Effects of stream-crossing by a pipeline on the benthic macroinvertebrate communities of a small mountain stream[1]

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Abstract

Aquatic environmental impact associated with stream-crossing by a pipeline was monitored at Archibald Creek, B.C. for two years. Water chemistry and benthic macroinvertebrates were used as monitoring tools. Results indicated that impacts arising from stream-crossing were short-term and non-residual.

Introduction

During the construction of the East Kootenay Link gas pipeline from Oasis to Yahk, British Columbia, several streams and rivers were traversed by the pipeline. This offered an opportunity to: 1) monitor and determine the effects of pipeline construction and stream-crossing activities on the benthic macroinvertebrate communities of a small stream; and 2) evaluate the use of zoobenthos as bioindicators of aquatic impacts related to pipeline constructions and stream-crossings.

Materials and methods

Study area

The pipeline crossing at Archibald Creek, British Columbia (49° 11′N; 117° 26′W) was chosen as the study site. Archibald Creek is a typical small mountain stream with widths of 4–5 m in the study area. The stream is fast-flowing with a summer discharge of 0.232 m^3/sec and the substrate is mainly cobble and gravel. The stream banks are heavely vegetated, stable and slightly undercut, however, there is no evidence of slumping. Fish inhabiting the stream include brook trout and rainbow trout.

Sampling program

Benthic macroinvertebrates were sampled from 4 stations. Station 1 (Control) was located 40 m upstream of the pipeline crossing, and Stations 2, 3 and 4 were 10 m, 75 m, and 100 m downstream of the pipeline crossing. Three replicate samples were taken at each station, with a 250 μ netting Surber. Similar substrate (stones 15–20 cm in diameter), velocity (0.3-0.5 m/sec), and depth (10–20 cm) were chosen for each sample.

Water samples preserved with Thymerosol were analyzed in the laboratory for turbidity (Hach Turbidimeter, Model 2100A) and suspended sediments.

Table 1 summarizes the timing of the zoobenthic and water quality sampling efforts in relation to major pipeline construction and maintenance activities.

Results

Water quality

Archibald Creek was crossed on September 19

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Table 1. Dates of major pipeline construction and maintenance activities, zoobenthos and water quality sampling at Archibald Creek, B.C., 1974 June – 1976 October 30.

Date	Pipeline construction activity	Zoobenthic sampling	Water quality sampling
1974 June	Survey cut-line cleared	–	–
1974 July	Clearing pipeline right-of-way	–	–
1974 August	Grading right-of-way	–	–
1974 Sept. 5	–	–	–
1974 Sept. 19–20	Trenching, pipe laying, and back-filling	–	+
1974 Sept. 21	Trenching, pipe laying, and back-filling	+ (Taken 12 hrs. after back-filling was completed)	+
1974 Nov. 5	–	+	+
1975 July	Final clean-up of right-of-way	–	-
1975 July 22	-	+	+
1975 August	Seeding of right-of-way for revegetation	–	-
1976 Oct. 30	–	+	–

– no samples taken
\+ samples taken

and 20, 1974. Trenching was done with a track-mounted P&H hydraulic hoe. Materials removed from the stream bed were deposited upstream, alongside the trench. After the pipe was laid, two machines were used in back-filling, a front-end loader and a caterpillar tractor. After trenching and backfilling were completed, the stream bottom at Station 1 (control) remained clean. At Station 2 (10 m downstream from the crossing), there was an extensive accumulation of silt and sand of the stream bed. At Station 3, there was a deposition of fine material (20–50 mm deep) over most of the stream bed. Station 4 remained relatively clean with only a thin coating (<1 mm) of silt in some areas. On November 5, 1974, there was no noticeable sedimentation at Station 1. Silt and sand still covered most of the bottom at Station 2, 10–20 mm deep in most places. At Station 3, silt covered most rocks up to a depth of 1 mm. At Station 4, there was only slight evidence of sedimentation (<1 mm). On the last visit in October 30, 1976, no signs of sedimentation can be observed at any of the sampling stations.

Data on turbidity and suspended solids of the water taken between September 9, 1974 to July 22, 1975 are summarized in Table 2.

Benthic macroinvertebrates

Benthic macroinvertebrate samples were analyzed for their species compositions and standing crops (number of organisms/m^2) and summarized by the Shannon-Weaver Species Diversity Index $\bar{d}$ (Shannon & Weaver, 1959). (Table 3).

Since Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) are the major components of the Archibald Creek benthic community, they were further analyzed and their standing crop data are presented in Figure 1, and Table 4.

Discussion

Stream sedimentation is the single most significant biological impact associated with the

Table 2. Turbidity (FTU) and suspended sediments (mg/l) from Stations 1, 2, 3, and 4 in Archibald Creek, B.C., September 5, 1974 – July 22, 1975.
The pipeline crossing was location 10m upstream from Station 2.

Date	Station 1 (control)		Station 2		Station 3		Station 4	
	Turbidity	Suspended sediments	Turbidity	Suspended sediments	Turbidity	Suspended sediments	Turbidity	Suspended sediments
1974 Sept. 5	0.5	0	0.85	0	1.2	4.0	2.2	7.0
1974 Sept. 19	0.7 (0905 hr)	7.0	4000.0 (0820 hr)[a]	7620.0	2100.0 (0910 hr)	3770.0	1650.0 (0915 hr)	2250.0
1974 Sept. 19	0.9 (1230 hr)	0	2800.0 (1220 hr)	6250.0	1400.0 (1240 hr)	2430.0	1450.0 (1245 hr)	2405.0
1974 Sept. 20	–	–	4.7 (0100 hr)[b]	9.0	–	–	–	–
1974 Sept. 20		–	350.0 (1130 hr)	456.0	–	–	–	–
1974 Sept. 20	–	–	5000.0 (1615 hr)[c]	10,660.0	–	–	–	–
1974 Sept. 21	2.3 (0800 hr)	0	0.7 (0900 hr)	0	–	–	5.6 (0700 hr)	11.0
1974 Nov.5	0.7	3.4	3.1	8.5	2.3	6.3	4.1	9.9
1975 July 22	–	–	0.61	2.9	–	–	–	–

[a] Trenching started
[b] No construction activity
[c] Back-filling

Table 3. The effects of pipeline crossing and related construction activities on the benthic macroinvertebrate communities of Archibald Creek, B.C. Station 1(Control) was 40m upstream of the crossing; Stations 2, 3, & 4 were 10m, 75m, and 100m downstream of the crossing respectively.

	Date	(Control) Station 1	Station 2	Station 3	Station 4
Shannon-weaver species diversity index ($\bar{d}$)	1974 Sept. 5	4.1265	3.9860	3.9584	3.4398
	1974 Sept. 21*	3.8667	4.1260	3.4883	3.7102
	1974 Nov. 5	3.8614	2.7336	3.8564	3.4182
	1975 July 22	3.8752	3.6336	3.5540	3.7805
	1976 Oct. 30	3.2161	3.0432	2.9629	3.2327
Total number of benthic invertebrate taxa	1974 Sept. 5	26	27	28	29
	1974 Sept. 21*	29	30	28	27
	1975 Nov. 5	36	19	24	24
	1975 July 22	31	26	28	29
	1976 Oct. 30	29	30	28	31
Standing crop (No./m^2)	1974 Sept. 5	1,666	1,497	717	1,279
	1974 Sept. 21*	2,523	1,233	1,186	1,953
	1974 Nov. 5	1,896	498	598	946
	1975 July 22	1,799	1,247	1,097	914
	1976 Oct. 30	2,792	2,212	2,130	1,872

* 12 hrs. after trenching, pipe-laying, and back-filling.

Table 4. Effects of stream crossing and related pipeline construction activities on the standing crops (no./m²) of the dominant Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) species in Archibald Creek, B.C. September 5, 1974 – October 30, 1976.

Taxon	(Control) Station 1	Station 2	Station 3	Station 4
Ephemeroptera				
Baetis spp.				
1974 Sept. 5	180	122	51	97
1974 Sept. 21	143	96	54	82
1974 Nov. 5	107	14	32	32
1975 July 22	93	72	58	43
1976 Oct. 30	283	197	161	96
Cinygmula sp.				
1974 Sept. 5	39	22	82	0
1974 Sept. 21	297	100	354	401
1974 Nov. 5	390	43	97	218
1975 July 22	315	243	215	111
1976 Oct. 30	82	190	390	290
Epeorus (Ironopsis) sp.				
1974 Sept. 5	25	65	11	43
1974 Sept. 21	75	14	0	29
1974 Nov. 5	64	0	0	0
1975 July 22	175	93	125	179
1976 Oct. 30	0	4	7	7
Rhithrogena sp.				
1974 Sept. 5	172	108	104	79
1974 Sept. 21	308	118	143	158
1974 Nov. 5	247	39	57	165
1975 July 22	0	0	0	18
1976 Oct. 30	247	261	118	211
PLECOPTERA				
Alloperla sp.				
1974 Sept. 5	226	125	57	5
1974 Sept. 21	304	129	204	147
1974 Nov. 5	107	68	75	43
1975 July 22	107	25	0	0
1976 Oct. 30	147	61	115	107
Brachyptera sp.				
1974 Sept. 5	0	365	8	426
1974 Sept. 21	483	143	90	190
1974 Nov. 5	261	29	47	0
1975 July 22	0	0	0	0
1976 Oct. 30	705	999	927	738
Eucapnosis sp.				
1974 Sept. 5	104	122	7	7
1974 Sept. 21	64	21	0	100
1974 Nov. 5	54	72	0	0
1975 July 22	32	11	21	21
1976 Oct. 30	29	75	39	14
Nemoura (Zapada) sp.				
1974 Sept. 5	151	90	82	11
1974 Sept. 21	186	57	36	354
1974 Nov. 5	200	21	39	25
1975 July 22	75	4	14	32
1976 Oct. 30	0	7	0	39
TRICHOPTERA				
Rhyacophila sp.				
1974 Sept. 5	115	39	11	4
1974 Sept. 21	122	43	54	50
1974 Nov. 5	32	0	25	32
1975 July 22	50	43	25	25
1976 Oct. 30	93	47	47	39

construction of pipeline across stream. Sedimentation could arise during:

1. *Construction Phase*
   a. Survey cutline
   b. Clearing of right-of-way
   c. Grading
   d. Trenching
   e. Back-filling
2. *Operating and Maintenance Phases*
   a. Erosion from right-of-way
   b. Traffic across stream on right-of-way

Silt deposited in the stream bed could physically smother the benthic invertebrates and also reduce the intra gravel habitat. When in suspension, silt could have an abrasive effect on the benthos and

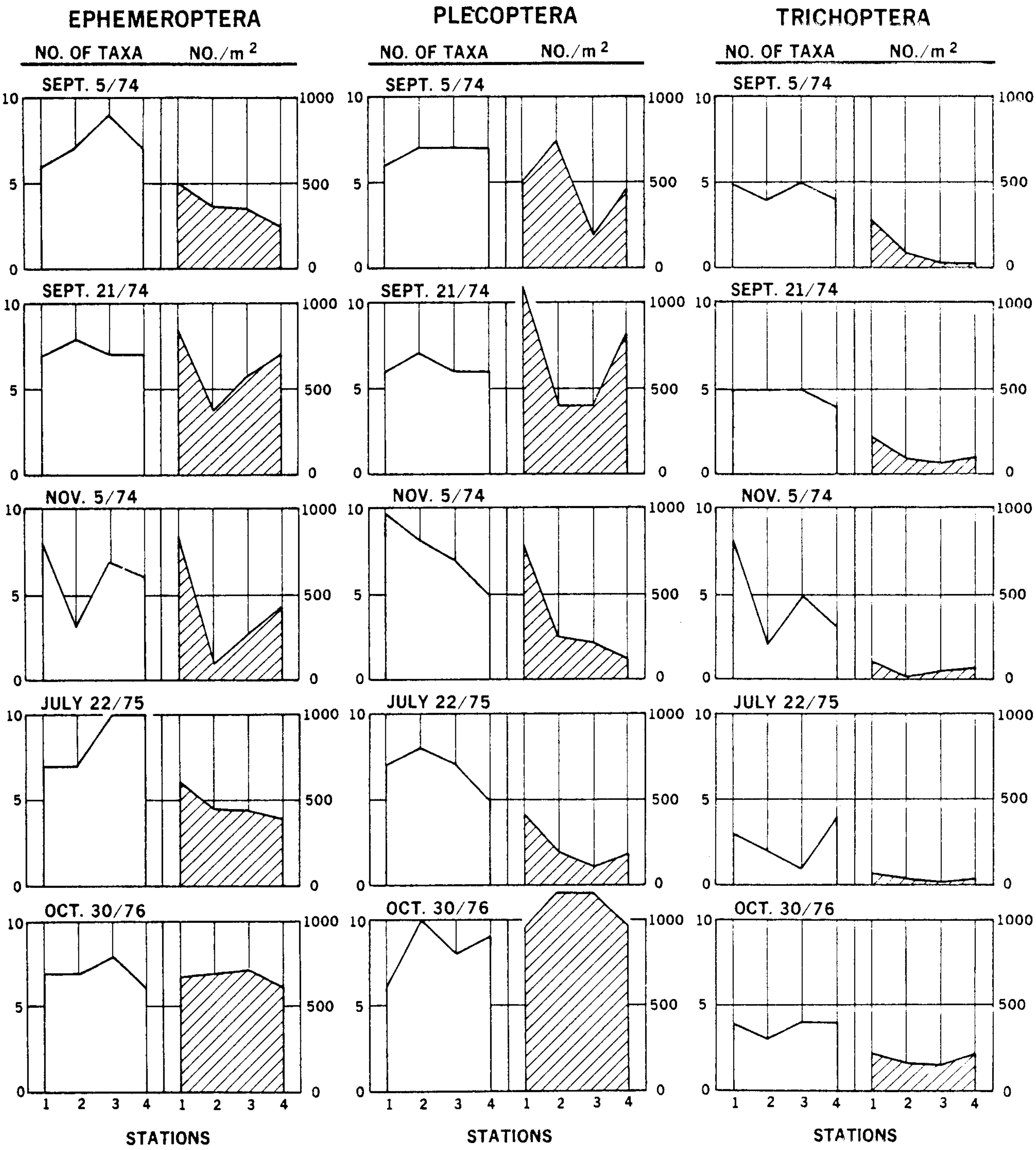

Fig. 1. Effect of stream crossing and related pipeline construction activities on the taxonomic diversity (number of taxa) and the standing crop (number/m²) of the Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) in Archibald Creek, B.C., September 5, 1974 – October 30, 1976.

interfere with the respiratory and feeding activities of the benthic animals.

Based on results obtained from this study, it appeared that stream-crossing by pipeline had a short-term effect on the water quality of the stream (Table 2). A general reduction in the Shannon-Weaver Species diversity indices of benthic communities downstream from the crossing was observed. However, this reduction was subtle and statistically insignificant (Table 3). An actual increase in species diversity occurred at Station 2 twelve hours after trenching was completed. This was probably due to a disproportionate reduction in the densities of the common and rare benthic taxa resulting in a more 'even' community and thus a higher diversity index value (Gammon, 1970; Rosenberg and Snow, 1975). Similarly, taxonomic diversities (i.e. total number of invertebrate taxa) was not significantly different for upstream and downstream stations except during the winter period of November 5, 1975 (Table 3, Figure 1). Effects of siltation on the benthos were probably more critical during the low flow period in winter.

Substantial reduction of benthic standing crop was, however, noted at downstream stations; up to 74% reduction in winter at station 2 (Tables 3–4, Figure 1). This appears to be a typical response of benthic communities to non-toxic or inert pollutants (Warren, 1971). Standing crop data from October 30, 1976 also indicated a recovery trend in the benthic communities at the downstream stations.

Among the mayflies (Ephemeroptera), potential indicator species, i.e. those showing a negative response to sedimentation, include *Baetis* spp., *Cinygmula* sp., *Epeorus (Ironopsis)* sp., and *Rhithrogena* sp. (Table 4). Most of these species possess large gill surface areas which apparently make them susceptible to high silt loadings. Stoneflys (Plecoptera) species showing a negative response to silt included *Alloperla* sp., *Brachyptera* sp., *Eucapnosis* sp., and *Nemoura (Zapada)* sp. (Table 4). Among the caddisflies (Trichoptera), *Rhyacophila* sp. appeared to be most sensitive to sedimentation. Data for the mayflies and stonefiles obtained from October 30, 1976 indicated a definite recovery trend (Figure 1, Table 4), except *Rhyacophila* sp. (Caddisfly) which showed a slower recovery rate.

Based on the response of benthic communities observed in this study, it appeared that stream-crossing by pipeline can have an impact on the water quality and biota of the stream. However, the nature of this impact is both short-term and non-residual. Proper post-construction stream bank protection and erosion control will substantially reduce the ecological impacts of stream-crossings.

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