2013	Continuous	Flow & Level		
05OJ020	Cooks Creek Diversion at Inlet	1990-2001	Seasonal	Flow	278	Yes
		2002-2013	Continuous	Flow & Level		
05OJ021	Red River Upstream of St. Andrew's Dam at Lockport	1996-2013	Continous	Level	286,000	Yes

Streamflow Characteristics:

The gross drainage area boundary is defined as the area at a specific location, enclosed by its drainage divide, which might be expected to entirely contribute runoff to that specific location under extremely wet conditions. The effective drainage area is that portion of a drainage area which might be expected to entirely contribute runoff to the main stem during a median (1:2 year event) runoff year under natural conditions. This area excludes marsh and slough areas and other natural storage areas which would prevent runoff from reaching the main stem in a year of average runoff. The effective to gross drainage area ratio is an indication of how well an area is drained. A perfectly drained area has a ratio of one.

The daily discharges for gauging stations 05OJ016 and 05OJ019 (highlighted in yellow in Table 5) were statistically analyzed to determine runoff characteristics of the CDCPA. The results of the analysis are presented as follows:

A. *Devil's Creek*

The gross drainage area of station 05OJ016 is 240 km^2. The station has an effective to gross drainage area ratio equal to 1.0 (PFRA drainage area database).

The mean monthly discharge data for Devil's Creek near Libau is shown in Table 6. Based on available data, the average runoff during the period 1971 to 2013 is equal to 18,520 dam^3 or an equivalent depth of 77.2 mm over the gross drainage area for station 05OJ016.

The annual runoff depths for the Devil's Creek from 1971 to 2013 are shown in Figure 4. The values range from a minimum of 7.4 mm in 1981 to a maximum of 208.4 mm in 2005. This figure also illustrates the variability in runoff from year to year, as well as the years above and below the average runoff.

Table 6: Devil's Creek near Libau (05OJ016)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Volume
	Monthly Mean Discharge (m^3/s)												
1971			0.08	7.21	0.56	0.32	0.20	0.04	0.15	0.22			22,853
1972			0.01	3.49	0.18	0.09	0.04	0.05	0.03	0.06			10,263
1973			1.23	0.25	0.07	3.42	0.27	0.09	0.31	0.59			16,364
1974			0.02	10.10	5.55	0.44	0.08	0.06	0.07	0.06			42,959
1975			0.02	2.63	0.36	2.47	0.52	0.10	0.05	0.08			16,239
1976			0.00	4.02	0.16	1.07	0.11	0.04	0.04	0.03			14,202
1977			0.09	0.41	0.07	0.09	0.11	0.08	1.37	0.32			6,663
1978			0.00	6.56	0.89	0.36	0.70	0.06	0.05	0.06			22,678
1979			0.00	7.82	2.14	1.28	0.10	0.06	0.13	0.06			30,213
1980			0.00	2.90	0.10	0.04	0.03	0.02	0.03	0.03			8,188
1981			0.29	0.08	0.07	0.05	0.03	0.03	0.02	0.10			1,776
1982			0.20	1.79	0.06	0.11	0.11	0.02	0.03	0.12			6,371
1983			0.40	3.47	0.13	0.18	0.17	0.03	0.04	0.03			11,584
1984			0.23	0.48	0.05	0.47	0.11	0.03	0.03	0.16			4,091
1985			1.33	1.03	0.27	0.07	0.15	0.73	0.51	0.49			12,107
1986			1.86	3.90	1.46	0.16	0.09	0.07	0.06	0.07			20,188
1987			0.02	3.79	0.09	0.05	0.51	1.68	0.15	0.09			16,733
1988			0.06	0.93	0.08	0.04	0.04	-	-	0.03			3,080
1989			0.00	1.79	0.13	0.10	0.04	0.02	0.02	0.02			5,492
1990			0.18	0.41	0.06	0.70	0.16	0.03	0.03	0.03			4,184
1991			0.09	0.35	0.12	4.30	0.93	0.12	0.13	0.15			16,151
1992			0.89	3.71	0.37	0.46	0.38	0.19	0.36	0.17			17,062
1993			1.32	1.94	0.28	0.11	2.65	4.96	0.69	0.32			32,643
1994			0.49	0.71	0.50	0.16	0.64	0.17	0.32	1.56			12,094
1995			4.17	0.89	0.66	0.15	0.09	0.14	0.08	0.09			16,678
1996			0.00	7.11	3.08	0.42	0.19	0.12	0.55	0.22			30,605
1997			0.00	11.50	3.96								40,414
1998			4.38	1.86	3.26								25,284
1999			0.14	0.33	0.27								1,948
2000			2.18	0.31	0.33								7,524
2001			0.47	5.19	1.39	0.72	1.82	2.37	0.15	0.13			32,255
2002			0.12	1.17	0.50	0.75	0.41	0.08	0.08	0.07			8,329
2003			0.57	0.67	0.22	0.07	0.05	0.04	0.04	0.04			4,475
2004			1.33	3.44	1.62	1.32	0.20	0.30	2.97	1.58			33525
2005			0.03	7.07	1.48	4.49	5.08	0.31	0.26	0.34			50,015
2006			0.22	5.34	0.45	0.16	0.09	0.09	0.08	0.12			17,056
2007			2.60	1.97	1.67	2.92	0.51	0.16	0.11	0.54			27,616
2008			0.00	2.13	0.39	1.01	0.36	0.25	0.64	0.77			14,509
2009			1.15	7.45	1.68	3.37	1.62	0.76	0.43	0.24			43,758
2010			1.55	0.72	3.35	4.67	1.56	0.36	1.65	1.63			40,867
2011			0.38	7.65	1.63	0.58	0.12	0.06	0.07	0.10			27,647
2012*			0.55	0.19	0.23	0.20	0.07	0.07	0.07	0.08			3,876
2013*			0.64	3.00	1.29	0.46	0.47	0.17					15,819
Mean			0.68	3.20	0.96	0.97	0.53	0.37	0.32	0.28			18,520
Max			4.38	11.50	5.55	4.67	5.08	4.96	2.97	1.63			50,015
Min			0.00	0.08	0.05	0.04	0.03	0.02	0.02	0.02			1,776

Note: Station operational from March to October. Blanks indicate missing data *Provisional Data

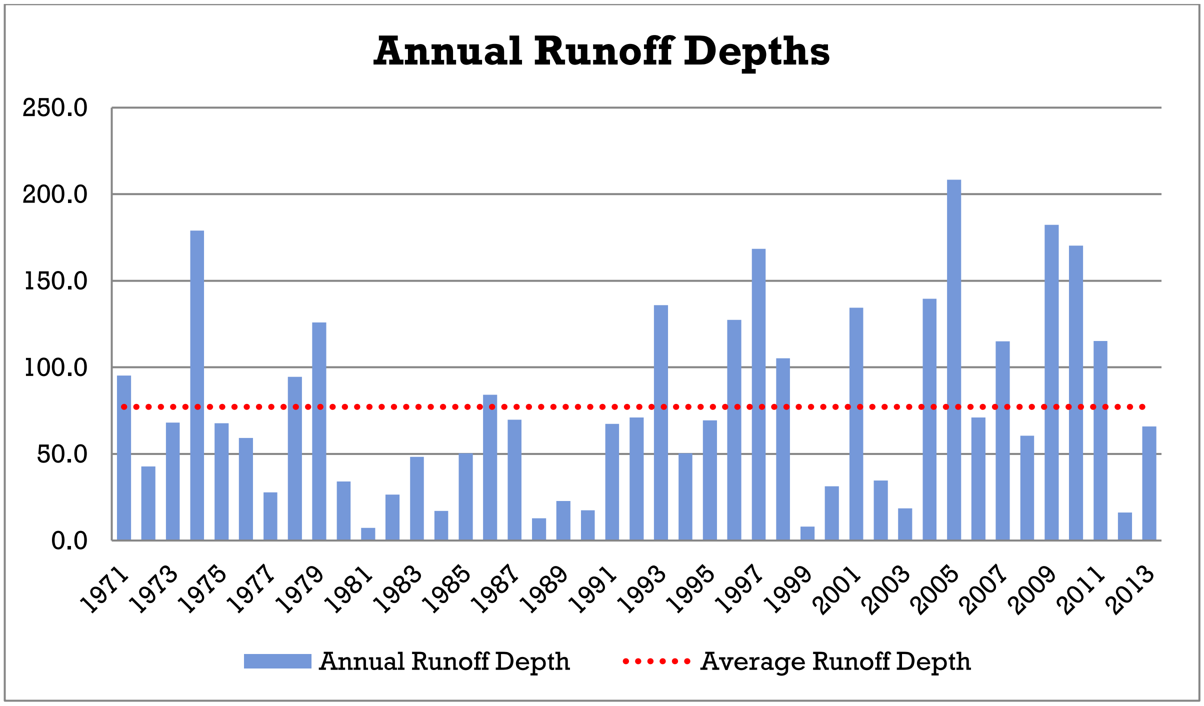

Figure 4: Equivalent Annual Runoff Depth for Devil's Creek (05OJ016)

Figure 5 illustrates the distribution of annual runoff for Devil's Creek. On average the majority of the runoff, 49%, occurs in April as a result of snowmelt and early spring rains when the watershed is still saturated. The maximum daily discharge of each year, as well as the date it occurred, was reviewed. In 42 of the 53 years of data, maximum daily discharge occurred during the spring runoff, in 10 out of 53 years the peak flow occurred during the summer growing period, and in 1994 the peak flow occurred in October.

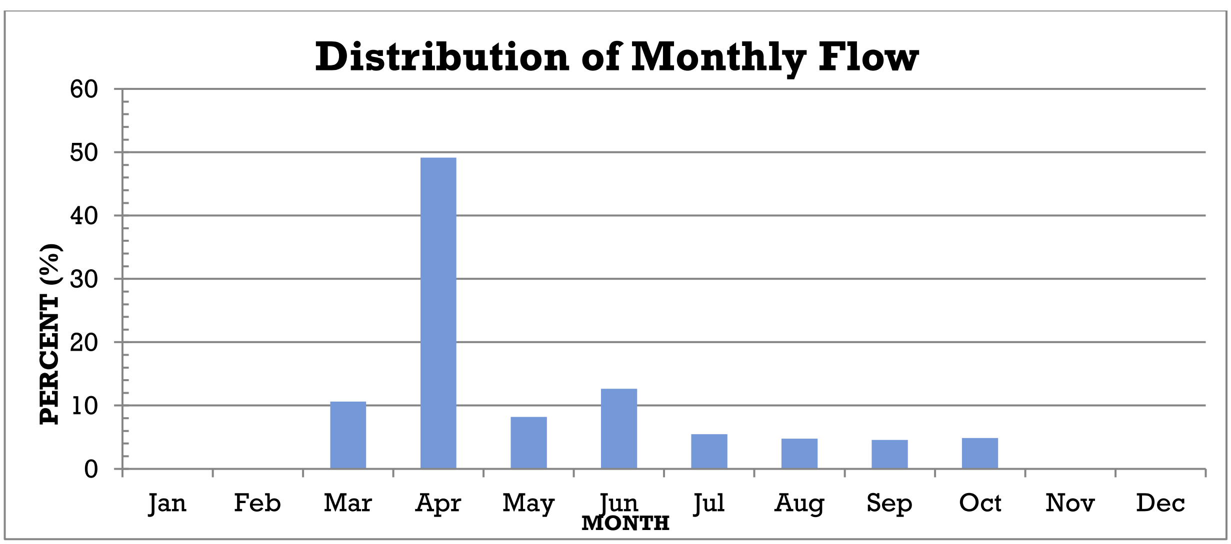

Figure 5: Distribution of Annual Runoff for Devil's Creek (05OJ016)

Table 7 lists the results of frequency analyses of flow data at Devil's Creek at gauging station 05OJ016. The expected annual peak discharge, runoff volume and corresponding unit depth for selected frequencies is given.

Table 7: Frequency of Flood Flows for Devil's Creek (05OJ016)

Flood Frequency	Annual Peak Discharge (m^3/s)	Annual Runoff Volume (dam^3)	Unit Runoff depth (dam^3/km^2)
1%	83.3	12,000	50.0
2%	68.8	9,885	41.2
5%	51.4	7,482	31.2
10%	39.6	5,904	24.6
50%	15.3	2,709	11.3
80%	8.0	1,674	7.0
90%	5.6	1,307	5.4

Devil's Creek recorded flow hydrographs for years representative of the 2 %, 5 %, 10 %, and 50 % floods are plotted in Figure 6. The runoff hydrographs show minimal variability from the date the initial peak discharge occurs. In general, the initial peak occurs between April 12 and April 26.

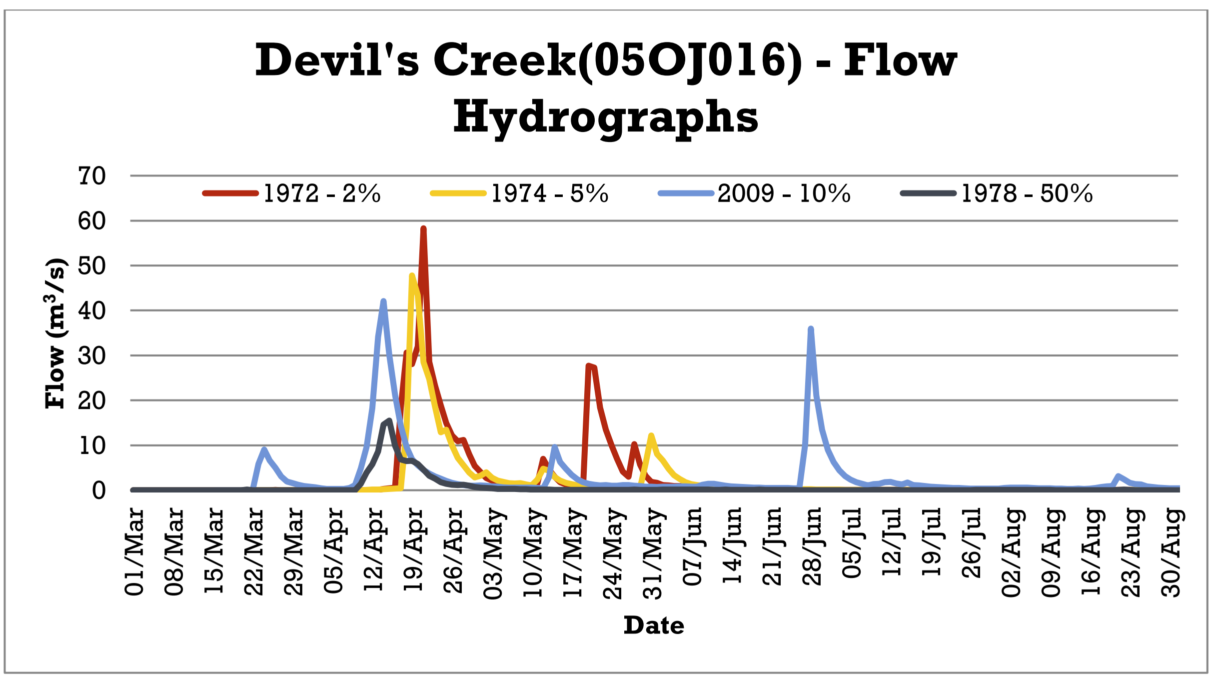

Figure 6: Devil's Creek near Libau (05OJ016) - Runoff Hydrographs

B. *Cooks Creek*

The gross drainage area of station 05OJ019 is 276 km^2. The station has an effective to gross drainage area ratio equal to one.

The mean monthly discharge data for Cooks Creek is shown in Table 8. Based on available data, the average runoff during the period 1990 to 2013 is equal to 11,626 dam^3 or an equivalent depth of 42.1 mm over the gross drainage area for station 05OJ019.

Monthly Mean Discharge (m^3/s)													Annual Volume dam^3
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	
1990			0.04	0.12	0.02	1.09	0.27	0.00	0.00	0.00			4,047
1991			0.02	0.22	0.26	0.54	0.31	0.00	0.00	0.01			3,575
1992			0.32	2.71	0.78	0.13	0.47	0.01	0.02	0.01			11,677
1993			0.12	0.58	0.22	0.05	0.70	2.01	0.69	0.22			12,174
1994			0.00	0.14	0.39	0.10	0.11	0.11	0.25	0.85			5,199
1995			0.94	1.08	0.85	0.26	0.04	0.05	0.04	0.03			8,706
1996			0.00	2.13	3.41	0.83	0.14	0.07	0.05	0.07			17,704
1997			0.00	5.48	2.19								20,070
1998			1.41	2.12	2.29								15,405
1999			0.11	0.29	0.29								1,844
2000			0.54	0.21	0.57								3,517
2001			0.04	3.17	2.37								14,680
2002			0.03	0.69	1.28								5,294
2003			0.30	0.35	0.75								3,706
2004			0.40	3.32	2.56								16,523
2005			0.01	3.74	2.57	4.40	4.16						39,146
2006			0.05	3.63	0.82								11,731
2007					1.03								2,759
2008			0.00		0.68								1,827
2009				2.40	1.82								11,095
2010			0.71	1.02	1.99	3.39	1.46	0.68	2.18	1.50			34,038
2011			0.34	3.77	1.94	1.23				0.02			19,118
2012*			1.12	0.21	0.09	0.05	0.00	0.00	0.00				3,937
2013*			0.31	1.79	1.06	0.95	0.12	0.04		0.02			11,260
Mean			0.31	1.78	1.26	1.08	0.71	0.30	0.36	0.27			11,626
Max			1.41	5.48	3.41	4.40	4.16	2.01	2.18	1.50			39,146
Min			0.00	0.12	0.02	0.05	0.00	0.00	0.00	0.00			1,827

Table 8: Cooks Creek below Cooks Creek Diversion (05OJ019)

Note: Station operational from March to October. Blanks indicate missing data * indicates Provisional data

Surface Water Management Section

The annual runoff depths for the Cooks Creek at gauging station 05OJ019 from 1990 to 2013 are shown in Figure 7. The values range from a minimum of 6.5 mm in 2008 to a maximum of 140.3 mm in 2005. This figure also illustrates the variability in runoff from year to year, as well as the years above and below the average runoff.

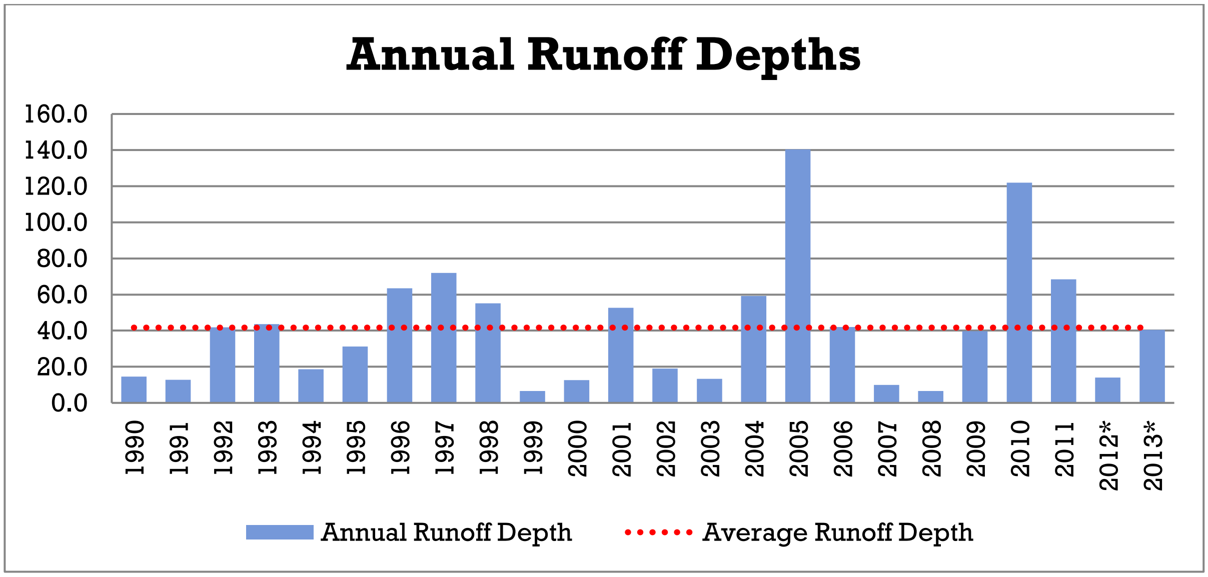

Figure 7: Equivalent Annual Runoff Depths for Cooks Creek (05OJ019)

Figure 8 illustrates the distribution of annual runoff for Cooks Creek. On average the majority of the runoff, 24 %, occurs in April as a result of snowmelt and early spring rains when the watershed is still saturated.

The maximum daily discharge of each year, as well as the date it occurred, was reviewed. In 19 of the 24 years of data, maximum daily discharge occurred during the spring runoff, in 4 out of 24 years the peak flow occurred during the summer growing period, and in 1994 the peak flow occurred in October.

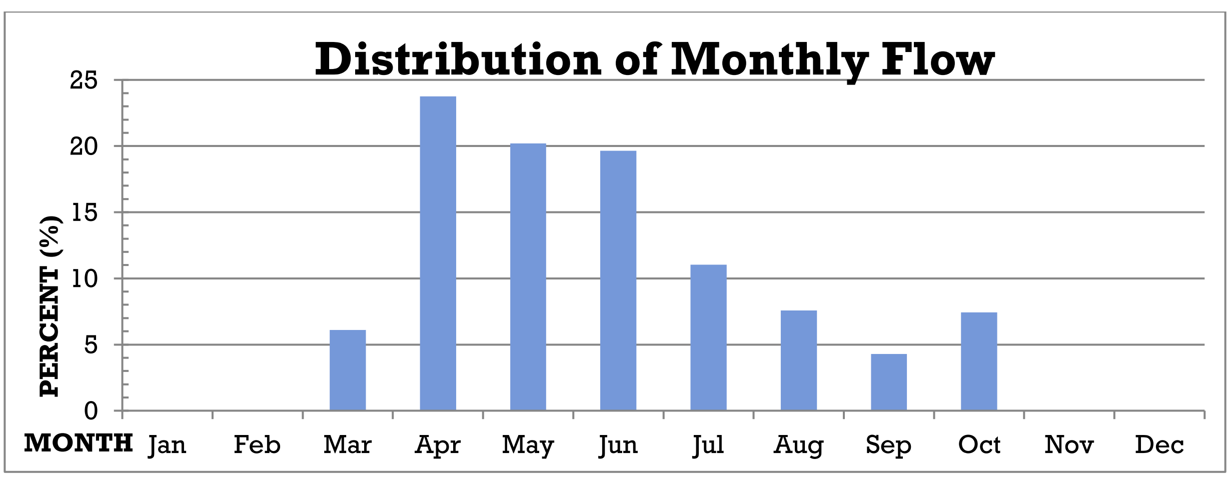

Figure 8: Distribution of Annual Runoff for Cooks Creek (05OJ019)

The result of a statistical analysis of the Cooks Creek flows is shown in Table 9. The expected annual peak discharge, runoff volume and corresponding unit depth for selected frequencies is given.

Flood Frequency	Annual Peak Discharge (m^3/s)	Annual Runoff Volume (dam^3)	Unit Runoff Depth (dam^3/km^2)
1%	17.1	14,333	51.9
2%	14.2	11,877	43.0
5%	10.6	8,868	32.1
10%	8.0	6,730	24.4
50%	2.7	2,271	8.2
80%	1.2	964	3.5
90%	0.7	578	2.1

Table 9: Frequency of Flood Flows for Cooks Creek (05OJ019)

Cooks Creek recorded flow hydrographs for years representative of the 2 %, 5 %, 10 %, and 50 % floods are plotted in Figure 9. The runoff hydrgraphs show some variability from the date the initial peak occurs. The runoff hydrographs show that the date of the initial peak flow occurred between March 15 and April 5.

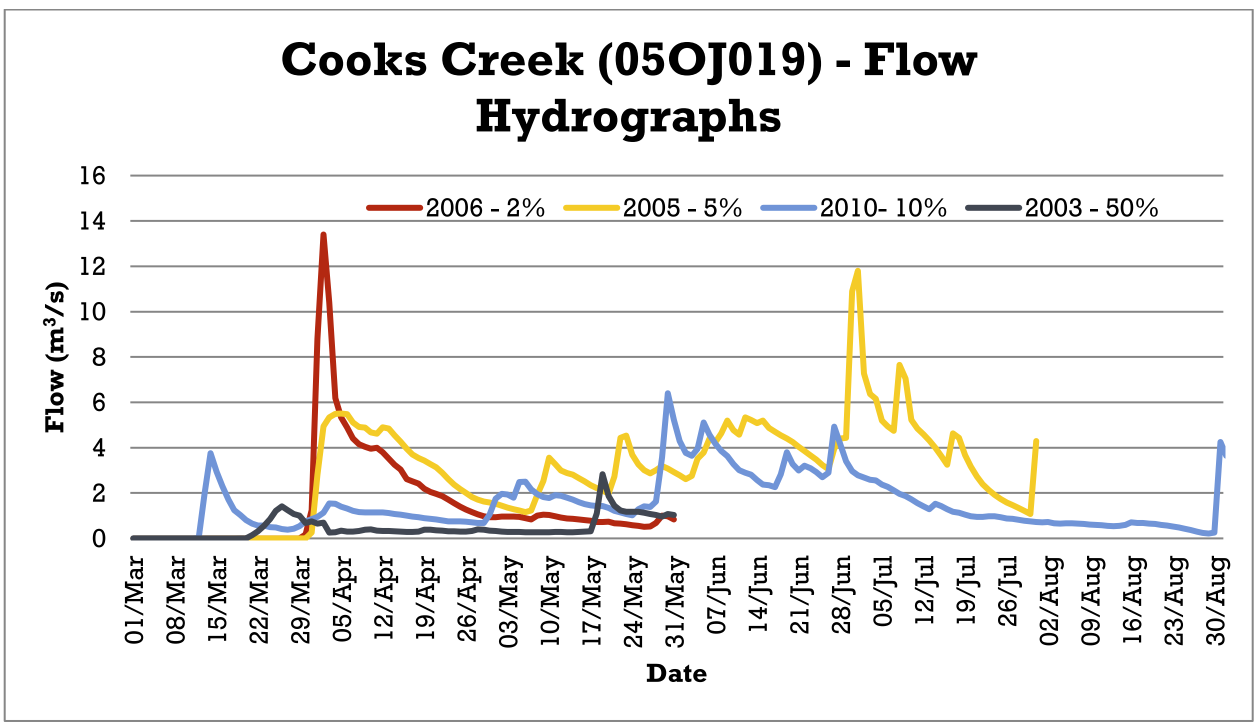

Figure 9: Cooks Creek below Cooks Creek Diversion (05OJ019) - Spring Runoff Hydrographs

C. *Summary of Findings*

Analysis of the available stream flow data in the CDCPA indicates the following:

- Stream flow varies considerably over the months and years.
- Annual stream flow usually peaks between April and May.
- On average, between 75 % and 80 % of the annual runoff volume occurs between March and May of a given year.
- On major watercourses, spring flooding is more significant than flooding from summer precipitation events. Smaller drainage areas (< 30km^2) are more sensitive to rainfall events. Localized flooding can occur in the smaller poorly drained areas from excessive rainfall events.
- Similar in size, Devil's Creek and Cooks Creek watersheds should exhibit similar general runoff characteristics.

Water Allocation:

The issuance of a water use licence requires the determination of the availability of water for human use allocation and the determination of instream flow needs (IFN). The IFN is a specified minimum instantaneous flow that determines when a user may pump from the stream. The allocation procedure depends on whether the stream is considered to be perennial or intermittent.

Intermittent:

The total spring volume (March to May) of water available for allocation on intermittent streams is based on the eight out of ten-year (80 %) risk level based on daily discharge frequency. This would apply to smaller tributary streams.

On intermittent streams, one half of the spring volume of water is available for human use in eight out of ten years. The other half is allocated to IFN for maintenance of stream health and to maintain the ecological integrity of the stream system. Only when the flow in the stream is greater than the IFN can pumping occur.

Perennial:

The Tessman Method has been adopted in Manitoba for determination of the IFN on perennial streams. This method establishes a range of instream flow recommendations for each month based on the following criteria:

1. For months where the average recorded flow for the period of record is less than 40% of the overall mean annual flow, the minimum instream flow is equal to the average monthly flow.

2. If the mean monthly flow is between 40% and 100% of the overall mean annual flow then the minimum instream flow is equal to 40% of the mean annual flow.

3. For months where the mean monthly flow is greater than the mean annual flow, then the minimum instream flow is equal to 40% of that month's overall mean flow.

Under the 80 % risk level, the volume of water available for human use allocation is the 80th percentile value from a duration curve of available volumes after the IFN requirements have been satisfied.

Cooks Creek and Devil's Creek are both considered to be perennial streams. The Tessman method was applied in determining an allocable volume of water at the two streams respective hydrometric stations, 05OJ016 and 05OJ019. The instream flow recommendations on a monthly basis for both streams are shown in Figures 10 and 11.

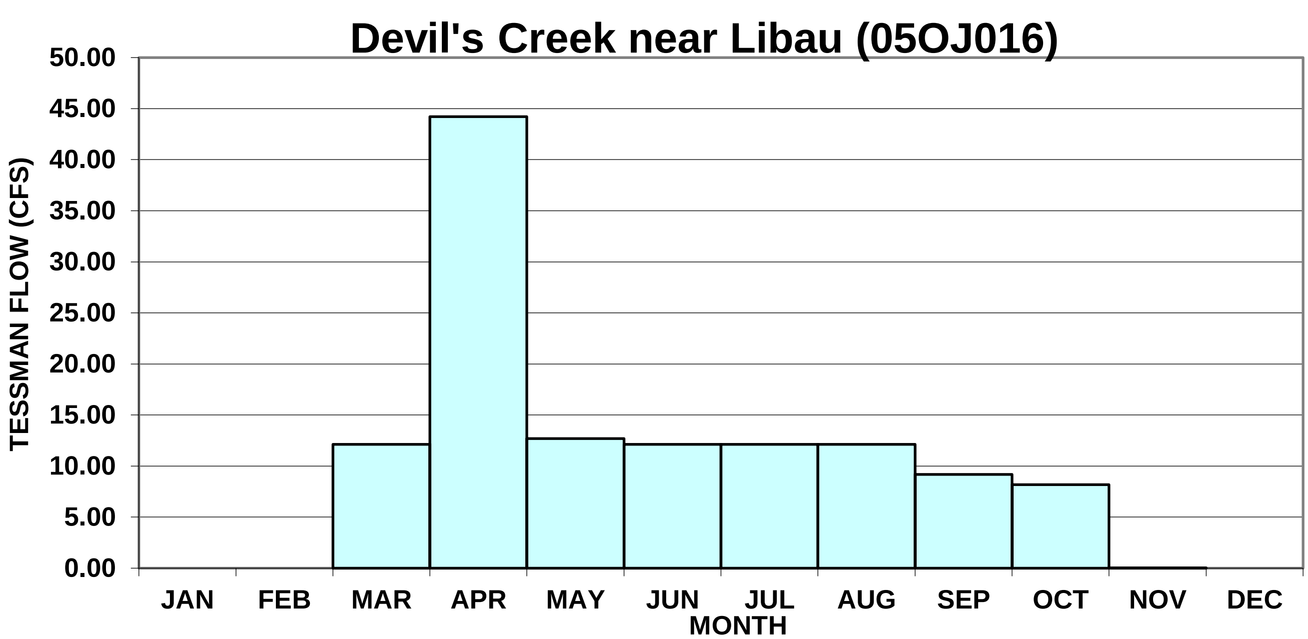

Figure 10: Tessman Flow plots for Devil's Creek

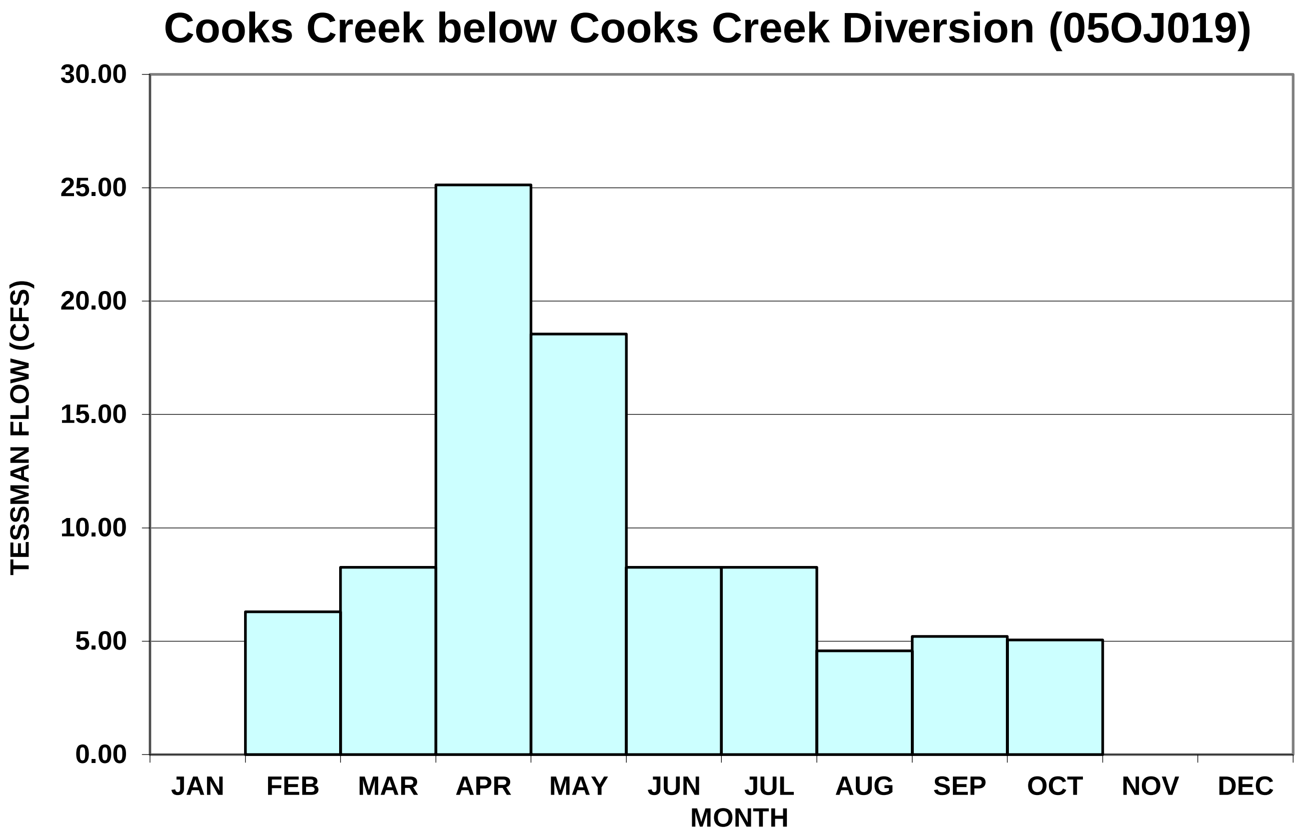

Figure 11: Tessman Flow plots for Cooks Creek