INVESTIGATION OF PPWB EXCURSIONS IN THE NORTH SASKATCHEWAN RIVER AT THE ALBERTA-SASKATCHEWAN BOUNDARY 1997

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EXECUTIVE SUMMARY

Water quality in the North Saskatchewan River is monitored for the Prairie Provinces Water Board (PPWB) at the Alberta-Saskatchewan border. Occasional exceedences of PPWB objectives for copper, fecal coliform bacteria, zinc and lead prompted an investigation into sources that may contribute to these high concentrations. Historical water quality data are available for point sources and the river in the urban area, but little is known about the contribution of the creeks and point sources discharging to the river along the last 100 km of river before it reaches the border.

A brief sampling program was conducted in May 1997 to gain some insight into the relative contribution of metals and fecal coliform bacteria in tributaries and effluents in the stretch of the river that extends from Myrnam Bridge to the border. This was not intended to be a definitive investigation of these sources, but a point-in-time survey to assess where future investigations should be focussed.

The study was conducted shortly after spring runoff peaked in the area. Grab samples were collected from each of nine tributaries and effluents, and composite or grab samples were collected from the river at several locations. Flow volume was measured or estimated for each sampling location, and mass loads were calculated to determine relative contributions.

Concentrations of all metals and fecal coliform bacteria in the North Saskatchewan River were below or at the Canadian Water Quality Guidelines (CWQG) and Prairie Provinces Water Board Objectives, except for aluminum, which exceeded CWQG for the protection of aquatic life.

Copper and zinc in several tributary and effluent samples exceeded CWQG, but their mass loads were so small that they would not have measurably elevated concentrations in the river. Similarly, counts of fecal coliform bacteria exceeded 100 per 100 mL in several creeks and the Elk Point Sewage Treatment Plant effluent. However, the dilution in the river is so great that the impact from these effluents, even if combined, would increase fecal coliform levels in the river by less than one count per 100 mL.

Specific sources for PPWB excursions were not determined during this study. Additional studies, particularly during high runoff periods, will be needed to further elucidate potential sources for PPWB excursions at the border, including one source near the border that was unaccounted for during the May 1997 sampling program.

ACKNOWLEDGEMENTS

John Willis, Ken Wegner and other staff of Monitoring Branch, Water Management Division conducted the sampling program on the North Saskatchewan River in May 1997. Bridgette Halbig prepared graphs and formatted the report. David Trew reviewed a draft of the report.

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1.0 INTRODUCTION

Environment Canada monitors water quality in the North Saskatchewan River (NSR) at the Alberta-Saskatchewan border for the Prairie Provinces Water Board (PPWB). The PPWB compares water quality data with objectives established to protect downstream uses of water flowing over the border. The sampling site at the border was originally located at Highway 3 bridge in Saskatchewan (approximately 37 km downstream of the border). In November 1982, it was relocated to Lea Park in Alberta (approximately 28 km upstream of the border), due to bridge construction activity in Saskatchewan. It was moved to the present-day site at Highway 17 bridge (located at the border, also called Lloydminster Ferry) in April 1988. The PPWB site is considered to be representative of the reach extending from Lea Park to the border.

Over the past two decades or so, there have been occasional exceedences of the PPWB objectives in the monthly samples collected at the border site. Copper, zinc, lead and fecal coliform bacteria are the variables that exceed the objectives most frequently. Very rarely, chromium and manganese also exceed the objectives. Potential sources for these excursions include 1) non-point sources throughout the watershed, 2) municipal and industrial discharges from the Edmonton-Fort Saskatchewan area, and 3) agricultural runoff and municipal discharges in the watershed near the border. The role that each of these major sources plays varies with season, flow in the river and activities within the watershed. Historical water quality data are available for water flowing from the upper watershed and for point sources in the urban area, but little is known about the contribution of the creeks and point sources discharging to the river along the last 100 km of river before it reaches the border.

A brief sampling program was conducted in May 1997 to gain some insight into the relative contribution of metals and fecal coliform bacteria for each of the major tributaries and point sources in the reach of the North Saskatchewan River that extends from Myrnam Bridge to the border, a distance of 106 km. The study was not designed to obtain the final word on sources of excursions of the PPWB objectives, because the issue is complicated and is undoubtedly affected by a variety of ever-changing factors. This document summarizes the results of this scoping-level study, and provides supplementary information on water quality of the Vermilion River, a major tributary of the North Saskatchewan River, which was sampled in 1996 and 1997.

2.0 BACKGROUND

Table 1 shows excursions of the objectives that have occurred at the PPWB site on the North Saskatchewan River over the period of record. Also listed are occasions when concentrations of these variables have been higher than PPWB objective levels at Alberta's long-term river network sites above and below the Edmonton-Fort Saskatchewan urban area. These are provided for comparison only; objectives established for the PPWB at the border are not applicable at these upstream sites.

2.1 METALS

Copper concentrations have exceeded objective levels most frequently. Often these excursions occurred in summer, especially when total suspended solids (TSS) concentrations in the river were high (Figures 1 and 2). Copper was strongly correlated with TSS and flow (TSS: r^2=0.92, P<0.0001, n=47), although excursions have also occurred when flow and TSS were low. High concentrations of TSS, and therefore copper and other metals, result from runoff draining urban and agricultural areas and from disturbance of the bed and banks of the river during high flows. Levels of total suspended solids increase naturally in a downstream direction as the geomorphology of the river channel changes (Shaw et al. 1994). Municipal and industrial effluents contribute copper and other metals as well, although concentrations in effluents from plants in the Edmonton-Fort Saskatchewan area are relatively low, and effluent discharge volumes are very small compared with flow in the river. Results of a study conducted jointly by industries and municipalities in the urban area in 1992-1994 (Golder 1995), suggested that metals contamination from these plants was largely insignificant in the river except immediately below Fort Saskatchewan and in a small zone below the Gold Bar Wastewater Treatment Plant. Metals showing higher concentrations in these areas were copper, zinc and chromium, but model simulations indicated that concentrations of these metals would never approach the USEPA chronic criteria for protection of aquatic life. For example, the highest simulated concentration of copper in the river below the Gold Bar WWTP was 0.0028 mg/L and below Sherritt at Fort Saskatchewan 0.0022 mg/L, whereas the USEPA chronic guideline is 0.0172 mg/L. Even if these concentrations were maintained all the way to the border, they would not exceed PPWB objectives.

Table 1. Excursions of the Prairie Provinces Water Board Objectives in the North Saskatchewan River (Lea Park to Lloydminster Ferry), 1974-1996. Also included (for comparison only) are the number of values exceeding these objectives at Devon (about 30 km above the city of Edmonton) and Pakan (100 km downstream of the city). Metals samples were collected only quarterly at the two upstream sites for the years before 1993. n.a. = data not available.

YEAR	EXCURSIONS (BORDER)	DEVON	PAKAN
1996	Cu (2), FC (1), D.O. (2), PH (1)	Cu (2), FC (1), Zn (2), Cr (2)	Cu (7), FC (8), Pb (1), Cd (1), Zn (1)
1995	Cu (4)	Cu (4), Pb (2), Zn (2), Mn (1), Cr (3)	Cu (1), FC (6), Pb (4), Zn (1), Cr (2)
1994	Cu (2), FC (2), Mn (1)	Cu (2), Zn (1)	Cu (6), FC (8), Zn (2)
1993	None	Cu (3)	Cu (3), FC (8), Zn (1)
1992	FC (1)	None	FC (7)
1991	Cu (2), FC (2)	Cu (1)	FC (6)
1990	Cu (3), FC (3), Pb (2), Cr (1), Zn (2)	None	Cu (1), FC (7), Pb (1), Zn (1)
1989	Cu (1), FC (1)	FC (1)	FC (8)
1974-1990	FC (21), Cu (21), Pb (9), Zn (2)	n.a.	n.a.

Variables:

FC = fecal coliform bacteria; Cu = copper; Mn = manganese
Pb = lead; Zn = zinc
Cr = chromium; Cd = cadmium

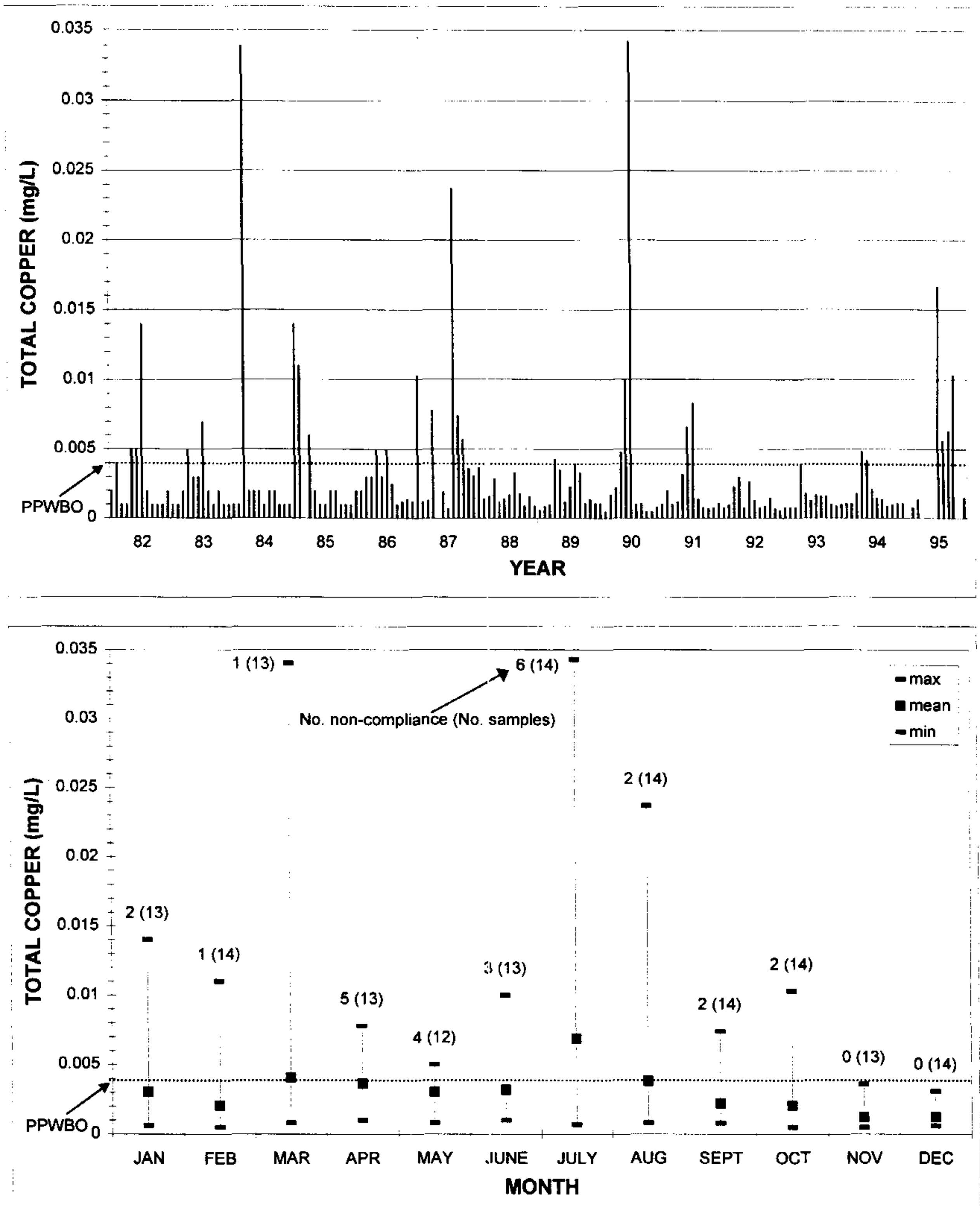


Figure 1. Total copper in the North Saskatchewan River at Lea Park/Hwy 17, 1982-1995. Top: monthly values; bottom: monthly mean values and non-compliance with PPWB objective.

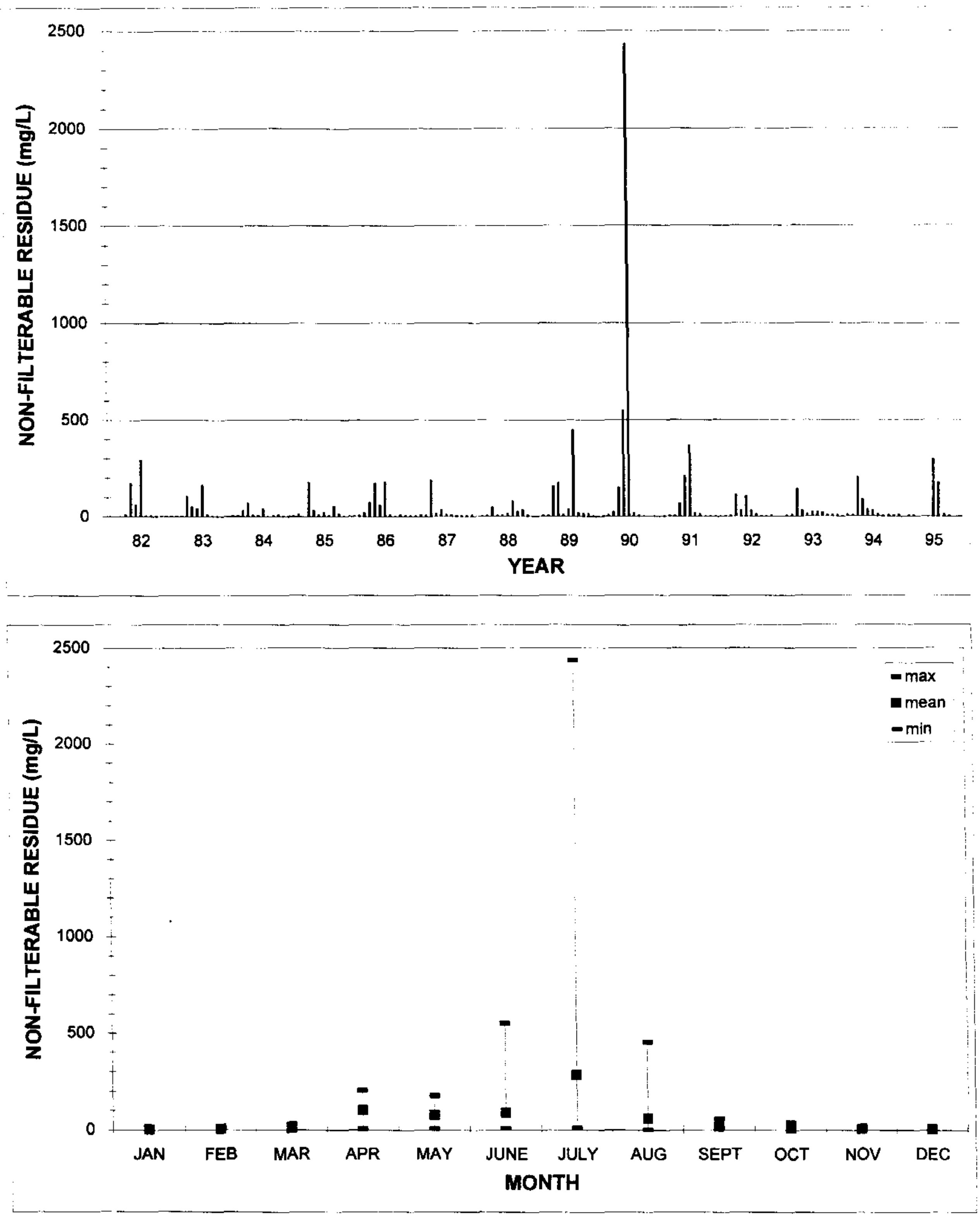


Figure 2. Non-filterable residue in the North Saskatchewan River at Lea Park/ Hwy 17, 1982-1995. Top: monthly values; bottom: monthly mean values and range of data.

Elevated concentrations of copper and other metals also occurred infrequently at Devon, the site upstream of Edmonton, and at Pakan, downstream of the city. Water quality at both sites is affected primarily by non-point sources of these substances; at Pakan, there is also a contribution from point sources in the urban area. Although it appears in Table 1 that high concentrations of various metals occurred more frequently at these two sites after 1993, metals were analyzed only quarterly prior to 1993. As well, analytical methods changed from atomic absorption (AA) to inductively coupled plasma (ICP) in mid-1994, and then to ICP-MS in mid-1995. It is not known whether these changes in analytical technique affected results.

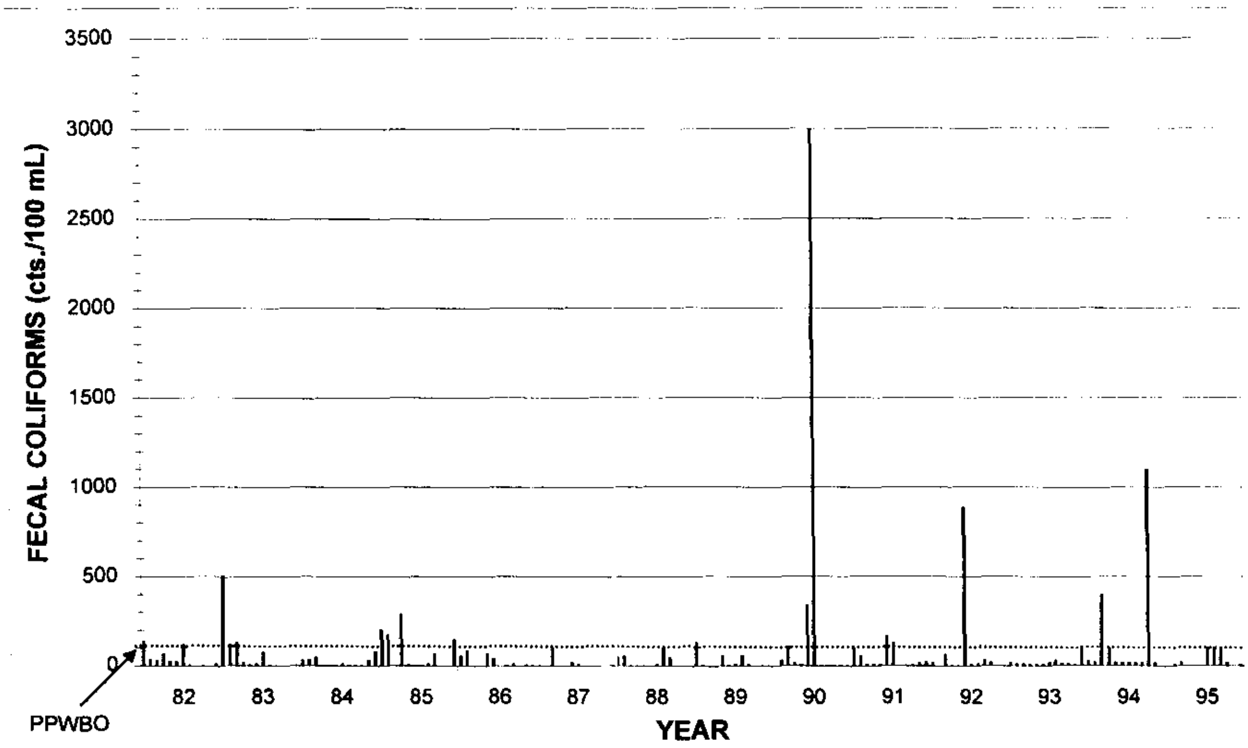
Excursions for zinc and lead occur too infrequently to be able to assess seasonal patterns or potential sources. For example, since 1990 all samples for lead and zinc were in compliance with PPWB objectives.

2.2 FECAL COLIFORM BACTERIA

Counts of fecal coliform bacteria occasionally exceed PPWB objectives at the Alberta-Saskatchewan border. Exceedences occurred all seasons of the year, but often in summer (Figure 3). For example, exceedences occurred in March and October 1994, in June 1992, and in June and July 1991. June and July are fairly rainy months, so excursions in summer may have resulted from agricultural runoff near the border. Presumably, high suspended solids and higher flow in the river would reflect runoff; there are weak relationships between flow and fecal coliforms and TSS and fecal coliforms (TSS vs. fecal coliforms: $r^2=0.18$, $P<0.01$, n=47).

The Edmonton-Fort Saskatchewan urban area is a potential source for some of these excursions at the border. At Pakan, about half the monthly samples collected each year contained counts above 100 counts/100 mL, whereas at Devon, which is above the urban area, fecal coliform bacteria almost never exceeded this level. However, an analysis of fecal coliform die-off rates as applied to the mass loading of coliforms entering the river suggest that coliforms originating in the urban area would not reach the border during summer.

Data from a synoptic water quality survey conducted in January 1995 suggest that fecal coliform bacteria from the urban area could affect the border site in winter. A winter coliform die-off rate (0.029/hr; Bowie et al. 1985) was applied to the measured loadings from the Gold Bar Wastewater Treatment Plant and other sources. The resulting predicted river



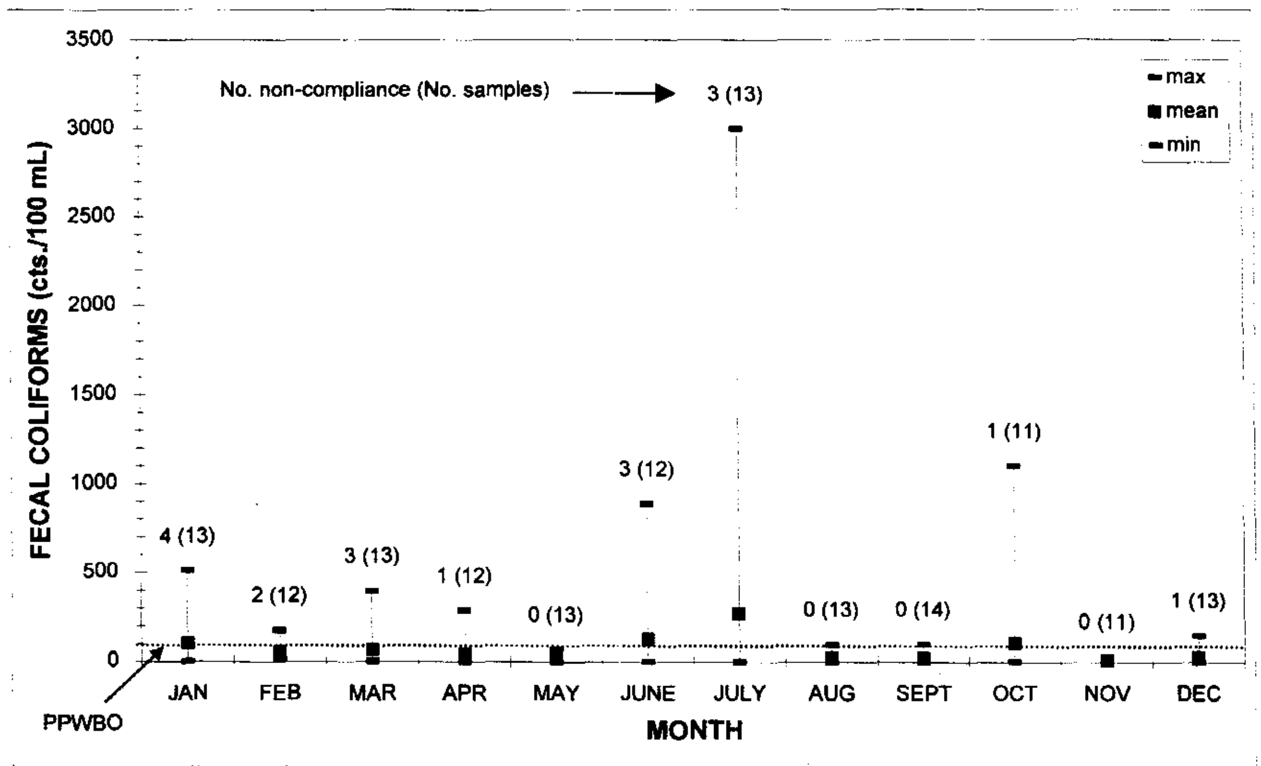


Figure 3. Fecal coliforms in the North Saskatchewan River at Lea Park/Hwy 17, 1982-1995. Top: monthly values; bottom: monthly mean values and non-compliance with PPWB objective.

concentration at the border (500 counts/100 mL) was similar to the concentration measured at the border (with an allowance for time of travel of the river). The Elk Point sewage treatment plant is also a possible source, because Elk Point is much closer to the border. At times, the short time of travel might allow high concentrations to reach the border even though the total load of fecal coliforms in the Elk Point effluent is lower than that from Gold Bar.

3.0 METHODS

During May 26-27, 1997, grab or water column integrated samples were collected and flow was measured at the sites shown in Figure 4 and listed in Table 2. The focus of the survey was on the metals and fecal coliform bacteria that have exceeded PPWB objectives, but other water quality attributes were also examined. Originally, it was intended to conduct the survey after a summer rainstorm when local tributary streams were flowing well. Attempts were made in 1995 and 1996, but no suitable rainstorms occurred those years. For 1997, it was decided to sample the tributaries and point sources at the end of spring runoff when flow was relatively high, and then attempt another storm event at a later date.

The Vermilion River was sampled every two weeks during the summer of 1996 and 1997 to assess agricultural impacts on water quality. Fecal coliform bacteria were analyzed in these samples, but metals were not.

Metals were analyzed at the Alberta Research Council Laboratory in Vegreville. All metals were analyzed by ICP-MS, as the total recoverable fraction. Fecal coliform bacteria were analyzed at the Provincial Laboratory of Public Health in Edmonton. Other variables, such as nutrients, major ions and organic carbon, were analyzed by EnviroTest Labs.

Instantaneous mass loads at the time of sampling were estimated from flow and concentration. At Lea Park and the border, North Saskatchewan River samples were collected from three-point transects; left and right bank samples were collected 40 m from shore on either side and the center sample from mid-channel. Flow in these sections was proportioned to area and velocity. Total flow was estimated from six-hour mean values from the Water Survey of Canada station at the border and time of travel.

Masses of various constituents were also estimated by adding the measured mass at the upstream North Saskatchewan River sampling station (e.g., Myrnam Bridge) and mass in the

Table 3. North Saskatchewan River near Alberta-Saskatchewan border: concentrations, instantaneous mass and mass balance results for selected variables, May 26-27, 1997. Mass is expressed in grams, milligrams or total counts in river per second.

SITE	Flow m3/s	Na mg/L	Na grams	Al ug/L	Al mg	Cd ug/L	Cd mg	Cr ug/L	Cr mg	Cu ug/L	Cu mg	Pb ug/L	Pb mg	Zn ug/L	Zn mg	F.C. cts/100 mL	F.C cts/s
1. NSR at Myrnam Br.	296	12	3552.00	2805	830280	0.037	10.95	2.99	885	2.89	855	2.25	666	8.24	2439	100	2.96E+08
2. Death River	0.0004	59	0.02	847	0	0.092	0.00	1.41	0.00	12.9	0.01	1	0.00	18	0.01	12	4.80E+01
3. Atimoswe Creek	0.209	26	5.43	237	50	***0.02***	0.00	0.469	0.10	1.41	0.29	0.126	0.03	2.01	0.42	140	2.93E+05
4. Elk Point STP effluent	0.015	73	1.10	129	2	0.058	0.00	0.624	0.01	8.94	0.13	0.394	0.01	13.5	0.20	2300	3.45E+05
5. Unnamed Creek near Gratz	0.022	25	0.55	1448	32	0.021	0.00	1.94	0.04	2.1	0.05	0.559	0.01	4.43	0.10	80	1.76E+04
6. Moosehills Creek	0.391	19	7.43	675	264	***0.02***	0.01	0.936	0.37	0.917	0.36	0.244	0.10	2.54	0.99	34	1.33E+05
7. Middle Creek	0.003	41	0.12	662	2	***0.02***	0.00	1.13	0.00	1.44	0.00	0.418	0.00	58.1	0.17	9	2.70E+02
8. Canada Salt effluent	0.263	87	22.88	4448	1170	0.082	0.02	5.24	1.38	5.07	1.33	1.77	0.47	16	4.21	14	3.68E+04
9. NSR at Heinsburg (composite)	296	12	3552	3534	1046064	0.057	16.87	3.87	1146	2.71	802	1.94	574	8.56	2534	23	6.81E+07
10. NSR at Lea Park Left bank	42	13	546	3012	126504	0.057	2.39	3.67	154	2.67	112	3.96	166	7.3	307	43	1.81E+07
Lea Park Centre	223	13	2899	3816	850968	0.058	12.93	3.86	861	4.03	899	1.34	299	8.37	1867	43	9.59E+07
Lea Park Right bank	34	13	442	2356	80104	0.027	0.92	2.5	85	2.24	76	1.02	35	7.04	239	84	2.86E+07
11. Vermilion R.	11.5	70	805	4331	49807	***0.02***	0.23	4.34	49.91	3.86	44.39	1.26	14.49	8.36	96.14	54	6.21E+06
12. Unnamed Creek near border	0.014	84	1.18	607	8	0.022	0.00	0.875	0.01	2.03	0.03	0.3	0.00	15.4	0.22	220	3.08E+04
13. NSR at Border Left bank	31	13	403	2911	90241	0.04	1.24	3.48	107.88	2.55	79.05	2.3	71.30	7.34	228	29	8.99E+06
Border Centre	176	13	2288	3523	620048	0.021	3.70	3.68	647.68	2.96	520.96	1.64	288.64	8.14	1433	23	4.05E+07
Border Right bank	85	21	1785	3677	312545	0.062	5.27	3.61	306.85	2.77	235.45	1.7	144.50	7.41	630	29	2.47E+07
Mass Balance																	
Measured Heinsburg			3552		1046064		16.87		1146		802		574		2534		6.81E+07
Balanced Heinsburg			3590		831799		10.99		887		858		667		2445		2.97E+08
Measured Lea Park			3887		1057576		16.25		1100		1087		500		2412		1.43E+08
Measured Border			4476		1022834		10.21		1062		835		504		2290		7.41E+07
Balanced Border			4396		881614		11.22		937		902		681		2541		3.03E+08
% Deviation Meas-Bal.			-1.8		-13.8		9.91		-11.8		8.0		35.0		11.0		309

Note: Values in bold italics are below analytical detection limit.

Table 3. Continued.

SITE	Flow m3/s	TSS mg/L	TSS grams	TOC mg/L	TOC grams	NO2+NO3 mg/L	NO2+NO3 grams	NH4-N mg/L	NH4-N grams	TKN mg/L	TKN grams	Diss.P mg/L	Diss.P grams	TP mg/L	TP grams	E.coli cts/100 mL	E.coli cts/s
1. NSR at Myrnam Br.	296	***2***	592.00	7	2072.00	0.313	92.65	0.03	8.88	0.88	260.48	0.075	22.20	0.08	23.68	60	1.78E+08
2. Death River	0.0004	***2***	0.00	23	0.01	0.013	0.00	0.119	0.00	1.93	0.00	0.144	0.00	0.24	0.00	12	4.80E+01
3. Atimoswe Creek	0.209	***2***	0.42	17	3.55	***0.006***	0.00	0.031	0.01	1.5	0.31	0.2	0.04	0.288	0.06	120	2.51E+05
4. Elk Point STP effluent	0.015	15	0.23	21	0.32	1.19	0.02	8.19	0.12	13.1	0.20	1.57	0.02	2.02	0.03	2000	3.00E+05
5. Unnamed Creek near Gratz	0.022	20	0.44	12	0.26	***0.006***	0.00	0.048	0.00	1.11	0.02	0.056	0.00	0.173	0.00	80	1.76E+04
6. Moosehills Creek	0.391	***2***	0.78	19	7.43	0.03	0.01	0.068	0.03	1.15	0.45	0.053	0.02	0.054	0.02	20	7.82E+04
7. Middle Creek	0.003	***2***	0.01	24	0.07	0.044	0.00	0.274	0.00	2.67	0.01	0.06	0.00	0.136	0.00	9	2.70E+02
8. Canada Salt effluent	0.263	85	22.36	10	2.63	0.427	0.11	0.068	0.02	0.79	0.21	0.076	0.02	0.183	0.05	14	3.68E+04
9. NSR at Heinsburg (composite)	296	***2***	592.00	7	2072.00	0.323	95.61	0.015	4.44	0.53	156.88	0.068	20.13	0.08	23.68	23	6.81E+07
10. NSR at Lea Park Left bank	42	***2***	84.00	7	294.00	0.37	15.54	***0.005***	0.21	0.62	26.04	0.078	3.28	0.145	6.09	20	8.40E+06
Lea Park Centre	223	67	14941.00	7	1561.00	0.356	79.39	0.009	2.01	0.76	169.48	0.067	14.94	0.112	24.98	29	
Lea Park Right bank	34	4	136.00	7	238.00	0.446	15.16	0.025	0.85	0.68	23.12	0.077	2.62	0.142	4.83	49	1.67E+07
11. Vermilion R.	11.5	***2***	23.00	20	230.00	0.01	0.12	0.086	0.99	1.7	19.55	0.17	1.96	0.299	3.44	34	3.91E+06
12. Unnamed Creek near border	0.014	12	0.17	17	0.24	***0.006***	0.00	0.029	0.00	1.41	0.02	0.067	0.00	0.113	0.00	210	2.94E+04
13. NSR at Border Left bank	31	***2***	62.00	7	217.00	0.358	11.10	0.022	0.68	0.81	25.11	0.071	2.20	0.138	4.28	9	2.79E+06
Border Centre	176	68	11968.00	7	1232.00	0.405	71.28	0.032	5.63	0.82	144.32	0.065	11.44	0.167	29.39	12	
Border Right bank	85	52	4420.00	8	680.00	0.327	27.80	0.016	1.36	0.83	70.55	0.086	7.31	0.163	13.86	6	5.10E+06
Mass Balance																	
Measured Heinsburg			592		2072		96		4		157		20		24		6.81E+07
Balanced Heinsburg			616		2086		93		9		262		22		24		1.78E+08
Measured Lea Park			15161		2093		110		3		219		21		36		2.51E+07
Measured Border			16450		2129		110		8		240		21		48		7.89E+06
Balanced Border			639		2317		93		10		281		24		27		1.82E+08
% Deviation Meas-Bal.			-96.1		8.8		-15.7		30.9		17.2		15.8		-42.6		2209.5

Note: Values in bold italics are below analytical detection limit.

Copper concentrations were below the Canadian Water Quality Guideline (CWQG) for protection of aquatic life (3 μg/L for hardness less than 180 mg/L) and the PPWB objective in North Saskatchewan River samples, although one value at Lea Park center channel was at the PPWB guideline level of 4 μg/L. It is likely that this somewhat elevated copper concentration at Lea Park resulted from the high concentration of total suspended solids observed in this sample. Copper concentrations were above both guidelines in the samples from the Death River, the Elk Point STP effluent and the Canadian Salt effluent. The mass loading in these inputs were so small that they would not measurably elevate concentrations in the river, however (see Table 4). Occasionally, copper concentrations in the effluent from Canadian Salt are considerably higher than that measured during this study: October 1994 - 127 μg/L, October 1995 - 100 μg/L. At other times, levels have been near the analytical detection limit. Even at a concentration of 127 μg/L and a high effluent volume, the increase in copper in the North Saskatchewan River from this effluent would amount to less than 1 μg/L, so it is unlikely that Canadian Salt is the source of copper excursions at the PPWB sampling site. The Vermilion River is a potential source of copper excursions, because its flow volume is high. The few measurements of copper in samples from the Vermilion River were below CWQG, however, and during the May study, copper in the Vermilion represented only 5% of the total load measured in the river (Table 4).

Concentrations of other metals analyzed during the study were well below PPWB objectives, except for one zinc value from Middle Creek (58 μg/L; PPWBO and CWQG are 30 μg/L). The flow in this creek was so low that the mass load would not measurably change the concentration in the river. Selenium levels were below CWQG in the North Saskatchewan River, but were above the objective value of 1 μg/L in several tributaries and effluents. Aluminum levels were fairly high in the North Saskatchewan River and some of the tributaries and effluents. Although all mainstem and tributary samples had levels that were below the PPWB objective for aluminum, several were well above the CWQG of 100 μg/L (e.g., at Myrnam – 2805 μg/L). This was true even when total suspended solids levels in the river were less than the analytical detection limit. The source of aluminum in these samples is unknown. A recent synoptic survey of the river (August 1997) indicated a three-fold increase in concentration between Devon and Lea Park. Most of this increase occurred in the Fort Saskatchewan area, but

Table 4. Percent of total effluent/tributary mass load and total river mass load for four water quality attributes contributed by tributaries and effluents on the North Saskatchewan River, May 1997.

SITE	COPPER		LEAD		ZINC		FECAL COLIFORMS	
	% of total inputs	% of mass in river	% of total inputs	% of mass in river	% of total inputs	% of mass in river	% of total inputs	% of mass in river
Death River	0.01%	<1%	0.00%	<1%	0.01%	<1%	0.00%	<1%
Atimoswe Creek	0.63%	<1%	0.17%	<1%	0.41%	<1%	4.14%	<1%
Elk Point STP effluent	0.29%	<1%	0.04%	<1%	0.20%	<1%	4.88%	<1%
Unnamed Creek near Gratz	0.10%	<1%	0.08%	<1%	0.10%	<1%	0.25%	<1%
Moosehills Creek	0.77%	<1%	0.63%	<1%	0.97%	<1%	1.88%	<1%
Middle Creek	0.01%	<1%	0.01%	<1%	0.17%	<1%	0.00%	<1%
Canada Salt effluent	2.86%	<1%	3.08%	<1%	4.11%	<1%	0.52%	<1%
Vermilion R.	95.27%	5.31%	95.95%	2.87%	93.83%	4.20%	87.88%	8.38%
Unnamed Creek near border	0.06%	<1%	0.03%	<1%	0.21%	<1%	0.44%	<1%
Sum of Effluent Loads, mg or counts/100 mL	46.59		15.10		102.46		7.07E+06	
Mass in River, mg or counts/100 mL		835		504.44		2290.03		7.41E+07

there was a gradual increase of about 1000 µg/L between Vinca Bridge downstream of Fort Saskatchewan and Lea Park.

4.3 FECAL COLIFORM BACTERIA

Counts of fecal coliform bacteria were at or below 100 per 100 mL in all samples collected in the North Saskatchewan River during the study (Table 3). Several tributary and effluent samples contained counts above this level: Atimoswe Creek, the Elk Point treated effluent and a small creek near the border. However, the dilution in the river is so great that the impact from these inputs, even if combined, would increase fecal coliform levels in the river by less than one count per 100 mL.

The balanced mass of fecal coliform bacteria at the border is much greater than the measured mass, as would be expected with natural die-off over the approximately 45 hours required for the river to flow between Myrnam Bridge and the border. There is an apparent loss of coliforms between Myrnam and Heinsburg (0.06/hr) that corresponds well with die-off rates in the literature and with a rate observed in the North Saskatchewan River in 1991 (Mitchell 1991). This suggests that the inputs along this stretch are minor. At Lea Park, however, the total amount of fecal coliforms in the river increased over the amount measured at Heinsburg. Other variables, notably total suspended solids, were also higher at Lea Park than at Heinsburg. Potential sources are two creeks between Heinsburg and Lea Park that were not sampled due to poor access. The highest count at Lea Park was on the right bank (84 cts/100 mL). A possible source is a fairly large, unnamed creek located on the right bank of the river about 5 km upstream of Lea Park. The other possible source is Frog Creek, located about 5 km downstream of Heinsburg on the left bank. It drains several lakes, and is therefore less likely to be a source than the right bank creek further downstream. Between Lea Park and the border, the calculated fecal coliform die-off rate was very similar to that between Myrnam and Heinsburg, again indicating that sources along this reach were minor at this time.

In the Vermilion River, fecal coliform bacteria were monitored approximately every two weeks during the summers of 1996 and 1997 at the Water Survey of Canada gauge at Marwayne. In 1996, counts ranged from 6 to 350/100 mL, median 66 counts/100 mL; in 1997 they ranged from 3 to 290/100 mL, median 47 counts/100 mL. If mixing in the North Saskatchewan River were complete by the time it reached the border, these levels would not affect samples collected for the PPWB due to dilution and fecal coliform bacterial die-off. During the May 1997 study, fecal coliform bacteria contributed by the Vermilion River represented only 8% of the total mass in the river at the border (Table 4).

5.0 CONCLUSIONS

Specific sources for PPWB excursions were not determined during this study. Counts of fecal coliform bacteria and concentrations of copper, lead and zinc were relatively low in the North Saskatchewan River, and in most of the tributaries. As well, flows in the tributaries and point sources were so low that dilution in the river would preclude high concentrations at the border. Additional surveys, especially during major rain events in the summer, will be needed to determine whether local sources contribute copper and fecal coliform bacteria to the North Saskatchewan River to the extent that PPWB objectives are exceeded. Specific conclusions of this preliminary study are:

- Tributary and effluent mass loadings of copper, lead, fecal coliform bacteria and other substances measured in May 1997 were so small that they would not appreciably change concentrations of these attributes in the North Saskatchewan River.
- Elevated concentrations of certain substances in the river appear to be linked to turbid water that was moving down the center of the channel. The source of this turbidity could either be further upstream, or from resuspension of the bottom sediments of the river.
- There are potential additional sources of fecal coliform bacteria and other substances in the stretch of the river between Heinsburg and Lea Park.
- Additional studies will be needed to elucidate causes of excursions to the PPWB objectives in the Lea Park to Lloydminster Ferry reach of the North Saskatchewan River.

6.0 REFERENCES

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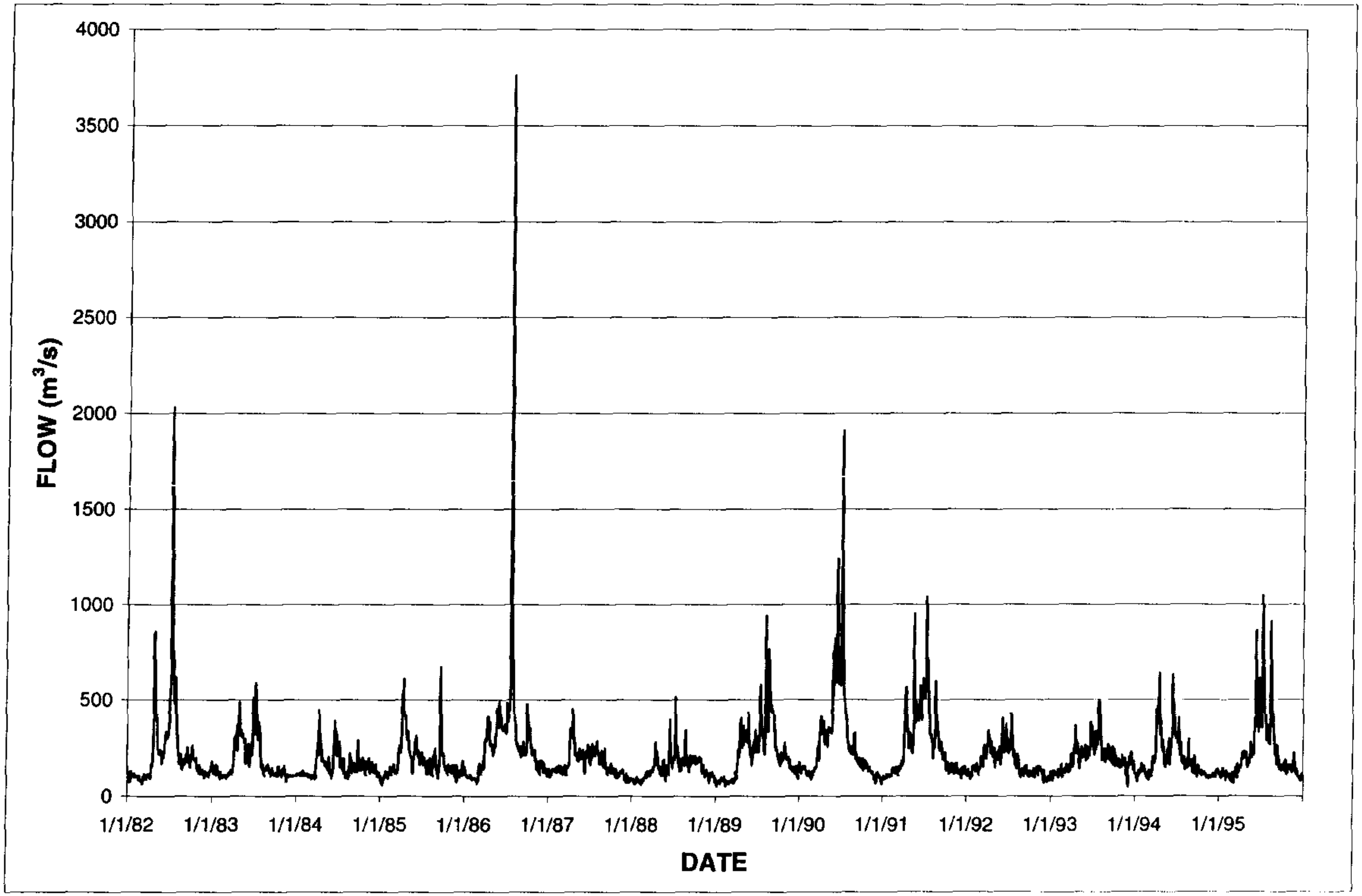
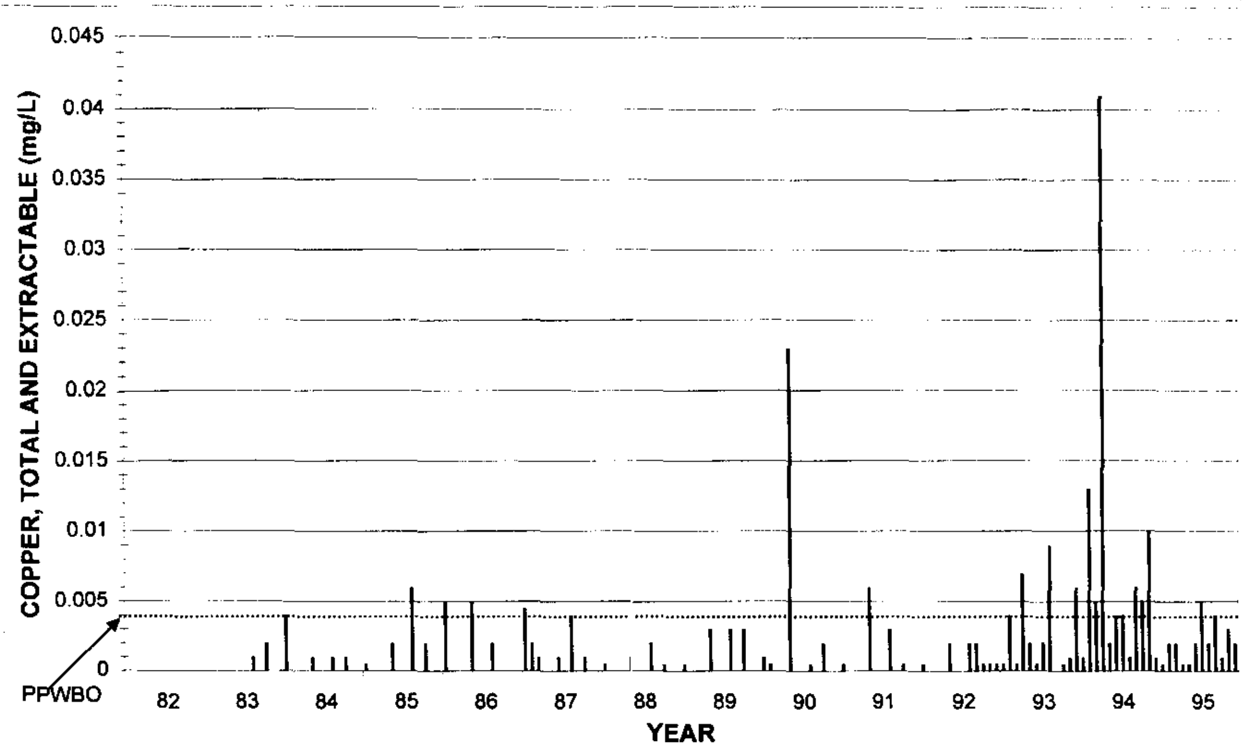
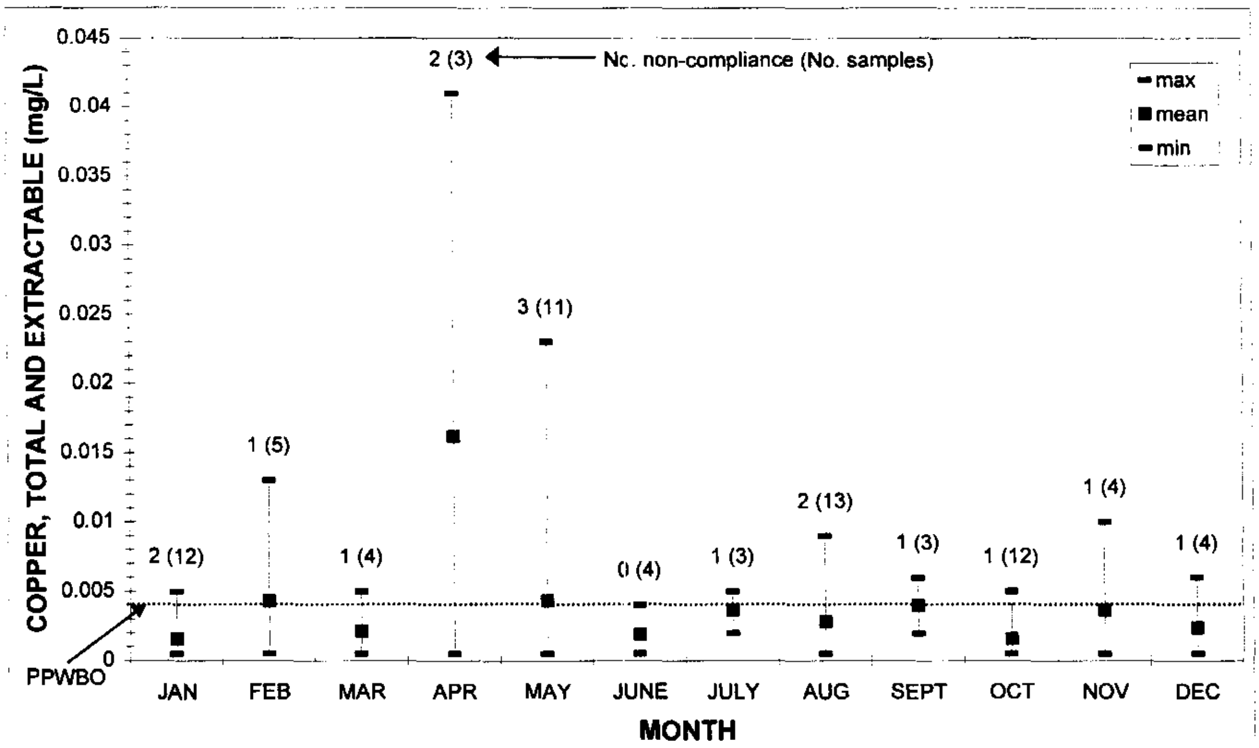
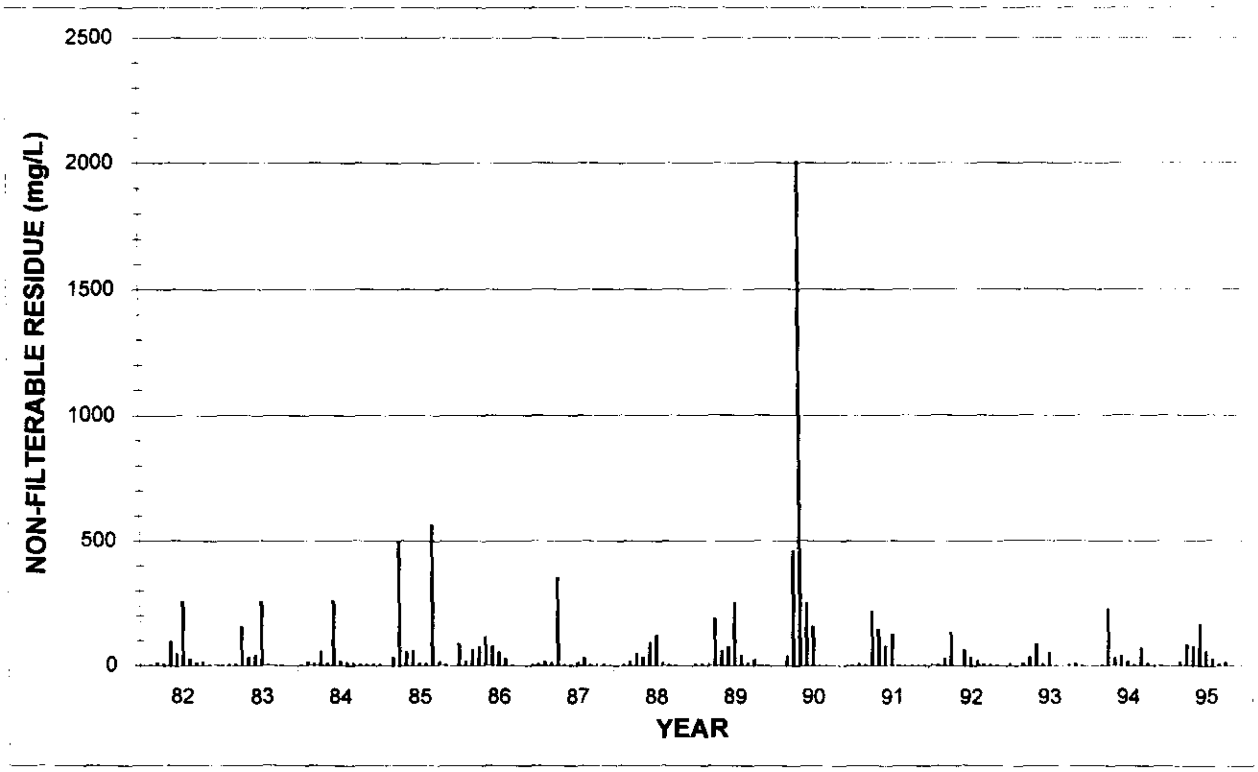


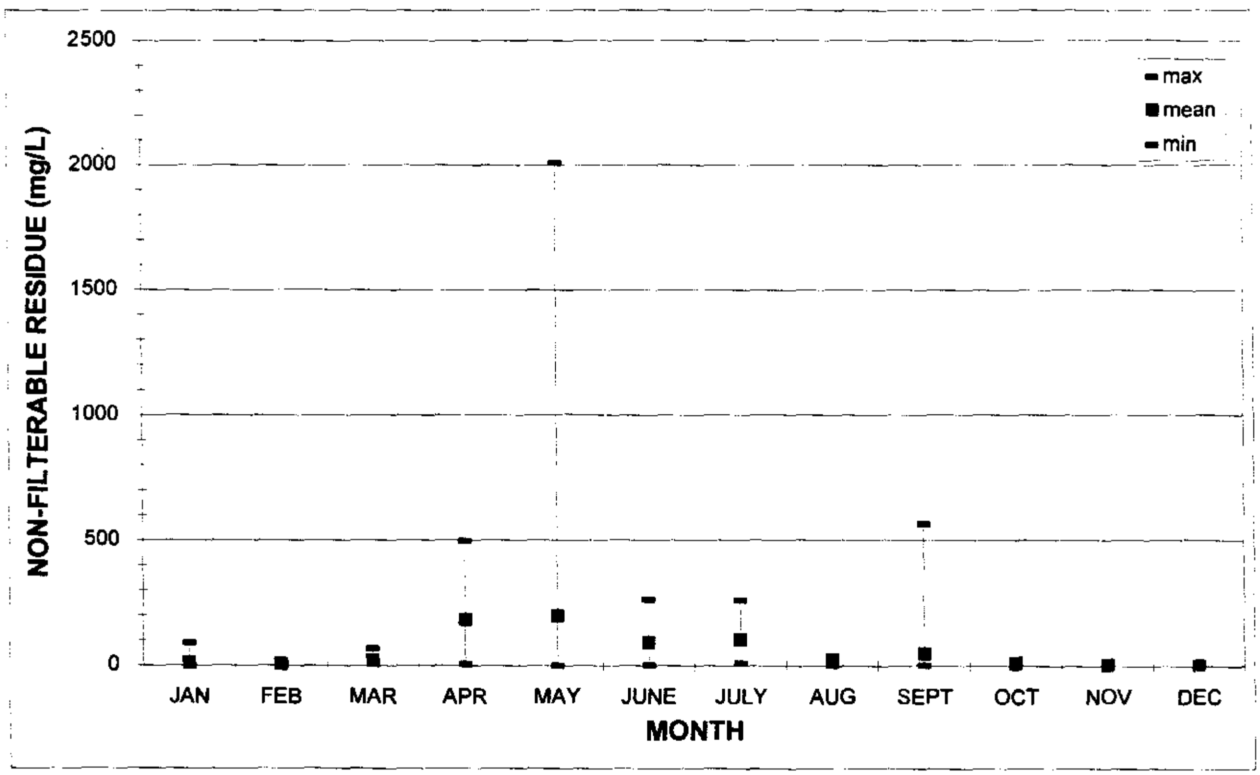
Appendix 1. Daily flows in the North Saskatchewan River near Deer Creek (05EF001), 1982 to 1995.



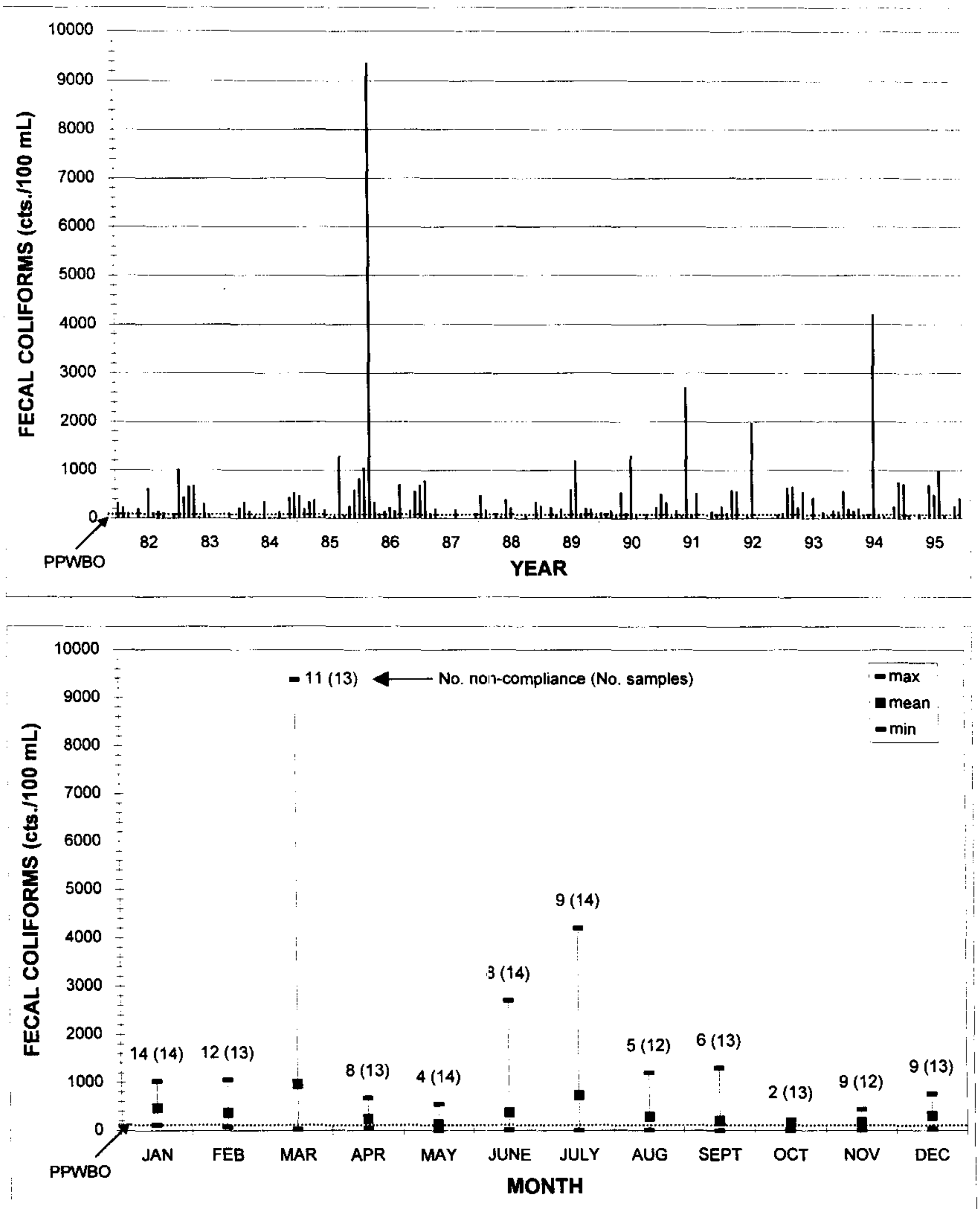


Appendix 2a. Copper in the North Saskatchewan River at Pakan, 1982-1995. Top: monthly values; bottom: monthly mean values and non-compliance with PPWB objective. (For comparison only.)





Appendix 2b. Non-filterable residue in the North Saskatchewan River at Pakan, 1982-1995. Top: monthly values; bottom: monthly mean values and range of data.



Appendix 2c. Fecal coliforms in the North Saskatchewan River at Pakan, 1982-1995. Top: monthly values; bottom: monthly mean values and non-compliance with PPWB objective. (For comparison only.)