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HYDROLOGIC AND WATER QUALITY INVESTIGATION OF THE GOLD RUN PASS AREA NEAR HEALY, ALASKA

By

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INTRODUCTION

This report describes the hydrology and water quality of the streams and groundwater associated with the Gold Run Pass area of the Hoseanna Basin. Coal mining has continued off and on in the area for the past twenty years. It is this activity which has compelled the Division of Water to undertake this study. This report will compare data collected for this study to previous studies conducted in the area by the Alaska Division of Geological and Geophysical Surveys and by the US Geological Survey.

Location

Hoseanna Creek Basin is located in the Nenana Coal Field (Merritt and Hawley, 1986) on the north flank of the Alaska Range. Hoseanna Creek flows east to west into the Nenana River approximately five miles north of the old Healy townsite. Gold Run Pass, located 11 miles northeast of Healy, separates the middle Healy and upper Hoseanna basins (see Figure 1). The Hoseanna side of Gold Run Pass is drained by Sanderson Creek on the east and north, Hoseanna Creek on the west, and Clinker Creek on the south and west. Elevations in the study area range from 3,300 feet at the headwaters of Clinker Creek east of the pass, to 2,500 feet at the pass, and 1,870 feet at the confluence of Clinker and Hoseanna creeks.

Geology

The Hoseanna Creek Basin is underlain by the highly-deformed Precambrian quartz-sericite Birch Creek Schist (Wahrhaftig, 1970). The schist is overlain by the mid-Tertiary Usibelli Group (Wahrhaftig, 1987), which is comprised of weakly consolidated sand, silt, clay and coal sequences. The late Tertiary Nenena Gravel tops the Usibelli Group (Wahrhaftig, 1987). This formation is composed of large cross-bedded coarse-grained sands and thick gravel sediments (Wilbur, 1989).

Both the Birch Creek Schist and the Usibelli Group are found in the Gold Run Pass area. The Birch Creek Schist is exposed in the southern portion of the area, while the Usibelli Group is exposed in the northern portion. Because of the north facing aspect of the schist terrain, much of the soils covering it are permafrost-rich and susceptible to solifluction, frost heaving and frost scarring (Wilbur, 1989). The Usibelli

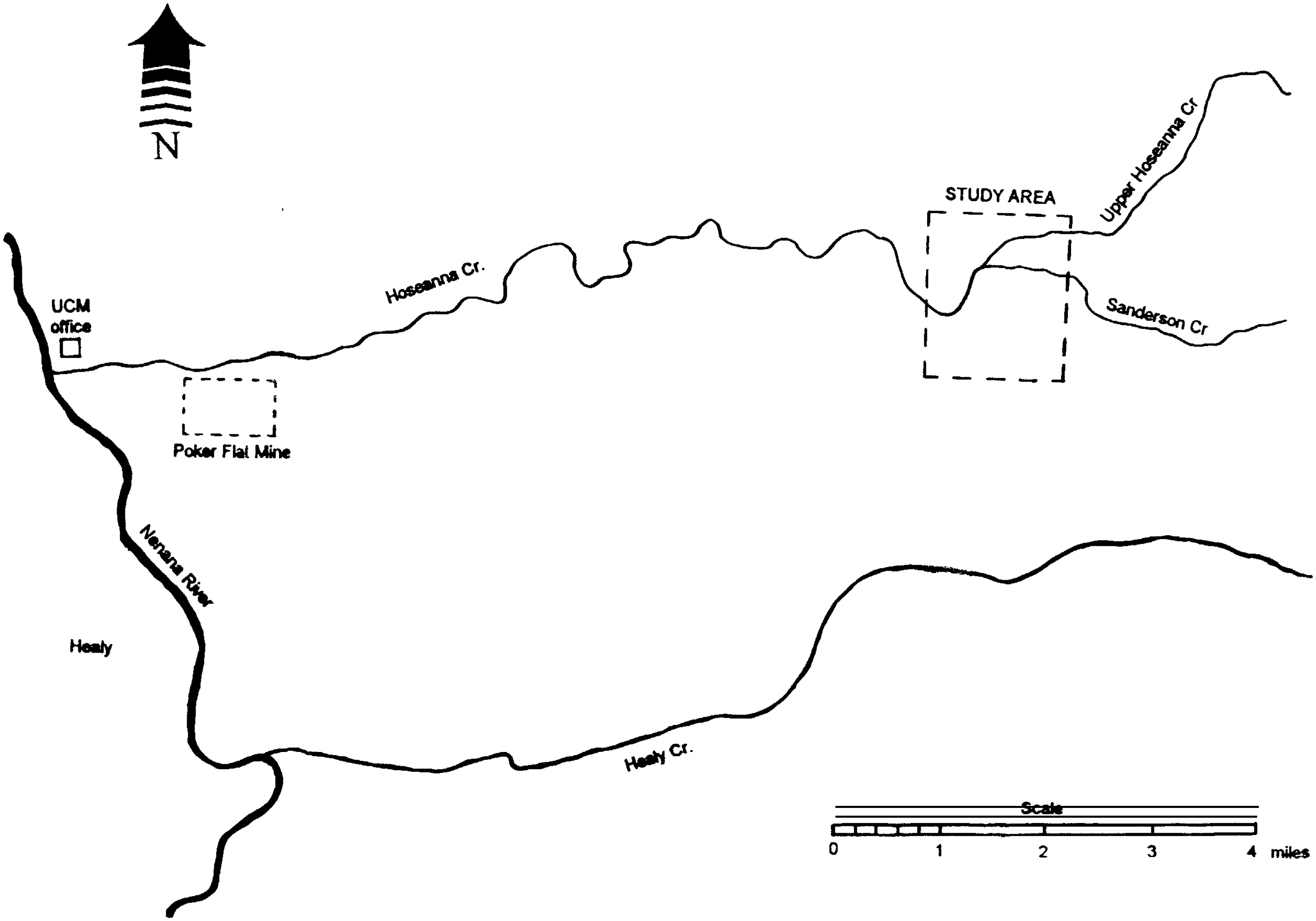

Figure 1. Map showing location of the Gold Run Pass study area.

Group is characterized by active landslides, soil creep and badlands topography (Wilbur and Beget, 1988). Two landslides in the study area are located to the east and to the west of the mine pit. Wilbur and Renshaw (1987) estimated average horizontal displacement of slides in the valley ranging from 2 to 75 feet per year.

Climate

Typical interior Alaskan summers are characterized as short and warm with average highs in July in the low 70s °F and lows in the lower 50s °F. Winters are long and cold with average January temperatures ranging from -20 °F to 0 °F. Precipitation generally falls as snow from October through April. Summer precipitation generally occurs as light showers with occasional heavier convective showers. The largest precipitation events are the result of large cyclonic storms from the Gulf of Alaska or Bering Sea. These moisture-laden storms are accompanied by low-level west-southwesterly winds which are capable of dropping more than two inches in 24 hours (Ray, 1990).

Mining History

Coal mining in the region began in the 1920's in the Healy Creek basin. During the early years, underground methods were used, but the use of these methods ceased by 1963. Surface mining methods have been used exclusively since.

Mining in the Hoseanna Creek basin began in the mid 1950's at Lignite near Louise Creek. Mining moved up the basin with the discovery of the Gold Run Pass reserves in the early 1970's. Mining continued in the Gold Run Pass pit until the late 1970's when the Poker Flat mine began operation. Mining began again in 1988 (on a small scale) when the newly completed road up the Hoseanna valley provided easy access to the pit. The current pit is near the end of operation. A new mine is proposed west of the present pit.

METHODS

Sampling Sites

Data was collected at seven surface water sampling sites during the summer of 199 1 and three wells were sampled in the fall of 1991. Table 1 summarizes the surface water sampling sites and Figure 2 (page 36) shows the sampling site locations. Previous types of data collected in the area are also summarized in Table 1. These data were reported by the following: Ray and Maurer (1989), Wilbur (1989), Mack (1988), Parks (1983), and Scully et al. (1981).

Table 1. Surface water sites used in this study, the year the sites were sampled, and the type of data collected. Map number refers to the site number on Figure 2 (page 36).

Map Number	Location	Year	Discharge	Continuous Discharge	Sediment	Chemistry
1	**Sanderson Creek**	1991	*Y*	*N*	Y	Y
	1.6 miles above	1988	*Y*	*Y*	Y	N
	Hoseanna Creek	1987	*Y*	*Y*	Y	N
	basin area = 4.7 mi^2	1981	*Y*	*N*	Y	Y
2	**Sanderson Creek**	1981	*Y*	*N*	*Y*	*Y*
	0.8 miles above	1980	*Y*	*N*	*Y*	*Y*
	Hoseanna Creek					
	basin area = 5.1 mi^2					
3	**Sanderson Creek**	1991	*Y*	*N*	*Y*	*Y*
	above Hoseanna Creek	1988	*Y*	*N*	*Y*	*N*
	basin area = 5.3 mi^2	1987	*Y*	*N*	*Y*	*N*
		1986	*Y*	*N*	*Y*	*N*
4	**Hoseanna Creek**	1991	*Y*	*N*	*Y*	*Y*
	above Sanderson Creek	1988	*Y*	*N*	*Y*	*N*
	basin area = 8.6 mi^2	1987	*Y*	*N*	*Y*	*N*
		1986	*Y*	*N*	*Y*	*N*
		1978	*Y*	*N*	*Y*	*Y*
		1977	*Y*	*N*	*Y*	*Y*
5	**Hoseanna Creek**	1991	*N*	*N*	*Y*	*N*
	below Sanderson Creek	1978	*Y*	*N*	*Y*	*Y*
	basin area = 14.1 mi^2	1977	*Y*	*N*	*Y*	*Y*
6	**Clinker Creek**	1991	*Y*	*Y*	*Y*	*Y*
	above Hoseanna Creek	1988	*Y*	*N*	*Y*	*N*
	basin area = 1.7 mi^2	1987	*Y*	*N*	*Y*	*N*
		1986	*Y*	*N*	*Y*	*N*

Table I (cont). Surface water sites used in this study, the year the sites were sampled, and the type of data collected. Map number refers to the site number on Figure 2 (page 36).

Map Number	Location	Year	Discharge	Continuous Discharge	Sediment	Chemistry
7	**North Clinker Creek** above Clinker Creek basin area = 0.08 mi^2	1991	Y	N	Y	Y
8	**East seep**	**1991**	**Y**	**N**	**Y**	**Y**
9	**West seep**	**1991**	**Y**	**N**	**Y**	**Y**

Three groundwater monitoring wells were installed at Gold Run Pass and sampled in 1991. The sites names (and Figure 2 labels) are as follows: **91GA-1 (#10), 91GA-3 (#1 1),** and **91GA-5 (#12).**

Sampling Procedures

Precipitation

Precipitation data were collected at Gold Run Pass using a barrel-type gage with a Wyoming shield. The gage is located at an elevation of 2,490 feet (Figure 2). The gage uses an electronic data storage unit which takes a rending every 30 minutes. The resolution of the gage is 0.01 feet (0.12 inches).

Discharge

Stream velocities used in the discharge calculations were measured with a standard pygmy meter. Velocities were measured at six-tenths depth, with sufficient numbers of sections such that no one section contained over ten percent of the flow. Discharge was calculated using the standard midpoint method (USDI, 1981).

Discharge at Clinker Creek was determined with a nine inch Parshall flume, using the rating curves supplied with the flume. The discharge from the flume was also field checked to ensure the accuracy of the calibration. Continuous stage levels were recorded at the upper Sanderson Creek site in 1987 and 1988 and at

Clinker Creek in 1991 using Omnidata DP320 stream gage recorders with pressure transducers. The recorder is capable of measuring water depths up to ten feet in intervals of 0.01 feet.

Discharge rating curves were developed for the Sanderson Creek site using the stage-discharge data. High flow events which were not directly measured were estimated using the indirect slope-area method (Dalrymple and Benson, 1984).

On streams with insufficient flow to measure with the pygmy meter, the flow was channelled into a six-foot long, four-inch diameter PVC pipe. A suitable location was chosen such that a five gallon bucket could catch the discharge from the pipe. After the stream had reached equilibrium with the pipe, the time it took to fill the bucket was recorded. The average of five such measurements was reported (in gallons per minute).

Water Quality

Surface Water

Surface water samples for water-quality analysis were obtained using a hand-held depth-integrating sediment sampler and a churn splitter (USDI, 1977). Samples collected from the churn splitter were processed according to each parameter in compliance with approved methods (USEPA, 1982). Filtering was done with 0.45 micron membrane filters. Acidification was done with Ultrex-grade nitric acid.

Water temperature and dissolved oxygen were measured in situ using portable meters. Conductivity and pH were measured on the composited sample. Alkalinity was measured electometrically on the composited sampled with the pH meter and digital titrator, using the gran-plot method (Martin, 1972).

Automated sediment samplers were installed at the sites with contiuous discharge measuring equipment. The sediment samplers were activated by high water levels during storm events. The samplers would then sample every hour until the sampler was full (24 samples). These samples were analyzed for total suspended solids and turbidity.

Groundwater

Prior to pumping the wells, water levels were measured using an electric water-level indicator and the volume of water in the casing calculated. Wells were purged using a QED "Purge Master" pump. Water temperature, **pH,** and conductivity were measured at regular intervals during the well purging. After at least three well casing volumes were purged from the well, the pumping stopped when the conductivity fluctuated less than ten percent. The pump was removed from the well, and samples were collected using Teflon bailers. Water was bailed and collected in the churn splitter until **sufficient** water was obtained for all the analyses. Parameters and sample preparation were the same as for the surface water. The pump was cleaned prior to purging the next well.

Laboratory Analysis

Water quality analyses for surface and ground waters were conducted in the Alaska Division of Water's Water-Quality Laboratory on the University of Alaska Fairbanks campus. The laboratory is a participant in the **USEPA** Performance Evaluation program as well as the USGS Standard Reference Water Sample Quality Assurance program. Analytical methods and detection limits are outlined in Table 2. For all parameters, calibrations were performed using NBS traceable standards where applicable. General data reduction procedures are described in Standard Methods (APHA, 1989).

Table 2. Analytical methods and detection limits for parameter determined in this study.

Parameter	EPA Method	Detection Limit
Alkalinity	310.1	0.1 mg/L as CaC03
Ahnninum	AES 0029	0.005 mg/L
Arsenic	206.2	0.001 mg/L
Barium	AES 0029	0.005 mg/L
Boron	AES 0029	0.01 mg/L
Cadmium	213.2	0.001 mg/L
Calcium	AES 0029	0.01 mg/L
Chloride	300.0	0.01 mg/L
chromium	218.2	0.001 mg/L

Table 2 (cont). Analytical methods and detection limits for parameter determined in this study.

Parameter	EPA Method	Detection Limit
Cobalt	AES 0029	0.01 mg/L
Conductivity	120.1	0.1 uS/cm
Copper	220.2	0.001 mg/L
Dissolved Oxygen	360.1	0.1 mg/L
Fluoride	300.0	0.01 mg/L
Iron	AES 0029	0.03 mg/L
Lead	239.2	0.001 mg/L
Magnesium	AES 0029	0.01 mg/L
Manganese	AES 0029	0.005 mg/L
Molybdenum	AES 0029	0.01 mg/L
Nickel	AES 0029	0.01 mg/L
Nitrate	300.0	0.02 mg/L as N
pI-I	150.1	0.01 unit
Phosphate	300.0	0.1 mg/L as P
Potassium	258.1	0.01 mg/L
Silicon	AES 0029	0.01 mg/L
Sodium	273.1	0.1 mg/L
Sulfate	300.0	0.01 mg/L
Total Suspended Solids	160.2	0.1 mg/L
Turbidity	180.1	0.1 NTU
Zinc	AES 0029	0.005 mg/L

HYDROLOGY

Precipitation

The precipitation gage at Gold Run Pass has been opreated by the Division of Water (formerly the Water Section of the Division of Geological and Geophysical Surveys) since 1987. The data from this gage is summarized in Table 3. The summer season totals range from 17 inches in 1988 to less than 8 inches in 199 1. The average precipitation total at the Poker Flat Mine (seven miles to the west of Gold Run Pass) for the period of May through September 1979-89 was 12.44 inches (Wilbur, 1989). The average May through September precipitation at the Poker Flat mine gage (1987-91) was 10.48 inches. This compares to the average for the Gold Run Pass gage (1987-9 1) of 13.11 inches (Table 3). Ray (199 1) attributes this difference in the precipitation amounts to the orographic effects of the upper basin.

Table 3. Monthly precipitation for Gold Run Pass. Ail values in inches.

Year	MAY	JUN	JUL	AUG	SEP	Total
1987	0.12	1.08	2.52	3.24	4.32	11.28
1988	2.16	5.88	4.92	2.52	1.56	17.04
1989	0.96	6.20	1.32	4.92	0.84	14.24
1990	0.96	0.96	4.44	4.92	4.08	15.36
1991	0.36	1.44	3.00	2.16	0.72	7.68
Average	**0.91**	**3.11**	**3.24**	**3.55**	**2.30**	**13.11**

Surface Water

Continuous discharge data was collected in the Gold Run Pass area at two sites. Flow was recorded at Sander-son Creek (1.6 miles above **Hoseanna** Creek) from June to October 1987 **(Mack,** 1988) and from May through September 1988 (Ray and Maurer, 1989). Flow was also recorded at Clinker Creek above **Hoseanna** Creek from May to October 199 1. The hydrographs of the streams are shown in Figures 3-5, with the average monthly and season discharge given in Table 4. The monthly averages are based on the amount of data available. For example, the May 1988 average for Sanderson Creek is based on five days of data.

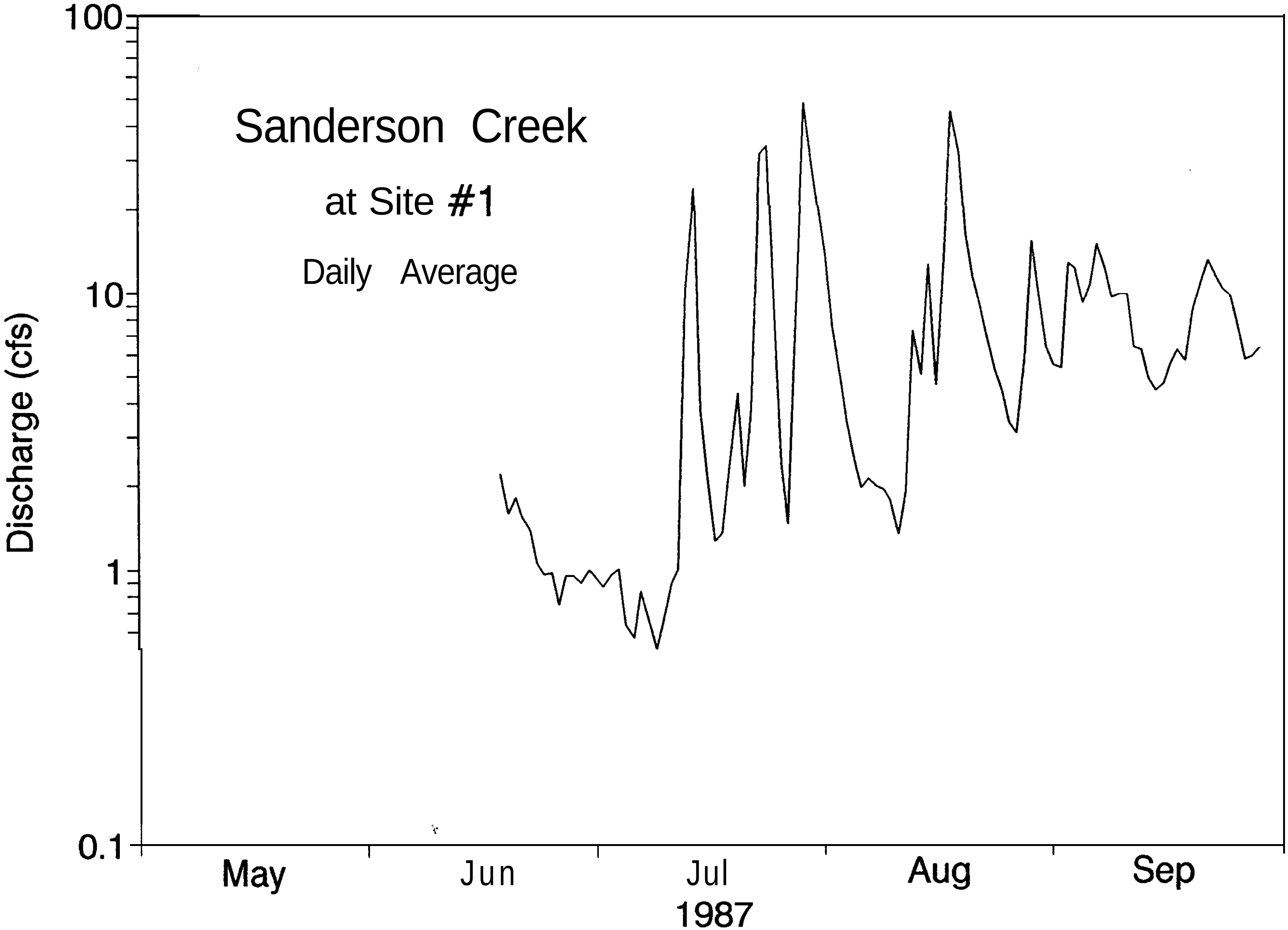

Figure 3. Hydrograph of Sanderson Creek at site #1, 1987.

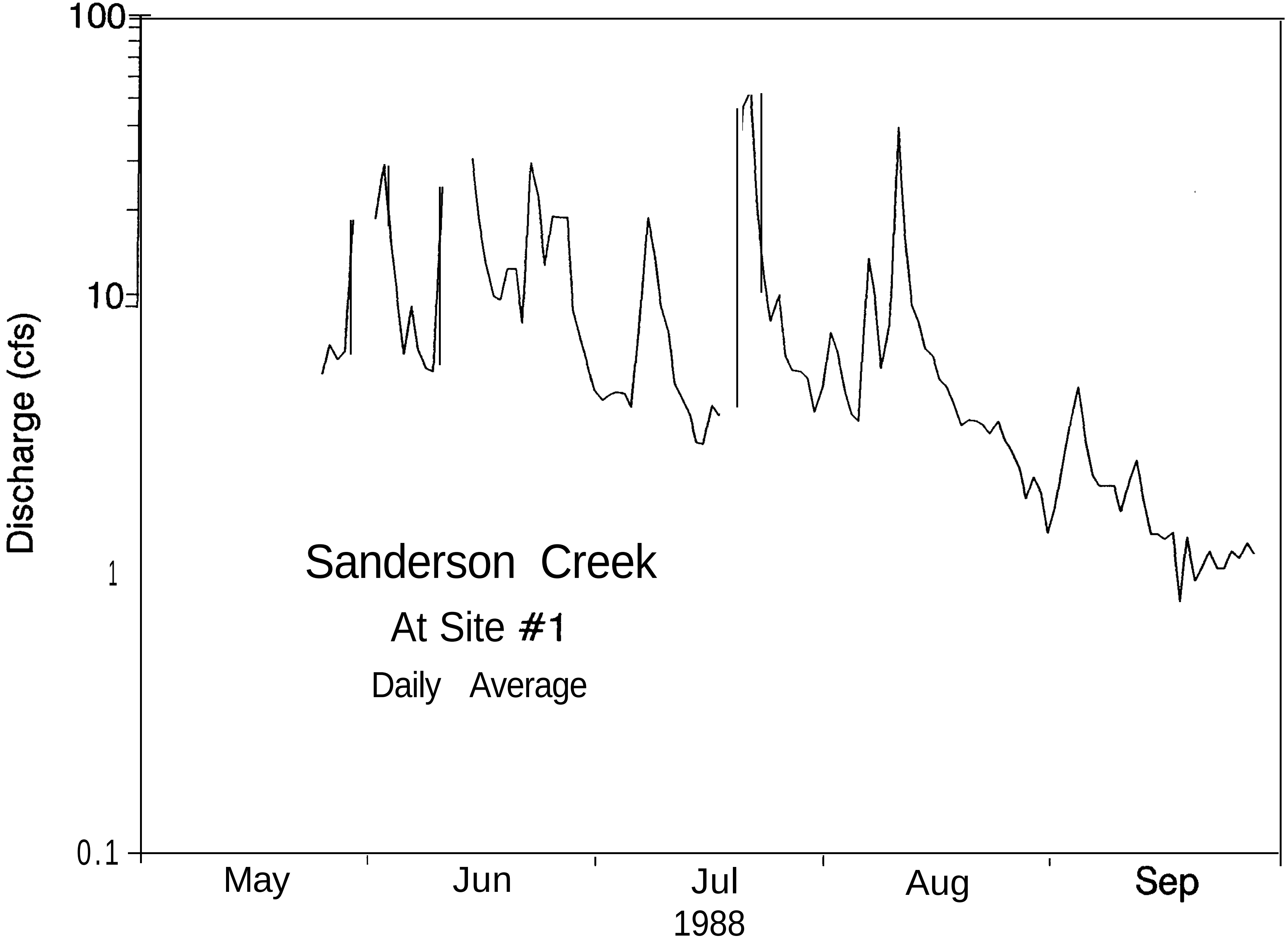

Figure 4. Hydrograph of Sanderson Creek at site #1, 1988

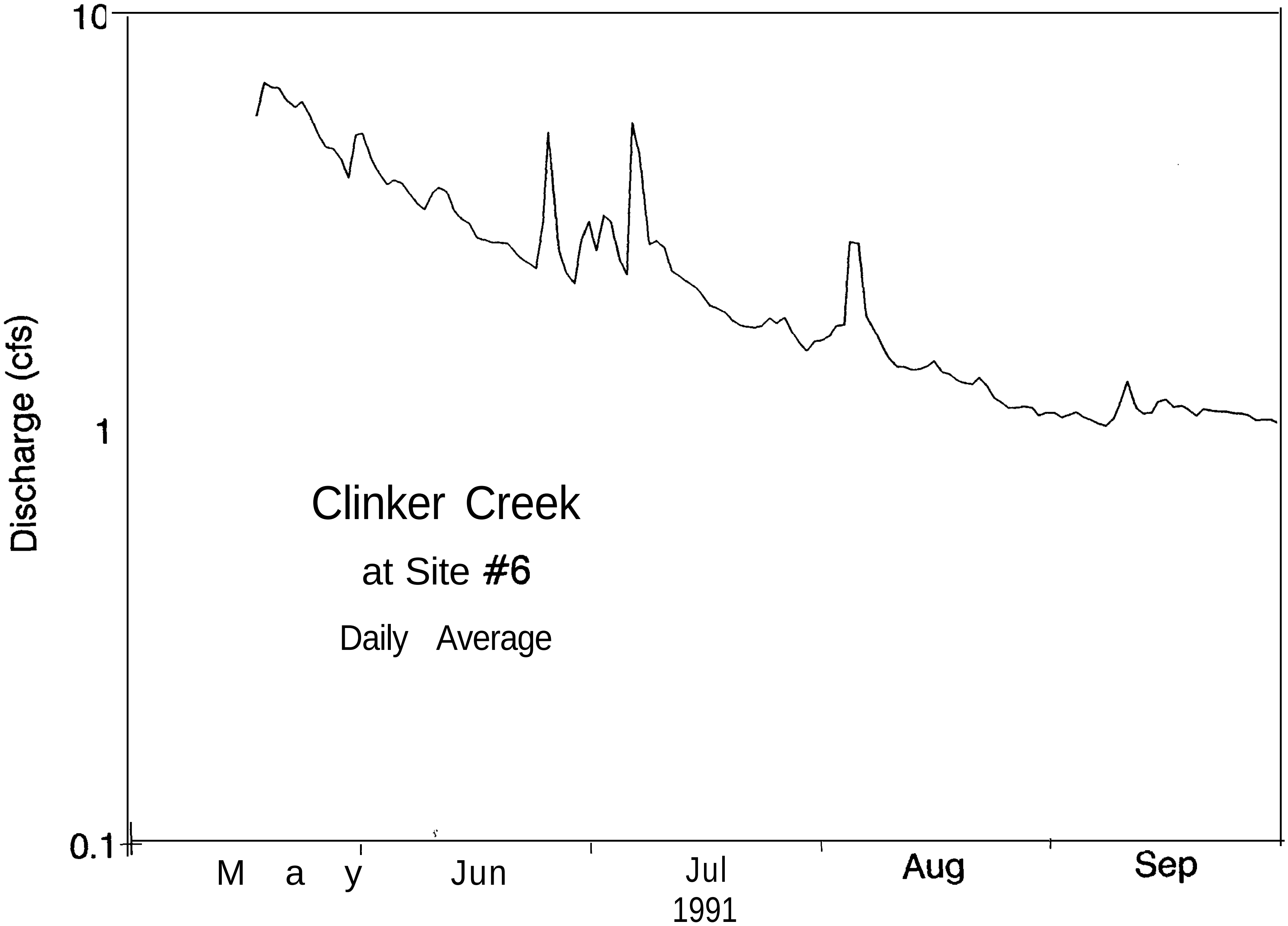

Figure 5. Hydrograph of Clinker Creek (site #6) above Hoseanna Creek, 1991.

Table 4. Monthly and season discharge for Sanderson and Clinker creeks. All discharge values in cfs.

	MAY	JUN	JUL	AUG	SEP	Average
Sanderson Cr						
1987	----	1.27	7.44	8.84	8.39	6.98
1988	8.42	14.8	10.3	6.75	1.87	8.23
Clinker Cr						
1991	5.61	3.39	2.35	1.43	1.03	2.39

The hydrographs should provide enough information as to the amount of data used in the monthly averages. The season average is an average of all the data, not an average on the monthly data.

Peak flow at Sanderson Creek above mining (site **#1)** during the study period was 225 cfs in 1988 (Ray and Maurer, 1989). The peak flow at Clinker Creek (site **#6)** during the study period was 12.3 cfs in 1991.

The flow in Sanderson Creek is closely represented by the monthly precipitation at Gold Run Pass. In May and June of 1987, only 1.20 inches of rain fell at Gold **Run** Pass. Although no discharge measurements were made in May, the late **June** flows at Sanderson Creek were less than one cfs. However, the precipitation increased each month from July through September, as did the discharge at Sanderson Creek. In 1988, about 13 inches of rain fell in May, June and July. The average flow for this period was over ten cfs at Sanderson Creek. Less rain fell in August and even less in September, resulting in a slow regression of the baseflow. The average flow in September was under two **cfs**. In 1991, the stream flow at Clinker Creek is not representative of the precipitation which fell early in the **summer** (only 0.36 inches in May). The high **baseflow** discharge early in the summer was due to an usually heavy snowpack (many places in the interior set all-time snowfall records). The heavy snowpack recharged the aquifer, which slowly discharged to the streams. Storms during July and August slowed the **baseflow** recession, but flows still dropped below one cfs during September.

The total runoff per unit area (inches) for July, August and September for Sanderson Creek **(1987),** Sanderson Creek **(1988),** and Clinker **Creek** (1991) are 6.0 inches, 4.6 inches, and 3.2 inches, respectively. The ratio of runoff to precipitation for the sites is **0.59, 0.71,** and 0.55, respectively. This means that during the period of July though September, 55 to 7 1 percent of the precipitation which fell in these basins ran off as stream flow. Both these basins are underlain by the Birch Creek Schist, with permafrost soils and a thin active layer with low infiltration capacity (Wilbur, 1989). As a result, the response of the creeks to storms tends to be rapid, with most of the water running off. In contrast, Two Bull Creek (seven miles to the west) is underlain by the Nenana Gravels and the Usibelli Group. In 1990 the **runoff** to precipitation ratio was 0.08. Only eight percent of the July through September precipitation ran off. This indicates a large groundwater storage capacity for that type of terrain.

Miscellaneous discharge measurements were made at the remaining surface water sites. These data are found in the appendices with the chemistry and sediment data. There are two measurements of note. In 199 1, measurements were made on Sanderson Creek during dry, **baseflow** runoff conditions. The flow at site **#1** (upstream) was 4.07 cfs. A few hours later, the flow at site **#3** (downstream) was 3.67 cfs. Based on the flow per square mile of the upstream site, the predicted flow at the lower site was 4.7 cfs. The flows could have been the same, with the variation in the flow data between the sites due to the error associated with each flow measurement. However, it appears that the downstream site was not greater than the upstream site or near the expected flow of 4.7 cfs.

Groundwater

The two formations which occur in the Gold Run Pass area are the Birch Creek Schist and the Usibelli Group. No information is available from the area on the schist aquifer. In general, highly metamorphosed crystalline rock has little, if any, primary porosity. In order for groundwater to occur, the metamorphosed crystalline rock must have secondary porosity resulting from fractures and faults (Petter, 1988). In the Fairbanks area, the groundwater aquifer in the hills is the Birch Creek Schist. The schist controls the nature of the aquifer through structural control of the groundwater movement. In particular, the spatial distribution of structural features such as fractures and joints which control the aquifer characteristics are anisotropic and heterogeneous. The geologic system produces high spatial variability of hydrologic variables over relatively short distances (Weber, 1987). Domestic wells in the aquifer are generally 100 to 200 feet deep, although a few may range up to 500 feet (Pewe, 1982). Sustained yields are typically less than 10 gpm, although a well finished in a large fracture system on Ester Dome yields 300 gpm (Walther, 1987).

The Usibelli Group in the Gold Run Pass area is composed of layers of sandstone, siltstone, clay, and coal. Of particular interest to the study, are two mineable coal seams: the Caribou seam and the Moose seam. These seams are located in the northwest portion of Gold Run Pass. The uppermost seam is the Caribou seam. The seam ranges in thickness from 10 to 16 feet, strikes east-west and dips to the north from 3 to 18 degrees (UCM, personal communication). Depth to the top of the seam ranges from 5 feet in the west to 130 feet in the east. The Moose seam is the lowest coal seam of interest in the area. With thickness ranging from 13 to 30 feet, it also strikes east-west and dips to the north from 3 to 18 degrees. Maximum known interburden depths are 59 feet (UCM, personal communication).

In preparation for future mining, three monitoring wells and eight piezometers were installed by Usibelli Coal Mine in the coal seams to evaluate the aquifers associated with the Usibelli Group. Coal is commonly an aquifer, with secondary porosity developed by the bedding planes and cleats (Fetter, 1988). Throughout the Hoseanna Creek Basin, the coal seams tend to be the aquifers with the overlying siltstones acting as aquitards, and the underlying clays acting as aquicludes (UCM, personal communication).

The Caribou seam is generally dry, except in well 91GA-5. The well log (Golder Associates, 1991) reports the seam became wet near the bottom. Since the underlying layer is clay, any water which has “leaked” into the coal seam might form a perched aquifer. However, this was not seen in the other logs and does not appear laterally extensive. Some of the other minor coal seams exhibit similar characteristics.

The Moose seam is the major aquifer of concern in the Gold Run Pass area. The aquifer has both confined and unconfined areas, with the siltstone interburden acting as the confining layer. The source of the water in the aquifer is the north-south trending faults which border the Moose seam (UCM, personal communication). The hydraulic gradient is approximately 14 feet per 100 feet. This is considerably higher than the 3 feet per 100 feet in the seams at the Poker Flat Mine. If one assumes the same flow per unit area through the seams (similar recharge) then the hydraulic conductivity would be about five time higher at the

Poker Flat Mine. This concurs with the field observations by the Alaska Division of Water when the wells were sampled. Well **91GA-1** (site **#10)** did yield a constant rate of approximately 13 gph, however the other two wells (9 **1GA-3** and 9 **1GA-5)** were much less (less than one gph). Once the well casings of these two wells were evacuated, these wells yielded little water. The depth to water in well 9 1 GA- 1 did recover quicker than the other wells. Four days after sampling, the depth to water was within one foot of the pre-sampling water level. Well **91GA-3** (site **#1** 1) did not recover as **fast,** and was **within** three feet of the pre-sampling level three days after sampling, Well **91GA-5** (site **#12)** was the worst, only recovering 70 percent (13 feet **below** the **pre-**sampling depth) after three days. It was still four feet below the pre-sampling level after nine days. A contributing factor of **the** slow recovery times was the well development (a considerable amount of sediment was pumped from all the wells). It is possible that the recovery was inhibited by the sediments in wells 9 **1GA-**3 and **91GA-5.**

WATER QUALITY

Surface Water

Sediment

Automatic sediment samplers were installed at Sanderson Creek (site **#1)** in 1987 and 1988, and at Clinker Creek (site **#6)** in 199 **1.** These samplers collected sediment data with the continuous discharge recorders. Grab samples were collected at the other sites for the sediment data. The samples were analyzed for total suspended sediment and turbidity. Using the sediment and discharge data, it is possible to develop sediment rating curves for **the** two sites. Figures 6 and 7 show the two rating curves developed for the sites using the sediment data collected. Table 5 summari zes the regression line coefficients and statistical-fit data.

Figure 6 plots the data collected (1986 through 1988) and the statistical regression line at Sanderson Creek (site **#1)** (Pay, 1990). Also plotted on Figure 6 is the statistical regression line for the data collected at Sanderson Creek (site **#3)** above **Hoseanna** Creek (Wilbur, 1989). Comparing the two regression lines shows that the upper site **(#1)** has much less sediment at low flows than the lower site **(#3).** Upper Sanderson Creek is underlain by the Birch Creek Schist, and has a limited supply of sediment available for transport at low flows. However, between the two sites the Usibelli Group is exposed. There are two landslides in this terrain which slump into Sanderson Creek, supplying ample sediment for transport, even at low flows. At high flows, the regression lines merge, indicating that a limited amount of sediment may be available from both terrains.

Table 5. ***Coefficients, r^2 value, and number of samples used (n) for the sediment rating equations for Sanderson and Clinker creeks. The equations are of the form: $TSS = aQ^b$.***

Site	a	b	[redacted]	
Sanderson Creek (site #1)				
1987	1.93	1.88	0.73	63
1988	**2.39**	**1.97**	**0.86**	**108**
1986-1988	2.25	**1.93**	0.80	173
Sanderson Creek (site #3)				
1986-1988	417	0.74	0.80	15
Clinker Creek (site #6)				
1991	14.6	2.16	0.65	112

Figure 7 shows the data collected from Clinker Creek and the statistical regression line. The regression line for Clinker Creek is similar to the regression line developed for Sanderson Creek site **#1**. The slope of the two lines are 2.16 and 1.93, respectively. The slope of the line for Sanderson Creek site **#3** is 0.74. The equality of the slope of the two lines indicates that the two basins respond similarly with respect to sediment. Since both basins are underlain by schist, and both are hydrologically similar, it is not surprising that the stream-sediment characteristics are similar.

Calculated sediment loads for the three sites are given in Table 6. The loads for Sanderson Creek at site **#1** and Clinker Creek (site **#6**) were calculated using the data collected from the automated sediment sampler and the average daily flow. When data from the automated equipment was not available, the predicted sediment value (based on the discharge) from the regression line was used. The load at Sander-son Creek at site **#3** was estimated using the regression line developed by Wilbur (1989) and using the flow data from site **#1** on Sanderson Creek. The load on Sanderson Creek is two to three times higher at site **#3** than at site **#1**. The load at Clinker Creek is much less since the basin is smaller, schist-underlain, and because of the

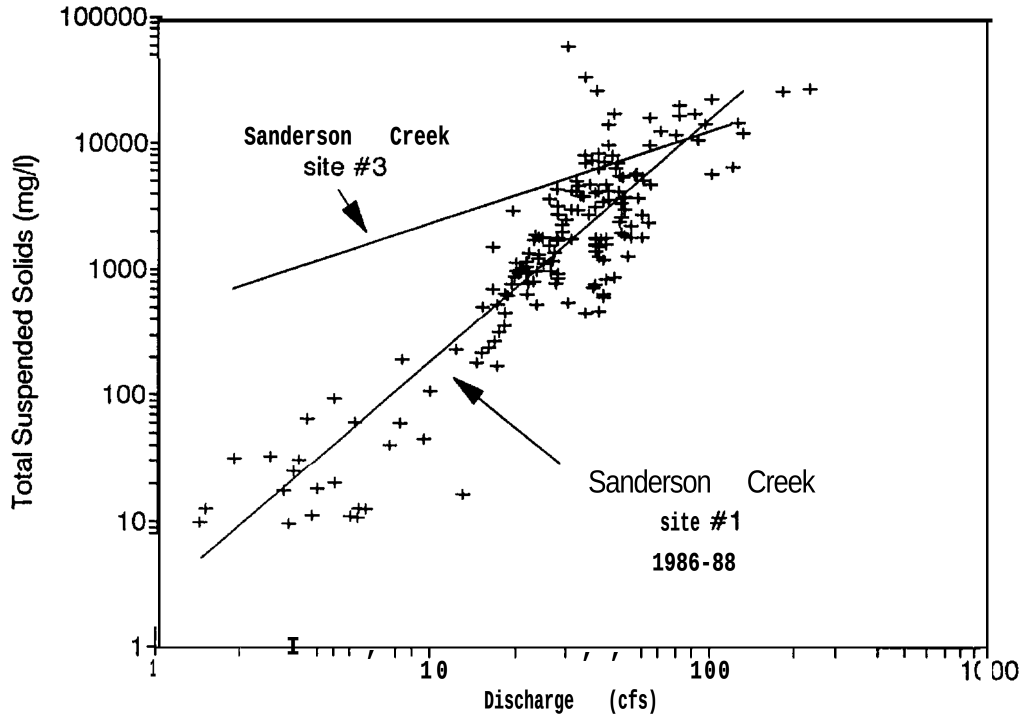

Figure 6. TSS versus discharge For Sanderson Creek (1986-88). Plotted data is from site #1. Regression lines from site #I and site #3 (see text).

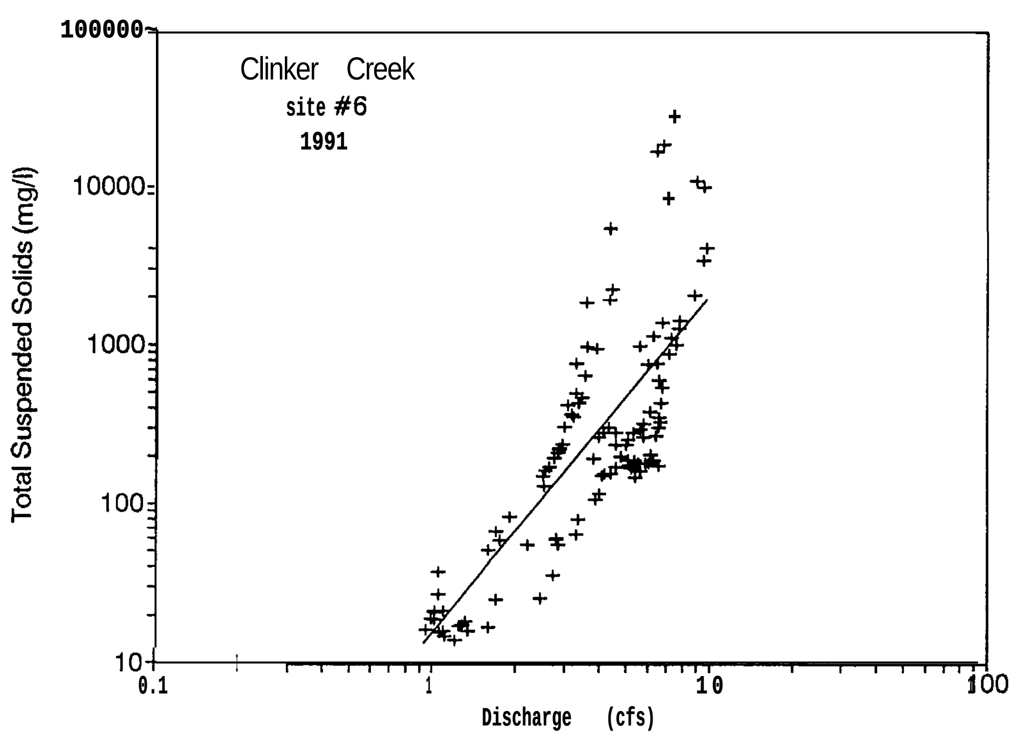

Figure 7. TSS versus discharge For Clinker Creek (1991 data).

lack of large storms during 199 1. The average high flow at Clinker Creek in 199 1 was due to the high baseflow from the spring recharge. This type of high flow does not contribute as much sediment to the stream as runoff from large precipitation events.

Table 6. Monthly and season sediment load for Sanderson (site #1 and #3) and Clinker (site #6) creeks All load values are in tons per day.

	MAY	JUN	JUL	AUG	SEP	Total
Sanderson Cr (site #1)						
1987	----	1.16	1120	980	600	**2700**
1988	**2040**	1490	**3030**	1010	**2.24**	**7570**
Sanderson Cr (site #3)						
1987	----	**22.0**	**2870**	**2530**	**1470**	**6890**
1988	**2500**	**4500**	**3540**	**1550**	113	**12200**
Clinker Cr						
1991	108	105	**30.2**	**25.5**	**1.26**	**268**

One other site has a sufficient quantity of sediment data to discuss. Grab samples were collected twice a week by Usibelli personnel from Hoseanna Creek below Sanderson Creek (site #5) during 199 1. Additional samples were collected by Alaska Division of Water investigators when on site. A total of 44 samples were collected. However, no flow data was collected. The mean TSS was 952 mg/l; median TSS was 300 mg/l; while the range was from 10,600 to 24.1 mg/l. These data are reported in Ray (1992). Other miscellaneous sediment samples were collected at the remaining surface water sites. These data are reported in the appendices with the flow and chemistry data.

Chemical Quality

Major Ions

Data used in this section are a compilation of data collected by the Alaska Division of Water in 1991 and from two USGS studies. Parks (1983) collected samples in the Gold Run Pass area in 1980 and 198 1.

Scully et al., (1981) collected samples in 1977 and 1978. The data from these studies are found in the Appendices A, B, and C.

The chemical quality of water is similar at all sampling sites on Sanderson Creek. These waters are characterized by calcium and magnesium as the dominant cations and sulfate and bicarbonate as the dominant anions. Site #1 was sampled in 198 1 and 199 1, with the results of the analyses very similar. During the 1991sampling, the dissolved-solids concentration (TDS) in Sanderson Creek drops from site #1 (550 mg/L) to site #3 (509 mg/L). The contribution of groundwater to stream flow must be low, if any, between the two sites since the flow dropped from site #1 (4.07 cfs) to site #3 (3.67 cfs). The TDS concentration of the groundwater must be lower than the TDS concentration at site #1 since the concentration dropped at site #3. Any groundwater contribution would be from the Usibelli Group. The hydraulic conductivity in sandstone and fractured-coal seams is generally higher than in a schist aquifer (Freeze and Cherry, 1979). If similar gradients are present then the residence time in the aquifer would be lower in the sanstone and fractured-coal seams. This results in lower dissolved-solid concentrations. Hoseanna Creek above Sanderson Creek (site #4) had a much lower dissolved-solids concentration (82.4 mg/L). The Upper Hoseanna basin is comprised of a larger percentage of the Usibelli Group (83 percent) than the Sanderson Creek basin (16 percent). This results in the lower dissolved-solids concentrations found in Upper Hoseanna Creek.

The percentage of constituents (based on milliequivalents) is different among the twelve sites sampled in 1991 (including the three groundwater sites). Figure 8 is a Piper diagram (Piper, 1944) which plots the average value of the twelve sites sampled during the study. The diagram shows that the waters at all sites dominated by sulfate and bicarbonate (right triangular plot), with almost no chloride. The cations (left triangular plot) have a fairly constant calcium percentage, with magnesium and sodium present in different percentages. The surface waters have more magnesium than sodium, however the groundwaters have higher sodium than magnesium. This forms a linear trend on the plot, with water from Sanderson Creek on the left, then water from Hoseanna and Clinker creeks, then the groundwater on the right. The Piper diagram can be used to differentiate the origin of the waters. Figure 9 shows a Piper diagram with the generalized characteristics of the waters shown, The Sanderson Creek samples plot in the area on top of the diamond. The waters are from a schist-dominated basin, The ares on the lower-left side of the diamond are waters from

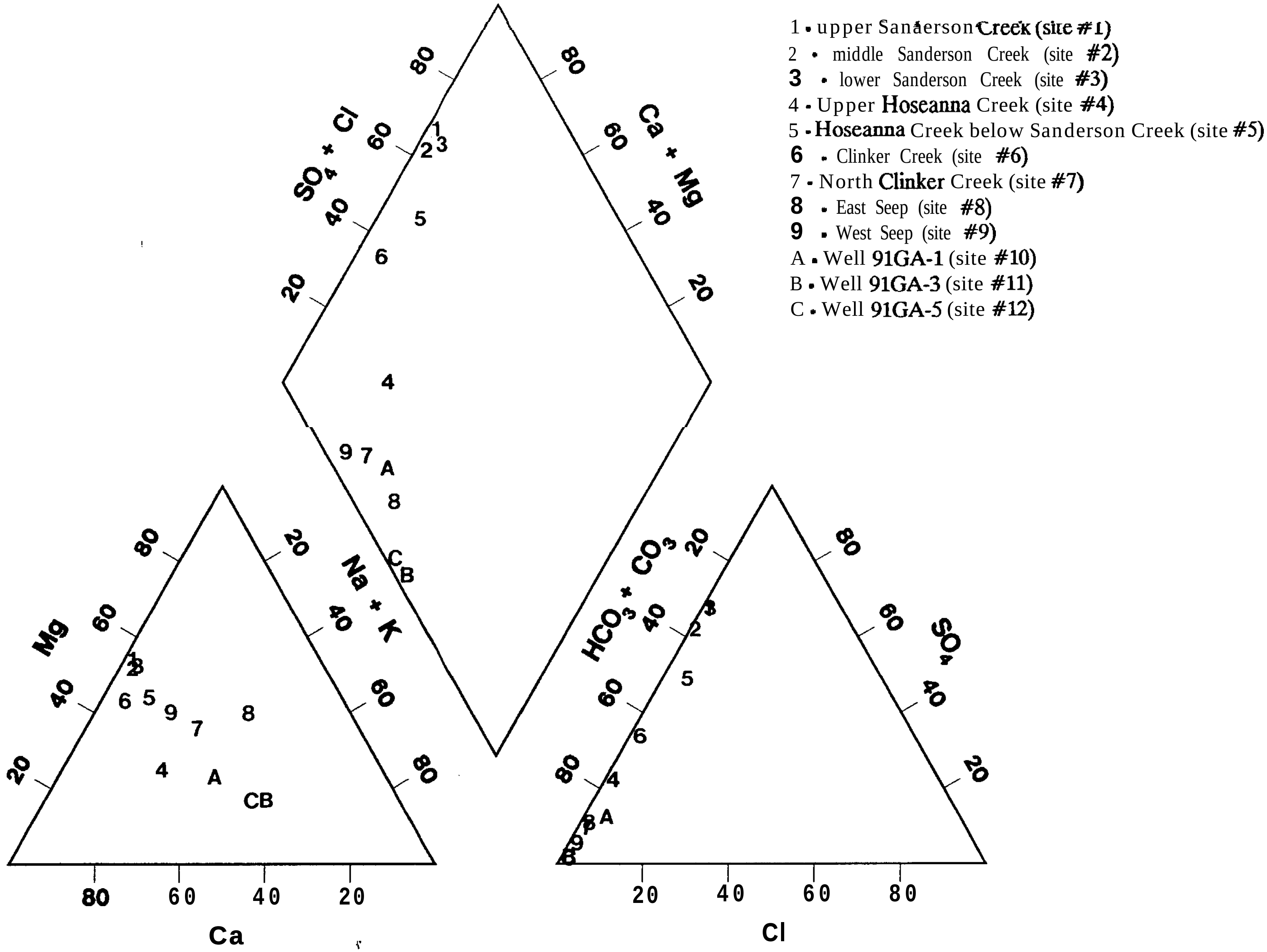

Figure 8. piper diagram plotting the average value from each of the twelve sites sampled

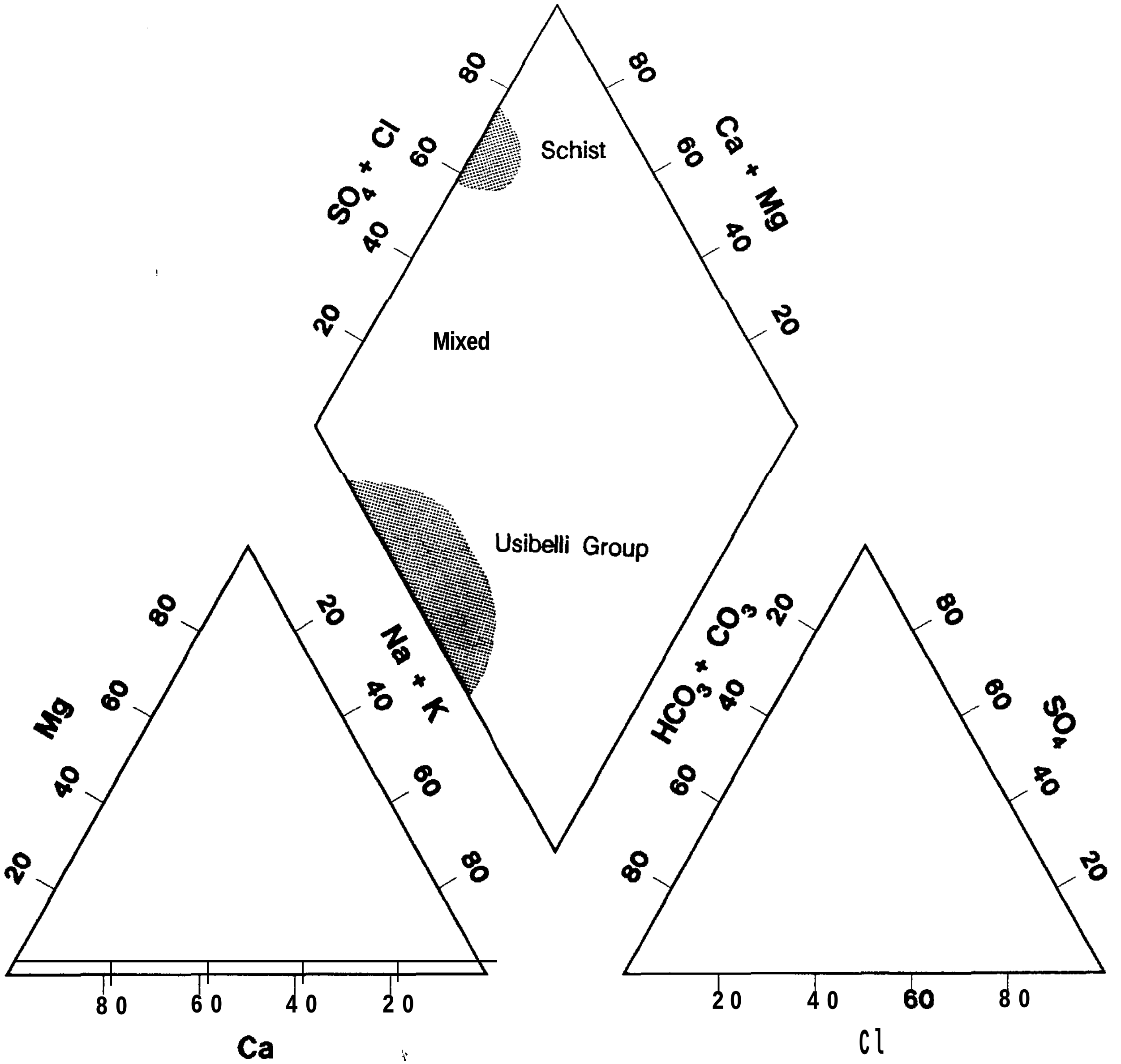

Figure 9. Piper diagram showing separation of basin types based on the water chemistry.

the Usibelli Group terrain. These include the groundwater samples from the Caribou coal seam (sites #10, #1 1 and #12), east and west seeps (sites #8 and #9), and North Clinker Creek (site #7). The sites which plot between these areas are streams which are made up of waters from both basin types.

Although the groundwater sample results plot with the surface waters with Usibelli Group origins, the concentrations of the groundwater is much higher. Site #10 (well 91GA-1) is the exception, The dissolved-solids concentration is very similar to the seeps. The well is at the top of the pass and is fairly shallow (depth to top of Moose seam is 42 feet). This water has not been in place very long, resulting in low dissolved solids. The other two wells (sites #1 1 and #12) are down-gradient of the pass, with the depths to the top of the Moose seam as 102 and 139 feet, respectively. These wells had dissolved-solids concentration six to seven times higher than site #10. These waters have a much longer residence time, resulting in the higher dissolved-solid concentrations. The results of the analyses from these wells are found in Appendix D.

Trace Metals

Samples for trace metal analysis were collected in this study and by Parks (1983). Most fresh waters in Alaska are regulated under drinking water-quality standards. The Alaska Department of Environmental Conservation (ADEC) has recently made changes in these criteria. Many factors determine whether a trace metal exceeds the water quality criteria. Factors such as: hardness of the water; type of sample (dissolved, total, or total-recoverable, length of average-time (instantaneous, 24-hour average, or 4day average) (ADEC, 1991). Table 7 gives the criteria for the seven priority pollutants analyzed in the two studies. Since only grab samples were collected, it is not possible to calculate 24-hour and 4day averages. All comparisons made are based only on instantaneous values. At no time was arsenic, cadmium, chromium, or nickel above the water-quality criteria for the surface waters at any of the sites. At Hoseanna Creek above Sanderson Creek (site #4) on July 30, 1991, the dissolved lead concentration was 2 ug/l. The water-quality criteria for lead (at a hardness of 64 mg/l) is 1.8 ug/l. The measured amount was only slightly over. On May 23, 1980, the lead concentration at Sanderson Creek (site #2) was reported at 5 1 ug/l. This certainly exceeded the waterquality criteria, however no hardness data was collected. However, the integrity of the sample is in question. At no other time or place in the study (Parks, 1983) did lead concentrations come close to that value, and most were less than 5 ug/l. However, every sample collected on May 23, 1980 had dissolved lead concentrations ranging from 34 to 5 1 ug/l. It appears that the samples were contaminated, possibly from the acid used to preserve the samples. The total-recoverable zinc values exceeded the waterquality criteria of 47 ug/l on every date sampled by Parks (1983) on both sites on Sanderson Creek (sites #1 and #2). The total-recoverable zinc values also exceeded the waterquality criteria on the Sanderson Creek sites in the samples collected during 1991 by the Alaska Division of Water.

In the groundwater samples, arsenic, cadmium, and copper were all below the water quality criteria. Dissolved lead in well 91GA-1 was 8 ug/l. The water quality criterion for lead at the hardness of the water (77.1 mg/l) is 2.3 ug/l. Chromium values also exceeded the water quality criteria in wells 91GA-3 and 91GA-5, with values of 14 and 38 ug/l, respectively, The water quality criterion for chromium is 11 ug/l and is not hardness dependent. The total-recoverable zinc value at well 91GA-3 was 690 ug/l. The water quality criterion is 47 ug/l and is not hardness dependent. The high total iron values at wells 91GA-3 and 91GA-5 are probably elevated due to the large amounts of sediment in the samples collected. Table 8 summarizes the samples which exceeded the water quality criteria.

Table 7. Water-quality standards for the priority pollutants at various hardness values for metals collected in this study. All values in micrograms per liter.

Metal	Sample Type	Hardness 50 mg/l	Hardness 200 mg/l	Hardness 400 mg/l	Time Period
Arsenic	Total	50 ug/l - not hardness dependent			Instantaneous
cadmium	Dissolved	0.66	2.0	5.6	4day Average
Chromium	Dissolved	11 ug/l - not hardness dependent			4-day Average
Copper	Dissolved	6.5	21	39	4day Average
Lead	Dissolved	1.3	7.7	19	4day Average
Nickel	Total Recoverable	56	160	274	24-hour Average
Zinc	Total Recoverable	47 ug/l - not hardness dependent			24-hour Average

Table 8. Sample which exceeded the water quality criteria. All water quality criteria for the metals except arsenic are based on averages. Therefore the samples for the other metals may not exceed the criteria, but are shown only for comparison.

Metal	Site #	Date	Concentarion (ug/L)	WQ Criteria (ug/L)
Arsenic	none			
Cadmium	none			
Chromium	**#11**	26 Sep 91	14	11
	#12	26 Sep 91	38	11
Copper	**#6**	22 Apr 91	25	17.6
Lead	**#4**	30 **Jul 91**	2	1.8
	#10	25 Sep 91	8	2.3
Nickel	none			
Zinc	**#1**	All	**>47**	47
	#2	All	**>47**	47
	#3	30 **Jul 91**	220	47
	#11	26 Sep 91	690	47

CONCLUSIONS

1. Sander-son and Clinker creeks have high runoff to precipitation ratios (0.55 to 0.71) as a result of the schist-underlain basins and permafrost-rich soils.

2. The high sediment load in Sanderson Creek is due to the landslides in the Usibelli Group supplying ample amounts of sediment to the stream.

3. The Moose coal seam is the main aquifer in the Gold Run Pass area. The sources of recharge appears to be the faults which deliniate the seam on the south and west sides, and downward vertical **perculation.**

4. The hydraulic conductivity of the Moose seam is lower than other coal seams in the basin.

5. The water chemistry data can be used to differentiate between waters of schist origin from waters of Usibelli Group origin,

6. Although the seeps were similar in composition as the wells, they were much more dilute than the deep wells. The residence time of the water in the deeper wells is longer than in the seeps and the shallow well, resulting in more dissolution of the aquifer material (including trace metals).

7. Since the water quality criteria is based on time averages for most of the metals, it is not possible to compare the collected samples with the criteria (except arsenic). However, every sample collected for zinc in Sanderson Creek exceeded the water quality criterion of 47 **ug/L.** Zinc is probably the only metal which exceeds the criterion, and is probably a result of the high sediment load in the creek.

8. Although the dissolved-solids concentrations were much higher in the wells, only a few metals exceeded the water-quality standards.

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Appendix A. 1991 data collected by Alaska Division of Water.

All values in mg/L unless otherwise specified.
All metals as dii unless otherwise specified.

Map #	Location	Date	Discharge (CFS)	Discharge (GPM)	Air Temp (°C)	Water Temp (°C)	Diss Oxy (mg/L)	% Sat	pH	Cond (uS/cm)	Alkalinity (mg $CaCO_3$/L)
1	Sanderson Creek 1.6 mi ab Hoseanna	30-Jul-91	4.07		15.4	14.0	6.5	86.3	7.75	697	133
3	Sanderson Creek ab Hoseanna	30-Jul-91	3.67		12.7	11.1	9.2	89.6	6.14	688	147
4	Hoseanna Creek above Sanderson	30-Jul-91	10.6		12.6	9.7	9.6	68.5	6.90	163	58.9
6	Clinker Creek	22-Apr-91	1.25		7.4	0.0	12.6	88.9	6.70	384	103
6	Clinker Creek	30-Jul-91	1.55		14.9	9.2	9.5	86.6	6.11	355	119
7	North Clinker Creek	30-Jul-91	--	9.7	16.4	11.1	8.9	84.8	8.04	422	217
8	East Seep	30-Jul-91	--	1.9	16.6	14.6	6.6	67.9	7.44	395	202
9	west seep	30-Jul-91	--	5.6	15.1	8.5	7.9	70.8	7.83	217	101

Map #	Location	Date	Hardness* (mg/L $CaCO_3$)	Turb (NTU)	TSS (mg/L)	TDS* (mg/L)	F	Cl	NO_3 (as N)	PO_4 (as P)	SO_4
1	Sanderson Creek 1.6 mi ab Hoseanna	30-Jul-91	429	32	38.8	550	1.36	0.71	0.08	<DL	330
3	Sanderson Creek ab Hoseanna	30-Jul-91	404	65	158	509	1.25	0.27	0.08	<DL	285
4	Hoseanna Creek above Sanderson	30-Jul-91	64.0	85	331	82.4	0.21	0.83	0.23	<DL	17.2
6	Clinker Creek	22-Apr-91	159	130	88.4	228	0.61	5.77	0.19	<DL	102
6	Clinker Creek	30-Jul-91	174	29	27.3	195	0.43	2.26	0.12	<DL	59.6
7	North Clinker Creek	30-Jul-91	185	14	24.7	242	0.54	0.71	0.03	<DL	23.1
8	East Seep	30-Jul-91	131	40	79.1	235	0.53	0.47	0.07	<DL	24.2
9	West Seep	30-Jul-91	94.2	11	9.77	108	0.29	0.10	0.15	<DL	5.71

. by calculation: Hardness = 2.497[Ca] + 4.11 6[Mg]
Total Dii Solids = [Ca] + [Mg] + [Na] + [K] + [Alkalinity] + [Cl] + [SO_4]

Appendix A (continued).

All values in mg/L unless otherwise specified.
All metals as dissolved unless otherwise specified.

Map #	Location	Date	Ca	Mg	Na	K	Al	As (total)	Ba	Cd	Cr
1	Sanderson Creek 1.6 mi ab Hoseanna	30-Jul-91	73.6	58.7	4.37	1.90	0.25	0.002	0.02	0.002	0.006
3	Sanderson Creek ab Hoseanna	30-Jul-91	69.6	56.0	7.66	2.39	0.16	<DL	0.03	0.002	0.002
4	Hoseanna Creekab Sanderson	30-Jul-91	14.7	6.64	6.62	1.07	0.06	0.014	0.06	<DL	<DL
6	Clinker Creek	22-Apr-91	28.5	21.4	6.90	1.93	0.06	0.011	0.05	<DL	<DL
6	Clinker Creek	30-Jul-91	36.2	20.4	3.65	1.33	0.70	<DL	0.04	<DL	<DL
7	North Clinker Creek	30-Jul-91	35.1	23.6	25.1	4.31	0.08	0.010	0.16	<DL	0.004
8	East Seep	30-Jul-91	19.8	19.9	42.2	7.78	0.12	0.007	0.16	<DL	0.002
9	West Seep	30-Jul-91	17.5	12.3	9.13	2.53	0.10	0.021	0.13	<DL	<DL

Map #	Location	Date	Cu	Fe	Fe (total)	Pb	Mn	Mn (total)	Ni	Zn (total recoverable)
1	Sanderson Creek 1.6 mi ab Hoseanna	30-Jul-91	0.005	0.03	7.17	0.004	0.03	0.63	0.06	0.34
3	Sanderson Creek ab Hoseanna	30-Jul-91	0.002	<DL	6.70	<DL	0.59	0.61	0.03	0.22
4	Hoseanna Creekab Sanderson	30-Jul-91	0.001	0.17	4.77	0.002	0.08	0.23	<DL	<DL
6	Cliiker Creek	22-Apr-91	0.025	0.26	14.6	<DL	0.17	0.24	<DL	0.02
6	Clinker Creek	30-Jul-91	0.003	<DL	5.63	0.003	0.03	0.05	<DL	<DL
7	North Clinker Creek	30-Jul-91	0.005	0.02	0.63	0.001	<DL	<DL	<DL	<DL
8	East Seep	30-Jul-91	0.011	<DL	<DL	0.001	<DL	<DL	0.02	<DL
9	West Seep	30-Jul-91	0.008	0.43	0.84	<DL	0.03	0.04	<DL	<DL

Appendix B. Data collected by Parks (1983).

All values in mg/L unless otherwise specified.
All metals as dissolved unless otherwise specified.

Map #	Location	Date	Discharge (CFS)	Water Temp (°C)	pH	TSS (mg/L)	TDS (mg/L)	Hardness noncarbonate	Hardness	Ca	Mn
1	Sanderson Creek 1.6 mi ab Hoseanna	11-Jun-81	3.1	9.0	8.1	9	513'	420	260	71	58
		30-Jul-81	4.2	6.5	7.6	15	571'	480		76	70
		12-Sep-81	4.2	5.0	7.8	11	559'	480	290	61	68
2	Sanderson Creek 0.8 mi ab Hoseanna	23-May-80	4.4	4.0	7.9	1270					
		09-Jul-80	3.3	10.0	7.5	136	485				
		28-Aug-80	12	6.5	6.3	343	464	380	210	'82	54
		22-Sep 80	13	2.5	6.0	215	442	350	200	62	48
		03-Apr-81	0.24	0.0	7.5	3	1130	800	550	140	110
		llJun61	3.7	7.5	8.0	119	499*	410	260	72	56
		30-Jul-81	4.5	9.0	7.5	132	545'	430		76	59
		12-Sep-81	5.1	5.5	7.5	106	533'	450	250	76	62

Map #	Location	Date	Na	K	Alkalinity (mg $CaCO_3$/L)	SO_4	Cl	F	NO_3+NO_2 (as N)	Fe dissolved	Fe suspended
1	Sanderson Creek 1.6 mi ab Hoseanna	11-Jun-81	6.7		160	300	1.5			0.010	1.90
		30-Jlll-81	5.9			300	0.8			0.010	4.60
		12-Sep-81	4.7		190	300	1.1			0.010	6.30
2	Sanderson Creek 0.8 mi ab Hoseanna	23-May-80	--		110					0.020	32.0
		09-Jul-80	--		140					0.040	5.10
		28-Aug-80	4.9	1.9	170	210	0.1	0.5	0.10	0.070	13.0
		22-Sep 80	4.3	1.6	150	210	0.7	0.6	0.26	0.040	8.50
		03-Apr-81	34	5.6	310	560	6.5	0.7		0.260	0.330
		llJun81	8.3		150	280	1.4			0.020	4.50
		30Jul-81	8.0			270	0.7			0.028	7.00
		12-Sep-81	7.0		200	280	0.7			0.010	8.20

● bycalculatll:Total dissolved solids based on specific conductance value

Appendix B (continued).

All values in mg/L unless otherwise specified.
All metals as dissolved unless otherwise specified.

Map #	Location	Date	Pb dissolved	Pb suspended	Mn dissolved	Mn suspended	Ni dissolved	Ni suspended	Silica	Zn dissolved	Zn suspended
1	Sanderson Creek 1.6 mi ab Hoseanna	11-Jun-81	0.001	0.007	0.300	0.020	0.048	0.002		0.050	0.140
		30-Jul-81	0.000	0.002	0.380	0.000	0.042	0.015		0.058	0.300
		12-Sep-81	0.000	0.009	0.550	0.020	0.070	0.024		0.072	0.420
2	Sanderson Creek 0.8 mi ab Hoseanna	23-May-80	0.051	0.008	0.500	0.500	0.027	0.073		0.030	0.310
		09-Jul-80	0.004	0.009	0.580	0.030	0.033	0.009		0.040	0.150
		28-Aug-80	0.000	0.013	0.310	0.190	0.022	0.038	2.1	0.170	0.210
		22-Sep 80	0.003	0.006	0.410	0.080	0.038	0.016	3.5	0.130	0.300
		03-Apr-81	0.002	0.002	2.20	0.100	0.085	0.001	9.0	0.190	0.010
		11-Jun 81	0.001	0.008	0.510	0.040	0.042	0.007		0.080	0.110
		30-Jul-81	0.002	0.013	0.540	0.060	0.034	0.024		0.082	0.260
		12-Sep-81	0.000	0.001	0.680	0.050	0.052	0.027		0.068	0.330

Appendix C. Data collected by **Scully** et. al. (1980).

All values in mg/L unless otherwise specified.
All metals as dissolved unless otherwise specified.

Map #	Location	Date	Discharge (CFS)	Water Temp (^oC)	pH	TDS (mg/L)	Silica	Hardness (mg/L as $CaCO_3$)	Bicarbonate (mg/L as HCO_3)	Ca
4	Hoseanna Creek ab Sanderson	04-Aug-77	5.4	17.0	7.6	125	19	81	91	20
		01-Nov 77	5.4	0.0	6.7	141	21	90	130	21
		07-Sep-78	6.5	7.0	7.5	111	16	70	84	16
5	Hoseanna Creek below Sanderson	04-Aug-77	8.3	18.0	7.8	237	14	180	124	36
		01-Nov 77	6.7	0.0	6.9	311	18	180	140	36
		12-May-78	29	0.0	7.6	162	6.2	130	80	24
		07-Sep-78	12	8.0	7.8	262	11	190	128	35

Map #	Location	Date	Mg	Na	K	SO_4	Cl	F	Fe	Mn	TSS (mg/L)
4	Hoseanna Creek ab Sanderson	04-Aug-77	7.5	9.3	1.4	22	2.2	0.1	0.400	0.210	212
		01-Nov77	9.1	10	1.3	23	2.1	0.1	0.190	0.240	373
		07-Sep-78	7.4	6.9	1.2	15	1.7	0.1	0.350	0.140	126
5	Hoseanna Creek below Sanderson	04-Aug-77	21	13	2.0	85	9.2	0.3	0.020	0.270	114
		01-Nov 77	23	14	1.7	100	9.2	0.3	0.090	0.340	216
		12-May-78	16	7.4	2.1	63	4.6	0.2	0.270	0.150	3400
		07-Sep-78	26	10	1.6	100	6.0	0.3	0.110	0.260	153

Appendix D. 1991 groundwater data collected by DNR/DOW.

AU values in mg/L unless otherwise specified.
All metals as dissolved unless otherwise specified.

Well ID	Map #	Date	Depth to H_2O (feet)	Casing Vol (gallons)	Vol Purged (gallons)	pH	Conductivity (uS/cm)	Alkalinity (mg $CaCO_3$/L)	TDS* (mg/L)	Hardness* (mg/L $CaCO_3$)
91 GA-l	10	25-Sep-91	56.52	1.9	15	6.17	162	169	206	77.1
91 GA-3	11	26-Sep-91	115.3	6.5	11	7.91	808	719	1210	408
91 GA5	12	26-Sep-91	76.75	9.0	9.0	7.47	615	627	1360	462

Well ID	Map #	Date	F	Cl	NO_3 (as N)	PO_4 (as P)	SO_4	Ca	Mg	Na
91 GA-1	10	25-Sep-91	0.52	3.26	0.23	<DL	16.9	16.2	8.93	13.9
91 GA-3	11	26-Sep-91	2.66	1.26	<DL	<DL	11.7	62.7	49.0	190
91 GA-5	12	26-Sep-91	3.19	0.96	0.05	<DL	7.54	100	51.7	167

Well ID	Map #	Date	K	Al	As (total)	Ba	B	Cd	Cr	Co
91 GA-1	10	25-Sep-91	5.26	0.65	<DL	0.35	0.22	<DL	0.004	<DL
91GA-3	11	26-Sep-91	611	5.24	<DL	0.21	0.52	<DL	0.014	0.02
91 GA-5	12	26-Sep-91	16.6	6.53	0.007	<DL	0.22	0.003	0.036	<DL

Well ID	Map #	Date	Cu	Fe	Fe (total)	Pb	Mn	Mo	Silica	Zn
91 GA-l	10	25-Sep-91	0.006	0.50	41.5	0.008	0.92	<DL	26.0	<DL
91 GA-3	11	26-Sep-91	0.014	1.41	335	0.017	12.4	<DL	37.6	0.69
91 GA-5	12	26-Sep-91	0.013	46.0	234	0.015	11.6	<DL	23.7	<DL

*by calculation: Hardness = 2.497[Ca] + 4.116[Mg]
Total Dissolved Solids = [Ca] + [Mg] + [Na] + [K] + [Alkalinity] + [Cl] + [SO_4]

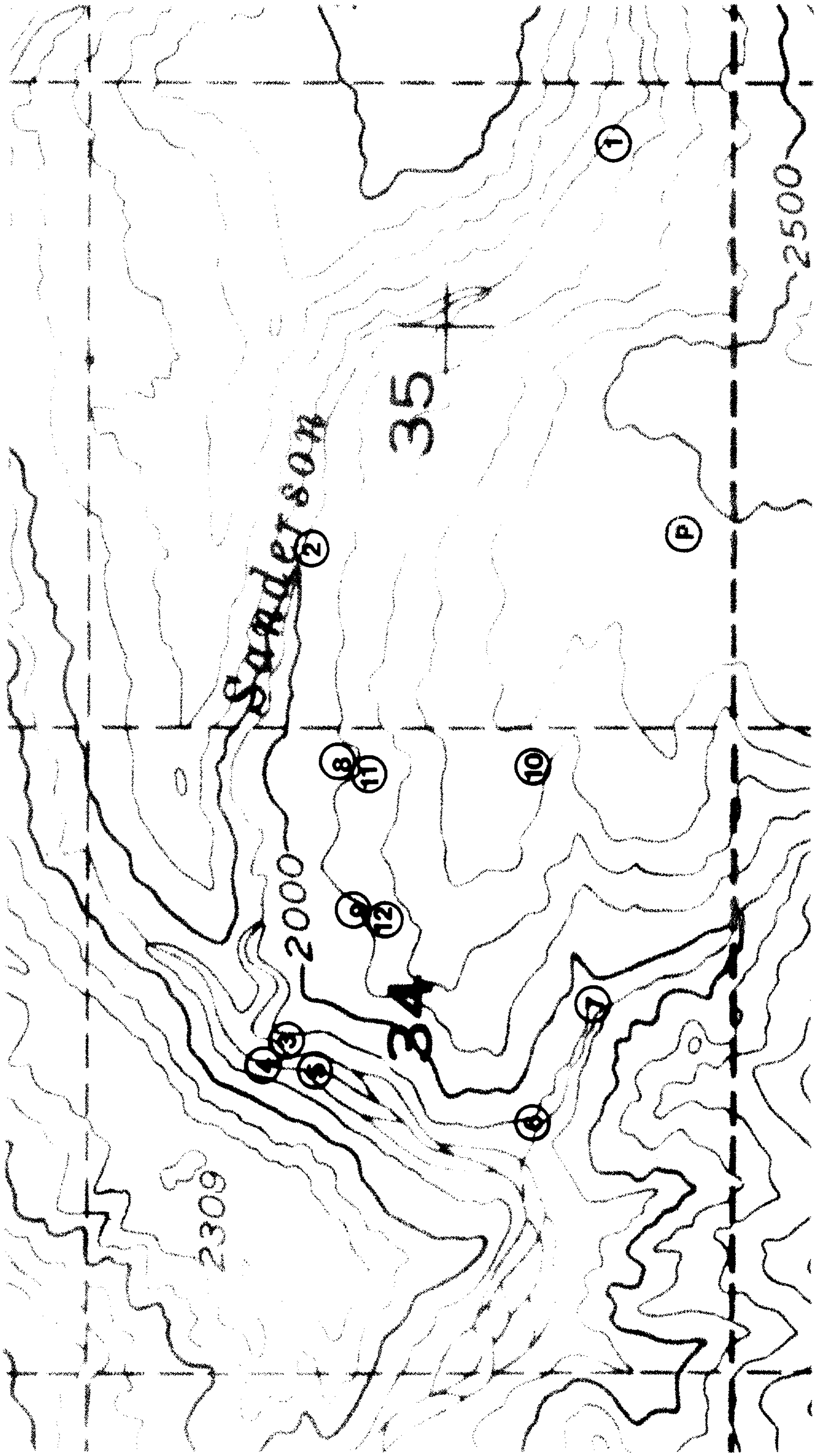

Figure 2. Map showing location ofsampling sites. Numbers 1-12 correspond to sites in Table 1. Site P is the precipitation gage. One inch equals one-quarter mile.