ATHABASCA RIVER MONITORING PROGRAM - 1981

G. Byrtus
Pesticide-Chemicals Branch
Pollution Control Division
Alberta Environment
1982

Abstract

The Pesticide Chemicals Branch of Alberta Environment conducted a monitoring program in 1981 related to two methoxychlor treatments of the Athabasca River for black fly (Diptera: *Simulium arcticum*) control. Three populations of black fly larvae were observed in 1981 and the first two populations were reduced by 95.4% (May 20/21 treatment) and 96.5% (June 19 treatment) respectively. Population reductions of non-target organisms due to methoxychlor was limited for the May 20/21 treatment but was considerable for the June 19 treatment. Water samples collected from the Athabasca River at Fort McMurray contained only trace amounts of methoxychlor. Adult black fly activity in the farming area peaked in late July, correlating with expected adult emergence.

Acknowledgements

I would like to express appreciation to all of the people that assisted in this program especially: K. Kilar, M. Schiller, L. Nickolas, Dr. B. W. Taylor, W. Boyd, B. Murray, H. Coli, Dr. Y. Kumar, and to P. Scholefield and J. McIntosh for reviewing this manuscript.

Table of Contents

List of Figures

List of Tables

List of Appendices

INTRODUCTION

As in 1979 and 1980, the Pesticide Chemicals Branch of Alberta Environment monitored a black fly (Diptera: Simuliidae) control program conducted along the Athabasca River in northern Alberta. The black fly control program was carried out by the County of Athabasca No. 12 to alleviate problems of black flies attacking cattle in the Grassland - Wandering River area (Figure 1). This area is subject to large and intense infestations of black flies (primarily *Simulium arcticum*) during the summer months and this has restricted expansion of livestock production in the area (Ryan and Hilchie, 1980).

There were a number of objectives involved in the 1981 program, namely;

(1) To monitor black fly larval populations and correlate numbers and development with the consultant in charge of the control program.

(2) To monitor the impact of the chemical (methoxychlor) on the non-target biota and to determine population reductions and recovery time,

(3) To monitor methoxychlor residues in the river water upstream of the City of Fort McMurray and to inform the City of the expected arrival time of methoxychlor contaminated water.

(4) To monitor methoxychlor residues in the silt bedload of the Athabasca River over the summer.

(5) To monitor adult black fly populations in the affected farming area to assess the efficacy of the treatment program.

SAMPLING SITES

The sampling sites used in 1981 were the same as those used in 1980 (Byrtus, 1981b). Seven sampling sites were located along the river from 20 km upstream to 240 km downsteam of the Town of Athabasca (Figure 1). River characteristics at these sites and of this reach of river have been described by Kellerhals et al. (1972), Haufe and Croome (1980) and Byrtus (1981a). The discharge levels of the Athabasca River at the Town of Athabasca for 1981 is presented in Figure 2.

TREATMENT

Monitoring of black fly larval development indicated that one treatment in two parts would be required on or about May 20. On May 20 at 1700 hrs the first part of of the treatment was injected 59.5 km downstream from Athabasca. River flow was 552 cubic meters per second, (m^3/s), velocity was 3.6 km/hr and 285.5 litres of methoxychlor (24% emulsifiable concentrate) was injected over 7.5 minutes to achieve a 276 parts per billion (ppb) concentration. The allowable treatment dosage of methoxychlor for the control of black fly larvae in the Athabasca River is 300 ppb

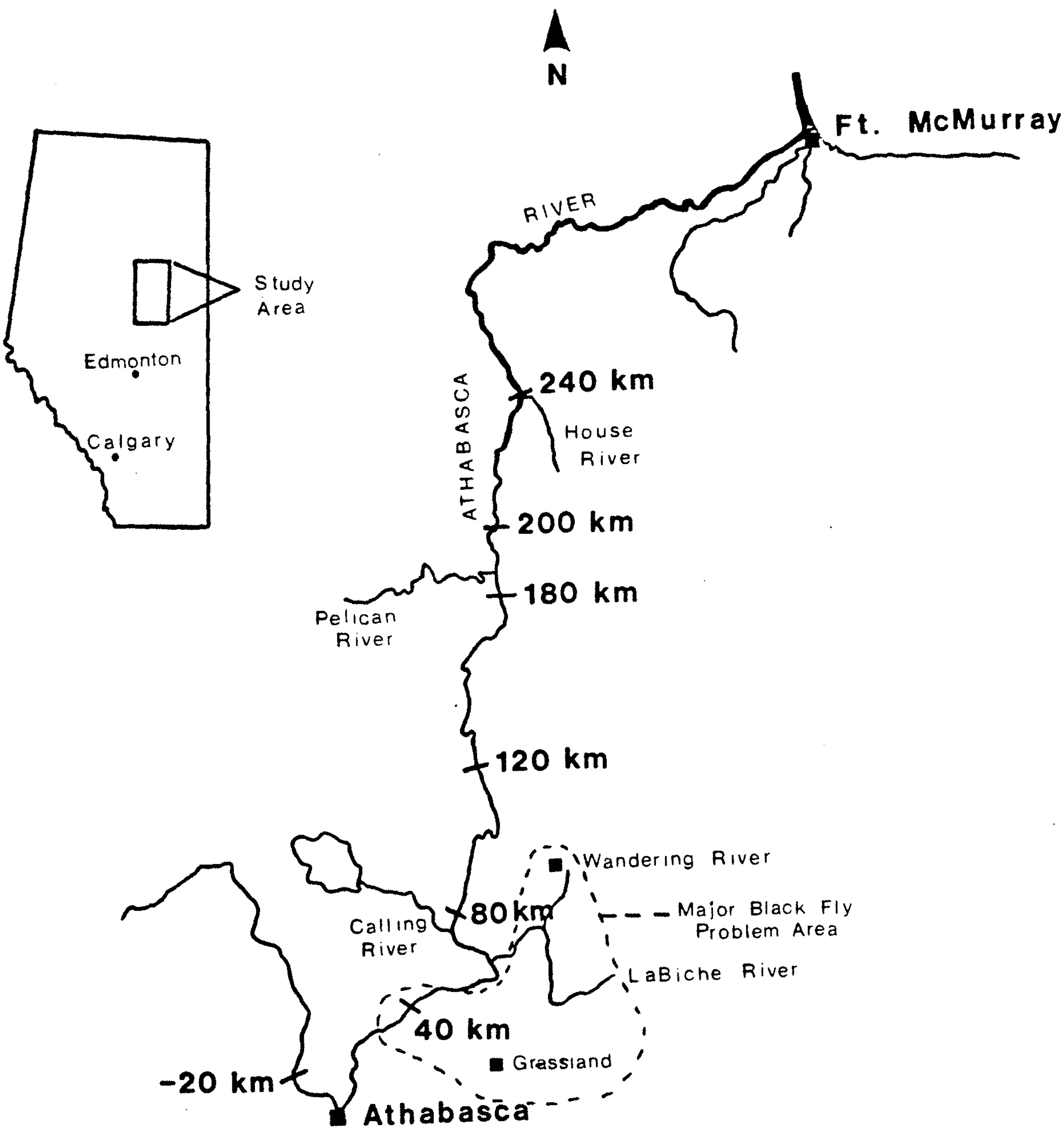

FIGURE 1 - Study Area and Sampling Sites

injected over 7.5 minutes. The second part of the treatment took place 100 km further downstream on May 21 at 1530 hours. River flow was again 552 m^3/s, velocity 4.1 km/hr and another 272 litres of methoxychlor was injected over 7.5 minutes to achieve a 263 ppb concentration.

Subsequent post-treatment larval monitoring found that a second population of black flies was approaching the treatment threshold level. A second treatment was scheduled at 145 km downstream from Athabasca for June 19 at 1415 hours. River discharge was 722.3 m^3/s, velocity 4.52 km/hr and 540 litres of methoxychlor was injected. As the second treatment was conducted under the auspices of an experimental research permit issued by Agriculture Canada, Ottawa (methoxychlor is currently registered for only one treatment per year in the Athabasca River), it was decided to lower the dosage rate and to extend the injection time to enable determination of the control efficacy at the lowered rate. The calculated dosage rate for the June 19 injection was 199 ppb of methoxychlor (injected over 15 minutes) as compared to 298 ppb (injected over 7.5 minutes) for the May 20 and 21 injections. The injection procedure and materials used are described by Depner _et al_. (1980a).

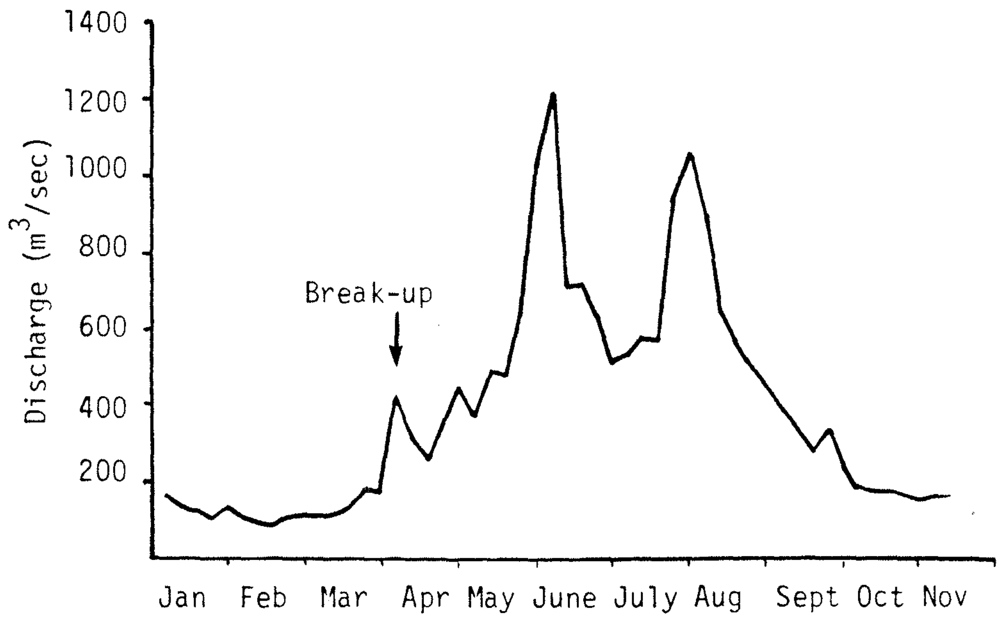

Figure 2 - Discharge of Athabasca River at Athabasca, 1981.
(Water Survey of Canada Station No. 07BE001)

SAMPLING METHODS

Larval Sampling

Black fly larvae were collected from each of the seven sites, on a weekly basis, using the artificial substrate (plastic cone) method described by Depner et al. (1980a) and Pledger and Byrtus (1980). The larvae were then placed into 1 oz. Universal sampling vials filled with 95% ethanol, and taken back to the laboratory, where aging (Fredeen, 1976) and enumeration of the larvae were carried out.

Non-target Organism Sampling

Non-target invertebrate organisms were collected during the summer at each of the seven sites using the rock tumble method described by Depner et al. (1980b) and Pledger & Byrtus (1980).

A slight modification in sampling method was employed in 1981. Instead of disturbing an area of river substrate 0.6 m x 3.0 m for one minute to collect one sample, three areas of 0.6 m x 1.0 m were each disturbed for one minute to collect three replicate samples. This was to ensure a greater degree of reliability in the sample data. Non-target organism sample sites were established in riffle areas near to shore and adjacent to the black fly larval sampling sites. The samples obtained were preserved in 95% ethanol and taken back to the laboratory for sorting and identification. Specimens were identifed to genus where possible using the keys in Ward and Whipple (1959), Usinger (1973), Pennak (1953), Merritt and Cummins (1978) and Wiggins (1977).

Percent reduction was calculated using unadjusted percent changes in pre and post-treatment populations as well as using the modified Abbott's formula to adjust for changes at control sites (Charnetski, Depner & Beltaos 1980). Diversity indices for each sample was calculated using the Shannon-Weiner formula ($D = -\Sigma p_i \log_2 p_i$) as presented by Smith (1974).

Methoxychlor Residues - Silt

Silt from the river bottom was collected for methoxychlor residue analysis. Collection was carried out by placing three modified Bogardi samplers (Charnetski and Depner, 1980) at each sampling site on the downstream trip and picking them up on the return trip the next day. The collected samples were mixed and placed into clean polyethylene bags, taken back to the laboratory, frozen and sent to the Pollution Control Laboratory in Vegreville for analysis.

Methoxychlor Residues - Water

In order to determine the actual concentration of methoxychlor in river water prior to its arrival at the City of Fort McMurray (396 km downstream from the Town of Athabasca), water samples were collected one day after treatment from points approximately 150 km upstream of the City of Fort McMurray. These samples were flown to the Pollution Control Laboratory, immediately analyzed, and the results of the analysis telephoned to the water treatment plant at Fort McMurray. This procedure was conducted for both the May and June treatments. For the treatment in May, additional water sampling was carried out at Fort McMurray. Samples were collected from the river, the water treatment plant, and the Syncrude water storage pond prior to and during the calculated passage of the methoxychlor contaminated water. Samples were not collected at the Suncor water storage pond as the plant was shut down for overhaul.

Barrel Traps

Barrel traps (Byrtus, 1981a) were again set out in 1981 in the farming area to monitor adult activity. Four traps were set up at various locations in the pasture of G. Lantz (SE1/4, Sec 29, Twp 68, Rge 19, W4th). The Tanglefoot® covered plastic on these traps was changed weekly and taken back to the laboratory where the black flies trapped on the sticky plastic were counted.

Results

Larval Sampling

Sampling for larval *S. arcticum* was conducted over a nine week period in 1981, commencing just prior to the first scheduled treatment on May 20/21. Sampling was discontinued four weeks after the second treatment. A graphical description of larval populations is given in Figure 3.

It is apparent from the graph that prior to treatment, larval populations were well above the treatment threshold level of 500 larvae/cone. The treatment threshold level was arbitrarily designated by Depner *et al*. (1980a) based on experience obtained during the research program conducted on the Athabasca River. Following each treatment however, larval populations were reduced severely. The cumulative percent reduction of larvae at each treated site is given in Table 1.

	Treatment Dates	
Site Locations (km)	May 20/21	June 19
80	83.6	-
120	96.8	-
180	98.1	95.6
200	99.7	98.5
240	98.9	95.5

Table 1 - Cumulative percent reductions of black fly larval populations in the Athabasca River (1981) following methoxychlor

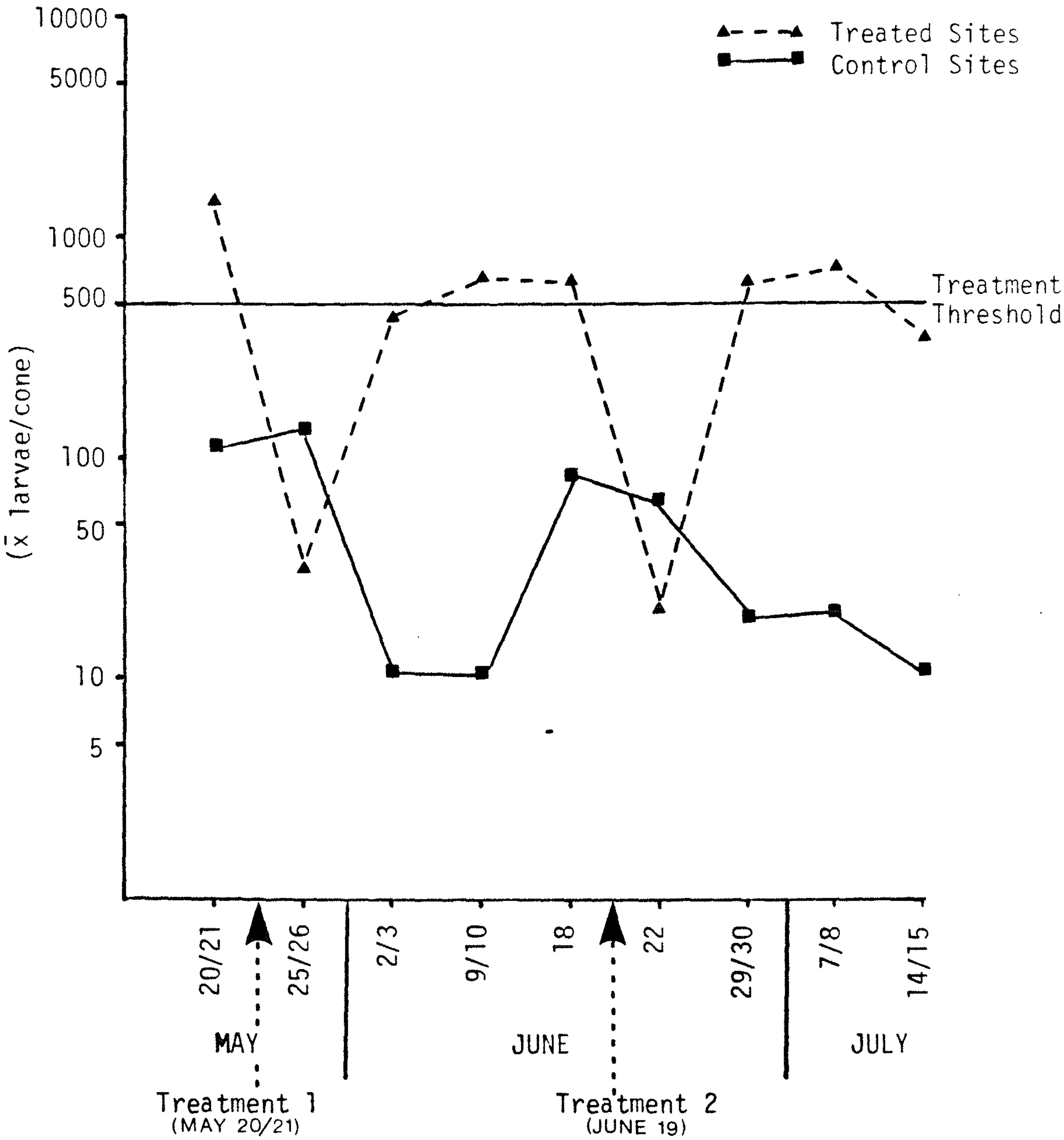

Figure 3 - Larval populations at treated and non-treated sites during 1981.

larviciding operations. (Adjusted by the modified Abbott's formula)

The percent reduction at all sites treated shows that methoxychlor had a considerable adverse effect on black fly larval populations based on the immediate post-treatment samples, reducing larval populations by 83.6 % to 99.7%.

The treatments were scheduled to reduce the larval population when it had become fairly mature (fifth and sixth instar) but before reaching pupation. It appears that hatching of the new population occurred during the expected pupation and emergence of the population undergoing development at the time. For example, in Appendix 6 (post-treatment), the data for the 120 km site (upstream of the treatment point) shows a very even distribution with the larval instars and pupae ranging from 9.8% and 16.4% of the the total number at that site. Yet in the next week's sample (Appendix 7), 61.4% of the larval numbers at 120 km are first and second instars. This also explains why the population reduction at 80 km is only moderate (83.6%). A contributing factor was low pre-treatment numbers, however subsequent to the treatment, 87.5% of the larvae that were collected at 80 km were first and second instar, indicating that a hatch had occurred at the time of treatment. There is also the possibility that a number of larvae drifted in from the untreated portion of the river upstream.

Although a considerable reduction in larval numbers was observed after each treatment, the second sampling period after each treatment shows a dramatic return to treatment threshold levels (Figure 3). This large rebound in larval populations is due mainly to development of early instar larvae (Appendix 3 and 7), as very few mature larvae were present at these times.

A clearer picture of the impact of the chemical on the larvae is given in the immediate post-treatment samples (Appendix 2 and 6). It is apparent from Appendix 2 that sites 80, 120 and 180 km were subject to either; reinfestation of younger larvae from upstream or, hatching of black fly eggs following treatment. It is more likely that reinfestation from untreated areas occurred, since very few first and second instar larvae were present at 200 and 240 km. However at 240 km there were a number of sixth and seventh instar larvae. This would indicate that a few black fly larvae survived the methoxychlor treatment. It is possible that, due to low river flows, the methoxychlor became so dispersed and diluted that it was still passing 240 km at the time of sampling, affecting the younger larvae that had hatched, but too dilute to affect the older larvae.

Appendix 6 shows the same as Appendix 2; that the majority of larvae collected at the treated sites were immatures. A large number of pupae were present at 240 km, indicating that some larvae pupated prior to the arrival of the methoxychlor. (Because the mode of action of methoxychlor requires ingestion of the material, it does not affect the non-feeding pupae).

Non-target Organism Sampling

Sampling of non-target invertebrate organisms commenced on May 13 and continued weekly until July 15, with one series of samples taken during the first week and one during the last week of August. The data collected is presented in Appendices 10 - 21.

The effect of methoxychlor appeared to be quite considerable on some taxa but not on others (Table 2). For example, the effect on Plecoptera at all treated sites after treatment was substantial. However the effect on Ephemeroptera, the other major taxa found in the river, was variable. For the treatments in May, a decrease at the 80 km site was observed followed by increases at the other sites further downriver. Yet for the June 19 treatment, numbers decreased at all three treated sites. Other taxa showed variability at the treated sites. However the decrease in total numbers of invertebrates at the treated sites was consistent for both treatments.

More detailed analysis of the data (Figures 4 -11) shows which genera were affected by the methoxychlor and to what degree. Haufe *et al*. (1980) suggested that nine invertebrate genera found in the Athabasca River were sensitive to methoxychlor. Only eight are graphed here because the ninth genera (*Hastaperla*) occurred in very low numbers all summer. (Treatment 1a was on May 20 at 60 km, 1b was on May 21 at 160 km and treatment 2 was on June 19 at 145 km.)

Figure 4 illustrates the population fluctuations of *Baetis* (Ephemeroptera) over the summer. Populations of *Baetis* were low

May 20/21 treatment

	40 km	80 km		120 km		180 km		200 km		240 km	
	Unadj.	Unadj.	Adj.	Unadj.	Adj.	Unadj.	Adj.	Unadj.	Adj.	Unadj.	Adj.
EPHEMEROPTERA	-63.7	-82.6	-52.0	-58.4	+14.7	-55.3	+23.3	-46.7	+47.2	+0.9	+179
PLECOPTERA	-14.7	-76.6	-72.6	-90.9	-89.3	-98.9	-98.8	-96.6	-97.0	-85.8	-83.4
TRICHOPTERA	-57.1	-92.1	-81.6	-88.9	-74.2	-43.4	+31.9	-56.5	+1.3	-71.2	-32.8
DIPTERA	-69.9	-87.4	-58.3	-81.1	-37.1	+12.7	+275	-96.8	-89.5	-51.9	+59.8
OTHER INVERTS.	-44.8	-27.8	+30.6	-61.2	-29.8	0.0	+81.0	-50.0	-9.5	-100	-100
TOTAL INVERTS.	-43.0	-80.3	-65.5	-80.5	-65.8	-87.1	-77.4	-87.3	-77.8	-64.7	-38.2

June 19 treatment

	Control*	180 km		200 km		240 km	
	Unadj.	Unadj.	Adj.	Unadj.	Adj.	Unadj.	Adj.
EPHEMEROPTERA	+127	-69.8	-86.7	-54.1	-79.8	-15.5	-62.8
PLECOPTERA	+82.2	-82.1	-90.2	-96.2	-97.9	-95.1	-97.3
TRICHOPTERA	+68.2	-72.5	-83.7	-73.1	-81.5	+102	+20.4
DIPTERA	+32.4	-76.9	-82.6	-33.6	-49.8	+33.5	+0.8
OTHER INVERTS.	-15.4	-91.9	-90.4	-18.2	-3.5	+344	+424
TOTAL INVERTS.	+78.0	-77.7	-87.5	-80.5	-89.1	-14.3	-51.9

*Mean value from sites -20, 40, 80 and 120 km

Table 2 - Percent change in non-target invertebrate Orders between pre and post-treatment samples (modified Abbott's formula used to adjust for changes at control sites)

at the time of the first treatment and no impact was observed but for the second treatment in June, a considerable reduction in numbers occurred. The data from the control sites show that at the time of the June 19 treatment Baetis populations were increasing. However at the treated sites, Baetis populations were reduced considerably, and recovery was not apparent until 4 to 7 weeks post-treatment. Figure 5 shows Ephemerella (Ephemeroptera) populations present at each site throughout the summer with no long-term disturbance in populations observed. Figure 6 shows that Heptagenia (Ephemeroptera) populations acted much the same as Baetis populations. Very few specimens were collected at the time of the first treatment with no effect noted. An effect was observed after the June 19 treatment, which seemed to cause a 3 to 4 week delay in population peaks, compared to the control. Figure 7 shows that the treatments had little observable effect on the genus Rhithrogena (Ephemeroptera).

Of all the genera, perhaps the genus most drastically affected was Isogenus (Plecoptera). Because populations at both control and treated sites were declining at the time of the first treatment on May 20/21, it is difficult to determine the effect of methoxychlor on Isogenus. A number of workers (Haufe et al. 1980, Murray, 1981) have observed Plecoptera exuviae on the shoreline of the Athabasca River prior to methoxychlor larviciding, suggesting that seasonal emergence is occurring at this time. However, the impact of the June 19 treatment on Isogenus populations had a considerable effect. Populations at the control sites were just

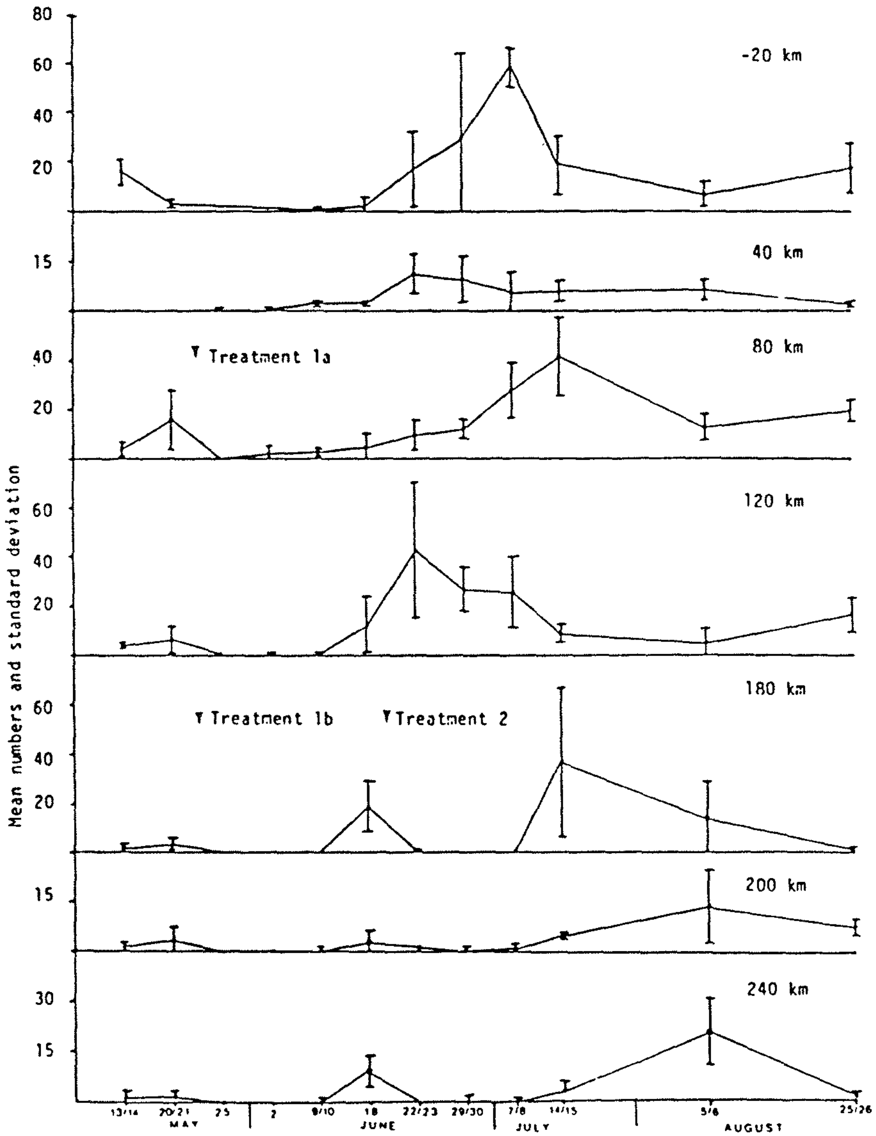

Figure 4 - Population fluctuations of *Baetis* at seven sites along the Athabasca River, 1981

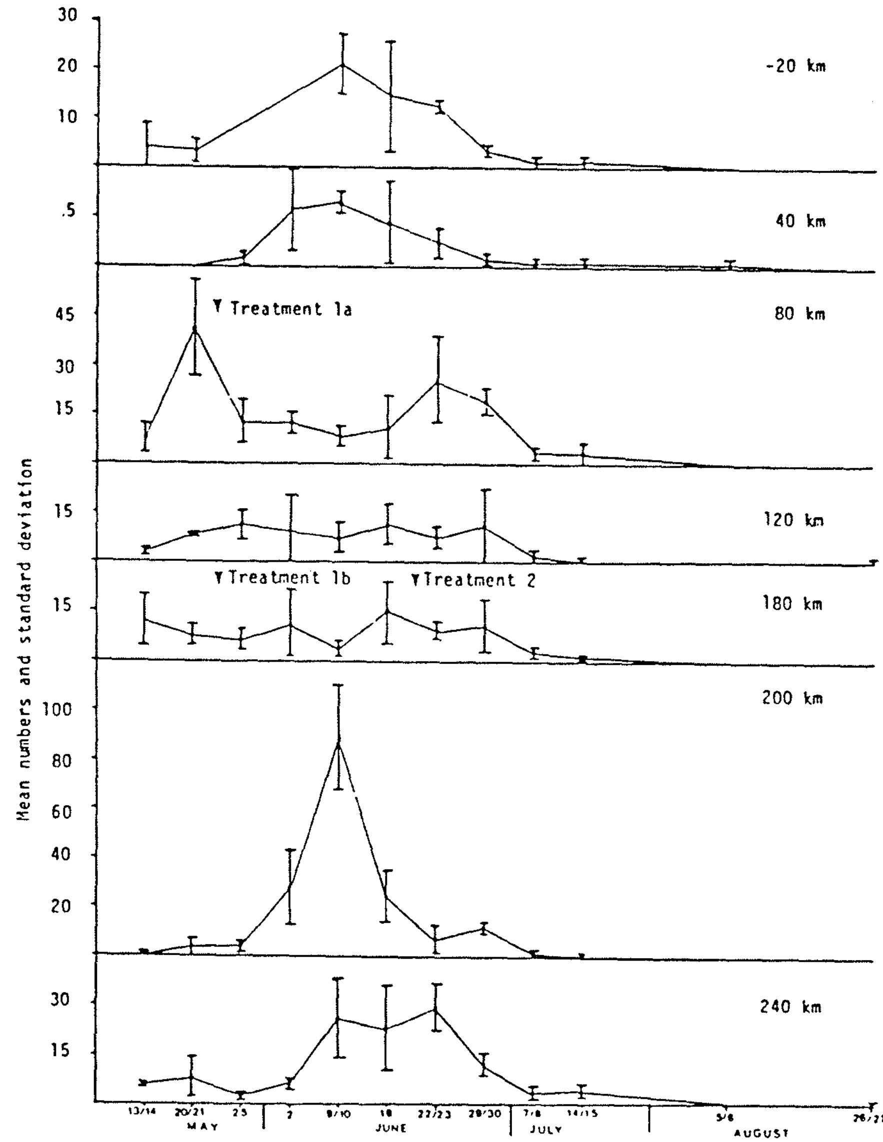

Figure 5 - Population fluctuations of *Ephemerella* at seven sites along the Athabasca River, 1981

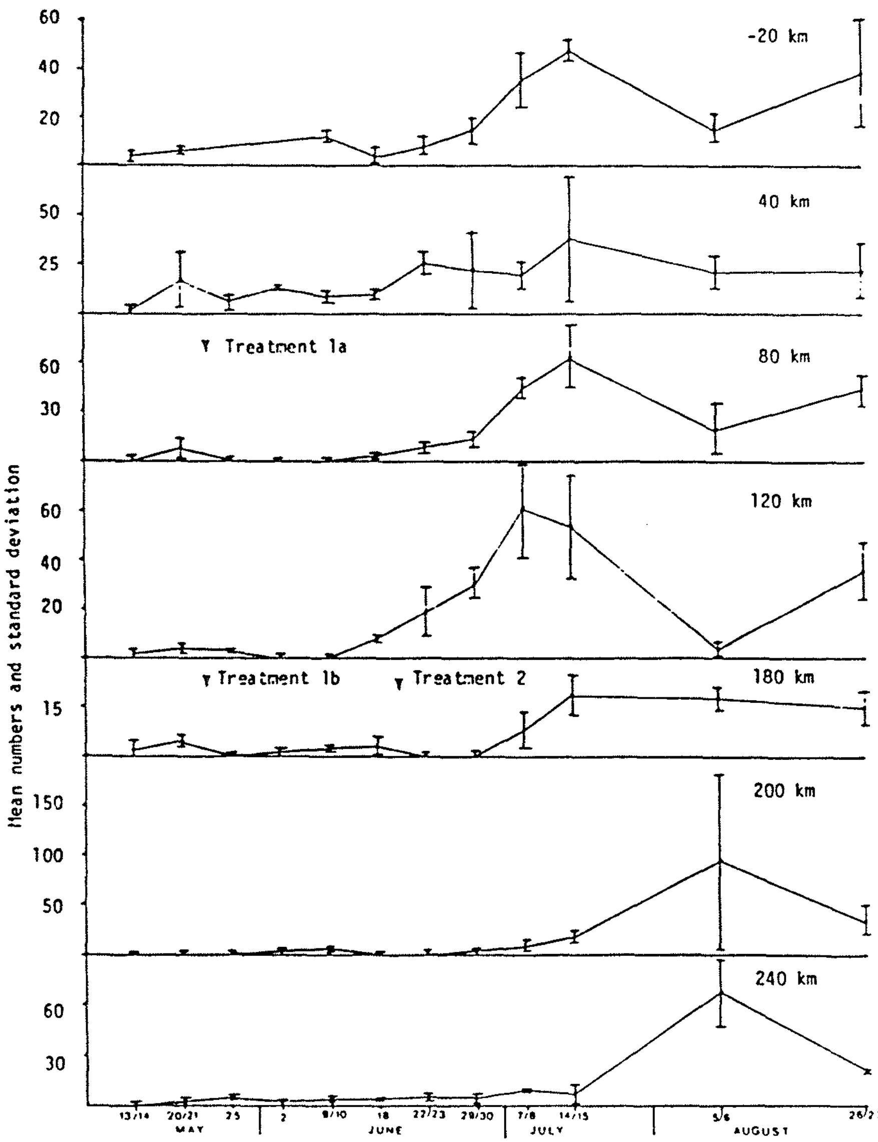

Figure 6 - Population fluctuations of *Heptagenia* at seven sites along the Athabasca River, 1981

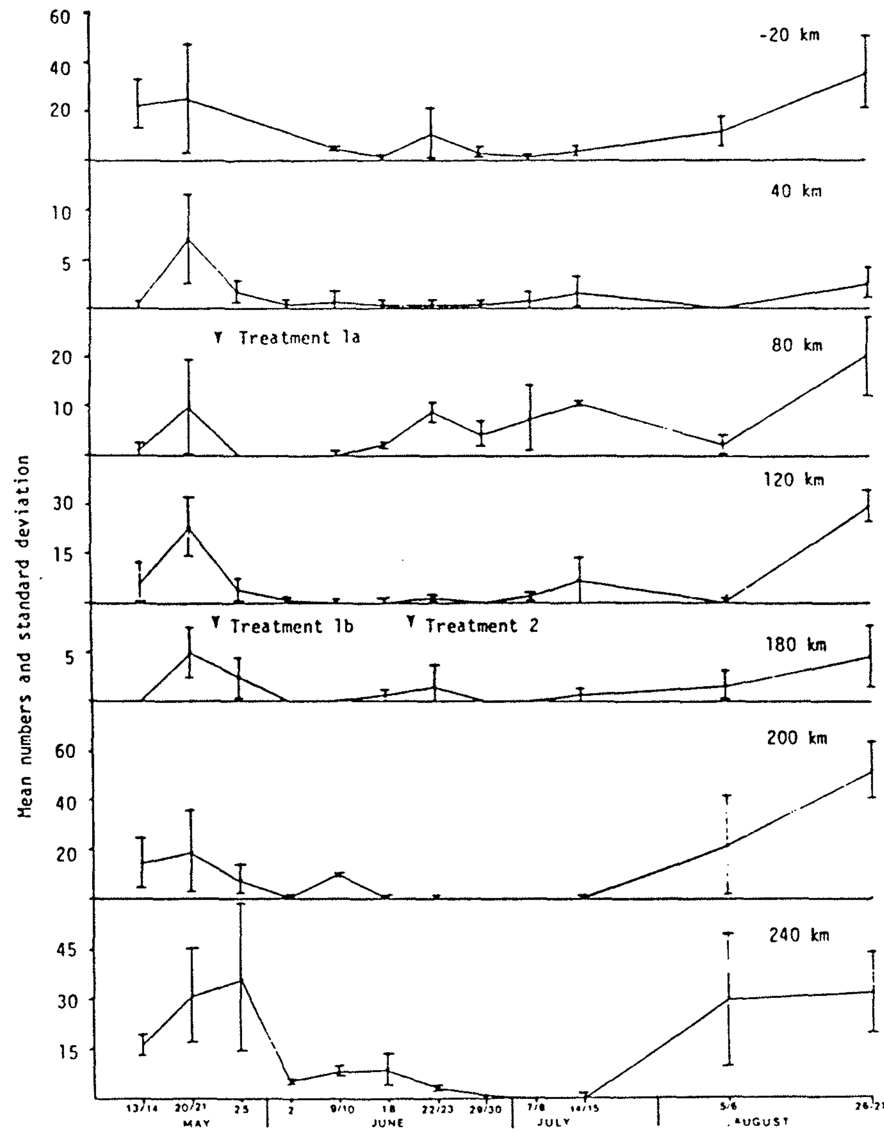

Figure 7 - Population fluctuations of *Rhithrogena* at seven sites along the Athabasca River, 1981

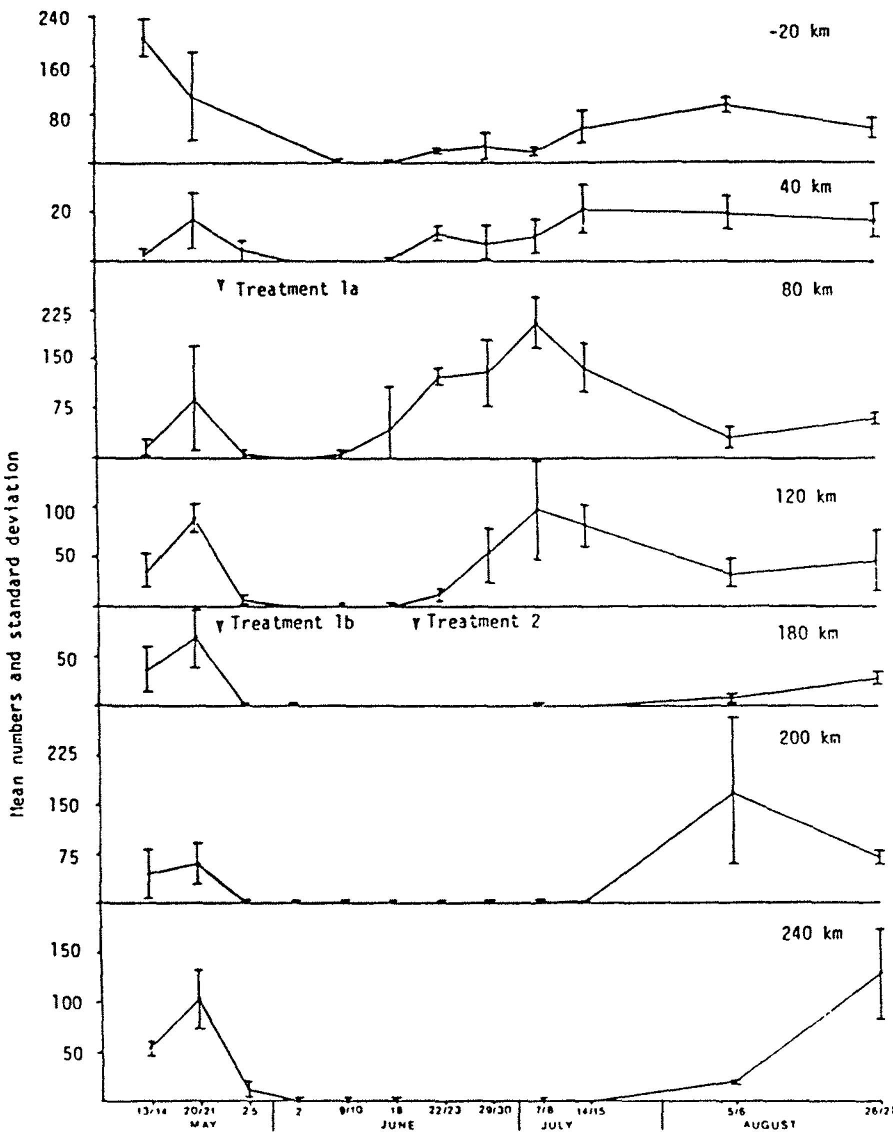

Figure 8 - Population fluctuations of *Isogenus* at seven sites along the Athabasca River, 1981

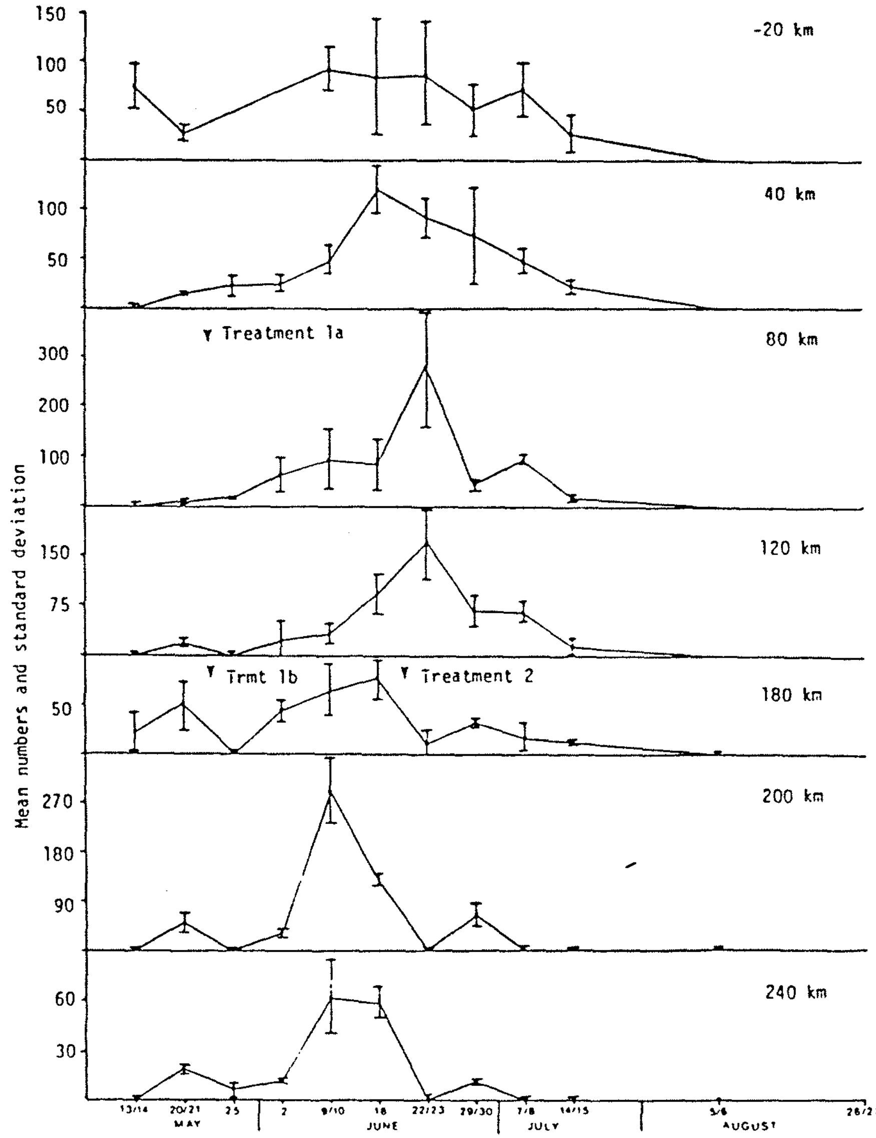

Figure 9 - Population fluctuations of *Isoperla* at seven sites along the Athabasca River, 1981

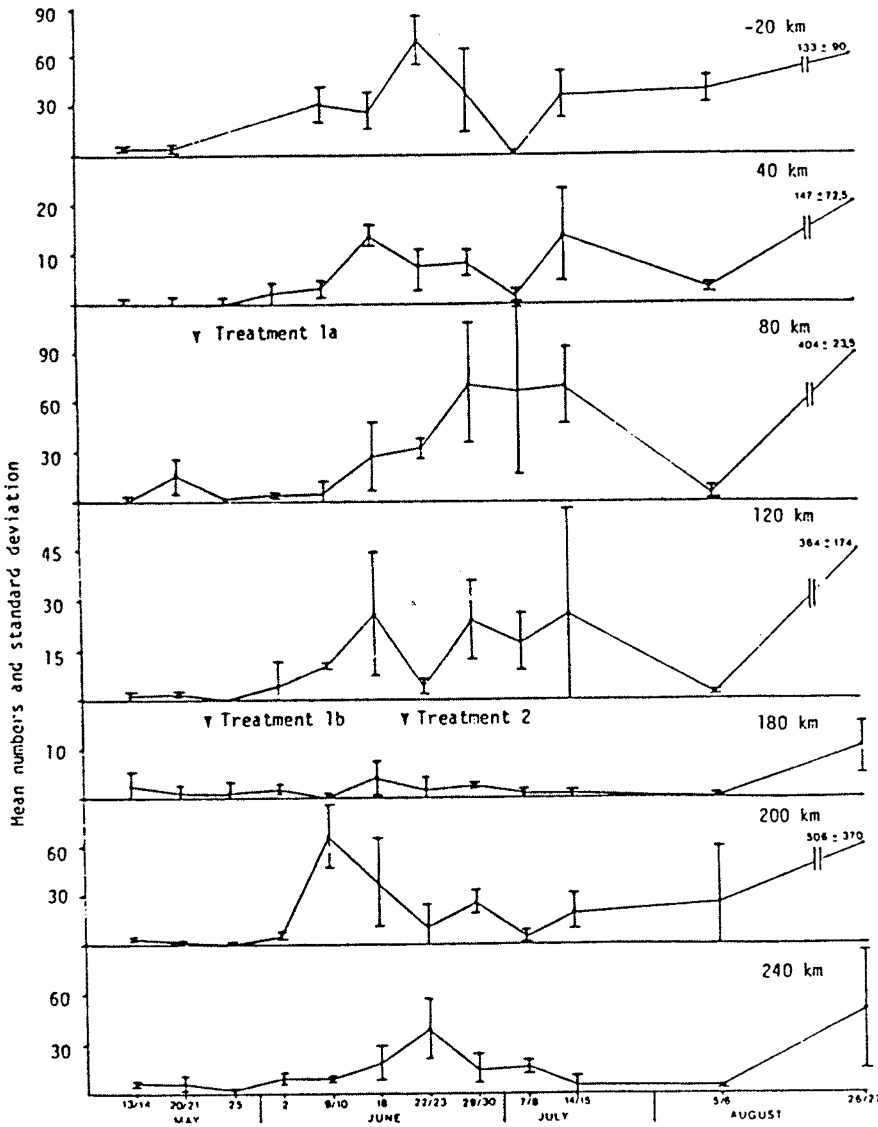

Figure 10 - Population fluctuations of *Cheumatopsyche* at seven sites along the Athabasca River, 1981

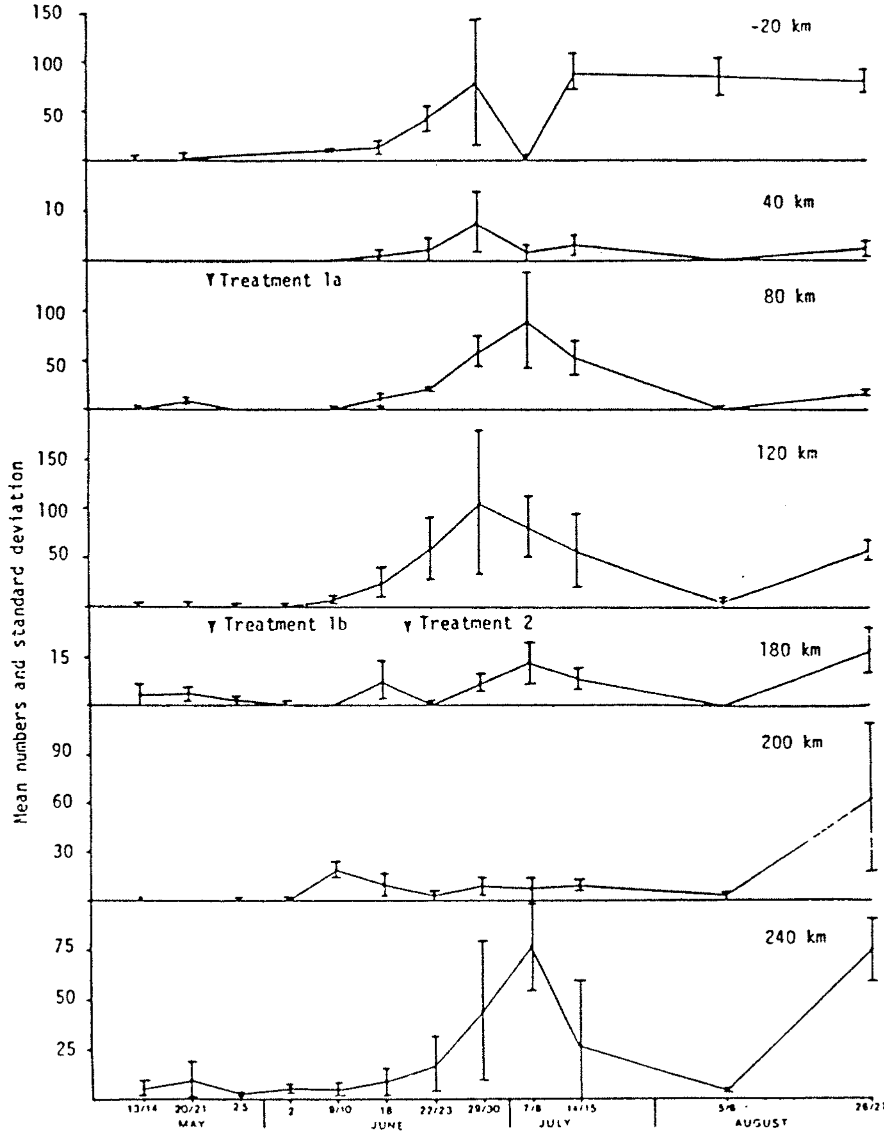

Figure 11 - Population fluctuations of *Hydropsyche* at seven sites along the Athabasca River, 1981

beginning to increase at the time of treatment and peaked about 3 weeks later. At the treated sites though, it was seven weeks before sufficient numbers were collected to achieve some level of recovery. The effect of the methoxychlor on the Isoperla (Plecoptera) was much less dramatic and appeared to be of only a very short duration (less than two weeks for each treatment). The impact of methoxychlor on the two Trichopteran genera (Hydropsyche and Cheumatopsyche) is not evident from the graphs.

Although diversity indices were calculated for the non-target organism data (Appendices 10 to 21), they were not analyzed because they did not show any conclusive trends. The use of diversity indices for the numerical description of aquatic macro-invertebrate communities subjected to pollution has been described by Wilhm (1972). Diversity indices are best utilized under situations of continuous organic loading, and are not suited to situations of short-duration pesticide loading, which may be why inconclusive results were observed in this study.

Methoxychlor Residues - Silt

Results of the methoxychlor residue analysis of silt samples were not completed at the time of writing this manuscript. Results and discussion are attached as Appendix 23.

Methoxychlor Residues - Water

The results of the spot water sampling conducted prior to the methoxychlor reaching Fort McMurray is given in Table 3. The results for both May and June treatments indicate that after roughly 20 hours in the river, the methoxychlor pulse had diluted or degraded to approximately 1-2/100 of the treatment dosage. These results correspond with results obtained by Charnetski, Depner and Beltaos (1980) during their research along the Athabasca River. An interesting observation is the two samples (2 and 3) collected near the east shoreline at 255 km for the first treatment with residue levels of 0.6 and 0.7 ppb. The other two samples (1 and 4) collected at 243 km and 259 km were collected near the west shoreline and had higher concentrations (2.3 and 2.0 ppb). It is possible that the House River, which drains into the Athabasca from the east at 239 km, may have diluted the concentration of methoxychlor, giving these odd results. The possibility of methoxychlor being carried on the west side of the river in this reach is remote, as the river is straight and very turbulent, being just upstream of the Grande Rapids.

The other aspect of the water sampling that was conducted at Fort McMurray for the treatment in May shows that very little methoxychlor was detected from the samples (Table 4). One unexpected piece of data is the trace level of methoxychlor in the sample of treated water collected on May 24 at 1900 hrs. It had been thought that with the low levels of methoxychlor in the river at Fort McMurray, the passage of the water through the settling pond (retention time of about four hours), and the water treatment process, no methoxychlor would find its way into the treated water supply. However, discussion with the research chemist involved in the analysis (Dr. Y. Kumar, pers comm.) suggests that at the low levels of detection involved here, the reliability of the data is uncertain. As no methoxychlor was detected in the first sample of treated water obtained at that time nor in the settling pond at any time, it is likely that the sample in question is not an accurate depiction of the quality of the city's water supply.

Table 3

Methoxychlor residues in water samples collected upstream of Fort McMurray

	Sample site	Day	Sample Time	Elapsed Time(hrs)	Amount Present (ppb)
	[May 20 (60 km @ 1700)/May 21 (160 km @ 1530) treatment]				
1	243 km	May 22	13:45	22.2	2.3
2	255 km	May 22	14:00	22.5	0.6
3	255 km	May 22	14:00	22.5	0.7
4	259 km	May 22	14:10	22.7	2.0
	[June 19 (145 km @ 1415) treatment]				
5	0 km	June 20	07:15	17.0	0.0(check sample)
6	219 km	June 20	09:10	18.9	2.7
7	228.5 km	June 20	09.17	19.0	4.7

Barrel Trap Sampling

The barrel traps were placed in the farming area on May 28 and were reset every week for the next seventeen weeks. The results are graphed in Figure 12. Samples from trap A were graphed separately as the numbers were significantly higher than the samples from the other three traps (B,C and D). The variability between the samples of these three traps was more acceptable (Appendix 22) and the mean number of flies from those traps are graphed. Although the numbers are different, the curves

TABLE 4

Results of water sampling at Fort McMurray and area for methoxychlor residues

Sample locations	May 23 1600 (48.5 hrs)	May 23 2100 (53.5 hrs)	May 24 0500 (61.5 hrs)	May 24 1200 (68.5 hrs)	May 24 1900 (75.5 hrs)
Athabasca River (384 km)	0	0	0	0	-
Athabasca River - Ft. McMurray Br. (396 km)	0	0	Trace*	0	-
Ath. River near city water intake (396 km)	0	Trace	0,0	Trace	-
Ft. McMurray settling pond	0	0	0,0	0,0	0,0
Ft. McMurray treated water	0	0	0	0,0	0,Trace
Syncrude raw water intake (429 km)	-	-	-	0	0
Syncrude settling pond	-	-	-	0	0

* Trace - < 1 ppb

(Time in brackets is time elapsed from May 21 treatment (160 km) at 15:30) of the graph are very similar. Both curves show a steady increase with a peak during the week ending July 30, followed by a steady decline until a second small peak in early September.

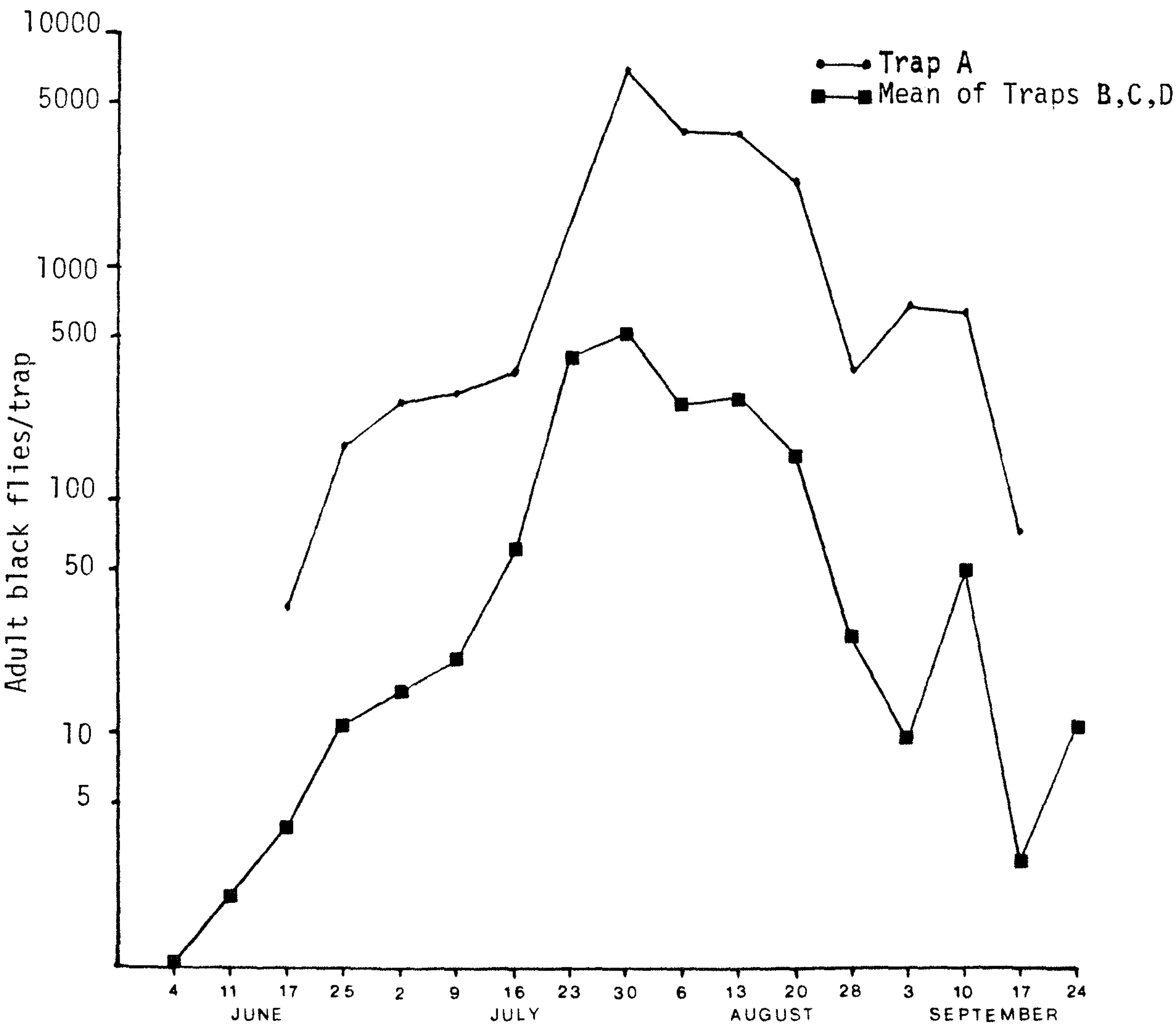

Figure 12 - Adult black flies collected on barrel traps during 1981

Discussion

Larval Sampling

One of the more apparent observations from the data is that there were three definite populations of black fly larvae in the Athabasca River during 1981, which was also observed in 1979 (Byrtus, 1981a). The immediate rebound in populations after the effect of the two treatments could be related to hatching occurring concurrent to each treatment. The implications of this multiplicity of larval populations leads to the conclusion that if adult populations are to be controlled for a significant period of time during the summer, more than one treatment per year is required. Data collected during the research program conducted between 1973 - 1977 (Depner *et al*. 1980a) showed no more than two hatches of larvae in any individual year, and that the second hatch (with one exception) was much lower in total numbers than the first hatch, which was associated with ice break-up. Data from 1979 (Byrtus 1981a, Murray 1980) showed larval numbers were less in the two succeeding populations. Data from 1980 (Murray 1981) showed that the second population was lower in numbers than the first population. Data from 1981 (Figure 3) shows that the two succeeding populations, following the first treatment, were similar in larval numbers. While it remains theoretical at this point, successive years of monitoring larval populations is beginning to show that they are cycling more frequently and at higher levels during mid-summer. Whether this is due to natural rhythms in *S. arcticum* phenology or due to the external pressures applied by six years of larvicide application remains uncertain. Shemanchuk and Anderson (1980), on the basis of data collected in 1974, suggested that "*S. arcticum* either had two generations per year, or that the eggs deposited by each seasonal 'wave' of flies diapause and hatch synchronously the following year", and they favoured the former theory. However, on the basis of the data presented here, showing hatches occur concurrently to emergence, this author favors their second theory. This second theory would explain why second and third populations of larvae have been getting larger in numbers. Supposedly with the initial population of larvae (associated with ice break-up) being reduced by repeated larvicide applications, ecological pressure (competition, non-sensitized host animals) on the adults of the succeeding populations is consequently being reduced. These surviving adults may thus be capable of producing more eggs that will hatch synchronously the following year. Therefore the purpose of the treatment is fulfilled by alleviating large numbers of adult flies in early June, but this may be creating larger populations of black flies later in the summer.

The effect of higher river discharge levels on treatment efficacy was easily observed in 1981. Compared to 1980, when low discharge levels (444 m^3/sec) resulted in a gap of about 20-40 km of ineffective control (Byrtus 1981b), higher river levels in 1981 (552 m^3/sec) resulted in consistent control levels throughout the monitored reach of river. Another factor was that spacing of the two-part treatment in May was 43 km closer than in 1980 (at 60 and

160 km rather than 60 and 203 km) and this in itself may have eliminated the gap of ineffective control, had discharge levels been lower.

In retrospect, it may appear that the first part of the May treatment should have been downstream of the 80 km site instead of above because of low pre-treatment larval populations at 80 km. However, reinfestation of the treated area would have likely been greater if the area upstream and downstream of 80 km had not been treated. As it was, repopulation of the treated area took place fairly quickly after treatment. It is difficult to assess the importance of larval drift as it relates to repopulation. It is still uncertain as to how far larvae will drift to find sites with sufficient water velocity for them to continue development. It is known that the adults of *S. arcticum* can travel great distances from their place of emergence to find host material (Fredeen, 1973; Rempel and Arnason, 1974), but the distance a larva can travel is uncertain, and would likely be dependent on river velocity, hydrology and substrate type.

Non-target Invertebrate Organism Sampling

The effect of the methoxychlor larviciding operations on non-target invertebrate organisms was limited for the May treatment because of the seasonal emergence of many invertebrate organisms. Haufe *et al*. (1980) showed a close correlation between phenology of non-target invertebrate organisms and *S. arcticum* larvae, concluding that "Phenological timing of river treatments is a major consideration in reducing the impact on non-target organisms as well as in achieving control of *S. arcticum*." This point is made more apparent by the effect on non-target organisms caused by the June treatment. In this case, mid-season populations of many invertebrates were increasing (Figures 4 - 11) when the methoxychlor application took place, causing a serious, long-term reduction in populations. This reduction was readily observed while collecting the samples in the field. The data from Table 2 substantiates these observations, where a decrease in control site non-target organism populations was observed between pre and post-treatment, thus indicating an emergence. On the other hand, control site populations for the June treatment were increasing, indicating build-up in populations.

The effect of the two treatments on sensitive genera appeared to be very similar to the results observed in 1979. Overall, the first treatment in both years did not have a major effect on any of the genera, while the second treatment, in both years, severely affected several of the genera. The impact on *Isogenus* populations was more noticeable than on the other genera, taking up to seven weeks in 1981 to return to control site population levels. This is also the same length of time that was required in 1979 for recovery of Isogenus populations after a mid-summer treatment.

From the data presented, it appears that the phenology of the river system is such that a larviciding operation conducted for the first larval population (generally associated with ice break-up) will not have a significantly adverse effect on non-target organism populations. This is providing that the larviciding operation is always conducted at such a time to have an effect on the later instars of S. arcticum larvae. The phenology of the river system appears to work against a second treatment having little effect on non-target organisms. This is due to non-target organism populations undergoing a mid-summer increase at the same time that a second population of S. arcticum larvae is approaching maturity.

Another possibility for the June 19 treatment having a greater effect on non-target organisms is the change in dosage rates and total amount of chemical applied. Although the dosage was reduced by one-third (from 300 ppb to 200 ppb), the injection time was doubled (from 7.5 minutes to 15 minutes). 540 litres of methoxychlor were required for the June 19 treatment, whereas if the dosage has remained at 300 ppb over 7.5 minutes, only 406 litres of methoxychlor would have been required. It is difficult to pinpoint the change in dosage rates or injection time as the cause for the adverse effect on non-target organisms however, as there is no previous data adequate enough regarding the effects of a mid-summer treatment of the Athabasca River on non-target invertebrates (the second treatment in 1979 was conducted during a period of high water, which masked the effect of the methoxychlor on non-target organisms, Byrtus 1981a). From population trends observed in 1979 and 1981, it appears that phenology, rather than slight changes in the dosage rate, has a greater influence in determining the effect of methoxychlor on non-target invertebrates.

Methoxychlor Residues - Water

The problem or possibility of methoxychlor contaminating the water supply of Fort McMurray was not addressed in the research program conducted between 1973 and 1977. However, Haufe (1980) made one reference to this aspect; "It is concluded on the basis of recovery ratios for methoxychlor in relation to hydraulics of river flow that required larvicidal treatments for black flies in the Athabasca River can be applied without any significant risk to quality of water and its associated washload. However, in the event of any future added dependence of industrial processing and community water supply on water resources downstream of treatments, re-evaluation will be necessary in relation to new patterns of water use." With results of water samples indicating that trace levels of methoxychlor are getting into the water treatment facilities [a trace of methoxychlor was detected in the raw water storage reservoir in 1979 (Byrtus 1981a) and in the treated water supply in 1981 (Table 4)], perhaps the time for a re-evaluation has arrived.

Health and Welfare Canada (1978), in establishing guidelines for drinking water quality, permit methoxychlor residue levels of up to 100 ppb. As well, Gardner and Bailey (1975) indicated that methoxychlor is readily metabolized by mammalian liver. Charnetski, Depner and Beltaos (1980) found residue levels of methoxychlor in river water at Fort McMurray to be less than 2 ppb during three years of sampling. Although the residue levels found at Fort McMurray appear to be of little consequence in regards to public health, the thought that even trace amounts of a chemical, used to kill insects, may be in their drinking water can cause much concern to many residents. The fact that the chemical is deliberately applied and not an accidental spillage makes it appear much more preventable. One solution would be to shut down the raw water intake as the methoxychlor passes Fort McMurray. This was attempted in 1981, however the reservoir was not up to full capacity due to work being carried out on the pumps (A. Pentney, pers. comm.), and the intake had to be left open. A new water treatment plant is being designed for Fort McMurray and a raw water reservoir with 10 days storage capacity is being proposed (Stanley Associates Eng. 1981.). This reservoir would easily enable shut down of the raw water intake during the passage of methoxychlor contaminated water (10-20 hours in duration).

Barrel Traps

The purpose of the barrel trap samples was to identify when adult black flies were most numerous in the farming area, and to correlate this information with larval population data. The correlation shows that adult numbers were peaking (Figure 12) as larvae from the third population of 1981 were maturing in development (Appendix 9). The adult data also shows that the two treatments in May and June were effective in reducing adult populations on the farm early in the summer, as compared to later in the summer when the July population of larvae was allowed to emerge unhindered and reach high numbers of adults. As a point of reference, the number of adults collected per trap during 1981 was higher overall than the number collected during 1979 (Byrtus 1981a) and 1980 (Byrtus 1981b).

A distinction was made in graphing the data from trap A and those from the other three traps. The location of trap A on a fence post was more acessible to the livestock in the pasture than the other three traps and they frequently rubbed against the fence post. In doing so, the amount of time spent by the host around this trap was much greater, resulting in higher numbers of black flies being collected on it.

Conclusions

1. Three distinct populations of black fly larvae were observed in the Athabasca River during 1981. Two of the three populations were reduced (by methoxychlor larvicide treatments) by 83.6 to 99.7% at monitored sites for the May 20/21 treatment, and by 95.5 to 98.5% for the June 19 treatment.

2. Non-target organism populations were only slightly affected by the May 20/21 treatment. The impact on non-target organisms for the June 19 treatment was considerably greater, especially on the Plecoptera.

3. Results of water sampling conducted at 80-100 km downstream of both May and June treatment points showed that methoxychlor residues in the water ranged from 0.6 to 4.7 ppb. Results of water sampling conducted at Fort McMurray for the May treatment showed only trace amounts of methoxychlor in the river.

4. Barrel trap data indicates that adult fly populations peaked in the farming area during late July. This correlated with the expected emergence of the third observed larval population.

List of References

BYRTUS, G. 1981a. Athabasca River Monitoring Program - 1979. Alberta Environment, Pollution Control Division. Edmonton. 69 pp.

BYRTUS, G. 1981b. Athabasca River Monitoring Program - 1980. Alberta Environment, Pollution Control Division. Edmonton. 61 pp.

CHARNETSKI, W. A., K. R. Depner. 1980. Distribution and persistence of methoxychlor in Athabasca River mud and bedload. p 63-73 in Haufe W.O. and G.C.R. Croome eds. 1980. Control of Black Flies in the Athabasca River: Technical Report. Alberta Environment, Pollution Control Division. Edmonton. 241 pp.

CHARNETSKI, W. A., K. R. Depner, S. Beltaos. 1980. Distribution and persistance of methoxychlor in Athabasca River water. p 39-61 in Haufe, W.O., G.C.R. Croome eds. Control of Black Flies in the Athabasca River: Technical Report. Alberta Environment, Pollution Control Division. Edmonton. 241 pp.

DEPNER, K. R., W. A. Charnetski, W. O. Haufe. 1980a. Population reduction of the black fly Simulium arcticum at breeding sites in the Athabasca River. p 21-31 in Haufe, W.O. and G.C.R. Croome eds. 1980. Control of Black Flies in the Athabasca River: Techical Report. Alberta Environment, Pollution Control Division. Edmonton. 241 pp.

DEPNER, K. R., W. A. Charnetski, W. O. Haufe. 1980b. Effect of methoxychlor on resident populations of the invertebrates of the Athabasca River. p 141-150 in Haufe, W. O. and G.C.R. Croome eds. 1980. Control of Black Flies in the Athabasca River: Technical Report. Alberta Environment, Pollution Control Division. Edmonton. 241 pp.

FLANNAGAN, J. F., B. E. Townsend, B. G. E. DeMarch. 1980. Acute and long-term effects of methoxychlor larviciding on the aquatic invertebrates of the Athabasca River, Alberta. p 151-158 in Haufe, W.O. and G.C.R. Croome eds. 1980. Control of Black Flies in the Athabasca River: Technical Report. Alberta Environment, Pollution Control Division. Edmonton. 241 pp.

FREDEEN, F. J. H. 1973. Black Flies. Agriculture Canada, Publication 1499. Ottawa. 19 pp.

FREDEEN, F. J. H. 1976. The seven larval instars of Simulium arcticum (Diptera: Simuliidae). Canadian Entomologist. 108:591-600.

GARDNER, D. R., J. R. Bailey. 1975. Methoxychlor: Its Effects on Environmental Quality. National Research Council of Canada. Ottawa. Publication No. NRCC 14102. 164 pp.

HAUFE, W. O. 1980. Control of Black Flies in the Athabasca River: Evaluation and Recommendations. Alberta Environment, Pollution Control Division. Edmonton. 38 pp.

HAUFE, W. O., G. C. R. Croome eds. 1980. Control of Black Flies in the Athabasca River: Technical Report. Alberta Environment, Pollution Control Division. Edmonton. p 1-20.

HAUFE, W. O., K. R. Depner, W. A. Charnetski. 1980. Impact of methoxychlor on drifting aquatic invertebrates. p 159-168 in Haufe, W. O. and G.C.R. Croome eds. 1980. Control of Black Flies in the Athabasca River: Technical Report. Alberta Environment, Pollution Control Division. Edmonton. 241 pp.

HEALTH AND WELFARE CANADA. 1978. Guidelines for Canadian Drinking Water Quality - 1978. Hull, Quebec. 76 pp.

KELLERHALS, R., C. R. Neill, D. I. Bray. 1972. Hydraulic and Geomorphic Characteristics of Rivers in Alberta. Alberta Research Council, River Engineering and Surface Hydrology Report 72-1.

KUMAR, Y. 1981. Alberta Environmental Centre, Chemistry Wing, personal communication.

MERRITT, R. W. and K. W. Cummins eds. 1978. An Introduction to the Aquatic Insects of North America. Kendall/Hunt Publishing Company. Dubuque, Iowa. 441 pp.

MURRAY, R. B. 1980. Athabasca River Black Fly Monitoring and Abatement Program - 1979. A report prepared for the County of Athabasca No. 12. 51 pp.

MURRAY, R. B. 1981. Athabasca River Black Fly Monitoring and Abatement Program - 1980. A report prepared for the County of Athabasca No. 12. 35 pp.

PENNAK, R. W. 1953. Freshwater Invertebrates of the United States. Ronald Press Co., New York. 769 pp.

PENTNEY, A. 1982. Alberta Environment, Municipal Engineering Branch, personal communication.

PLEDGER, D. J. and G. Byrtus. 1980. Athabasca River Monitoring Program - 1978. Alberta Environment, Pollution Control Division. Edmonton. 29 pp.

REMPEL, J. G., A. P. Arnason. 1947. An account of three successive outbreaks of the black fly S. arcticum, a serious livestock pest in Saskatchewan. Scientific Agriculture 27:428-445.

RYAN, J. K., G. J. Hilchie. 1980. Black Fly Problem Analysis, A Survey of Biting Fly Problems in Athabasca County and Improvement District No 18. A report prepared for Alberta Environment, Pollution Control Division. Edmonton. 80 pp.

SHEMANCHUK, J. A., J. R. Anderson. 1980. Bionomics of biting flies in the agricultural area of central Alberta. p 207-214 in Haufe, W.O. and G.C.R. Croome eds. Control of Black Flies in the Athabasca River: Technical Report. Alberta Environment, Pollution Control Division. Edmonton. 241 pp.

SMITH, R. L. 1974. Ecology and Field Biology. Second Edition. Harper and Row, New York. 850 pp.

STANLEY ASSOCIATES ENGINEERING. 1974. New Town of Fort McMurray, Engineering Study of Utility Systems. A report to the New Town of Fort McMurray. Edmonton.

STANLEY ASSOCIATES ENGINEERING. 1981. City of Fort McMurray, Expansion of Water Supply and Treatment Facilities. A report to the City of Fort McMurray. Edmonton.

USINGER, R. L. 1963. Aquatic Insects of California. University of California Press. Berkely and Los Angeles. 507 pp.

WARD, H. B. and G. C. Whipple. 1959. Freshwater Biology. Second Edition. Edited by W. T. Edmundson. John Wiley and Sons Inc., New York. 1248 pp.

WIGGINS, G. B. 1977. Larvae of North American Caddisfly Genera (Trichoptera). University of Toronto Press. 401 pp.

WILHM, J. 1972. Graphic and mathematical analysis of biotic communities in polluted streams. Annual Review of Entomology. 17:223-252.

Appendix 1 - Distribution of black fly larval instars in Athabasca River

May 20-21, 1981 Pre-treatment

Site locations (km downstream from Town of Athabasca)

	-20		40		80		120		180		200		240		Overall	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Instar 1	43	11.2	25	5.9	99	10.4	358	13.3	1080	11.9	109	4.6	642	7.4	2356	9.2
2	211	55.1	219	52.3	321	33.6	840	31.2	2388	26.4	356	15.1	1054	12.1	5389	21.1
3	93	24.3	92	21.9	318	33.3	795	29.5	1828	20.2	331	14.0	1115	12.8	4572	17.9
4	27	7.0	47	11.2	107	11.2	614	22.8	624	6.9	338	14.3	705	8.1	2462	9.6
5	9	2.3	25	5.9	56	5.9	403	14.9	822	9.0	490	20.8	838	9.6	2643	10.3
6	0	0.0	8	1.9	48	5.0	402	14.9	1724	19.0	641	27.2	1704	19.6	4527	17.7
7	0	0.0	3	0.7	6	0.6	272	10.1	564	6.2	94	4.0	2643	28.3	3582	14.0
Pupae	0	0.0	0	0.0	0	0.0	0	0.0	20	0.2	0	0.0	0	0.0	20	0.1
Total	383		419		955		3684		9050		2359		8701		25551	
No of Cones	3		4		4		4		3		3		4			
$\bar{x}$/cone	127.7		104.7		238.7		921.0		3016.7		786.3		2175.3			
Std. Dev.*	52.0		75.3		53.3		139.1		437.4		595.5		2219.5			

	Control	Treated
Total	802	24749
No of Cones	7	18
$\bar{x}$/cone	114.6	1374.9
Std. Dev.*	62.4	1407.7

*Standard deviation derived from original data

Appendix 2 - Distribution of black fly larval instars in Athabasca River

May 25-26, 1981 Post-treatment

Site locations (km downstream from Town of Athabasca)

	-20		40		80		120		180		200		240		Overall	
Instar	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
1	17	6.3	38	6.3	74	25.6	76	33.6	18	25.7	1	2.9	3	1.7	227	13.9
2	25	9.2	179	29.4	179	61.9	118	52.2	40	57.1	8	23.5	1	0.6	550	33.7
3	87	32.1	157	25.8	23	8.0	2	0.9	0	0.0	1	2.9	1	0.6	271	16.6
4	40	14.8	114	18.7	5	1.7	1	0.4	0	0.0	2	5.9	4	2.3	166	10.2
5	47	17.3	61	10.0	1	0.3	1	0.4	0	0.0	6	17.6	5	2.9	121	7.4
6	18	6.6	46	7.6	5	1.7	5	2.2	0	0.0	10	29.4	38	21.8	122	7.5
7	6	2.2	8	1.3	2	0.7	3	1.3	0	0.0	5	14.7	60	34.5	84	5.1
Pupae	0	0.0	5	0.8	0	0.0	12	5.3	12	17.1	1	2.9	62	35.6	92	5.6
Total	240		608		289		218		70		34		174		1633	
No of Cones	1		5		6		6		1		6		6			
$\bar{x}$/cone	240		121.6		48.2		36.3		70		5.7		29			
Std. Dev.*	0.0		143.9		70.5		66.9		0.0		2.3		9.3			

	Control	Treated
Total	848	785
No of Cones	6	25
$\bar{x}$/cone	141.3	31.4
Std. Dev.*	137.4	47.3

*Standard deviation derived from original data

Appendix 3 - Distribution of black fly larval instars in Athabasca River

June 2-3, 1981

Site locations (km downstream from Town of Athabasca)

Instar	-20 N	-20 %	40 N	40 %	80 N	80 %	120 N	120 %	180 N	180 %	200 N	200 %	240 N	240 %	Overall N	Overall %
1	12	18.5	23	37.7	36	15.4	183	16.0	1886	31.9	165	15.2	1135	33.4	3440	28.2
2	20	30.8	16	26.2	109	46.6	249	21.8	2050	34.7	509	47.0	1498	44.0	4451	36.5
3	6	9.2	9	14.7	56	23.9	355	31.0	1345	22.8	333	30.8	667	19.6	2771	22.7
4	7	10.8	2	3.3	30	12.8	305	26.6	775	13.1	73	6.8	175	5.1	1367	11.2
5	6	9.2	6	9.8	5	2.1	34	3.0	20	0.3	1	0.0	24	0.7	96	0.8
6	9	13.8	5	8.2	12	4.8	17	1.5	3	0.0	1	0.0	0	0.0	47	0.4
7	5	7.7	0	0.0	0	0.0	2	0.2	0	0.0	0	0.0	1	0.0	8	0.1
Pupae	0	0.0	0	0.0	1	0.4	0	0.0	0	0.0	0	0.0	1	0.0	2	0.0
Total	65		61		249		1145		6079		1082		3501		12182	
No of Cones	6		5		6		4		5		6		6			
$\bar{x}$/cone	10.8		12.2		41.5		286.3		1215.8		180.3		583.5			
Std. Dev.*	10.9		11.9		13.8		192.6		1623.2		118.2		276.5			

	Control	Treated
Total	126	12057
No of Cones	11	27
$\bar{x}$/cone	11.4	446.5
Std. Dev.*	10.8	787.5

*Standard deviation derived from original data

Appendix 4 - Distribution of black fly larval instars in Athabasca River
June 9-10, 1981

Site locations (km downstream from Town of Athabasca)

	-20		40		80		120		180		200		240		Overall	
Instar	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
1	14	25.4	7	14.0	57	40.7	55	22.7	564	17.5	134	8.1	528	4.8	1359	8.3
2	7	12.7	19	38.0	54	38.6	38	15.7	865	26.9	240	14.6	5959	54.4	7182	44.1
3	14	25.4	9	18.0	21	15.0	15	6.2	635	19.7	330	20.0	1749	16.0	2773	17.0
4	6	10.9	3	6.0	3	2.1	22	9.1	363	11.3	300	18.2	1765	16.1	2462	15.1
5	4	7.3	4	8.0	2	1.4	29	12.0	403	12.5	421	25.5	848	7.7	1711	10.5
6	5	9.1	3	6.0	5	3.6	54	22.3	298	9.3	194	11.8	86	0.8	645	4.0
7	3	5.4	5	10.0	2	1.4	21	8.7	66	2.0	31	1.9	17	0.2	145	0.9
Pupae	2	3.6	0	0.0	2	1.4	8	3.3	10	0.3	0	0.0	0	0.0	22	0.1
Total	55		50		146		242		3204		1650		10952		16299	
No of Cones	3		6		6		4		5		3		6			
$\bar{x}$/cone	18.3		8.3		24.3		60.5		643.4		550.0		1825.3			
Std. Dev.*	11.0		8.4		18.1		47.8		451.1		384.1		1500.6			

	Control	Treated
Total	105	16194
No of Cones	9	24
$\bar{x}$/cone	11.7	674.7
Std. Dev.*	9.9	1030.4

*Standard deviation derived from original data

Appendix 5 - Distribution of black fly larval instars in Athabasca River

June 18, 1981 Pre-treatment

Site locations (km downstream from Town of Athabasca)

	-20		40		80		120		180		200		240		Overall	
Instar	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
1	12	11.9	7	16.7	9	18.7	129	12.9	237	8.1	65	3.3	32	1.2	491	5.6
2	28	27.7	8	19.0	22	45.8	241	24.1	949	32.5	449	22.9	492	19.2	2189	25.1
3	22	21.8	5	11.9	4	8.3	146	14.6	459	15.7	327	16.7	476	18.6	1439	16.5
4	25	24.7	8	19.0	9	18.7	114	11.4	469	16.1	334	17.0	492	19.2	1451	16.6
5	9	0.9	1	2.4	1	2.1	137	13.7	380	13.0	281	14.3	652	25.5	1461	16.8
6	2	2.0	3	7.1	2	4.2	125	12.5	431	14.8	394	20.1	360	14.1	1317	15.1
7	3	3.0	5	11.9	0	0.0	51	5.1	82	2.8	103	5.3	52	2.0	296	3.4
Pupae	0	0.0	5	11.9	1	2.1	55	5.5	4	0.1	6	0.3	4	0.2	75	0.9
Total	101		42		48		998		3011		1959		2560		8719	
No of Cones	3		3		4		4		3		6		3			
$\bar{x}$/cone	33.7		14		12		249.5		1003.7		326.5		853.3			
Std. Dev.*	20.3		3.6		10.1		171.9		438.4		468.3		431.9			

	Control	Treated
Total	1189	7530
No of Cones	14	12
$\bar{x}$/cone	84.9	627.5
Std. Dev.*	136.5	511.4

*Standard deviation derived from original data

Appendix 6 - Distribution of black fly larval instars in Athabasca River

June 22-23, 1981 Post-treatment

Site locations (km downstream from Town of Athabasca)

Instar	-20 N	-20 %	40 N	40 %	80 N	80 %	120 N	120 %	180 N	180 %	200 N	200 %	240 N	240 %	Overall N	Overall %
1	3	2.0	8	36.4	18	25.4	90	11.6	85	69.7	9	60.0	75	43.8	288	22.0
2	15	10.2	0	0.0	12	16.9	76	9.8	24	19.7	0	0.0	4	2.3	131	10.0
3	15	10.2	6	27.3	11	15.5	99	12.8	5	4.1	2	13.3	2	1.2	140	10.7
4	23	15.6	3	13.6	14	19.7	82	10.6	4	3.3	1	6.7	2	1.2	129	9.9
5	26	17.7	4	18.2	6	8.4	106	13.7	0	0.0	0	0.0	1	0.6	143	10.9
6	30	20.4	1	4.5	7	9.9	92	11.9	1	0.8	1	6.7	5	2.9	137	10.5
7	33	22.4	0	0.0	2	2.8	127	16.4	3	2.5	2	13.3	1	0.6	168	12.9
Pupae	2	1.4	0	0.0	1	1.4	84	10.8	0	0.0	0	0.0	83	48.5	170	13.0
Total	147		22		71		775		122		15		171		1306	
No of Cones	3		4		4		5		5		4		6			
$\bar{x}$/cone	49		5.5		17.8		155		24.4		3.75		28.5			
Std. Dev.*	16.6		2.9		7.9		161.1		15.5		4.5		22.6			

	Control	Treated
Total	1015	308
No of Cones	16	15
$\bar{x}$/cone	63.4	20.5
Std. Dev.*	106.1	19.2

*Standard deviation derived from original data

Appendix 7 - Distribution of black fly larval instars in Athabasca River

June 29-30, 1981

Site locations (km downstream from Town of Athabasca)

		-20		40		80		120		180		200		240		Overall	
		N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Instar	1	2	3.8	0	0.0	15	20.3	126	45.5	1386	28.0	974	36.3	826	25.4	3329	29.4
	2	16	30.2	3	20.0	33	44.6	44	15.9	1712	34.5	914	34.0	1441	44.4	4165	36.8
	3	3	5.7	3	20.0	20	27.0	27	9.8	1161	23.4	554	20.6	813	25.0	2581	22.8
	4	2	3.8	2	13.3	6	8.1	10	3.6	541	10.9	225	8.4	146	4.5	932	8.2
	5	7	13.2	1	6.7	4	5.4	12	4.3	79	1.6	10	0.4	3	0.1	116	1.0
	6	13	24.5	3	20.0	3	4.0	21	7.6	38	0.8	1	0.0	2	0.1	81	0.7
	7	10	18.9	3	20.0	3	4.0	22	7.9	24	0.5	4	0.1	2	0.1	68	0.6
	Pupae	0	0.0	0	0.0	0	0.0	16	5.8	16	0.3	4	0.1	0	0.0	36	0.3

	-20	40	80	120	180	200	240	Overall
Total	53	15	84	278	4957	2686	3233	11308
No of Cones	4	6	6	6	6	6	5	
$\bar{x}$/cone	13.3	2.5	14.0	46.3	826.2	447.7	646.6	
Std. Dev.*	6.6	2.5	6.2	39.5	203.3	140.7	166.9	

	Control	Treated
Total	430	10878
No of Cones	22	17
$\bar{x}$/cone	19.5	639.9
Std. Dev.*	26.2	230.8

*Standard deviation derived from original data

Appendix 8 - Distribution of black fly larval instars in Athabasca River July 7-8, 1981

Site locations (km downstream from Town of Athabasca)

	-20		40		80		120		180		200		240		Overall	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Instar 1	4	10.5	0	0.0	19	12.4	53	19.8	154	2.9	203	5.9	171	6.5	604	5.2
Instar 2	12	31.6	2	11.8	61	46.4	81	30.2	1161	22.2	397	11.6	593	22.5	2307	19.7
Instar 3	13	34.2	6	35.3	30	19.6	54	20.1	1094	20.9	448	13.2	371	14.1	2016	17.2
Instar 4	4	10.5	7	41.2	22	14.4	38	14.2	915	17.5	894	26.2	496	18.8	2376	20.3
Instar 5	2	5.3	2	11.8	11	7.2	8	3.0	1031	19.7	727	21.3	442	16.8	2223	18.9
Instar 6	3	7.9	0	0.0	6	3.9	3	1.1	617	11.8	578	17.0	499	18.9	1706	14.5
Instar 7	0	0.0	0	0.0	3	2.0	0	0.0	207	3.9	128	3.8	60	2.3	398	3.4
Pupae	0	0.0	0	0.0	1	0.6	1	0.4	46	0.9	33	1.0	6	0.2	87	0.7
Total	38		17		153		238		5225		3408		2638		11717	
No of Cones	5		5		6		6		6		6		4			
$\bar{x}$/cone	7.6		3.4		27.2		39.7		870.8		568		659.5			
Std. Dev.*	5.8		6.0		10.9		45.8		646.0		257.8		400.8			

	Control	Treated
Total	446	11271
No of Cones	22	16
$\bar{x}$/cone	20.3	704.4
Std. Dev.*	23.6	460.8

*Standard deviation derived from original data

Appendix 9 - Distribution of black fly larval instars in Athabasca River

July 14-15, 1981

Site locations (km downstream from Town of Athabasca)

	-20		40		80		120		180		200		240		Overall	
Instar	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
1	1	4.2	1	11.1	9	17.3	27	14.4	89	6.4	153	6.6	100	7.4	380	7.1
2	4	16.7	3	33.3	19	36.5	75	39.9	472	33.9	336	14.4	314	23.3	1223	23.0
3	10	41.7	4	44.4	8	15.4	45	23.9	279	20.0	276	11.9	169	12.5	791	14.8
4	3	12.5	0	0.0	4	7.7	12	6.4	270	19.4	461	19.8	229	17.0	979	18.3
5	2	8.3	0	0.0	4	7.7	7	3.7	174	12.5	419	18.0	228	16.9	834	15.6
6	4	16.7	1	11.1	6	11.5	14	7.4	91	6.5	387	16.6	183	13.6	686	12.8
7	0	0.0	0	0.0	2	3.8	7	3.7	15	1.1	262	11.3	87	6.4	373	7.0
Pupae	0	0.0	0	0.0	0	0.0	1	0.5	3	0.2	32	1.4	39	2.9	75	1.4
Total	24		9		52		188		1393		2326		1349		5341	
No of Cones	4		6		6		6		4		6		4			
$\bar{x}$/cone	6		1.5		8.7		31.3		348.2		387.7		337.3			
Std. Dev.*	3.4		1.4		4.6		25.9		90.4		101.6		81.8			

	Control	Treated
Total	273	5068
No of Cones	22	14
$\bar{x}$/cone	12.4	362.7
Std. Dev.*	17.7	89.2

*Standard deviation derived from original data

APPENDIX 10 - Benthic Macro-invertebrates collected from the Athabasca River May 13-14, 1981

TAXA \ Site Location	-20			40			80			120			180			200			240		
Sample No.	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
COLEOPTERA																					
Agabus																					
Gyrinus										1											
Heleophorus																					
Hydaticus																					
Optioservus		1																			
Oreodytes																					
DIPTERA																					
Atherix																					
Ceratopogonidae				1		1					1										
Chelifera																					
Chironomidae	2	4	2	15	10	20	64	22	19	10	8	7	13	10	6	2	4	10	2	4	5
Dolichopodidae																					
Erioptera																					
Helius																					
Hemerodromia				1			4								1				1		
Hexatoma													1								
Muscidae																					
Simulium										2	2	5	4	1	1	6	2	14	9	4	2
Tipula																					
EPHEMEROPTERA																					
Ametropus																					
Baetis	18	10	20				2	3	8	4	4	5	2	3	2		2	3		1	3
Baetodes																					
Caenis																					
Centroptilum																					
Cinygma																					
Cinygmula																					
Epeorus																					
Ephemerella	2	9	1				13	6	4	4	3	2	15	18	4		1	2	6	5	7
Ephoron																					
Heptagenia	2	4	6	5	1		3	1			1	5		6				1	1	1	1
Hexagenia																					
Isonychia																					
Leptophlebia		1																			
Metretopus																					
Neocloeon																					
Parameletus	1	3										1							1		
Rhithrogena	11	27	28		1		3	1		4	2	13				11	7	27	13	18	18
Siphloplecton																					
Tricorythodes																					
PLECOPTERA																					
Acroneuria																					
Classenia																					
Hastaperla			2							1		3				2		6	1	1	
Isogenus	174	205	233	5		3	28	8	7	30	24	55	30	63	22	13	37	86	46	59	57
Isoperla	97	75	53	1	1	2	6	5	6	3	1	2	28	39	1	3	3	1	2	1	1
Pteronarcella	1																				
Pteronarcys	2	3	1							1		3		2	1	1	3	1	2	1	
TRICHOPTERA																					
Brachycentrus																					
Cheumatopsyche	3	4	7	1			3		1	2		2	2	6		4	4	6	5	6	9
Glossosoma																					
Glossosomatidae													1								
Hydropsyche	1	4	1				2				1	3	3	8		1	1	1	3	10	5
Limnophilidae																					
Neureclepsis																					
Platycentropus													1								
Psychomyiidae																					
HEMIPTERA																					
Corixidae						1				2	2	1									1
ODONATA																					
Ophiogomphus	2			2				1		2	1	1						1			
GASTROPODA				1			3	12	22												
HIRUDINEA																					
Glossiphonidae																		1			
PELECYPODA																					
OLIGOCHAETA																					
Gordidae																					
Naididae				3	1	5	1		2	14	17	28		1		1		5	2	1	1
TOTAL	316	350	354	35	14	32	132	59	69	80	67	136	100	157	38	44	64	165	94	112	110
SUM TOTAL			1020			81			260			283			295			273			316
NO. OF TAXA			16			12			13			18			15			15			16
DIVERSITY INDEX			1.86			2.58			2.67			3.09			2.64			2.62			2.50

APPENDIX 11 - Benthic Macro-invertebrates collected from the Athabasca River May 20-21, 1981 Pre-Treatment

Site Location	-20			40			80			120			180			200			240		
TAXA / Sample No.	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
COLEOPTERA																					
Acabus																					
Gyrinus																					
Heleophorus																					
Hydaticus																					
Optioservus																	1				
Oreodytes																					
DIPTERA																					
Atherix							1														
Ceratopogonidae			1					1									1				
Chelifera																					
Chironomidae		6	5	12	15	13	30	67	69	3	1	5	4	3	6		6	3	4	9	3
Dolichopodidae																					
Erioptera																					
Helius																					
Hemedromia	1						1	1	8											2	
Hexatoma									1												
Muscidae																					
Simulium												2			1	27	31	27		3	2
Tipula																					
EPHEMEROPTERA																					
Ametropus																1					
Baetis	2	6	3				12	30	5	13	2	5	2	5	5		1	8	1	3	
Bactodes																					
Caenis																					
Centroptilum																					
Cinygma																					
Cinygmula																					
Epeorus																					
Ephemerella	6	2	2				29	58	38	9	9	8	5	12	8	1	3	8	3	15	6
Ephoron																					
Heptagenia	6	4	7	2	20	29	3	14	5	7	3	4	2	6	5	1	6	4	4	2	
Hexagenia																					
Isonychia																					
Leptophlebia																					
Metretopus																					
Neocleon																					
Parameletus																					
Rhithrogena	28	46	1	2	11	8	9	20	1	26	13	31	4	3	8	6	13	38	20	47	26
Siphloplecton																					
Tricorythodes																					
PLECOPTERA																					
Acroneuria																					
Classenia																					
Hastaperla	4	4			2	3	3	10	2	2	5	3			1	1	5	7	3	7	3
Isogenus	97	186	43	8	12	29	59	180	31	100	91	74	36	105	77	35	51	98	84	137	89
Isoperla	35	27	20	15	15	12	18	13	4	27	17	15	36	38	79	42	39	73	16	21	20
Pteronarcella								1													
Pteronarcys	1	2								3		1	1		1			1		1	
TRICHOPTERA																					
Brachycentrus																					
Cheumatopsyche	5	7	1		1	1	6	25	17	3	1	3	3		1	1	3	3	6	12	1
Glossosoma																					
Glossosomatidae																					
Hydropsyche	1	9					6	13	9	2	3	7	6	2	4				7	20	3
Limnophilidae																					
Neureclepsis																					
Platycentropus																					
Psychomyiidae																					
HEMIPTERA																					
Corixidae					2																
ODONATA																					
Ophiogomphus	2	1		1	1	7	1	2	4			1							1	1	
GASTROPODA				14	3	4	7	5	1		2										
HIRUDINEA																					
Glossiphonidae																					
PELECYPODA																					
OLIGOCHAETA																					
Gordidae																					
Naididae		1		12	22	17	1	6	2	20	10	11	2	1		3		4	1	3	3
TOTAL	188	301	83	66	104	123	186	446	197	215	157	170	101	175	196	118	160	274	150	283	156
SUM TOTAL			572			293			829			542			472			552			589
NO. OF TAXA			15			11			18			15			13			15			15
DIVERSITY INDEX			2.16			3.07			3.02			2.63			2.15			2.61			2.41

APPENDIX 12 - Benthic Macro-invertebrates collected from the Athabasca River May 25, 1981 Post-Treatment

TAXA / Site Location	-20			40			80			120			180			200			240		
Sample No.	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
COLEOPTERA																					
Agabus																					
Gyrinus																					
Heleophorus																					
Hydaticus																					
Optioservus																					
Oreodytes																					
DIPTERA																					
Atherix																					
Ceratopogonidae									1												
Chelifera																					
Chironomidae				3	6	3		10	4			2	8	7		1		2	1	4	4
Dolichopodidae																					
Erioptera																					
Helius																					
Hemedromia																				1	
Hexatoma																					
Muscidae																					
Simulium													1								1
Tipula																					
EPHEMEROPTERA																					
Ametropus				1																	
Baetis				1																	
Baetodes																					
Caenis																					
Centroptilum																					
Cinygma																					
Cinygmula																					
Epeorus																					
Ephemerella				1		1		8	17	7	16	10	10	5	5	5	6	2	3	3	
Ephoron																					
Heptagenia				8	8	1		1		2	2	4	1		1	4	4	3	2	6	5
Hexagenia																					
Isonychia																					
Leptophlebia		(a)					(b)														
Metretopus																					
Neocleon																					
Parameletus																					1
Rhithrogena				3	1	1				2	8	3	3	4		6	15	3	49	50	10
Siphloplecton																					
Tricorythodes																					
PLECOPTERA																					
Acroneuria																					
Classenia																					
Hastaperla					1				2		2					1	1	1			
Isogenus				7	6				9	2	5	12	1			3	1		17	16	2
Isoperla				25	31	12		17	22	5	4	1		3			3	2	7	10	2
Pteronarcella																					
Pteronarcys																					
TRICHOPTERA																					
Brachycentrus																					
Cheumatopsyche					1			2	2				4				1		3	3	1
Glossosoma																					
Glossosomatidae																					
Hydropsyche											1	1	3		2		1	1	3	3	1
Limnophilidae																					
Neureclepsis																					
Platycentropus																					
Psychomyiidae																					
HEMIPTERA																					
Corixidae																					
ODONATA																					
Ophiogomphus					1	2			1							2		1			
GASTROPODA				2	14				11		2	4									
HIRUDINEA																					
Glossiphonidae																					
PELECYPODA																					
OLIGOCHAETA																					
Gordidae																					
Naididae				5	7	15			2	2	8	1	2		1			1			
TOTAL				56	76	35		38	71	20	48	38	33	19	9	22	32	16	85	96	27
SUM TOTAL						167			109			106			61			70			208
NO. OF TAXA						13			11			10			10			11			11
DIVERSITY INDEX						2.68			2.60			2.84			2.91			2.81			2.41

* (a) Samples not collected due to rising water levels.
* (b) Sample lost.

APPENDIX 13 - Benthic Macro-invertebrates collected from the Athabasca River June 2, 1981

Site Location / TAXA — Sample No.	-20			40			80			120			180			200			240		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
COLEOPTERA																					
Agabus																					
Gyrinus																					
Heleophorus																					
Hydaticus																					
Optioservus												1									
Oreodytes																					
DIPTERA																					
Atherix																					
Ceratopogonidae					1			1	1			1									
Chelifera																					
Chironomidae				2		1	1	2	5	3	2		3		2		5	2	2		2
Dolichopodidae								2			5	2									
Erioptera																					
Helius						1															
Hemedromia							1														
Hexatoma							1														
Muscidae																					
Simulium																					
Tipula																					
EPHEMEROPTERA																					
Ametropus																3		1			
Baetis				1		1	1	7		1		1									
Baetodes																					
Caenis																					
Centroptilum																					
Cinygma																					
Cinygmula																					
Epeorus																					
Ephemerella				7	1	9	11	16	10	7		21	22	4	7	29	43	13	6	8	5
Ephoron																					
Heptagenia				12	11	14		1	2			2	3	3		4	9	2	2	1	3
Hexagenia												1									
Isonychia																					
Leptophlebia		(a)																			
Metretopus																					
Neocleon																					
Parameletus																					
Rhithrogena				1							1	2					1		4	5	6
Siphloplecton				15	24	20		2											1		
Tricorythodes																					
PLECOPTERA																					
Acroneuria															1						
Classenia																					
Hastaperla				1		1			3	1						4	2	3	2	1	
Isogenus														1		2	1			1	1
Isoperla				24	18	34	38	104	52	12	6	56	56	46	34	30	40	30	11	13	11
Pteronarcella																		1			
Pteronarcys																			1		
TRICHOPTERA																					
Brachycentrus						1	1						1								
Cheumatopsyche					4	2	6	6	1	1		13	2	1	3	4	8	7	8	13	6
Glossosoma																					
Glossosomatidae																					
Hydropsyche										1		3	1			1			9	5	6
Limnophilidae																					
Neureclepsis																					
Platycentropus																					
Psychomyiidae																					
HEMIPTERA																					
Corixidae									1												
ODONATA																					
Ophiogomphus				1		1		1		1						1	1		1		
GASTROPODA				3	3			1			1									1	
HIRUDINEA																					
Glossiphonidae																					
PELECYPODA																					
OLIGOCHAETA																					
Gordidae																					
Naididae				3		7						4	12	10	8				3	12	4
TOTAL				70	62	92	60	143	75	27	15	107	100	65	55	78	110	59	50	60	54
SUM TOTAL						224			278			149			220			247			164
NO. OF TAXA						15			16			16			10			12			14
DIVERSITY INDEX						2.63			1.72			2.64			1.78			2.39			3.43

* (a) Samples not collected due to rising water levels.

APPENDIX 14 - Benthic Macro-invertebrates collected from the Athabasca River June 9-10, 1981

TAXA \ Site Location / Sample No.	-20 1	-20 2	-20 3	40 1	40 2	40 3	80 1	80 2	80 3	120 1	120 2	120 3	180 1	180 2	180 3	200 1	200 2	200 3	240 1	240 2	240 3
COLEOPTERA																					
Agabus																					
Gyrinus																					
Heleophorus																					
Hydaticus																					
Optioservus														1			1		1		
Oreodytes																					
DIPTERA																					
Atherix																					
Ceratopogonidae							1	2	1												
Chelifera																					
Chironomidae	3	6				2	3		1	1	1	3			2	14	7	5	3	5	7
Dolichopodidae							2					2									
Erioptera																					
Helius																					
Hemedromia		2	1									1									
Hexatoma																					
Muscidae																					
Simulium							1								1	1	6				
Tipula																					
EPHEMEROPTERA																					
Ametropus					1						1			1							
Baetis			1	4	3	2	1	6	2	1	1					1	1				1
Baetodes																					
Caenis																					
Centroptilum																					
Cinygma																					
Cinygmula																					
Epeorus																					
Ephemerella	22	26	14	5	7	7	5	11	8	7	3	12	2	4	5	65	101	102	16	24	39
Ephoron																					
Heptagenia	11	14	10	8	12	6		1		1		1	3	2	4	10	5	6	4	5	1
Hexagenia																					
Isonychia																					
Leptophlebia																					
Metretopus																					
Neocleon																					
Parameletus																					
Rhithrogena	4	5	4		2			1		1	1					10	9	10	6	9	9
Siphloplecton				23	7	16	1			1											
Tricorythodes																					
PLECOPTERA																					
Acroneuria						1															
Classenia		3	1													1					
Hastaperla	2	4	1		2	2		2			1	1		1	1	6	8	4		1	2
Isogenus	2		1				1	13			1					1				1	
Isoperla	99	113	68	34	48	63	69	165	53	34	21	52	46	54	97	343	226	317	63	39	85
Pteronarcella																					
Pteronarcys	1	1																	2	1	
TRICHOPTERA																					
Brachycentrus	1							1								9		2			
Cheumatopsyche	39	18	34	4	3	1	2	13	1	12	11	10		1		69	85	47	7	11	10
Glossosoma																					
Glossosomatidae																					
Hydropsyche	11	12	8					1		12	4	9				17	16	25	1	6	8
Limnophilidae																					
Neureclepsis																					
Platycentropus																					
Psychomyiidae																					
HEMIPTERA																					
Corixidae					1																1
ODONATA																					
Ophiogomphus							2		1							1	2				
GASTROPODA																					
HIRUDINEA																					
Glossiphonidae																					
PELECYPODA																					
OLIGOCHAETA																					
Gordidae																					
Naididae			1	3	5			2		3	3	5	2	6	4					2	3
TOTAL	195	204	144	81	91	100	88	218	67	73	48	96	53	70	114	548	467	518	103	104	166
SUM TOTAL			543			272			373			217			237			1533			373
NO. OF TAXA			15			13			17			15			10			15			14
DIVERSITY INDEX			2.33			2.25			1.56			2.41			1.16			1.97			2.33

APPENDIX 15 - Benthic Macro-invertebrates collected from the Athabasca River June 18, 1981 Pre-treatment

Site Location	-20			40			80			120			180			200			240		
TAXA / Sample No.	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
COLEOPTERA																					
Agabus																					
Gyrinus																					
Heleophorus																					
Hydaticus																					
Optioservus						1	1			1											
Oreodytes																					
DIPTERA																					
Atherix																					
Ceratopogonidae					1	1					1						1				
Chelifera																					
Chironomidae	13	3	7	16	8	8	8	4	1	3	3	6	12	17	4	9	15	12	12	19	17
Dolichopodidae																					
Erioptera																					
Helius																					
Hemedromia			1																		1
Hexatoma																					
Muscidae																					
Simulium													3	2	1	1	3	1	1	8	1
Tipula											1										
EPHEMEROPTERA																					
Ametropus																					
Baetis	7		1	4	2	3	13	3	1	7	5	26	32	11	16	1	7	2	6	15	6
Bactodes																					
Caenis																					
Centroptilum																					
Cinygma																					
Cinygmula																					
Epeorus												2									
Ephemerella	27	5	11	8	5		22	4	7	12	5	17	26	13	7	23	37	16	16	38	16
Ephoron																					
Heptagenia	4	1	8	9	8	12	6	2	2	7	8	10	7	1	4	1	2	4	3	3	5
Hexagenia																					
Isonychia																					
Leptophlebia																					
Metretopus																					
Neocleon																					
Parameletus																					
Rhithrogena	2		2	1			3	2	2	1	1		1	1		1	1		8	14	5
Siphloplecton																					
Tricorythodes																					
PLECOPTERA																					
Acroneuria						2															
Classenia	9	1	10						1	2	1										
Hastaperla				2			1	1				2		2	2	1		1	3	1	1
Isogenus	2	1		1	1		118	5	7		1					1	1		1	2	
Isoperla	145	27	85	148	113	100	142	50	67	121	66	97	109	65	61	125	146	122	58	67	51
Pteronarcella																					
Pteronarcys		2	1										1								
TRICHOPTERA																					
Brachycentrus								1											1	1	
Cheumatopsyche	32	14	33	16	13	12	49	8	25	43	6	29	4	8	1	28	69	18	19	29	8
Glossosoma																					
Glossosomatidae																					
Hydropsyche	17	6	18	2		1	16	4	10	32	7	34	8	13	2	7	18	5	16	12	1
Limnophilidae																					
Neureclepsis																					
Platycentropus																					
Psychomyiidae							1	1													
HEMIPTERA																					
Corixidae																					
ODONATA																					
Ophiogomphus				1	1		1	1	2	1		1					2	3	1	1	
GASTROPODA				17	16	12		2		6	1										
HIRUDINEA																					
Glossiphonidae																					
PELECYPODA																					
OLIGOCHAETA																					
Gordidae																					
Naididae			1	14	15	11	7			3	3	6	11			2	1	2	4		2
TOTAL	258	60	178	239	183	163	388	88	125	239	109	230	214	133	98	200	303	186	159	210	114
SUM TOTAL			496			585			601			578			445			689			483
NO. OF TAXA			13			16			17			18			12			14			15
DIVERSITY INDEX			2.32			2.12			2.56			2.52			2.33			2.09			3.04

APPENDIX 16 - Benthic Macro-invertebrates collected from the Athabasca River June 22-23, 1981 Post-treatment

TAXA \ Site Location / Sample No.	-20			40			80			120			180			200			240		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
COLEOPTERA																					
Agabus																					
Gyrinus																					
Heleophorus											1										
Hydaticus																					
Optioservus												2									
Oreodytes																					
DIPTERA																					
Atherix																					
Ceratopogonidae									1	1											
Chelifera																					
Chironomidae	6	8	11	5	12	12	6	5	13	11	3	8	2	2	5	8	14	4	26	28	20
Dolichopodidae								1													
Erioptera																					
Helius																					
Hemerodromia	6	1					1		1										1		1
Hexatoma						1															
Muscidae																					
Simulium																	1	1	1	1	1
Tipula																					
EPHEMEROPTERA																					
Ametropus				1	1																1
Baetis	4	14	33	14	23	8	5	16	10	71	43	15			1	1	1	1			
Baetodes																					
Caenis																					
Centroptilum																					
Cinygma																					
Cinygmula																					
Epeorus																					
Ephemerella	11	13	13	1	4	2	27	38	12	10	9	4	8	8	12	2	14	6	37	25	26
Ephoron																					
Heptagenia	4	8	11	20	33	24	12	9	5	31	15	11	1	1		1	7	5	5	3	7
Hexagenia																					
Isonychia																					
Leptophlebia																					
Metretopus																					
Neocleon																					
Parameletus																					
Rhithrogena	6	22	5		1		9	7	11	1	3	1	1	4				1	4	4	2
Siphloplecton				2							1										
Tricorythodes																					
PLECOPTERA																					
Acroneuria					1																
Classenia	3	5	4			1			1	4		1									
Hastaperla		2	1											2			1				1
Isogenus	15	21	16	14	12	8	127	120	122	14	18	6						1			
Isoperla	28	106	131	83	77	114	420	217	211	235	159	124	5	29	7	4	6	2	3	1	1
Pteronarcella												1									
Pteronarcys	1			1			1		1			1					1		3		
TRICHOPTERA																					
Brachycentrus	4	4	1		1	1	1		2					1	1				4	1	
Cheumatopsyche	56	66	87	2	10	8	29	38	29	3	7	3	1	5		4	27	3	58	38	22
Glossosoma																					
Glossosomatidae																					
Hydropsyche	26	52	45		5	1	23	19	22	92	56	29	2			1	8	2	34	11	8
Limnophilidae																					
Neureclepsis																					
Platycentropus																					
Psychomyiidae																					
HEMIPTERA																					
Corixidae						1											1				
ODONATA																					
Ophiogomphus				1		2	9	5	5	2		2				1	1		1	1	1
GASTROPODA					1			9		1	2	1				1					
HIRUDINEA																					
Glossiphonidae																					
PELECYPODA																					
OLIGOCHAETA																					
Gordidae																					
Naididae				5	8	43			1	1	1	3		1		2		2	4	3	26
TOTAL	170	322	358	149	189	226	670	484	447	477	318	212	20	53	26	25	82	27	181	116	117
SUM TOTAL			850			564			1601			1007			99			134			414
NO. OF TAXA			14			20			18			19			11			15			15
DIVERSITY INDEX			2.84			2.54			2.20			2.30			2.41			3.04			2.80

APPENDIX 17 - Benthic Macro-invertebrates collected from the Athabasca River June 29-30, 1981

TAXA \ Site Location	-20			40			80			120			180			200			240		
Sample No.	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
COLEOPTERA																					
Agabus																					
Gyrinus																					
Helophorus																					
Hydaticus																					
Optioservus																					
Oreodytes																					
DIPTERA																					
Atherix																					
Ceratopogonidae	1																				
Chelifera																					
Chironomidae	34	5	23	13	9	29	28	30	18	15	20	17	18	13	15	12	9	35	10	30	13
Dolichopodidae																					
Erioptera																					
Helius																					
Hemedromia							1	1	1							1					
Hexatoma																					
Muscidae																					
Simulium													5	1	1						
Tipula																					
EPHEMEROPTERA																					
Ametropus																					
Baetis	68	4	16	2	19	17	10	17	10	20	37	24					2		1	1	
Baetodes																					
Caenis																					
Centroptilum																					
Cinygma																					
Cinygmula																					
Epeorus																					
Ephemerella	5	4	2	1		1	15	23	19	8	24	3	8	5	20	10	12	15	12	16	9
Ephoron											1										
Heptagenia	20	9	13	1	29	37	15	17	8	38	27	28	1	2	1	1	2	10	1	7	5
Hexagenia																					
Isonychia					2	2			1	1											
Leptophlebia																					
Metretopus																					
Neocleon																					
Parameletus																					
Rhithrogena	5	2	2	1			7	4	2										1	1	1
Siphloplecton				1																	
Tricorythodes		1																			
PLECOPTERA																					
Acroneuria						1															
Classenia	2	1	1													1					
Hastaperla						1					1										
Isogenus	50	13	15		14	8	158	160	69	38	83	37				2					
Isoperla	77	26	50	18	105	98	38	39	58	44	70	88	29	36	36	46	64	90	9	12	13
Pteronarcella																					
Pteronarcys		1				1	1	1				1			1	1		2	3	1	
TRICHOPTERA																					
Brachycentrus	7	1	2			1		3			3	2	5		1		2	1	1	7	1
Cheumatopsyche	68	21	27	5	10	9	110	67	38	22	37	14	3	2	3	26	33	19	6	16	24
Glossosoma																					
Glossosomatidae																					
Hydropsyche	146	21	68	1	7	14	65	70	41	146	150	22	6	5	10	14	10	4	5	59	70
Limnophilidae																					
Neureclepsis																					
Platycentropus																					
Psychomyiidae		1																			
HEMIPTERA																					
Corixidae																					
ODONATA																					
Ophiogomphus					3	5	6	7	14	1	5	1					4	4	2	2	3
GASTROPODA				1	8	7			2	1	4		1								
HIRUDINEA																					
Glossiphonidae																					
PELECYPODA																					
OLIGOCHAETA																					
Gordidae																					
Naididae			2	5	4	5	1	7	3	4	5	8	2	7	4	3		1		9	6
TOTAL	483	110	221	49	210	236	455	446	284	338	464	255	78	71	92	117	138	181	51	161	145
SUM TOTAL			814			495			1185			1057			241			436			357
NO. OF TAXA			16			18			16			16			11			14			12
DIVERSITY INDEX			2.91			2.74			2.88			2.95			2.93			2.43			2.87

APPENDIX 18 - Benthic Macro-invertebrates collected from the Athabasca River July 7-8, 1981

TAXA \ Site Location	-20			40			80			120			180			200			240		
Sample No.	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
COLEOPTERA																					
Agabus																					1
Gyrinus																					
Heleophorus																					
Hydaticus											1										
Optioservus							1														
Oreodytes																					
DIPTERA																					
Atherix																					1
Ceratopogonidae									2												
Chelifera							1														
Chironomidae	19	6	8	11	14	32	93	45	89	39	18	27	30	17	27	61	13	17	73	40	59
Dolichopodidae																					
Erioptera																					
Helius																					
Hemerodromia							1														
Hexatoma																					
Muscidae																					
Simulium													1		2	9	2	9	6	45	8
Tipula																					
EPHEMEROPTERA																					
Ametropus																					
Baetis	58	51	66	17	2	4	37	16	30	42	17	19				3				1	
Baetodes																					
Caenis													1								
Centroptilum												2									
Cinygma																					
Cinygmula																					
Epeorus																					
Ephemerella		2	1		1		2	3	5	1	4		2	2	5	3	2		6	2	4
Ephoron							4	3	3	1	1	1									
Heptagenia	30	48	27	20	13	27	52	43	41	78	40	63	11	2	12	14	4	10	10	8	11
Hexagenia																					
Isonychia		4		1	1	4	7	10	15	4	4	10									
Leptophlebia																					
Metretopus																					
Neocloeon																					
Parameletus																					
Rhithrogena	3	1	1	2			15	6	2	4	2	1									
Siphloplecton													1								
Tricorythodes									1								1				
PLECOPTERA																					
Acroneuria																					
Classenia									1												1
Hastaperla		1																			
Isogenus	15	24	15	17	4	8	233	160	226	156	71	68	1			5	1				2
Isoperla	49	101	63	51	35	61	105	95	85	53	65	82	7	17	32	7	6	3		1	1
Pteronarcella																					
Pteronarcys	1																		1	4	3
TRICHOPTERA																					
Brachycentrus						1			2	3		2				1				1	
Cheumatopsyche		1	1	3	1	1	126	31	44	26	9	18	2	1		10	2	4	15	14	21
Glossosoma																					
Glossosomatidae																					
Hydropsyche	4	2	7	3		2	133	38	96	96	45	101	11	9	20	16	3	2	53	78	100
Limnophilidae																					
Neureclepsis																					
Platycentropus																					
Psychomyiidae																					
HEMIPTERA																					
Corixidae																					
ODONATA																					
Ophiogomphus		2		2	2	4	26	26	31	3	2	2	2			2		3	1	2	3
GASTROPODA				3			9	3	1	6	2	3									
HIRUDINEA																					
Glossiphonidae																					
PELECYPODA								1													
OLIGOCHAETA																					
Gordidae	2						3					2							1		
Naididae			1	5	16	2	3		1	8	4	9	7	2		5		1	2	2	4
TOTAL	181	243	190	135	89	146	851	480	675	520	285	410	76	50	98	136	34	49	168	198	219
SUM TOTAL			614			370			2006			1215			224			219			585
NO. OF TAXA			15			14			23			18			12			13			17
DIVERSITY INDEX			2.40			2.68			3.02			3.01			2.61			2.86			2.40

APPENDIX 19 - Benthic Macro-invertebrates collected from the Athabasca River July 14-15, 1981

TAXA \ Site Location	-20			40			80			120			180			200			240		
Sample No.	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
COLEOPTERA																					
Agabus																					
Gyrinus																					
Heleophorus																					
Hydaticus																					
Optioservus	1																				
Oreodytes																				1	
DIPTERA																					
Atherix																					
Ceratopogonidae							1										1				
Chelifera																					
Chironomidae	31	34	26	24	32	31	13	29	43	20	11	10	32	70	14	6	28	76	10	14	15
Dolichopodidae																					
Erioptera																					
Helius																					
Hemerodromia			1																		
Hexatoma																					
Muscidae																					
Simulium	1		2			5						1	7	3	20	5	5	18	19	26	38
Tipula																					
EPHEMEROPTERA																					
Ametropus																					
Baetis	7	18	32	4	7	13	25	43	57	9	13	6	23	16	71	5	5	6	1	2	7
Baetodes																					
Caenis														1							
Centroptilum																					
Cinygma																					
Cinygmula																					
Epeorus																					
Ephemerella	2		2	1			1	7	1		2		1	1	2		2		2	5	6
Ephoron					1							2									
Heptagenia	52	43	46	15	25	74	43	67	81	60	71	31	13	25	18	13	21	26	7	2	14
Hexagenia																					
Isonychia	5	8	7	1	3	6	5	6	11	10	7	16									
Leptophlebia																					
Metretopus					1	1															
Neocleon																					
Parameletus																					
Rhithrogena	4	2	6	3		2	10	11	11	4	15	2	1		1		1	2			2
Siphloplecton																					
Tricorythodes													1					1			
PLECOPTERA																					
Acroneuria																					
Classenia									1												
Hastaperla																					
Isogenus	71	25	73	23	11	31	100	136	175	81	103	62				3	3	3			
Isoperla	48	13	21	22	29	16	13	20	23	10	30	5	14	11	17	1	2	1		1	1
Pteronarcella																					
Pteronarcys	1	1	1						2	1		2	1								2
TRICHOPTERA																					
Brachycentrus	1	1	2			1	2						4		8	3	2	1			6
Cheumatopsyche	51	24	34	6	11	24	46	91	74	62	14	3		2		8	29	23		3	12
Glossosoma								1		2											
Glossosomatidae																					
Hydropsyche	108	71	87	5	1	3	35	53	69	99	46	27	11	5	9	8	14	7	2	17	64
Limnophilidae																					
Neureclepsis																					
Platycentropus			1																		
Psychomyiidae																					
HEMIPTERA																					
Corixidae																					
ODONATA																					
Ophiogomphus	1			1	5	1	4	14	30	11	3			2			3	5		2	3
GASTROPODA				8	5	8		2	1	3	6	4	1							1	
HIRUDINEA																					
Glossiphonidae									1												
PELECYPODA																					
OLIGOCHAETA																					
Gordidae																					
Naididae	2			1			1		2	7		2	11	2			3	20	1	1	1
TOTAL	386	240	341	114	131	216	299	480	582	379	321	173	120	138	160	52	119	189	42	75	169
SUM TOTAL			967			461			1361			873			418			360			286
NO. OF TAXA			18			17			19			17			16			15			15
DIVERSITY INDEX			2.94			3.07			2.99			2.99			2.82			2.99			2.75

APPENDIX 20 - Benthic Macro-invertebrates collected from the Athabasca River August 5-6, 1981

TAXA \ Site Location	-20			40			80			120			180			200			240		
Sample No.	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
COLEOPTERA																					
Agabus																					
Gyrinus																					
Heleophorus																					
Hydaticus																					
Optioservus																					
Oreodytes																					
DIPTERA																					
Atherix																					
Ceratopogonidae																					
Chelifera																					
Chironomidae		1	1			4	1		3		3		3	2	4			7		2	5
Dolichopodidae					2		4				1	3	2		1						
Erioptera														1							
Helius																					
Hemedromia																					
Hexatoma																					
Muscidae													1								
Simulium													1					1			
Tipula																					
EPHEMEROPTERA																					
Ametropus								1										4			
Baetis	2	12	8	6	6	14	9	19	11	4	2	13	4	9	31		6	22		14	26
Baetodes																					
Caenis																					
Centroptilum																		1			1
Cinygma																					
Cinygmula																					
Epeorus																					
Ephemerella									1												
Ephoron																					
Heptagenia	18	20	8	14	19	30	4	24	34	3	8	1	20	20	14		31	157		55	83
Hexagenia																					
Isonychia	1	6	2																		
Leptophlebia																(a)			(b)		
Metretopus																					
Neocleon																					
Parameletus				1																	
Rhithrogena	6	18	12					3	4	2			2		3		8	36		16	44
Siphloplecton																					
Tricorythodes												1						2			1
PLECOPTERA																					
Acroneuria																					
Classenia	2	1	1																		
Hastaperla	1																				
Isogenus	106	90	85	25	12	21	11	44	39	39	47	20	6	5	13		93	249		22	20
Isoperla															2		1			1	1
Pteronarcella																					
Pteronarcys			1															1		1	3
TRICHOPTERA																					
Brachycentrus		1																		2	1
Cheumatopsyche	35	48	33	3	4	2	1	4	10	2	2	3			1		1	50		4	5
Glossosoma																					
Glossosomatidae																					
Hydropsyche	61	96	94				1		2	6	11						1	5		5	4
Limnophilidae																					
Neureclepsis																					
Platycentropus																					
Psychomyiidae																					
HEMIPTERA																					
Corixidae																					
ODONATA																					
Ophiogomphus			1	2	1		1	3		5	1	2	1		2						1
GASTROPODA							2		6		1									3	4
HIRUDINEA																					
Glossiphonidae																					
PELECYPODA																					
OLIGOCHAETA																					
Gordidae																					
Naididae		1		3	1			1				1		5	1						4
TOTAL	232	294	246	54	45	71	21	99	110	61	76	44	40	42	72		144	535		125	205
SUM TOTAL			772			170			230			181			154			679			330
NO. OF TAXA			14			9			13			12			13			13			15
DIVERSITY INDEX			2.26			2.33			2.15			2.17			2.54			2.01			2.67

* (a) Sample lost.
* (b) Sample lost.

APPENDIX 21 - Benthic Macro-invertebrates collected from the Athabasca River August 26-27, 1981

TAXA \ Site Location	-20			40			80			120			180			200			240		
Sample No.	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
COLEOPTERA																					
Agabus																					
Gyrinus																					
Heleophorus																					
Hydaticus																					
Optioservus																					
Oreodytes																					
DIPTERA																					
Atherix	1							1			1									4	
Ceratopogonidae																					
Chelifera																					
Chironomidae	1	2	2	2	3	4	2	2	3	2	2	5	1	2	1	4	1	1			
Dolichopodidae																					
Erioptera																					
Helius																					
Hemedromia		11								2		4				10	3	1	30	4	9
Hexatoma																					
Muscidae																					
Simulium																					
Tipula																					
EPHEMEROPTERA																					
Ametropus																					
Baetis	28	15	9	1	3	3	19	16	24	16	24	10	1	3	2	9	8	5	3		2
Baetodes												1									
Caenis																					
Centroptilum																					
Cinygma												1									
Cinygmula							2														
Epeorus																					
Ephemerella												2							1		1
Ephoron							1					1									
Heptagenia	25	64	25	18	10	38	33	48	50	24	47	37	21	14	11	24	35	51	22	22	24
Hexagenia																					
Isonychia																					
Leptophlebia																					
Metretopus																					
Neocleon		1																			
Parameletus																					
Rhithrogena	36	51	22	4	1	3	28	21	12	31	25	34	4	8	2	48	42	66	43	19	35
Siphloplecton				10		12		1	1									1			
Tricorythodes																					
PLECOPTERA																					
Acroneuria		1																			
Classenia																					
Hastaperla																					
Isogenus	42	70	54	14	11	24	55	57	71	12	70	58	35	22	31	85	64	68	112	98	179
Isoperla																					
Pteronarcella																					
Pteronarcys	1	2						1	1	1	3			1		2	4		2	1	1
TRICHOPTERA																					
Brachycentrus	1				2			2	1	1	1		3	4		4	2	5	29	10	11
Cheumatopsyche	80	237	81	112	98	230	377	415	420	165	439	487	9	16	6	932	266	319	91	22	40
Glossosoma																					
Glossosomatidae																					
Hydropsyche	69	91	82	2	4	1	18	16	21	47	67	63	23	18	9	115	46	29	84	56	85
Limnophilidae						1				1									2		1
Neureclepsis														1							
Platycentropus																					
Psychomyiidae																					
HEMIPTERA																					
Corixidae																					
ODONATA																					
Ophiogomphus		1		2	3	6	9	16	17	7	9	12	5		1	6		8	6	3	5
GASTROPODA		1		6	5	8	2	11	15	1		7		1	2				4	5	
HIRUDINEA																					
Glossiphonidae							1														
PELECYPODA																					
OLIGOCHAETA																					
Gordidae																					
Naididae				5	7	7		1			2	6		1	1		1		2		5
TOTAL	284	547	275	176	147	313	547	608	636	310	690	728	102	91	66	1239	472	554	431	244	398
SUM TOTAL			1106			636			1791			1728			259			2265			1073
NO. OF TAXA			15			13			17			19			13			13			15
DIVERSITY INDEX			2.97			1.60			1.80			1.99			2.75			1.74			2.72

BARREL TRAP

Date	A	B	C	D	Mean ($\overline{x}$) (B, C, D)	Std. Dev.
June 4	-	-	1	0	0.5	0.7
June 11	-	4	2	0	2.0	2.0
June 17	35	6	3	3	4.0	1.7
June 25	168	23	2	10	11.7	10.6
July 2	276	28	7	9	14.7	11.6
July 9	295	27	22	15	21.3	6.0
July 16	362	44	40	101	61.7	34.1
July 23	-	196	420	641	419.0	222.5
July 30	6898	784	227	585	532.0	282.3
Aug. 6	3840	382	122	286	263.3	131.5
Aug. 13	3733	85	196	562	281.0	249.6
Aug. 20	2323	103	104	237	148.0	77.1
Aug. 28	386	31	14	36	27.0	11.5
Sept. 3	692	12	6	11	9.7	3.2
Sept. 10	640	86	23	42	50.3	32.3
Sept. 17	73	1	2	6	3.0	2.6
Sept. 24	-	5	1	26	10.7	13.4

Appendix 22 - Barrel trap sample data - 1981

Appendix 23. Results and discussion - Sediment residue samples.

The results of sediment samples collected during 1981 are presented in the following table. The samples were analyzed by the Alberta Environmental Centre in Vegreville. A series of replicate samples collected on June 22/23 and June 29/30 were also analyzed by the Food Lab of Alberta Agriculture in Edmonton.

The results do not show any large accumulations of methoxychlor residues in the sediment at any sample location in the Athabasca River over the summer. However, the results do show that low concentrations of methoxychlor were found at the control site(s). This is consistent with Charnetski and Depner's (1980) findings that background levels of about 4.0 ppb of a chemical (not suspected to be methoxychlor) is present in the Athabasca River upstream and downstream of the treatment sites.

SEDIMENT SAMPLES - 1981

Sample Dates	DISTANCE FROM ATHABASCA (km downstream) Control 40	80	120	160	180	200	Fort McMurray 8 km u/s	Bridge
	Treatment at 60 km on May 20							
May 21	0.2	16.0	ND	ND	ND	---		
	Treatment at 160 km on May 21							
May 23							---	ND
May 24							17.2 at 05:25	13.1 at 05:55
							14.0 at 11:55	4.4 at 14:00
May 25/26	ND	ND	12.1	6.9	9.0	16.6		
June 2/3	ND	2.9	5.1	5.4	5.9	7.7		
June 9/10	ND	ND	12.3	2.1	2.1	3.1		
June 18/19	6.1	ND	8.6	4.9	ND	---		
	Treatment at 145 km on June 19 0.2 ppm for 15 min.							
June 22/23	6.1 (ND)*	8.1	6.2 (ND)*	7.7	6.5 (3.0)*	6.8 (7.0)*		
June 29/30	5.0 (ND)*	3.8	ND (ND)*	5.4	--- (1.0)*	9.9 (2.0)*		
July 7/8	1.1	ND	2.1	ND	ND	4.2		
July 14/15	1.4	0.7	2.6	ND	ND	ND		
Aug. 5/6	1.8	1.5	1.6	---	1.3	0.3		
Aug. 26/27	ND	ND	ND	3.2	ND	2.8		

ND - not detectable at a level of 0.5 ppb (AEC)
(ND)* - not detectable at a level of 0.2 ppb (Food Lab)
( )* - Food Lab analysis of replicate samples

All results expressed in ppb (parts per billion), wet weight basis.