WATER QUALITY AND AQUATIC HABITAT ASSESSMENTS OF GOLDSTREAM CREEK DRAINAGE

Prepared for Tanana Chiefs Conference

by
Phyllis K. Weber
and
Matthew H. Robus

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Don W. Collinsworth
Commissioner

Bruce H. Baker
Acting Director

Department of Fish and Game
Division of Habitat
P.O. Box 3-2000
Juneau, Alaska 99802-2000

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EXECUTIVE SUMMARY

Since the early 1900's, the Goldstream Valley near Fairbanks has been mined for placer gold. At one time, hydraulic stripping and dredging operations moved massive quantities of overburden and gravel, changing the character of the Goldstream Valley and washing large quantities of fine sediments down Goldstream Creek. It is believed that approximately 14.3 million cubic yards of mud and silt were flushed down the creek. This amount of sediment would fill an area of approximately two square miles to a depth of 50 feet.

Except for a lull during the second world war, placer mining has continued along Goldstream Creek since the early gold discovery in 1902. Placer gold mining in the Goldstream Valley resulted in an almost constant input of sediment to Goldstream Creek and its headwater tributaries. Much of the sediment load carried by Goldstream Creek is eventually deposited in the stream channel and in Minto Flats.

This study investigated the sources and quantities of point and non-point source sediment pollution to Goldstream Creek. The study also considered fish use and fish habitat suitability of the creek, as affected by sediment pollution.

Our study showed that Goldstream Creek and its headwater tributaries have constantly elevated turbidity and total suspended sediment loads. During periods when there is no active mining, resuspension of sediments deposited in previous mining seasons causes the water to remain turbid. Suspended sediment levels are especially high during spring high water flows and during periods of active mining.

Fish populations in the upper part of the Goldstream Creek drainage appear to have been reduced since the resurgence of placer mining in the late 1970's. Anecdotal information suggests that arctic grayling populations were higher in the mid-1970's to early 1980's, before the resurgence of mining, than they are today. High stream water turbidities combined with elevated settleable solids levels and the resultant deposition on streambeds have probably been major factors responsible for reducing fish populations and angler success in the upper portion of the drainage.

There were not sufficient baseline data to determine if or to what extent fishery resources in Minto Flats may have been affected by the input of sediment from placer mining. Various investigators have stated that the infilling of Minto Lakes have resulted in improved summer rearing habitat for fish and the possible elimination of overwintering habitat.

Navigation in Goldstream Creek in Minto Flats is currently limited during low water by mud shallows in Bridge Lake and possibly by mud shallows in Sixmile Lake. Deposition in these lakes is believed to have resulted from dredging and hydraulic stripping in the upper portion of the drainage.

This study also investigated the Goldstream Creek drainage for the presence of toxic metals that may be associated with placer mining. Water samles for toxic metals were collected from the headwaters to the mouth and sediments were collected from the stream channel and from Minto Lake. Information on heavy metals content will be included in a later supplement to this report.

INTRODUCTION

The Goldstream Valley near Fairbanks, Alaska has been mined since gold was first discovered on Pedro Creek in 1902. Hydraulic giants and dredges were commonly used for stripping and mining until the 1950's, and much of the fine silts and sediments from overburden were flushed down Goldstream Creek. Mining operators relocated and channelized at least two sections of Goldstream Creek. Goldstream Creek between Sheep Creek Road and Dunbar is a deeply incised, tightly meandering stream. Below Dunbar, the creek becomes straighter with broad meanders. Goldstream Creek in Minto Flats flowed into Minto Lake until the lake inlet filled with sediment and the stream relocated entirely to a channel west of Big Minto Lake. Aerial photos indicate that this change occurred prior to 1954. Although downcutting and channel relocation are natural phenomena of stream dynamics, the occurrence of these events may have been accelerated by elevated sediment loads and increased velocities associated with decreased stream length.

Placer gold mining in the Goldstream Valley resulted in an almost constant input of sediment to Goldstream Creek and its headwater tributaries. These sediments often become deposited on the streambed, and are resuspended during higher flow periods. As a consequence of mining and resuspension, Goldstream Creek remains turbid throughout the ice free season. Much of the sediment load carried by Goldstream Creek is eventually deposited in the stream channel and in Minto Flats where the creek becomes a low gradient, low energy system.

Shepherd and Matthews (1986) reported that siltation in Minto Flats was a major reason for declines in many species of fish and wildlife. Streams flowing into some lakes have filled with sediment and relocated, eliminating the sources of water to the lakes. Lakes have also filled with sediment or become shallower, shortening their natural life. Drying of lakes and closing of lake inlets is said to have contributed to the loss of muskrat and blackfish. The decline in muskrat populations appears to result from habitat deterioration, including siltation, gradual drying, and other habitat changes associated with siltation. Shepherd and Matthews also reported that Minto residents complained of spruce, birch, and willow trees dying as a result of the silt and mud deposition.

The fish and wildlife resources of Minto Flats may be affected by both short-term and long-term effects of placer gold mining in the Goldstream Valley. Sediment may be originating from both point and non-point sources. For example, sediment may be from currently active mines and from non-point sources such as resuspension of the streambed or erosion from abandoned mine sites. Heavy or pollutant metals, often associated with gold bearing areas, may also be detrimentally affecting fish and wildlife resources.

OBJECTIVES OF STUDY

The objectives of this study are to determine sources and quantities of point and non-point sediment pollution to Goldstream Creek and to determine fish use and fish habitat suitability of the creek, as affected by sediment pollution.

MATERIALS AND METHODS

The water quality of the Goldstream Creek drainage was sampled in the headwater tributary streams, Pedro and Gilmore creeks, downstream to the mouth of Goldstream Creek in Minto Flats. Fish presence was determined in Goldstream Creek above Ballaine Road and in Minto Flats, from the mouth to 23 km upstream. Locations of sampling sites are shown in Figure 1.

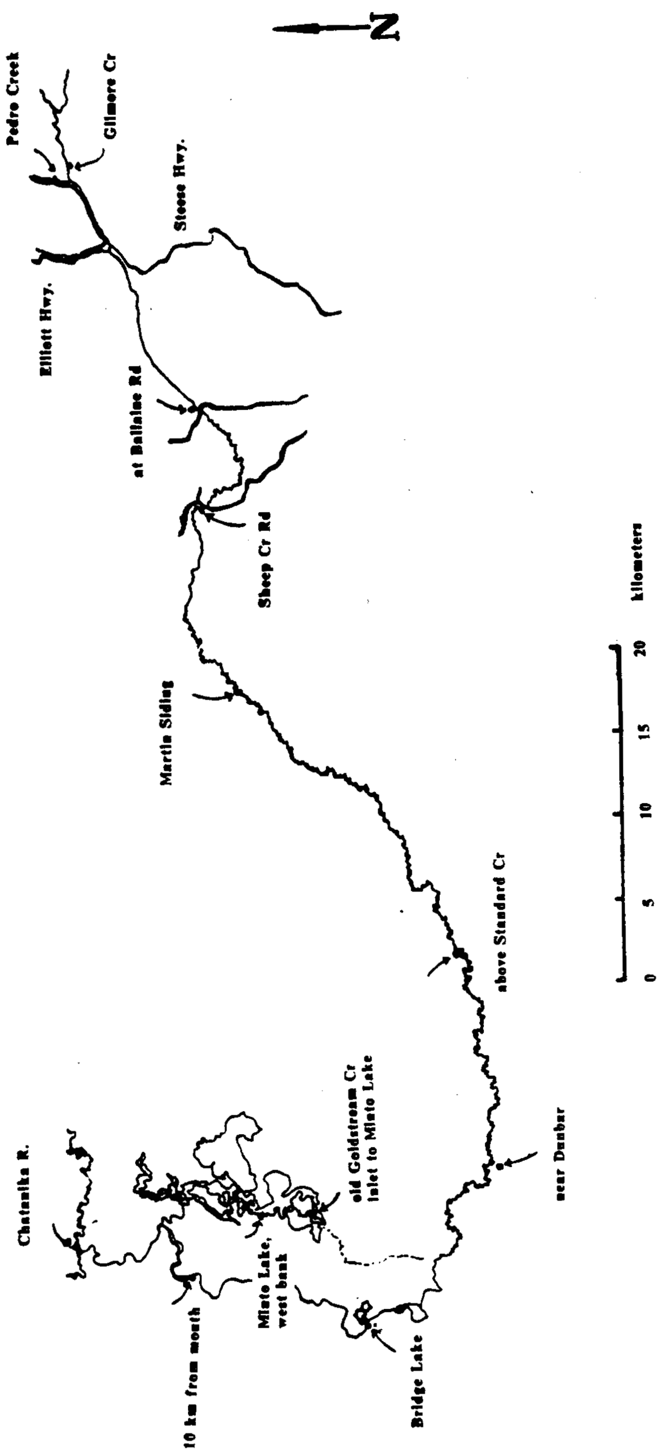
Water samples were collected with an ISCO automatic water sampler in Pedro and Goldstream creeks. Samples were collected four times per day and composited into one sample. Sampling was conducted for one week in fall 1986. After spring break up in 1987, ISCO water samplers were used to collect water samples from Pedro Creek and Goldstream Creek above Ballaine Road. After three weeks the water sampler at Pedro Creek was moved to Goldstream Creek in Minto Flats, 12 km above the mouth. Water samples were analyzed for turbidity, total suspended solids (TSS), and settleable solids according to standard methods (APHA 1984).

Stream water was tested for toxic metals concentrations before and during the active mining season in 1987. Water samples were collected in bottles washed with nitric acid and preserved with ultra-pure nitric acid (Ultrix). Target metals include arsenic, lead, zinc, mercury, copper, and silver. Analyses for target metals will be conducted in September 1987 by Alaska Department of Natural Resources, Division of Geological and Geophysical Surveys. Results of the metal analyses will be presented in a supplemental report on Goldstream Creek. Alkalinity of the stream water was determined at the time water samples for metals were taken. Alkalinity was determined according to Standard Methods titrating with acid to pH 4.5.

Water samples collected with a grab method were filtered through a series of filters of pore size 0.2 um, 0.45 um, and 0.8 um to determine metals concentrations associated with different sediment particle sizes. Each aliquot filtrate was analyzed for concentrations of target metals.

Continuous water surface levels in Goldstream Creek at the Ballaine Road crossing were recorded with an Omnidata DP320 automatic stream stage recorder (datapod), calibrated with discharge measurements taken with a Marsh-McBirney electromagnetic flow meter and top-setting wading rod. The datapod was installed in a stilling well on May 19, 1987 and recorded stream flows at 30-minute intervals throughout the sampling period. Stream discharge at the Ballaine Bridge was measured during both high and low flow periods to establish calibration curves. Discharge at other sites was measured with a Marsh-McBirney flow meter.

Figure 1. Locations of sampling sites for habitat investigations of Goldstream Creek, 1986-1987



Fish presence in the upper reaches of Goldstream Creek was sampled with a Smith-Root gas-powered electrofisher. The lower reaches of Goldstream Creek were sampled from a boat, using hook and line and a gill net. Goldstream Creek in Minto Flats was also sampled by Alaska Department of Fish and Game, Sport Fish Division for fish species present.

ADF&G coordinated with researchers from the University of Alaska to collect water samples for sediment content (turbidity, TSS, and settleable solids) and for heavy metals content. Samples were collected periodically throughout the summer at Minto Lake and at the mouth of Goldstream Creek. Sediment cores were also taken from Minto Lake to determine heavy metals content of the sediments deposited in the lake. All water samples were collected and preserved with the same methods used by ADF&G.

Stream length and distances between sampling sites were estimated from a U.S. Geological Survey map of the Fairbanks quadrangle, using a computerized digitizer.

A literature search was conducted to gather data from Goldstream Creek on water quality, fish presence, and macroinvertebrate populations collected prior to this study and the history of resource development, including mining, in this drainage. These data were used to compare conditions of the creek prior to the resurgence in mining to conditions after mining was reactivated in the mid-1970's.

DESCRIPTION OF STUDY AREA

Goldstream Creek is formed by the confluence of Pedro and Gilmore creeks at an elevation of 270 m, then flows westward until it joins the Chatanika River at Minto Flats at an elevation of about 125 m. The stream is about 145 km long and drains an area of about 1300 km^2. Base flows are estimated to be between 0.5 and 0.6 cubic meters per second (U.S. Geological Survey Water Year Data 1978-79).

Goldstream Creek flows mainly through undifferentiated silt and to a minor extent through organic silt (Pewe 1955). The upper portion of Goldstream Creek is characterized by a sand, gravel, and cobble bottom, shallow water, low banks, and overhanging vegetation primarily of dense willows. The lower portion of the creek below Ballaine Road, consists of a mud and silt bottom, deep water, high banks, and an abundance of overhanging vegetation and tall trees. Numerous streams are tributary to Goldstream Creek, including Fox, Big Eldorado, O'Connor, and Moose creeks from the north and Engineer and Sheep creeks from the south.

Vegetation in the Goldstream Valley consists of mixed evergreen and deciduous trees on well-drained hill slopes (Anderson 1970). Tree species include white spruce, black spruce, quaking aspen, balsam poplar, and white birch; undergrowth includes thick moss, low brush, and grasses (Anderson 1970). Minto Flats, at the mouth of Goldstream Creek, and low areas along Goldstream Creek are dominated by deciduous brush and muskeg, consisting of low willow, alder, dwarf birch, heath, dwarf black spruce, blueberry and cranberry, mosses, and sedges (Anderson 1970).

Gold was first discovered in Pedro Creek in 1902. Hydraulic dredges were used in the Goldstream Creek area in late 1920's, and in 1930 the U.S. Smelting, Refining, and Mining Company had 12 dredges in operation in the Fairbanks Mining District. In 1926, the Fairbanks Exploration Company employed from 650 to 850 men in preparation for large scale dredging of Goldstream, Gilmore, and Cleary creeks. In this year, the F.E. Company hydraulically stripped about 75 acres on Goldstream Creek and about 40 acres around Gilmore Creek (Wimmler 1926). The Goldstream, Pedro, and Engineer creeks areas were dredged from 1927 until 1959 (Egan 1973).

Wolff (1985) believed that there was more than 100 million cubic yards of muck carried by the Chatanika River and Goldstream Creek as a result of hydraulic mining. Boswell (1979) reported that during the 30-year life of the stripping operations which ended in 1958 in the Fairbanks area, 257,000,000 cubic yards of muck and silt were removed. The peak year of operations was in 1940 when 23,911,000 cubic yards were removed. Significant amounts of this muck were transported by Goldstream Creek (Shepherd and Matthews 1985). Bundtzen (per. comm) cites estimates of the total amount of muck flushed down Goldstream Creek to be approximately 60% of the 23,911,000 cubic yards removed, or 14.3 million cubic yards. This amount of muck would fill a 5 km^2 area to a depth of 15 meters.

Goldstream Creek once formed the main inlet channel to Minto Lake, but heavy sediment loads deposited from Goldstream Creek filled the inlet channel to Minto Lake sometime between 1929 and 1952. Deposition of mud from Goldstream Creek into Minto Lake created a shallow and eutrophic body of water that was vastly different from the deep, clear, and forest-lined lake of the past (Shepherd and Matthews 1985). After filling the inlet channel to Minto Lake, Goldstream Creek formed a new channel in the flats and eventually migrated into its present channel west of Big Minto Lake. Goldstream Creek and Little Goldstream Creek presently flow within the same channel in Minto Flats.

Aggradation and channel migration of Goldstream Creek within the past 80 years appears to have caused a number of small lakes in Minto Flats to be filled in. These changes are evident from aerial photographs taken in 1954 that show Goldstream Creek flowing through 6 Mile Lake and Bridge Lake (Wolff 1982).

Shepherd and Matthews (1985) states that infilling and restructuring of lakes in Minto Flats were beneficial to waterfowl and fish and possibly detrimental to muskrats over the years. The shallower, eutrophic Minto Lake provides an excellent rearing area for many young fish and waterfowl, and supports a rich biota that enhances growth. Lakes that were completely infilled by hydraulic mucks were lost to both fish and waterfowl production.

HISTORICAL WATER QUALITY DATA

Limited data are available on Goldstream Creek water quality conditions and biological parameters prior to the resurgence of mining in the mid-1970's. The Institute of Water Resources (IWR), University of Alaska, Fairbanks monitored water quality in Goldstream Creek from 1970 through 1971, however, no samples were collected for heavy metals content. (Refer to LaPerriere and Nyquist 1973, Peterson 1973, Ward 1972).

Water quality monitoring conducted in 1970-71 by IWR indicate that turbidity levels in Goldstream Creek were generally below 30 NTU and exceeded 45 NTU on only two occasions (fig. 2). Generally, turbidity was low throughout the winter months and did not show a significant increase until spring breakup. Turbidity levels decreased after runoff subsided and remained relatively constant throughout the summer of 1971, except in mid-July, when turbidity was highest.

Total suspended solids levels were also low in Goldstream Creek during 1970-71 (fig. 2) and increases in TSS levels corresponded to increases in turbidity levels. Peterson (1973) states that high turbidity and suspended solids levels in July 1971 corresponded to periods of heavy rainfall.

Water quality in Goldstream Creek was sampled in 1982-1984 by ADEC and in late spring 1984 by ADF&G. Turbidity levels measured in these years were consistently higher than measured in early 1970 before the resurgence of mining (fig. 3). For example, the turbidity in Goldstream Creek in August 1983 (measured below Fox) averaged 271 NTU (s=40, n=34) compared to an average turbidity of 10.7 NTU (se=7.4, n=10) in August 1970 and 1971. TSS levels were also higher in 1982-84 than in 1970-71, as shown in figure 4. For example, the average TSS level in August 1983 was 304 mg/L (s=159, n=34) compared to 8.2 mg/L in August 1970-71 (se=4.5, n=5). TSS measurements from 1970-71 were collected at various sites below Fox.

Resuspension of stream bed sediments and erosion during spring breakup have been implicated as natural causes of high turbidity and settleable solids levels in stream systems. However, historical data for Goldstream Creek collected before and after the resurgence of placer mining in the mid-1970's indicates that sediment loads are considerably higher during spring following a placer mining season.

ADF&G measured turbidity and settleable solids in May and June 1984, before active mining began for the summer. There had been active mining in Goldstream Creek and its tributaries during the previous summer. At this time, turbidity levels ranged from 96 to 1560 NTU, with an average of 315 NTU. In 1970 and 1971, turbidity levels during spring breakup in Goldstream Creek ranged from 7 to 35 NTU with an average of 28 NTU (se=11.6, n=10). Most of the sediment found in 1984 is probably a result of resuspension of sediments deposited during low flow periods, especially during the mining season when suspended sediment loads are high.

Settleable solids were also high during spring breakup following an active mining season. In spring 1984 the settleable solids levels in Goldstream Creek exceeded both the State and Federal water quality standards 100% of the time (fig. 5). Settleable solids levels ranged from 0.25 ml/L to 8.5 ml/L, with an overall average of 1.2 ml/L. (The federal standard for SS = 0.2 ml/L and the State standard = no measurable increase above background.) No record was found of settleable solids levels in Goldstream Creek during spring breakup before the resurgence of mining activity.

Water quality data were collected during the 1982 and 1983 mining seasons above and below one placer mine on Gilmore Creek, a tributary to Goldstream Creek (fig. 6). In 1982, turbidity of the stream water above the mine (but not above all mining) ranged from 17 to 48 NTU with an average of 31 NTU (se=12, n=5). Turbidity levels measured below the placer mine were, on the average, 17 times

Figure 2. Water quality conditions in Goldstream Creek drainage, 1970-71. Data from University of Alaska, Institute of Water Resources (rf. Peterson 1973.)

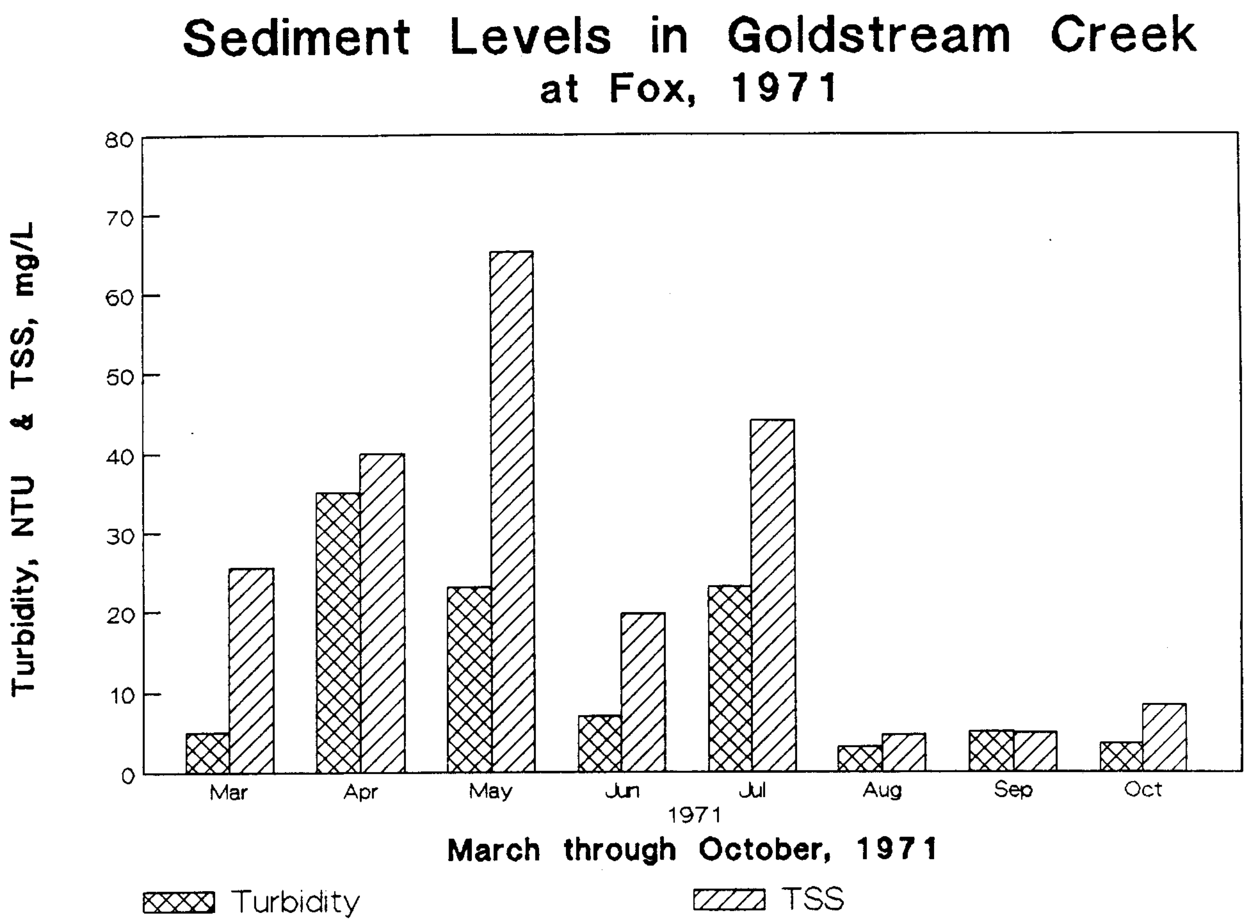


Figure 3. Comparisons of turbidity levels in Goldstream Creek drainage before and after the resurgence of placer mining, 1970-71 and 1982-84. Data from IWR, ADEC, and ADF&G.

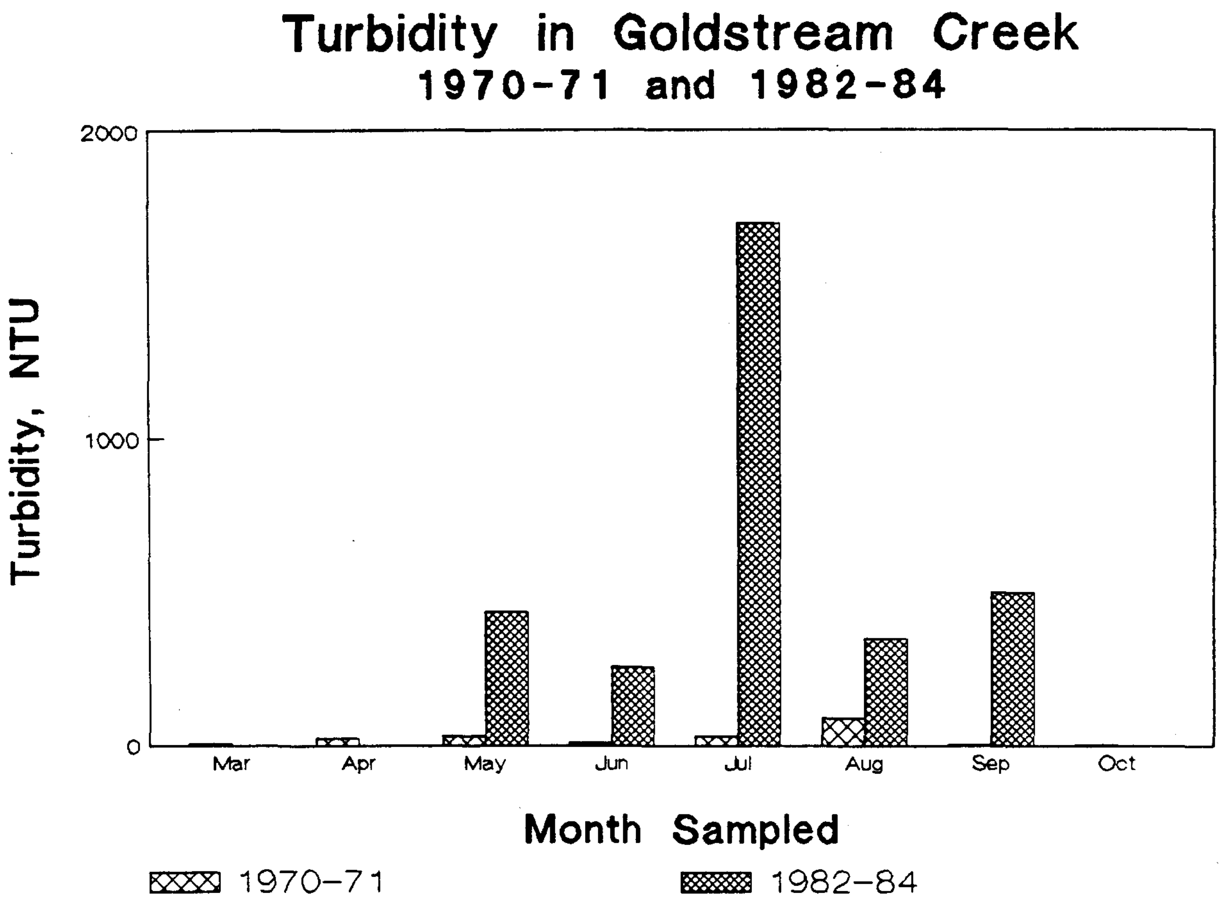


Figure 4. Comparisons of total suspended solids concentrations in Goldstream Creek drainage before and after the resurgence of placer mining, 1970-71 and 1982-84. Data from IWR, ADEC, and ADF&G.

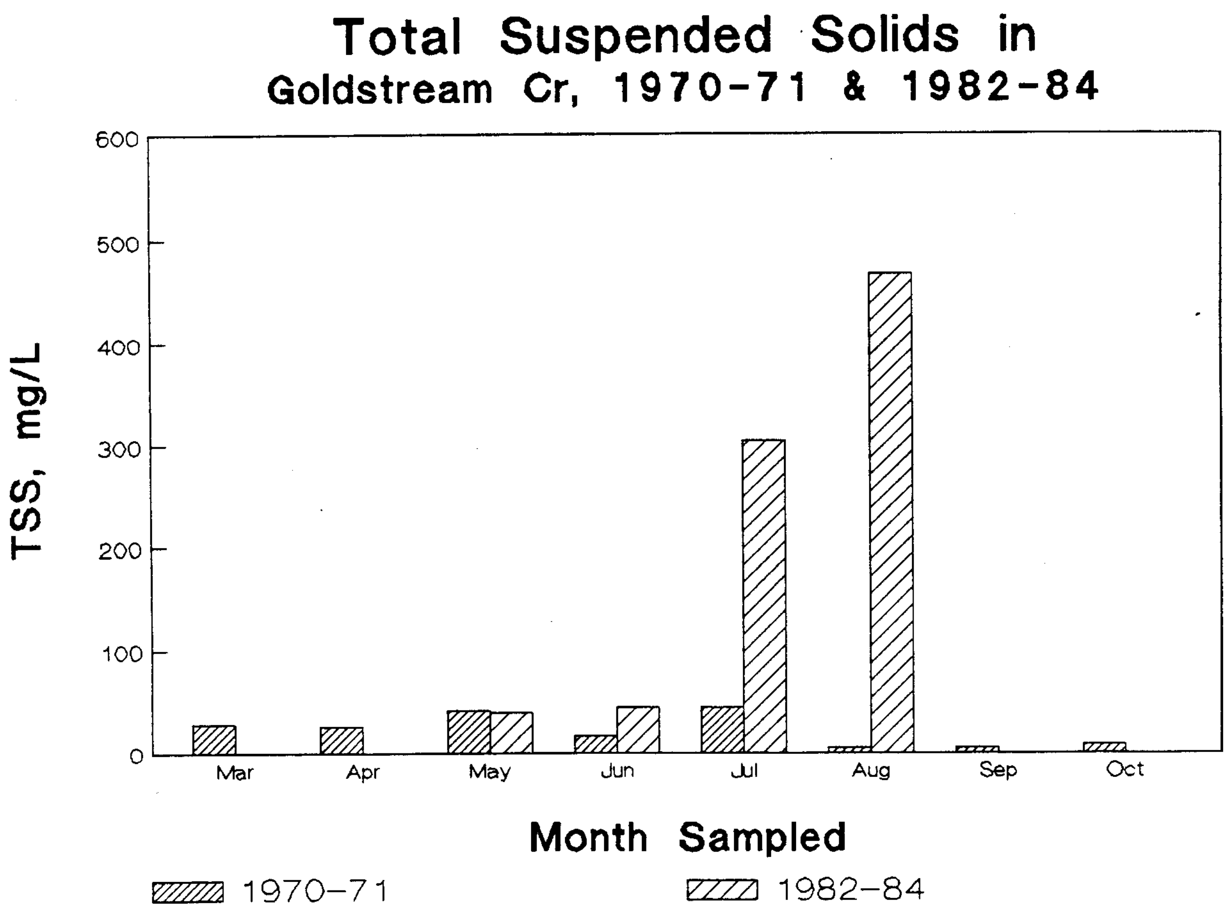


Figure 5. Settleable solids levels in Goldstream Creek drainage in spring 1984 before the onset of the mining season. Data from ADF&G.

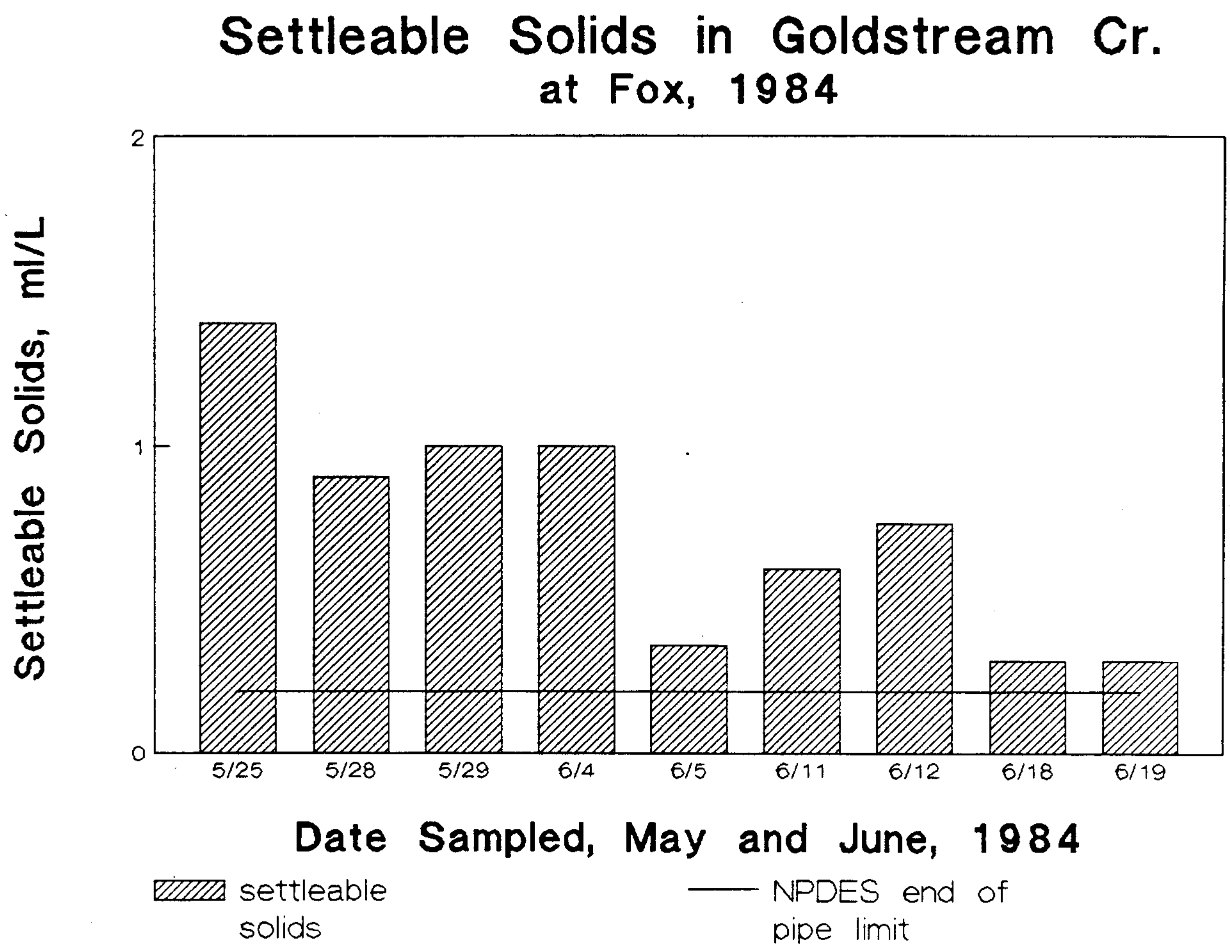
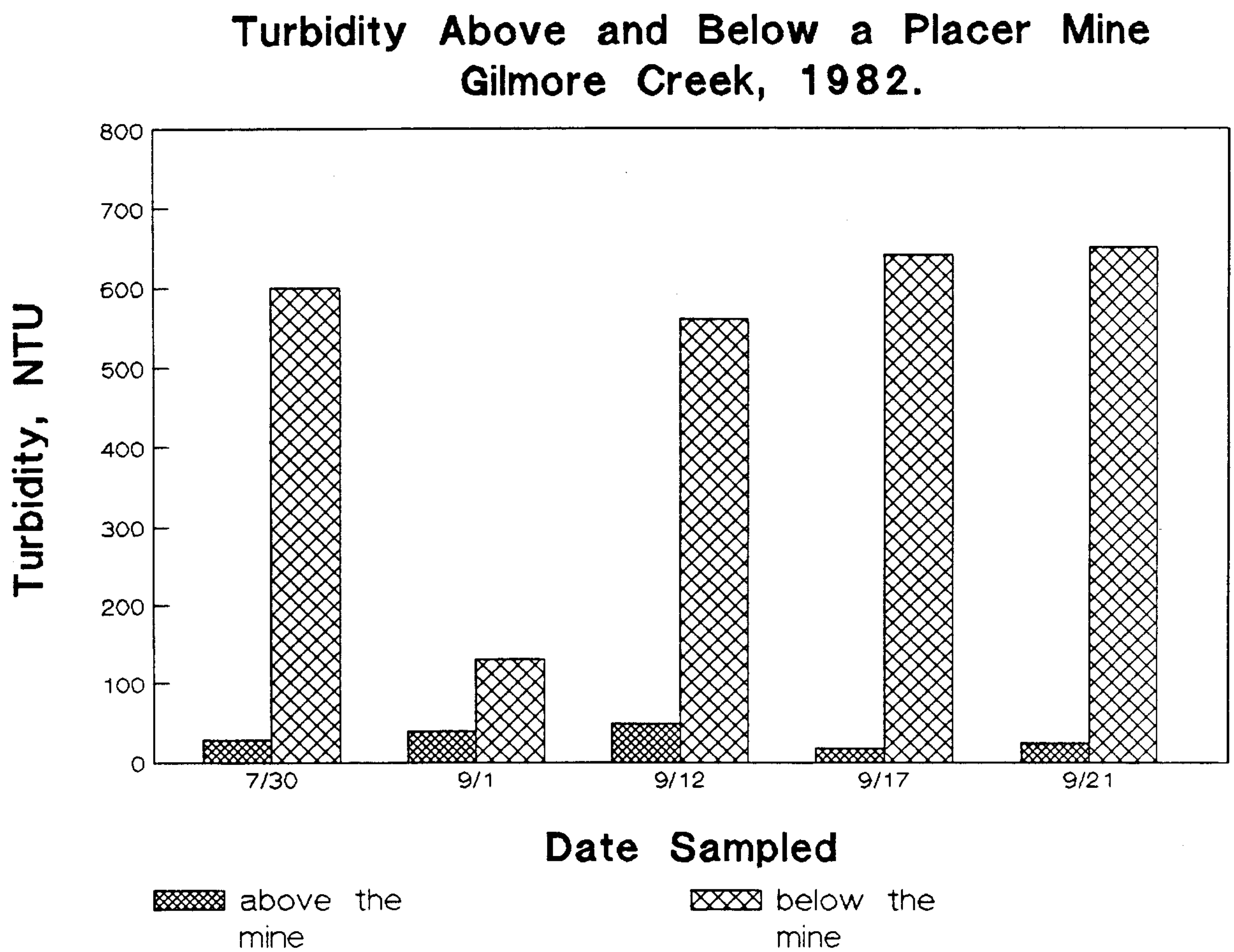


Figure 6. Comparison of water quality conditions in Gilmore Creek above and below a placer mine, 1982. Data from ADEC.



higher and ranged from 130 to 650 NTU with an average of 516 NTU for the months measured (se=195, n=5). In 1983, one water quality measurement was taken above and below the same placer mine on Gilmore Creek: on July 22, the turbidity above the mine was 85 NTU and below the mine it was 2800 NTU. The higher turbidity levels measured at the downstream site can be attributed to effluent from this one mine.

Sediment loads in Goldstream Creek result from mining along the creek and mining in the tributaries. Recent historical data suggest that mining on Gilmore Creek contributes most of the sediment to Goldstream Creek. For example, water quality sampled three times during August 1982 in Gilmore Creek at the confluence with Pedro Creek had turbidity levels ranging form 700 to 1040 NTU and TSS levels ranging from 404 to 592 mg/L. Two water quality samples were taken from Pedro Creek at the same time. The turbidities in these samples were 56 to 70 NTU and the TSS levels were 34 and 70 mg/L.

There are no baseline data available for concentrations of heavy or toxic metals or suspended sediment particle size for the Goldstream Creek drainage.

Historical data for the Goldstream Creek drainage are presented in Appendix I.

The Alaska Department of Fish and Game, Division of Sport Fish conducted a study of the species composition and migration patterns of fish in the Minto Flats area (DeCeccio, per comm. 1987). Using a variety of catch gear, they sampled Goldstream Creek from the mouth to about 11 km upstream, the outlet of Big Minto Lake to the confluence with Goldstream Creek, and the mouth of the Tolovana River. The following fish species were found:

Goldstream Creek: broad whitefish, humpback whitefish, sheefish, least cisco, arctic grayling, and northern pike.

Outlet to Minto Lake: least cisco, humpback whitefish, broad whitefish, and northern pike.

Mouth of the Tolovana River: long-nosed suckers, broad whitefish, humpback whitefish, least cisco, northern pike, and burbot.

Common and scientific names of fish species found in the Goldstream Creek drainage are listed in Appendix II.

RESULTS OF THE PRESENT STUDY

Water Quality

In autumn 1986 water quality was sampled in the Goldstream Creek drainage below active mining. At this time, Goldstream Creek had turbidity levels that were consistently high and approximately ten times higher than the state water quality standard for fish and wildlife (fig. 7). The average turbidity in Goldstream Creek, measured at the Sheep Creek Road crossing, in September and October 1986 was 274 NTU (s=19, n=8). TSS levels in Goldstream Creek were also high (fig. 8), ranging from 131 mg/L to 183 mg/L. The average TSS level in Goldstream Creek for the fall sampling period was 163 mg/L (s=18, n=8).

Figure 7. Turbidity levels in Goldstream Creek during active mining, September-October, 1986.

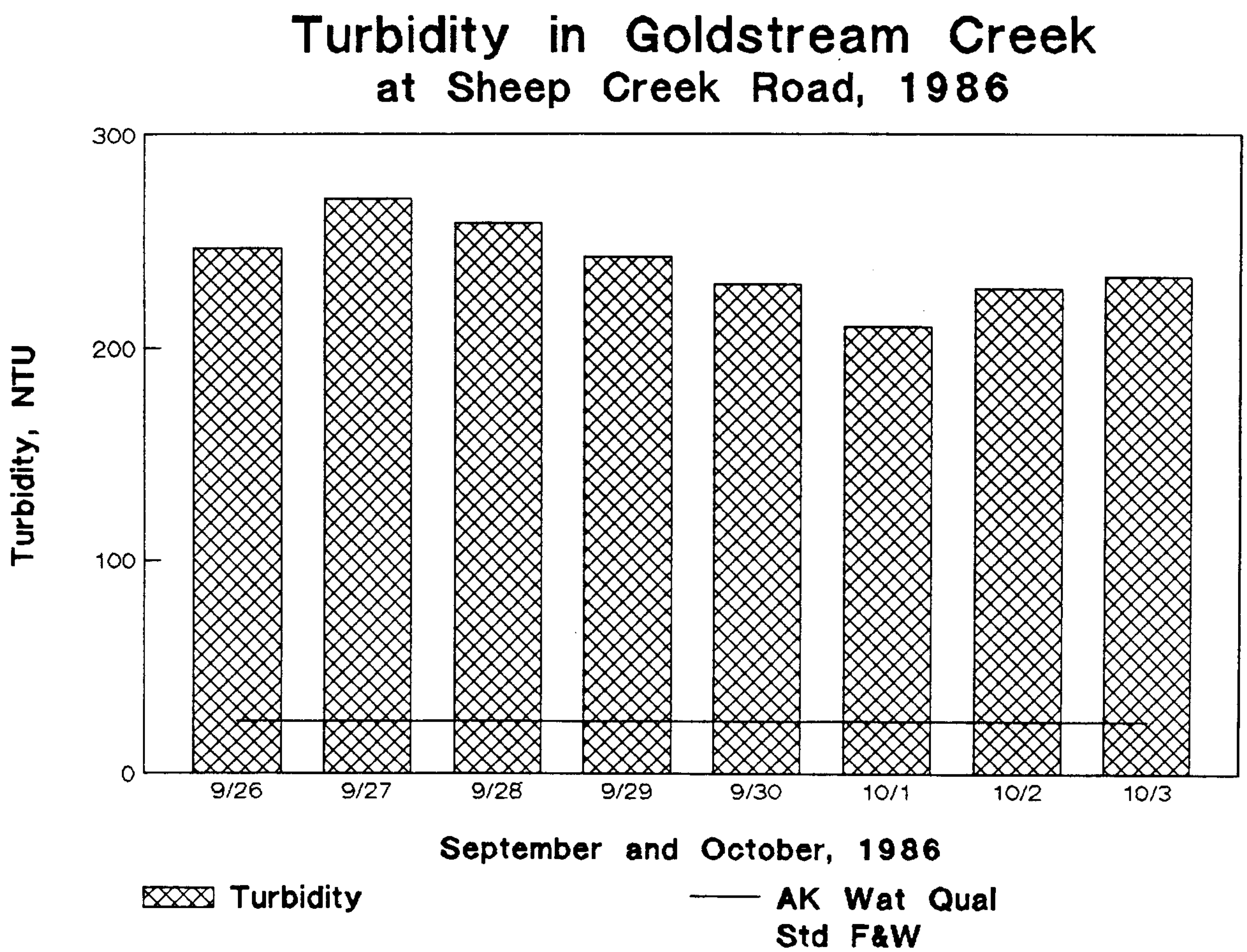
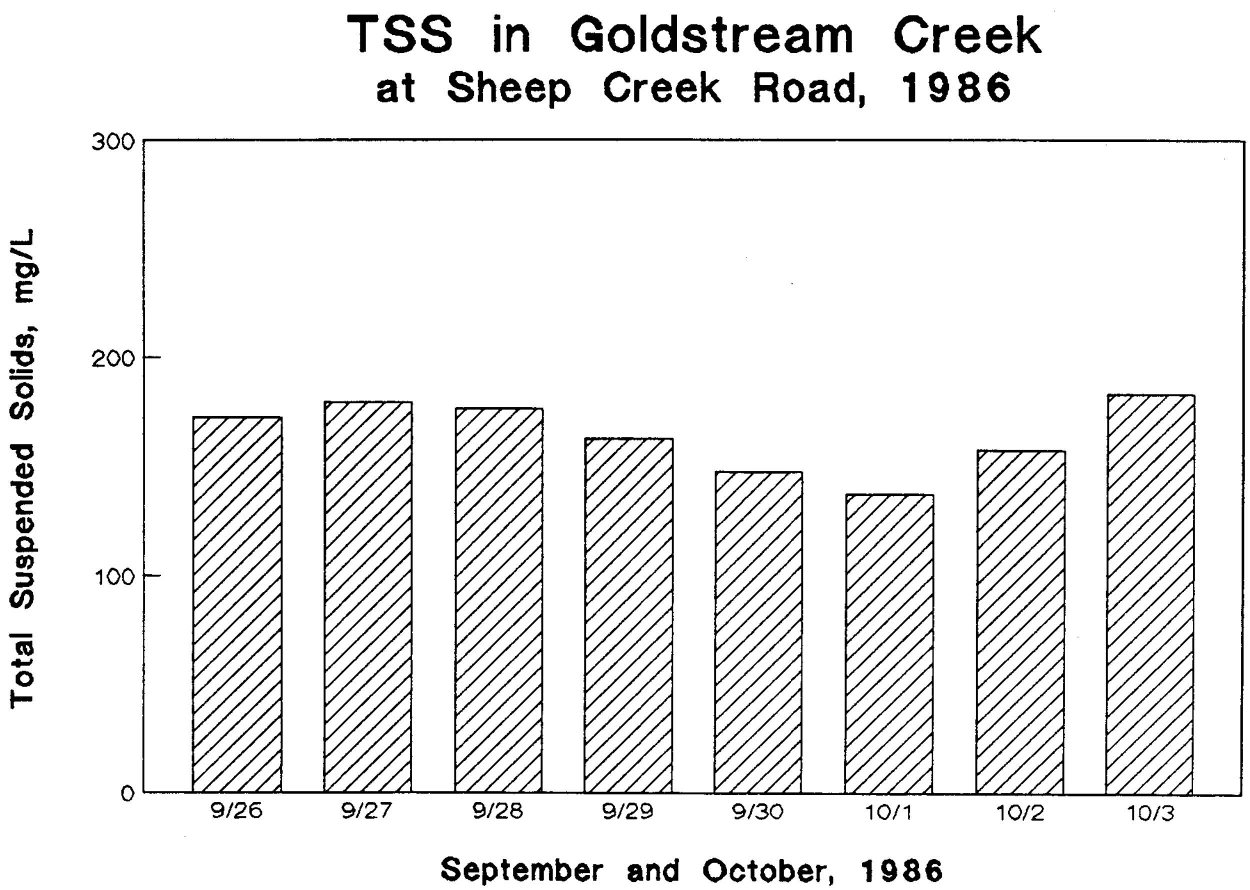


Figure 8. Total suspended solids concentrations in Goldstream Creek during active mining, September-October, 1986.



The primary sources of sediment to Goldstream Creek appeared to be placer mining in Pedro and Gilmore creeks and placer mining in the upper reaches of Goldstream Creek. During September and October 1986, Pedro Creek had an average turbidity of 287 NTU (s=273, n=6). The average concentration of TSS in Pedro Creek at the same time was 279 mg/L (s=300, n=6). The water quality in Gilmore Creek was measured one time in the fall before freeze-up. On September 5, 1986 the turbidity in Gilmore Creek was 1148 NTU and the concentration of TSS was 722 mg/L.

The relatively higher turbidity and total suspended sediment levels found in Gilmore Creek during active mining suggest that Gilmore Creek probably contributes more sediment to Goldstream Creek than Pedro Creek during periods of active mining.

Other tributaries that may be contributing minor amounts of sediment to the Goldstream Creek watershed are First Chance Creek, a tributary to Gilmore Creek, and Steamboat Creek, a tributary to Goldstream Creek above the Steese Highway. These creeks were sampled in early September with grab samples. At that time the turbidity in First Chance Creek was 7.5 NTU and in Steamboat Creek it was 26 NTU. Active placer mining was also occurring on Flume Creek; however, this miner practiced 100% recycle of the washwater and did not discharge into the stream. The turbidity below this mine was 7.3 NTU with 6.8 mg/L TSS.

Water quality was measured in Goldstream Creek at the Standard Creek Road in September. This site is located approximately 50 km downstream from Goldstream Creek at the Sheep Creek Road. The creek at this downstream site is a slower flowing, meandering, and deeply incised stream. On September 5, the turbidity at this site was 31 NTU and the TSS level was 36 mg/L. The turbidity at this downstream site was about 25% of the turbidity in Goldstream Creek at Sheep Creek Road. TSS at the Standard Creek Road were about 50% of the TSS concentrations found in Goldstream Creek at Sheep Creek Road. Dilution from tributary streams and settling in the more quiescent areas of the downstream site probably accounted for the lower sediment levels. Figure 9 shows the average turbidity and TSS levels found in the Goldstream Creek drainage during autumn 1986.

The average turbidity levels and TSS concentrations for each site sampled are shown on table 1.

The water quality of Goldstream Creek and its two major tributaries, Pedro and Gilmore creeks was sampled in spring 1987 before active mining began for the season. At that time there was no mine discharge to any of the streams sampled. Pedro Creek was sampled continuously for three weeks from breakup to mid May. Water quality was monitored continuously in Goldstream Creek for 45 days.

Stream water turbidity in Goldstream Creek was slightly higher than in Gilmore Creek and about twice as high as in Pedro Creek during spring 1987. The turbidity in Goldstream Creek exceeded the state water quality standard for fish and wildlife on about 50% of the days sampled (table 2, fig. 10). During the 37 days sampled, the turbidity of the stream water ranged from 10.5 to 105 NTU, with an average over the 37 days sampled of 37.2 NTU (s=23.7, n=37). The average turbidity in Gilmore Creek was similar to Goldstream Creek: 35 NTU (s=21, n=8) and ranged from 19.6 NTU to 80 NTU. The state water quality turbidity standard for fish and wildlife was exceeded 50% of the time in the Gilmore

Figure 9. Average turbidity levels found throughout the Goldstream Creek drainage in September-October, 1986.

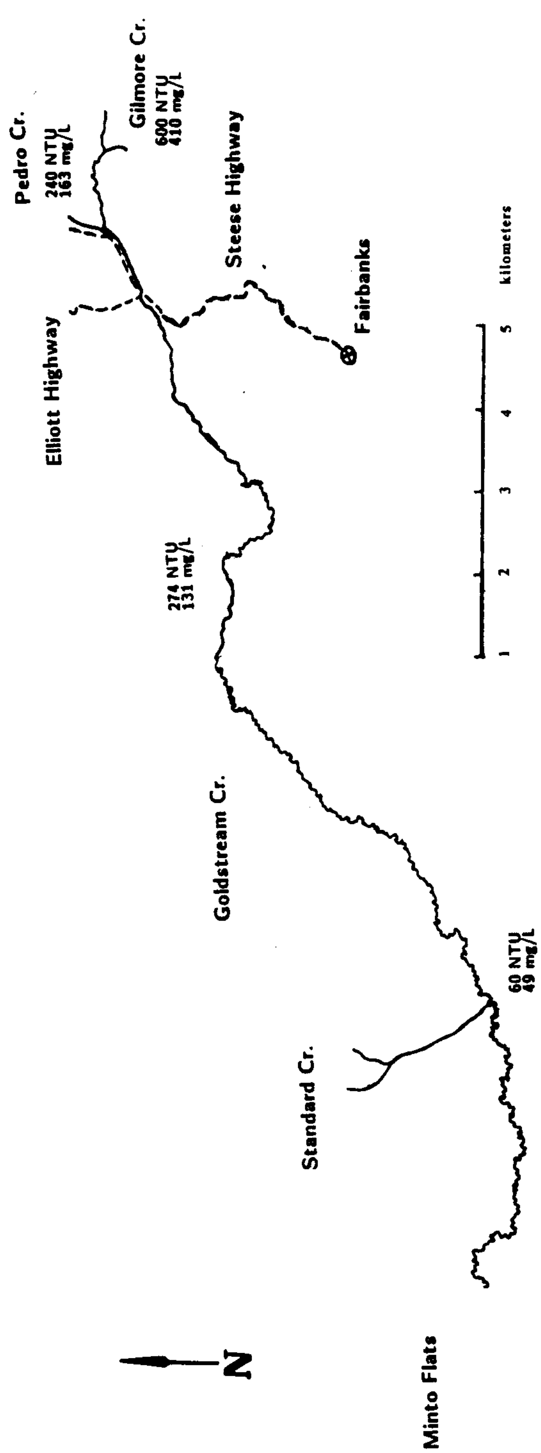


Table 1. Turbidity, total suspended and settleable solids, Goldstream Creek drainage, Sept-Oct. 1986.

Location	Turbidity (NTU)	TSS (mg/L)	SS ml/L	n
Pedro Creek	238.3	239.0	tr	6
Gilmore Creek	1148.0	722.0	tr	1
First Chance Creek	7.3	6.8	tr	1
Flume Creek at Steese	2.5	2.4	nd	1
Steamboat Creek at Steese Highway	26.0	284.0	0.3	1
Goldstream Creek at Goldstream Rd	334.0	261.0	0.1	1
Goldstream Creek at Ballaine Rd	80.0	129.0	0.05	1
Goldstream Creek at Sheep Cr Rd	236.1	158.2	tr	30
Goldstream Creek at Standard Creek	60.0	48.0	tr	2

Figure 10. Turbidity level in Goldstream Creek during spring 1987 before the active mining season.

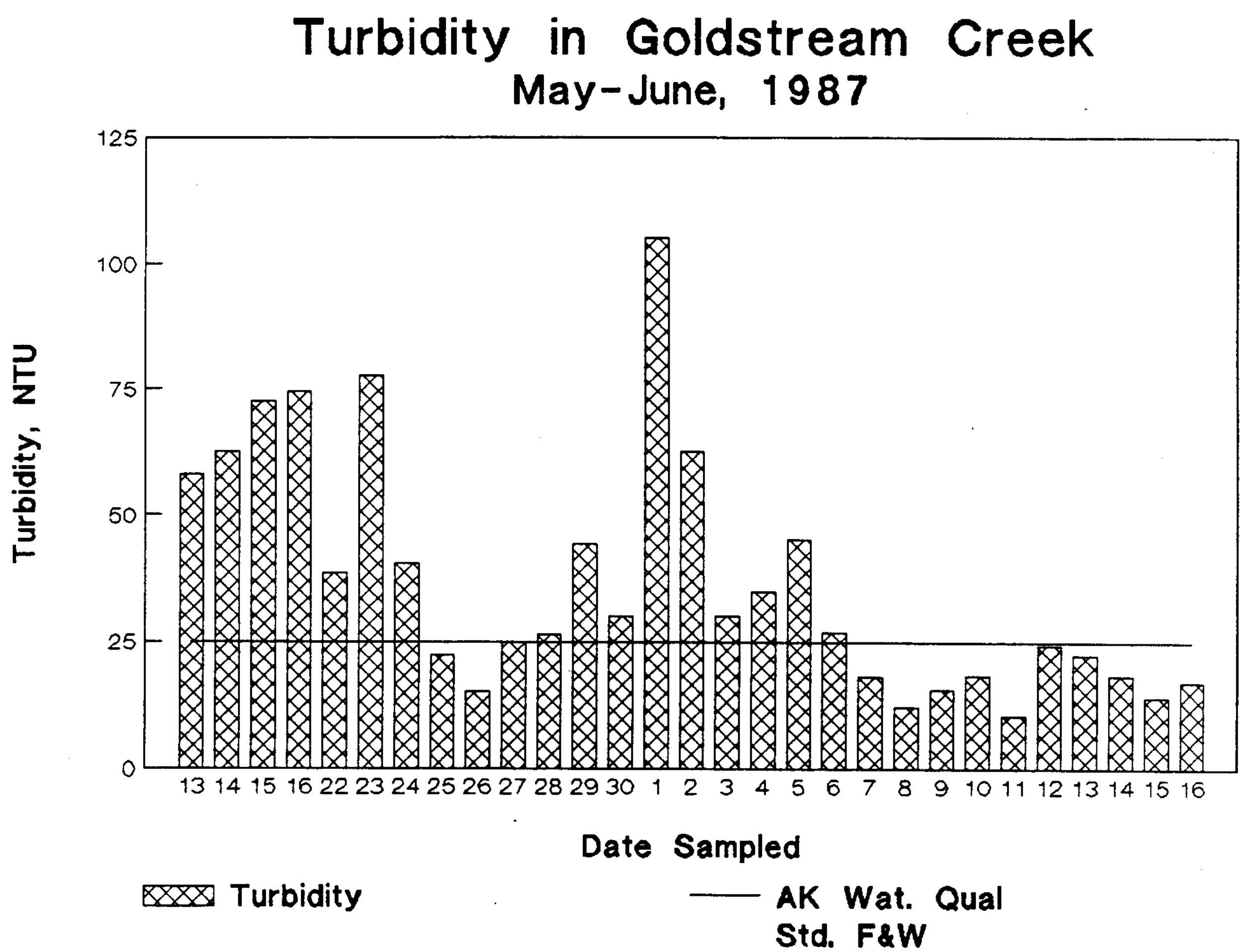


Table 2. Turbidity in Goldstream Creek drainage, May-June 1987.

Location	Avg. turbid	n	SE turbid	min turbid	max turbid	#days >25 NTU
Pedro Creek	18.0	24	6.1	7.8	27.7	3
Gilmore Creek	35.0	8	21.1	19.6	80.0	3
Goldstream Creek at Ballaine Rd	37.2	37	23.7	10.5	105.0	15
Goldstream Creek at Goldstrm Rd	39.0	1				
Goldstream Creek at Sheep Creek Rd	12.5	1				
Goldstream Creek at Martin Siding	16.1	1				
Goldstream Creek 23 km upstream	4.4	1				
Goldstream Creek 10 km upstream	6.1	20	1.4	4.2	9.6	0
Chatanika River at Goldstrm Creek	11.0	1				
Minto Lake						
surface	4.5	3				0
depth=1.5 m	4.7					
old Goldstream Creek channel	10.2	2				

SE = Standard Error

Creek samples (table 2, fig. 11). The turbidity in Pedro Creek was the lowest of the three creeks sampled and ranged from 7.8 to 27.7 NTU, with an average of 18 NTU (s=6.09, n=24). The water quality turbidity standard for fish and wildlife was exceeded on 9% of the days Pedro Creek was sampled (table 2, fig. 12).

Elevated turbidity levels in Goldstream Creek resulted from inputs from Pedro and Gilmore creeks as well as from resuspension of sediments deposited on the bed and erosion within and next to the stream channel. Higher turbidity levels in these creeks appeared to correspond to periods of high flow. (Discharge data recorded for this watershed will not be available until September 1987. These data will be included in the supplemental report.)

Although turbidities were lowest in Pedro Creek, this creek contained the highest TSS levels: the concentration of TSS in Pedro Creek was about 18 times higher than in Gilmore Creek and about 3 times higher than in Goldstream Creek (table 3). TSS levels in Pedro Creek during spring 1987 were also 3.5 times higher than during the previous fall when active mining was occurring. The concentration of TSS in Pedro Creek ranged from 104 mg/L to 3932 mg/L, with an average of 527 mg/L (s=793, n=24) (fig. 13). During the same time, Gilmore Creek had an average of 29.5 mg/L TSS (s=19, n=8) with a range of 14.5 to 63.4 mg/L (fig. 14), and Goldstream Creek had an average concentration of 166.9 mg/L TSS (s=98,n=37) with a range of 54.9 to 381 mg/L (fig. 15).

In spring 1987, before the onset of the mining season, settleable solids levels in Goldstream Creek ranged from trace to 0.8 ml/L (fig. 16). Settleable solids levels exceeded the NPDES criteria for the end of pipe limit on 50% of the days Goldstream Creek was sampled. During the same time period, settleable solids levels in Pedro Creek were trace to 0.5 ml/L and exceeded the NPDES end of pipe limits on one of the days sampled (fig 17). Water samples from May 18, when the level of settleable solids was 0.5 ml/L, contained abundant sand that appeared to be resuspending from the streambed. TSS levels on the same day were 3932 mg/L, the highest measured in the sampling period. In spring 1987, the settleable solids levels in Gilmore Creek remained at trace or below 0.2 ml/L and did not exceed NPDES limits (fig. 18).

In mid-June, a placer miner began preparing ground to work a claim located on Goldstream Creek near Moose Creek, about 3 km downstream from the Sheep Creek Road crossing. The miner diverted Goldstream Creek back into the old channel that had been unused since about 1955 and stripped ground. When observed on June 30, Goldstream Creek was flowing in both the old and new channels which converged about 0.8 km below his site. His operation caused a slight increase in the stream water turbidity: on June 17, the turbidity below his operation was 16 NTU and upstream of his operation, 12.5 NTU. Settleable solids levels measured trace at both sites. He was not actively mining at this time.

The water quality of Goldstream Creek in Minto Flats, 11 km above the mouth, was sampled continuously from June 1 through June 30 with an ISCO automatic water sampler. Between June 1 and June 18, the turbidity in Goldstream Creek at this site ranged from 4.2 to 9.6 NTU, with an average of 6.1 NTU (se=1.35, n=20) (fig 19). The turbidity in the downstream site was, on the average, only 16 percent of the turbidity measured in Goldstream Creek at Ballaine Road, about 135 km upstream.

Figure 11. Turbidity level in Gilmore Creek during spring 1987 before the active mining season.

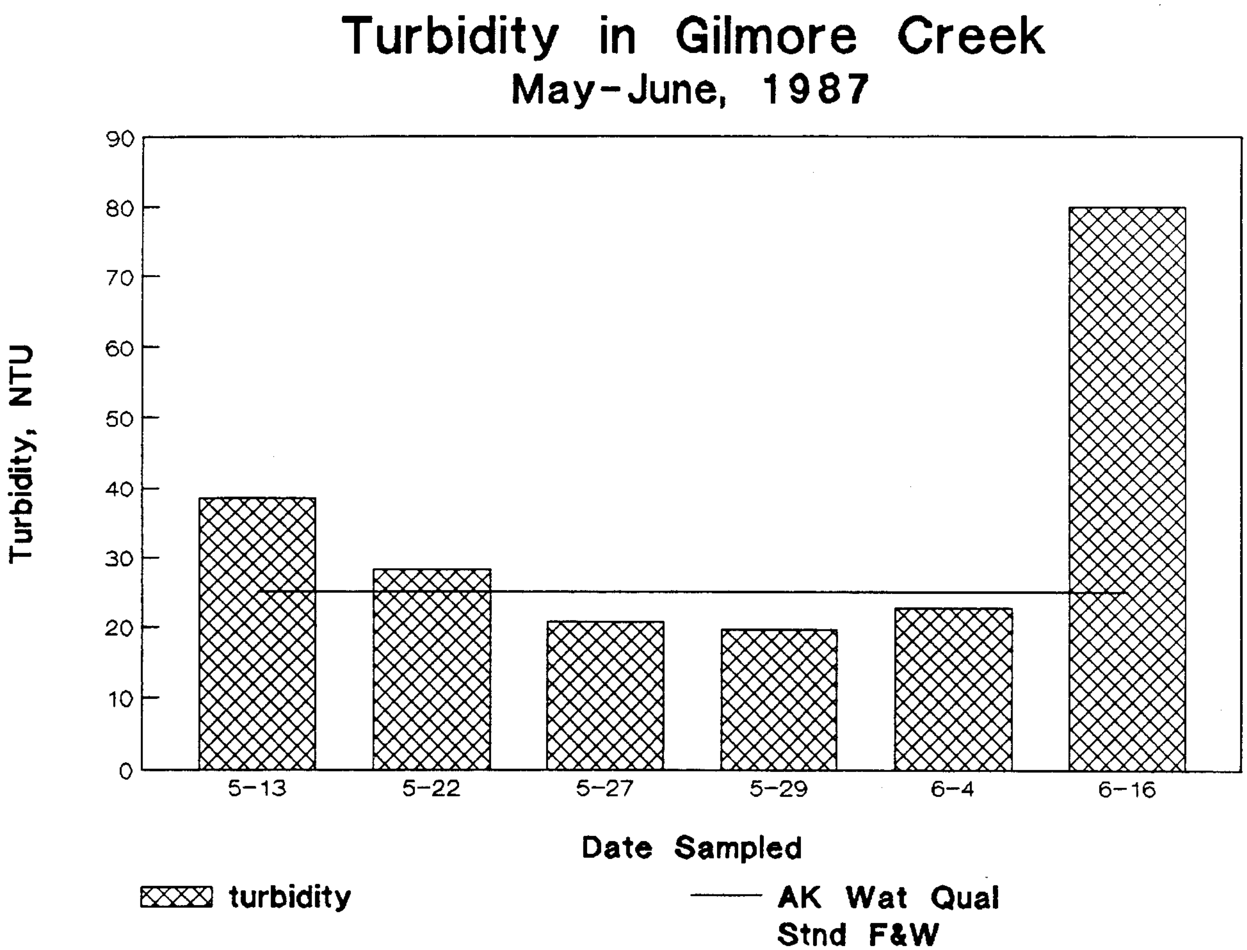


Figure 12. Turbidity level in Pedro Creek during spring 1987 before the active mining season.

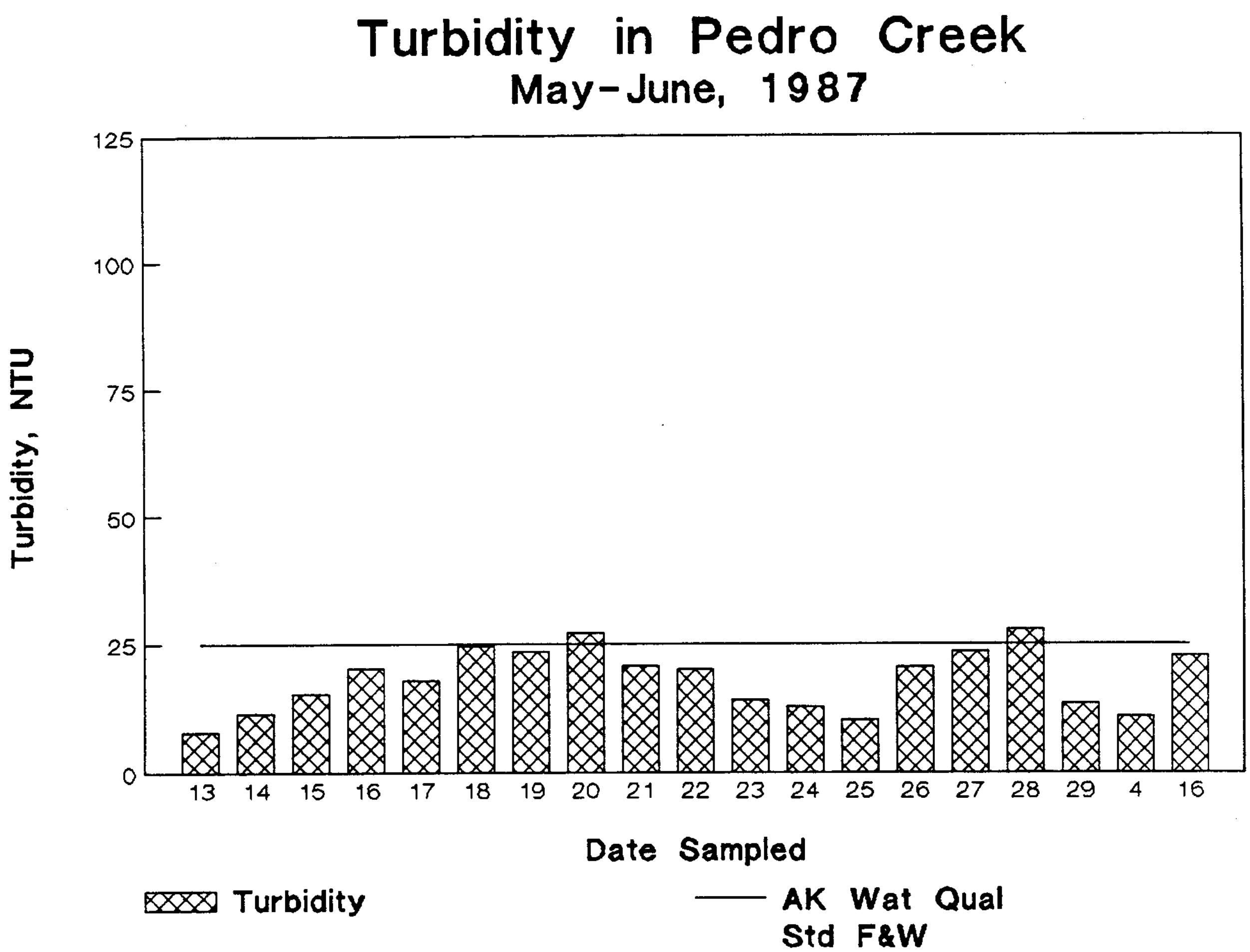


Table 3. Total suspended solids, Goldstream Creek drainage, May-June 1987.

Location	Avg TSS	n	SE TSS	Min TSS	Max TSS
Pedro Creek	526.9	24	792.8	104.0	3932.0
Gilmore Creek	29.5	8	19.3	14.5	63.4
Goldstream Creek at Ballaine Rd.	166.9	37	98.1	54.9	381.0
Goldstream Creek at Sheep Creek Rd.	13.1	1			
Goldstream Creek at Martin Siding	26.8	1			
Goldstream Creek at Standard Creek	9.3	1			
Goldstream Creek W of Dunbar Tr.	19.5	1			
Goldstream Creek at Bridge Lake	26.4	2			
Goldstream Creek 10 km upstream	22.2	20	0.1	11.7	35.3
Chatanika River at Goldstrm Creek	63.1	1			
Minto Lake					
surface	11.4	3			
depth=1.5 m	5.9	1			
at old Goldstream Creek channel	56.4	2			

SE = Standard Error

Figure 13. Total suspended solids concentrations in Pedro Creek during spring 1987 before the active mining season.

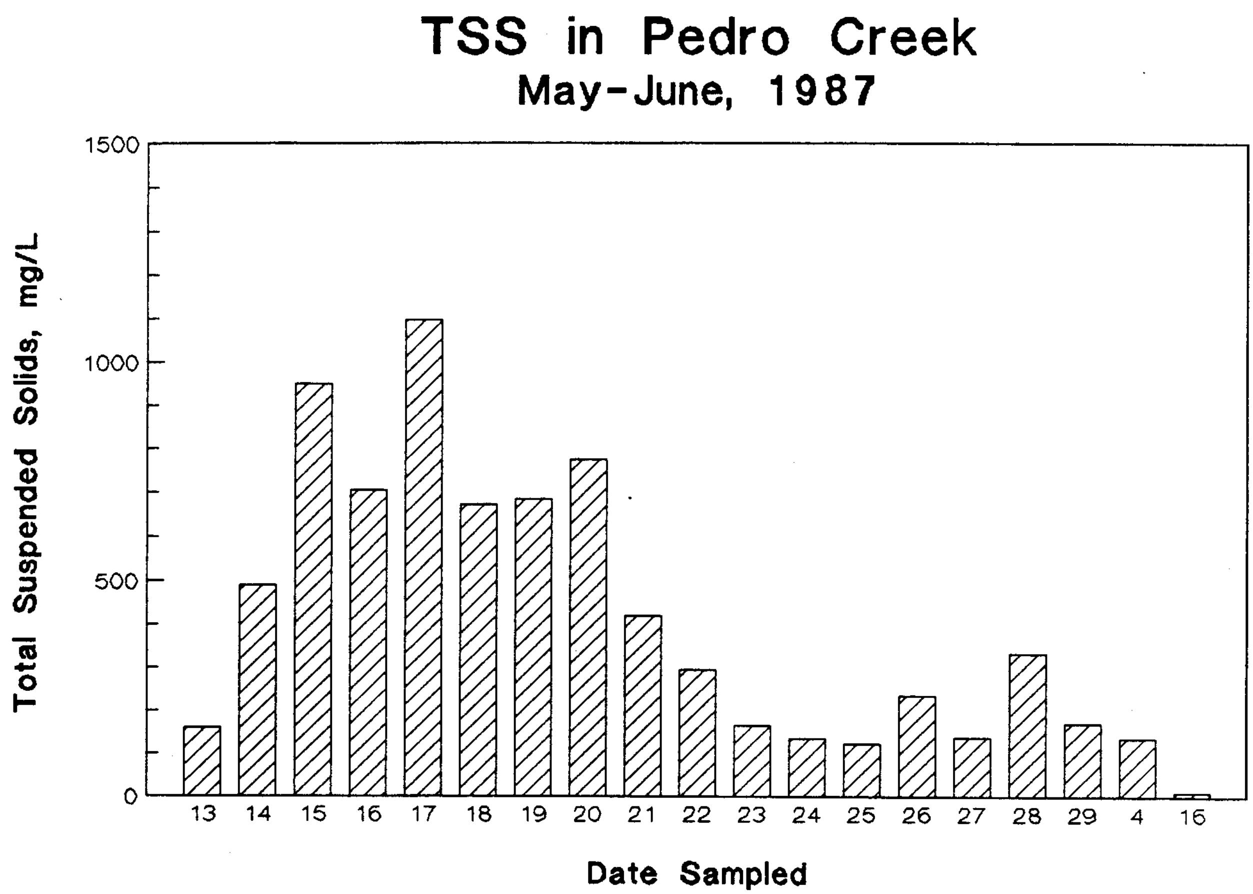


Figure 14. Total suspended solids concentrations in Gilmore Creek during spring 1987 before the active mining season.

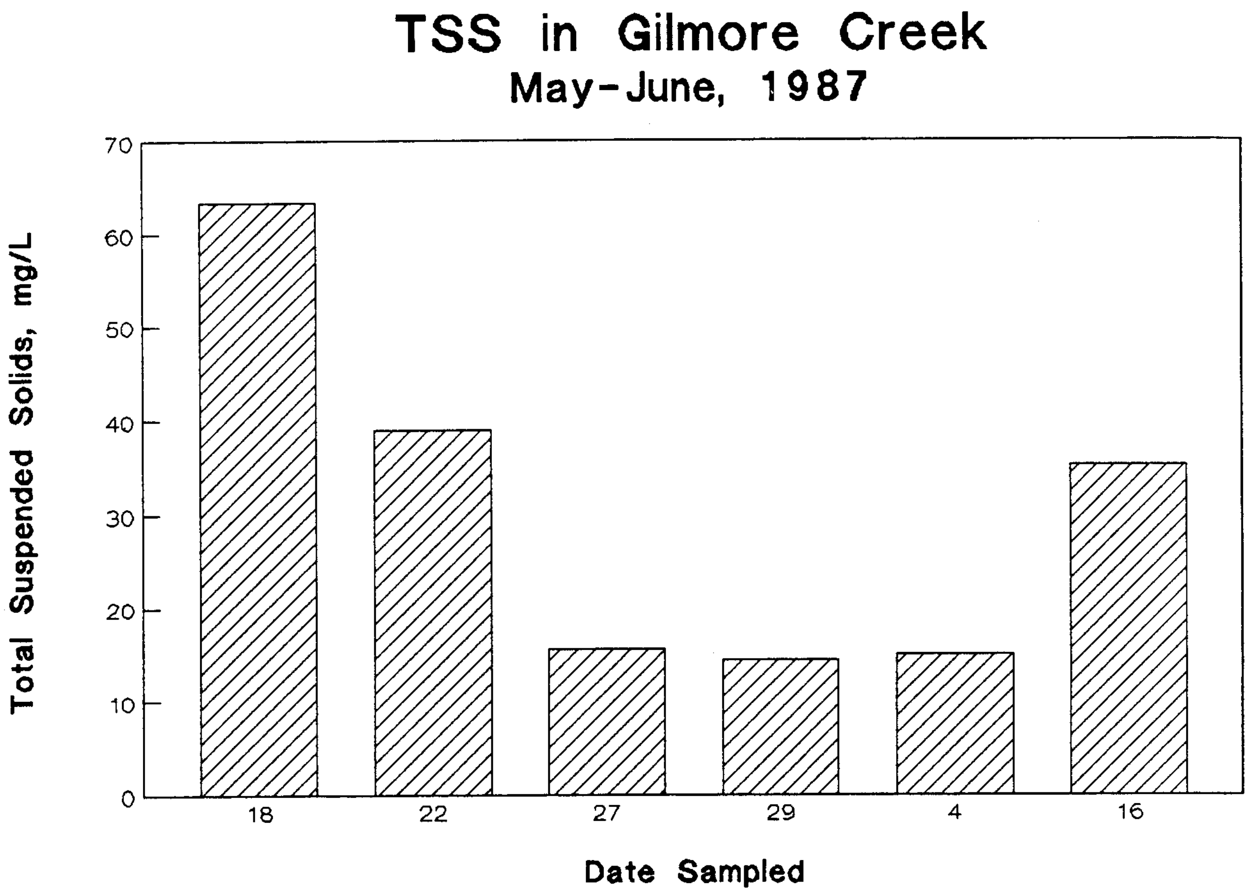


Figure 15. Total suspended solids concentrations in Goldstream Creek during spring 1987 before the active mining season.

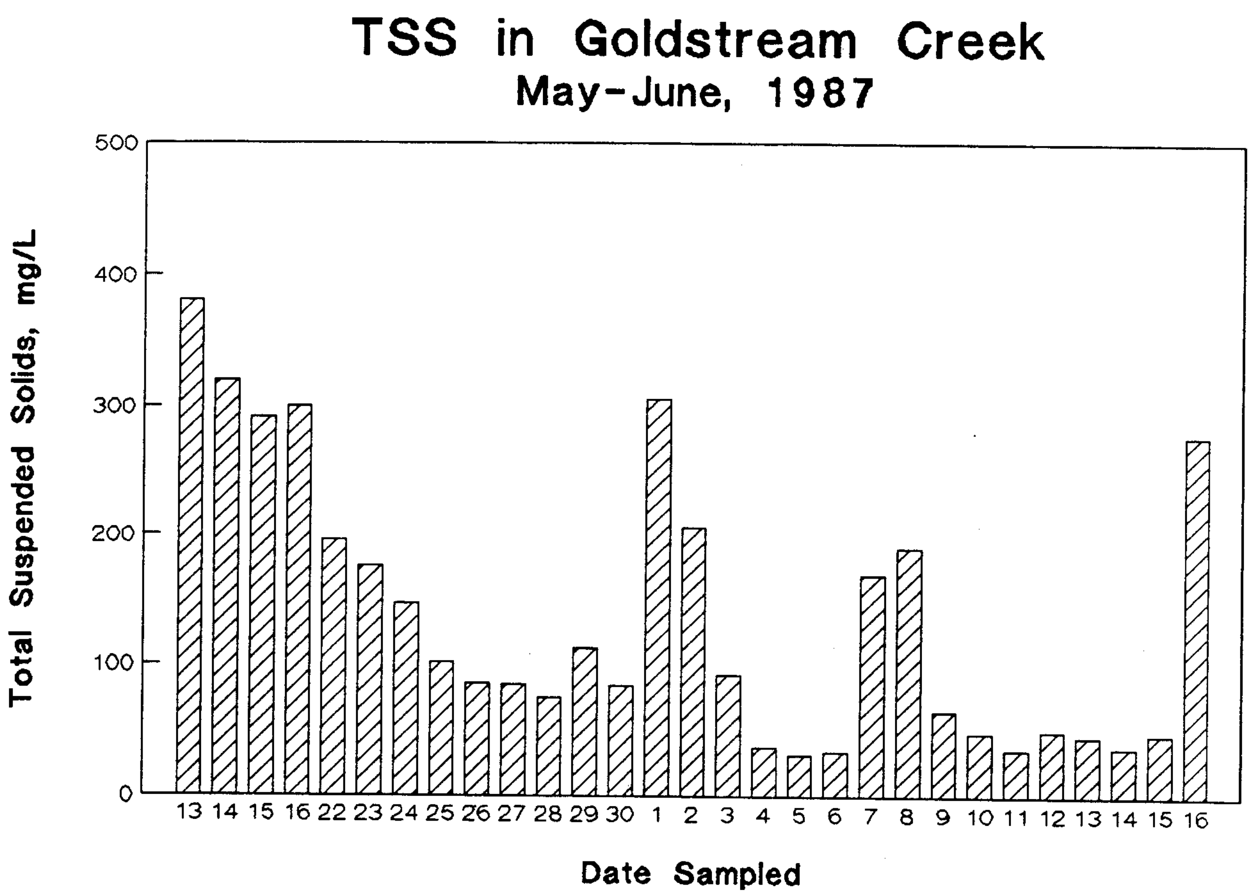


Figure 16. Settleable solids levels in Goldstream Creek during spring 1987 before the active mining season.

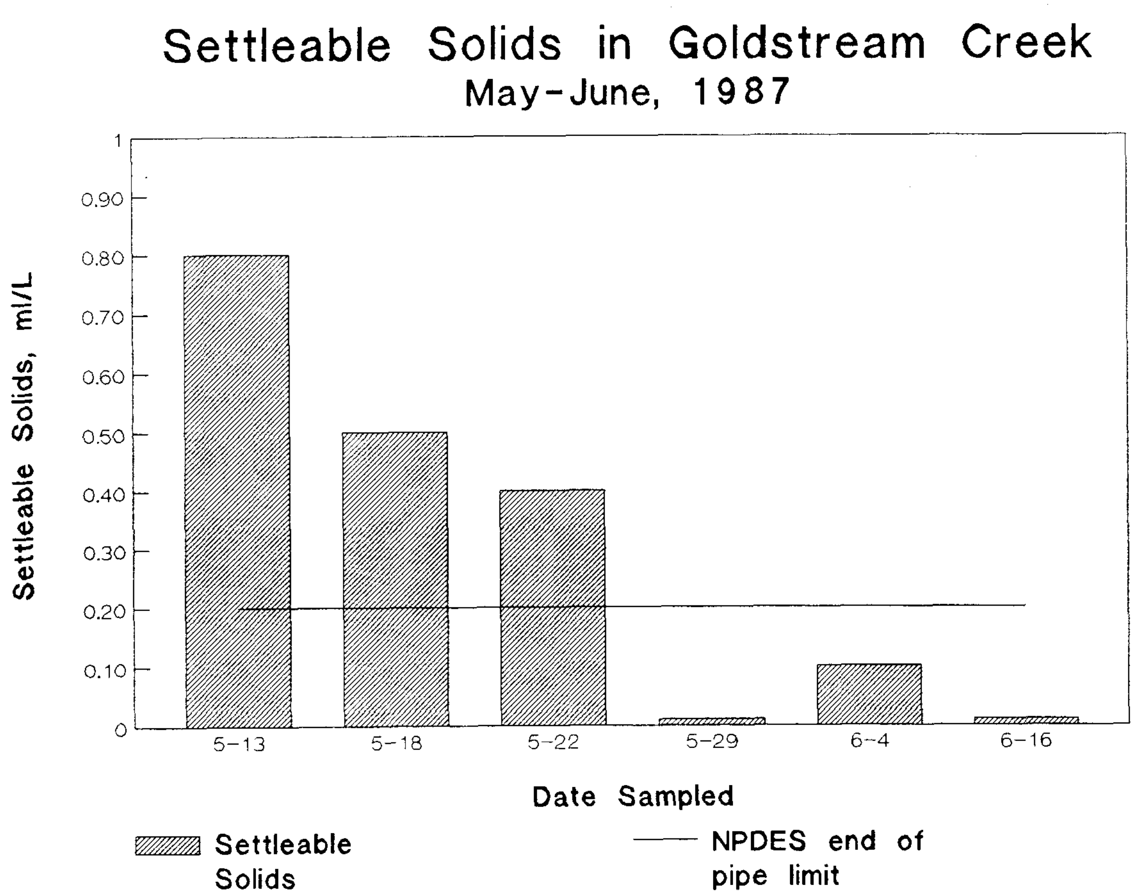


Figure 17. Settleable solids levels in Pedro Creek during spring 1987 before the active mining season.

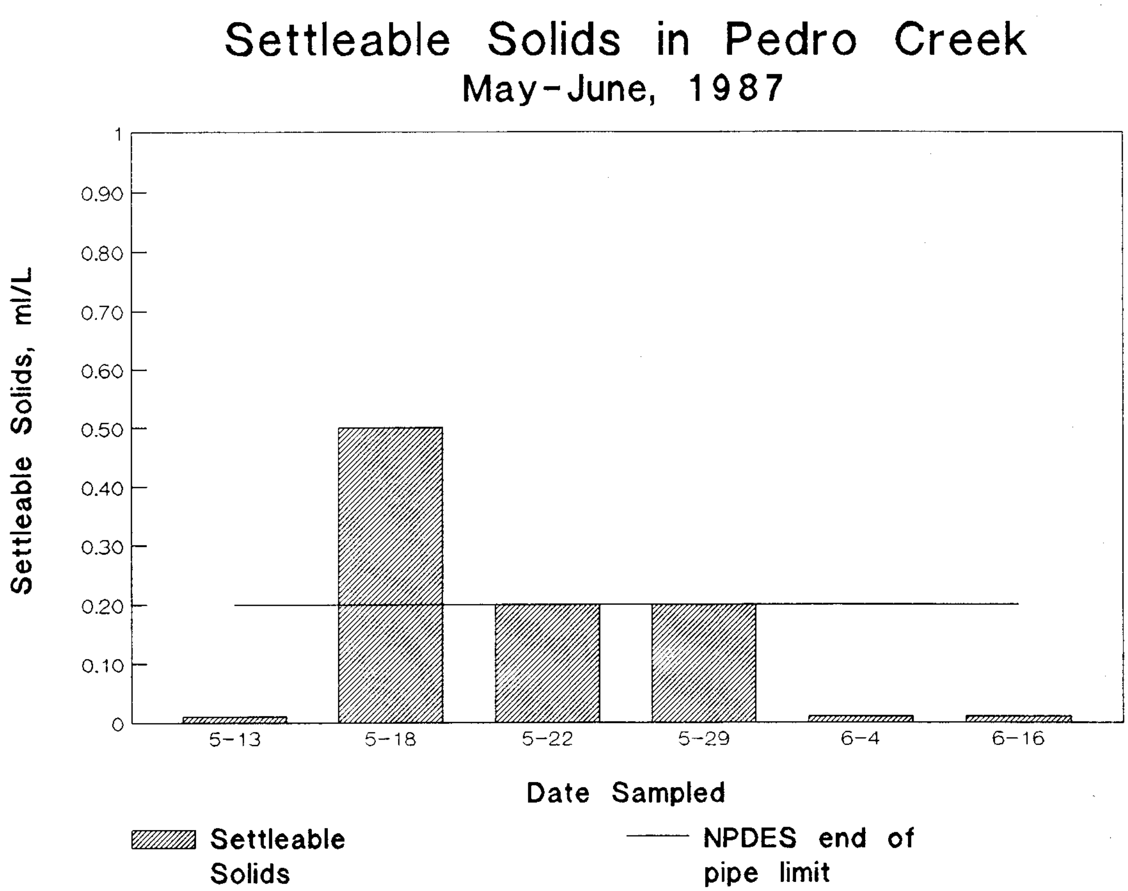


Figure 18. Settleable solids levels in Gilmore Creek during spring 1987 before the active mining season.

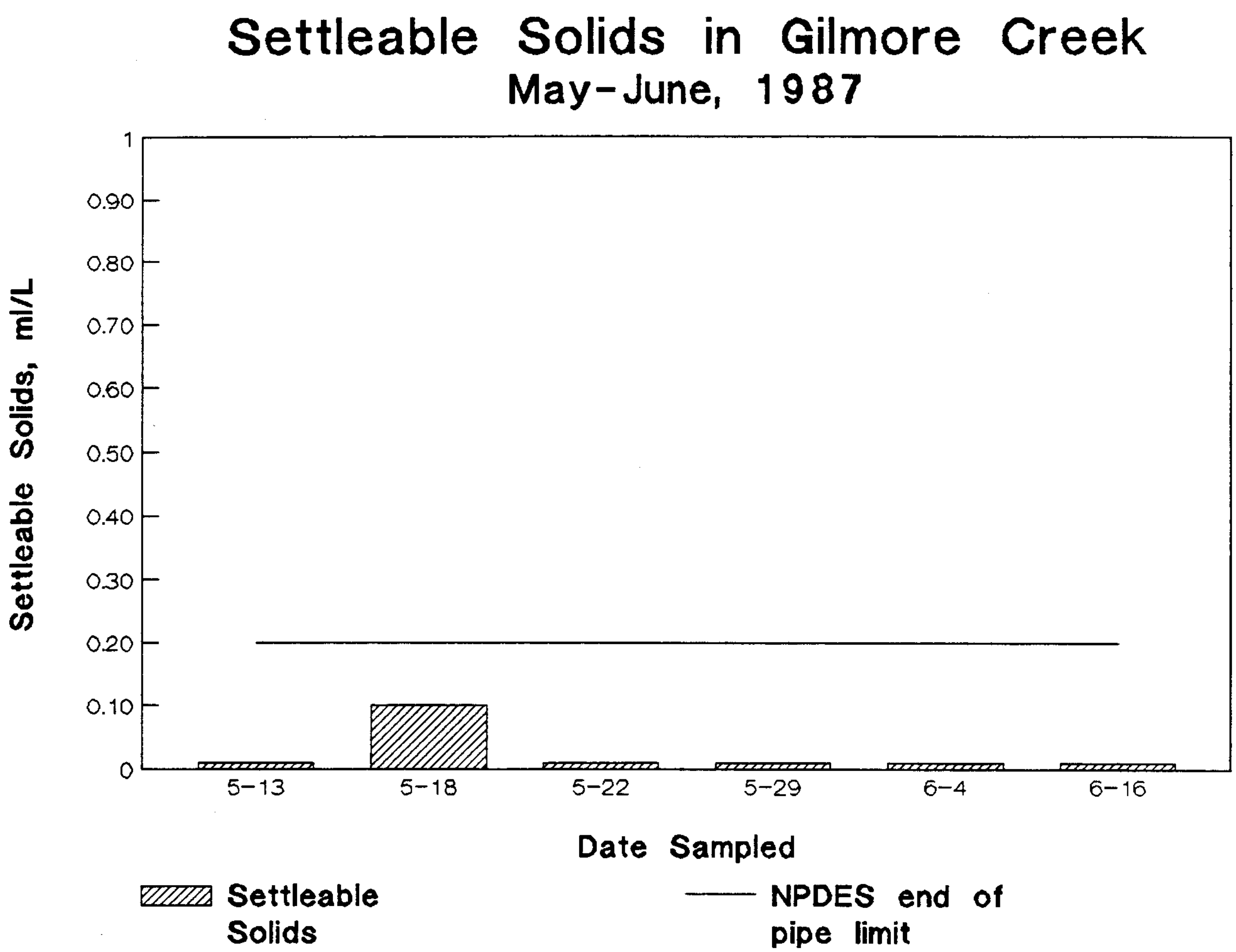
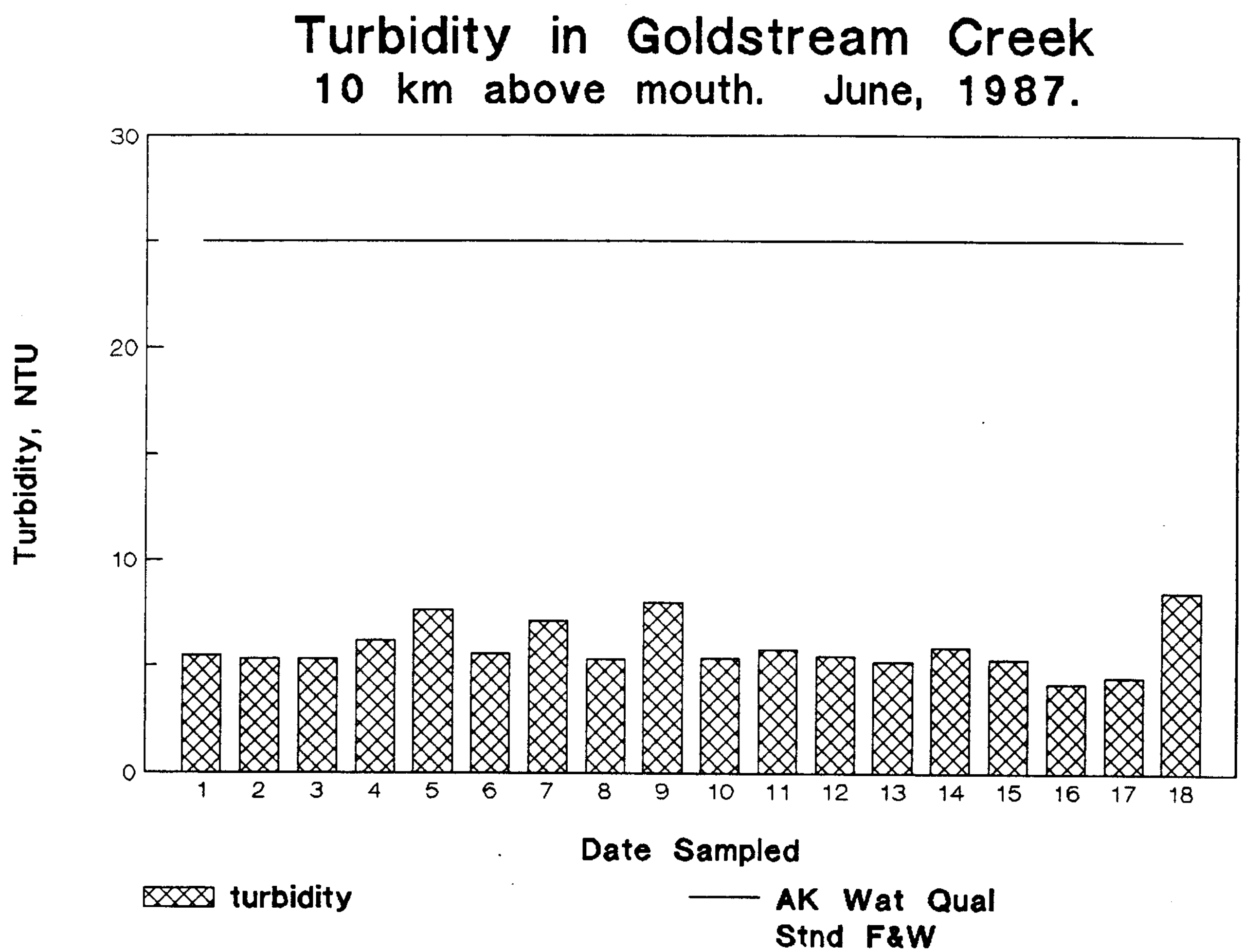


Figure 19. Average daily turbidity in Goldstream Creek at Minto Flats, June 1987.



The concentration of total suspended solids in Goldstream Creek at Minto Flats, 11 km above the mouth, was lower than found at any of the other sites: in June 1987, TSS concentrations at this downstream site ranged from 15 mg/L to 35 mg/L, with an average of 24 mg/L (fig. 20).

Stream water turbidities increased from Pedro Creek to Goldstream Creek at Ballaine Road, and decreased abruptly with distance downstream (table 4, fig. 21). The slight increase in turbidity between Goldstream Creek at the Sheep Creek crossing and at Martin Siding (15 km downstream) may have been caused by recently diverting the creek into its old channel and by placer mining activity (stripping and site preparation) at Moose Creek. Stream water turbidities measured in Goldstream Creek measured between the Standard Creek crossing (15 km downstream of the Sheep Creek Road crossing) and Goldstream at the mouth (123 km below the Sheep Creek Road crossing) were below 10 NTU.

Water quality was sampled periodically in Minto Lake and its outlet stream with grab samples. The turbidity in this channel was 5 NTU on June 1, which was lower than measured in the downstream site of Goldstream Creek on the same date, where the turbidity was 9.6 NTU.

Water quality in Minto Lake was measured at the surface and at 1.5 m depth along the west bank and at the point where Goldstream Creek used to flow into the lake. Not surprisingly, sediment levels in Minto Lake were highest near the old Goldstream Creek inlet where they were five times higher than along the west bank at the surface and eleven times higher than along the west bank at 1.5 m depth (table 3). Turbidities were also highest near the old Goldstream Creek channel. The turbidity at the west bank of Minto Lake at the surface was 9.6 NTU on June 2 and 3.9 NTU on June 20, and the turbidity at 1.5 m depth on June 20 was 4.7 NTU.

Settleable solids in lower Goldstream Creek, the outlet to Minto Lake, and Minto Lake were at trace levels, except for one sample from the lake that contained 0.5 ml/L zooplankton.

Fish and Game personnel traveled up lower Goldstream Creek from the mouth to 28 km upstream in a riverboat with a jet unit. We were able to navigate up to Bridge Lake, an old lake bed that is almost entirely filled in with sediments. The channel through the lake appeared to be navigable at higher stream flows.

The aquatic and semi-aquatic habitat associated with Bridge Lake appeared to be considerably degraded by deposition of sediments (fig 22). There were few grasses or other riparian vegetation established on the sediment banks and little food or cover for furbearers, nesting birds, or larger mammals. The area appeared to have limited use by gulls, pintail ducks, lesser yellowlegs, semi-palmated sandpiper, and various shorebirds. Because of limited food and cover, Bridge Lake in its present sedimented condition is not considered to be high in value as waterfowl habitat.

The Goldstream Creek channel was flown by helicopter from the mouth at Minto Flats upstream to the Murphy Dome crossing to identify areas where excessive sediment may have settled, thus blocking the channel to boat navigation. A second, unnamed lake (called Sixmile Lake by Wolff (1982)) upstream of Bridge Lake was also filled in by sediment; however, the stream channel flowed through the old lake bed and appeared to be navigable. Other, smaller lakes along the channel had been partially filled in (fig. 22).

Figure 20. Average daily total suspended solids concentrations in Goldstream Creek at Minto Flats, June 1987.

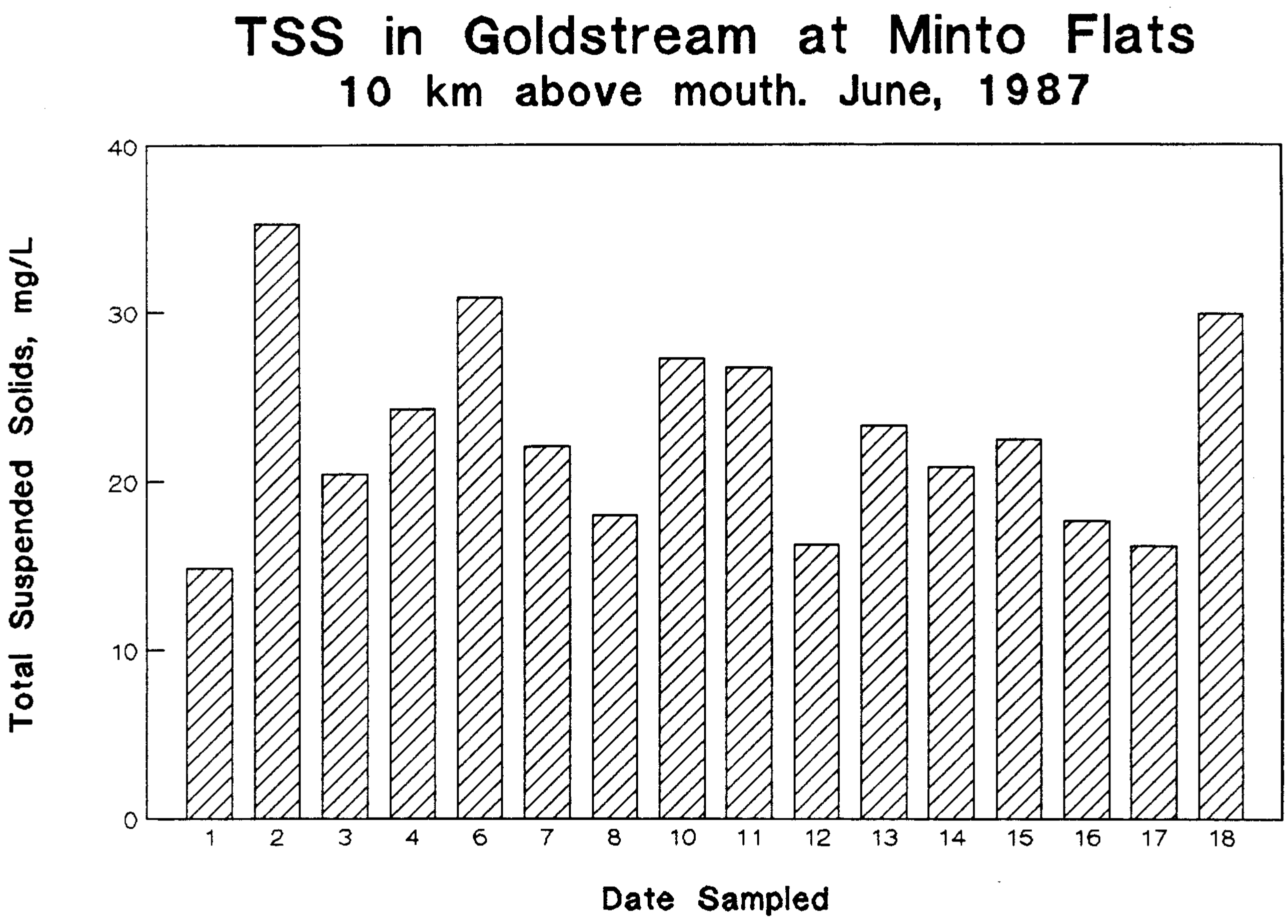


Table 4. Turbidity and TSS in the Goldstream Creek drainage, measured from Pedro Creek at the headwaters downstream to the mouth of Goldstream Creek, 1987.

Location	Distance Downstream kilometers	Turbid. NTU	TSS mg/L	n
Pedro Creek	0	18	527	24
Goldstream Creek at Ballaine Rd	14	37	134	37
Goldstream Creek at Sheep Creek Rd	23	12.5	13.1	1
Goldstream Creek at Martin Siding	40	16.1	26.8	1
Goldstream Creek at Standard Creek	73	8.3	9.3	1
Goldstream Creek at Dunbar	96	9.3	19.5	1
Goldstream Creek at Bridge Lake	119	7	33	1
Goldstream Creek 10 km above mouth	134	6	22	20

Figure 21. Turbidity levels measured in Goldstream Creek drainage from Pedro Creek to Minto Flats on various dates.

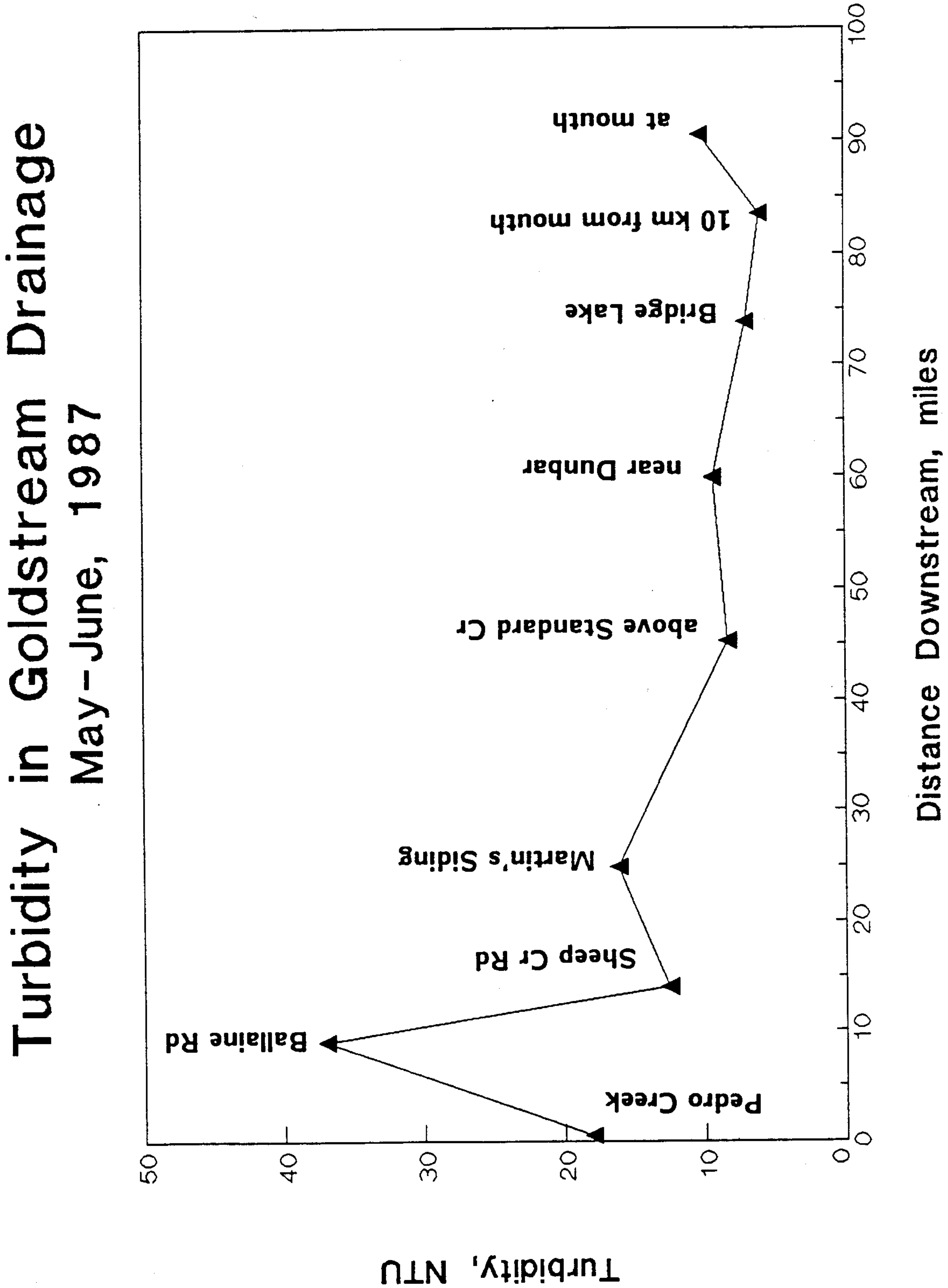
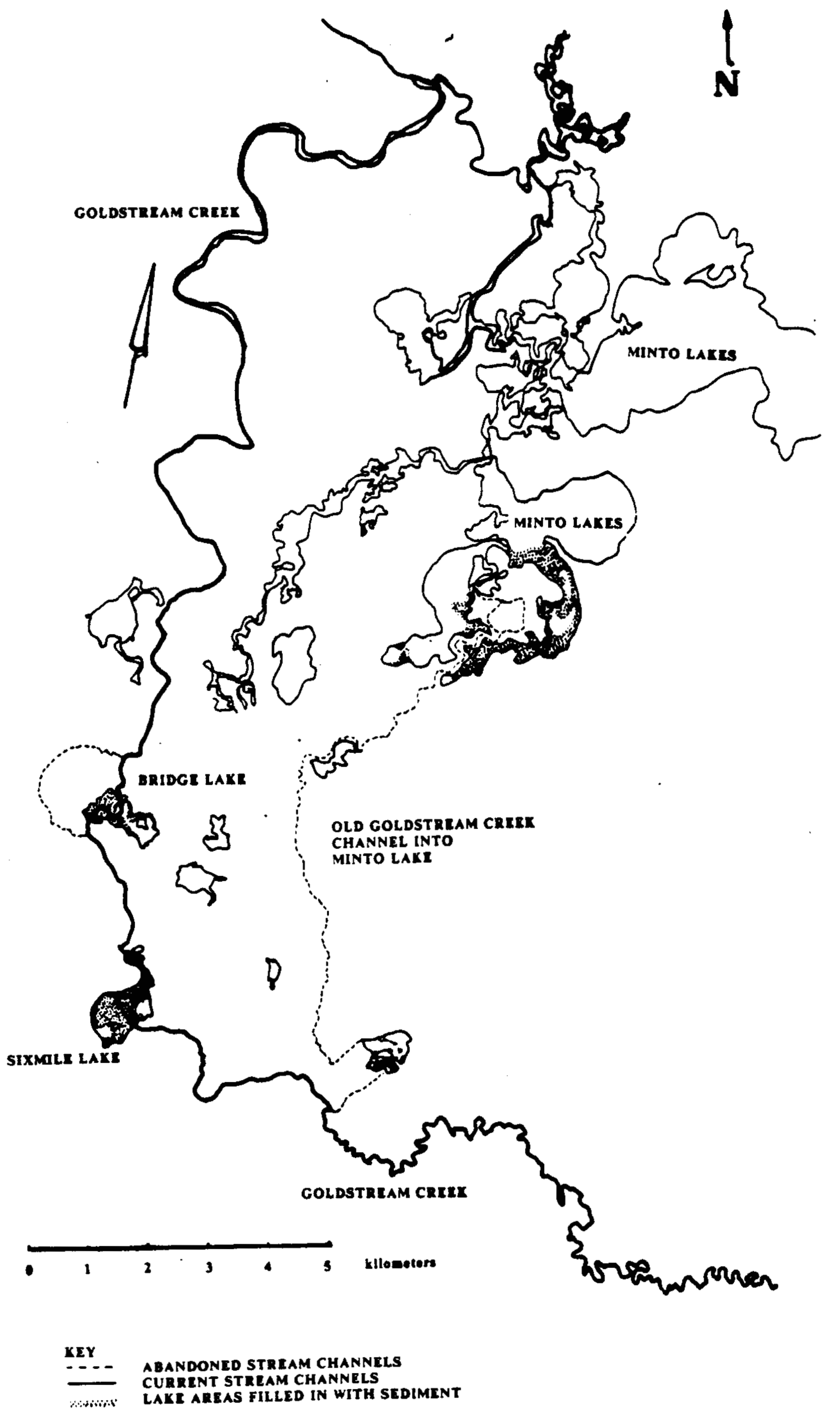


Figure 22. Map of selected waterbodies in Minto Flats, showing changes in the morphology of various lakes and stream channels between 1949 and 1978.



Goldstream Creek from the Sheep Creek Road crossing to Minto Flats is a slow, meandering stream; stream velocities were 0.13 meters per second at the Standard Creek crossing, 0.15 meters per second near Dunbar, and 0.3 meters per second in the channel flowing through Bridge Lake. Numerous beaver dams along the creek partially impounded the water and may have facilitated increased settling; however, none of these areas appeared to be infilled. The beaver dams and a large debris dam above Minto Flats would prevent boat travel.

Water quality data for the Goldstream Creek drainage, including Goldstream Creek in Minto Flats, for 1986-87 are presented in Appendix III.

Fishery Resources of Goldstream Creek Drainage

Fish in the lower reaches of Goldstream Creek were sampled with hook and line and with a gill net from the mouth upstream to Bridge Lake. We observed one fish at the outflow of Bridge Lake but were unable to capture it for positive identification. The gill net, placed about 16 km upstream of the mouth, caught five fish over 3.5 hours: one least cisco moving upstream, one least cisco moving downstream, and three northern pike moving downstream. ADF&G, Division of Sport Fish reported the following fish species from lower Goldstream Creek: broad whitefish, humpback whitefish, sheefish, least cisco, arctic grayling, and northern pike. Fish species found in Minto Lake and the lake outlet are: broad whitefish, humpback whitefish, least cisco, and northern pike (ADF&G Division of Sport Fish, per. comm. 1987, rf. Appendix II).

We electrofished four areas of the Goldstream Creek drainage: Pedro, Gilmore, and Flume creeks and Goldstream Creek above the Goldstream Creek Road crossing. No fish were found at any of these sites; however, high turbidities at all sites except Flume Creek severely limited visibility and may have prevented successful capture of any fish that might have been in the creeks. Arctic grayling have been reported in Goldstream Creek at Moose Creek up through summer 1986 (S. Pedersen, per. comm. 1987). ADF&G observed one arctic grayling in Flume Creek, a tributary to Pedro Creek in September 1986.

At the same time electrofishing was conducted, we made observations of the condition of the streambeds in all areas sampled and sampled qualitatively for aquatic invertebrates. The substrate of Pedro Creek was firmly embedded in silt and sand, and no aquatic invertebrates were found. Gilmore Creek had a varied substrate of medium sized gravel to cobble in the riffle areas and sand and silt in pools. The gravel-cobble areas were not embedded. Several species of mayflies (Ephemeroptera), stoneflies (Plecoptera), and true flies (Diptera) were observed in Gilmore Creek. The streambed of Goldstream Creek was primarily silt and sand, with a few areas where gravel or cobble were still exposed. Goldstream Creek at Goldstream Road, at Ballaine Road, and at Martin siding downstream to Minto Flats appeared to be largely depositional. Goldstream Creek at Sheep Creek Road had a streambed of large gravel and cobble in the region of the bridge. No aquatic invertebrates were observed in Goldstream Creek at Goldstream Road or at Ballaine Road. Goldstream Creek at Sheep Creek Road was probably a more suitable habitat for aquatic invertebrates; however, no observations were made in this area.

DISCUSSION

Historical data, photographs, old maps, and anecdotal information suggest that hydraulic stripping and dredging in the Goldstream Valley caused significant changes to the Goldstream Creek channel and lakes in Minto Flats. Comparisons of topographical maps produced in 1940-1950 with aerial photographs taken in 1978 showed that Bridge Lake and another unnamed lake upstream of Bridge Lake, were recently filled in by sediment. Earlier photographs taken prior to 1949, show some sedimentation in Bridge Lake. Other smaller lakes along the Goldstream Creek channel were partially filled in with sediment. There were fewer morphological changes among lakes not connected to the stream channel; most of these unconnected lakes appeared unchanged from the 1940's to 1979. Minto Flats and lower Goldstream Creek are naturally depositional areas where stream channels are expected to change course and lakes to gradually fill in and die. However, the estimated 14.3 million cubic yards of sediments flushed down Goldstream Creek from dredging undoubtedly accelerated these natural processes. This input of sediment was probably the primary cause of lakes along the stream channel filling in and of the Goldstream Creek channel diverting from Minto Lake into its present channel. Comparisons of 1949 U.S. Geological Survey maps with 1979 photographs suggest that Goldstream Creek flowed to just below the confluence with Little Goldstream Creek then split, with part of the channel flowing into Minto Lakes and the remainder flowing to the west, through Bridge Lake (the channel split in T1S, Section 35). Although Little Minto Lake had been sedimented in the southern end, the creek probably still flowed through the lake. A smaller lake, located in Section 25 and 26, T1S, became sedimented in the southern lobe between 1949 and 1978. At this time, Goldstream Creek was probably cut off from its original channel and migrated into the existing west fork.

Goldstream Creek appears on the 1949 USGS map as a meandering, low gradient stream. The photographs taken in 1978 and our observations made in 1987 show that the channel has not changed significantly in the past 48 years. The creek has a stable channel with deeply incised banks (particularly in the reach from Martin Siding to Dunbar). The slow, meandering character of Goldstream Creek combined with the silty bottom observed throughout most of the channel suggest that mining sediments have deposited throughout the stream from the Goldstream Valley to Minto Flats.

The water quality investigation conducted by ADF&G on the Goldstream Creek drainage showed that Goldstream Creek and its headwater tributaries have constantly elevated turbidity and total suspended sediment levels. Sediments have been deposited along most of the stream channel from the headwaters to Minto Flats. During periods when there is no active mining, resuspension of sediments deposited in previous mining seasons causes the water to remain turbid. Suspended sediment levels are especially high during spring high water flows and during periods of active mining.

Pedro Creek had the highest TSS levels during late spring and early summer 1987. At this time, there was no active mining in the drainage. The high suspended sediment levels in Pedro Creek indicate that this creek may be a primary contributor of resuspended sediment to downstream Goldstream Creek during spring breakup and during periods of high flows. In fact, total suspended solids levels in Pedro Creek were higher during spring breakup than during active mining in the previous autumn. The difference in the TSS levels suggests that high flows in Pedro Creek contribute more suspended solids by resuspension of previously deposited sediments than are contributed by present placer mining. The streambed of Pedro Creek was firmly embedded in sand and silt; there was little available benthic habitat for aquatic invertebrates.

Water quality data collected from Goldstream Creek at Ballaine Road suggest that this stream reach contains abundant stream bottom sediments that resuspend during period of medium to high flows. The stream bottom in this region contains a thick layer of mud and deposited sediments that are continuously resuspending. It was not determined how much material was resuspending or depositing in given stream reaches; however, it appeared that resuspended sediments from this region caused elevated turbidities downstream.

Continued mining activity in this creek combined with resuspension of deposited sediments cause the water quality in this drainage to be consistently degraded. The relative contribution of sediment from each tributary stream would be expected to change during the mining season and would depend upon the numbers of miners operating on each creek as well as the effectiveness of each treatment system. The consistently poor water quality in Pedro, Gilmore, and Goldstream creeks during periods when mining is inactive suggest that even if mining were eliminated from this drainage, it would take several years for the water quality to improve as deposited sediments are resuspended and flushed downstream. All sediments flushed from the channel would eventually deposit in Minto Flats.

Sediment levels in Goldstream Creek appear to drop to levels that are similar to those found in Gilmore Creek within 15 km below the last disturbance. This suggests that at low or average flows, most of the suspended sediments in Pedro, Gilmore, and Goldstream creeks deposit within a relatively short distance downstream. However, it is probable that most of the deposited sediments are resuspended at high flows, and are gradually flushed to Minto Flats, where they are finally deposited. Therefore, although placer mining may not directly cause sedimentation in the lower reaches, the gradual movement of the input sediments will continue to deposit in quieter areas, filling lakes, and causing the stream channel to migrate.

The shift of the Goldstream Creek channel from Minto Lake to the west fork of the channel exemplifies the gradual process of channel migration resulting from sedimentation. Sediments deposited in the old inlet channel to Minto Lake appear to continually resuspend and erode into the lake. These resuspended sediments are probably the primary contributor to elevated TSS and turbidity levels measured in the southern end of the lake.

There were not sufficient baseline data to determine if or to what extent fishery resources in Minto Flats may have been affected by the input of sediment from placer mining. Turbidities in Goldstream Creek at Minto Flats are low, usually less than 10 NTU. This is below the Alaska Water Quality Standard for fish and wildlife, which is 25 NTU. Although elevated turbidity levels may not have a direct physical effect on fish, higher sediment levels may affect fish populations by altering the lake or stream habitat. Changes in lake habitat resulting from sedimentation may be either beneficial or detrimental, depending upon the amount of sediments deposited. Various investigators (e.g., Shepherd and Matthews 1985) speculated that fish summer rearing habitat in Minto Lake has improved as the lake has become shallower and primary productivity has increased; however, overwintering habitat may have been eliminated. Bridge Lake, which is completely filled in by sediment, has limited habitat for fish in the stream channel that cuts through the old lake bed. Two unnamed lakes near Bridge Lake are also filled in with sediment. Neither of these lakes is expected to support fish populations. Nesting and rearing by waterfowl and other birds occurs along the vegetated edges of Bridge Lake; however, the old lake bed appears to have limited use by birds.

Fish populations in Goldstream Creek from Sheep Creek Road upstream to the headwater tributary streams appear to have been reduced since the resurgence of placer mining in the late 1970's. Anecdotal information suggests that arctic grayling populations were higher in the mid-1970's to early 1980's, before placer mining increased significantly. Local Goldstream Valley residents state that they either observed or caught fish in Goldstream Creek, its tributaries, and in ponds connected to the creek as late as 1982 (Shideler, per. comm.).

High stream water turbidities combined with elevated settleable solids levels and the resultant deposition on streambeds have probably been major factors responsible for reducing fish populations and angler success. Pedro Creek and Goldstream Creek in the vicinity of Ballaine Road had streambottom substrates that were almost totally embedded in silt and sand. Aquatic invertebrates, the major food of arctic grayling and any other sight-feeding fish, were not observed in either Pedro or Goldstream creeks. The absence of aquatic invertebrates was probably due to poor habitat; most aquatic invertebrates found in Alaska prefer clean, cold flowing water with substrates of gravel and cobble.

SUMMARY AND CONCLUSIONS

Minto Flats, as a low-lying area at the mouth of Goldstream Creek, is naturally an area of sediment deposition. Shallow lakes and ponds connected or previously connected to Goldstream Creek serve as settling basins for suspended material, including those introduced during hydraulic stripping, dredging, and placer mining since the late 1920's through the present.

Millions of cubic yards of sediment were flushed down Goldstream Creek from hydraulic mining, and this sediment eventually deposited in Minto Flats. Lakes and ponds connected to Goldstream Creek exhibited dramatic, or catastrophic, change, while those lakes separated from the creek underwent a more gradual transition of expansion or drying. Minto Lake, which was partially infilled by sediment, became a shallower, eutrophic, body of water. These changes may have improved rearing habitat for fish and waterfowl; however, the overwintering capacity of Minto Lake may have been destroyed. Bridge Lake and an unnamed ("Sixmile") lake upstream have been completely filled in by sediment and no longer support fish or waterfowl. Bridge Lake is currently a nearly barren mud flat while Sixmile Lake has revegetated with willow and other shrubs.

Navigation upstream in Goldstream Creek is currently limited during low water by mud shallows in Bridge Lake. During high water, the channel through the infilled lake is passable. Sediments resuspended from the streambed of Goldstream Creek and currently input from placer mining activity will continue to deposit in Minto Flats, causing accelerated infilling of lakes and migration of the stream channel. Deeper lakes may benefit by increasing littoral zones, nutrient inputs, and resultant productivity; however, overwintering habitat for fish may become limiting. Shallower lakes will continue to infill, becoming mudflats that eventually revegetate.

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APPENDICES

Appendix I. Historical data from Goldstream Creek drainage, 1970-1984.

1. Data Collected Before the Resurgence of Mining 1970-1971 (Peterson 1972)

Location	Date NTU	Turbidity mg/L	TSS
Goldstream Creek at Fox	10-Aug-70	2.00	
	21-Aug-70	15.00	
	02-Sep-70	15.00	
	18-Sep-70	0.00	
	03-Oct-70	5.00	
	28-Oct-70	5.00	
	13-Mar-71	5.00	25.50
	23-Apr-71	35.00	40.00
	06-May-71	23.00	65.20
	10-Jun-71	7.00	19.60
	13-Jul-71	23.00	44.00
	19-Aug-71	3.10	4.60
	17-Sep-71	5.00	4.90
	22-Oct-71	3.50	8.30
Goldstream Creek above construction site	18-Sep-70	15.00	
	03-Oct-70	5.00	
	28-Oct-70	5.00	
	10-Jun-71	7.00	8.40
Goldstream Creek below construction site	10-Aug-70	5.00	
	21-Aug-70	12.00	
	02-Sep-70	22.00	
	18-Sep-70	15.00	
	03-Oct-70	5.00	
	28-Oct-70	5.00	
	06-May-71	35.00	39.20
	10-Jun-71	7.00	9.20
	13-Jul-71	29.00	58.80
	19-Aug-71	3.20	3.90
	17-Sep-71	6.80	10.30
	22-Oct-71	3.80	3.90

1. continued

Location	Date	Turbidity NTU	TSS mg/L
Goldstream Creek at Ballaine Rd	10-Aug-70	11.00	
	21-Aug-70	18.00	
	02-Sep-70	19.00	
	18-Sep-70	20.00	
	03-Oct-70	10.00	
	28-Oct-70	5.00	
	09-Jan-71	4.00	25.50
	13-Mar-71	7.00	30.50
	23-Apr-71	22.00	12.50
	06-May-71	22.00	17.20
	10-Jun-71	11.00	14.00
	13-Jul-71	33.00	87.60
	19-Aug-71	6.10	12.90
	17-Sep-71	15.00	20.20
	22-Oct-71	5.40	31.00
Goldstream Creek at Sheep Creek Rd	10-Aug-70	15.00	
	21-Aug-70	25.00	
	02-Sep-70	25.00	
	18-Sep-70	15.00	
	03-Oct-70	15.00	
	28-Oct-70	15.00	
	09-Dec-70	22.00	
	09-Jan-71	4.00	26.50
	27-Feb-71	22.00	
	13-Mar-71	66.00	65.50
	23-Apr-71	33.00	16.00
	06-May-71	34.00	189.20
	10-Jun-71	7.00	2.40
	13-Jul-71	13.00	10.00
	19-Aug-71	6.60	6.60
	17-Sep-71	12.00	4.50
	22-Oct-71	7.50	3.30
Goldstream Creek at Dome Creek	21-Aug-70	28.00	
	02-Sep-70	25.00	
	18-Sep-70	20.00	
	03-Oct-70	25.00	
	28-Oct-70	15.00	
	06-May-71	34.00	168.00
	10-Jun-71	20.00	42.80
	13-Jul-71	78.00	103.30
	19-Aug-71	7.50	13.20
	17-Sep-71	8.20	6.50
	22-Oct-71	7.00	2.10

2. Data Collected in August-September 1983 (Alaska Dept. of Environmental Conservation)

Location	Date	Turbid. NTU	TSS mg/L
Goldstream Creek at Fox	06-Aug-83	330	556
	08-Aug-83	300	292
	08-Aug-83	300	272
	14-Aug-83	260	250
	14-Aug-83	270	250
	14-Aug-83	270	282
	14-Aug-83	260	268
	14-Aug-83	250	160
	14-Aug-83	280	268
	14-Aug-83	240	176
	15-Aug-83	240	156
	15-Aug-83	240	160
	15-Aug-83	230	160
	15-Aug-83	250	276
	15-Aug-83	230	176
	15-Aug-83	230	140
	15-Aug-83	220	144
	15-Aug-83	220	140
	15-Aug-83	230	176
	15-Aug-83	250	256
	15-Aug-83	240	248
	15-Aug-83	300	548
	16-Aug-83	320	636
	16-Aug-83	350	588
	16-Aug-83	370	736
	16-Aug-83	360	580
	16-Aug-83	320	436
	16-Aug-83	280	312
	16-Aug-83	260	268
	16-Aug-83	270	264
	16-Aug-83	270	344
	16-Aug-83	260	308
	16-Aug-83	260	252
	16-Aug-83	260	252

2. continued

Location	Date	Turbid. NTU	TSS mg/L	SS ml/L	Fec. colf # Coln/ 100 ml
Goldstream Creek at Sheep Creek Rd	06-Aug-83	660	770		500
	08-Aug-83	280	224		
	08-Aug-83	260	224		
	14-Aug-83	230	172		
	16-Aug-83	260	196		
Gilmore Creek above Bedrock Creek mine	30-Jul-82	28		0.1	
	01-Sep-82	39			
	12-Sep-82	48		0.8	
	17-Sep-82	17		0.1	
	21-Sep-82	24		0	
	22-Jul-83	85	47		
Gilmore Creek 500' below mine	30-Jul-82	600			
	01-Sep-82	130			
	12-Sep-82	560			
	17-Sep-82	640			
	21-Sep-82	650			
	22-Jul-83	2800	1087		
Gilmore Creek above mouth	14-Aug-83	1040	528		
	14-Aug-83	1040	592		
	16-Aug-83	700	404		
Pedro Creek above mouth	14-Aug-83	70	34		
	16-Aug-83	56	70		

3. Data Collected in May-June 1984 (Alaska Dept. of Fish and Game, Habitat Division)

Location	Date	Turbid NTU	TSS mg/L	Temp Deg
Goldstream Creek at Ballaine Rd	25-May-84	250	1.40	
	28-May-84	243	0.90	38
	28-May-84	190	1.00	41
	04-Jun-84	183	1.00	44
	05-Jun-84	141	0.35	37
	11-Jun-84	208	0.60	48
	12-Jun-84	240	0.75	42
	18-Jun-84	280	0.30	51
	19-Jun-84	250	0.30	43
Goldstream Creek at pipeline crossing	25-May-84	225	1.50	
	28-May-84	141	0.50	36
	28-May-84	1560	8.50	40
	04-Jun-84	96	0.70	45
	05-Jun-84	201	0.60	44
	11-Jun-84	104	0.25	48
	12-Jun-84	760	0.85	47
	18-Jun-84	320	1.10	51
	19-Jun-84	280	0.75	50

4. Data Collected August 7-16, 1984 (Alaska Dept. of Environmental Conservation)

Location	Date	Turbid NTU	TSS mg/L	Fec colf # col/ 100 ml
Goldstream Creek at Fox	10-Aug-84	64	260	90
	12-Aug-84	400	310	
	13-Aug-84	790	1400	
Pedro Creek above mouth	10-Aug-84	90	93	8
	13-Aug-84	30	34	
Gilmore Creek above mouth	10-Aug-84	560	350	40
	13-Aug-84	550	150	
Goldstream Creek below Sheep Creek	10-Aug-84	140	38	50
	12-Aug-84	358	250	
	13-Aug-84	348	450	
Goldstream Creek at Chatanika River confluence	15-Aug-84	38	68	
Goldstream Creek at Ballaine Rd				670

Appendix II. Common and scientific names of fish reported from the Goldstream Creek drainage.

broad whitefish	Coregonus nasus
humpback whitefish	Coregonus pidschian
sheefish (Inconnu)	Stenodus leucichthys
least cisco	Coregonus sardinella
arctic grayling	Thymallus arcticus
northern pike	Esoxo lucius

Appendix III. Water quality data collected by ADF&G, 1986-87 for Goldstream Creek drainage.

1. Data Collected From Various Sites, Sept.-Oct. 1986.

Location	Date	Turbid (NTU)	TSS (mg/L)	Set. sol ml/L
First Chance Creek	5-Sep-86	7.3	6.8	tr
Flume Creek at Steese	5-Sep-86	2.5	2.4	nd
Goldstream Creek	5-Sep-86	31.3	36.2	tr
at Standard Creek	26-Sep-86	90.0	61.8	
Goldstream Creek	5-Sep-86	118.0	64.0	tr
at Sheep Creek Rd	26-Sep-86	256.0	202.0	
	26-Sep-86	257.0	175.0	
	26-Sep-86	227.0	138.0	
	27-Sep-86	248.0	124.0	
	27-Sep-86	262.0	174.0	
	27-Sep-86	274.0	186.0	
	27-Sep-86	294.0	232.0	
	28-Sep-86	275.0	202.0	
	28-Sep-86	248.0	170.0	
	28-Sep-86	253.0	169.0	
	28-Sep-86	261.0	161.0	
	29-Sep-86	246.0	174.0	
	29-Sep-86	245.0	146.0	
	29-Sep-86	240.0	166.0	
	29-Sep-86	241.0	160.0	
	30-Sep-86	244.0	148.0	
	30-Sep-86	228.0	144.0	
	30-Sep-86	231.0	152.0	
	30-Sep-86	217.0	143.0	
	1-Oct-86	210.0	130.0	
	1-Oct-86	211.0	128.0	
	1-Oct-86	212.0	131.0	
	1-Oct-86	207.0	135.0	
	2-Oct-86	218.0	155.0	
	2-Oct-86	228.0	151.0	
	2-Oct-86	231.0	167.0	
	2-Oct-86	235.0	154.0	
	3-Oct-86	231.01	51.0	
	3-Oct-86	236.0	215.0	

nd = none detected, tr = trace

1. continued

Location	Date	Turbid (NTU)	TSS (mg/L)	Set. sol ml/L
Goldstream Creek	20-May-86	214.0	524.0	
Goldstream Creek at Ballaine Rd	5-Sep-86	80.0	129.0	0.05
Goldstream Creek at Goldstream Rd	5-Sep-86	334.0	261.0	0.1
Pedro Creek at Goldpan site	5-Sep-86	113.0	84.0	nd
	26-Sep-86	63.6	57.1	
Pedro Creek at First Chance	5-Sep-86	326.0	201.0	tr
Pedro ISCO	26-Sep-86	78.0	79.6	
Pedro ISCO	26-Sep-86	359.0	428.0	
Pedro ISCO	27-Sep-86	781.0	824.0	
Gilmore Creek	20-May-86	74.0	98.8	0.15
Gilmore Creek	5-Sep-86	1148.0	722.0	
Steamboat Creek	5-Sep-86	26.0	284.0	0.3

nd = none detected, tr = trace

2. Data Collected From Goldstream Creek Drainage and Minto Lake, May-June 1987.

Location	Date	Turbidity (NTU)	TSS (mg/L)	Set. solids ml/L
Pedro Creek below gold pan site	13-May-87	8.6		tr
	18-May-87		3932.00	0.5
	22-May-87	27.5	239.00	0.2
	13-May-87	7.8	161.00	
	14-May-87	11.5	489.00	
	15-May-87	15.4	949.00	
	16-May-87	20.3	706.00	
	17-May-87	18.0	1098.00	
	18-May-87	24.6	673.00	
	19-May-87	23.5	686.00	
	20-May-87	27.0	776.00	
	21-May-87	20.6	420.00	
	22-May-87	20.0	296.00	
	23-May-87	14.0	164.80	
	24-May-87	12.7	134.20	
	25-May-87	10.2	123.30	
	26-May-87	20.5	234.00	
	27-May-87	23.5	137.00	
	28-May-87	27.7	333.00	
	29-May-87	13.4	171.00	
	27-May-87	13.8	104.00	
	29-May-87	19.6	160.00	0.2
	04-Jun-87	10.9	134.30	tr
	16-Jun-87	22.7	11.00	tr
Gilmore Creek near tracking station	13-May-87	38.5		tr
	18-May-87	63.4		0.1
	22-May-87	28.2	39.00	tr
	27-May-87	20.8	15.60	
	29-May-87	19.6	14.50	tr
	04-Jun-87	22.8	15.10	tr
	16-Jun-87	80.0	35.20	tr

nd = none detected, tr = trace

2. continued

Location	Date	Turbidity (NTU)	TSS (mg/L)	Set. solids ml/L
Goldstream Creek at Ballaine Bridge	13-May-87	73.0		0.8
	18-May-87	197.0		0.5
	22-May-87	76.5	240.00	0.4
	27-May-87	39.5	89.90	
	29-May-87	18.2	54.90	tr
	13-May-87	58.0	381.00	
	14-May-87	62.5	320.00	
	15-May-87	72.5	292.00	
	16-May-87	74.5	300.00	
	22-May-87	38.5	196.00	
	23-May-87	77.5	176.00	
	24-May-87	40.5	146.50	
	25-May-87	22.5	102.30	
	26-May-87	15.2	86.10	
	27-May-87	25.0	85.30	
	28-May-87	26.5	75.20	
	29-May-87	44.4	112.90	
	30-May-87	30.0	84.30	
	01-Jun-87	105.0	306.10	
	02-Jun-87	62.5	205.70	
	03-Jun-87	30.0	92.70	
	04-Jun-87	30.7	63.30	
	04-Jun-87	20.2	65.50	<0.2
	16-Jun-87	14.2	84.90	
	04-Jun-87	39.9	37.80	
	05-Jun-87	45.1	31.80	
	06-Jun-87	26.8	33.90	
	07-Jun-87	18.1	169.00	
	08-Jun-87	12.2	190.00	
	09-Jun-87	15.5	64.80	
	10-Jun-87	18.4	48.40	
	11-Jun-87	10.5	35.80	
	12-Jun-87	24.4	50.10	
	13-Jun-87	22.4	45.50	
	14-Jun-87	18.4	37.80	
	15-Jun-87	14.1	47.50	
	16-Jun-87	17.0	78.00	tr
Goldstream Creek at Goldstream Rd	13-May-87	39.0		0.1

tr = trace

2. continued

Chatanika River at	01-Jun-87	11.0	63.10	0.1
Goldstream	20-Jun-87	10.2		
Goldstream Creek	01-Jun-87	9.6	14.90	nd
2.5 mi. u/s	01-Jun-87	5.5		
mouth	02-Jun-87	5.3	35.3	
	03-Jun-87	5.3	20.4	
	04-Jun-87	6.2	24.2	
	05-Jun-87	7.6		
	06-Jun-87	5.6	30.9	
	07-Jun-87	7.1	22	
	08-Jun-87	5.3	18	
	09-Jun-87	8.0		
	10-Jun-87	5.4	27.2	
	11-Jun-87	5.8	26.7	
	12-Jun-87	5.5	16.3	
	13-Jun-87	5.2	23.2	
	14-Jun-87	5.9	20.8	
	15-Jun-87	5.3	22.4	
	16-Jun-87	4.2	17.7	
	17-Jun-87	4.5	16.2	
	18-Jun-87	8.5	29.9	
	18-Jun-87	5.3	11.7	tr
Miscellaneous Goldstream sites				
Sheep Creek Bridge	17-Jun-87	12.5	13.1	tr
Martin Siding	17-Jun-87	16.1	26.8	tr
10 km u/s	18-Jun-87	4.4	33.2	tr
10 km u/s	30-Jun-87	9.5		nd
W Dunbar T	30-Jun-87	9.3		nd
above Standard Cr	30-Jun-87	8.3		nd
Minto Lake				
surface	01-Jun-87	5.0	5.00	nd
surface	02-Jun-87	9.6	24.50	(zp)0.5
surface	20-Jun-87	3.9	4.81	nd
z=1.5 m	20-Jun-87	4.7	5.86	tr
at old Gold-stream Cr. chan.	20-Jun-87	10.2	56.4	0.1

nd = none detected, tr = trace, zp = zooplankton