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STREAMFLOW, SEDIMENT LOAD, AND WATER QUALITY STUDY OF HOSEANNA CREEK BASIN NEAR HEALY, ALASKA: 1988 PROGRESS REPORT

BY

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EXECUTIVE SUMMARY

Alaska Division of Geological and Geophysical Surveys investigators measured precipitation, measured discharge, and collected surface and ground water samples in 1988. Precipitation was slightly above normal (based on records from Poker Flat). Storm events were greater than those measured in 1987, and resulted in greater runoff. Approximately 59000 tons of suspended sediment moved past Bridge 3 on Hoseanna Creek between May 31 and October 5. This is a 48 percent increase from 1987. Most of the sediment was transported at high flows, especially during the spring.

Sediment rating equations for Sanderson Creek and Hoseanna Creek at Bridge 3 were similar to those calculated in 1987. The low r^2 values for the sediment rating equations on small streams may reflect local mass wasting events where mixing is not as thorough.

Surface water samples for water quality analysis were collected three times during the summer at sites located on Hoseanna Creek at Bridge 3 (above mining) and at Bridge 1 (below mining). Generally, no appreciable difference was found in the field-determined parameters or between the ionic constituents.

Ground water samples for water quality analysis were collected from three shallow wells near Hoseanna Creek (one located in undisturbed soil, two located in disturbed soil), and from one well upgradient of the mine (located in a coal seam). The major ion concentrations varied widely among the wells. Classification of the four wells are: sodium bicarbonate-chloride, calcium-potassium bicarbonate, sodium chloride, and sodium bicarbonate.

TABLE OF CONTENT?3

EXECUTIVE SUMMARY i

TABLE OF CONTENTS ii

LIST OF FIGURES iii

LIST OF TABLES iv

INTRODUCTION 1

METHODS 4
- Precipitation 4
- Discharge 4
- Sediment Rating Equations 4
- Water Quality 5
  - Surface Water 5
  - Ground Water 6
  - Laboratory Analysis 6

RESULTS 7
- Precipitation 7
- Discharge 7
- Sediment Load 10
  - Sanderson Creek 10
  - North Hoseanna Creek 12
  - Hoseanna Creek at Bridge 6 12
  - Popovitch Creek 12
  - Louise Creek 14
  - Frances Creek 14
  - Hoseanna Creek At Bridge 3 14
  - Two Bull Creek 14
- Water Quality 17
  - Surface Water 17
  - Ground Water 18

DISCUSSION 24
- Water Quality 26
  - Surface Water 26
  - Ground Water 30

CONCLUSIONS 31

REFERENCES CITED 32

APPENDIX A. Precipitation record from Gold Run Pass 35

APPENDIX B. Summary of daily average discharge values 36

APPENDIX C. Summary of daily sediment loads 42

APPENDIX D. TSS, turbidity, and discharge data 48

APPENDIX E. Methods and detection limits for water quality analyses 59

APPENDIX F. Water quality analysis results 61

LIST OF **FIGURES**

Figure 1. **Hoseanna** Creek Basin 3

Figure 2. **Hydrographs** for **Hoseanna** Creek at Bridge 3, Sanderson and Frances Creeks 9

Figure 3. TSS versus discharge for Sanderson Creek (r^2 = 0.86) 11

Figure 4. TSS versus discharge for North **Hoseanna** Creek (r^2 = 0.47) 11

Figure 5. TSS versus discharge for **Hoseanna** Creek @ Brd 6 (r^2 = 0.72) 13

Figure 6. TSS versus discharge for Popovitch Creek (r^2 = 0.59). 13

Figure 7. TSS versus discharge for Louise Creek (r^2 = 0.75) 15

Figure 8. TSS versus discharge for Frances Creek (r^2 = 0.55) 15

Figure 9. TSS versus discharge for **Hoseanna** Creek at Brd 3 (r^2 = 0.74) 16

Figure 10. TSS versus discharge for Two Bull Creek (r^2 = 0.74) 16

Figure 11. Discharge and TSS plotted versus time for storm event at Frances Creek on July **21, 1988**.. 27

Figure 12. TSS versus discharge for two storm events 28

LIST OF TABLES

Table 1. Basin characteristics of sampling sites (after Mack, 1988) 2

Table 2. Monthly precipitation for the two gage sites 7

Table 3. Flow data for the 1987 and 1988 field seasons 8

Table 4. Coefficients, r^2 value, and number of samples used (n) for the sediment rating equations 10

Table 5. Percentages of the major ion composition (in meq/l) at Hoseanna Creek on May 23, July 19, and September 8, 1988 17

Table 6. Mean values of selected water quality constituents from Hoseanna Creek sites, 1987 and 1988, and respective Alaska Water Quality Standards 19

Table 7. Coordinates for ground water monitoring wells at Usibelli Coal Mine 20

Table 8. Initial water level readings and purging protocol for ground water monitoring wells at Usibelli Coal Mine 21

Table 9. Percentages of the major ion composition (in meq/l) of ground water monitoring wells at Usibelli Coal Mine, 1988 22

Table 10. Mean values of selected water quality constituents from the ground water monitoring wells and respective Alaska Drinking Water Standards 23

Table 11. Sediment load estimates (for the period of discharge record) and basin distribution for 1987 and 1988 25

Table 12. The percentage of seasonal sediment load in short durations 26

Table 13. Percentages of the major ion composition (in meq/l) at Hoseanna Creek sites, 1987 and 1988 29

INTRODUCTION

This report discusses sediment, streamflow, and water quality data collected during the 1988 summer field season by Alaska Division of Geological and Geophysical Surveys (DGGS) investigators in Hoseanna Creek basin. Hoseanna Creek flows west into the Nenana River approximately three miles north of Healy, Alaska. The total basin area is approximately 48 mi^2. Hoseanna Creek appears on USGS topographic maps as Lignite Creek. However, research by Usibelli Coal Mine employees discovered two other names: Hosanna and Hoseanna Creeks (Boddy, pers. comm.), Hoseanna being the earliest spelling. Previous DGGS reports refer to the creek as Hosanna Creek (Mack, 1988; Mack, 1987). This report and subsequent reports by DGGS will refer to the creek as Hoseanna Creek.

The lithologies of the basin (see Wahrhaftig, 1987: Wilbur and Clark, 1987; Wahrhaftig, et al, 1969) produce mass wasting, which contributes to high sediment loads in some of the streams in the basin. The purpose of this study is to estimate the discharge and quantify the sediment yield of selected basins above mining influence.

In 1986, five sites were chosen to represent different geologic aspects of the basin: Sanderson Creek (above mining), North Hoseanna Creek (unmined), Popovitch Creek (unmined), Frances Creek (future mining), and Hoseanna Creek at Bridge 3 (main channel, above mining)(Mack, 1987). Results of the 1986 season indicated that most of the sediment moves during high flow events, and that future field seasons should concentrate effort on measuring such events. Mack (1987) also concluded that the only way to obtain reliable data from small sediment-laden streams was with a parshall flume. The design of this flume prevents sediment from clogging the path of water flow, a problem which occurs with weirs or H-flumes. Parshall flumes were installed at Frances and Popovitch Creeks. Samples taken during high flow events by automated samplers were combined with grab samples taken at all flow stages to develop sediment rating equations. The equations were used to predict total suspended sediment (TSS) from discharge data in order to estimate daily and seasonal sediment loads for the various sites.

In an attempt to establish background data from the upper Hoseanna basin in 1987, a non-automated sampling site was added on Hoseanna Creek above its confluence with North Hoseanna Creek.

Two additional sites were added in 1988: Two Bull Creek (future mining) and Louise Creek (future mining). These are small tributaries in the lower basin (Figure 1). Two Bull creek flows into Hoseanna Creek below Bridge

3, while Louise Creek is 1.4 miles upstream of Bridge 3. We collected grab samples and measured discharge throughout the season, and placed automated equipment at these sites in August.

During the winter of 1988, Usibelli Coal Mine completed a haul road to Gold Run Pass, which now allows easy access to the upper basin sites. The site on Hoseanna Creek above North Hoseanna Creek was moved to the newly installed Bridge 6, which is about one-half mile downstream of North Hoseanna Creek. The bridge site is ideal for developing stage-discharge relationships. Automated equipment was placed at this site in late-July. Figure 1 shows the study location with each subbasin and sampling site indicated. Table 1 gives the basin characteristics of each sampling site.

Table 1. Basin characteristics of sampling sites (after Mack, 1988).

Site	Area (mi^2)	Percent of total basin area	Principle Lithology
Sanderson	5.1	11.6	Schist
North Hoseanna	3.1	7.2	Coal Group
Hoseanna @ Brd 6	20.8	47.5	Mixed
Popovitch	4.1	9.3	Nenana Gravel, Coal Group
Louise	1.6	3.6	Nenana Gravel, Coal Group
Frances	1.7	3.9	Nenana Gravel, Coal Group
Hoseanna @ Brd 3	43.8	100.0	Mixed
Two Bull	0.9	----	Nenana Gravel, Coal Group

Surface water quality sampling began in 1987 and continued in the 1988 summer field season. Two sampling sites on Hoseanna Creek, Bridge 3 (above mining) and Bridge 1 (below mining), are used to quantify the effect of the Poker Plats mine on water chemistry. The sites were sampled three times during the field season and analyzed for major ions and trace elements.

Water quality samples were also collected during the 1988 summer season from three shallow wells (one upgradient of mine disturbance and two disturbed) and one deep well (undisturbed coal seam). The shallow wells were sampled three times (at the same time as the surface water quality samples) with the deep well sampled once at mid-summer. The samples were analyzed for major ions and trace elements.

METHODS

PRECIPITATION

The precipitation data for the basin is gathered in two locations. DGGS operates a Wyoming gage with a datapod recording device at Gold Run Pass (see Mack (1988) for location and construction specifications). Readings are taken every 30 minutes, with changes as small as twelve one-hundredths of an inch recorded. The other reporting station is operated by Usibelli Coal Mine personnel and is located at Poker Flats mine. The gage at Poker Flats is a small (four inch diameter) cylindrical type and is read approximately every 24 hours. This gage is calibrated at one-hundredth of an inch intervals.

DISCHARGE

Stream velocities used in the calculation of discharge were measured with a Marsh-McBirney model 201 digital flowmeter. Velocities were measured at six-tenths depth, with sufficient number of sections such that no one section contained over ten percent of the total flow. Discharge was calculated using the standard midpoint method (US Dept. of Interior, 1981). At sites with flumes, discharge was estimated using the standard equation for parshall flumes (US Dept. of Interior, 1981). The flume at Frances Creek became difficult to level due to extreme aufeis buildup during the winter. A correction factor was therefore necessary for that flume.

A continuous stage record was recorded at each site using Omnidata DP320 stream stage recorders with pressure transducers. The small, battery operated device can measure water levels from 0 to 10 feet in intervals of one-hundredth of a foot. The data are stored on EPROM microchips, which are then read by a computer at the lab.

Discharge rating curves were calculated for each site using the discharge stage and data. High flow events which were not directly measured were estimated using the indirect slope-area method (Dalrymple and Benson, 1984). The rating equations were then used to convert the continuous stage record into a continuous discharge record.

SEDIMENT RATING EQUATIONS

Sediment rating equations were calculated at each site to estimate sediment concentrations from discharge data. Leopold and Maddock (1953) found that equations of the form:

$$TSS = aQ^b$$

where TSS = total suspended solids (mg/l)
Q = discharge (cfs)
a,b = numerical constants

adequately approximate the relationship. Using the TSS data from the grab and automated samples, these equations were developed as linear log-log plots (log TSS = a + b log Q) Using the actual and estimated sediment concentrations and the continuous discharge data, we calculated the daily sediment load. Whenever possible, the actual values (automated or grab) were used in the calculation. The daily loads were then added to estimate the season load.

WATER QUALITY

To ensure consistency of data between the different field seasons, the same water quality sampling and analytical methods were used during the 1987 and 1988 field seasons (see also Mack, 1988).

Surface Water

Surface water for chemical analyses was obtained and composited from Hoseanna Creek at locations shown on Figure 1 with a hand-held depth-integrating suspended-sediment sampler and a churn splitter, according to the methods of the U.S. Department of the Interior (1977). Samples collected from the splitter at each site were: filtered, for determining dissolved major anions; unfiltered, for determining suspended solids; and filtered and acidified, for determining dissolved trace metals and major cations. Water for major ion and dissolved trace-metal analyses was immediately pumped through 0.45 micron membrane filters. All acidified samples were collected in pre-acid-washed bottles, and acidified with Ultrex-grade nitric acid, to a concentration of 1.5 ml acid per liter sample.

Water temperature, dissolved oxygen, and specific conductance of surface water samples were measured in situ with a digital 4041 Hydrolab. An Orion digital pH meter was used to measure pH on a composited sample. Alkalinity was measured electrometrically on a composited sample with an Orion pH meter and a Hach digital titrator, according to the methods of the U.S. Environmental Protection Agency (1983). Settleable solids were determined in the field with Imhoff Cones according to the methods of the American Public Health Association, and others (1985).

Ground Water

Ground water samples were obtained from wells shown in Figure 1. Water levels in all wells were measured prior to pumping with a Johnson Watermark electric water-depth indicator. "Well Wizard" equipment was used to purge and sample all wells. The submersible bladder pump and tubing are composed of non-metallic materials. Water temperature, pH, and specific conductance were measured at regular intervals with a digital 4041 Hydrolab during well purging. After at least one well casing volume was removed from the well, sampling commenced when specific conductance fluctuated less than 10 percent. Water samples were obtained according to the methods of Scalf and others (1981). Water was collected in a churn splitter at the well head. Water temperature, pH, specific conductance and alkalinity were determined in the field using the same instrumentation and methods described for surface water samples, Samples for chemical constituent analysis were also treated and preserved in the same manner as surface water samples. Two additional samples were collected at each site: filtered, for determining nutrients, and unfiltered and acidified, for determining total iron. The sample for determining nutrients was kept on ice and placed in a freezer within one hour of collection.

Laboratory Analysis

Water quality analyses for surface water and ground water were conducted in the DGGS hydrology laboratory located in the Water Research Center on the University of Alaska/Fairbanks (UAF) campus. Some trace metal analyses were also performed with the generous help and use of equipment of the UAF Forest Soils Laboratory. Laboratory procedures used to analyze surface water are described in Mack (1988). Analytical methods and detection limits for surface water and ground water constituents are shown in Appendix E. The laboratory is a participant in EPA analytical quality assurance studies, and has participated in the USGS Standard Reference Water Sample Quality Assurance program since 1980. For all analyses calibrations were performed using in-house analytical standards and blanks, and were monitored and verified by running previously analyzed USGS Standard Reference Water Samples along with the water samples collected for this study.

RESULTS

PRECIPITATION

The precipitation total at Gold Run Pass for the period of May 1 to September 30 was 17.0 inches. The total for the same period at Poker Fiats was **13.9** inches. Table 2 gives the monthly precipitation for the two gages. The daily precipitation for Gold Run Pass is reported in Appendix A.

The average precipitation total at Poker Fiats for the period of May - September is 12.7 inches (Wilbur, 1989). This year the total precipitation at Poker Fiats exceeded the average by approximately ten percent. **Mack** (1988) reported that although the average precipitation of the two stations is similar, individual storm event totals at Gold Run Pass are greater. This relationship was reinforced this season as the precipitation at Gold Run Pass was approximately 22 percent greater than Poker **Flats.** Isolated, convective rain events are possible throughout the basin and are not exclusive to the upper basin. On June **18, 1988, 1.28** inches fell in one hour at Poker Fiats, while no precipitation was recorded at Gold Run Pass.

Table 2. Monthly precipitation for the two gage sites. All values in inches.

Site	MAY	JUN	JUL	AUG	SEP	TOTAL
Gold Run Pass	2.16	5.88	4.92	2.52	1.56	17.04
Poker Fiats	**2.15**	4.25	4.28	1.87	1.43	13.90

DISCHARGE

A few problems at some of the sites prevented the collection of continuous discharge records. Appendix B gives the daily discharges for the sites sampled. Complete records were collected at Frances Creek, North **Hoseanna** Creek, and **Hoseanna** Creek at Bridge 6. The starting date for each respectively are: June 1 (delayed due to ice in flume), June 15 (delayed due to aufeis), and July 29 (waited for rip-rap to be placed around bridge). Although the start-up dates for the streams with aufeis were delayed, it should be emphasized that flow did occur during that time with considerable sediment transport. Sanderson Creek was started on May 26, however the staff gage (and attached pressure transducer) was washed-out on May 30. The staff gage was repaired on June 2, but washed out again on June 11. The location of the staff gage in the channel was changed on June **15,** and no further problems were experienced. The **datapod** at Popovitch Creek was started on May 26 but was replaced on June 2 due to electrical problems. The data recorded prior to June 2 could not be used. The recorded data from Popovitch Creek was "noisy" throughout the summer. **Mack** (1988) reported the same problem during the 1987 field season. The **datapod** at Bridge 3 was started on May 26, however the high flow event on May 31 bent over the staff gage and buried it and the pressure transducer under two feet of sediment. The staff gage was washed out again on July 23. The record, however, is complete. Discharges for the data gaps were estimated from USGS data at Bridge 1. The continuous data recorded for Louise Creek and Two **Bull** Creek were not **useable.** The flow in these streams is usually very low (0.1 cfs). The change in stage with discharge was very **small** to nonexistent. This produced "noise" in the recorded data. If these streams are to be gaged with datapods, flumes are necessary.

Peak flows during the summer of 1988 were much greater than those of the previous summer. Figure 2 plots **discharge** for **Hoseanna** Creek at Bridge 3, Sanderson Creek, and Frances Creek. Table 3 gives the peak discharge and season average for the summers of **1987, 1988.** After further evaluation of data gathered by **Mack (1988),** we have changed the peak discharge on **Sanderson** (from % to **150** cfs), North **Hoseanna** (from **20** to 10 cfs), and Popovitch Creeks (from 1.1 to 0.9 cfs) for 1987.

*Table 3. Flow data **for** the 1987 and **1988 field** seasons. AN values in **cfs.***

Site	Peak Plow 1987	Peak Plow 1988	Season Average 1987	Season Average 1988
Sanderson	**150** *	**225**	**7.0**	8.2
North **Hoseanna**	**10** *	**13**	---	2.7
Hoseanna @ Brd 6	---	**150**	---	18.9
Popovitch	**0.9** *	**3.5**	---	0.50
Louise	---		---	---
Frances	**1.5**	**3.3**	**0.13**	0.17
Hoseanna @ Brd 3	**449**	**740**	**35.9**	42.6
Two **Bull**	---		---	---

* Changed from **Mack** (1988)

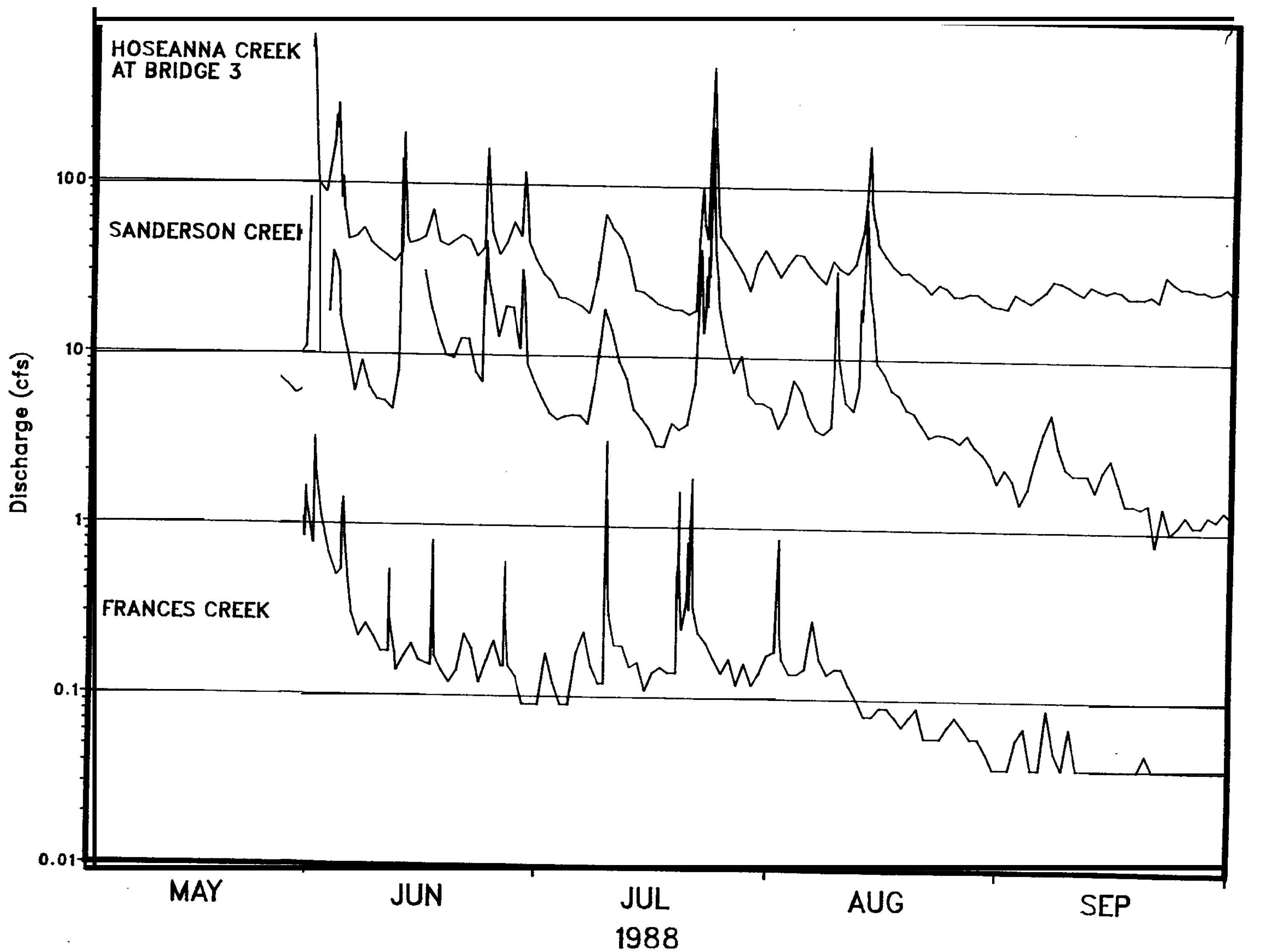

Figure 2 Hydrographs for Hoseanna Creek at Bridge 3, Sanderson and Frances Creeks.

SEDIMENT LOAD

The results of the regressions of log TSS on log Q were good to fair as r^2 values ranged from 0.86 to 0.47. The variances of the sediment rating equations are due to the quality of the discharge records, differences between grab and automated samples, and natural processes. The sediment rating equations are statistically significant and were used to estimate TSS for the calculation of the daily and seasonal sediment loads. Table 4 gives the coefficients, r^2 value, and number of samples used to generate the equations. Each site will be discussed separately.

Table 4. Coefficients, r^2 value, and number of samples used (n) for the sediment rating equations. The equations are of the form: $TSS = aQ^b$. Top row is from 1988, bottom from 1987.

Site	a	b	r^2	n
Sander-son (1988)	2.39	1.97	0.86	108
(1987)	1.50	2.02	0.81	18
North Hoseanna	164	2.04	0.47	70
	425	1.10	0.65	21
Hoseanna @ Brd 6	1.41	1.83	0.72	39
	----	----	----	--
Popovitch	2730	4.69	0.59	19
	730	4.38	0.65	24
Louise	95000	2.27	0.75	14
	----	----	----	--
Frances	16400	1.91	0.55	57
	7260	1.47	0.28	32
Hoseanna @ Brd 3	2.82	1.56	0.74	126
	1.81	1.59	0.71	113
Two Bull	186000	3.37	0.74	13
	----	----	----	--

Sanderson Creek

Figure 3 shows the plot of TSS versus discharge for this creek. This site had the best r^2 value at 0.86. The equation calculated by Mack (1988) is very close to the equation calculated in this report. Both equations are plotted in Figure 3. As discussed by Mack (1988) and Van Sickle and Beschta (1983), hysteresis is common during the flood events due to depletion of the sediment supply. This accounts for some of the scatter in the data.

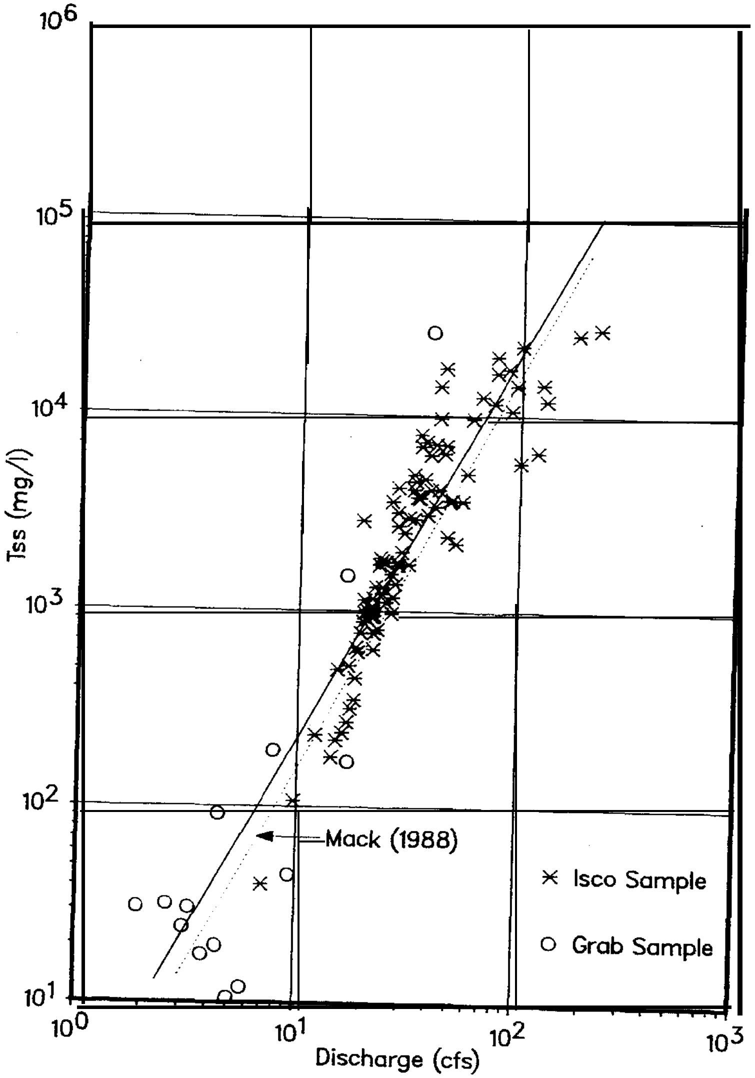

Figure 3. TSS versus discharge for Sanderson Creek (r^2 = 0.86).

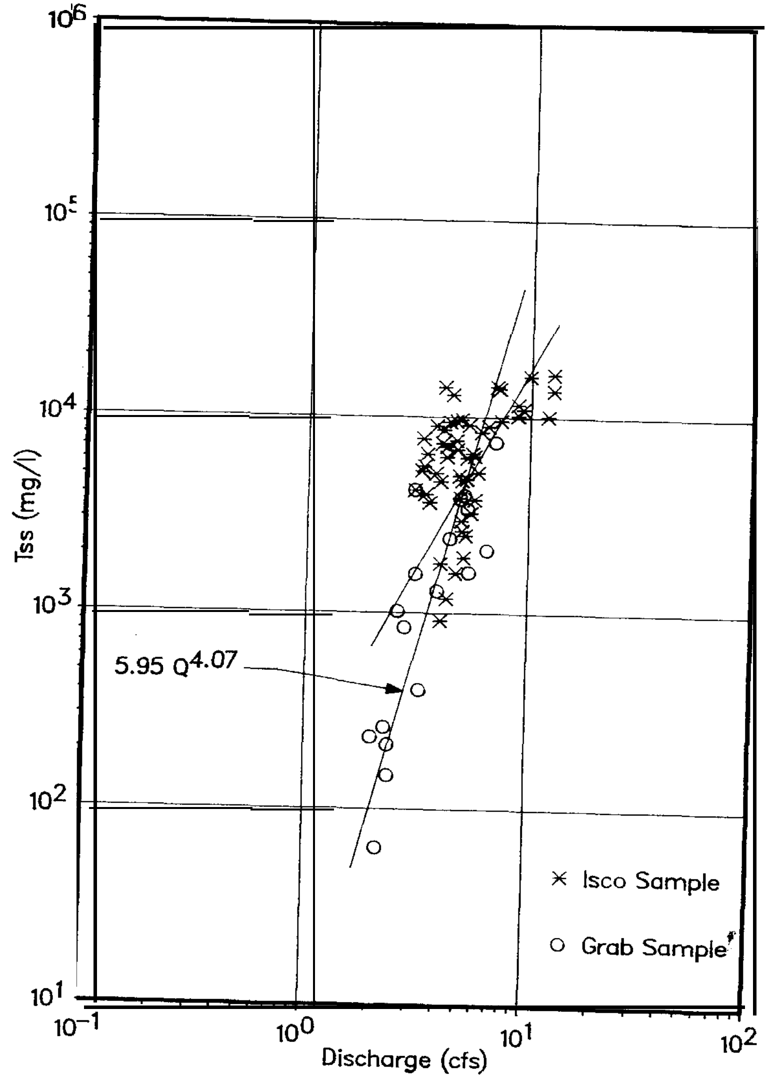

Figure 4. TSS versus discharge for North Hoseanna Creek (r^2 = 0.47).

The estimated suspended load for the period of May 26 to September 30 is 7570 tons. This is **12.8** percent of the load for **Hoseanna** Creek at Bridge 3 for the same period. Appendix C gives the estimated dally loads for all the sites.

North Hoseanna Creek

Figure 4 shows the plot of TSS versus discharge for this creek. The r^2 value for this site is 0.47, the lowest of any of the sites. The large cluster of data at the higher values has a strong influence on the equation. This results in a poor **fit** for the lower values. If the effect of the cluster is eliminated, the equation resulting is: TSS = 5.95 Q $^{4.07}$ (also plotted on Figure 4). This is a much better fit, particularly for the lower values. Both equations were used to calculate the sediment load; the first equation on the high flows and the second on the low flows. The total sediment load for the period of June **15** to October 6 was **1020** ton, which is 4.5 percent of the load for **Hoseanna** Creek at Bridge 3 for the same period. The daily load can be found in Appendix C.

Hoseanna Creek at Bridge 6

Figure 5 shows the plot of TSS versus discharge for this creek. The r^2 value is 0.72. Since the site was established late in the season, only one storm was sampled by the automatic sampler; the remaining data were grab samples throughout the season. The estimated load for the period of July 29 to October 6 was 2610 tons. This is 61 percent of the load for **Hoseanna** Creek at Bridge 3 for the same period. The flow during this period accounted for 61 percent of the total flow at Bridge 3.

Popovitch Creek

Figure 6 shows the plot of TSS versus discharge for this creek. The r^2 value is 0.59. The number of samples used to calculate the equation was less since this site has no automated sampling equipment. The calculated sediment rating equation for this site has the steepest slope. The steep slope results from an unusually large range in the sediment concentrations. The estimated suspended load for the period of June 1 to September 30 was **88** tons. **Mack** (1988) reported that **bedload** at this site was an important part of the total load, and that at flows greater than one cfs the **bedload** was ten times greater than the suspended load. Wilbur and Clark (1988) reported

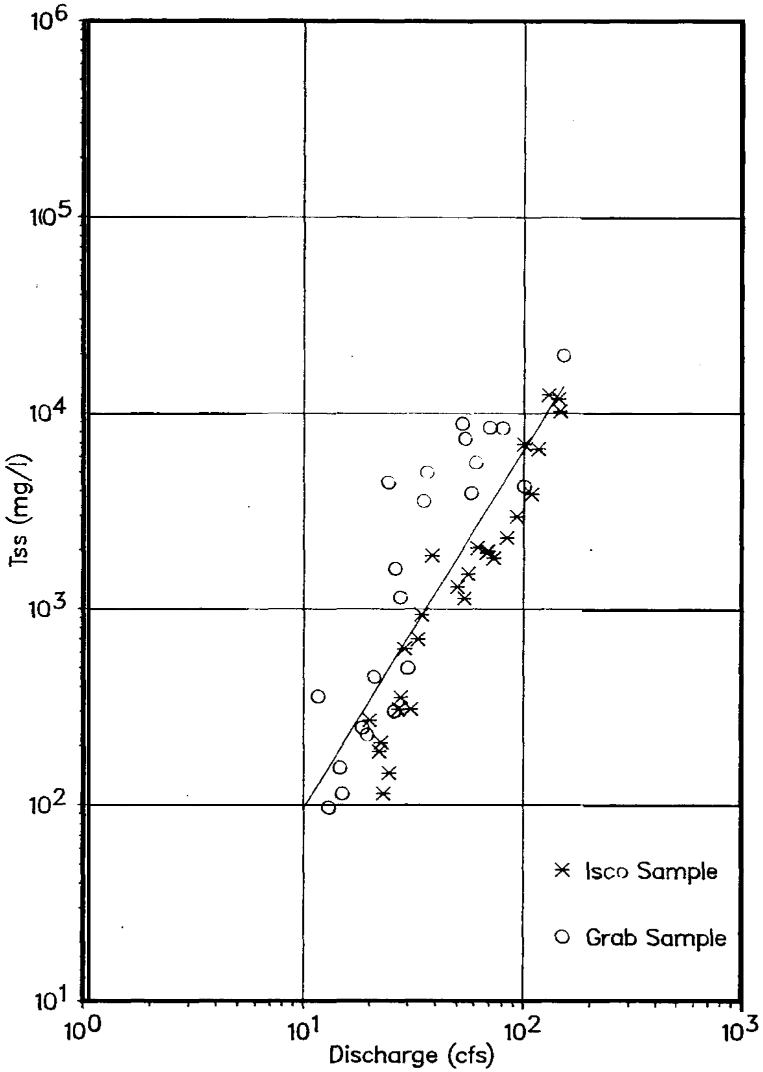

Figure 5. TSS versus discharge for Hoseanna Creek at Brd 6 (r^2 = 0.72).

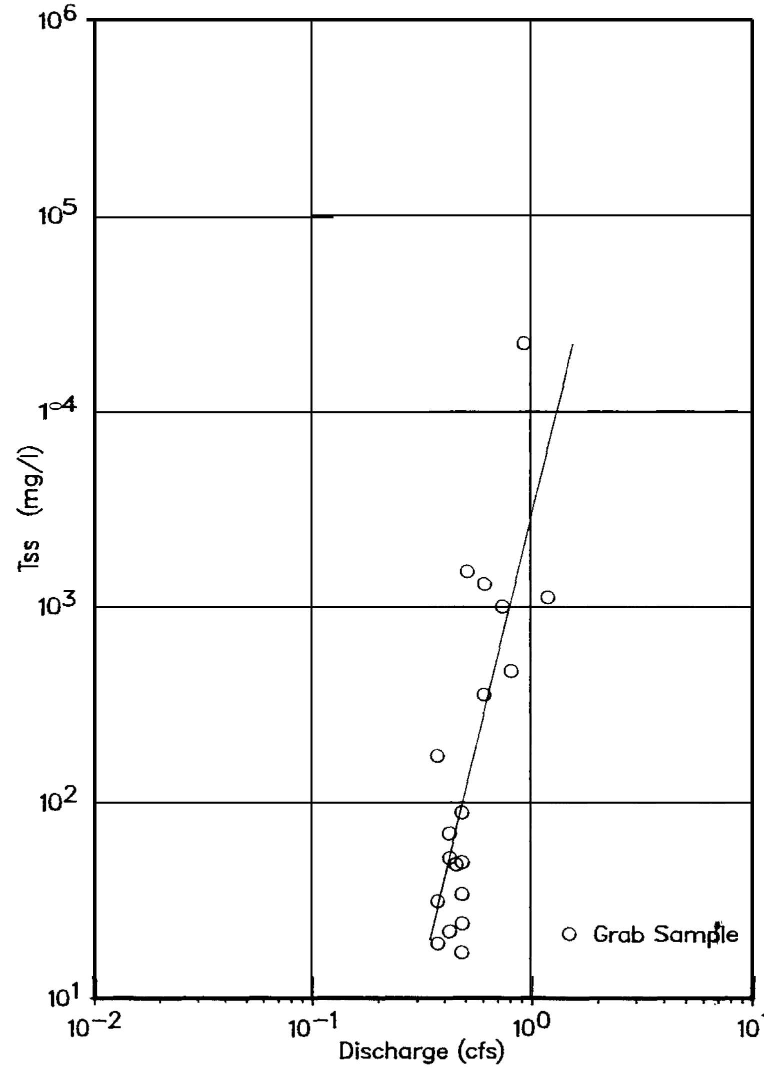

Figure 6. TSS versus discharge for Popovitch Creek (r^2 = 0.59).

that the percent bedload for Popovitch Creek ranged from 34 to 94 percent of the total load The contribution of this creek to the total sediment load at Bridge 3 is small.

Louise Creek

Figure 7 shows the plot of TSS versus discharge for this creek. The r^2 value is 0.75. The rating equation was calculated from grab samples only. The automated equipment never sampled since the change in water surface level was small. There is no continuous discharge record, so no estimate of sediment load was made. The basin size and sediment rating equation is similar to that of Frances Creek, so one might expect a similar seasonal sediment load, although it may be greater since the slope of the sediment rating equation for Louise Creek is steeper.

Frances Creek

Figure 8 shows the plot of TSS versus discharge for this creek. The r^2 value is 0.55. The sediment load estimated for June 1 to October 6 is 401 tons. This is 1.2 percent of the estimated load for Hoseanna Creek at Bridge 3 for the same time period.

Hoseanna Creek at Bridge 3

Figure 9 shows the plot of TSS versus discharge for this creek (also plotted is the equation used by Mack (1988)). The r^2 value is 0.74. This site has the most data of all the sites. Although the r^2 value is good, the plot shows that the relationship between TSS and Q is not quite linear (a slight curve might give better results). Therefore at lower flows, the rating equation over estimates the TSS. For this reason, a better fit equation was applied to the lower flow values (less than 50 cfs) when estimating the daily and seasonal sediment loads. The total sediment load for May 26 to October 5 was 59,200 tons.

Two Bull Creek

Figure 10 shows the plot of TSS versus discharge for this creek. The r^2 value is 0.74. For the same reason as Louise Creek, only grab samples were used for calculating the sediment rating equation and no estimate was made of the sediment load.

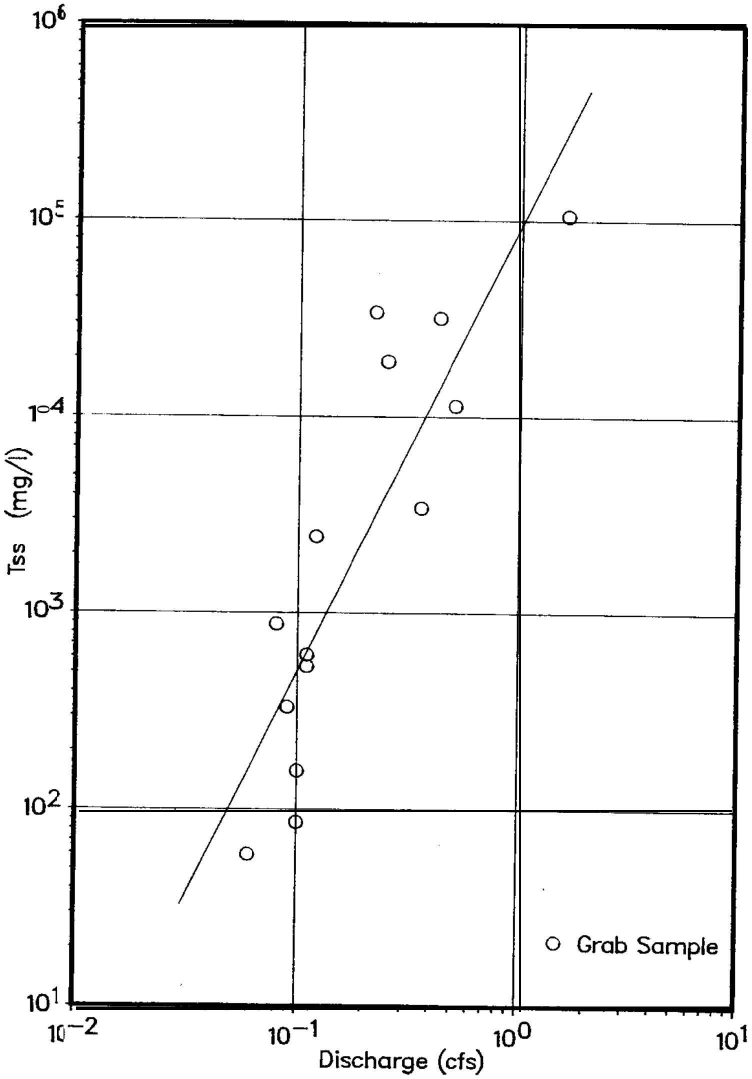

Figure 7. TSS versus discharge for Louise Creek (r^2 = 0.75).

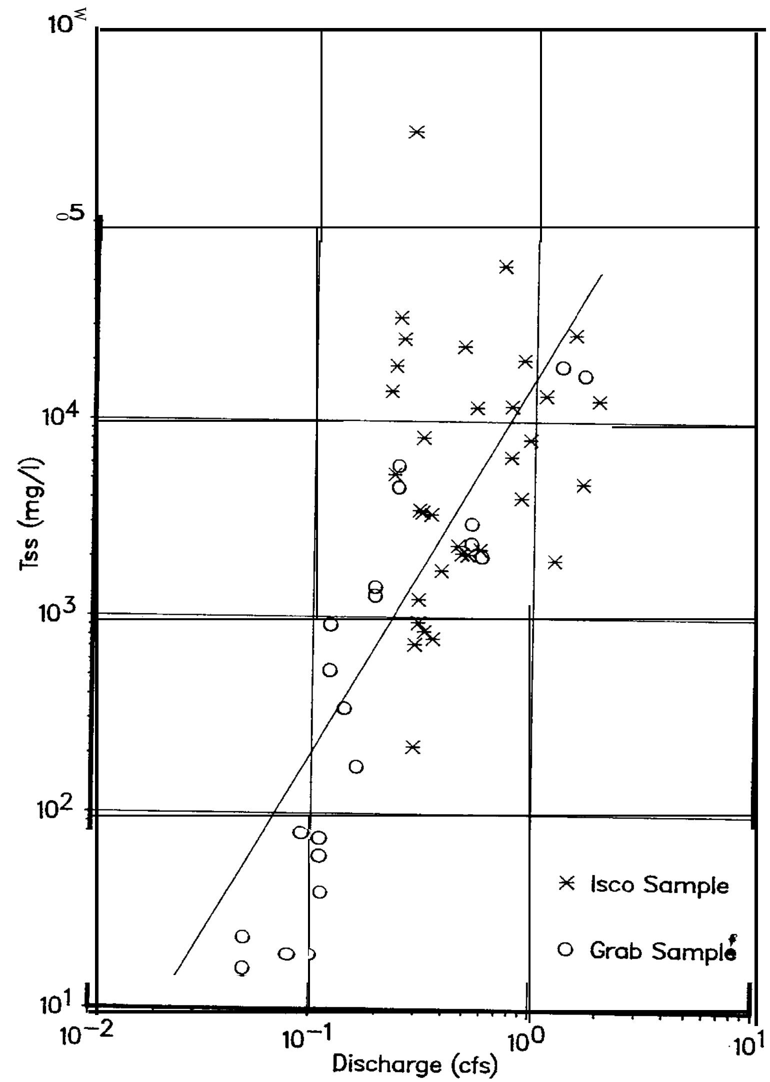

Figure 8. TSS versus discharge for Frances Creek (r^2 = 0.55).

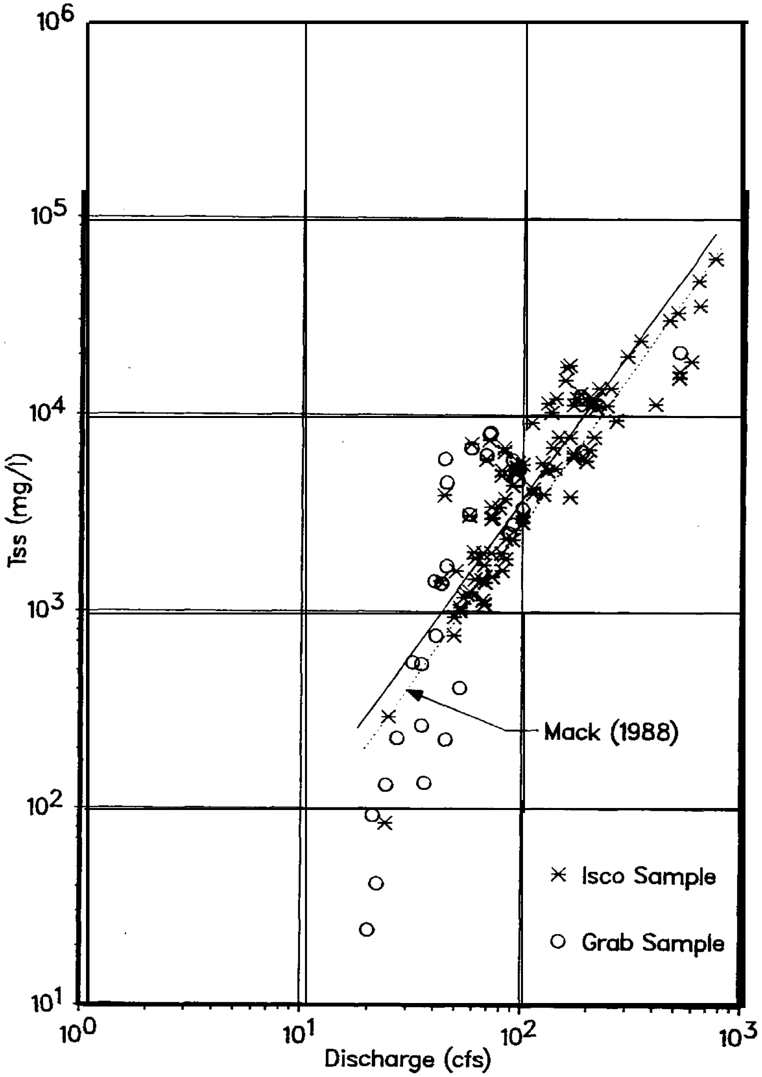

Figure 9. TSS versus discharge for Hoseanna Creek at Brd 3 (r^2 = 0.74).

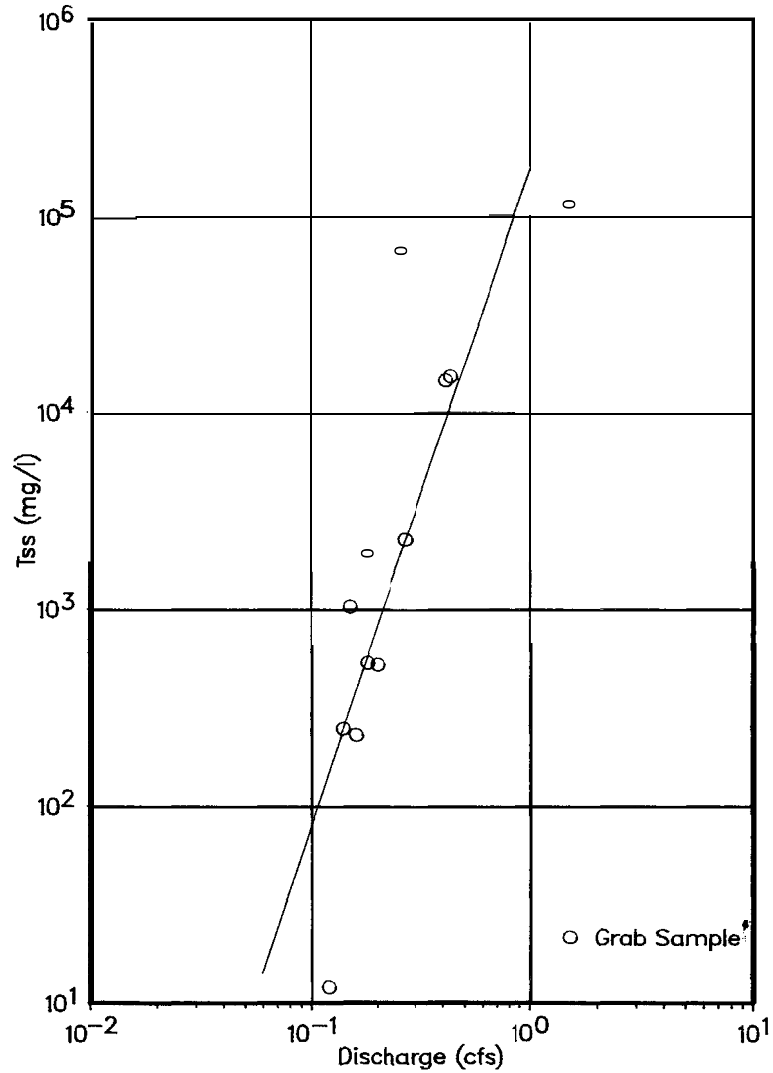

Figure 10. TSS versus discharge for Two Bull Creek (r^2 = 0.74).

WATER QUALITY

Surface Water

Appendix F shows the results of the water chemistry analyses of the samples collected during 1988 at sites located on Hoseanna Creek at Bridge 3 (upstream of Poker Flats mine) and Bridge 1 (downstream of Poker Flats mine). Field-determined parameters of water temperature, pH, dissolved oxygen, and conductivity were simiiar between sites. Water temperature and dissolved oxygen concentrations varied between sites on July 19 because irradiation warmed the stream throughout the day. Except for water temperature and dissolved oxygen, field-determined parameters were similar on the three sampling dates. Stream pH at both sites was slightly basic. Dissolved oxygen concentrations were at or near saturation on each sampling date. The mean value for specific conductance was 494 umhos/cm at Bridge 3 and 533 umhos/cm at Bridge 1. Calcium-carbonate alkalinity averaged 121 mg/l at Bridge 3 and 122 mg/l at Bridge 1.

The ionic composition, expressed as percentages of major cations and anions, was similar between sites and among sampling dates (Table 5).

Table 5. Percentages of the major ion composition (in meq/l) at Hoseanna Creek on May 23, July 19, and September 8, 1988.

	Bridge 3			Bridge 1		
	5/23	7/19	9/8	5/23	7/19	9/8
Calcium	38	37	36	38	37	34
Magnesium	57	53	42	56	52	39
Sodium	5	9	20	6	10	25
Potassium	<1	1	2	<1	1	2
Bicarbonate	45	42	54	45	43	51
Sulfate	31	29	32	27	28	31
Chloride	24	29	14	28	29	18
Nitrate	c l	<1	<1	<1	Cl	<1

Magnesium was the predominant cation in May and July. The percentage of sodium ions increased at both sites in September. No anion predominated during May and July, but the percentage of bicarbonate ions increased and chloride ions decreased in September. Nitrate concentrations represented less than one percent of the ionic composition at both sites and no elevated concentrations were measured during early summer sampling. Heavy metal and trace element concentrations were similar between sites and among dates (Appendix F). Arsenic, cadmium, copper, lead and zinc concentrations were below the detection limits of the laboratory analyses. Manganese exceeded the secondary maximum contaminant concentration (0.05 mg/l) for Alaska public drinking water supplies (Alaska Department of Environmental Conservation (ADEC), 1982), averaging 0.39 mg/l at Bridge 3 and 0.41 mg/l at Bridge 1. No other trace element exceeded Alaska driig water standards (Table 6).

Physical properties of the streams were similar between sites (Appendix F). The mean color value was 40 PCU at Bridge 3 and 47 PCU at Bridge 1. Turbidity ranged from 29.5 to 342 NTU at Bridge 3 and 36 to 444 NTU at Bridge 1, with the highest values measured during the early summer sampling period. Total suspended sediment concentration also varied among sampling dates, ranging from 84.2 to 1440 mg/l at Bridge 3 and 78.6 to 2360 mg/l at Bridge 1. Settleable solids were measured in trace or very low volumes at both sites (Appendix F).

Ground Water

The locations of six ground water monitoring wells (GAMW-IA - GAMW-5) are given in Table 7. A detailed description of the wells and installation procedures is given by Golder Associates (1987). GAMW-3 obtained water from alluvial materials east of Runaway Creek, upgradient of Poker Flats Mine spoils. GAMW-4 and GAMW-5 are located on the Poker Flats Mine spoil slopes between the active mining area and Hoseanna Creek, and are situated to intercept ground water discharge from the mined areas (Golder Associates, 1987). GAMW-IA, GAMW-1B, and GAMW-1C are located uphill of the mine and tap coal seam #4, the interburden between the #3 and #4 coal seam, and coal seam #3, respectively, of the unmined Suntrana Formation (Golder Associates, 1987).

Table 6. Mean values of selected water quality constituents from ***Hoseanna*** *Creek sites, 1987 and 1984 and respective Alaska* ***Water Quality Standards.*** *Mean values based on six samples. All values in* ***mg/l*** *unless* ***otherwise*** *noted*

	1987	1988	Alaska Water Quality Standard’
Field Determination			
pH	*7.29*	7.24	6.0-8.5
Dissolved oxygen	12.8	11.0	> 4.0
Specific Conductance (umhos/cm)	510	545	---
Cations			
Calcium	34.8	35.6	---
Magnesium	27.4	26.9	---
sodium	14.1	15.9	**250**
Potassium	3.6	3.9	---
Anions			
Bicarbonate	143.5	147.7	---
Sulfate	70.6	66.9	*250*
Chloride	27.7	32.6	*250*
Nitrate	0.34	3.99	10
Trace Elements			
Arsenic	**<0.004**	**<0.004**	0.05
Barium	0.085	0.108	1.0
Cadmium	**<0.01**	co.01	0.01
Chromium	**<0.002**	co.002	0.05
Iron (dissolved)’	0.04	0.04	0.3
Manganese	0.33	0.26	0.05
Lead	< 0.03	< 0.03	0.05
Zinc	**<0.02**	co.02	5.0
Lab Determinations			
Color **(pcu)**	33	*36*	**75**
Total Suspended Sediment	740	*894*	--- [3]
Turbidity (NTU)	205	*250*	--- [4]
Acidity	5.1	4.2	---
Total Dissolved Solids	329	348	500

[1] Alaska Water Quality Standards are based on the following freshwater use: Water supply - drinking, culinary and food processing (ADEC, 1987).
[2] The mean is estimated by assigning values to “less than” values, assuming a uniform distribution of data between 0 **mg/l** and the detection limit.
[3] No increase above natural conditions.
[4] Ten percent above natural conditions.

*Table 7. Coordinates **for ground** water monitoring wells at Usibelli Coal Mine.*

Well Name	Longitude	Latitude
GAMW-1A	**148°-55'-29.819"**	**63°-53'-50.416"**
GAMW-1B,1C	**148°-55'-27.170"**	**63°-53'-51.192"**
GAMW-3	**148°-54'-42.493"**	**63°-54'-26.560**
GAMW-4	**148°-55'-33.900**	**63°-54'-26.906**
GAMW-5	**148°-56'-57.164"**	**63°-54'-18.897"**

Initial water levels and response to purging and sampling of each of the ground water monitoring wells is shown on Table 8. Because wells were not developed at the time of installation (Golder Associates, 1987) additional purging was done during May 1988 prior to sampling to reduce turbidity in **GAMW-3** and **GAMW-4.** Very low water yield, high turbidity, and unstable **specific** conductance were encountered on each sampling date at GAMW-5.

Attempts were made to sample **GAMW-1A, GAMW-1B,** and **GAMW-1C** in November 1987, but were unsuccessful because of equipment failure caused, in part, by subzero temperatures. **GAMW-1C** was sampled in July 1988; but samples from **GAMW-1B** or **GAMW-1A** were not obtainable. **GAMW-1B** had a very low water yield and the sampling pump continually clogged with sediment. The PVC casing in **GAMW-1A** was constricted at the 50 ft depth, and pumps malfunctioned when they were forced past the constriction.

The results of water quality analyses of samples collected three times in 1988 in GAMW-3, **GAMW-4,** and GAMW-5 and once in **GAMW-1C** are shown in Appendix F.

Values of field-determined parameters varied among sites. Specific conductance varied considerably among wells, ranging from a mean value of 455 **umhos/cm** in **GAMW-4** to 6254 **umhos/cm** in GAMW-5. Alkalinity averaged 358 **mg/l** in **GAMW-3, 207 mg/l** in **GAMW-4, 579 mg/l** in **GAMW-5,** and 1680 **mg/l** in **GAMW-1C.** The alkalinity in **GAMW-1C** may be slightly underestimated because the water sample was effervescent. Water temperature was generally consistent among sampling dates and averaged less than 4 **°C** in all wells. Ground water in all wells was slightly acidic.

Table 8. Initial water level readings and purging protocol for ground water monitoring wells at Usibelli Coal Mine.

Well Name	Date	Initial[1] Depth to Water (ft)	Calc Casing Volume (gal)	Volume Pumped (gal)	Pumping Rate (gal/hr)	Comments
GAMW-3	9-15-87	26.86	---	---		
	5-23-88	25.97	1.5	1.4	---	2
	5-24-88	27.69	1.2	8.0	---	3
	7-18-88	27.59	1.3	4.1	5.0	
	9-07-88	28.04	1.2	8.0	6.4	
GAMW-4	9-15-87	7.68	---	---		
	5-24-88	7.96	3.6	6.8	---	4
	5-25-88	8.28	3.6	17.0	12.7	
	7-18-88	8.74	3.5	14.7	9.8	
	g-07-88	8.62	3.6	12.0	13.1	
GAMW-5	9-15-87	72.22	---	---	---	
	5-25-88	71.84	3.9	7.0	2.3	
	7-18-88	82.70	2.3	5.3	1.3	
	7-19-88	-----	---	---	1.1	5
	9-07-88	82.87	2.2	---		6
GAMW-1C	9-15-87	221.61	---	---		
	11-23-87	222.03	---	---	---	
	7-20-88	224.16	20.2	27.5	3.1	
GAMW-1B	9-15-87	210.87	---	---	---	
	11-23-87	192.58	---	---	---	
	7-19-88	197.04	---	---	---	
GAMW-IA	9-15-87	153.73	---	---		
	7-21-88	157.51	---	---	---	

Comments:

1. All measurements are from top of PVC casing.
2. Irregular pumping rate due to low water yield and pump failure.
3. Irregular pumping rate due to low water yield.
4. Irregular pumping rate due to ice in well.
5. Pumped well from 2330 hrs, 7-18-88 to 1040 hrs, 7-19-88 due to very low water yield.
6. Pumped well from 1755 hrs, 9-7-88 to 1053 hrs, 9-8-88 due to very low water yield.

Ground water inorganic chemistry, represented by average percentages of the major ions, varies widely among wells (Table 9). Ground water is classified as sodium bicarbonate-chloride water (GAMW-3), calcium-potassium bicarbonate water (GAMW-4), sodium chloride water (GAMW-5), and sodium bicarbonate water (GAMW-1C).

Mean values and ranges for trace element concentrations and field-measured parameters for ground water are shown on Table 10. Constituents which exceeded the Alaska Drinking Water Standards (ADEC, 1982) were cadmium in GAMW-4, fluoride and barium in GAMW-5, lead and pH in GAMW-3 and GAMW-5, and iron and manganese in all wells (Table 10). Total dissolved solids concentrations exceeded the Alaska Drinking Water Standard of 500 mg/l in GAMW-3, GAMW-5, and GAMW-1C. Concentrations of the major nutrients, nitrate and orthophosphate, were below detection limits in all wells except GAMW-1C, where the orthophosphate concentration was 5.35 mg/l.

There was no significant observable variability in ground water quality in GAMW-3, GAMW-4, and GAMWJ (Appendix F), except for the magnesium concentration in GAMW-5 which was significantly lower during September (Appendix F).

Table 9. Percentages of the major ion composition (in meq/l) of ground water monitoring wells at Usibelli Coal Mine, 1988.

	GAMW-3	GAMW-4	GAMW-5	GAMW-1C
Calcium	21	43	19	7
Magnesium	16	20	18	13
Sodium	59	7	62	76
Potassium	4	30	1	4
Bicarbonate	47	87	20	86
Chloride	42	2	78	13
Sulfate	11	10	2	1
Fluoride	<1	1	<1	C1

Table 10. Mean values of selected water quality constituents from the ground water monitoring wells and respective Alaska Drinking Water Standards. Mean values based on three samples, except for well GAMW-1C (single sample). All values are in mg/l unless otherwise noted.

	GAMW-3	GAMW-4	GAMW-5	GAMW-1C	Alaska Drinking Water Standard
Arsenic	*co.004*	0.01[1]	*0.009*	<0.004	0.05
Aluminum	*0.284*	0.192	0.261	*0.294*	---
Barium	*0.348*	0.303	1.27	0.245	1.0
Beryllium	< 1.0	c 1.0	< 1.0	< 1.0	---
Cadmium	<0.001	0.02[1]	0.002[2]	co.001	0.01
Copper	0.10'	0.28	0.05[1]	c 0.01	1.0
Chromium	0.003	<0.001	0.003	0.002	0.05
Iron (total)	42.2	10.9	53.2	0.35	---
Iron (dissolved)	29.7	6.45	38.2	0.28	0.03
Manganese	1.23	0.67	8.84	0.12	0.05
Nickel	co.05	co.05	< 0.05	< 0.05	co.05
Lead	0.109	co.03	0.184	0.05	0.05
Zinc	CO.02	0.18	< 0.02	0.28	5.0
Fluoride	0.815	1.21	5.57	0.59	2.4
Nitrate	< 0.2	<0.2	<0.2	<0.2	10.0
Phosphate	< 0.05	< 0.05	co.05	5.35	---
Field Determinations					
Water Temperature (°C)	2.6	1.7	3.6	3.8	---
PI-I	6.2	6.7	6.3	6.7	6.5-8.5
Specific Conductance (umhos/cm)	1582	455	6253	3318	---
Alkalinity	358	207	579	1680	---
Lab Determinations					
Total Dissolved Solids	1090	406	3788	3093	500
Acidity	164	57.3	218	71.4	---

1 The mean is estimated by assigning the detection limit value to the "less than" value.
2 The mean is estimated by assigning values to "less than" values, assuming a uniform distribution of data between zero mg/l and the detection limit.

DISCUSSION

Gold Run Pass received 17.04 inches of precipitation for the 1988 summer season. This was 39 percent greater than the 12.24 inches which fell in 1987, and 22 percent greater than the amount which fell at Poker Flats in 1988. The total at Gold Run Pass was 30 percent greater than Poker Flats during the months of June, July and August, but only five percent greater during May and September. This suggests that convective showers during the warmer months accounts for the difference at the two sites (some of the difference may be due to the different types of gages used). The convective showers appear to be more frequent or heavier in the upper basin. Although the convective events can produce heavy rainfall, they are usually isolated and are a short duration. These events are not responsible for significant sediment production, since they do not result in wide spread runoff. The events responsible for significant runoff are the large cyclonic storms from the Gulf of Alaska which produce large amounts of rain for 24 to 48 hours. These storms can produce an excess of two inches. If such an event occurs early in theseason (late May or Early June), melting snow and frozen ground will contribute to the water available for runoff. An example of this happened on May 31, 1988. A tremendous amount of sediment was transported in a single event.

The increase in storm activity this year resulted in an increase in the total runoff for the season. Table 3 showed the season average and peak flows for each site for the two summers. Each site had higher peak flows (except North Hoseanna Creek). Mack (1988) reported season averages for three basins. The season average for 1988 for the same sites was up an average 22 percent from 1987 (up 19 percent at Hoseanna Creek at Bridge 3). The peak flows for Hoseanna Creek at Bridge 3 and Sanderson Creek were up 65 and 50 percent respectively.

The increase in runoff produced an increase in the sediment load. Table 11 gives the sediment loads for 1987 and 1988 (these estimates do not include spring runoff and are for the period of discharge record). The sediment load during 1988 for Hoseanna Creek at Bridge 3 was 48 percent higher than in 1987 although the average flow increased by only 19 percent. This shows the importance of the high flow events in determining the seasonal sediment load of the basins. Both Sanderson and Popovitch Creeks contributed approximately the same percentage of the seasonal sediment load for Hoseanna Creek at Bridge 3 in 1987 and 1988. However, there are large differences at North Hoseanna and Frances Creeks. A more comprehensive data set was gathered for Frances Creek in 1988, much more than Mack (1988) obtained in 1987. It is difficult to say whether one data set is better than the other, as annual differences will produce different equations. This is especially true for the smaller creeks.

Table 11. Sediment load estimates (for the period of discharge record) and basin distribution for 1987 and 1988.

Site	Estimated load	Brd 3 load, same period	Percent of Brd 3 load	Percent of total basin area
Sanderson (1988)	7570	59200	12.8	11.6
(1987)	5600	40000	14.0	
North Hoseanna	1020	22488	4.54	7.2
	7500	40000	18.8	
Hoseanna @ Brd 6	2606	4262	61.2	47.5

Popovitch	88	33031	0.27	9.3
	60	40000	0.15	
Frances	401	33042	1.21	1.7
	45	40000	0.11	
Hoseanna @ Brd 3	59200	59200	100	100
	40000	40000	100	

The majority of sediment transported during a season occurs over a relatively short period of time. To illustrate this, Table 12 shows the percentage of sediment transported in discrete periods of time. The table shows that an average of 80 percent of the sediment transported occurs in less than ten days.

The statistical quality of the sediment rating equations is a function of the physical parameters of the basin. The larger streams (Sanderson and Hoseanna Creeks) had higher r^2 values than the smaller creeks. This is due to small mass wasting events which supply pulses of sediment to the smaller streams. Figure 11 shows such an event on Frances Creek occurring on the recession limb of a high-flow hydrograph on July 21, 1988. This creates a large variation in the sediment concentration for that discharge. This results in a lower r^2 value for that stream. This is not as great of a factor on the large streams due to the wider channels and higher flows diluting the pulses.

Another factor which lowers the r^2 value of the rating equations is the seasonal variation of sediment available for transport. The supply of readily available sediment decreases through the summer (Wilbur, 1989). Data collected from Hoseanna Creek at Bridge 3 is used to illustrate this. Plotted in Figure 12 is data from storm events on June 3 and **July** 21-23. The data indicate that the sediment concentration was lower for the July storm, especially at lower flows.

*Table 12. The percentage **of** seasonal sediment load in **short** durations.*

Site	DAYS 1	2	3	5	10
Sanderson	26	48	62	77	88
North Hoseanna	17	29	40	47	60
Hoseanna @ Brd 6	55	62	68	71	a2
Popovitch	27	36	44	53	67
Frances	27	41	52	71	93
Hoseanna @ Brd 3	44	55	65	78	87
Average	33	45	55	66	80

WATER QUALITY

Surface Water

Hoseanna Creek water quality determinations made during 1987 (Mack, 1988) and 1988 are representative of a narrow range of stream discharges (23 to 46 cfs), which represent ambient early spring to late summer low-flow conditions. Sampling trip timing did not coincide with major rainfall events, and Hoseanna Creek water quality under high-flow conditions is not represented. However, because rainfall events were normally of short duration and the stream quickly returned to ambient low flow conditions during 1987 and 1988, the analyses are representative of Hoseanna Creek water quality during most of the open-water time period.

Mean values of water ionic constituents, based on two years of data collected at a site upstream of mining (Bridge 3) and a site downstream of mining (Bridge 1), show no significant difference between the two sites (Table 13), except for nitrate concentrations which were elevated at Bridge 1 in June 1987. This may have been a result of fertilizer application near the stream prior to sampling. In May 1988, Hoseanna Creek was sampled two days before aerial fertilization of spoil slopes, and elevated nitrate concentrations were not observed.

The water-type classification of Hoseanna Creek, based on mean ionic compositions shown on Table 6, is calcium-magnesium bicarbonate water. However, ionic composition did vary slightly between 1987 and 1988 at both

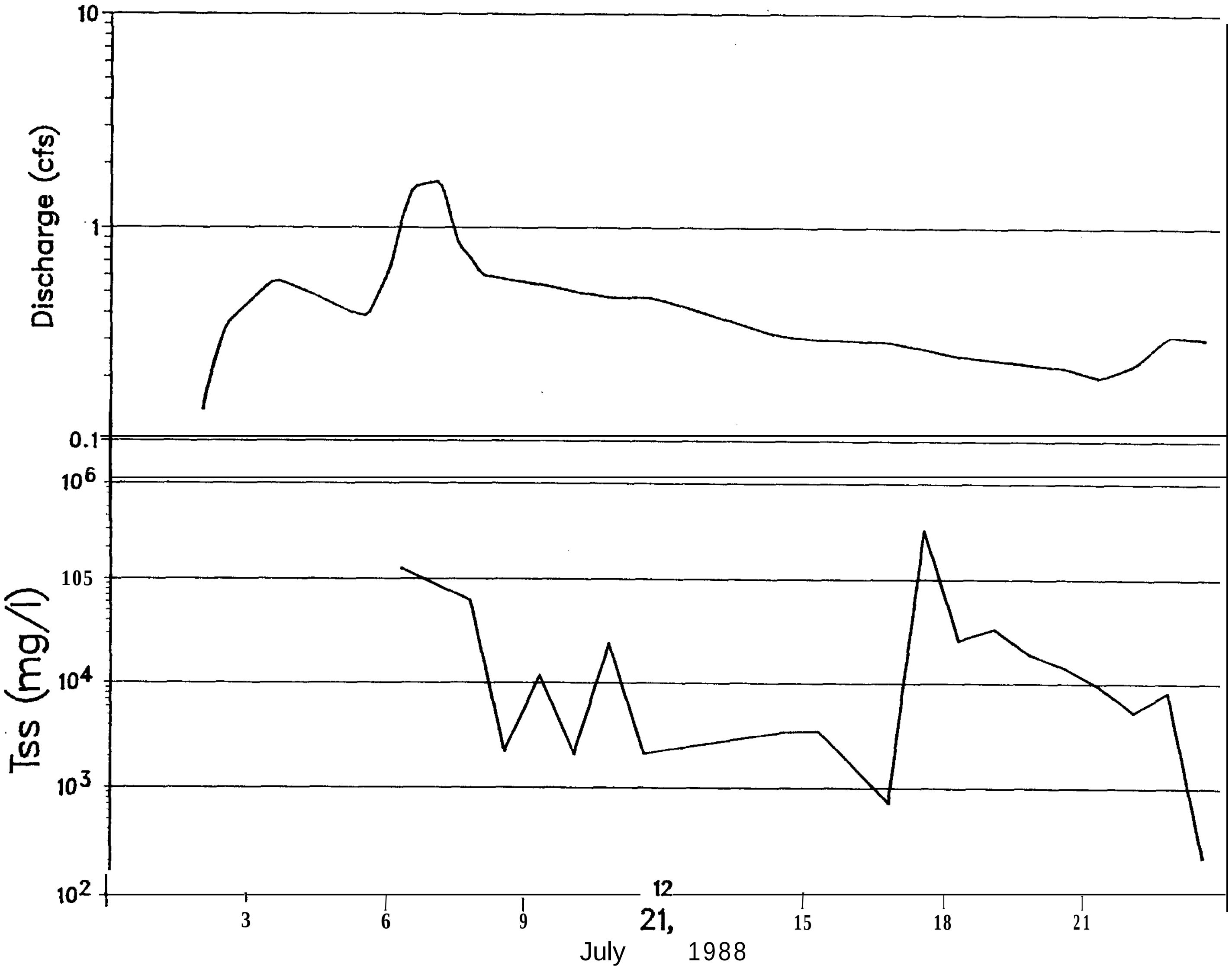

Figure II. Discharge and TSS plotted versus time for storm event at Frances Creek on July 21, 1988. Sharp rise in TSS at 1700 hrs is due to mass wasting event upstream of sampling station.

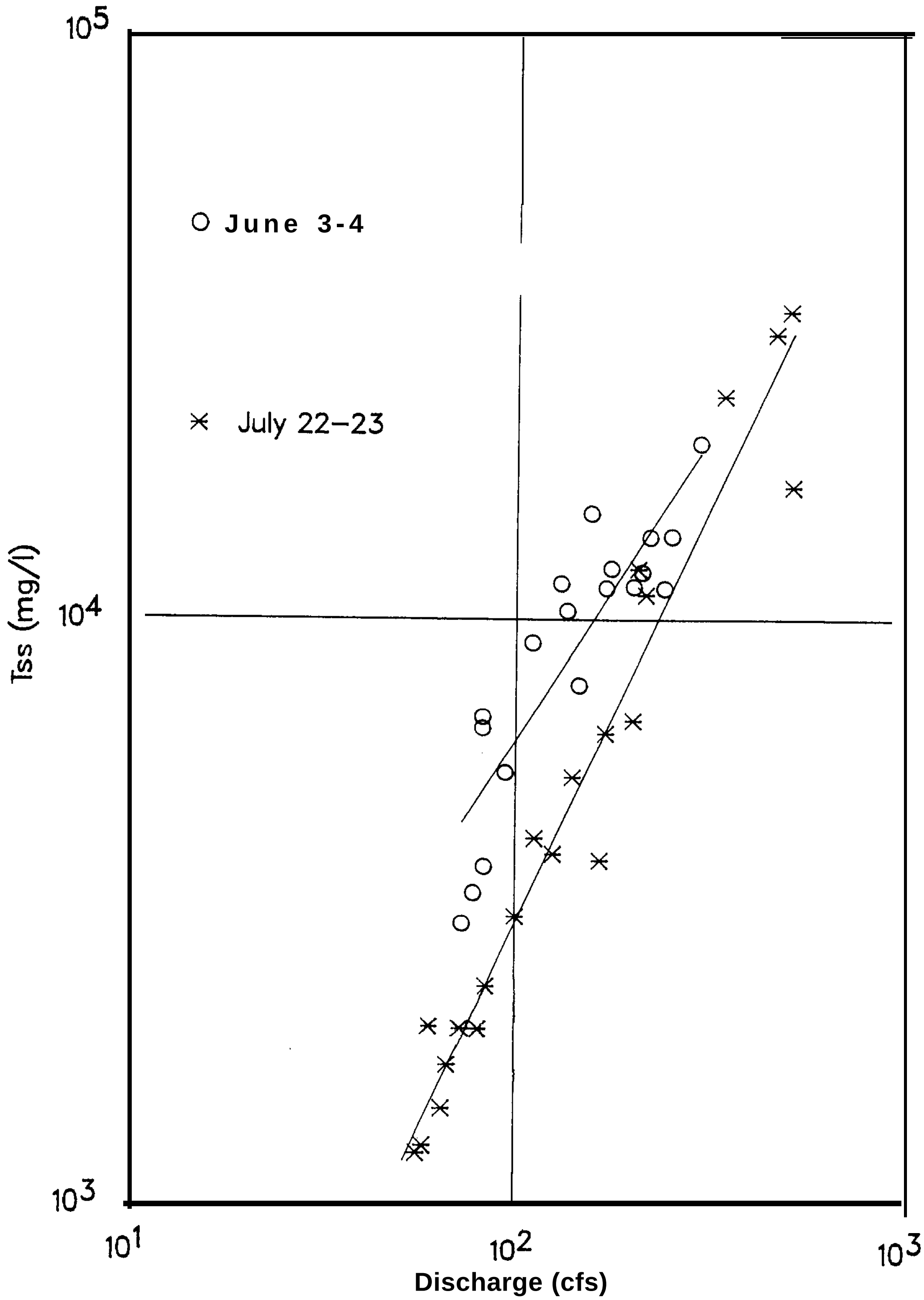

Figure 12. TSS versus discharge for two storm events.

sites (Table **13).** There was a **slight** increase in the percentage of magnesium ions and a corresponding decrease in sodium ions in 1988. This trend was reversed in September 1988, that is, lower magnesium and higher sodium percentages. The percentage of chloride ions was higher in 1988 than in 1987. As a result, ionic concentrations and, therefore, total dissolved solids concentrations were **slightly** higher in 1988 at both sites (Table **13).** These trends are observed at sampling stations both upstream and downstream of the active mining area.

*Table 13. Percentages **of** the major ion composition (in **meq/l**) at **Hoseanna** Creek sites, 1987 and 1988.*

	1987			1988		
	6/8	**8/3**	**9/14**	**5/23**	**7/19**	**9/8**
BRIDGE 3 (upstream)						
Calcium	36	38	37	38	37	36
Magnesium	43	44	47	57	53	42
sodium	18	15	14	5	9	20
Potassium	3	3	2	<1	1	2
Bicarbonate	56	55	58	45	42	54
Sulfate	33	35	33	31	29	32
Chloride	10	10	9	24	29	14
Nitrate	C1	<1	<1	<1	<1	<1
Total Dissolved Solids	245	314	341	305	402	368
	Mean value = 300			Mean value = 358		
BRIDGE 1 (downstream)						
Calcium	37	39	38	38	37	34
Magnesium	42	43	45	56	52	39
Sodium	18	15	14	6	10	25
Potassium	3	3	3	<1	1	2
Bicarbonate	54	55	58	45	43	51
Sulfate	26	32	30	27	28	31
Chloride	11	13	11	28	29	18
Nitrate	9	<1	<1	<1	<1	<1
Total Dissolved Solids	285	338	364	322	409	372
	Mean value = 329			Mean Value = 368		

Ground Water

A topic important to the interpretation of ground water quality data is the representativeness of samples obtained from each well. Even though wells were not developed prior to sampling, samples from GAMW-3, GAMW-4, and GAMW-5 are inferred to be representative of local ground water because inorganic chemistry did not vary over the summer sampling period. The single sample at GAMW-1C also appears to be representative of local ground water because the specific conductance varied less than 8 percent during seven hours of well purging.

The purpose of the ground water monitoring program is to monitor ground water quality of the undisturbed Suntrana formation, mined spoils, and Hoseanna Creek alluvium. GAMW-3 is the "control well" with respect to Poker Flats mine spoils because it is up gradient of spoil slopes. GAMW-4 and GAMW-5 are installed in alluvial material according to Golder Associates (1987), but are physically situated in Poker Flats mine spoil areas. Interpretation of ground water quality in GAMW-3, GAMW-4, and GAMW-5 is complicated by the fact that GAMW-4 and GAMW-5 have very different major ion composition. In fact, total dissolved solids concentration in GAMW-4 is lower than in the control well, GAMW-3 (Table 10). The reason for the relatively unmineralized water of GAMW-4 is unknown, but may be a result of a relatively low residence time of water within the ground water flow system.

The concentration relationship between potassium and sodium ions in GAWM-4 is unusual. Normally in natural waters potassium concentrations do not exceed sodium concentrations unless both are below five mg/l (Hem, 1985). The potassium concentration is seven times higher than the sodium concentration in GAWM-4 (Appendix F) which indicates the ground water has uncommon geochemistry.

Ground water quality of GAMW-5 differs from GAMW-4 and GAMW-3 in that it is classified as a sodium chloride water and has a significantly higher total dissolved solid content. The reason for the higher sodium and chloride concentrations is unknown. Two physical attributes that may affect ground water quality at GAMWJ are that it is a deeper well at 95 ft than GAMW-3 and GAMW-4, which are 33 ft and 29 ft, respectively, and the well yield is lower.

The water quality of GAMW-1C is characterized by high alkalinity. The water sample was visibly effervescent at atmospheric pressure, which is presumably due to release of carbon dioxide because there was no obvious hydrogen sulfide odor associated with water from GAMW-1C.

CONCLUSIONS

1. Large cyclonic storms are responsible for most of the sediment transport, while the isolated convective storms result in minor sediment production.

2. A large portion of the seasonal sediment load occurs during the first major flood event of the season (may coincide with break-up), often before the hydrologic stations can accurately be monitored.

3. Most of the seasonal sediment load is transported over a relative few days during high-flow events.

4. Rating equations have a limited accuracy, in that they are power functions.

5. Good sediment rating equations (high r^2 values) are difficult to obtain for small creeks with mass wasting events.

6. Some streams are better suited for the establishment of good rating equations (also noted by Wilbur, 1989).

7. Hysteresis results in additional variance in the calculation of the sediment rating equations.

8. The available sediment for transport decreases through the summer, resulting in additional variance in the calculation of the sediment rating equations.

9. Water quality at two sites in Hoseanna Creek, Bridge 3 (upstream of Poker Plats mining) and Bridge 1 (downstream of Poker Plats mining) is similar during low streamflow periods in the summer.

10. The water type classification for the four ground water monitoring wells is significantly different.

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APPENDIX A

GOLD RUN PASS

DAILY PRECIPITATION (in)

	MAY	JUN	JUL	AUG	SEP	OCT
1		0.36		0.12		
2		0.24		0.12		
3		0.48		0.36	0.12	
4			0.24	0.12		
5				0.12	0.36	
6		0.36			0.24	
7		0.12				
8			0.48	0.48	0.24	
9			0.72	0.12		
10			0.12			
11		0.60	0.36	0.24	0.24	
12	0.12	0.48		0.60	0.12	
13						
14						
15	0.24	0.36				
16		0.24				
17						
18						
19						
20		0.24	0.24			
21		0.36	0.96	0.12	0.12	
22	0.24	0.72	1.20			
23		0.48	0.36			
24	0.24					
25						
26		0.48			0.12	
27		0.36	0.24			
28						
29	0.12					
30	0.48		0.12			
31	0.72			0.12		
Total	2.16	5.88	4.92	2.52	1.56	

Season Total = 17.04

APPENDIX B

SANDERSON CREEK

DAILY AVERAGE DISCHARGE (cfs)

	MAY	JUN	JUL	AUG	SEP	OCT
1			5.60	3.89	2.01	
2		la.7	4.60	4.80	1.45	
3		29.3	4.23	7.53	1.79	
4		16.7	4.43	6.43	2.69	
5		10.5	4.51	4.61	3.82	
6		6.10	4.47	3.81	4.92	
7		9.12	4.01	3.63	3.10	
a		6.38	7.48	13.9	2.36	
9		5.44	19.2	10.1	2.17	
10		5.33	14.3	5.59	2.17	
11		24.3	9.33	a.10	2.17	
12			7.47	40.8	1.74	
13			4.88	17.3	2.29	
14			4.36	9.53	2.68	
15		31.0	3.80	a.29	1.98	
16		la.5	3.01	6.61	1.45	
17		13.2	2.99	6.20	1.45	
la		9.93	4.10	5.10	1.40	
19		9.62	3.77	4.87	1.48	
20		12.5	4.04	4.14	0.84	
21		12.5	22.2	3.54	1.42	
22		7.90	48.4	3.70	1.00	
23		30.0	55.1	3.64	1.10	
24		22.6	20.0	3.53	1.27	
25		12.9	11.8	3.30	1.10	
26	5.15	19.4	a.25	3.66	1.10	
27	6.57	19.1	10.3	3.12	1.27	
28	5.81	19.0	6.13	2.85	1.20	
29	6.18	a.90	5.48	2.46	1.36	
30	la.4	6.92	5.45	1.93	1.24	
31			5.13	2.32		
AVG	a.42	14.84	10.28	6.75	1.87	

	DAILY	INSTANT
MIN	0.84	0.84
MAX	55.1	225

SEASON AVG a.23

APPENDIX B (cont)

NORTH HOSEANNA CREEK

AVERAGE DAILY DISCHARGE (cfs)

	MAY	JUN	JUL	AUG	SEP	OCT
1			2.82	2.82	2.04	2.40
2			2.73	3.12	1.97	2.31
3			2.43	3.07	1.95	1.99
4			2.42	2.86	2.34	1.68
5			2.30	2.65	2.35	1.65
6			2.43	2.53	2.16	1.60
7			2.20	2.58	1.99	
8			2.74	2.74	1.97	
9			5.26	2.51	2.04	
10			4.33	2.37	2.00	
11			3.22	2.82	2.15	
12			3.26	4.47	1.93	
13			3.40	3.18	2.04	
14			3.77	2.82	1.94	
15		2.72	3.45	2.83	1.86	
16		3.68	2.68	2.81	1.89	
17		2.92	3.01	2.70	1.94	
18		3.00	2.40	2.61	1.89	
19		3.29	2.36	2.39	1.89	
20		3.15	2.24	2.46	1.78	
21		2.81	3.58	2.43	2.38	
22		2.59	5.78	2.50	1.85	
23		3.47	6.97	2.27	1.78	
24		2.90	4.19	2.33	1.78	
25		2.72	4.07	2.19	1.78	
26		3.21	3.54	2.49	1.68	
27		4.16	3.84	2.31	1.62	
28		4.88	4.02	2.22	1.84	
29		3.52	3.60	2.17	1.75	
30		3.34	3.77	2.04	1.69	
31			3.20	2.13		
AVG		3.27	3.42	2.63	1.94	1.94

	DAILY	INSTANT
MIN	1.60	1.28
MAX	6.97	13.2

SEASON AVG 2.72

APPENDIX B (cont)

HOSEANNA CREEK - BRIDGE 6

AVERAGE DAILY DISCHARGE (cfs)

	MAY	JUN	JUL	AUG	SEP	OCT
1				22.6	11.6	13.7
2				27.8	10.8	14.7
3				34.4	13.2	14.9
4				30.8	16.7	12.5
5				24.6	18.8	13.4
6				23.2	21.7	14.0
7				22.1	16.4	
8				38.4	12.4	
9				32.3	13.2	
10				23.9		
11				29.7	15.3	
12				90.4	13.5	
13				43.0	13.2	
14				29.1	14.0	
15				23.0	12.4	
16				19.1	10.8	
17				18.5	10.0	
18				17.8	11.5	
19				15.9	12.8	
20				14.0	11.3	
21				15.4	16.8	
22				16.4	14.8	
23				13.0	12.4	
24				12.3	12.4	
25				13.8	12.4	
26				11.8	13.2	
27				11.9	12.4	
28				11.6	11.9	
29			**28.9**	12.4	20.0	
30			33.2	10.8	13.9	
31			27.3	12.0		
AVG			29.8	23.3	13.7	13.8

	DAILY	INSTANT
MIN	10.0	7.99
MAX	90.4	150

SEASON AVG 18.9

APPENDIX B **(cont)**

POPOVITCH CREEK

AVERAGE DAILY DISCHARGE (cfs)

	MAY	JUN	JUL	AUG	SEP	OCT
1			0.28	0.37	0.28	
2		0.60	0.36	0.42	0.28	
3		0.90	0.31	0.42	0.35	
4		0.90	0.32	0.32	0.50	
5		0.82	0.33	0.34	0.54	
6		0.83	0.29	0.22	0.42	
7		0.80	0.35	0.31	0.35	
a		0.74	0.38	0.41	0.50	
9		0.66	0.37	0.41	0.50	
10		0.75	0.79	0.29	0.50	
11		0.72	1.02	0.31	0.61	
12		0.72	0.71	0.68	0.42	
13		0.67	0.37	0.56	0.48	
14		0.63	0.41	0.50	0.50	
15		0.46	0.35	0.55	0.48	
16		0.38	0.28	0.47	0.49	
17		0.50	0.37	0.42	0.58	
18		0.54	0.26	0.43	0.58	
19		0.53	0.37	0.34	0.77	
20		0.40	0.26	0.49	0.75	
21		0.36	0.44	0.46	0.77	
22		0.36	0.86	0.42	0.53	
23		0.43	1.23	0.33	0.58	
24		0.41	0.80	0.30	0.50	
25		0.35	0.75	0.35	0.58	
26		0.40	0.70	0.34	0.50	
27		0.44	0.54	0.28	0.50	
28		0.39	0.60	0.29	0.47	
29		0.32	0.63	0.31	0.44	
30		0.33	0.59	0.31	0.40	
31			0.41	0.37		
AVG		0.57	0.51	0.39	0.51	

	DAILY	INSTANT
MIN	0.22	0.10
MAX	1.23	3.53

SEASON AVG 0.50

APPENDIX B **(cont)**

FRANCES CREEK

DAILY AVERAGE DISCHARGE (cfs)

	MAY	JUN	JUL	AUG	SEP	OCT
1		1.07	0.09	0.14	0.04	0.04
2		0.96	0.09	0.18	0.04	0.04
3		1.62	0.09	0.23	0.04	0.04
4		1.00	0.14	0.17	0.06	0.05
5		0.67	0.12	0.14	0.07	0.07
6		0.83	0.09	0.14	0.04	0.04
7		0.48	0.09	0.15	0.04	0.04
8		0.30	0.18	0.29	0.09	
9		0.22	0.24	0.17	0.05	
10		0.26	0.15	0.14	0.04	
11		0.22	0.45	0.15	0.07	
12		0.20	0.28	0.15	0.04	
13		0.21	0.20	0.12	0.04	
14		0.14	0.20	0.10	0.04	
15		0.17	0.15	0.08	0.04	
16		0.20	0.16	0.08	0.04	
17		0.16	0.11	0.09	0.04	
18		0.26	0.14	0.09	0.04	
19		0.17	0.15	0.08	0.04	
20		0.14	0.14	0.07	0.04	
21		0.12	0.41	0.08	0.08	
22		0.14	0.60	0.09	0.04	
23		0.23	0.35	0.06	0.04	
24		0.19	0.24	0.06	0.04	
25		0.12	0.21	0.06	0.04	
26		0.16	0.17	0.07	0.04	
27		0.21	0.14	0.08	0.04	
28		0.25	0.17	0.07	0.04	
29		0.15	0.12	0.06	0.04	
30		0.13	0.16	0.06	0.04	
31			0.12	0.05		
AVG		0.37	0.19	0.11	0.05	0.05

	DAILY	INSTANT
MIN	0.04	0.04
MAX	1.62	3.30

SEASON AVG 0.17

APPENDIX **B (cont)**

HOSEANNA CREEK - BRIDGE 3

DAILY AVERAGE DISCHARGE (cfs)

	MAY	JUN	JUL	AUG	SEP	OCT
1		100	30.1	30.3	25.0	26.1
2		88.7	27.1	35.7	23.5	26.7
3		192	22.1	41.1	22.2	27.8
4		83.6	21.8	40.6	24.0	25.0
5		47.0	20.7	34.8	26.0	25.4
6		49.0	19.6	30.9	30.0	
7		55.0	17.9	28.0	29.2	
8		45.0	28.5	38.0	27.9	
9		41.0	68.6	34.0	26.2	
10		38.0	56.1	32.1	24.9	
11		35.0	50.0	36.3	28.1	
12		90.4	38.6	111	26.8	
13		45.0	24.6	68.1	25.8	
14		46.5	24.1	47.6	26.8	
15		49.2	22.4	40.5	26.2	
16		70.9	20.5	35.4	24.0	
17		45.9	19.7	32.3	24.0	
18		43.8	19.0	32.8	24.0	
19		47.1	19.0	30.0	24.9	
20		50.5	18.0	28.0	23.1	
21		47.6	63.1	25.0	32.6	
22		38.1	153	28.0	29.7	
23		102	178	26.8	27.8	
24		52.8	51.7	24.6	27.8	
25		39.0	45.0	24.0	26.8	
26		45.7	38.0	25.0	27.0	
27		60.8	32.0	25.0	25.8	
28		76.3	25.0	23.0	26.3	
29		46.4	36.2	21.3	28.0	
30		36.3	43.4	21.0	25.6	
31	369		36.4	20.5		
AVG	369	60.3	41.1	35.0	26.3	26.2

	DAILY	INSTANT
MIN	20.5	14.6
MAX	369	740

SEASON AVG 42.6

APPENDIX C

SANDERSON CREEK

DAILY SEDIMENT LOAD (tons/day)

	MAY	JUN	JUL	AUG	SEP	OCT
1		200"	1.07	0.36	0.05	
2		38.5	0.60	0.68	0.02	
3		145	0.47	2.58	0.04	
4		27.2	0.53	1.61	0.12	
5		6.82	0.56	0.60	0.34	
6		1.38	0.55	0.34	0.73	
7		4.55	0.40	0.30	0.19	
a		1.58	2.53	59.6	0.08	
9		0.98	41.2	6.11	0.06	
10		0.92	17.2	1.06	0.06	
11		83.3	4.87	3.20	0.06	
12		100*	2.52	884	0.03	
13		80*	0.71	30.3	0.08	
14		50*	0.51	5.19	0.12	
15		172	0.34	3.43	0.05	
16		37.3	0.17	1.75	0.02	
17		13.8	0.17	1.45	0.02	
18		5.86	0.42	0.81	0.02	
19		5.33	0.33	0.71	0.02	
20		11.7	0.41	0.44	0.00	
21		11.5	192	0.22	0.02	
22		2.97	1610	0.31	0.01	
23		275	1084	0.19	0.01	
24		69.6	47.0	0.27	0.01	
25		12.8	9.78	0.22	0.01	
26	3.58	42.8	3.38	0.30	0.01	
27	1.72	41.0	6.57	0.19	0.01	
28	1.19	40.1	1.40	0.14	0.01	
29	1.43	4.23	1.00	0.09	0.02	
30	36.6	2.01	0.99	0.05	0.01	
31	2000"		0.83	0.08		
TOTAL	2040	1490	3030	1010	2.24	

SEASON TOTAL 7570

* estimate

APPENDIX C (cont)

NORTH HOSEANNA CREEK

DAILY SEDIMENT LOAD (tons/day)

	MAY	JUN	JUL	AUG	SEP	OCT
1			4.09	4.09	1.20	2.22
2			3.62	6.00	1.05	1.92
3			2.32	5.64	1.01	1.09
4			2.29	4.31	2.01	0.57
5			1.89	3.23	2.05	0.54
6			2.32	2.71	1.49	0.48
7			1.59	2.92	1.09	
8			3.67	3.67	1.05	
9			110	2.63	1.20	
10			33.2	2.11	1.11	
11			6.76	4.09	1.46	
12			7.09	35.2	0.97	
13			8.32	6.45	1.20	
14		30.6	12.3	4.09	0.99	
15		3.57	8.79	4.14	0.84	
16		11.2	3.37	4.03	0.90	
17		4.67	5.24	3.47	0.99	
18		5.17	2.22	3.05	0.90	
19		7.34	2.08	2.18	0.90	
20		6.22	4.98	2.44	0.71	
21		4.03	34.9	2.32	2.15	
22		2.96	175	2.59	0.83	
23		8.98	125	1.80	0.71	
24		4.55	18.4	1.98	0.71	
25		3.57	16.5	1.57	0.71	
26		6.69	9.69	2.55	0.57	
27		17.9	13.2	1.92	0.50	
28		32.8	15.7	1.65	0.81	
29		9.48	10.3	1.51	0.67	
30		34.6	12.3	1.20	0.59	
31			6.61	1.41		
TOTAL		194	664	127	31.4	6.81

SEASON TOTAL 1020

APPENDIX C (cont)

HOSEANNA CREEK - BRIDGE 6

DAILY SEDIMENT LOAD (tons/day)

	MAY	JUN	JUL	AUG	SEP	OCT
1				12.7	3.94	1.87
2				26.6	3.22	1.58
3				86.9	5.69	2.16
4				25.6	11.0	0.87
5				9.66	15.5	0.91
6				7.14	23.1	1.02
7				11.1	10.5	
a				195	6.10	
9				71.4	5.72	
10				13.4	4.76	
11				56.7	8.62	
12				1429	6.00	
13				139	5.69	
14				53.5	6.72	
15				27.2	4.76	
16				16.1	3.22	
17				14.8	2.59	
la				13.2	3.88	
19				9.63	5.18	
20				6.72	3.63	
21				8.78	11.3	
22				10.5	7.88	
23				5.42	4.76	
24				4.62	4.76	
25				6.50	4.76	
26				4.09	5.69	
27				4.27	4.76	
28				3.94	4.26	
29			22.3	4.74	4.56	
30			63.0	3.25	6.54	
31			22.7	4.32		
TOTAL			108	2290	199	a.4

SEASON TOTAL 2605

APPENDIX C (cont)

POPOVITCH CREEK

DAILY SEDIMENT LOAD (tons/day)

	MAY	JUN	JUL	AUG	SEP	OCT
1		6.18	0.01	0.03	0.01	
2		1.04	0.02	0.05	0.01	
3		4.04	0.01	0.05	0.02	
4		4.04	0.01	0.01	0.14	
5		2.38	0.01	0.02	0.22	
6		2.55	0.01	0.00	0.05	
7		2.07	0.02	0.01	0.02	
8		1.33	0.03	0.05	0.14	
9		0.69	0.03	0.05	0.14	
10		1.43	1.92	0.01	0.14	
11		1.13	8.24	0.01	0.44	
12		1.13	1.05	0.82	0.05	
13		0.75	0.03	0.27	0.11	
14		0.53	0.05	0.14	0.14	
15		0.09	0.02	0.24	0.11	
16		0.03	0.01	0.10	0.13	
17		0.14	0.03	0.05	0.33	
18		0.22	0.00	0.06	0.33	
19		0.20	0.03	0.02	1.66	
20		0.04	0.00	0.13	1.43	
21		0.02	0.07	0.09	1.66	
22		0.02	3.12	0.05	0.20	
23		0.06	23.9	0.01	0.33	
24		0.05	2.07	0.01	0.14	
25		0.02	1.43	0.02	0.33	
26		0.04	0.97	0.02	0.14	
27		0.07	0.22	0.01	0.14	
28		0.03	0.40	0.01	0.10	
29		0.01	0.53	0.01	0.07	
30		0.01	0.37	0.01	0.07	
31			0.05	0.03		
TOTAL		30.3	44.6	2.36	10.8	

SEASON TOTAL 88.1

APPENDIX C (cont)

FRANCES CREEK

DAILY SEDIMENT LOAD (tons/day)

	MAY	JUN	JUL	AUG	SEP	OCT
1		54.0	0.04	0.15	0.00	0.00
2		39.4	0.04	0.30	0.00	0.00
3		109	0.04	0.62	0.00	0.00
4		44.4	0.15	0.26	0.01	0.01
5		13.9	0.09	0.15	0.02	0.02
6		25.8	0.04	0.15	0.00	0.00
7		5.26	0.04	0.18	0.00	
8		1.34	3.20	1.22	0.04	
9		0.54	0.70	0.26	0.01	
10		0.88	2.70	0.15	0.00	
11		0.54	36.8	0.18	0.02	
12		0.41	1.10	0.18	0.00	
13		0.48	0.41	0.09	0.00	
14		0.27	0.41	0.06	0.00	
15		0.24	0.18	0.03	0.00	
16		0.69	0.22	0.03	0.00	
17		0.22	0.02	0.04	0.00	
18		0.88	0.15	0.04	0.00	
19		0.26	0.18	0.03	0.00	
20		0.15	0.15	0.02	0.00	
21		0.09	32.5	0.03	0.03	
22		0.15	10.4	0.04	0.00	
23		0.62	2.29	0.01	0.00	
24		0.36	0.70	0.01	0.00	
25		0.09	0.48	0.01	0.00	
26		0.22	0.26	0.02	0.00	
27		0.48	0.15	0.03	0.00	
28		0.79	0.26	0.02	0.00	
29		0.18	0.09	0.01	0.00	
30		0.12	0.22	0.01	0.00	
31			0.09	0.01		
TOTAL		302	94.0	4.31	0.22	0.04

SEASON TOTAL 401

APPENDIX C **(cont)**

HOSEANNA CREEK - BRIDGE 3

DAILY SEDIMENT **LOAD** (tons/day)

	MAY	JUN	JUL	AUG	SEP	OCT
1		900	10.4	42.5	11.1	2.51
2		650	6.57	64.5	9.55	2.84
3		6630	2.64	92.6	8.30	3.23
4		1080	2.50	89.5	10.1	1.21
5		73.7	2.00	60.3	8.10	1.29
6		88.5	1.58	44.6	8.58	
7		147	1.06	34.7	7.14	
8		60.8	8.18	75.7	4.14	
9		40.4	1400	57.0	12.5	
10		28.9	780	44.0	11.0	
11		20.1	360	67.3	14.8	
12		774	31.1	2460	13.2	
13		60.8	4.25	255	12.0	
14		200	3.89	50.0	13.2	
15		90.3	2.81	28.0	12.4	
16		630	1.91	13.0	10.1	
17		66.3	1.61	15.3	10.1	
18		53.7	1.37	14.8	10.1	
19		74.6	1.37	16.3	11.0	
20		101	1.08	14.8	9.15	
21		78.0	625	17.9	21.4	
22		29.2	5930	14.9	16.9	
23		1040	5120	16.0	14.4	
24		123	112	14.6	14.4	
25		32.5	55.0	12.7	13.2	
26		65.1	46.0	10.4	13.4	
27		280	38.0	8.40	12.0	
28		600	32.0	6.90	12.6	
29		69.9	27.0	5.20	14.6	
30		82.0	118	18.4	11.8	
31	26200		75.4	17.3		
TOTAL	26200	14200	14800	3680	351	11

SEASON TOTAL 59200

APPENDIX D

TSS, tubidity and discharge data. "a" indicates automated sample.

Site		Date	Time	TSS (mg/l)	Turb (NTU)	Q (cfs)
FRANCES		26-May-88	1120	1380	240	0.19
FRANCES		26-May-88	1120	1470	350	0.19
FRANCES		01-Jun-88	1430	7100	1400	0.69
FRANCES		01-Jun-88	1900	56900	11000	1.00
FRANCES		02-Jun-88	950	4740	640	
FRANCES		14-Jun-88	1845	914	380	0.12
FRANCES		15-Jun-88	1300	534	170	0.12
FRANCES		16-Jun-88	1515	1290	280	0.19
FRANCES		30-Jun-88	1630	343	90	0.14
FRANCES		08-Jul-88	1720	5910	1900	0.24
FRANCES		10-Jul-88	1315	4590	1600	0.24
FRANCES		11-Jul-88	1620	19100	5700	1.31
FRANCES		17-Jul-88	1830	19.2	11	0.10
FRANCES		20-Jul-88	1110	39.8	240	0.11
FRANCES		21-Jul-88	640	17200	5400	1.66
FRANCES		21-Jul-88	930	2050	930	0.58
FRANCES		21-Jul-88	1135	2380	910	0.52
FRANCES	a	21-Jul-88	615	125000	12000	1.11
FRANCES	a	21-Jul-88	745	62000	1900	0.71
FRANCES	a	21-Jul-88	830	2230	1000	0.57
FRANCES	a	21-Jul-88	915	11800	880	0.54
FRANCES	a	21-Jul-88	1000	2100	880	0.50
FRANCES	a	21-Jul-88	1045	24100	1300	0.47
FRANCES	a	21-Jul-88	1130	2120	940	0.47
FRANCES	a	21-Jul-88	1430	3450	1000	0.31
FRANCES	a	21-Jul-88	1515	3530	870	0.30
FRANCES	a	21-Jul-88	1645	729	330	0.29
FRANCES	a	21-Jul-88	1730	298000	270	0.27
FRANCES	a	21-Jul-88	1815	26200	270	0.25
FRANCES	a	21-Jul-88	1900	33600	210	0.24
FRANCES	a	21-Jul-88	1945	19100	190	0.23
FRANCES	a	21-Jul-88	2030	14200	190	0.22
FRANCES	a	21-Jul-88	2200	5340	130	0.23
FRANCES	a	21-Jul-88	2245	8260	130	0.31
FRANCES	a	21-Jul-88	2330	219	120	0.29
FRANCES		22-Jul-88	1340	3010	1100	0.52
FRANCES	a	22-Jul-88	1630	3360	1000	0.34
FRANCES	a	22-Jul-88	1715	12000	4200	0.78
FRANCES	a	22-Jul-88	1800	13600	4200	1.11
FRANCES	a	22-Jul-88	1845	8090	3600	0.95
FRANCES	a	22-Jul-88	1930	4080	1400	0.87
FRANCES	a	22-Jul-88	2100	27700	11000	1.50
FRANCES	a	22-Jul-88	2145	12800	5500	1.93
FRANCES	a	22-Jul-88	2230	4830	2800	1.66
FRANCES	a	22-Jul-88	2315	1970	1200	1.24

APPENDIX D (cont)

Site	Date	Time	TSS (mg/l)	Turb (NTU)	Q (cfs)
FRANCES a	22-Jul-88	0	20600	1300	0.88
FRANCES a	23-Jul-88	45	6590	1300	0.78
FRANCES a	23-Jul-88	345	2330	620	0.45
FRANCES a	23-Jul-88	430	1740	500	0.38
FRANCES a	23-Jul-88	515	782	380	0.35
FRANCES a	23-Jul-88	600	852	360	0.32
FRANCES a	23-Jul-88	645	942	330	0.30
FRANCES a	23-Jul-88	730	1240	460	0.30
FRANCES	25-Jul-88	1505	173	38	0.16
FRANCES	29-Jul-88	1630	74.9	25	0.11
FRANCES	10-Aug-88	1610	60.6	15	0.11
FRANCES	16-Aug-88	1220	79	6.8	0.09
FRANCES	23-Aug-88	1430	16.4	5.6	0.05
FRANCES	29-Aug-88	1210	22.8	10	0.05
FRANCES	07-Sep-88	1540	5.2	7.6	0.05
FRANCES	29-Sep-88	1820	19.1	9.8	0.08
HOSEANNA B1	23-May-88	1800	2360	440	
HOSEANNA B1	26-May-88	815	5560	560	
HOSEANNA B1	26-May-88	815	3990	750	
HOSEANNA B1	01-Jun-88	1925	4040	940	
HOSEANNA B1	02-Jun-88	800	3450	970	
HOSEANNA B1	14-Jun-88	2010	1860	1500	
HOSEANNA B1	15-Jun-88	720	1310	640	
HOSEANNA B1	15-Jun-88	1805	3620	1700	
HOSEANNA B1	16-Jun-88	1700	9880	2700	
HOSEANNA B1	30-Jun-88	1840	652	210	
HOSEANNA B1	19-Jul-88	1410	82.8	38	
HOSEANNA B1	19-Jul-88	1455	252	37	
HOSEANNA B1	21-Jul-88	820	5990	1500	
HOSEANNA B1	21-Jul-88	1235	6420	1300	
HOSEANNA B1	22-Jul-88	1510	5000	1300	
HOSEANNA B1	29-Jul-88	1745	289	140	
HOSEANNA B1	10-Aug-88	1830	498	49	
HOSEANNA B1	12-Aug-88	1530	11700	3300	
HOSEANNA B1	23-Aug-88	1515	41.6	5.4	
HOSEANNA B1	08-Sep-88	1305	78.6	36	
HOSEANNA B1	08-Sep-88	1315	61.9	31	
HOSEANNA B3	23-May-88	1545	1440	340	42.4
HOSEANNA B3	26-May-88	930	1550	240	43.3
HOSEANNA B3	26-May-88	930	1240	280	43.3
HOSEANNA B3 a	31-May-88	0	48900	8600	620
HOSEANNA B3 a	31-May-88	200	63100	16000	740
HOSEANNA B3 a	31-May-88	400	36400'	13000	630
HOSEANNA B3 a	31-May-88	600	19000	6300	575
HOSEANNA B3 a	31-May-88	800	15700	5600	510

APPENDIX D (cont)

Site	Date	Time	TSS (mg/l)	Turb (NTU)	Q (cfs)
HOSEANNA B3 a	31-May-88	1000	11500	4300	400
HOSEANNA B3 a	31-May-88	1200	9450	3200	265
HOSEANNA B3 a	31-May-88	1400	7790	2900	210
HOSEANNA B3 a	31-May-88	1600	5880	2200	195
HOSEANNA B3 a	31-May-88	1800	6130	2200	170
HOSEANNA B3	01-Jun-88	1715	3350	780	100
HOSEANNA B3	02-Jun-88	930	2800	900	90.0
HOSEANNA B3	02-Jun-88	1830	2510	910	87.0
HOSEANNA B3 a	03-Jun-88	0	12200	4600	141
HOSEANNA B3 a	03-Jun-88	200	13800	4200	220
HOSEANNA B3 a	03-Jun-88	400	13800	4500	250
HOSEANNA B3 a	03-Jun-88	600	11300	4700	240
HOSEANNA B3 a	03-Jun-88	800	12000	4100	210
HOSEANNA B3 a	03-Jun-88	1000	19900	8100	295
HOSEANNA B3 a	03-Jun-88	1200	11400	4700	200
HOSEANNA B3 a	03-Jun-88	1400	7740	2900	145
HOSEANNA B3 a	03-Jun-88	1600	11300	4900	170
HOSEANNA B3 a	03-Jun-88	1800	11500	4500	130
HOSEANNA B3 a	03-Jun-88	2000	15100	5600	155
HOSEANNA B3 a	03-Jun-88	2200	10300	4300	135
HOSEANNA B3 a	04-Jun-88	0	6530	2600	82.0
HOSEANNA B3 a	04-Jun-88	200	9130	4100	110
HOSEANNA B3 a	04-Jun-88	400	5460	2700	94.0
HOSEANNA B3 a	04-Jun-88	600	3770	1800	83.0
HOSEANNA B3 a	04-Jun-88	800	3400	1900	78.0
HOSEANNA B3 a	04-Jun-88	1000	3010	1200	73.0
HOSEANNA B3 a	04-Jun-88	1600	6830	3300	82.0
HOSEANNA B3	14-Jun-88	1820	1710	800	45.2
HOSEANNA B3	15-Jun-88	1750	4530	2100	45.0
HOSEANNA B3	15-Jun-88	825	1430	700	40.0
HOSEANNA B3	16-Jun-88	1545	8150	2000	70.8
HOSEANNA B3 a	28-Jun-88	1130	5420	1600	93.0
HOSEANNA B3 a	28-Jun-88	1130	5100	1700	93.0
HOSEANNA B3 a	28-Jun-88	1225	5210	1600	130
HOSEANNA B3	30-Jun-88	1710	757	270	40.5
HOSEANNA B3	09-Jul-88	910	8010	2600	70.0
HOSEANNA B3 a	09-Jul-88	9910	7460	2700	70.0
HOSEANNA B3 a	10-Jul-88	1305	3910	1400	44.0
HOSEANNA B3	10-Jul-88	1310	5990	2000	44.0
HOSEANNA B3	10-Jul-88	1810	6800	2700	58.0
HOSEANNA B3 a	10-Jul-88	1810	7130	2600	58.0
HOSEANNA B3	11-Jul-88	1615	6270	1900	68.0
HOSEANNA B3 a	11-Jul-88	1615	5960	2500	68.0
HOSEANNA B3	19-Jul-88	1004	291	45	24.7
HOSEANNA B3	20-Jul-88	1009	41.5	17	22.0
HOSEANNA B3	21-Jul-88	905	3130	1100	57.0
HOSEANNA B3	21-Jul-88	1215	5940	1500	89.6

APPENDIX D (cont)

Site		Date	Time	TSS (mg/l)	Turb (NTU)	Q (cfs)
HOSEANNA B3		21-Jul-88	1542	4680	1200	95.0
HOSEANNA B3	a	21-Jul-88	900	3080	1200	57.0
HOSEANNA B3	a	21-Jul-88	1030	3420	960	72.0
HOSEANNA B3	a	21-Jul-88	1200	5240	1400	80.0
HOSEANNA B3	a	21-Jul-88	1330	5200	1700	93.0
HOSEANNA B3	a	21-Jul-88	1500	4410	1200	90.0
HOSEANNA B3	a	21-Jul-88	1630	5770	1500	95.0
HOSEANNA B3	a	21-Jul-88	1800	5660	1900	100
HOSEANNA B3	a	21-Jul-88	1930	4940	2000	80.0
HOSEANNA B3	a	21-Jul-88	2100	2980	1100	72.0
HOSEANNA B3	a	21-Jul-88	2230	1990	950	66.0
HOSEANNA B3	a	21-Jul-88	0	1460	480	61.0
HOSEANNA B3	a	22-Jul-88	130	1180	360	54.0
HOSEANNA B3	a	22-Jul-88	300	1010	350	52.0
HOSEANNA B3	a	22-Jul-88	430	936	310	49.0
HOSEANNA B3	a	22-Jul-88	600	756	250	49.0
HOSEANNA B3	a	22-Jul-88	730	1610	600	50.0
HOSEANNA B3	a	22-Jul-88	900	1870	640	61.0
HOSEANNA B3		22-Jul-88	1400	5320	1700	96.0
HOSEANNA B3		22-Jul-88	2340	21100	5500	510
HOSEANNA B3	a	22-Jul-88	1730	3860	1800	165
HOSEANNA B3	a	22-Jul-88	1900	12200	3800	205
HOSEANNA B3	a	22-Jul-88	2030	24000	6000	340
HOSEANNA B3	a	22-Jul-88	2200	30700	6100	460
HOSEANNA B3	a	22-Jul-88	2330	16800	5700	510
HOSEANNA B3	a	23-Jul-88	100	33600	6900	500
HOSEANNA B3	a	23-Jul-88	530	11000	3000	215
HOSEANNA B3	a	23-Jul-88	700	6730	2800	200
HOSEANNA B3	a	23-Jul-88	830	6400	2500	170
HOSEANNA B3	a	23-Jul-88	1000	5360	1800	140
HOSEANNA B3	a	23-Jul-88	1130	3960	1500	125
HOSEANNA B3	a	23-Jul-88	1300	4210	1300	112
HOSEANNA B3	a	23-Jul-88	1430	3100	1300	100
HOSEANNA B3	a	23-Jul-88	1600	2350	1100	84.0
HOSEANNA B3	a	23-Jul-88	1730	1990	900	80.0
HOSEANNA B3	a	23-Jul-88	1900	1990	1000	72.0
HOSEANNA B3	a	23-Jul-88	2030	1720	820	67.0
HOSEANNA B3	a	23-Jul-88	2200	1450	750	65.0
HOSEANNA B3	a	23-Jul-88	2330	2010	970	60.0
HOSEANNA B3	a	24-Jul-88	100	1260	640	58.0
HOSEANNA B3	a	24-Jul-88	230	1220	760	56.0
HOSEANNA B3	a	24-Jul-88	400	1040	630	52.0
HOSEANNA B3		23-Jul-88	755	6540	2200	185
HOSEANNA B3		25-Jul-88	1455	409	150	52.0
HOSEANNA B3		29-Jul-88	1700	263	100	35.0
HOSEANNA B3		10-Aug-88	1700	551	45	31.8
HOSEANNA B3		12-Aug-88	1425	12600	4100	182

APPENDIX D (cont)

Site			Date	Time	TSS (mg/l)	Turb (NTU)	Q (cfs)
HOSEANNA	B3	a	12-Aug-88	1300	7730	1800	163
HOSEANNA	B3	a	12-Aug-88	1430	12900	3200	182
HOSEANNA	B3	a	12-Aug-88	1600	18000	4900	162
HOSEANNA	B3	a	12-Aug-88	1730	17500	5000	157
HOSEANNA	B3	a	12-Aug-88	1900	12200	3100	141
HOSEANNA	B3	a	12-Aug-88	2030	6840	2400	137
HOSEANNA	B3	a	12-Aug-88	2200	5720	1700	123
HOSEANNA	B3	a	12-Aug-88	2330	4010	1400	112
HOSEANNA	B3	a	13-Aug-88	100	2860	910	100
HOSEANNA	B3	a	13-Aug-88	230	2330	750	90.0
HOSEANNA	B3	a	13-Aug-88	400	1860	640	84.0
HOSEANNA	B3	a	13-Aug-88	530	1630	660	81.0
HOSEANNA	B3	a	13-Aug-88	700	1510	460	73.0
HOSEANNA	B3	a	13-Aug-88	830	1410	490	68.0
HOSEANNA	B3	a	13-Aug-88	1000	1090	400	67.0
HOSEANNA	B3	a	13-Aug-88	1130	1090	410	67.0
HOSEANNA	B3	a	13-Aug-88	1300	1140	430	66.0
HOSEANNA	B3		14-Aug-88	1820	224	92	45.0
HOSEANNA	B3		16-Aug-88	1140	135	55	36.0
HOSEANNA	B3		23-Aug-88	1440	227	8.6	27.0
HOSEANNA	B3		29-Aug-88	1200	92.1	16	21.0
HOSEANNA	B3		08-Sep-88	1020	84.2	29	24.0
HOSEANNA	B3		08-Sep-88	1000	131	28	24.0
HOSEANNA	B3		29-Sep-88	1750	541	180	35.0
HOSEANNA	B3		07-Oct-88	915	24.1	18	20.0
HOSEANNA	B6		26-May-88	1610	1610	340	26.2
HOSEANNA	B6		26-May-88	1610	1620	380	26.2
HOSEANNA	B6		01-Jun-88	1815	5610	1100	60.9
HOSEANNA	B6		02-Jun-88	1610	3570	1000	35.1
HOSEANNA	B6		14-Jun-88	1930	5000	1700	36.5
HOSEANNA	B6		15-Jun-88	1115	4440	2100	24.3
HOSEANNA	B6		16-Jun-88	1420	8870	1600	52.4
HOSEANNA	B6		30-Jun-88	1500	1150	270	27.7
HOSEANNA	B6		09-Jul-88	1025	3920	980	57.7
HOSEANNA	B6		20-Jul-88	1200	247	26	18.5
HOSEANNA	B6		21-Jul-88	1055	7440	2000	54.2
HOSEANNA	B6		21-Jul-88	1611	8390	2400	80.0
HOSEANNA	B6		22-Jul-88	1250	8440	2700	70.0
HOSEANNA	B6		23-Jul-88	45	19700	5800	150
HOSEANNA	B6		29-Jul-88	1445	501	150	30.0
HOSEANNA	B6	a	29-Jul-88	1200	628	170	28.9
HOSEANNA	B6	a	30-Jul-88	1200	703	200	33.2
HOSEANNA	B6	a	31-Jul-88	1200	308	110	27.2
HOSEANNA	B6	a	01-Aug-88	1200	207	78	22.6
HOSEANNA	B6	a	02-Aug-88	1200	354	120	27.8
HOSEANNA	B6	a	03-Aug-88	1200	936	230	34.4

APPENDIX D (cont)

Site	Date	Time	TSS (mg/l)	Turb (NTU)	Q (cfs)
HOSEANNA B6 a	04-Aug-88	1200	308	91	30.8
HOSEANNA B6 a	05-Aug-88	1200	145	54	24.6
HOSEANNA B6 a	06-Aug-88	1200	114	53	23.2
HOSEANNA B6 a	07-Aug-88	1200	187	83	22.1
HOSEANNA B6 a	08-Aug-88	1200	1880	590	38.4
HOSEANNA B6 a	10-Aug-88	1430	270	82	20.0
HOSEANNA B6	10-Aug-88	1430	227	11	19.5
HOSEANNA B6	12-Aug-88	1615	4240	1200	100
HOSEANNA B6 a	12-Aug-88	800	6960	3200	100
HOSEANNA B6 a	12-Aug-88	930	12400	3600	129
HOSEANNA B6 a	12-Aug-88	1100	10300	3700	145
HOSEANNA B6 a	12-Aug-88	1230	11900	4400	143
HOSEANNA B6 a	12-Aug-88	1400	6580	2600	116
HOSEANNA B6 a	12-Aug-88	1530	3870	1600	108
HOSEANNA B6 a	12-Aug-88	1700	2970	1200	93.0
HOSEANNA B6 a	12-Aug-88	1830	2320	780	84.0
HOSEANNA B6 a	12-Aug-88	2000	1820	680	73.0
HOSEANNA B6 a	12-Aug-88	2130	1980	700	69.0
HOSEANNA B6 a	12-Aug-88	2300	1940	560	68.0
HOSEANNA B6 a	13-Aug-88	30	2060	560	62.0
HOSEANNA B6 a	13-Aug-88	200	1510	440	56.0
HOSEANNA B6 a	13-Aug-88	330	1140	430	54.0
HOSEANNA B6 a	13-Aug-88	500	1310	430	50.0
HOSEANNA B6	14-Aug-88	1855	301	89	26.0
HOSEANNA B6	21-Aug-88	1735	113	25	15.0
HOSEANNA B6	23-Aug-88	1350	96.9	11	13.0
HOSEANNA B6	08-Sep-88	1401	154	25	14.6
HOSEANNA B6	29-Sep-88	1440	357	29	11.6
HOSEANNA B6	06-Oct-88	1600	450	31	21.0
LOUISE	15-Jun-88	1245	2450	52	0.12
LOUISE	16-Jun-88	1450	611	140	0.11
LOUISE	30-Jun-88	1600	156	19	0.10
LOUISE	08-Jul-88	1940	19100	8000	0.25
LOUISE	10-Jul-88	1325	34000	11000	0.22
LOUISE	21-Jul-88	650	31800	11000	0.43
LOUISE	21-Jul-88	930	3440	910	0.36
LOUISE	22-Jul-88	1100	106000	27000	1.62
LOUISE	22-Jul-88	1310	13400	4400	0.51
LOUISE	29-Jul-88	1600	533	31	0.11
LOUISE	10-Aug-88	1545	879	75	0.08
LOUISE	23-Aug-88	1415	332	8.7	0.09
LOUISE	29-Aug-88	1225	86.1	6.4	0.10
LOUISE	07-Sep-88	1600	59.4	7.8	0.06
N HOSANNA	01-Jun-88	1630	7830	1100	7.00
N HOSANNA	02-Jun-88	1600	7090	530	7.00

APPENDIX D (cont)

Site		Date	Time	TSS (mg/l)	Turb (NTU)	Q (cfs)
N	HOSANNA	14-Jun-88	1945	2090	400	6.50
N	HOSANNA	15-Jun-88	1000	1020	260	2.60
N	HOSANNA	16-Jun-88	1400	2410	570	4.40
N	HOSANNA a	30-Jun-88	1400	4220	440	3.04
N	HOSANNA	30-Jun-88	1430	4230	110	3.04
N	HOSANNA	09-Jul-88	1040	4000	750	5.10
N	HOSANNA a	08-Jul-88	2350	6850	1100	4.69
N	HOSANNA a	09-Jul-88	20	9460	3700	4.32
N	HOSANNA a	09-Jul-88	150	9020	2200	3.76
N	HOSANNA a	09-Jul-88	450	7610	1400	4.64
N	HOSANNA a	09-Jul-88	620	9120	2400	5.30
N	HOSANNA a	09-Jul-88	750	6200	1600	5.21
N	HOSANNA a	09-Jul-88	920	4760	1300	4.95
N	HOSANNA a	09-Jul-88	1050	3880	880	4.85
N	HOSANNA a	09-Jul-88	1220	2960	860	4.95
N	HOSANNA a	09-Jul-88	1350	2620	750	5.00
N	HOSANNA a	09-Jul-88	1520	2490	620	5.20
N	HOSANNA a	09-Jul-88	1650	8400	2100	6.04
N	HOSANNA a	09-Jul-88	1820	14000	4500	7.20
N	HOSANNA a	09-Jul-88	1950	14300	3600	7.00
N	HOSANNA a	09-Jul-88	2120	8970	2100	6.48
N	HOSANNA a	09-Jul-88	2250	6540	1500	5.50
N	HOSANNA a	10-Jul-88	20	4830	1200	5.20
N	HOSANNA a	10-Jul-88	150	5010	1100	4.80
N	HOSANNA a	10-Jul-88	620	1800	430	4.00
N	HOSANNA	10-Jul-88	1915	1300	260	3.90
N	HOSANNA	20-Jul-88	1300	232	22	2.00
N	HOSANNA	21-Jul-88	1015	3830	490	4.90
N	HOSANNA a	21-Jul-88	1730	6260	1400	4.20
N	HOSANNA a	21-Jul-88	1900	4700	990	3.95
N	HOSANNA a	21-Jul-88	2030	5170	860	3.76
N	HOSANNA a	21-Jul-88	2200	3680	770	3.55
N	HOSANNA a	21-Jul-88	2330	4050	840	3.40
N	HOSANNA a	22-Jul-88	100	5610	960	3.33
N	HOSANNA a	22-Jul-88	230	5300	1100	3.25
N	HOSANNA a	22-Jul-88	400	7750	1300	3.29
N	HOSANNA a	22-Jul-88	530	6490	1100	3.43
N	HOSANNA a	22-Jul-88	700	7360	1000	4.00
N	HOSANNA a	22-Jul-88	830	14200	1400	4.06
N	HOSANNA a	22-Jul-88	1000	8640	1100	4.06
N	HOSANNA a	22-Jul-88	1130	7090	1500	4.21
N	HOSANNA a	22-Jul-88	1300	13000	2000	4.41
N	HOSANNA a	22-Jul-88	1430	9580	1800	4.61
N	HOSANNA a	22-Jul-88	1600	9730	1800	4.86
N	HOSANNA a	22-Jul-88	1730	9590	2200	7.37
N	HOSANNA a	22-Jul-88	1900	10200	1700	8.79
N	HOSANNA a	22-Jul-88	2030	16200	2100	9.87

APPENDIX D (cont)

Site	Date	Time	TSS (mg/l)	Turb (NTU)	Q (cfs)
N HOSANNA a	22-Jul-88	2200	16600	2300	12.6
N HOSANNA a	22-Jul-88	2330	13700	2100	12.6
N HOSANNA a	23-Jul-88	100	10200	2000	12.0
N HOSANNA a	23-Jul-88	230	11000	2100	9.18
N HOSANNA a	23-Jul-88	400	11600	2200	8.71
N HOSANNA	22-Jul-88	1235	3400	560	5.30
N HOSANNA	25-Jul-88	1540	1580	90	3.10
N HOSANNA	29-Jul-88	1300	405	86	3.30
N HOSANNA	10-Aug-88	1330	148	11	2.41
N HOSANNA	12-Aug-88	1645	1620	420	5.40
N HOSANNA a	12-Aug-88	930	6320	1300	5.63
N HOSANNA a	12-Aug-88	1100	5200	1300	5.85
N HOSANNA a	12-Aug-88	1230	3800	930	5.69
N HOSANNA a	12-Aug-88	1400	3250	660	5.49
N HOSANNA a	12-Aug-88	1530	1920	600	5.10
N HOSANNA a	12-Aug-88	1700	1600	450	4.70
N HOSANNA a	12-Aug-88	1830	1190	310	4.30
N HOSANNA a	12-Aug-88	2000	917	280	4.05
N HOSANNA	14-Aug-88	1920	842	23	2.80
N HOSANNA	21-Aug-88	1705	212	8	2.40
N HOSANNA	23-Aug-88	1335	260	7.2	2.30
N HOSANNA	08-Sep-88	1430	63.4	6.6	2.16
N HOSANNA	29-Sep-88	1410	96	9.4	
N HOSANNA	06-Oct-88	1440	20	8	
POPOVITCH	26-May-88	1245	1180	34	0.62
POPOVITCH	26-May-88	1245	1430	26	0.62
POPOVITCH	Ol-Jun-88	1500	4040	1100	0.89
POPOVITCH	02-Jun-88	1100	471	44	0.82
POPOVITCH	14-Jun-88	1915	69.6	9.5	0.43
POPOVITCH	15-Jun-88	1140	88.8	8.8	0.49
POPOVITCH	16-Jun-88	1440	34	8.8	0.49
POPOVITCH	30-Jun-88	1530	19.1	4.1	0.38
POPOVITCH	08-Jul-88	1955	173	24	0.38
POPOVITCH	10-Jul-88	1340	1510	260	0.52
POPOVITCH	10-Jul-88	1800	1120	360	1.20
POPOVITCH	20-Jul-88	1140	31.4	6.1	0.38
POPOVITCH	21-Jul-88	950	355	36	0.62
POPOVITCH	22-Jul-88	1130	22200	11000	0.93
POPOVITCH	22-Jul-88	1304	1000	330	0.75
POPOVITCH	29-Jul-88	1515	22	3.9	0.43
POPOVITCH	10-Aug-88	1450	17.1	1.8	0.49
POPOVITCH	14-Aug-88	1935	48.3	5.2	0.46
POPOVITCH	23-Aug-88	1400	49.6	1.1	0.49
POPOVITCH	29-Aug-88	1230	24.1	8.3	0.49
POPOVITCH	08-Sep-88	1330	52.2	11	0.52

APPENDIX D (cont)

Site		Date	Time	TSS (mg/l)	Turb (NTU)	Q (cfs)
SANDERSON		26-May-88	1455	192	25	7.76
SANDERSON		02-Jun-88	1520	170	30	17.0
SANDERSON		15-Jun-88	1630	26500	11000	38.9
SANDERSON		16-Jun-88	1830	1510	460	16.4
SANDERSON	a	23-Jun-88	500	9680	3300	42.7
SANDERSON	a	23-Jun-88	650	7120	4000	41.2
SANDERSON	a	23-Jun-88	800	4200	2100	42.7
SANDERSON	a	23-Jun-88	950	3110	1300	38.2
SANDERSON	a	23-Jun-88	1100	3790	1400	34.8
SANDERSON	a	23-Jun-88	1250	1740	600	31.3
SANDERSON	a	23-Jun-88	1400	1380	550	27.4
SANDERSON	a	23-Jun-88	1550	1180	620	26.8
SANDERSON	a	23-Jun-88	1700	977	390	26.5
SANDERSON	a	23-Jun-88	1850	949	450	21.6
SANDERSON	a	23-Jun-88	2000	1820	670	23.8
SANDERSON	a	23-Jun-88	2150	3630	1300	26.2
SANDERSON	a	23-Jun-88	2300	3200	850	28.0
SANDERSON	a	24-Jun-88	50	1790	900	24.7
SANDERSON	a	24-Jun-88	200	1330	490	23.8
SANDERSON	a	24-Jun-88	350	1050	420	21.5
SANDERSON	a	24-Jun-88	500	1030	350	21.0
SANDERSON	a	24-Jun-88	650	954	410	21.9
SANDERSON	a	24-Jun-88	800	1000	400	20.4
SANDERSON	a	24-Jun-88	950	1140	490	19.8
SANDERSON	a	24-Jun-88	1100	1230	510	23.8
SANDERSON	a	24-Jun-88	1250	1730	620	23.0
SANDERSON	a	24-Jun-88	1400	1110	510	25.0
SANDERSON	a	24-Jun-88	1550	1340	470	22.1
SANDERSON		30-Jun-88	1030	45.2	13	9.28
SANDERSON	a	30-Jun-88	1025	40.2	24	7.00
SANDERSON		17-Jul-88	1540	17.6	15	3.80
SANDERSON	a	21-Jul-88	1320	4730	1100	36.7
SANDERSON	a	21-Jul-88	1420	14100	3100	42.5
SANDERSON	a	21-Jul-88	1520	7320	2100	37.1
SANDERSON	a	21-Jul-88	1620	4180	1000	32.8
SANDERSON	a	21-Jul-88	1720	2960	860	33.1
SANDERSON	a	21-Jul-88	1820	2010	420	29.1
SANDERSON	a	21-Jul-88	1920	1780	340	27.8
SANDERSON	a	21-Jul-88	2020	809	220	22.8
SANDERSON	a	21-Jul-88	2120	926	160	20.3
SANDERSON	a	21-Jul-88	2220	616	170	18.5
SANDERSON	a	21-Jul-88	2320	452	110	18.2
SANDERSON	a	22-Jul-88	20	351	110	18.0
SANDERSON	a	22-Jul-88	120	316	87	17.3
SANDERSON	a	22-Jul-88	220	269	98	16.7
SANDERSON	a	22-Jul-88	320	238	73	15.9
SANDERSON	a	22-Jul-88	420	217	74	14.9

APPENDIX D (cont)

Site		Date	Time	TSS (mg/l)	Turb (NTU)	Q (cfs)
SANDERSON	a	22-Jul-88	520	179	72	14.3
SANDERSON	a	22-Jul-88	620	501	150	15.1
SANDERSON	a	22-Jul-88	720	879	160	19.6
SANDERSON	a	22-Jul-88	820	2730	700	28.1
SANDERSON	a	22-Jul-88	920	1550	380	26.1
SANDERSON	a	22-Jul-88	1020	774	230	21.9
SANDERSON	a	22-Jul-88	1200	639	210	21.8
SANDERSON	a	22-Jul-88	1300	1720	450	28.1
SANDERSON	a	22-Jul-88	1400	6290	2100	39.0
SANDERSON	a	22-Jul-88	1500	3820	1200	34.0
SANDERSON	a	22-Jul-88	1600	3010	680	31.3
SANDERSON	a	22-Jul-88	1700	2510	400	30.0
SANDERSON	a	22-Jul-88	1800	7060	980	46.0
SANDERSON	a	22-Jul-88	1900	17400	5400	87.0
SANDERSON	a	22-Jul-88	2000	22600	6100	100
SANDERSON	a	22-Jul-88	2100	14200	3200	95.0
SANDERSON	a	22-Jul-88	2200	14500	3200	125
SANDERSON	a	22-Jul-88	2300	27800	6300	225
SANDERSON	a	23-Jul-88	0	26000	4800	180
SANDERSON	a	23-Jul-88	100	12000	1900	130
SANDERSON	a	23-Jul-88	200	6530	1400	120
SANDERSON	a	23-Jul-88	300	5750	1100	100
SANDERSON	a	23-Jul-88	400	10600	990	90.0
SANDERSON	a	23-Jul-88	500	11600	910	75.0
SANDERSON	a	23-Jul-88	600	9720	780	60.0
SANDERSON	a	23-Jul-88	700	5060	560	57.0
SANDERSON	a	23-Jul-88	800	3770	520	49.0
SANDERSON	a	23-Jul-88	900	2410	490	47.0
SANDERSON	a	23-Jul-88	1000	6410	460	45.1
SANDERSON		25-Jul-88	1615	91.5	25	4.40
SANDERSON		29-Jul-88	1110	10.6	5.9	5.00
SANDERSON	a	08-Aug-88	1155	2890	860	19.3
SANDERSON	a	08-Aug-88	1255	4600	1300	33.4
SANDERSON	a	08-Aug-88	1355	4270	1100	27.8
SANDERSON	a	08-Aug-88	1455	1870	730	23.2
SANDERSON	a	08-Aug-88	1555	1160	460	21.6
SANDERSON	a	08-Aug-88	1655	939	360	21.5
SANDERSON	a	08-Aug-88	1755	975	400	19.8
SANDERSON	a	08-Aug-88	1855	770	320	19.1
SANDERSON	a	08-Aug-88	1955	648	300	18.2
SANDERSON	a	08-Aug-88	2055	523	230	16.9
SANDERSON	a	09-Aug-88	355	231	96	12.0
SANDERSON	a	09-Aug-88	1055	107	61	9.70
SANDERSON		10-Aug-88	1110	12	9.1	5.70
SANDERSON	a	12-Aug-88	430	6950	1300	35.4
SANDERSON	a	12-Aug-88	530	4160	950	39.0
SANDERSON	a	12-Aug-88	630	7960	910	35.1

APPENDIX D (cont)

Site		Date	Time	TSS (mg/l)	Turb (NTU)	Q (cfs)
SANDERSON	a	12-Aug-88	730	4970	540	32.7
SANDERSON	a	12-Aug-88	830	3430	900	41.0
SANDERSON	a	12-Aug-88	1030	20000	4600	76.8
SANDERSON	a	12-Aug-88	1130	16500	2800	76.8
SANDERSON	a	12-Aug-88	1230	12500	1700	65.8
SANDERSON	a	12-Aug-88	1330	3720	1100	54.5
SANDERSON	a	12-Aug-88	1430	2230	1100	51.3
SANDERSON	a	12-Aug-88	1530	3710	640	48.0
SANDERSON	a	12-Aug-88	1630	17400	600	44.9
SANDERSON		21-Aug-88	1430	24.2	18	3.12
SANDERSON		23-Aug-88	1230	19.6	21	4.40
SANDERSON		03-Sep-88	1500	31.8	27	2.60
SANDERSON		08-Sep-88	1530	30.4	25	3.28
SANDERSON		29-Sep-88	1205	30.7	31	1.92
SANDERSON		06-Oct-88	1300	6.3	7.8	
TWOBULL		15-Jun-88	1350	1900	330	0.18
TWOBULL		16-Jun-88	1405	2270	410	0.27
TWOBULL		30-Jun-88	1820	1030	190	0.15
TWOBULL		08-Jul-88	1655	66000	22000	0.26
TWOBULL		11-Jul-88	1550	113000	36000	1.50
TWOBULL		21-Jul-88	845	14600	2100	0.41
TWOBULL		22-Jul-88	1505	15300	2300	0.43
TWOBULL		29-Jul-88	1730	523	4.8	0.20
TWOBULL		10-Aug-88	1730	229	22	0.16
TWOBULL		16-Aug-88	1105	534	12	0.18
TWOBULL		23-Aug-88	1500	247	5.3	0.14
TWOBULL		07-Sep-88	1235	12.4	4.8	0.12
TWOBULL		29-Sep-88	1035	7.5	2.8	0.07

APPENDIX E

GROUNDWATER

Constituents	Method	Detection limit (ppm)
Major ions		
Alkalinity	Electrometric titration (in field)	0.6
F	DIONEX ion chromatography	0.01
Cl	DIONEX ion chromatography	0.01
NO_3	DIONEX ion chromatography	0.02
PO_4	Persulfate digestion of filtered sample then phosphomolydate colorimetry using Technicon Autoanalyzer	0.05
SO_4	DIONEX ion chromatography	0.01
Na	Flame atomic absorption spectrophotometry	0.1
K	Flame AA	0.01
Ca	Direct Current Plasma Emission spectrophotometry (DCP)	0.001
Mg	DCP	0.001
Trace metals		
As	AA, hydride	0.004
Al	DCP	0.002
Ba	DCP	0.001
Be	DCP	1.0
Cd	DCP	0.001
cu	DCP	0.01
Cr	DCP	0.001
Fe dissolved	0.1um filter, DCP	0.03
Fe total	unfiltered, HCl digestion, DCP	0.03
Mn	DCP	0.005
Ni	DCP	0.05
Pb	DCP	0.03
Zn	DCP	0.02
Other determinations		
Total dissolved solids	calculated for analytical data	
PH	pH meter (field)	0.1 pH unit
Specific conductance	conductivity meter (field)	
Acidity	Electrometric titration (field)	0.1 ppm $CaCO_3$

APPENDIX E (cont)

SURFACE WATER

Constituents	Method	Detection limit (ppm)
Major ions		
Alkalinity	Electrometric titration (in field)	0.6
Cl	DIONEX ion chromatography	0.01
NO_3	DIONEX ion chromatography	0.02
SO_4	DIONEX ion chromatography	0.01
Na	Flame atomic absorption spectrophotometry	0.1
K	Flame AA	0.01
Ca	DCP	0.001
Mg	DCP	0.001
Trace metals		
As	AA, hydride	0.004
Ba	DCP	0.001
Cd	DCP	0.001
cu	DCP	0.01
Cr	DCP	0.001
Fe	DCP	0.03
Mn	DCP	0.005
Pb	DCP	0.03
Zn	DCP	0.02
Other determinations		
Total dissolved solids	calculated for analytical data	
pH	pH meter (field)	0.1 pH unit
Specific conductance	conductivity meter (field)	
Acidity	Electrometric titration (field)	0.1 ppm $CaCO_3$
Temperature	Meter (field)	
Dissolved oxygen	Meter (field)	
Color	spectrophotometer (lab)	1 PCU
Settleable solids	Imhoff cone (field)	0.1 ml/l
Total suspended solids	Filtration (lab)	1 mg/l
Turbidity	Turner turbidimeter	0.1 NTU

APPENDIX F

SITE	DATE	TIME	Tw	pH	Acidity	DO	% SAT	Color	TSS	TURB	ss	Q
HOSEANNA Bl	23 NAY	1840	9.2	7.24	4.25	10.6	96	80	2360	444	1.3	46.2
	19 JULY	1500	20.1	7.32	2.19	8.3	95	30	253	37.6	0.1	23.0
	08 SEPT	1230	5.9	7.84	2.50	12.9	100	30	78.6	36.0	Tr	26.4
HOSEANNA B3	23 NAY	1620	8.6	7.19	5.90	12.4	100	70	1440	342	0.8	42.4
	19 JULY	1010	12.2	7.76	2.75	14.1	100	30	292	45.1	0.8	24.7
	08 SEPT	1000	3.0	7.92	2.32	14.0	100	20	84.2	29.5	Tr	24.0
GAMW 1C	20 JULY	1805	3.8	6.71	71.4							
			2.4									
GAMW 3	24 NAY	1650	3.9	6.40	66.6							
	18 JULY	1450	[illegible]	6.15	147							
	07 SEPT	1415	1.5	5.96	278							
GAMW 4	25 NAY	1000	1.2	6.70	32.5							
	18 JULY	1700	1.9	6.95	56.3							
	07 SEPT	1650	1.9	6.35	83.3							
GAMW 5	25 NAY	1710	4.9	6.30	129							
	19 JULY	1200	3.7	6.24	224							
	08 SEPT	1100	2.3	6.36	302							

All units are mg/l except:

Yater Temp (Tw) - ^{o}C
pH - pH units
Color - PCU
Turbidity - NTU
Settleable Solids (SS) - ml/L
Discharge (Q) - cfs
Conductivity - umhos/cm at 25 ^{o}C
Alkalinity - mg/l as $CaCO_3$

SITE	DATE	Cond	TDS	Ca	Mg	Na	K	ALK	F	CL	NO3	SO4	PO4
HOSEANNA Bl	23 NAY	459	322	36.3	32.6	6.78	1.03	106	0.633	47.0	0.205	61.6	co.05
	19 JULY	571	409	45.9	38.5	13.4	3.45	129	0.799	62.3	0.265	79.7	co.05
	08 SEPT	570	372	36.2	24.9	30.9	4.58	130	0.808	32.2	1.41	76.2	so.05
HOSEANNA B3	23 HAY	433	305	36.7	33.7	5.63	0.968	100	0.561	38.5	0.255	65.9	<0.05
	19 JULY	516	402	44.8	38.4	11.8	3.22	125	0.745	60.6	0.255	82.9	<0.05
	08 SEPT	532	368	35.4	25.6	23.2	3.99	139	0.791	24.5	1.16	77.4	so.05
GAMW 1C	20 JULY	3318	3093	52.2	57.1	661	64.4	1680	0.588	171	<0.02	24.1	5.35
GAMW 3	24 NAY	1562	1101	64.8	35.9	164	19.3	346	0.798	248	<0.02	85.4	so.05
	18 JULY	1538	1092	55.6	18.6	195	20.5	354	0.811	245	<0.02	71.7	co.05
	07 SEPT	1645	1076	45.9	22.4	187	27.6	373	0.835	201	<0.02	86.9	<0.05
GAMW 4	25 NAY	415	373	35.8	9.06	5.62	45.1	186	1.01	3.85	0.055	21.3	<0.05
	18 JULY	504	445	42.8	12.9	8.56	47.9	230	1.43	3.84	<0.02	21.8	<0.05
	07 SEPT	445	401	30.6	9.51	6.73	55.8	204	1.18	3.54	<0.02	25.9	so.05
GAMW 5	25 NAY	4013	3399	190	133	792	10.5	454	4.39	1570	<0.2	61.7	<0.05
	19 JULY	7841	4062	283	193	893	15.6	645	6.23	1730	<0.2	72.0	<0.05
	08 SEPT	6905	3902	251	89.6	956	11.2	638	6.10	1680	<0.2	63.1	<0.05

APPENDIX *F* (cont)

All units are mg/l

SITE	DATE	Al	As	B	Ba	Be	cd	Co	Cr
HOSEANNA B1	23 MAY	0.058	co.004	0.13	0.110	<1.0	<0.001	0.009	0.001
	19 JULY	0.061	so.004	0.15	0.107	<1.0	<0.001	0.010	0.003
	08 SEPT	0.057	co.004	0.17	0.099	<1.0	<0.001	0.011	0.002
HOSEANNA B3	23 MAY	0.057	<0.004	0.12	0.091	4.0	<0.001	0.012	<0.001
	19 JULY	0.059	<0.004	0.14	0.076	<1.0	<0.001	0.011	0.002
	08 SEPT	0.059	<0.004	0.16	0.064	<1.0	<0.001	0.012	0.005
GAMW 1C	20 JULY	0.294	<0.004	<0.01	0.245	4.0	<0.001	0.023	0.002
GAMW 3	24 MAY	0.287	<0.004	1.71	0.404	<1.0	<0.001	0.027	0.004
	18 JULY	0.276	0.004	1.53	0.398	<1.0	<0.001	0.041	0.003
	07 SEPT	0.290	<0.004	2.82	0.242	<1.0	0.002	0.040	0.003
GAMW 4	25 MAY	0.175	0.009	0.45	0.420	cl.0	0.017	0.009	<0.001
	18 JULY	0.211	so.004	0.50	0.355	<1.0	<0.001	<0.001	<0.001
	07 SEPT	0.191	0.016	0.29	0.135	<1.0	0.042	0.002	<0.001
GAMW 5	25 HAY	0.271	0.010	1.53	1.37	<1.0	<0.001	0.412	0.004
	19 JULY	0.252	0.005	1.41	1.13	<1.0	<0.001	0.267	0.005
	08 SEPT	0.261	0.013	2.90	1.32	<1.0	0.005	0.345	0.001

SITE	DATE	cu	Fe (T)	Fe (D)	Mn	Mo	Ni	Pb	Si	Zn
HOSEANNA B1	23 HAY	so.01		0.08	0.47	0.019		<0.03	5.52	so.02
	19 JULY	<0.01		0.04	0.41	0.020		co.03	6.12	co.02
	08 SEPT	<0.01		co.03	0.36	0.022		<0.03	5.43	<0.02
HOSEANNA B3	23 MAY	<0.01		0.07	0.41	0.019		x0.03	5.54	so.02
	19 JULY	<0.01		co.03	0.39	0.022		<0.03	6.24	co.02
	08 SEPT	<0.01		co.03	0.38	0.020		co.03	5.43	so.02
GAMW 1C	20 JULY	<0.01	0.35	0.28	0.12	0.032	<0.05	0.05	6.79	<0.02
GAMW 3	24 MAY	0.13	47.2	39.2	1.23	0.026	<0.05	0.109	8.98	0.21
	18 JULY	0.15	43.4	31.9	1.19	0.041	<0.05	0.111	5.34	0.23
	07 SEPT	<0.01	36.1	18.0	1.26	0.028	<0.05	0.108	7.09	0.10
GAMW 4	25 MAY	0.01	12.7	8.45	0.66	0.012	<0.05	<0.03	9.34	co.02
	18 JULY	0.02	12.1	7.12	0.78	0.017	so.05	co.03	11.2	co.02
	07 SEPT	0.81	7.75	3.78	0.58	0.013	<0.05	co.03	8.57	so.02
GAMW 5	25 MAY	0.13	57.7	45.8	10.9	0.143	<0.05	0.175	10.4	0.30
	19 JULY	0.02	59.2	46.1	7.32	0.124	<0.05	0.168	12.4	0.34
	08 SEPT	<0.01	42.8	22.7	8.30	0.112	so.05	0.209	10.2	0.20

NOTE:
Fe (T) = Total Iron
Fe (D) = Dissolved Iron