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THE EFFECTS OF PLACER MINING ON THE ENVIRONMENT IN CENTRAL ALASKA

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Abstract

Within the Tolovana Mining District, as a result of placer mining, 800 acres of land have been disturbed (0.25% of the land area) and 4 million cubic yards of muck have been transported down the Tolovana River through the subsiding Minto Flats. This has increased the rate of sedimentation of the lakes adjacent to the Tolovana River. Mine tailings are about 50% revegetated by natural species. Approximately 60 million cubic yards of muck must be removed to mine the Livengood deposits. A large area of settling ponds will be needed if the deposit is stripped by hydraulic means, or a large area for stacking overburden if mechanical stripping is required.

The Crooked Creek area, mined for 80 years, has 1,900 acres disturbed (0.7% of the land area) and 200,000 cubic yards of muck has been stripped. No correlation is apparent between mining and the non-anadromous fish population, although sport fishing is considered by some to be not as good as a result of mining. Portions of the stream system observed to be impacted with mud showed evidence of having been periodically flushed out. Sieve analysis and trace element analysis were applied in an attempt to trace sediments back to their sources, but were not successful.

Mining is the pioneer industry around which much of the State of Alaska developed. The transportation network required by the mining industry benefits sportsmen, the tourist industry, and directly increases the value of adjacent land. The profit from mining brought much of the early population to the state, and will be a steady source of revenue in years to come.

Acknowledgements

This report is an edited and revised form of an original report by the same authors entitled "A Study of Placer Mining in Central Alaska as it Affects and Affected the Environment" which had been funded by the U.S. Bureau of Mines under contract No. J017734.

This report is a compilation of the efforts of a number of individuals of diverse backgrounds and vocations.

Mr. Doug Weir, environmental consultant from Scotland and currently retained by Charles Hawley and Associates, accompanied the team on two trips to Minto Flats. He also studied the Crooked Creek district. His comments are presented in Appendices A, B and C.

Mr. Dennis Ward of Environmental Services Ltd. conducted a field survey of benthic and fish species of the Crooked Creek district. He also collected water samples from both the Crooked Creek district and the Minto Flats area. His work is documented in Appendix D.

Members of the Alaska Miners Association were effective in initiating this report and maintained an active interest in its progress.

Dr. Nils Johansen spent a part of one summer collecting water samples.

Mr. Leo Titus was a helpful guide in the lower Tolovana, Chatanika, Goldstream and Tatalina drainage systems, as well as the Minto Flats. His contributions are related in Chapter 4.

Long time residents in Interior Alaska, enumerated in Chapter 4, have been most helpful in recording the impressions of those who have lived and worked during the earlier years of mining, hunting, trapping and homesteading.

Mr. James Mason and Mr. Charles Green contributed by making the resources of Asamera Mining Company available when needed.

Dr. Chris Lambert aided in the editing of this report. Thanks go to Carol Wells and Louella Finch for many hours of typing and retyping of this manuscript. Significant portions of the text were written by Bruce W. Campbell who also completed the editing and publishing of this report.

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Chapter 1

Introduction

Mining of placer gold in Alaska began on the Kenai River in 1848 and reached peaks of production during World War I and again in the 1930's. A resurgence of placer gold production after World War II peaked about 1950 and thereafter began a slow and variable decline. Placer mining in Alaska is now increasing in response to higher gold prices.

A recent survey by the U.S. Bureau of Mines indicates that there are about 198 active placer mines, located in at least 28 of the 35 placer mining districts of Alaska, identified by Thomas, et al. (1959). In response to a spurt in the price of gold to over $500, numerous other mines have also become active in areas not shown by Thomas, et al. About half of these placer mines are located on or near the interconnected Alaskan road system. Distribution of operations throughout Alaska is summarized in Table 1. These operations are highly variable in the kind of deposit and the type of process used. Mining methods include dredging, hydraulicking and various combinations of bulldozer-dragline-hydraulic equipment. The character of the receiving waters include clear streams, turbid streams, small creeks, large rivers, lakes and the ocean. Fish may or may not be present. Each of these situations presents a different environmental situation. Table 2 summarizes the variable nature of the placer streams and the receiving streams.

Table 1: Distribution of Active Placer Operations

Drainage	Number and % of Operations
Upper Yukon	51 = 25%
Middle Yukon (incl. Koyukuk)	33 = 17%
Lower Yukon	1 = .5%
Norton Sound	13 = 6.5%
Kotzebue Sound	5 = 2.5%
Kuskokwim River	18 = 9%
Bristol Bay	2 = 1%
Cook Inlet	69 = 35%
Other - Bering Sea, Aleutians, S.E. Alaska	6 = 3%
	198 = 100%

During the years in which placer mining was in decline, several laws were passed and agencies created that are aimed at regulating industrial activities, among them placer mining. The purpose of these laws is to protect other resources and values while allowing the activity, in this case, placer mining, to continue. Unfortunately, there are practically no data to identify the interference and damage that placer mining might do to other resources - fish, wildlife, water quality, surface resources or even scenery. Without hard factual data, the agencies cannot effectively regulate, and the mining industry cannot function efficiently in the face of regulation. Such regulation needs to be based upon factual data in order to be rational and not damaging to all vitally needed resources.

The present meager bases for regulating placer operations are experience and study from other areas in the U.S.A. (or other nations), and the very limited base provided by a reconnaissance study of placer mining in Alaska made by the FWPCA in 1968 (U.S. Dept. Interior, 1969). This work is the only identified environmentally oriented study made of Alaskan placer operations. It involved approximately 15 days field work by a party of two or three people. Primary attention was given to the Fairbanks district (8 field days). Other field work was as follows: Tolovana district (50 miles N.W. of Fairbanks) - 2 days; Iditarod district - 1 day; Seward Peninsula - 1 day; Koyukuk district - 1 day; Wiseman district - 2 days. Although the scope of this work is limited, it touches many of the parameters which must be understood prior to the creation of regulations affecting the mining industry. It is time to improve the information base upon which Alaskan placer regulations are founded, and this study is aimed at furthering our knowledge of the effects of placer mining on the environment.

Table 2: Distribution of Various Types of Placer Streams

Water Character			
Placer Stream	Receiving Stream	Number	% of Total
Clear	Clear	68	34%
Clear	Turbid	39	20%
Clear	Glacial	37	18%
Clear	Lake	8	4%
Glacial	Glacial	40	21%
Clear	Salt Water	6	3%
		198	100%

Area of Study

Two districts in Interior Alaska are easily reached by road, and are typical of many districts that present many of the problems common to all placer mines in Alaska. These are the Tolovana mining district, in which is located the town of Livengood, and the Crooked Creek area, part of the Circle district, one of the oldest in the Interior (Plates 1 and 2). During the 1930's, all of the claims on Livengood Creek were consolidated into one large property. A well engineered operation was begun, but was stopped by World War II. The unfavorable situation for gold mining during the post war era caused the operation to remain almost dormant until the 1970's.

For the past several years there has been a placer mining operation on Livengood Creek. The Asamera Oil Company and its successor now intends to mine the property, which contains very substantial reserves. This mining operation can provide seasonal employment for thirty to forty people for decades. The situation in the Crooked Creek area is somewhat different, with many small operations. The area proposed for study contains about seven such operations. The experience gained recently by miners both at Livengood and in the Crooked Creek area has raised technical, economic and environmental questions which must be addressed. These questions may be summarized by stating the following findings:

1. Livengood Creek contains about 30 million cubic yards of pay gravel and twice that volume of muck.

2. In the past the muck has been stripped with water and allowed to go down the Tolovana River to the Tanana and Yukon Rivers. Tailing water from the sluicing operation likewise went down the river.

3. In the Circle district, less muck is present, but some must be dealt with. However, fines from sluicing traditionally have been released down the creeks.

4. It would greatly enhance the economic viability of the operations if muck could be stripped with water rather than by mechanical, fuel-consumptive, means.

5. Environmental regulatory agencies object to muck or other fines going down the creeks and rivers. Allowable upper limits have been identified for settleable solids and turbidity.

It is hoped that this study will provide background data so that the economic, technical and environmental problems may be more accurately addressed and understood in the planning of additional research, and these valuable mining projects allowed to develop and produce.

AREA SHOWN IN THIS REPORT

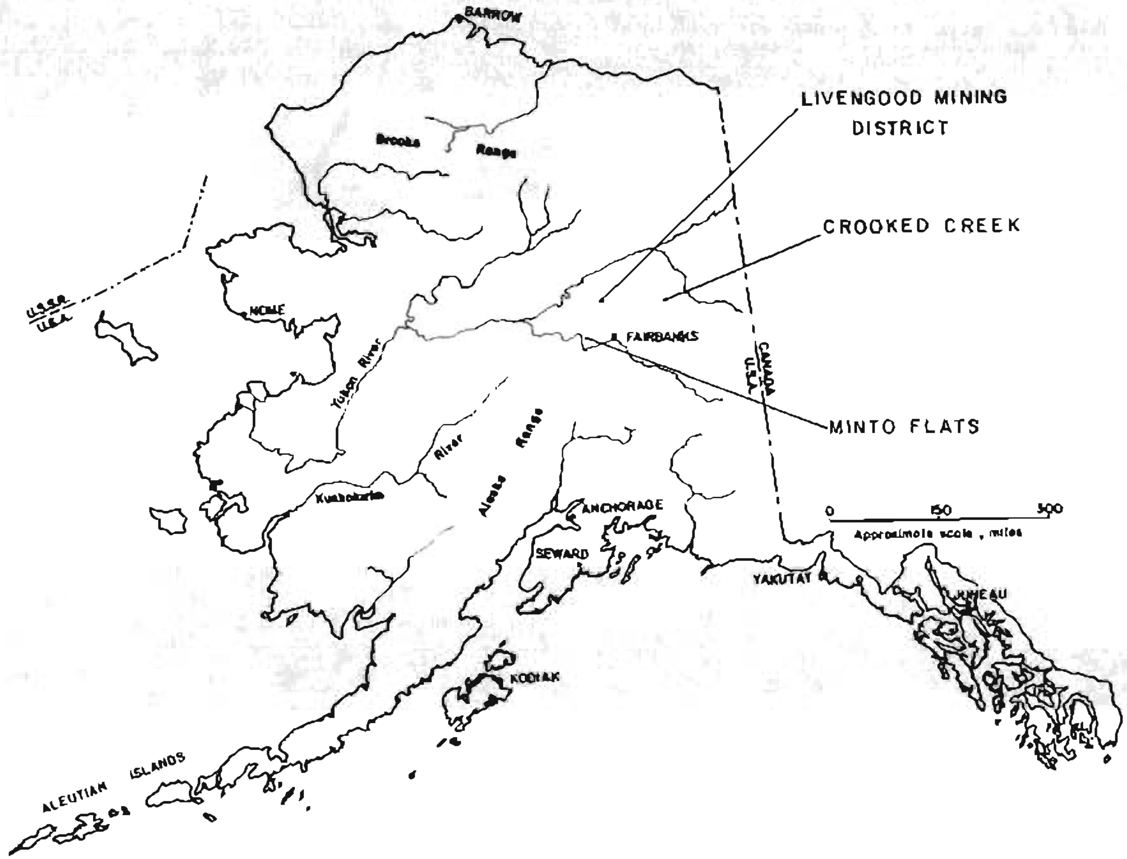
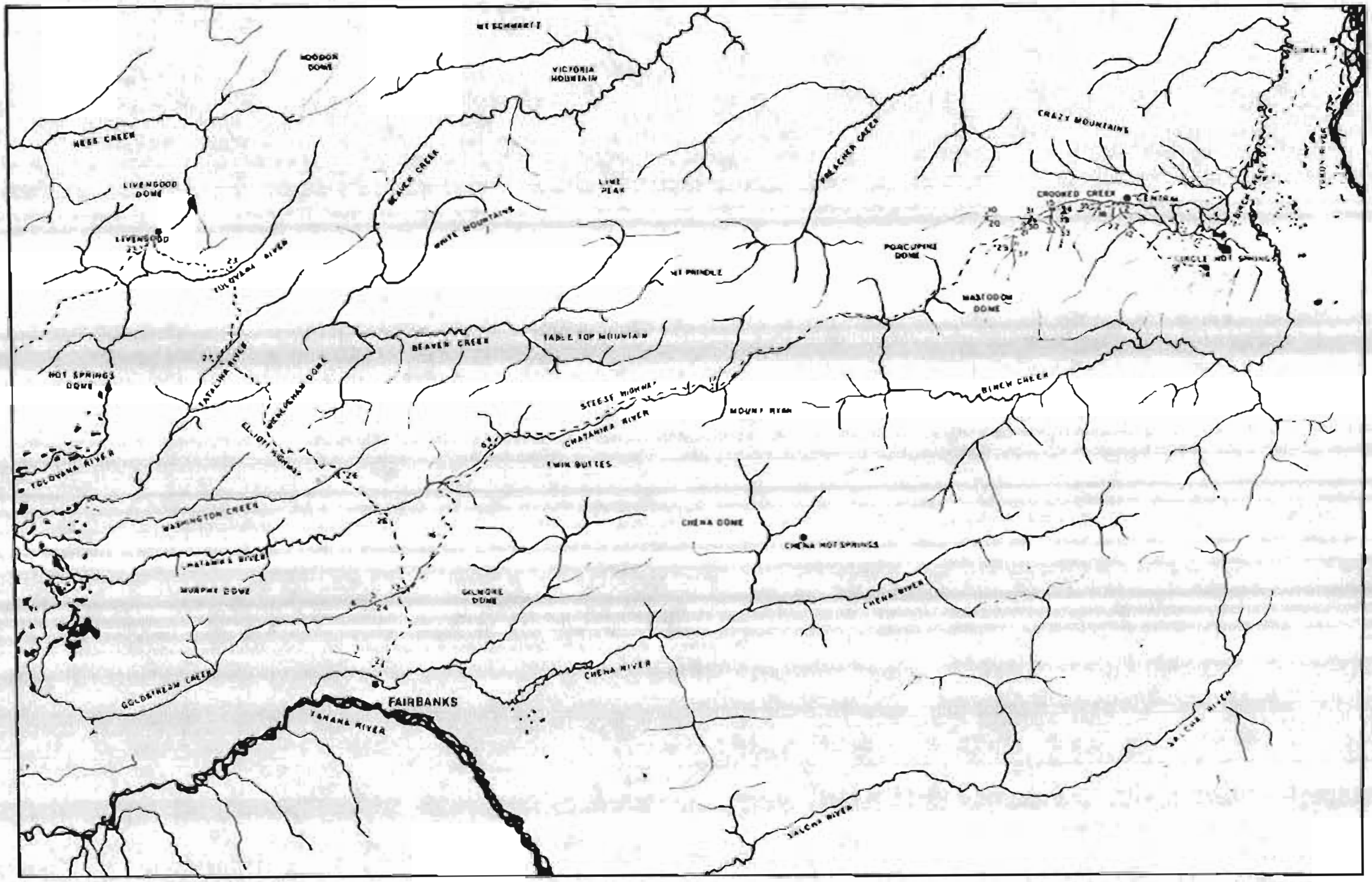


PLATE 2



10 0 10 20 30 40 MILES

LOCATIONS OF STREAM SEDIMENT SAMPLES —— 29
(SEE TABLE)

PART OF YUKON - TANANA UPLAND
SHOWING AREAS COVERED IN THIS REPORT

Scope of Work

Field work for this project was planned to provide data on all aspects of the environment affected by the Livengood and Crooked Creek operations in the past. These aspects include fish, vegetation, water quality, sedimentation and hydrology. Millions of cubic yards of muck have been sluiced down the Tolovana Valley. This muck had to traverse the Minto Flats, whose rivers, sloughs and innumerable lakes supported and support a large fish and waterfowl population. Part of the time during which mining was progressing, the village of Minto was located on the Tanana River. For the past several years it has been located at the head of the Minto embayment. From both locations, the people of the village have hunted and fished in the Minto Flats, and should be able to supply first hand information as to the effects of the muck stripping. Field work included interviewing people at Minto regarding these effects.

Similar studies of Crooked Creek in the Circle District were made. Interviews were conducted at Central, Circle and Fairbanks.

Another phase of the field work was an examination of the valleys mentioned to see whether any sedimentation has taken place, and also those parts of the Minto Flats nearest the discharge ends of the Tolovana River. These examinations were carried out by two people trained in placer mining and mining engineering. A hydrologist and a fish biologist assisted.

The upper portions of the mined streams contain the coarse tailings, deposited by both dredge and bulldozer-dragline methods. These tailings were examined for revegetation, and rates estimated. Some attempt was made to determine whether, and to what extent, they serve as habitat for mammals and wild fowl.

Chapter 2

Tolovana Mining District

Brief History

The general area in which the Tolovana or Livengood placer deposits are located was first visited by prospectors in 1892 when Mike Hess, for whom Hess Creek was named, reported finding placer gold. This may have been in the general area of the later discovery.

The discovery of gold and subsequent stampede to the Klondike set off feverish prospecting all over the interior of Alaska, but it was not until 1914 that these efforts were successful in the Tolovana area. In the meantime, the Fairbanks placers had been discovered, and in fact, all other placer districts in Alaska, of which there are more than fifty. Thus the Livengood placer district was the last to be discovered in Alaska, ending an era of discovery which had begun, in the interior, with the finding of gold on Franklin Creek in the Fortymile district in 1886.

On July 24, 1914, Jay Livengood and N.R. Hudson discovered gold in the present channel of Livengood Creek. Given the mood prevalent in Alaska at the time, there was a stampede of prospectors and miners to the area, and within a short time all the creeks had been staked, and also the wide bench on the right limit (north and west side) of Livengood Creek itself. The story has often been told relating how successive late comers found the creek staked and had to stake the wide bench in "tiers" of claims parallel to the creek claims. The richest claims by far were those several tiers from the creek, under as much as 100 feet of muck and gravel.

In the years immediately following the strike, underground (drift) mining was rapidly expanded, chiefly on the deep ground of the bench of Livengood Creek. Some small scale open pit mining was also initiated in the present channel of Livengood Creek and on some of the other creeks, namely Olive, Ruth, Amy, Gertrude and Wilbur. These creeks have smaller reserves and produced less gold than Livengood Creek. Although the streams in the Hess Creek drainage were prospected, they never developed into productive placer streams.

With the development of the bulldozer in the early 1930's, mechanized mining with bulldozer and dragline became important. Freight into the district was brought in by boats up the Tolovana River from the Tanana River. This route was expensive and difficult. The head of navigation for any type of boat was at West Fork, where the main Tolovana and West Fork of the Tolovana join. This was about seven miles from the town of Livengood on Livengood Creek. Trappers Cabin, 16 miles downstream from West Fork, was also a supply point. There was a very large log jam 56 miles below West Fork. Small scows could ascend the river to this point. Freight was portaged around this jam on cars running on wooden rails.

Such a transportation system was clearly insufficient to support mechanized mining. In 1936 the Alaska Road Commission completed a gravel road from Livengood to Fox on the Steese Highway via the mining area of Olness.

About 1930 Clifford Smith, an Alaskan mining engineer, began consolidating the claims on Livengood Creek under one ownership for the purpose of developing a unified dredging operation. He was successful, and Livengood Placers was formed as a subsidiary of Callahan Mining Company. Capital was procured by means of a loan from the Reconstruction Finance Corporation and by 1941 a dredge had been assembled. Following a shutdown because of World War II, dredging was resumed. An earth fill dam was built across Hess Creek and the impounded water to be used for stripping muck and thawing gravel was brought to Livengood Creek through a tunnel.

The operation suffered from the trouble common to the times, and inflation raised costs relative to the price of gold. Finally the R.F.C. sold the assets to satisfy the debt. The dredge was purchased by the U.S.S.R. & M. Company and taken to Hog River about 1955.

During these years smaller scale mining on the other streams was taking place in the Livengood area, using bulldozers and in some cases draglines. During the 1960's, open pit mining was conducted on the Livengood bench itself by the Yukon Mining Company. In 1972 the consolidated property was taken over by Klondike Placer Gold, a subsidiary of Stanford Mines, and worked by bulldozers. In 1977 Asamera Oil Company took an active part in the operation, with the same management. In 1981 management passed into other hands and the name of the operation was changed to Livengood Joint Venture.

A number of other major developments that affect the area have taken place. In 1959-60 the road was extended from Livengood to Eureka, connecting to Manley so that Livengood is no longer at the end of the road. About 1970 the town of Minto on the Tanana River was abandoned and the people moved to a site at the head of the Minto Flats embayment on the Tolovana River. In circa 1973, a road was built by the State of Alaska from West Fork north to the Yukon River. In 1969 an ice road, unofficially known as the Hickel Highway, was pushed from Livengood through Anaktuvuk Pass to Prudhoe Bay. After a delay of several years, a permanent road was built north to the oil fields from the Yukon River, which was bridged at the end of the road from the West Fork. The years 1975-1977 saw very heavy traffic through Livengood as the pipeline was built to the north.

The latest development of importance to the area is the rise in the price of gold, which has stimulated gold mining, and led to more capital expenditures.

General Description

The Livengood mining district is about 55 air miles slightly west of north from Fairbanks. It is about 68 miles by the Elliott Highway from Fox. Manley lies about 80 miles to the west by road. The area is one of moderate relief with rolling hills interspersed with low flat areas containing numerous small lakes. It lies near the divide between the Yukon drainage and the Tanana drainage, where numerous drainage interruptions and reversals are evident. This region of the Yukon-Tanana plateau is lower than that farther east, with ridges about 1500 feet in elevation and peaks something over 2000 feet (See Plate 3).

The principal streams that have been mined are Livengood, including the creek and the bench, Olive, Amy, Gertrude, Ruth, Lillian and Wilbur. Most of these are contained in an area about four miles by seven miles, with Wilbur Creek about four miles outside of this rectangle.

Areas and Volumes Disturbed and Removed

Livengood Creek bench has been drift mined partially over an average width of 500 feet for about five miles. This means that there are isolated piles of tailings scattered over an area of 300 acres. These are grown up and hidden by vegetation. There are about 20 acres of tailings in the creek bed completely covered by vegetation and another 90 acres partly on the creek and partly on the bench. Additional areas covered by tailings include:

Olive Creek - 40 acres

Wilbur Creek - 10 acres

Amy Creek - 30 acres

Gertrude Creek - 30 acres

Lillian Creek - 5 acres

Ruth Creek - 5 acres.

A trench was started to tap the reservoir and conduct its water to the Livengood-Circle drainage. This disturbed 25 acres. The main ditch on Livengood Creek has disturbed another 10 acres. Roads in the area contain about 55 acres, the airfield 9 acres, the dam and borrow pit occupy about 30 acres and the lake created by the dam on Hess Creek probably occupies 380 acres when full.

In summary there are about 230 acres of tailings. Other works occupy about 510 acres, of which the lake contains the most area. Total surface disturbance including the town and drift tailing piles is about 800 acres, all within an area of approximately 50 square miles (32,000 acres). Livengood district has the most concentrated mining and related cultural development

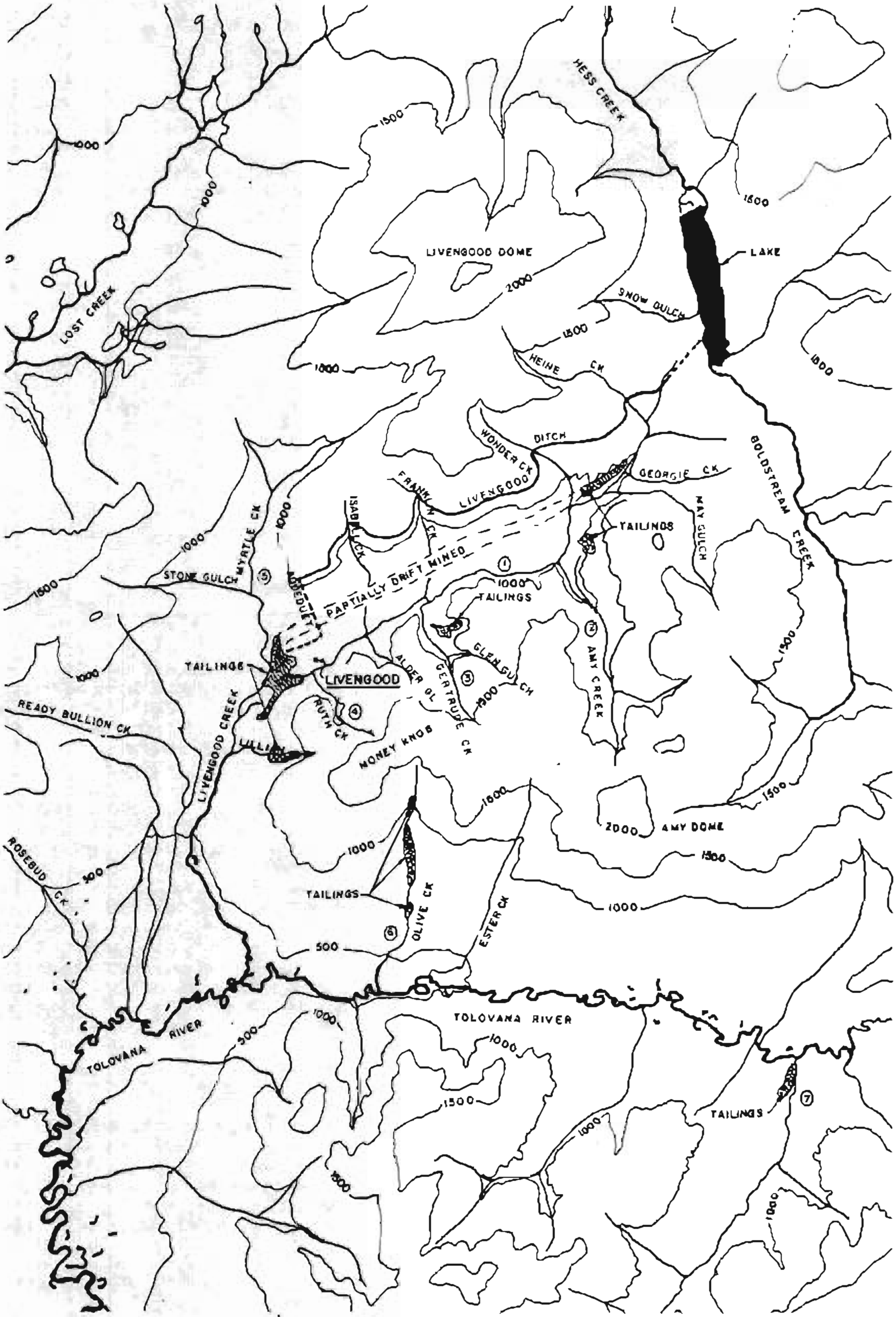


PLATE 3

0 1 2 3 4 MILES

LIVENGOOD OR TOLOVANA
MINING DISTRICT

encountered in this study, yet has only disturbed 0.25% of the land area. Table 3 compares this disturbance to other forms of surface utilization in the United States. The remaining land in the Livengood District would then be classified as natural forest.

Table 3: Land Use Data (from U.S. E.P.A., 1973)

	Millions of Acres	% of Land Use in the U.S.
Total land area in all 50 states	2,264	
Land in grass	540	24%
Crop land, plus farmsteads and roads	412	18%
Commercial forest	500	22%
Subsurface mines	7	0.3%
Surface mines	3	0.1%
Urban America	60	2.6%
Maximum density of surface utilization within the Livengood District		0.25%

Rather accurate records of the volume of muck removed at Livengood are available. Prior to the 1981 season, about 3.2 million cubic yards was removed from Livengood Creek with another 800,000 cubic yards from the adjacent creeks, for a total of close to 4 million cubic yards with perhaps 25 percent ice. Initial experiments have indicated a swell factor as high as 1.9, however, accurate measurements over several years may result in a lower estimate.

Reclamation

No attempt has been made to reclaim disturbed areas at Livengood. In considering reclamation, attention must be given to the type of original disturbance. For example, the lake created by the dam on Hess Creek now presents a pleasing appearance and has recreational values in contrast to the surrounding vistas of tundra and scrub spruce. The isolated small conical tailing piles left from drift mining are almost completely obscured by vegetation. The roads may be considered as beneficial or not, depending on the view of the observer. At any rate vegetation is encroaching upon them. Of the tailings, only those of recent years are completely barren of vegetation. All of the older mined areas support some vegetation, and are roughly fifty percent reclaimed. Past reclamation at Livengood is not a problem, and large scale mining today must meet severe reclamation requirements.

Value of Tailings

Tailings, like other gravel, have value only by virtue of being near a market. The market presented by road building at Livengood is transitory, unlike that at Fairbanks where continuing building requires large amounts of aggregate fill. The fact that the pipeline activity has come and gone without creating an appreciable demand may be taken as an indication that little will exist in the future. However, up to 3 million cubic yards of tailings could well be crushed and transported for as much as 20 miles for the upgrading of the Elliott Highway. Their value in place should be about $2.40 per cubic yard.

Alternative Methods of Stripping Muck

The Livengood deposit contains about 25 million cubic yards of gravel, with another probable 5 million cubic yards on the adjacent creeks. The ratio of muck to gravel is about two to one, with about 60 million cubic yards of muck to be removed. Obviously, a stripping ratio of two to one is a key factor in determining whether or not a mining operation is economically viable.

There are basically three ways in which the muck can be stripped:

1. If ample water is available for hydraulic stripping, this is the simplest and cheapest method (Figure 1). Estimated cost today is about $1.50 per cubic yard of muck removed. However, as is explained elsewhere in this report, it is desirable to keep additions of silt to a minimum in the Tolovana River.

2. The muck can be ripped and stacked mechanically with loaders, scrapers, or draglines. This has the advantage of keeping the silt removed from the stream, but it becomes more difficult and expensive as the depths increase. Recent experience (1981) with stripping relatively shallow ground indicates a cost of approximately $2.60 per cubic yard of muck, or $5.20 per cubic yard of gravel exposed at a stripping ratio of two to one. Since the muck may be as deep as 60 to 80 feet in places, increasing the stripping ratio as much as four to one, these costs are likely to be prohibitive. At any rate, it will be expensive and viable only with rich ground, high gold price or both. There is also the problem of disposing of such quantities of muck.

3. The muck might be hydraulically stripped, either directly to a large settling area, or to a sump from which it could be pumped as a slurry to a series of ponds. This alternative method would be a compromise between the other two. Stripping costs will vary widely depending upon configuration of terrain and complications of disposal. An average of $2.00 per yard of muck stripped is estimated. This alternative presupposes that there is enough room to provide adequate storage space for the mobilized muck.

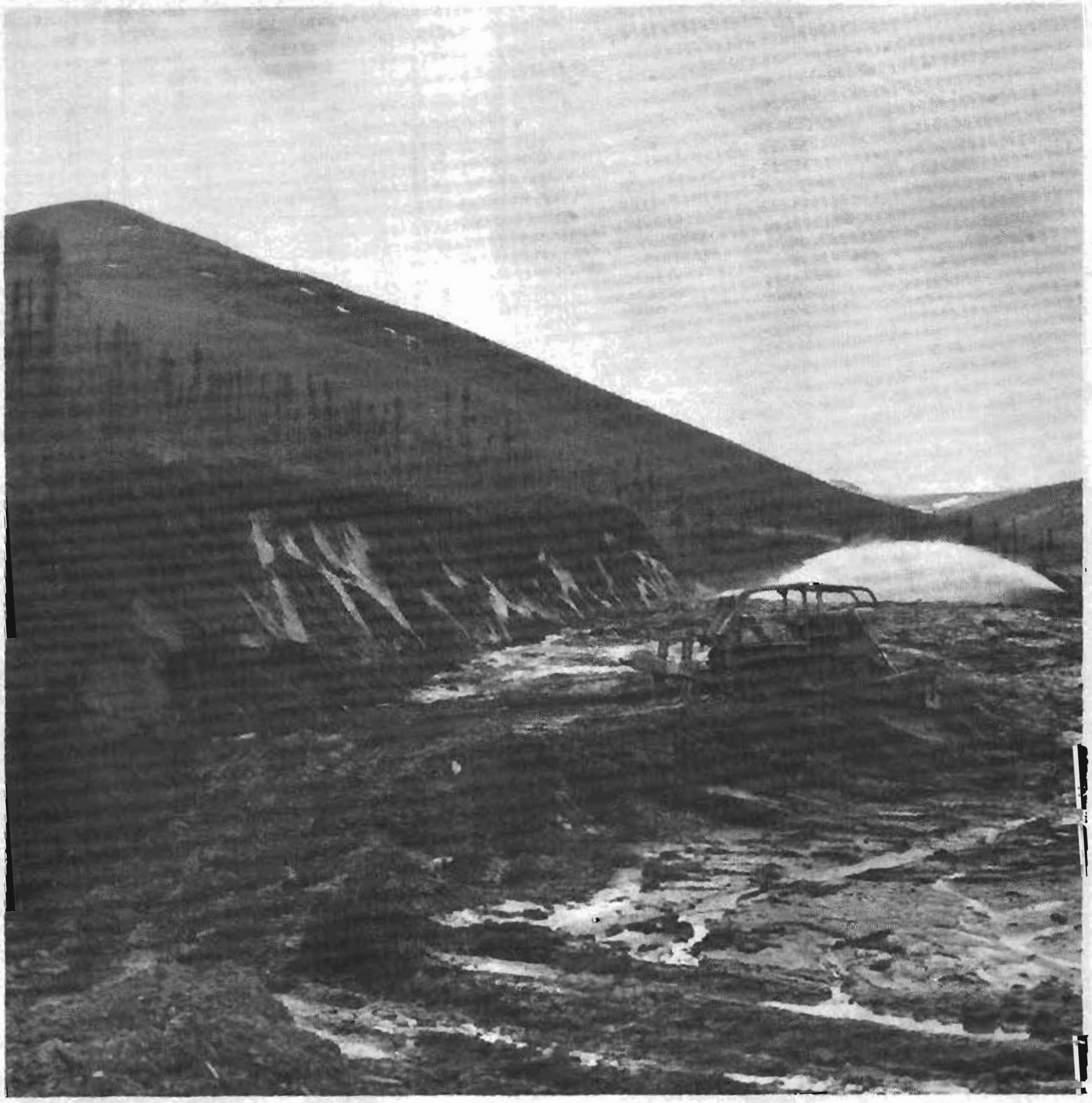
The following rough calculation is merely intended to illustrate the magnitude of the problem, not offered as a solution. If it is assumed that sixty million cubic yards of muck with a 25 percent ice content will make close to sixty million cubic yards of material after swell, then the muck would fill almost two square miles of land to a depth of 30 feet. This is 40,000 acre feet, for which storage must be found.

Possible Areas for Settling Basins

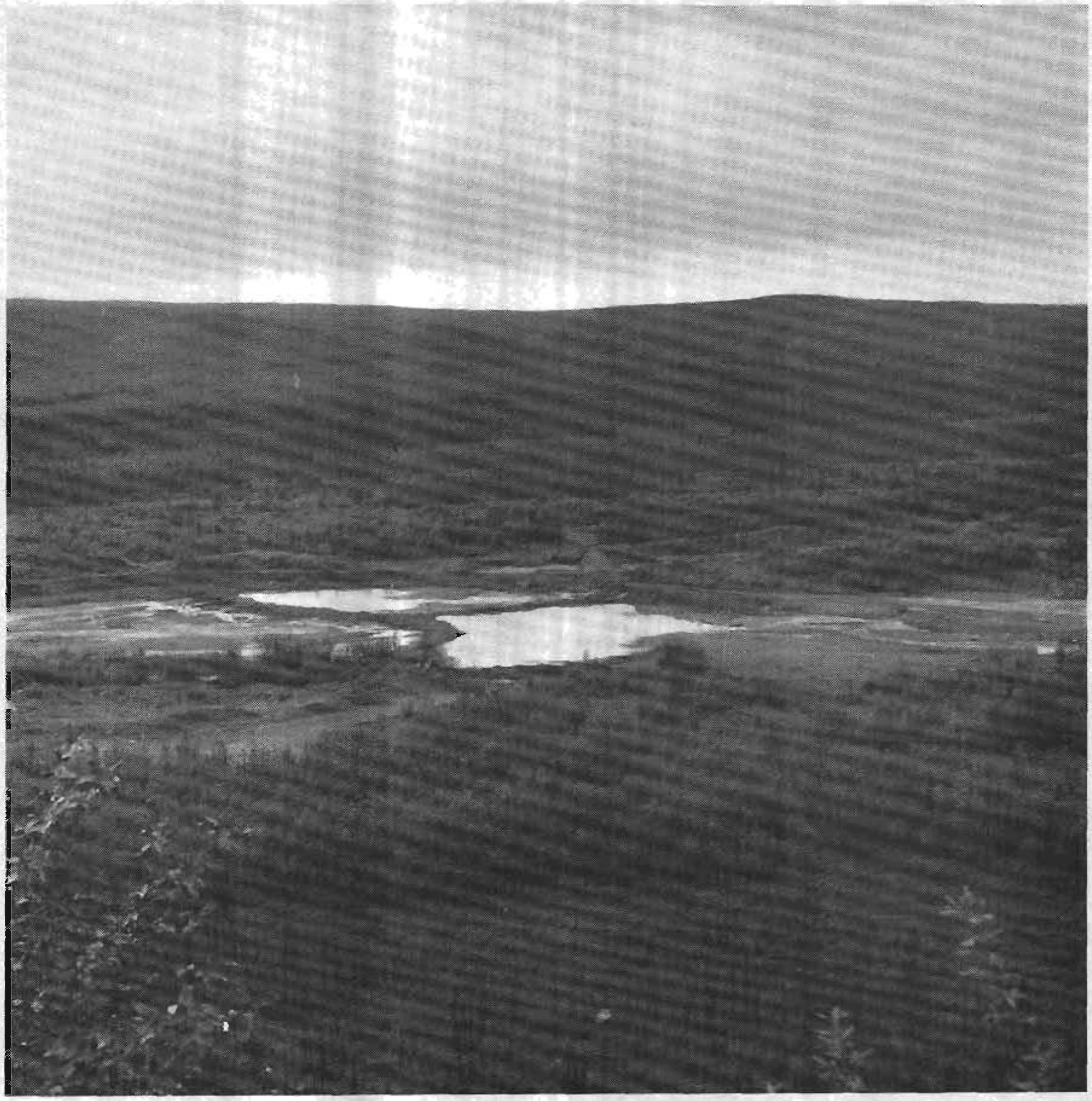
Settling basins for fines derived from sluicing can possibly be made in the old cuts as mining proceeds upstream. However, if the muck overburden is to be stripped hydraulically and then allowed to settle out in ponds, a considerably larger area will be needed. In order to find the necessary space, it may be necessary to pump the muck from a sump as a slurry to a location a little above the stream bed. Most storage, however, would have to be on lower Livengood Creek, where retaining dams would have to be built (Figure 2). The problem viewed from this standpoint is easier to overcome than the storage of tailings at a mine such as Climax, Colorado. There, a volume on the order of 30,000 cubic yards of finely ground tailings are impounded every day. Such filled shallow reservoirs could become good farm and timber land, or could provide substantial browse for wildlife, in a very short time.

Beneficial Effects

A perusal of the literature and written comment on Interior Alaska prior to about 1960 will indicate that the finding and development of mines was viewed as almost entirely beneficial. The U.S. Geological Survey literature and other government publications, as well as the newspapers, looked upon such enterprises as necessary to the support of the people; there being little else in the country to create wealth. Indeed, the economic principle that a region must produce goods or services that people of some other region are willing to pay for is as valid today as it was then. Only the emphasis on what those goods and services consist of changes. The only criticism of the discovery, development and mining of placer deposits in the Interim



1) The stripping of muck by hydraulic and mechanical methods.



2) Settling basins at Livengood.

was that it disrupted the natives' way of life and brought to them the bad (often the worst) social aspects of civilization, along with its material blessings. This view was vigorously put forward by the Episcopal Archdeacon Hudson Stuck of Fort Yukon (1917). There is no easy cure for this damage, yet there are offsetting factors, such as the overall improvement of the natives' material lot.

The most obvious beneficial effect remains the general one that mining creates wealth and provides a means for sustenance. Specifically, the Livengood mining district has supported its populace for 67 years. The district has produced about 400,000+ ounces of gold (Committee print 1964). If it is assumed that it requires 100 ounces per year to support one household, then the average number of households supported during the past 67 years would be about sixty, not all in Livengood.

This 400,000 ounces has been added to our stockpile of gold, and except for a small amount lost, is still in existence, available for monetary and industrial purposes. There are perhaps 700,000 troy ounces left in the district, which will be added to the country's stockpile as it is mined.

An important long range benefit of every mining district is the base and infrastructure that it furnishes for other productive enterprises. Minerals produced yield a profit to some individual or enterprise. This profit represents retained earnings, or wealth — in short the capital upon which our industrial civilization is based. The difference between developed nations and developing and undeveloped nations is a base of capital. Thus, the Elliott Highway became of great importance as a key link in the road system that allowed the Trans Alaska Pipeline to be built, just as earlier it allowed the road to Manley Hot Springs to be constructed. This in turn made possible the moving of the town of Minto onto higher ground in the early 1970's. It allows outdoorsmen access to Hess Creek and other navigable waterways. Finally it allows tourists and other service industries to become established.

Downstream Effects

In this report an attempt has been made to describe the effects of the placer mining in the Tolovana district. This district, the last discovered, is small and relatively compact. The effects upon the environment in the actual mining areas can only be described as minor. This section of this report will describe the drainage downstream from the district, where major changes have taken place, not so much in the Tolovana drainage as in the drainage from the Fairbanks district.

The area between the Yukon and Tanana Rivers in Alaska, from the confluence of the two rivers on the west to the Canadian border on the east, is one of moderate to rugged relief. Elevations are higher in the east, gradually dropping toward the west. This region contains 11 of Alaska's 56 placer mining districts. Of these, five drain into the Tanana River, and six into the Yukon. Both the Yukon and Tanana are glacially fed streams and therefore laden with silt and glacial flour. The middle section of the Tanana River is characterized by a large lowland, similar to those prevalent throughout Alaska. This lowland is fault bounded and the faults are generally active. North of Nenana at the western end of the lowland is a large flat-lying embayment called Minto Flats. The streams from the Fairbanks district, the largest gold producer in Alaska, and the Tolovana district, drain into the Minto Flats (Figure 3).

Gravity surveys by D.F. Barnes of the U.S. Geological Survey (1961) and earthquake studies by the Geophysical Institute, University of Alaska-Fairbanks (1971) have helped to define the basin underlying the Minto Flats. The gravity low in the Minto Flats (Figure 4) is interpreted to represent approximately 10,000 feet of cenozoic and recent sediments (Figure 5, Barnes, 1961). The basin is fault bounded and earthquake records show that these faults are active today (Gedney, 1971). Neither the present rate of subsidence nor that occuring at various times during Cenozoic time, has been determined.

Variability in the rate of subsidence combined with the dramatic climatic changes of the past 10,000 years are only 2 of the many variables which make it very difficult to document the rate of siltation from natural causes (annual high water, floods, forest fires, etc.) versus that produced by mining (Figure 6). Add to this the erratic manner by which a river, in a low energy regime such as the Minto Flats, changes its course and in this case taps various lakes,

3) The subsiding northern side of the Minto Flats viewed from the highway near the village of Minto. Note the Tolovana River and adjacent lakes.

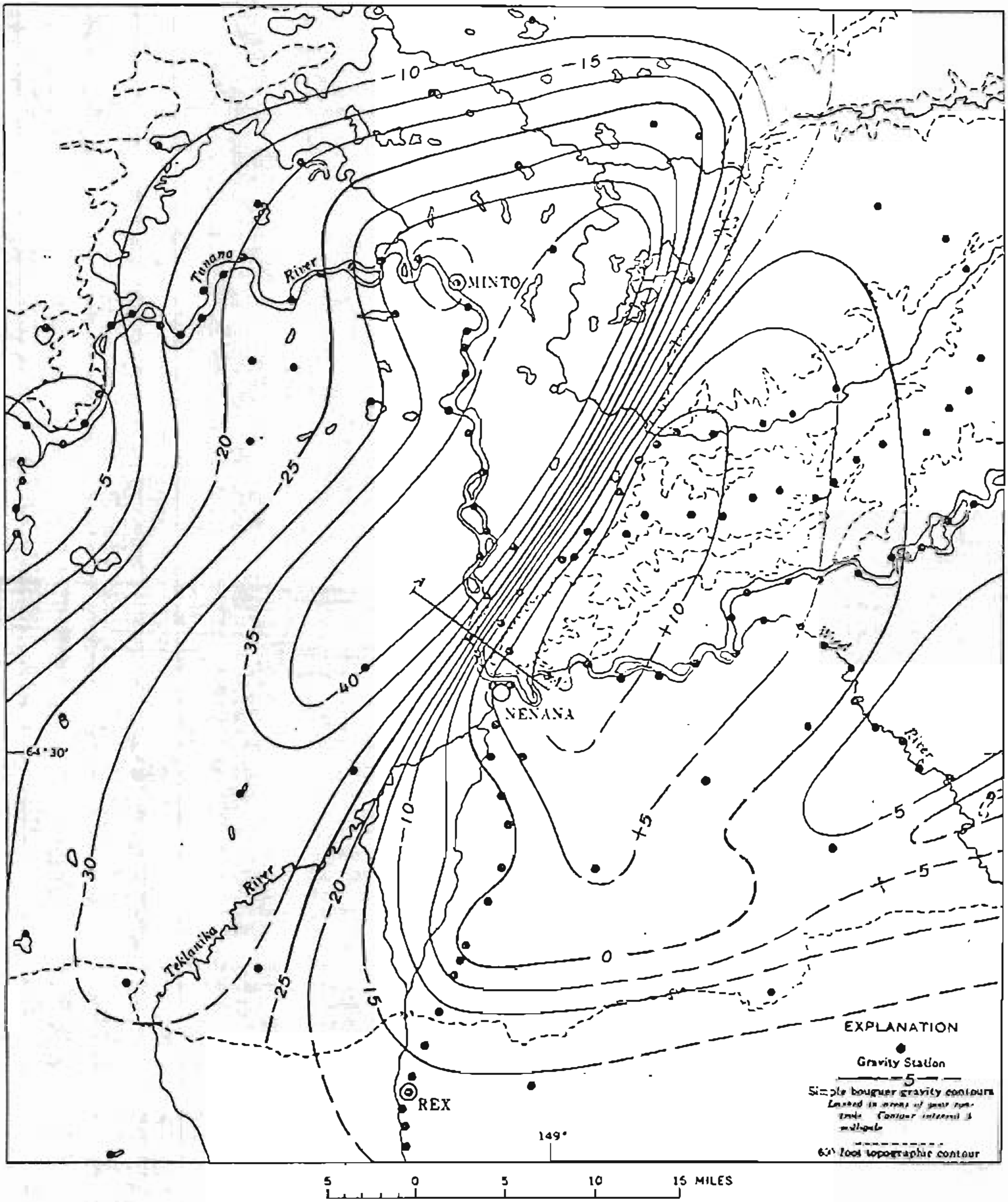


Figure 4: Contour map of simple Bouguer gravity anomaly, Minto Flats, Alaska.

and little can be done to record whether the silt in a given lake bed is a product of hydraulic mining, or a flood such as the 1967 flood which left large quantities of mud and silt throughout much of Fairbanks.

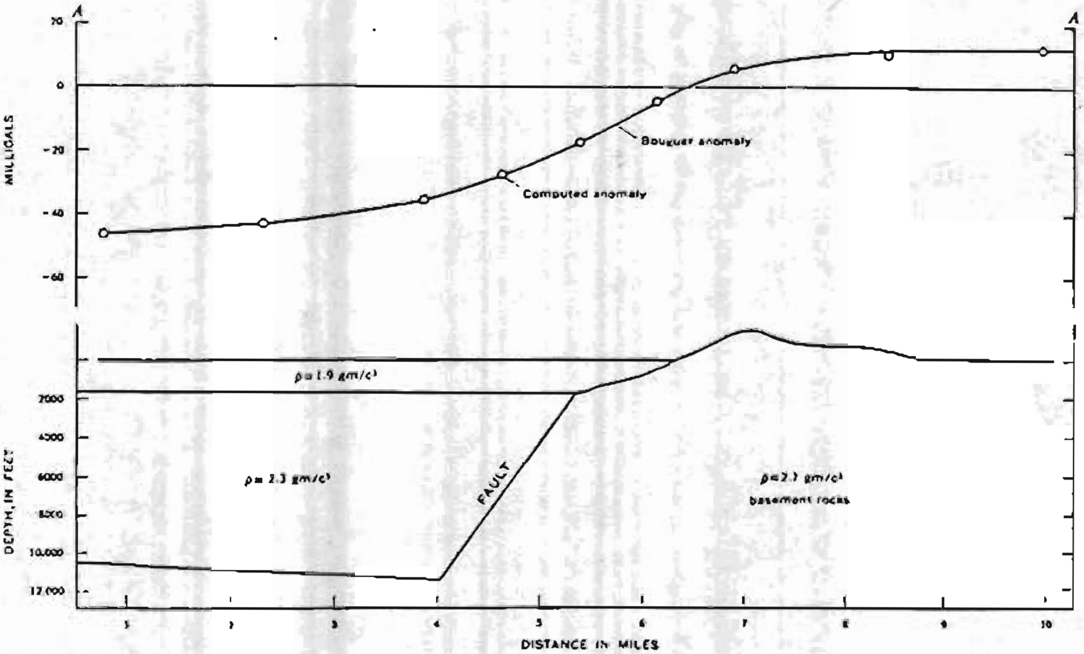


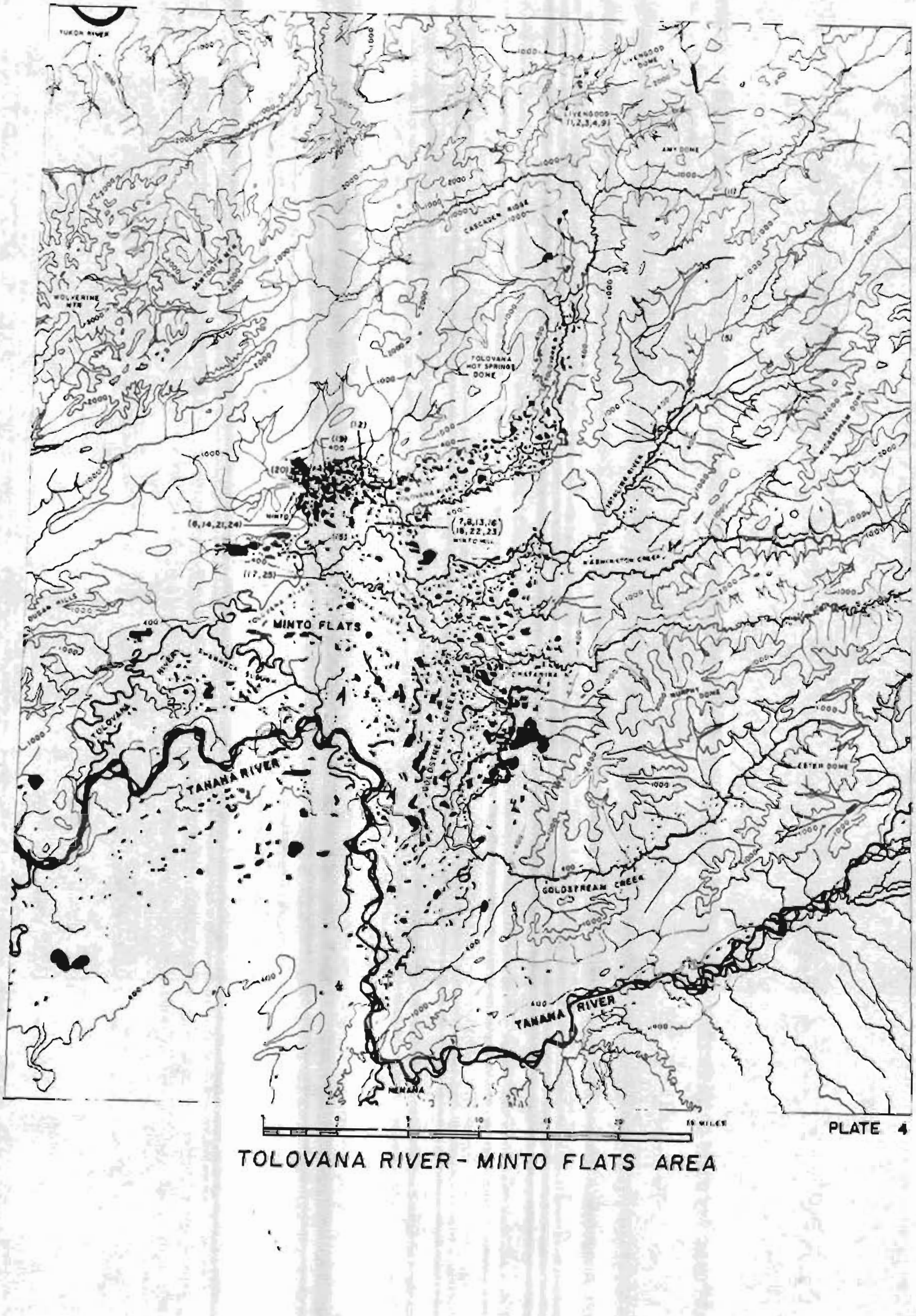
Figure 5: Observed and computed gravity on profile A-A' north of Nenana and suggested subsurface configuration.

To discuss in more than the cursory manner of this report the relative effects of the 6 million cubic yards of muck hydraulicked in the Fairbanks district, a study of the hydrology of the region would be necessary. The discharge into the Minto Flats needs to be quantified and measurements of the average annual load of silt and sediment determined as a first step in documenting the relative affect produced by hydraulic stripping in the Fairbanks district.

Most of the mining in the Fairbanks district was done by dredging, which does not allow very much sediment to enter the streams. However, all the muck, removed hydraulickally prior to the dredging operation, was washed down three streams; the Chena River and thence into the Tanana River below Fairbanks, the Chatanika River, and Goldstream Creek, both of which flow through the Minto Flats. The muck from Livengood (the Tolovana mining district) has gone down the Tolovana River, and has had to traverse literally hundreds of miles of sluggish winding river before entering the glacial-silt laden Tanana River.

Even a preliminary examination of the topographic maps of the region indicates that the eastern and northern parts of the Flats (Plate 4) are in an active tectonically controlled basin with rapid subsidence (Van Wormer, 1973). In the central and southern parts, the lakes are regularly shaped and generally round, as one would expect of thaw lakes or lakes impounded behind natural levees. On the eastern and northern parts, the lakes are extremely irregular, and in the northern embayment, which is an extension of the Tolovana Valley, many of the lakes are connected to the Tolovana River. In this subsiding basin the Tolovana River maintains a slightly higher position relative to the lakes by alluviating its bed and banks, as do most

6) Sedimentation of lakes in the Minto Flats.



TOLOVANA RIVER - MINTO FLATS AREA

rivers when their gradient drops significantly. Further evidence of the subsidence of the north end of the Flats is the big loop northward made by the Tatalina River. Also, in traversing the Tolovana River in the vicinity of New Minto in the northern part of the Flats, one can stand up in a boat and look out across the countryside, indicating that the area is not much higher than the water's surface. South of the Tolovana basin, as one approaches the mouth of the Chatanika River from upstream, the banks become higher and the river is incised ten to fifteen feet below the surrounding country. From the few elevations of lake surfaces to be found on the maps, it appears that the area south of the mouth of the Chatanika River is five to ten feet higher than the active embayment to the north.

It is evident that water will flow from the Tolovana River into the lakes north of the mouth of the Chatanika River during periods of high water. Fine solid material suspended in the river water will also flow in and settle, and during spring breakup, following heavy rains, or when mining is in progress upstream the increased silt load will produce faster sedimentation. Aerial photographs (Figure 7) taken twenty five years ago do indeed show sediment flowing from the Tolovana River into the connecting lakes. These lakes today appear cloudy when viewed from the air. It was not determined whether this was due to recent rains or merely an algal bloom enhanced by the nutrient laden waters entering the lake.

The muck from the Fairbanks district that entered the Chena River caused some blockage of the lower Chena drainage while stripping was in progress, but is now completely removed. That muck which went down the Chatanika River and Goldstream Creek also traversed the valleys without being deposited until it reached the Flats.

After reaching the Flats, the silt being transported in the Chatanika drainage continued on to the Tolovana River and thence to the Tanana River. The silt being carried by Goldstream Creek, however, caused a number of drainage changes after reaching the Flats. It appears that, prior to the heavy introduction of silt, Goldstream Creek flowed through the large Minto Lake. As the mud carried by Goldstream increased, the lake bottom partially filled, and a large delta was formed (Figure 8). Goldstream Creek abandoned its channel and connected to Little Goldstream Creek. It now flows down the former channel of Little Goldstream. Three or four lakes are completely or partially filled with sediment or with vegetation along the course of this stream. Older abandoned stream channels are also evident on the air photos (Figure 8).

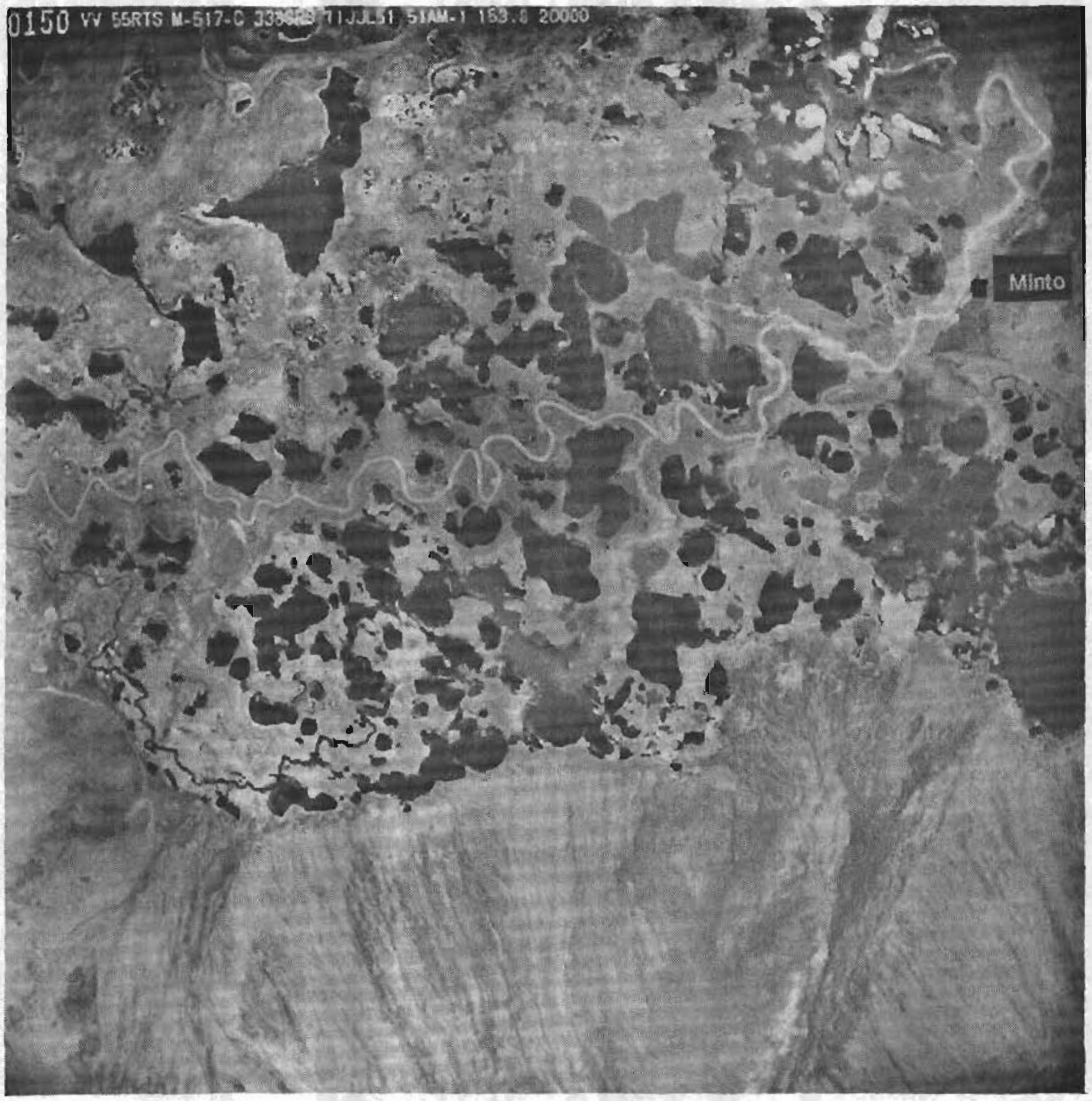
Rate of Revegetation

Even though the growing season is short, vegetation replaces itself very rapidly in the North because of the long days. During drift mining days, the valley of Livengood Creek was completely logged off to provide firewood and mine timbers. A low level aerial photograph taken in 1940, twenty six years after the discovery, shows the Livengood bench almost bare, with the remains of drift tailings easily visible. Today the bench is completely covered by alder and willow, with birch and spruce up to 20-30 feet tall.

Observations elsewhere indicate that wherever any fine material is available, all deciduous trees rapidly take root, with spruce following later. A tailing settling pond at Livengood, used in 1977, was completely covered with grass by fall, 1978. Willows had also taken root. Nowhere in the Livengood area are there any tailings of such coarseness that plants cannot take hold (Holmes, 1981).

Effects on Vegetation

The sediment load of the rivers entering the Minto Flats has little or no effect upon the vegetation on the river banks (Figure 9). A change in water level, as a function of the regional tectonics, or during the infilling of a lake can, however, alter the types of trees which can subsist in an area. Sedimentation affects trees only when a particularly thick deposit of silt occurs during flood stage and buries the root systems of certain trees. The addition of sediment to a lake may, however, increase the process of eutrophication as a result of the increased nutrient load. Having observed the thick pea-green nature of the lakes in the Minto Flats, with little correlation to the nearness of the main rivers, one suspects that the long summer sunlight and overturning of the shallow lakes are the major processes by which vegetation encroaches upon and fills in lakes in the Minto Flats (Figures 10 and 11).



7) The fault bounded and subsiding northern portion of the Minto Flats. The turbid Tolovana River is adding silt to the lower lakes adjacent to it. North is at the bottom of the photo.

8) Goldstream Creek is building a delta in Six Mile Lake and adding silt to Bridge Lake. Bridge Lake is also being encroached upon by vegetation. North is at the bottom of the photo.

9) Dead riparian trees along the Tolovana River above the village of Minto.

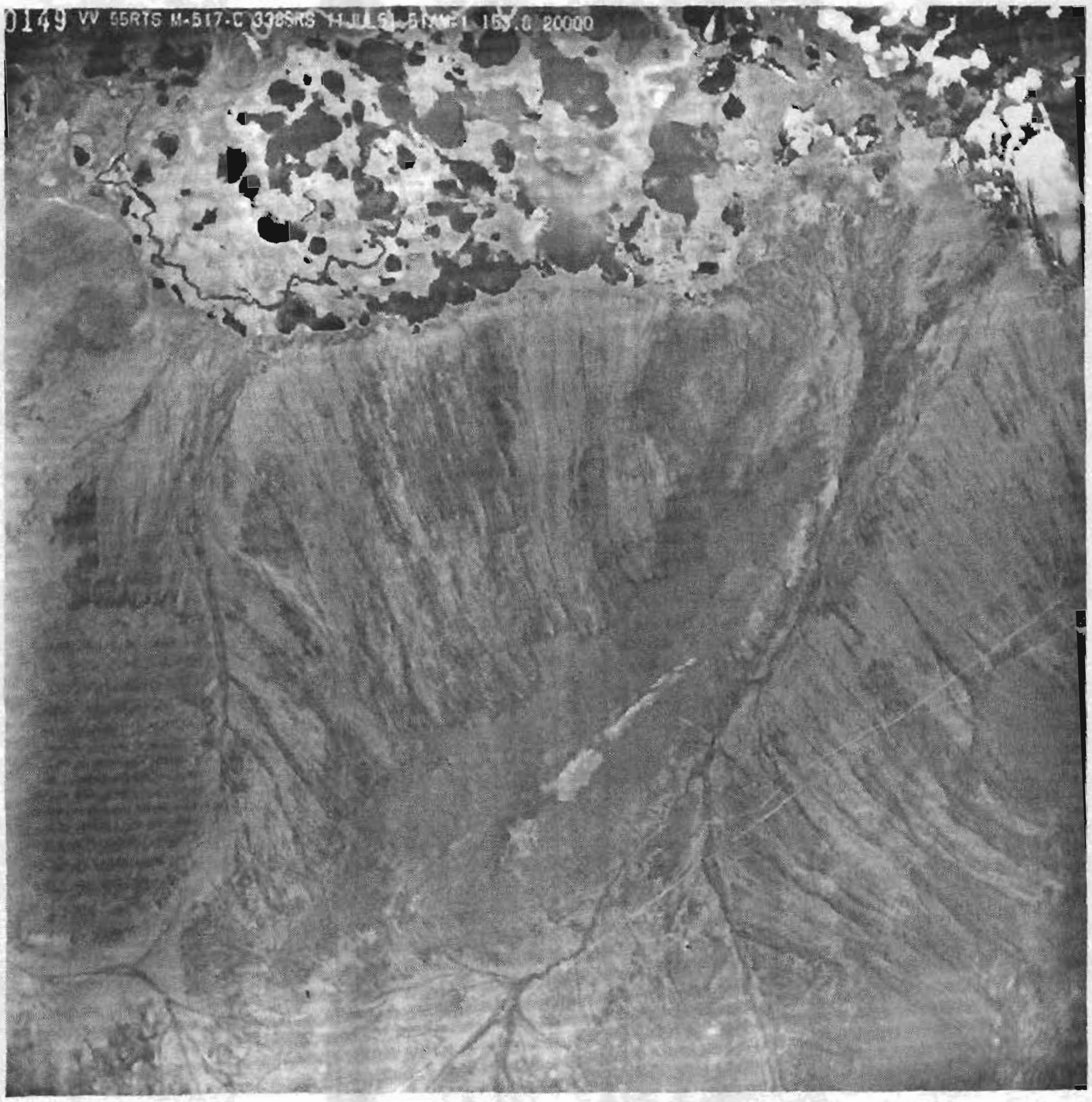
10) Vegetation filling in an old lake bed.

4) Partial infilling of a lake in the Minto Flats.

Effects on Fish

There are two classes of fishing in the Livengood region: sport fishing and subsistence fishing. Near Livengood itself, sport fishing for grayling has long been practiced. There are no accounts of grayling in Livengood Creek itself, but grayling have been fished in the Tolovana and the West Fork ever since the mines were discovered. According to long time residents, the grayling in the Tolovana were never very large, but fishing was generally as good as elsewhere. Today the fishing also is about as good as ever, except when or where the Tolovana is turbid, either from natural causes or because of mining. Fishing remains good in the West Fork, even when the main Tolovana is turbid.

No comparisons of the yields of whitefish and other subsistence fish in Minto Flats have yet been made. Subsistence fishing appears to be less important than formerly, yet there also appear to be a large number of fish drying in Minto. When the village was located on the Tanana River, salmon fishing was more important to the economy of the Minto natives than it is today. There is an apparent decline in subsistence fishing for cultural reasons, independent of the condition of rivers and lakes in the Minto Flats.



12) Natural sediment build up on the north flanks of the Minto Flats.

Crooked Creek flows east across the trench and into Birch Creek, where it meanders along the south edge of the Yukon Flats. A number of placer mining streams enter Crooked Creek from both sides. These include, from east to west: Porcupine, with its tributaries, Yankee and Bonanza; Mastodon with tributaries Miller, Mammoth and Independence; Deadwood, with a number of tributaries but principally Switch Creek; Ketchem; and Portage. Another productive stream is Harrison, also a tributary of Birch Creek, that runs parallel to Crooked Creek about 20 miles to the south. Both the North and South Forks of Harrison have been and are being mined. The principal tributaries of Harrison Creek are Bottom Dollar and its tributary Half Dollar. To the east, across Eagle Summit, the head of Birch Creek has several tributaries that have produced gold. These include Eagle with its forks; and Gold Dust, Ptarmigan and Butte; as well as Birch Creek itself. A number of other streams in the area have been mined but have not proven economic. These include Boulder, Greenhorn, Bedrock and Sawpit, among others.

The area lies on the border of two physiographic provinces, the uplands and the Yukon Flats, and has considerable topographic relief. Mastodon Dome, a central mountain from which many of the productive creeks flow, is 4,418 feet high, while Medicine Lake, 25 miles away, is 735 feet in elevation.

Areas and Volumes Disturbed and Removed

The area is not one with a thick cover of muck, such as the Livengood district. About the only placer creeks that have had muck are Mastodon and Miller. Most of the other streams have only about one to two feet of soil. A rough estimate of the amount of muck removed in the Crooked Creek drainage would be 200,000 cubic yards.

Reclamation

So far as is known, no special attempts have been made to reclaim mined areas in the district (Figures 13 through 18). As in most other placer districts in Alaska, a great deal of revegetation has taken place naturally. Until the disturbed ground is needed for other purposes, its present function of furnishing moose browse is probably as high a use as any to which it could be put. At one or two places, temporary road construction camps have been placed on old tailings, but the total area is so small that this cannot be called reclamation.

No attempt has been made to estimate the amount of land reclaimed naturally. There are only a few acres that do not show vegetation. The general effect, when viewed from a distance, is that the mined valley bottoms present a view of solid vegetation with here and there tailings showing. An overall estimate of such natural coverage would put the figure at 75%.

Value of Tailings

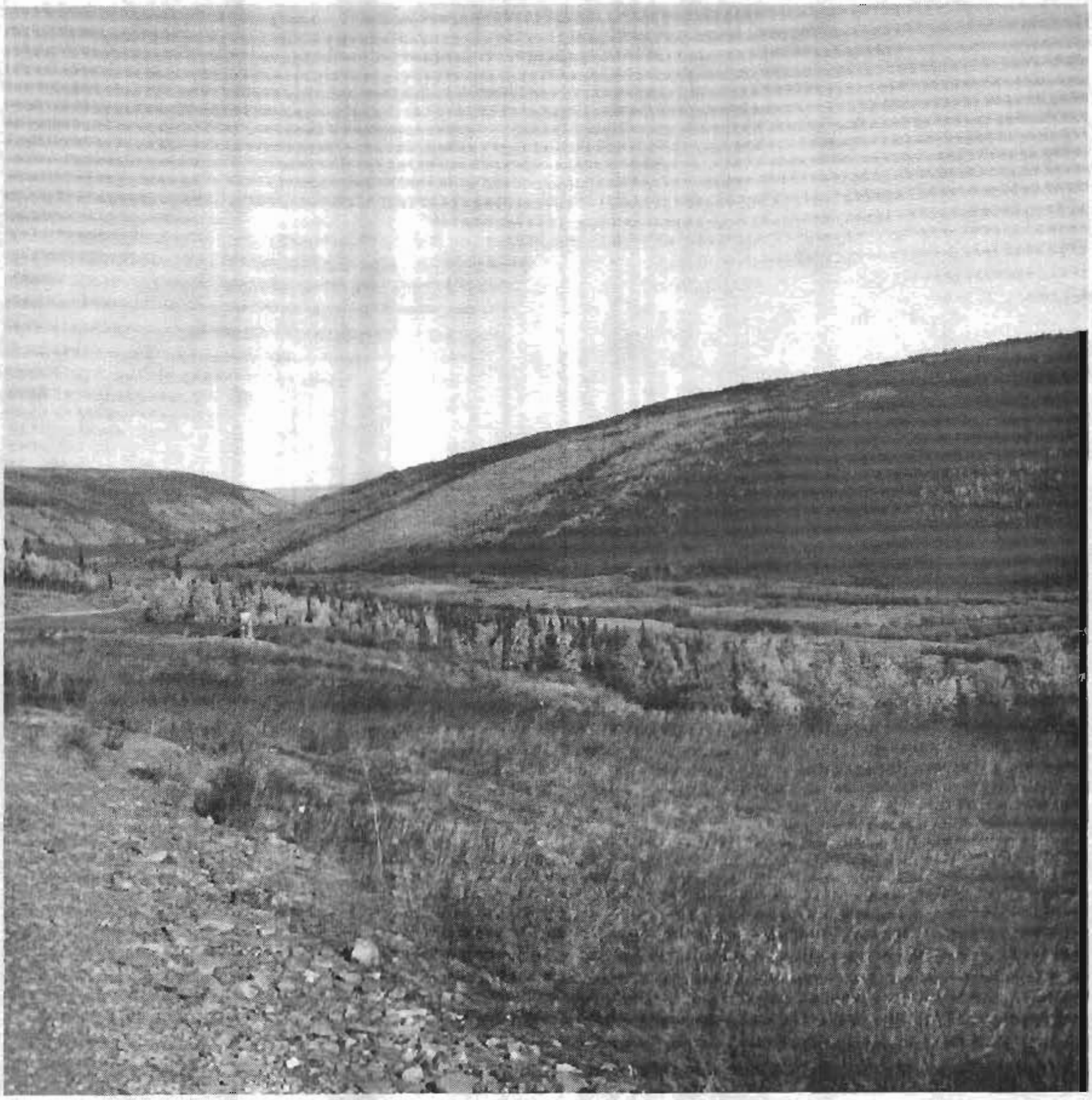
In the season of 1978, about 25 miles of the Steese Highway was rebuilt. This road runs through the Birch Creek - Eagle Creek area, just southwest of the Crooked Creek drainage, and utilized tailings for part of the crushed rock needed. The value of this material was $1.00 per yard in place. Tailings for road building and repair were also obtained from Porcupine and Bonanza Creeks. Although these tailings were furnished without charge, they constitute a significant contribution to the value of the road.

It is not anticipated that a heavy demand will develop in the near future for tailings, but there will always be some need for road repair. Present plans call for paving the Steese Highway, and should this occur, there will be a need for large amounts of tailings.

The following approximate areas have been altered by mining on the various creeks:

13) Tailings on Ketchum Creek, Circle District, mined 25-30 years ago.

14) The Ketchum Creek valley with roads and tailings, mined 25-30 years ago.



15) Crooked Creek, dredged 30 years ago.

16) Vegetation on tailings.

17) Slow revegetation of native species on coarse tailings that were mined thirty years ago.

18) Coarse tailings with minimal vegetation 20 years after mining.

Creeks	Acres
Porcupine Creek	45
Bonanza Creek	70
Yankee Creek	10
Miller Creek	85
Mammoth	470
Mastodon	240
Independence	60
Crooked	30
Deadwood	330
Switch	7
Ketchum	35
Portage	45
Small creeks formerly prospected	10
Total area in Crooked Creek drainage	1437
Harrison	
Eagle	160
Gold Dust	20
Bottom Dollar	20
Half Dollar	20
Total	220

Mining Roads in Crooked Creek area	Miles
Mammoth-Independence	12
Portage-Bottom Dollar	10
Deadwood	12
Ketchum	4
Miller	3
Porcupine	11
Crooked Creek	3
Boulder	3
	58 (50' wide) = 352 acres

Other Roads in District	
Harrison	14
Eagle	4
	18 (50' wide) = 110 acres

To this total should be added miscellaneous trails, cabin sites, etc. of perhaps 10 acres.	10 acres
Total Roads and Trails	472 acres
Total Disturbed Land in Crooked Creek Area	1,909 acres
Total Land Area in which this disturbance is concentrated (430 square miles)	275,000 acres
Maximum Density of Land Disturbance	0.7%

Beneficial Effects

The Birch Creek or Circle mining district was discovered in 1893, at a time when there were only a few hundred white people in the Interior of Alaska. A trading post had been established at the site of Circle City in 1887, and this rapidly became the distribution point for the district. According to early visitors from the U.S. Geological Survey, Circle City in the mid-1890's was the cultural and economic center of the Interior, with a library, stores and other needed services. Without this beginning, the rest of the area would not have been explored or made to support a population based upon anything other than hunting and trapping. Thus, a beneficial effect of placer mining in the area can be said to be that it was the pioneer industry that allowed all else to develop. To this day, the only other income in the area is derived from seasonal tourism, a small amount of trapping and a few fish wheels. The tourism is based partly upon the hot springs, but the development of the springs was made possible only by mining. The hot springs furnished services that were purchased by the early miners (lodging, baths and vegetables). Without mining, which brought in outside money, the services would have been unsaleable. After the Steese Highway was built to serve the mines, it furnished a transportation route for tourists, now the principal revenue source for the Hot Springs.

The principal beneficial effect of a mine, of course, is the metal produced and its contribution to human welfare. According to the U.S. Geological Survey (Committee Print, 1964) the Circle district had produced 730,000 troy ounces of gold up to 1960. A conservative estimate of production to the present would be 760,000 troy ounces. If it is again assumed that 100 ounces of gold would support a family for a year, then the district has supported directly about 100 families. The income multiplier for Alaskan mining is estimated at 2.93, with an employment modifier of 1.25 (Lodgeson, 1975).

The beneficial results of the placer mining in the Crooked Creek area can be summarized as follows:

1. Established civilization in interior.

2. Supported 100 families directly since its inception, and many more by secondary industry.

3. Established roads.

4. Allowed development of hot springs and tourist industry.

5. Created building material (tailings).

6. Profit from mining contributed significantly to the capital base of the country.

Effects on Other Resources

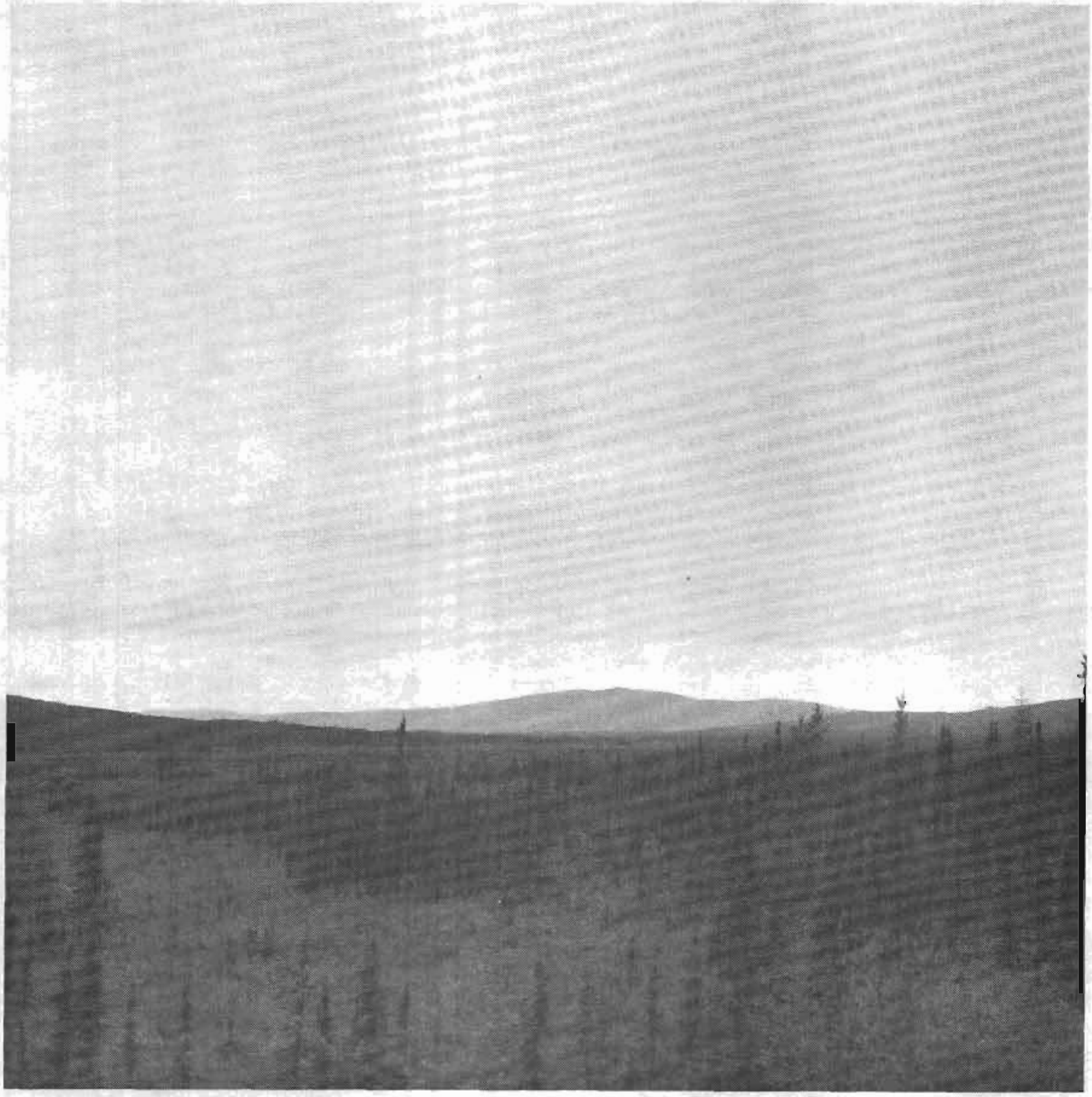
The other resources of the area are timber, the hot springs (which makes agriculture possible), fish, game and the general attractiveness of the area to tourism and recreation. To this should be added the possibility of lode mining in the area. Deadwood Creek is known to contain much placer tin and tungsten, and one or two gold lodes are known.

The effects of placer mining on the above resources are beneficial, with the possible exception of fish and game, the utilization of which is enhanced by the transportation system provided by mining. Tourism would be nonexistent if placer mining had not established the roads now in use, and the mines provide a destination for tourists. Any agriculture in the region was dependent for markets first on placer mining and now on tourists. Land values, in the State of Alaska's land disposal program, are significantly greater if the parcel or lot is near or adjacent to a mine road, or cat trail.

Effects on Fish

Neither Crooked Creek nor Birch Creek contain salmon (ADFG, 1975), so fishing in the area is restricted to sports fishing for grayling. The following observations apply to the area:

19) Industrial utilization of tailings
at Fox, Fairbanks District.



20) Muskeg and tundra in an undredged portion of Goldstream Creek, Fairbanks District.

Although settling ponds are used by the mines to remove settleable solids, it is impossible to remove all turbidity. When the water is turbid for any cause, it is safe to say that angling with hook and line is poor. However, it is apparent that the fish are in the area, and fishing in clear tributaries is as good as ever. Moreover, the streams eventually lose their turbidity.

On September 7 and 8, 1977, observations were made in the drainage. Biologists of Environmental Services Ltd. made these observations, Dennis Ward in charge. His report is appended as Appendix E. Briefly his findings are these: Samples were taken at four sites over a distance of eleven miles. At least three mines were operating intermittently, and had not been sluicing for about 12 hours. The map E-1 in Appendix E shows the sample points. Turbidity ranged from 45 NTU to 30 NTU. Four species of fish were found: grayling, slimy sculpin, long nose sucker and round whitefish. Both fry and juveniles were found (Figures 21). These observations indicate that these species are living and feeding in turbid water, and further that grayling were spawned in the water in 1977 (Figure 22). In periods of high water during the summer, the reservoir on one of the tributary creeks was washed out four times. For brief periods the turbidity was very high, yet four species of fish managed to spawn. Grayling were caught consistently in Miller Creek above the mine in 1977 and 1978. In September, when the grayling migrate downstream, they were observed in both years in muddy water on their way down.

About June 1, 1978 there occurred a big flood in the Crooked Creek drainage. The water was turbid and over the banks in many places. One of the miners reported seeing a school of grayling in an eddy, either waiting for the flood to abate or feeding in clearer water.

The following information was obtained from Tury Anderson, who mined the Porcupine area from 1950 to 1954. It was he who dredged the single cut down Crooked Creek from Mammoth to Bedrock Creeks. At that time there was one mine on Porcupine Creek, and one each on Miller, Mastodon and Independence, as well as the dredge on Crooked Creek. He reports that there were always grayling in Mastodon, which could be caught in somewhat turbid water with a spinner, and that grayling could be caught in the dredgepond on Crooked Creek. He also reported that during the hydraulic mining on upper Porcupine Creek during the 1930's, grayling were caught both above and below the mine. At that time, Porcupine's tributary, Bonanza, was being hydraulicked. During the early 1950's, mining was in progress on Portage, Crooked, Mammoth, Mastodon, Miller, Deadwood, Ketchem and Independence Creeks. At this time, whitefish were netted in quantity for dogfeed in Birch Creek just below the mouth of Crooked Creek.

Effects on Stream Bottoms

The real possibility was investigated that although fish may be present in the streams being mined, the bottoms may have been silted so as to make spawning difficult. During the seining of Crooked Creek for fish, the following general observations were made: As noted earlier, samples were taken at four points (see Appendix D). At the uppermost sample point, near the mouth of Mastodon Creek, mud coated the rocks on the sides of the creek to as much as one inch, and the holes in the stream bottom contained clay. At Bedrock Creek, two miles downstream, there was only a slight coating of clay or mud on the rocks, but there was up to one foot of clay in the bottom pools. At Boulder Creek and at Central, the other two sites, eight and ten miles downstream, respectively, there was no visible sedimentation, although the water was slightly turbid.

To get a more quantitative estimate of siltation, samples were taken from the bottoms along the side as a way of determining the amount of fine material present (smaller than 200 mesh). The locations of these samples are shown in Plate 2 and the analytical results in Table 4. Perhaps the first observation to be made is that the problem of the effects of placer mining does not lend itself readily to quantification. Several other remarks can be made.

The sediments in Crooked Creek, at Boulder Creek, two miles above Central and 8 miles below the confluence of the creeks being mined, contained 17 percent minus 200 mesh material. At Central, two miles downstream, it was less than 1 percent. Mammoth Creek at Miller House, just below the mouth of Miller Creek, actively being mined, was 8 percent minus 200 mesh. Porcupine Creek (also being mined) at its mouth was 6.5 percent. However, Porcupine Creek just above Bonanza Creek, four miles closer to the mine, shows only 3 percent. Bedrock Creek at the road crossing had 11.5 percent and at its mouth, 14 percent. However, there is no mining on

21) Studying the biota in Crooked Creek, Circle mining district.

22) Analyzing stomach contents of seived fish from the Crooked Creek, Circle mining district.

Bedrock Creek. The figures apparently are of no use in judging whether a stream bottom is impacted by mining to the point where it could not support spawning. Probably there are a number of variables that cannot be analyzed quantitatively. It is obvious that some reaches are impacted (such as the potholes on Crooked Creek with clay observed in them). It is also obvious that this clay is cleaned out periodically, otherwise the holes would not remain holes.

Table 4: Percentage of Various Sediment Sizes in Stream Bottom Samples. (Sample numbers refer to region-wide sampling net, prefixed with A. See Plate 2 for locations.)

Sample Number	Location	Mesh Size +4	-4+20	-20+200	-200
A 1	Eva Creek Stream Cripple Creek	1.6	8.9	18.4	71.1
A 2	Crooked Creek at Central	57.2	25.4	17.9	0.4
A 3	Cripple Cr., 3 mi. below Eva Cr.	0	0	5.5	94.5
A 4	Chatanika River, Middle of Stream	99.3	0.7	1.1	0.4
A 5	Goldstream Crossing *	19.8	0.6	28.1	52.1
A 6	Goldstream at Sheep Creek	95.6	3.9	0.8	0.3
A 7	Little Goldstream Crossing	72.0	18.3	9.7	0.3
A 8	Chatanika, Side of Channel	96.4	1.8	3.6	0.6
A 9	Ketchem at road	47.0	32.4	16.1	4.4
A10	Porcupine at Bonanza	66.3	18.7	13.5	3.0
A11	Mammoth at Miller House	53.9	13.7	24.8	7.9
A12	Deadwood at road **	78.6	11.0	10.2	1.6
A13	Goldstream at Fox	1.9	1.9	37.0	63.0
A14	Portage Creek below mining **	69.8	25.1	6.4	0.9
A15	Crooked Creek at Bedrock Cr. **	71.4	17.3	8.8	3.6
A16	Pedro at Discovery	84.1	13.8	2.2	0.7
A17	Faith Creek at bridge **	51.5	14.8	31.1	.0.8
A18	Boulder Creek at road	64.0	27.8	8.2	0.1
A19	Sawpit Creek at road	67.1	19.1	13.3	0.8
A20	Bonanza Mouth	53.5	29.2	19.1	0.4
A21	Mammoth at bridge **	74.5	17.3	8.3	0.3
A22	Stack Pup Creek at road	73.9	17.1	9.4	1.0
A23	Tolovana at Elliott	76.1	20.3	7.3	0.2
A24	Goldstream at Ballaine Road *	0	0.7	12.6	87.4
A25	Livengood Creek at bridge **	29.5	0.5	5.5	64.6
A26	Washington Creek at road *	11.5	0.4	15.4	73.1
A27	Tataline at Elliott	1.2	0.8	44.6	53.1
A28	Chatanika at Elliott	76.8	18.5	6.6	0
A29	Miller Creek above mine	7.3	39.9	49.4	3.9
A30	Mammoth at mouth **	0	0	25.1	74.9
A31	Porcupine at mouth **	0	2.6	93.5	6.5
A32	Mammoth - Porcupine **	0.7	5.4	86.5	8.1
A33	Bedrock Creek at road	0	6.1	82.4	11.5
A34	Bedrock Creek at mouth	12.8	29.2	43.4	13.9
A35	Crooked Creek at Boulder **	0.2	11.8	70.5	17.6
A36	Crooked Creek at Central	0	0	36.5	63.5
A37	Independence Creek	2.2	14.6	68.9	14.6

* Creek flowing on muck
** Mining upstream

Very likely a large proportion of the bottom of any particular stretch of stream is completely cleaned out of fines during high water, while other parts of the same stream bottom have fines deposited during the same high water.

It is certain that grayling spend the summers at least in the upper reaches of some of the streams being mined, because they are seen and caught there. In the fall they are seen migrating down, even through the muddy water, apparently with no ill effects.

The best that can be said at this time is that we do not know if grayling and other fish spawn in turbid areas below the mines. Certainly they spawn in the Crooked Creek drainage, but the spawning may have been above the mines. Observations made in the Fairbanks district (Chatanika River) while much stripping and mining were in progress indicate that the fishing was good above the mines, just as good as today when the fish do not have to traverse a considerable stretch of muddy water to get there. Perhaps it would be safe to say that fishing is not as good in the turbid stretches as where the water is clear, but even here, some people interviewed maintained that they caught fish with spinners in turbid water.

Downstream Effects

The effects of sedimentation downstream from the Livengood area have been noted and discussed. There, the abrupt flattening of the streams as they enter Minto Flats has caused extensive sedimentation of lakes and cut off channels during atleast the past 10,000 years.

The situation in the Crooked Creek area is somewhat different, but in some respects it is similar. East of the area under discussion, the Tintina Trench, a fault of continental proportions, extends along the south side of the Yukon. In the Circle Hot Springs-Central area it extends northwest-southeast. The eastern edge of the trench appears to form the highland front that is evident near Circle Hot Springs and Central. North and east of this front the ground is low and marshy, but this lowland does not merge with the Yukon Flats; there is a bedrock ridge between. The area of the Trench lowland that lies just in front of Circle Hot Springs is obviously the lowest, containing several lakes, the largest of which is Medicine Lake.

The position of the south side of the Trench is pretty well known because bedrock drops off abruptly just east (downstream on Crooked Creek) from the place where Sawpit Creek flows into Crooked Creek. The lake in Section 21, T.9N, R.13E may lie on this fault. Bedrock on Crooked Creek at the mouth of Sawpit Creek is perhaps 12 feet below the surface, while a short way downstream a shaft 80 feet deep did not reach bedrock. It would appear that the southwest side of the trench is subsiding faster than the rest of the trench, since the lakes lie clustered in that area. Once Crooked Creek flows into the Tintina trench it becomes a meandering river with high mud banks. The small amount of mud and turbidity which the creek can transport into the low area cannot begin to equal the fine material available for transport and deposition in times of high water in this marshy lowland.

The largest of these lakes, as mentioned, is Medicine Lake. Crooked Creek follows a tortuous route just north of this lake, with a channel connecting the lake to the Creek. Ordinarily, there would be a slight flow from the lake to Crooked Creek since several streams flow into the lake. It is evident, however, that at some time in the past, Crooked Creek has partially filled the north end of the lake. This sedimentation is not in progress now, nor has it been in historical time. Undoubtedly, Crooked Creek in times of high water must deposit sediment in some of the lakes, but since little actual volume of silt is liberated by mining (as distinguished from stripping muck), the contribution from mining is probably a minor part of the total load in high water. Thus, although sedimentation of a low subsiding area has been important in the past, as it is today at Minto Flats, it is not occurring now in the Crooked Creek area. Sediment coming down Crooked Creek, and Birch Creek too for that matter, is periodically flushed into the Yukon.

Chapter 4

Interviews With Long Time Residents

Introduction

Interviews were conducted with several persons who have had extensive experience in Livengood, Minto Flats, Circle and other areas. As might be expected, those with close and extensive contact with the wilderness environment of Alaska are natives and others who have lived the subsistence life style: trappers, hunters, miners and those dependent upon these individuals for a livelihood.

Comments, of course, reflect each person's interpretation of change as they see it affecting their lives. Yet, fact can be sifted from the whole story. A definite change in wildlife, fish, vegetation and terrain is discernable, even though the magnitude and desireability of that change may be open to question. In general, there is little degradation that time and natural forces can not heal. Much of the impact of placer mining is to increase the rate at which change would have eventually taken place by natural processes.

Livengood Area

Charles Ulsh has lived in the Livengood area as long ago as 1923; Laila Ulsh as long ago as 1930. Their comments follow:

1. Fishing is good now and was good then in the Tolovana and West Fork. However, it is necessary to go above or below the bridge crossing, because the rivers near them are fished out.

2. When the dredge was operating, fishing was good in the Tolovana and below the dam in Hess Creek. At dam in Hess, fish were thick in the pond which was very muddy.

3. During drift mine days Livengood Creek ran very muddy in the spring when the winter dumps were being sluiced. No fish were caught in the muddy water but grayling could be caught in Myrtle Creek, a tributary of Livengood. This is still possible.

4. In the spring before sluicing starts, grayling can be seen in Livengood Creek. When Livengood Creek was muddy fish could be seen going through the mud and into Myrtle Creek, which was clear.

5. Heavy fishing is what cleans out fish. They have seen the Tolovana muddy, yet have been able to catch plenty of fish above the dam.

6. Caribou were plentiful when mining was in progress. They would jump across the ditch. They walked down the streets of Livengood in the 1930's. The drift mines had steam boilers and each had a whistle. The whistles didn't disturb the caribou.

Circle District

Messrs. Frank Young and Charles Laird were interviewed regarding their recollections of conditions in the Crooked Creek drainage area.

1. They made positive statements that turbidity never stopped fish, namely salmon and grayling, from coming upstream.

2. Fish are caught below mining operations. Grayling came right up to the mines.

3. Disturbance by mining is temporary.

4. When Eagle Creek was being hydraulicked, fish could not be caught when actually washing gravel. Fish could be caught in lower Eagle Creek after the splash stopped. Fish could always be caught in Ptarmigan Creek, a tributary from the north below the mining area.

5. Fishing is good on Crooked Creek now, but respondent does not know about 1930's when much hydraulicking was in progress. A contrary opinion was that fishing never was very good in Crooked Creek, but he never noticed it to be worse when mining.

6. As soon as foliage comes back after mining, the moose move in, for example along ditches and airstrips.

7. Mud from mining does not drive fish completely out of the stream being mined; they can always be found above the mining area.

Mr. Tury Anderson, a long time miner and resident of the Interior, mined on Porcupine Creek from 1950 to 1952, dredged on Crooked Creek from 1953 to 1954 and also mined on Independence and Greenhorn in 1954. He stated that fishing was always good in Porcupine Creek.

Messrs. Tury Anderson, Bruce Thomas and Frank Young, all active miners or consultants in the Fairbanks and Circle Districts, had this to say regarding mining activities and systems:

1. There were always fish in Mammoth Creek.

2. Grayling can be caught in muddy water by using a bright spinner which they could see.

3. There were fish in the dredge pond. A beaver lived in the dredge pond and used to dive under the bucket line.

4. The main thing that affects fishing is high water.

5. In the early 1950's, a man in Central netted much whitefish in Birch Creek below the mouth of Crooked Creek, which was muddy.

6. In the Chatanika River (on the Tanana side of the divide) while muck was being stripped into the river, the grayling fishing was good above the operation. The fish would come through the muddy water to the clear water above.

7. The same was true on Coal Creek tributary to the Yukon above Circle.

8. On Vault Creek in the Fairbanks District, a miner was observed pumping muddy water. The fish would swim right up to the pump screen.

Minto Flats

Mr. Jack Jones and Mr. Pete Hagglund, two white men who have spent much time in the Flats as hunters and fishermen, were also interviewed. One of them is a commercial pilot who has seen almost all of Alaska. He reports that there appears to be a drying tendency of late years. The water level of Minto Lake has lowered over the last 30 years. A lot of dry beach is exposed. Also, Harding Lake, 80 miles from the Minto Flats, is receding and some wells in Fairbanks indicate lower water tables. He also states that the growing in of lakes by vegetation is accelerating.

Mr. Jack Jones also reported that the shore line of the northernmost of the Big Minto lakes has receded considerably in late years. He stated that pike fishing in that lake is poorer than formerly. He attributes this to the receding waters, but more to the heavier fishing in recent years. Before 1970, the people of Minto lived on the Tanana River and depended to a large extent on salmon. About then, the village moved to its present site at the north end of the Flats. Fishing pressure has shifted from salmon to pike and whitefish.

The senior author and Mr. Dennis Ward were guided through an extensive part of the Minto Flats by Mr. John Titus. They were taken up the Tolovana from New Minto and shown several dry lake basins connected to the river during high water. Our guide stated that these basins formerly had been occupied by water but that silt from mining operations at Livengood had filled them in. One dry lake had been full the day before; obviously the river had dropped and the water ran out. It is difficult to believe that an excess of sediment in the water caused the drying up of the basins; the basins are bordered by encroaching vegetation and the channels between the rivers and the dry lakes are too narrow to admit much silt. Mr. Titus attributed the turbidity present to mining operations at Livengood.

Mr. Titus states that trees along the Tolovana River have been killed by mud from mining operations. When questioned about possible subsidence of the north part of the Flats, our guide stated that a small hill appears to be more submerged than formerly.

Mr. Peter John, born in Minto in 1900, stated that the first big influx of mud arrived in 1929, and attributes a decline in fish, big game and fur to the drying and filling of the lakes. He stated that the whole Flats has been affected by the infilling. He saw several caribou mired and drown in a muddied lake. According to him people can no longer make much money trapping and the hunting is spoiled. The only thing that the Flats are good for is waterfowl.

TABLE A-1. Locations of Sediment Samples, Livengood—Minto Flats Area (see Plate 4)

Sieve Analyses by Weight Percent

Sample No.	x 100	100 x 150	150 x 200	200 x 270	270 x 400	-400	
B 1	3.6	2.1	2.9	3.8	15.4	72.2	Dry sediment pond, Livèngood camp
B 2	2.0	.9	4.0	12.3	39.8	40.7	Mud alongside creek at Livengood camp
B 3	3.4	2.5	2.1	2.1	9.2	80.7	Undisturbed, in place, silt bank at Livengood camp
B 4	.7	1.6	5.9	9.3	23.8	58.6	Settling pond at Livengood
B 5	7.1	6.6	8.6	9.4	21.9	46.4	Tatalina River at Elliot Highway crossing
B 6	6.7	3.0	2.7	2.2	6.4	79.3	Tolovana across from Minto village
B 7	12.1	24.6	21.4	9.5	5.5	26.9	Tatalina River in Flats, 2 1/2 ' above water
B 8	10.1	29.5	28.6	12.7	6.0	13.5	Tatalina River at water's edge - gravel
B 9	3.5	2.0	2.2	2.6	9.7	80.4	Muck bank, in place, west side of lower cut of 1977
B 10	3.6	2.1	2.9	3.8	15.4	72.2	Tatalina River in Flats, 8' above water
B 11	71.8	5.4	3.4	2.2	2.4	14.8	Tolovana at Elliot Highway crossing above Livengood
B 12	2.1	3.9	6.7	7.8	23.9	55.7	Tolovana at butte above Village
B 13							Tolovana River water in Minto Flats
B 14	15.8	5.8	4.7	3.3	7.5	63.0	Tolovana River bank across from Minto Village
B 15	2.3	2.6	5.6	7.9	29.9	51.8	Mud from Rock Island Slough below Village
B 16	1.4	15.7	38.2	26.6	12.9	5.2	Sand dune 10' above water, Tatalina River in Flats
B 17	6.7	5.3	9.4	11.6	33.9	33.1	Chatanika River in Flats, 1' above water
B 18	25.3	28.1	15.2	5.5	4.6	21.3	Tatalina River in Flats, 1' above water
B 19	6.0	3.4	3.0	2.5	4.4	60.6	Idaho Slough, shoreline, surface
B 20	14.6	7.8	7.1	5.1	8.6	56.8	From bottom of Channel to lake, just above Village
B 21	13.1	6.1	5.1	3.9	9.1	62.6	Tolovana, surface, across from Village
B 22	10.1	29.1	30.0	14.9	8.3	7.6	Tatalina in Flats, auger hole
B 23	17.7	30.5	24.1	10.0	5.5	12.2	Tatalina in Flats, 4' above water, shovel sample
B 24	5.5	6.6	12.2	13.1	30.9	31.7	Tolovana across from Village
B 25	9.2	5.3	4.4	2.9	6.7	31.5	Chatanika in Flats, 2' auger hole

23) Tailings provide a very desirable building foundation, Fox, Alaska.

24) Tailings utilized for subdivision roads, Fairbanks District.

Chapter 5

CONCLUSIONS

There are significant natural forces at work in the Minto Flats area. As mentioned in Chapter 2, there is clear evidence that the north and east areas of the Minto Flats are subsiding. Earthquake research supports this. Dr. D. Van Wormer, et al, 1973 state: "Noteworthy active areas are .... the Fairbanks area, and the Minook Fault near Rampart ...." These active areas are immediately to the north and east of the Minto Flats.

Also, as related in Chapter 4, the shore line gives evidence by both eye witnesses and photographs that the Minto Flats may be drying out. Whether this is a continuing or temporary trend is not known. Neither is it known if the causes of the changes in shore line reflect a change in climate or result from alluvium from placer mines. Certainly the natural filling in of lakes by vegetation is also an ongoing factor in the evolution of the Minto Flats.

Alluvium from placer mines has in the past, and in part is now being discharged into the streams. In many respects and in many locations along the course of a stream this creates conditions that are transitory, particularly in the headwaters and upper reaches. As an example, pools observed as having mud bottoms during one season become clear gravel stretches the next season. This identifies a more critical zone of a stream as likely being the discharge into a low-lying or swampy area, or into a glaciated or otherwise continuously turbid river.

Appendix D details the work of Dennis L. Ward, Associate Aquatic Biologist of Environmental Services, Ltd. Water samples were taken at four points starting below two working placer mines on the Crooked Creek drainage system during the summer of 1977. The two sites closest to the mines were highly turbid with suspended solids as high as 45 NTU and 207 mg/l. Yet it was reported that six orders of insects were present at each of the four sites. Trichopterans were absent from station #2 sample and Plecopterans were absent from station #3 sample. Exuviae were found at all stations but were most abundant at stations 2 and 3. Grayling were reported caught at all four stations.

Doug Weir (see Appendices A and B) reports considerable evidence of plant and animal food for fish and birds. He also commented aside from his written report that such life forms appeared to be more abundant along the Tatalina River banks than along other streams. The Tatalina has not been subject to placer mining.

In Appendix C, Mr. Weir states: "Assuming that much of the sediment had been transported from the mining districts (and the material should be tested to confirm this), then mining sediments were implicated in marked silting of the channels of two streams and of certain nearby lakes". As noted elsewhere, there is no question of heavy silting along Goldstream Creek and adjacent lakes. The effects on other streams are harder to assess. A factual and quantitative evaluation of the impact of placer mining on various aspects of the environment will require further study. This study must relate the rate of impact of the geomorphic, biologic, tectonic and cultural processes which affect the Alaskan environment.

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Appendix A

Discussion of Sieve Analyses of Sediment Samples Taken at Minto Flats and in the Livengood Area

Two sets of samples were taken during the study. One set covered a wide area as shown on Plate 4 and Table 4. Another set was taken in the Livengood district and on the banks of streams in Minto Flats. These later samples are reported on below. Fines means minus 400 mesh.

Tatalina River

Sample nos. 16, 22, 23, 8, 18 and 7, that were taken on the bank of the Tatalina River in Minto Flats, all have less than 30% fines (minus 400 mesh). These samples are moderately well to well sorted and probably represent either sand bars or sand dunes.

Sample no. 5, taken where the Elliot Highway crosses the Tatalina River, contains almost 50% fines and is poorly sorted to very poorly sorted.

Sample no. 10 was taken at the same locality as sample no. 8, but is considered to be representative of the sediment presently being deposited by the Tatalina River at Minto Flats. This sample contains over 70% fines and the sorting is similar to sample no. 5.

Sample no. 5 and sample no. 10 are similar in their degree of sorting and differ only in their median size. Sample no. 10 contains around 25% more fines than sample no. 5, most likely reflecting its downstream location in the flats where the stream competency has been decreased.

Tolovana River

All of the samples taken along the Tolovana River are poorly sorted. Sample no. 11 is the coarsest, containing 15% fines and 70% plus 100 mesh. Sample nos. 6, 12, 14, 21 and 24 have between 30% to 80% fines, and a median in the silt size range.

As expected, the coarsest sample (no. 11) is from the Tolovana above Livengood and the finer sediments are from the Minto Flats. The range in the samples taken at Minto Flats are considered to be a function of where along the stream bank the samples were taken.

Chatanika River

The two samples taken at the Chatanika River at Minto Flats (nos. 17 and 25) are both poorly sorted with a median size in the silt size range. Sample no. 17 contains 34% fines and sample no. 25 contains 70% fines. These two samples are similar, as one would expect, to the samples taken along the Tolovana River at Minto Flats.

Livengood Area

The five samples taken in the Livengood area have median sizes that fall within the silt size range. All the samples are poorly sorted and contain between 40% to 82% fines. The sample taken in a settling pond and along the bank of a creek has less fines than those taken directly from the muck. These samples show the characteristics of most loess deposits (median in the silt size range and poorly sorted). The settling ponds and the creeks contain less fines and are better sorted than the loess found in place, due probably to the ability of the streams to carry the fines in suspension through the overflows, and to other hydraulic factors. This difference is not well shown and it therefore is not a conclusive observation.

TABLE A-1. Locations of Sediment Samples, Livengood--Minto Flats Area (see Plate 4)

Sieve Analyses by Weight Percent

Sample No.	x 100	100 x 150	150 x 200	200 x 270	270 x 400	-400	
B 1	3.6	2.1	2.9	3.8	15.4	72.2	Dry sediment pond, Livengood camp
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B 5	7.1	6.6	8.6	9.4	21.9	46.4	Tatalina River at Elliot Highway crossing
B 6	6.7	3.0	2.7	2.2	6.4	79.3	Tolovana across from Minto village
B 7	12.1	24.6	21.4	9.5	5.5	26.9	Tatalina River in Flats, 2 1/2 ' above water
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B 16	1.4	15.7	38.2	26.6	12.9	5.2	Sand dune 10' above water, Tatalina River in Flats
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B 20	14.6	7.8	7.1	5.1	8.6	56.8	From bottom of Channel to lake, just above Village
B 21	13.1	6.1	5.1	3.9	9.1	62.6	Tolovana, surface, across from Village
B 22	10.1	29.1	30.0	14.9	8.3	7.6	Tatalina in Flats, auger hole
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B 24	5.5	6.6	12.2	13.1	30.9	31.7	Tolovana across from Village
B 25	9.2	5.3	4.4	2.9	6.7	31.5	Chatanika in Flats, 2' auger hole

Table A-2. Turbidity of Natural Waters from Livengood Creek, Spring, 1977

Sample	Description	NTQ
1	Livengood Creek at bridge May 2	49
2	9 a.m., May 6 at bridge	339
3	May 10	105
4	May 14	84
5	May 18	99
6	May 22, Water down to about 1/2 flood, 6" deep, 8' wide	81
7	May 30, Creek slightly higher, rained yesterday	59
8	June 3, Two days heavy rain	120
9	June 11, Upper bridge, water clear	18
10	June 11, Lower bridge	26
11	June 15, Lower bridge, 36 hours after heavy rain	57
12	June 15, Upper bridge, 36 hours heavy rain	57
13	June 19, Upper bridge, Livengood	28
14		58

Table A-3. Turbidity Measurements

Sample Location	Readings (NTU)	Average Reading (NTU)
Mouth of Tatalina	2.8, 3.0, 3.2, 3.6, 3.4	3.2
Tolovana, 1 mile below Chatanika in Flats	3.0, 3.2, 2.8, 3.6, 3.2	3.16
1 water percolated through settling dam	2520, 2670, 2640, 2520, 2610	2592
Chatanika, below Tatalina (definite mixing zone above this)	7.1, 6.4, 7.0, 7.1, 6.9	6.9
Chatanika in Flats	3.6, 3.8, 4.4, 4.4, 4.2	4.08
Tolovana, just above Chatanika	6.8, 7.2, 7.2, 7.3, 7.6	7.22
2 discharge water from 1st dam	2760, 2820, 2790, 2880, 2700	2790
Water 3, intake to pond at Livengood Camp	2580, 2520, 2550, 2550, 2580	2556
Tolovana at village	3.6, 4.4, 3.5, 3.8, 3.8	3.82
Tatalina	3.8, 4.0, 4.0, 4.5, 4.5	4.16
Rock Island Slough below village	1.2, 1.1, 1.2, 1.4, 1.1	1.2
	7.4, 8.0, 7.6, 8.2, 8.0	7.84

Minto Flats

The three samples (15, 19 and 20) taken in the Minto Flats are similar in both median size and sorting to those samples taken along the Tolovana River and Chatanika River in the Minto Flats, and the one sample taken along the Tatalina River that is assumed to be representative of the sediment deposited by that river in the Flats. The samples contain between 50% and 80% fines.

General Conclusion

All of the samples taken in the Minto Flats, excluding the samples taken along the Tatalina River that are assumed to be either from sand dunes or sand bars, are both poorly to very poorly sorted and fine grained (median size being silt size or finer).

The samples taken upstream of the Minto Flats on both the Tatalina and the Tolovana have less fines than the samples taken in the Flats, but are also poorly to very poorly sorted. These observations correspond to those found in natural fluvial systems.

Appendix B

FTR7801 Douglas Weir to Ernest Wolff copy C.C. Hawley

05/06 June Ecological Reconnaissance Circle Mining District for University of Alaska Bureau of Mines Study

ITINERARY 05 June briefly visited Fred Wilkinson's mine on Miller Ck and met rest of team. 06 June inspected stream state and plant colonization at Crooked Ck (Central Branch), Deadwood Ck, Crooked Ck at Boulder Ck campsite and finally Miller Ck.

CROOKED CK (CENTRAL BR) Plant colonization of transects of an old gravel roadbed and adjacent river shingle was examined. The stream was circa 20 meters wide, ran at moderate speed and was turbid from mining. The surrounding vegetation was riparian broad leaved woodland, birch aspen with some spruce and a willow understorey, canopy circa 18 meters.

The roadbed transect was circa 10 meters of slope from river shingle, compacted top and slope to landward. The river shingle - top slope was circa 70% vegetated with alder, willow, birch to 1.2 meters, roses, fireweed and other herbs, horsetails and grasses. The top was circa 10% vegetated with 4 species of willow, birch and spruce to 1.0 meter, fireweed, other herbs and grasses. The top-landward slope was < 10% vegetated with 2 species of willow, birch to 1.0 meter and grasses.

The river shingle transect was circa 10 meters from waterside to the foot of the roadbed, of stable, somewhat silted shingle, < 5% vegetated with 2 species of willow to < 1.0 meter and grasses. Wader footprints and beak probes indicated invertebrate life in the strand.

DEADWOOD CK The area was mined from circa 1900. It was surrounded by silver/black spruce woodland with some aspen and a willow understorey. Tailings 1-3 years old were invegetated. An older tailing of uncertain age was examined. The compacted top was < 5% vegetated with scattered spruce (largest 11-20+ years old and < 0.1-0.4 meters high) and some very small birch and willow. Mosses and Saxifrages were present. The reclining angle slope was unstable, vegetated < 5% with Saxifrages, other alpines and some grasses. The slope foot was silt/sand-/gravel without standing water and had a circa 2 meters wide, discontinuous band of alder-willow to 1.5 meters with a partial floor layer of grasses. It adjoined a dry roadbed/stream channel.

The creek bed gravels were compacted and 'cemented' by silt. The water was clear with some reddish staining. Across the creek from the tailings were more or less flat, well vegetated strippings and tailings, dating from the 1930s or earlier. There was continuous canopy broad leaved woodland, circa 4 meters high, of alder-birch-willow-aspen with a few spruces to 1.5 meters. The floor was circa 50% bare, stony in parts, with cover mainly of grasses.

CROOKED CK (BOULDER CK CONFLUENCE) The dredge had operated down stream in a single cut from circa 1953 to 58 and the lowermost 400 meters was inspected. River scouring had flattened and dispersed tailings or stripped the coarse gravels from the still-eroding cores of fines. Plant colonization was similar to that of adjacent natural shingle bars. Overburden piled on the banks was well vegetated by willow with a grass-herb floor layer and colonization by spruce had begun. Streambed insect larvae were present.

MILLER (MASTODON/) CK The surrounding vegetation was Montana black spruce, with birch-aspen, canopy circa 12 meters and, lying on the upper edge of very extensive tracts of nearly pure, small black spruce. Mechanical-hydraulic stripping of the bench edge on the right limit was nearly complete. Very turbid water was discharged directly to the creek but arrangements had been made to discharge by pipe during sluicing into a dry, off-channel complex of old dredge tailings downstream. The overburden was vegetated with black spruce to 4 meters and a dry heath tundra floor. It consisted of black, silty organic material, up to 6.5 meters thick with no soil profile evident and extensive ice lenses from circa 1.5 meters below the surface. There were numerous subfossil bones of large mammals, some in browner, sandier buried soils.

Tailings up to 3 years old were unvegetated but plant colonization of a 5 year old tailing was reported. Strippings on the edge of the bench, piled away from the sluicing area, were well colonized in 1-2 years, initially by mosses which might form 100% cover. 'Relict' fragments of heath tundra communities were thriving and there were vigorous invasions of willow, fireweed and grasses. The creek bed gravels were severely compacted by silt.

Two tailings 28-32 years old were examined. On the first, the compacted top was 5-10% vegetated, with spruce (5-20+ years old and 0.1-0.7 meters high), 4+ species of willow to 1.5 meters, some birch, no grasses, numerous flowering plants and no mosses. The reclining angle sides were vegetated 5-10% with willow, flowering plants and grasses. The foot had no standing water, dense willow stands to 5 meters and a grassy floor. The second tailing had the compacted top vegetated circa 20% with spruce (to 20+ years old, up to 1.5 meters high, recent growth to 15 centimeters p.a.), willow, white cottonwood, birch, flowering plants, a little grass, some moss and lichens. The steep sides were similarly but less vegetated. Slope foot and inter tailing spaces were variably dry to wet with dense willow thickets to 7 meters and 100% canopy, some spruce to 5 meters and generally grassy floors. Creek bed gravels were only moderately compacted (the area was upstream of recent mining). There was some staining of the clear creek water by organic/mineralized material draining from an old wet cut.

BIRDS AS INDICATORS Spring migration was still in progress, with passage/arrival of at least 4 species noted and some others appeared to be still absent. Mergansers, Terns, Kingfishers and Dippers would indicate that fishes/supporting stream fauna were common; none of these birds were seen during this short visit to waters which might not have been very suitable for other reasons. Spotted Sandpipers and Northern Water Thrushes would suggest at least moderate stream margin invertebrate faunas; both species were present at a minority of sites but Spotted Sandpipers were still migrating thru the area at the time. The presence of many smaller, bird-eating raptors would indicate high biological productivity (Weir, in press); a probably nesting Merlin and a nesting Sharp Shinned Hawk were seen. Neither would be common in virgin wilderness locally but these two sightings could have been fortuitous.

Douglas Weir 8 June 78

Reference

Weir, D.N., in press, Raptor and owl populations of a southwest Alaska mountain valley, Raptor Research.

Appendix C

FTR7802 Douglas Weir to Ernest Wolff copy C.C Hawley

08/09 June ECOLOGICAL RECONNAISSANCE LIVENGOOD & MINTO FLATS FOR UNIVERSITY OF ALASKA/BUREAU OF MINES STUDY

ITINERARY Left Fairbanks 08 June, arrived Livengood circa 1430 hrs., inspected settling pond system, ENW sampled water, soils. Arrived Minto circa 1830 hrs arranged for boat with Mr. L. Titus as guide for 09 June. Left Minto by boat circa 0730 hrs on 09 June, downriver Tolovana to confluence and briefly up both Tatalina and Chatanika Rivers, throughout noting some riparian-aquatic life forms and sampling water and soils. Returned to village and travelled up Tolovana and into adjoining channels. Completed reconnaissance circa 1430 hrs and returned to Fairbanks.

LIVENGOOD NOTES Sluicing began with one shift 15 May, with two from 05 June. Settling pond systems were extended since 1977 season with a complex of five (not visited) above Livengood town and four below. Very turbid water (visibility < 5 centimeters) was entering the lower part of the system, which was of large, well planned and made ponds. There was evident settling out of substantial silt burdens in all ponds and a visible progressive improvement in water quality but the water discharged into Livengood Creek was still markedly turbid. The silt burden in the discharge appeared to be of very fine, presumably suspended particles which the system was clearly unable to settle. Ernie Wolff took soil and water samples.

MINTO FLATS; LIFE FORMS IN RELATION TO DEPOSITED SILTS The aim was to make a simple assessment of the distribution of riparian-aquatic mammals and birds and of some food organisms in relation to known distribution of 'Livengood' silts (see earlier reports by Ernest N. Wolff, Mr. Dennis Ward and Doug Weir). The value of partly subjective assessments from a single short field trip is clearly limited but they may prove useful in discussing Minto Flats wild fowl data with USFWS (Mr. J. King, Fairbanks). At the time of the trip the water level was thought to be unusually low but whitefish were being taken by the village in probably more than average numbers.

Travelling along rivers by boat, in fine weather, the numbers and species of ducks/waders flushed were noted, as was the presence of some other birds and mammals. At one to three topographically comparable points along each section of river the shore was examined. Recent feeding or resting use by ducks, waders and beaver was noted from tracks and sign as was the presence and approximate variety of free moving riparian-aquatic invertebrates within 1 meter of the stream edge. Ernie Wolff took soil and water samples at these and other points. The biological observations are compared in Table one. Subject to qualifications (above) they were consistent with higher stream edge productivity where 'mining' silts were absent; the tentative nature of this suggestion is again stressed as is the need to discuss the subject with USFWS.

Douglas Weir 10 June 78

Table C-1: Indications of Abundance of Some Riparian-aquatic Life Forms in Different River Sections of the Minto Flats.

River Section & Length in Km	Approx. No. & Species of; Dabbling Ducks	Waders	Other Selected Life Forms	Stream Margin Use by Ducks/Waders & Variety Riparian-Aquatic Invertebrate Noted	
Tolovana below Minto, Km	C140 - 5	C30 - 2	Can. Goose two pr Moose 1 0 Beaver 1 Buffelhead one pr	ducks some waders heavy	5+
lower Tatalina Km	c80 - 6	c60 - 3	Swan one pr Kingfisher 2 Scaup 1 pr	ducks v heavy waders v heavy	15+
lower Chatanika Km	c20 - 4	c10 - 1	Can Goose one pr	ducks slight waders slight	2+
Tolovana above	c40 - 6	c20 - 3		ducks slight to moderate waders moderate	2+

Notes:

1. lower Chatanika was the only section where the slope of the stream margin was steep and thus less suitable for ducks/waders.
2. the Tolovana above Minto was probably subject to most boat disturbance which might affect resting/feeding use of the margin by ducks.
3. the dabbling duck species noted were, in order of abundance; Baldpate, Greenwing Teal, Mallard, Pintail, Shoveler and Bluewinged Teal.
4. the wader species noted were, in order of abundance; Spotted Sandpiper, Solitary Sandpiper and Lesser Yellowlegs.

Appendix D

Report to Dr. Ernest N. Wolff, Associate Director of M.I.R.L.,
University of Alaska, Fairbanks, from Douglas Weir

Introduction: The questions asked in the study were: a) had the Tolovana River and Goldstream Creek transported placer mining sediments from the Livengood and Fairbanks districts, respectively, to the Minto Flats and there deposited them in streams and lakes? and b) if a) were so, had the sediment deposition seriously affected the natural ecosystem of the Flats? I took part in the two September/October '77 field trips to the Flats, inspected 1949-54 aerial photos for evidence of silting and made suggestions about biological data which could be sought within the cost and time limits of the study.

Topographical Mapping Photos: A written report was given to Dr. Wolff on 04 October '77 and is summarized; photos of part/all of the Flats were taken in the months of June to August 1949, '51 and '54, and showed that Washington Creek., Tatalina River and Chatanika River (above the confluence with Goldstream Creek) were in no case visibly opaque. There was no placer mine discharge into these streams. Tolovana River and Goldstream Creek were visibly opaque in all photos and could usually be seen depositing silt in adjacent lakes and oxbows. A complication was that the lower 12 miles of the Tolovana River and the southwest part of the Flats around Swanneck Slough were commonly flooded with turbid water from the Tanana River.

Field Trips: Field Trip One was by Dr. Wolff, Dennis Ward, a consultant fisheries biologist, and myself on 27-28 September '77. We drove to Minto Village to arrange for a boat and guide to visit the Flats and to interview Peter John, whose testimony in a lands hearing had sparked the investigation. Guiding arrangements were made with Leo Titus who was familiar with the Flats from the first alleged silt deposition in the late 1920s. Peter John stated that the main mud flow down Goldstream was first evident in 1929 (2-3 years after the start of major operations at Fairbanks). Infilling of lakes was claimed to have reduced the numbers of fish, especially of pike, to have reduced mink and muskrat numbers and to have adversely affected moose. An instance was given of 16 caribou mired and drowned while crossing a lake. Bad weather prevented actual fieldwork and we returned to Fairbanks on 28 September inspecting the Livengood mining area on the way.

Field Trip Two was on 30 September by the same party. We flew the course of Goldstream Creek from Fairbanks and inspected lakes where photos (above) had shown silt deposition. This was still evident, some 15-20 years after the end of major discharges into Goldstream Creek. Effects were only evident in the creek channels, those of the Chatanika River above and below it's confluence with Goldstream and in certain immediately adjacent lakes. The Tolovana presented a broadly similar picture, with continuing silt deposition in some lakes close to Minto Village. We traveled about 10 miles up the Tolovana with Leo Titus, by boat, and were shown a number of lakes, generally with direct connection to the river, in various stages of infilling from moderate shallowing to completely filled marsh/meadow/willow scrub. Another notable feature was the relatively recent death of riparian trees. This was widespread among white cottonwoods, willows and even birches along the whole lowland (Flats) course of the Tolovana; like the lakes infilling, Leo Titus attributed the tree deaths to mining sediments. The area is notably rich in wildfowl (Table One). Mammal sign was also very evident and the impression was that moose, black bear and other carnivores and beaver were regularly present.

Comment: Assuming that much of the sediment had been transported from the mining districts (and the material should be tested to confirm this), then mining sediments were implicated in marked silting of the channels of two streams and of certain nearby lakes. If, as seemed possible, the Flats were drying out extensively, it would be very difficult to assess the role of mining sediments in relation to that of natural successions in flood plain formation or to geological or hydrological changes.

The wildlife changes complained of by Peter John were generally compatible with the general drying up process. In one sense they could be readily examined without much cost. The flats were long known as an important wildfowl breeding area and USFWS carried out censuses of breeding wildfowl over a long period. Theoretically, general drying of the area should have led to both an increase in waterfowl breeding numbers and in the proportion of shallow water 'dabbling' ducks in the total. The data could be examined for this.

Table D-1. Some Birds Seen During Second Minto Flats Field Trip, September 1977.

Species	Indication of Numbers
Trumpeter & Whistling Swans	ca 150
Lesser Canada Goose	ca 600
Mallard	over 1,000
Pintail	some hundreds
Baldpate	few
Greenwing Teal	some tens
Shoveler	very few
Scaup, sp.	few
Bufflehead	1
Bald Eagle	2 (adult pair)
Marsh Hawk	1 ('Ringtail')
Ruffed Grouse	3
Short eared Owl	2
Raven	some tens
Gray Jay	several

Medium and small passerines were not specially noted but late migrants included a part of water pipits and bank swallow; the latter an exceptionally late Alaskan date (Gabrielson & Lincoln, 1959, 'Birds of Alaska').

Appendix E

October 14, 1977, Dennis L. Ward to Ernest N. Wolff

As per your request of October 13, 1977, I am respectfully submitting a brief summary of our progress on the MIRL study.

A field survey was conducted on September 7 and 8, 1977, of the Crooked Creek drainage. During this survey we collected physical, chemical and biological samples from four (4) locations between Central and the confluence of Mastadon and Porcupine creeks. Laboratory analyses have been completed on the majority of samples collected. In summary, the benthic samples contained most genera commonly associated with Interior Alaska streams. Four species of fish were caught including grayling, round whitefish, slimy sculpin, and long nose sucker. Young-of-the-year, one and two year old grayling were caught. The female Cottus was preparing to spawn.

A second survey was conducted of the Minto Flats area on October 2 and 3, 1977. Water samples were collected from selected areas.

Upon completion of analyses a final report will be submitted which will present our findings.

Environmental Services, Ltd., Dennis L. Ward, Associate, Aquatic Biologist.

December 19, 1977, Dennis Ward to Ernest N. Wolff

As per your request I have completed the report which includes data collected on our field investigations of Crooked Creek and Tolovana drainages during the 1977 field season.

Environmental Services, Ltd., Dennis L. Ward, Associate, Aquatic Biology

INTRODUCTORY The Mineral Industry Research Laboratory (MIRL) has received a grant from the U.S. Bureau of Mines to provide a preliminary assessment of effects of placer mining on selected Alaskan environments including the Crooked Creek and Tolovana drainages. As a portion of this program, Environmental Services, Ltd. has been subcontracted to collect a limited amount of baseline data on fisheries within both of the study areas. The fishery surveys consisted of approximately four field days and basic life history information generated from collected specimens. Other data were collected and included benthic macroinvertebrate and water quality samples. The results of this investigation are presented and discussed in the following report.

OBJECTIVES

1. To determine basic fishery distribution within the study area.
2. To assess general benthic invertebrate distribution within the study area.

METHODOLOGY All methods used in this study were standard or approved techniques for collection and laboratory analyses of raw data. All methods used in water quality data colletion and analyses are approved by EPA and are in accordance with Standard Methods for the Examination of Water and Wastewater (14th edition).

Fish

A. Fishery Collection

All fish were collected with a standard 12 foot, 1/4 inch mesh seine. Captured fish were either released alive or kept for detailed laboratory analysis.

B. Laboratory Analysis

Detailed examination of fish samples included determinations of fork length (tip of snout to fork in tail), total weight, sex and maturity. Fish classified as mature were those which would spawn in the coming season or show signs of previous spawning (i.e. retained eggs or irregularly shaped gonads). Fish which would not spawn in the coming spawning season and showed no signs of previous spawning were called immature or juvenile. The condition of mature gonads would be classified as either ripe (sexual products could be expressed by gentle pressure on the abdomen) or green (sexual products could not be expressed by pressure).

Scales and otoliths were taken and used for age determinations. Otoliths were stored in 100 percent glycerine and will be read under a dissecting microscope. Age determinations will be made following similar techniques used by Nordeng (1971). Validation of the first annulus can be made by direct comparison of otoliths from young-of-the-year to otoliths from increasingly larger fish collected in the same study area.

Stomach contents were identified and recorded to Order.

Water Quality

A. Laboratory Analysis

Turbidity values were measured utilizing an EPA approved HF Turbidimeter. Suspended sediments were analyzed by the non-filterable residue technique and reported as mg/l.

Benthic Invertebrates

A. Benthic samples were collected with a 1-square foot surber sampler. Approximately 3 ft^2 were sampled. Samples were not quantified due to the nature of the substrate, and flood water present during the time of sampling. Samples were preserved in 10% formalin solution and transported to the laboratory for analysis.

RESULTS AND DISCUSSION

A. Crooked Creek Drainage

The Crooked Creek drainage had two active mines on it during the 1976 and 1977 season. One of the mines was located on Mastadon Creek and the other on Porcupine Creek (figure 1). Both mines employed settling ponds and both used mechanically loaded sluice boxes. During the field visit of September 7 and 8, 1977, both mines were sluicing intermittently, and both had been operating throughout the summer.

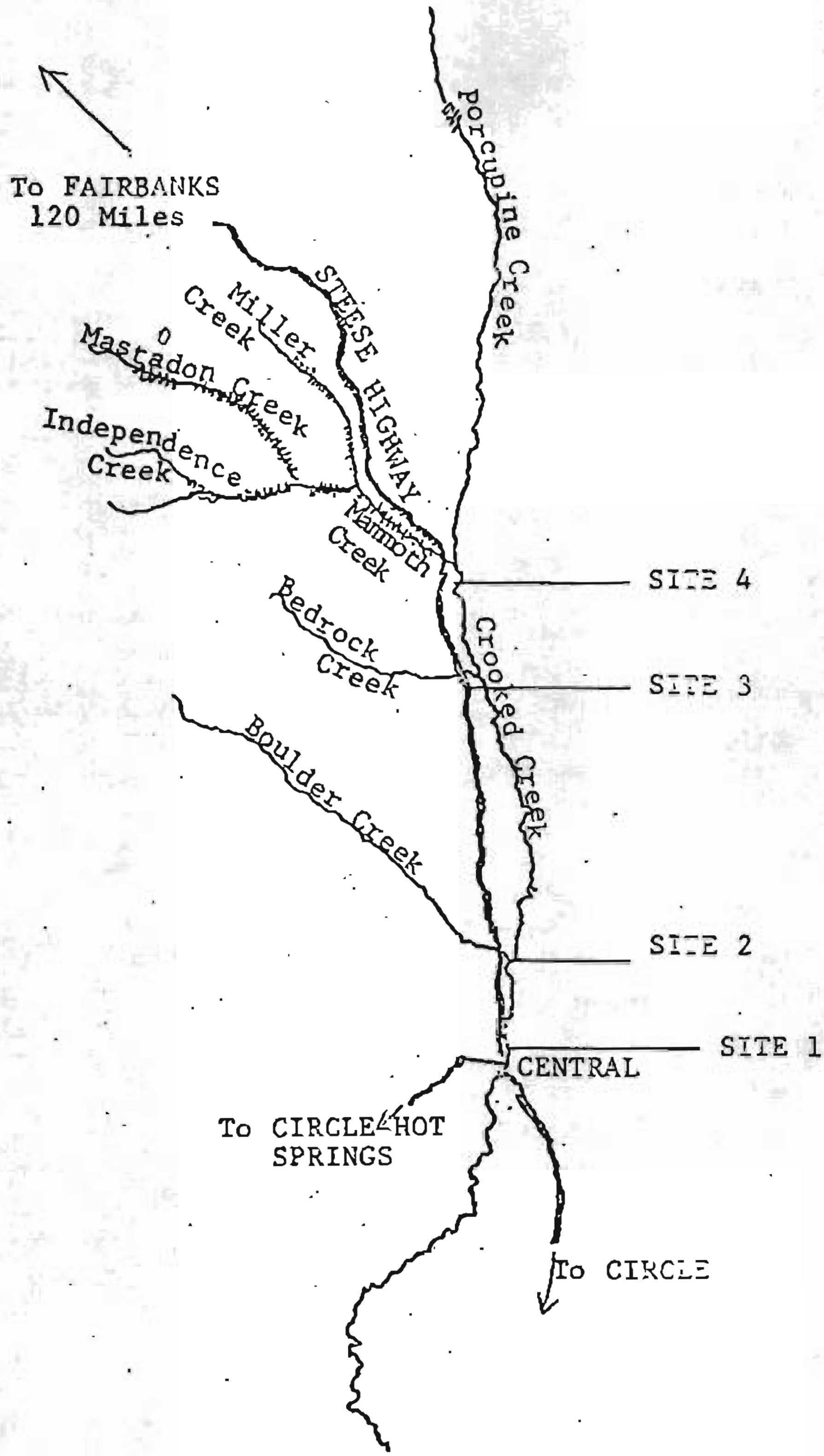
Four sites were sampled during the two day field trip (figure 1). The first was 75 yards above the highway bridge at Central; the second site was on Crooked Creek, 50 yards above the confluence with Boulder Creek; the third was on Crooked Creek, 50 yards above the confluence with Bedrock Creek; and the fourth was 200 yards below the Mammoth Creek Bridge. Data collected at all four sites included suspended solids, turbidity, benthic invertebrates, and fish.

Turbidity and suspended solids were as low as 30 NTU and 14 mg/l respectively at the downstream most sites (stations 1 and 2), and as high as 45 NTU and 207 mg/l at the upstream sites (Table 1). Mud and silt deposits were not present at sites 1 and 2 but were observed at sites 3 and 4.

Preliminary examination of benthic samples indicate, generally, that six orders of insects were present at each site during the sampling period (Table 2). These orders included Trichoptera, Ephemeroptera, Plecoptera, Amphipoda, Arachnida, and Diptera. Exceptions to this were the absence of Trichopterans in station #2 sample, and the absence of Plecopterans in the station #3 sample. Exuviae were found at all stations but were most abundant at stations 1 and 3.

Four species of fish were caught by seine in the study area and including grayling (Thymallus arcticus), long nose sucker (Catostomus catostomus), slimy sculpin (Cottus cognatus), and round

Plate E-1: Location of Sampling Sites During the September 7-8, 1977, Field Trip, Crooked Creek, Alaska.



Scale 1:250,000

1" = 4 Miles

whitefish (Prosopium cylindraceum) (Table 1). Grayling were caught at all four stations, long nose sucker and slimy sculpin at station 1 and round whitefish were captured at station 4.

Juvenile grayling were found at stations 1 and 2 whereas numerous fry were found at all four stations. The presence and abundance of fry throughout the drainage, and especially in the upper reaches, supports that grayling successfully spawned in Crooked Creek during the 1977 spawning season. The female cottus was green and preparing to spawn in the coming season. The round whitefish was also greening up for the fall spawning season. Scales and otoliths were collected from all laboratory samples for future aging.

Nine fish stomachs were examined and found to be 20-90% full. Stomach contents were identified and included Plecopteran (Perlodidae) and parts, Coleopterans, Trichopterans, Tipulid and Chironomid larvae, Empididae, and Amphipods (Table 3). Most of these were probably ingested by sight feeding. Although one of the juvenile grayling had injested small particles of sand (1-3mm), the other stomachs examined contained no visible sand or gravel particles. None of the fish were heavily parasitized.

B. Tolovana Drainage

Data collected on the Tolovana drainage will not be analyzed until further field investigations are conducted in the Spring of 1978.

TABLE E-1: Water Quality and Fish Data Collected from Crooked Creek, Alaska, September 7-8, 1977

Water Quality Parameters	9/7/77 Station 1	9/7/77 Station 2	9/8/77 Station 3	9/8/77 Station 4
Turbidity, NTU	35	30	40	45
Suspended Solids, mg/1	17	14	128	207
Fish Species				
Grayling				
Fry (less than 1 year)	X	X	X	X
Juvenile (1 year +)	X		X	
Slimy Sculpin	X			
Long Nose Sucker	X			
Round Whitefish				X

TABLE E-2: Benthic Invertebrates Collected in 3 ft^2 with a Surber Sampler, Crooked Creek Alaska, September 7-8, 1977. Samples not quantified.

Organisms	Station 1	Station 2	Station 3	Station 4
Trichoptera			X	
Larva	X			
With Cases			X	
Ephemeroptera				
Heptageniidae				X
Siphlonuridae				X
Baetidae				X
Exuviae				
Ephemerellidae (*Ephemerella*)	X			
Other	X	X	X	
Plecoptera				
Periodidae				
Nemouridae				X
Exuviae				
Periodidae	X			
Other	X		X	X
Amphipoda	X		X	X
Arachnida				
Hydracarina	X	X	X	X
Diptera				
Adult	X	X	X	
Chironomidae				
Pupae	X	X	X	X
Exuviae		X	X	
Larvae	X		X	
Exuviae		X		
Pupae	X			
Empididae	X			X
Exuviae		X		
Homoptera				
Exuviae				X

TABLE E-3: Food Items Identified from Fish Stomachs from Crooked Creek, Alaska, September 7-8, 1977.

Composite Samples

Plecoptera, Periodidae and Parts	Coleoptera Parts
Trichoptera, Head, 2 Cases, 1 Partial Case	Tipulidae Larvae
Empididae Larvae	Chironomidae Larvae
Middle Part of Eyeball from Fish	Amphipoda