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PEAK FLOWS FROM RHOADS-GRANITE CREEK (1987), MT. HAYES QUADRANGLE, ALASKA

by

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Mt Hayes Quadrangle

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ABSTRACT

A large fire in late May in the Rhoads-Granite Creek drainage increased concerns of flooding across the Alaska Highway and sedimentation of Clearwater Creek. DGGS investigators and SCS cooperators installed recording equipment and measured flows at sites in upper Granite Creek and above the highway crossing on the 1408 Road. The equipment was in place when a mid July rainstorm produced flood flows across the Alaska Highway. The rainstorm was later estimated to have a 10 year return period. The peak flow at the upper gage site was estimated to be 2850 cfs which falls between the 10 and 25 year floods estimated for the upper gage site in a 1987 report using HEC-1 computer model to predict flood flows at the Alaska Highway Crossing. The peak flow at the highway site was estimated to be 340 cfs, much lower than what was predicted by the 1987 HEC-1 model. An explanation for this is that at very large flows excess water enters the old channel of Granite Creek and other distributary channels and is lost to the system. If this hypothesis is correct, the potential for sedimentation of Clearwater Creek is small. During the 1987 summer no noticeable impacts from the fire on flood levels or erosion occurred.

INTRODUCTION

This report discusses the work done by Alaska Division of Geological Surveys (DGGS) investigating peak flows in the Rhoads-Granite Creek drainage during 1987. Flooding from this drainage is a concern because of massive erosion in newly developed agricultural lands and because of potential long-term sedimentation of Clearwater Creek. In 1987 this concern was further heightened by a large (43,500 acres) forest fire that burned much of the lower parts of the drainage in late May. The concern from this fire is that the further loss of ground cover will substantially increase erosion potential which, in turn, will increase the potential risk of the sedimentation of Clearwater Creek.

The flood analysis project started in this drainage in 1986 with the installation of a precipitation gage in the Granite Mountains and discharge measurements in upper Granite Creek. DGGS and Soil Conservation District personnel were at the upper and highway sites during a flood event in 1986 and from observations made at the time were able to estimate flood peaks. The 1986 observations, discharge measurements and survey work, were used to develop a HEC-1 model (a computer flood model developed by the US Army Corps of Engineers) to explain and predict the flooding the occurs in the drainage (Mack, 1987). The results of that study were included in Granite Mountain - Clearwater Creek Water Quality Planning Project report which describes the erosion and water quality concerns in detail and contains mitigation recommendations (Salcha-Big Delta Soil and Water Conservation District, 1987).

The 1987 report recommended continuation of stage and discharge measurements and records at the upper Granite Creek site and initiation of stage and discharge measurements at a site above the Alaska Highway. Due to concern about impacts from the fire, funds were made available from the Salcha-Big Delta Soil and Water Conservation District to purchase the equipment to record stage at the site above the Alaska Highway. The 1987 data were used to improve and refine the 1986 model, thus significantly improving the hydrologic analysis of the Rhoads Creek - Granite Creek drainages.

BACKGROUND

The combined Rhoads-Granite Creek drainage above the Alaska Highway crossing has a total area of approximately 81 square miles. The flow at the Alaska Highway crossing originates in the Granite Mountains and is slowed down, and except for infrequent storms, totally lost in the lower, forested part of the drainage. The mountainous part of drainage has an area of 47.1 square miles and the forested drainage 34.1 square miles. Of that, upper Granite Creek (the Granite Creek drainage above the gage site) has an area of 32.2 square miles, approximately 40 percent of the total area and 68 percent of the mountainous area. The mountainous portion of the Rhoads Creek drainage has an area of only

4.64 square miles. Thus, while the road crossing flows have frequently described as coming from Rhoads Creek, most of the flow can be attributed to the upper Granite Creek drainage. The remainder of the mountainous part of the drainage (10.1 square miles) comprises Till Valley Creek and two unnamed creeks.

Granite Creek, just below the present upper gage site, appears to have changed channels within the past five to ten years (see Sheet 1). Previous to the channel change the total Granite Creek flow was directed in a more westerly channel. Flow in this channel would cross the Alaska Highway approximately five miles closer to Delta Junction. Dividing the flow carried by the present Rhoads-Granite Creek system of channels so that 60 percent was carried in a totally different channel system would create much greater surface area for system losses and allow for much greater attenuation of flood peaks. This may be part of the reason flood peaks across the Alaska Highway have not been noticed until recently. The recent channel change appears to be permanent with little chance of natural redirection to the older channel at normal flows.

In our 1987 report we estimated the return period flows for the upper gage site and used the HEC-1 model to develop the corresponding flow at the highway crossing (Table 1). The predicted flows above the highway range from 320 to 3730 cfs. The time it takes these flows to reach the Alaska Highway from the start of the storm ranges between 48 and 31.5 hours, respectively. The flows at the highway were calculated to be between 38 to 69 percent of those predicted for the upper site. When flows at the upper site drop below 300 cfs the model showed no flow at the highway. Previous work by Ed Grey of the Soil Conservation Service indicated that the culverts at the Alaska Highway could pass 130 cfs. This means that the estimated 2 year return peak flow (or flow that has a 50 percent chance happening in any given year) would be too much for the highway culverts (Mack, 1987).

Table 1. 1987 HEC-1 Model Results.

RETURN PERIOD	UPPER GRANITE PEAK (cfs)	ALASKA HIGHWAY PEAK (cfs)	TIME OF PEAK AT GAGE (1)	TIME OF PEAK AT HIGHWAY (1)	RATIO OF HYW TO GRANITE	CHANNEL LOSSES (cfs)
Q2	840	320	18.0	48.0	0.38	379
Q5	1300	770	10.5	40.5	0.59	415
Q10	2070	1090	10.0	37.5	0.53	433
Q25	3020	1600	10.5	34.5	0.53	436
Q50	3900	2030	10.5	33.0	0.52	440
Q100	5400	3730	13.0	31.5	0.69	440

Flows less than 300 cfs at the Upper Granite Creek site do not make it to the Alaska Highway

(1) Hours from start of storm precipitation.

These results tend to fit the observed flows of the past few years. The 1986 storm was estimated to fit in the range of a two year event or, in other words, was an event with a 50 percent chance of happening in any given year. Recent flooding across the highway appears to fall in the this range. Larger flows than these have not been reported (Mack, 1987).

METHODS

1. Precipitation data from Granite Mountain. The Granite Mountain precipitation gage is located in the NW¼, SW¼, Section 33, T13S, R12E, FM near the headwaters of Granite Creek and approximately 3800 feet above mean sea level (Sheet 1). The gage consists of an aluminum container 12 inches in diameter and 10 feet high. A Wyoming type shield was constructed on June 10, 1987 to break the force of the wind that blows over the orifice of the can.

The rain gage is connected to a stilling well which rises as precipitation is added to the gage. The changes in fluid levels are read half-hourly by an Omnidata datapod model 214. The Omnidata recorder is programmed to establish a fluid level trend line and then to record deviations greater than 0.02 feet from the trend line and at least once per day. Thus, during periods of no precipitation the recorder will record data only once per day, while during an intense storm the recorder may record at half-hour intervals.

2. Discharge. We established gage sites at two locations: on Upper Granite Creek in the NW¼, NE¼, Section 15, T13S, R11E, FM at the foot of the Granite Mountains at approximately 1825 feet above mean sea level, and on the 1408 Road above the Alaska Highway crossing in the SW¼, SW¼, Section 26, T11S, R12E, FM approximately 1225 feet above mean sea level.

The 1408 Road site is in a straight reach where all the Rhoads-Granite Creek flood flow is collected into one channel. At both the upper and highway sites continuous water surface levels were recorded with Omnidata DP320 Stream Stage Recorders. The DP320 is a small, battery operated device with a submersible pressure transducer which measures and records water levels between 0 to ten feet to the nearest hundredth of a foot. Water level data are stored in a solid state memory called a data storage module. The water level recorders monitored water levels at 30 minute intervals.

Velocities used to calculate discharge, in cases, were measured with a Marsh McBirney Model 201 Flowmeter. Velocities were measured six tenths of the depth from the surface. Discharges were calculated using the standard midpoint method (USDOI, 1981) from at least twenty velocity measurements taken across the stream cross section. Rating curves were developed for each site by using the available discharge measurements combined with peak flows estimated using the slope-area method (Dalrymple and Benson, 1984). The rating curves were then used to estimate discharge from the recorded water levels.

3. HEC-1 model. HEC-1 is a program developed by the U.S. Army Corps of Engineers Hydrologic Engineering Center to model peak runoff from precipitation data. With the program one can divide the watershed

into subbasins, spatially distribute rainfall events, and use a variety of methodologies to model the rainfall event (U.S. Army Corps of Engineers 1981).

The refined model used in this report is essentially the same model as that developed for the 1987 report, with one important exception. A major question raised by the data collected in 1987 was with the large discharge at the upper site from the July 13-14 storm, why was the discharge at the highway site no larger than that previously reported? One explanation for this is that very large flows from upper Granite Creek spill into the old Granite Creek channel and become distributed away from the 1408 Road. This is supported by field observations in 1986 during the large flow we observed on June 19. This flow, estimated at approximately 800 cubic feet per second (cfs), came close to entering the old Granite Creek channel. For the model used in this report we assumed a diversion function where at flows above 800 cfs a portion of the excess flows into the old channel and is lost to the system. Figure 1 is a schematic diagram of the Rhoads-Granite Creek model, including the peak flow diversion. Each box represents a subbasin (G1 stands for the first Granite Creek subbasin, for example) or a model routine, such as a combination of flows from two or more subbasins (COMn) or routing of flow through a stream reach (RTn) (see Sheet 1 for the geographic location of the model components).

Figure 1. Schematic diagram of Rhoads-Granite Creek model

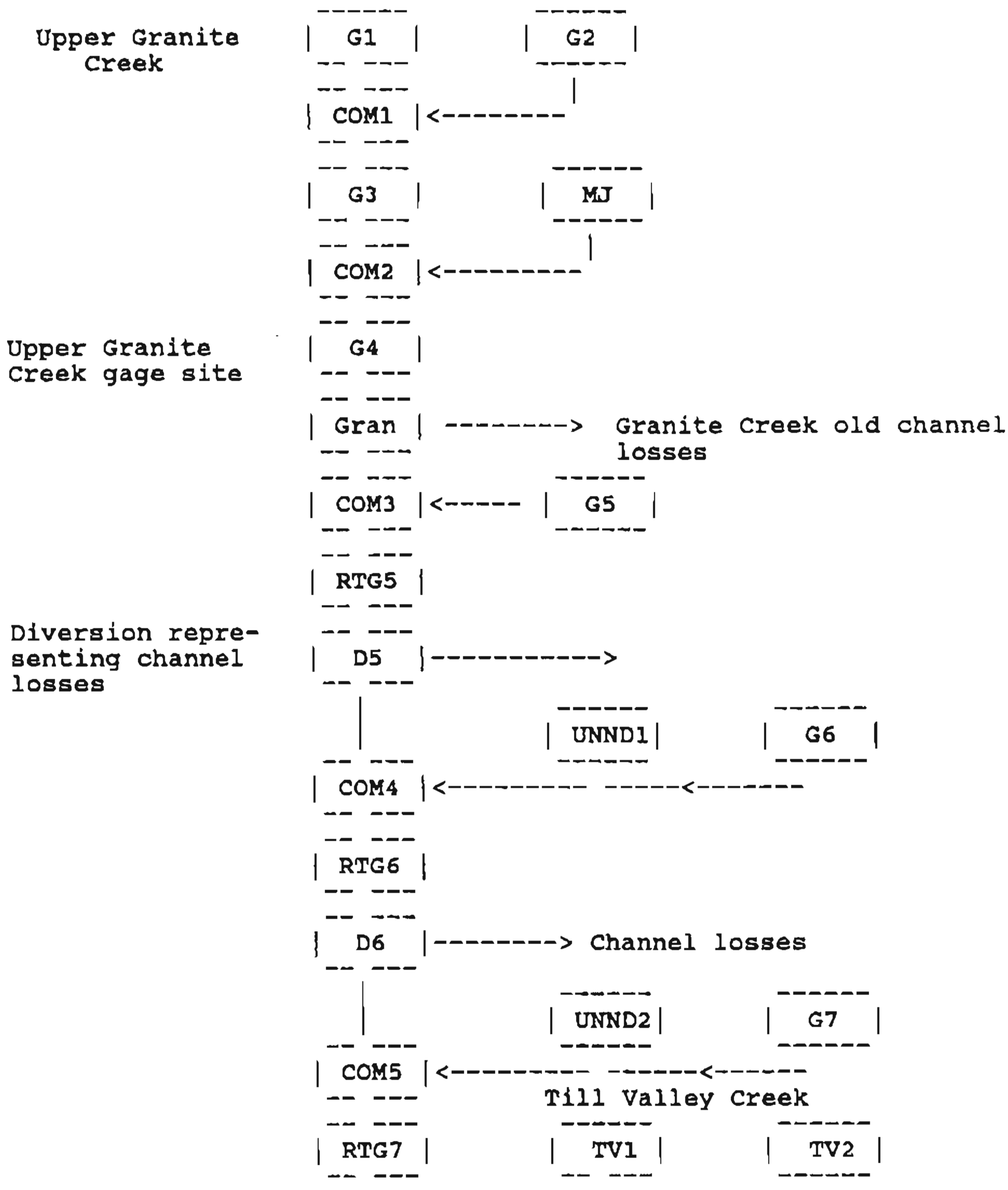
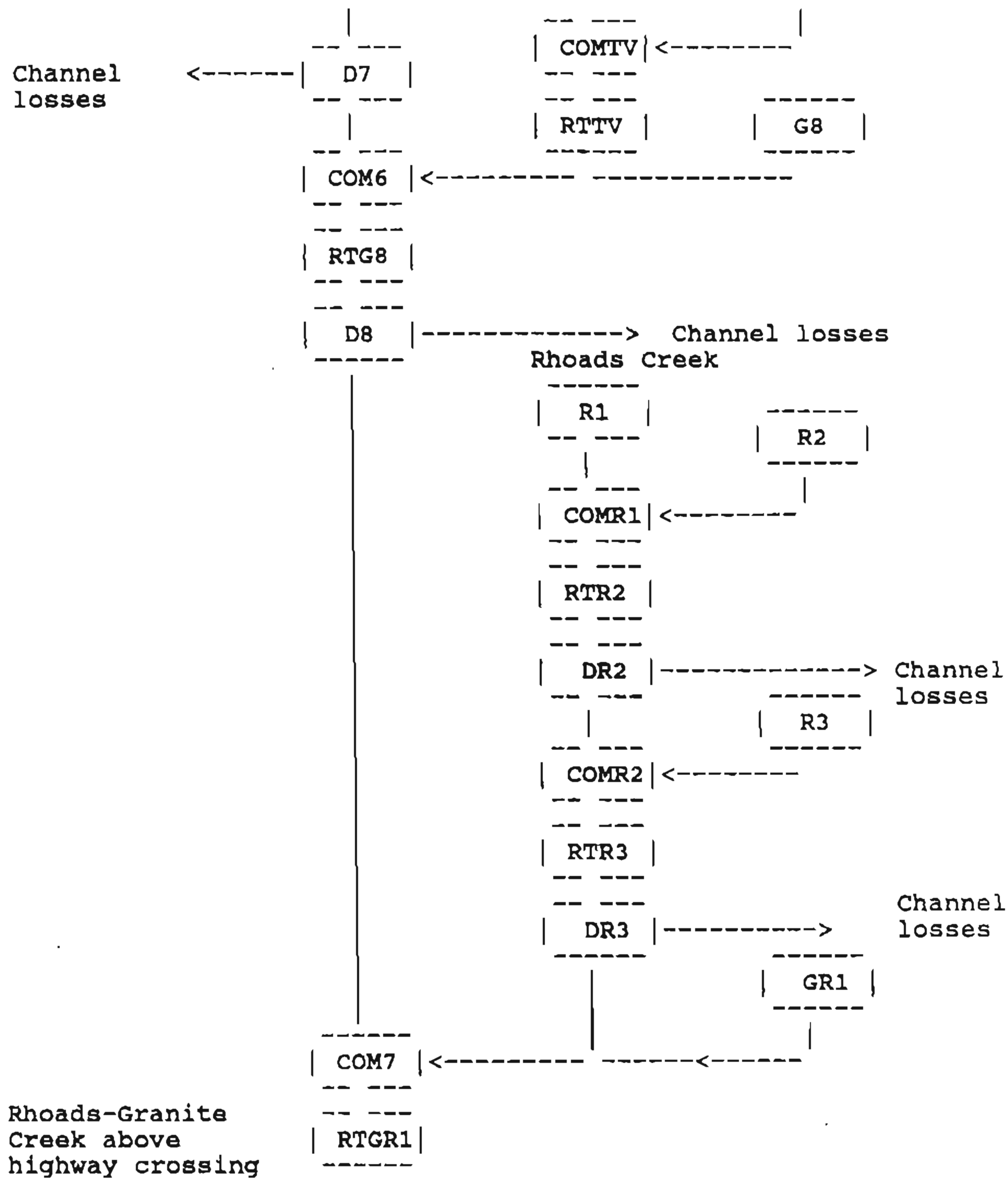


Figure 1. Schematic diagram of Rhoads-Granite Creek model (cont)

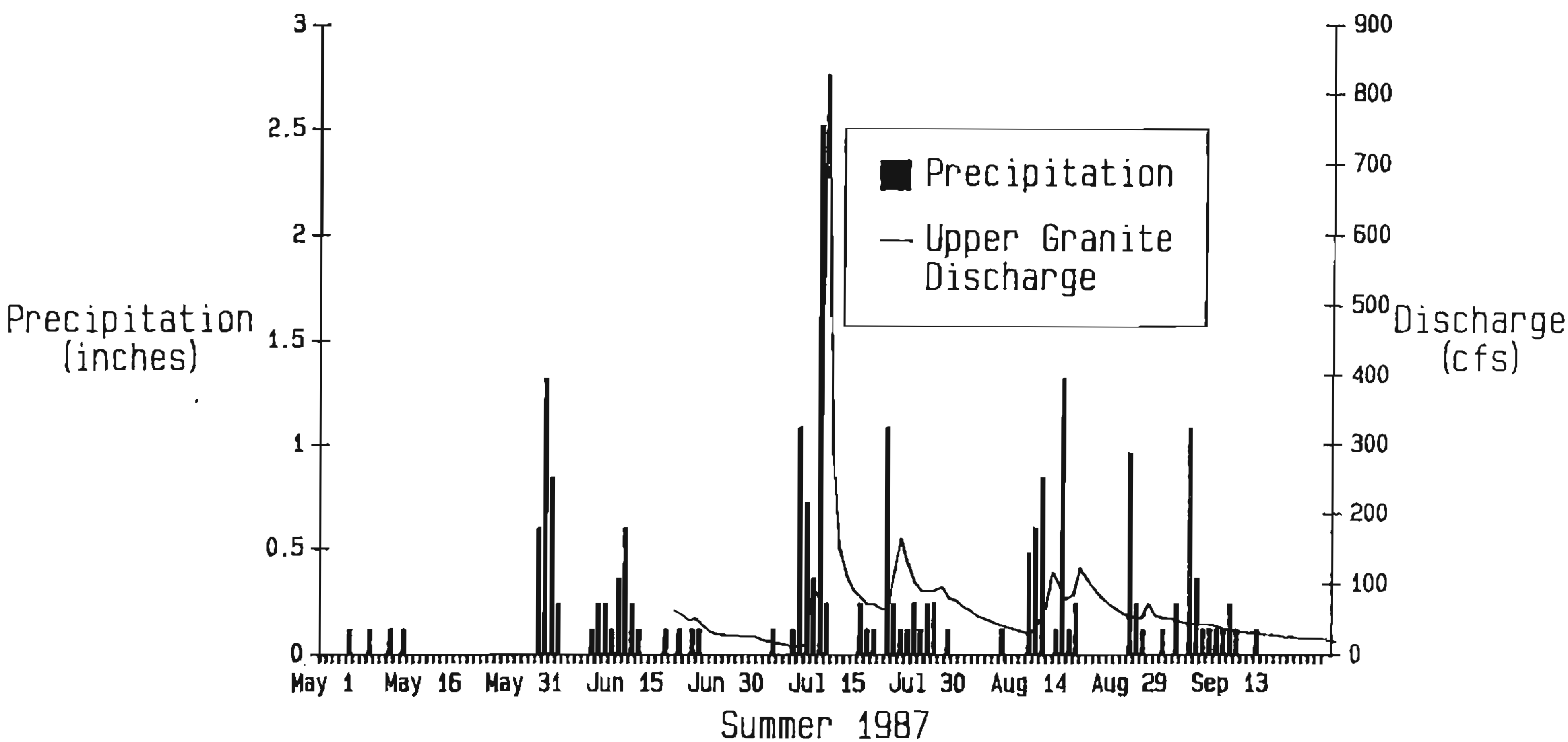


RESULTS

1. Precipitation and discharge. Figure 2 shows the precipitation recorded at the Granite Mountain precipitation gage and the average daily discharge estimated at the Upper Granite Creek gaging site for the 1987 summer. Precipitation for the period May 1 to September 26 was 22.1 inches. The maximum for any one day was 2.52 inches on July 14. The second highest daily value was 1.32 inches on June 3 and August 19. Flows were noticed at the highway after the June storm, but not after the late August storm.

The upper Granite Creek gage site was started on June 22 and a gage was started at the site above the Highway on July 13. Two large flows were observed at the highway site this summer: the first after the early June rainstorm (at the end of the forest fire and before any recording equipment was put into the field) and the second on July 15 which was recorded by stream gages at both sites. The flood for which recording equipment was operating is discussed below. At the upper site average discharge for the period we recorded state was 65.1 cfs. Other than the flows from the July 13-14 storm discussed below, no flow was recorded at the highway site. Appendix 1 contains the seasonal precipitation at the Granite Mountain Wyoming gage and discharge at the Upper Granite Creek gage site.

Figure 2. Precipitation and discharge at Upper Granite Creek, 1987

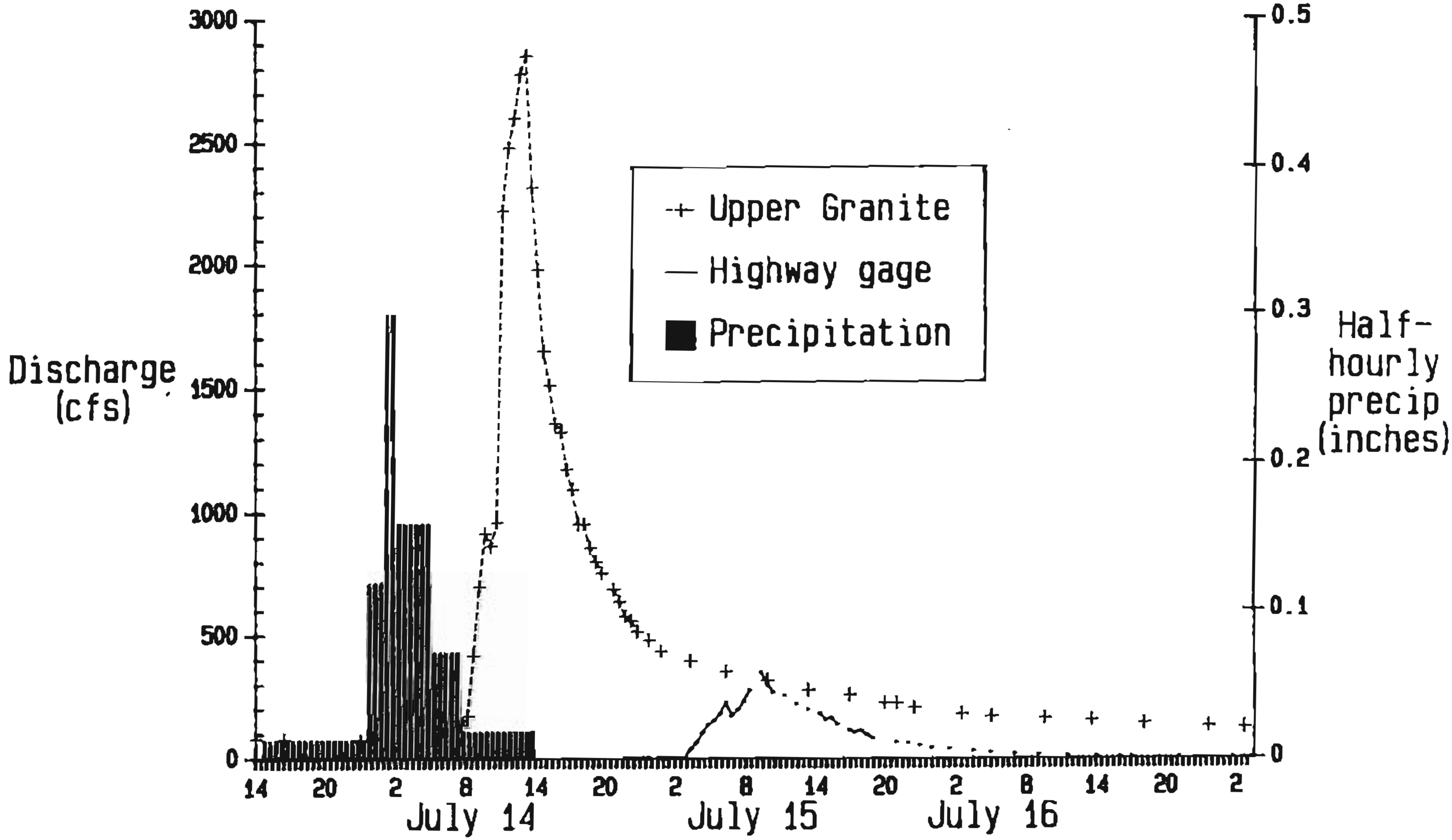


2. July 13-14 storm and flooding. Figure 3 shows the precipitation at the Granite Mountain gage and hydrographs at the upper and highway sites for the July 13-14 storm. The most intense rain was in the early morning of July 14. Elsewhere runoff from this storm closed the Richardson Highway. Preliminary estimates of the rainfall at the Alaska Department of Transportation Trimms Camp indicated that the storm had approximately a 10 year return period (or a 10 percent chance of happening in any given year) (Jones, 1988).

The peak discharge (estimated at 2850 cfs) occurred at the upper site at approximately 12:30 pm on July 14 and reached the highway site at approximately 9:00 am on July 15. The peak at the highway site was estimated to be 340 cfs. The travel time for the peak between those two sites was 18 hours. Besides the great difference in peak discharges the flow volumes at the two sites are remarkably different. 296 acre-feet (af) flowed passed the highway site through the entire flow event. For the same time period, assuming an 18 hour travel time approximately 2000 af passed the upper site. 85 percent of the water that flowed during the flood event at the upper site was lost.

Based on the return period estimates made for the 1987 report (in Table 1), the peak flow on July 14 at the upper site falls somewhere

Figure 3. Precipitation and discharge from July 13-14, 1987 storm



between a 10 and 25 year event. The peak flow at the lower site comes nowhere near what was predicted by the 1987 model and is still in the two year event range. If the flow at the lower site had followed the model prediction it should have been in the 1400 cfs range.

3. Model operation. Initially, the July 13-14 storm precipitation values were put into the upper basin portion of the flood model developed in 1987 without any adjustment of parameters. The peak value and hydrograph obtained were remarkably similar to that estimated from the upper gage site records, although the travel times were different. Adjustment of some of the parameters brought the travel time close to what was recorded.

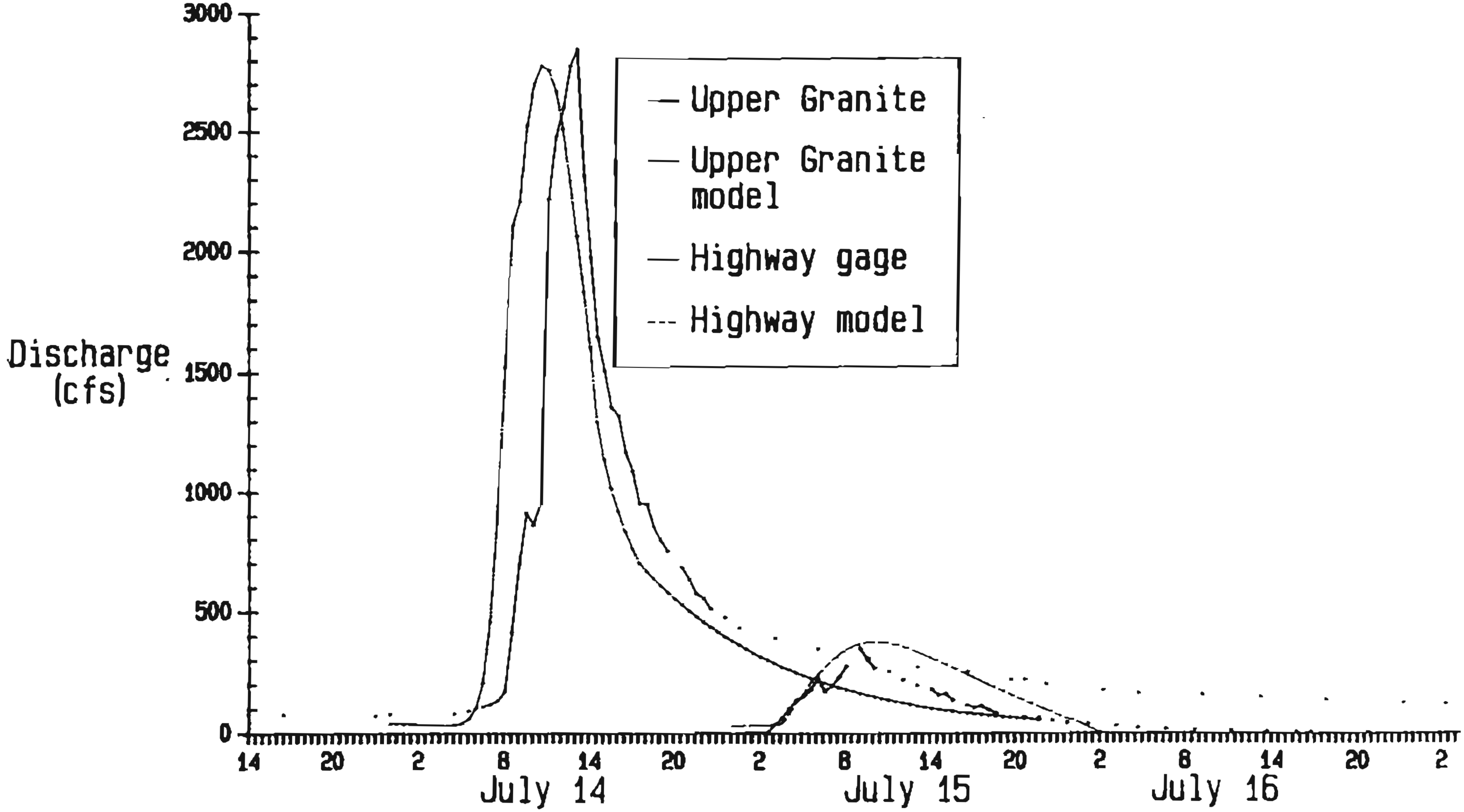
Even though the 1987 model worked reasonably well for the upper basin, it was obvious that it would not accurately predict the flow estimated at the highway site. Assuming that the flows estimated in 1986 for the model development and the flows estimated from the recorded stage records were reasonably accurate, we needed an explanation for the relatively level flood flows at highway crossing in relation to the large disparity in upper site flows.

In 1986 it was noted that Granite Creek just below our gage site no longer flowed in its historical channel. Sometime within the last ten years it had abandoned that channel and joined with Rhoads Creek to produce the flooding at the highway crossing. At the 1986 flood level all the water was in the new Granite Creek channel. However, we observed that at the peak stage, water did not have far to rise before it could enter the old Granite Creek channel. At that point the old channel is approximately 250 feet wide (compared to less than 100 feet for the new channel), free of vegetation with a bottom of cobbles, sand and boulders. The 1987 peak was approximately 1.5 feet higher than the observed 1986 peak. With the resistance of the narrow new channel it seems likely that much of the flow of Granite Creek could flow in the old channel if the river stage is high enough. We added that assumption to the flood model by adding a diversion function that put water in the old channel once the model discharge reached above 800 cfs. Running the model with this addition, plus adjustment of some model antecedent conditions gave the result shown in Figure 4. The assumption that the old Granite Creek channel carries water during larger flood events can explain the moderation of very large flood upper site peaks at the highway.

DISCUSSION

1987 was an eventful year for the Rhoads-Granite Creek drainage. A late May forest fire burned much of the lower forested watershed and a mid July rainstorm had an intensity estimated in the 10 year return period range based on rainfall records from other parts of the local area. Recording equipment at the upper and above highway gage sites were able to record data for good estimates of the flood levels at both

Figure 4. Model and gage discharges from July 13-14, 1987 storm



sites. Field trips, flyovers, and aerial photography analysis conducted in 1987 after the fire have increased the knowledge of the drainage system.

Results from the 1987 field season show that the model developed for the 1987 report operated reasonably well for the Upper Granite Creek portion of the drainage but overpredicted flows at the highway site for the storm we had this summer. Table 1 (above) may be accurate for the return period flows at the Upper Granite Creek site, but does not appear accurate for the above highway site. The multitude of overflow channels in the drainage, especially the old Granite Creek channel, provides many avenues for excess flows to be distributed in the lowland. This threshold overflow mechanism works to mitigate peak flows at the highway crossing. Inspection of the aerial photography flown this summer gives ample evidence of this, as well as the model results.

The evaluation of the effect of sediment transport to the Clearwater River is a major objective of this study. The potential sedimentation impact on Clearwater Creek is less than expected, based on the 1987 analyses which support the hypothesis that larger flows are attenuated by distribution channels.

Now that the upper and lower gaging sites are operating well, the HEC-1 model is most useful for instructive purposes. Model runs can show if various theories, such as the excess flows going into the old Granite Creek channel, are workable, but the synthetic hydrographs produced are not as useful as the hydrographs recorded at the gage sites. Most useful for furthering our knowledge of the Rhoads-Granite Creek drainage is continuation of the gaging and precipitation collection done this summer.

Antecedent moisture conditions probably play a large role in the magnitude of flows crossing the highway from storms in the mountains. Looking at the precipitation data from this summer (Figure 2 above), rainstorms early in the season produce flooding while similar sized storms later do not. The rainstorm at the end of the forest fire produced flooding across the highway, yet a similar sized storm in mid August, with the same one-day peak intensity, did not. For the earlier storm base flow in Granite Creek was higher, and soil conditions were much wetter. For the later storm it is possible that the precipitation at higher altitudes fell as snow. From the observations of the past two years, it seems likely that storms earlier in the summer will produce greater flows at the highway crossing, than equal sized storms later on. This is a largely qualitative observation at this time. With the amount of data we have now the seasonal variation cannot be reliably plugged into the model. It may be that a storm of the July 13-14 intensity occurring in early June would have produced much larger flows at the highway, because of of antecedent moisture conditions.

The late May forest fire caused concern about flooding in the drainage. Much of the lower drainage was burned; in some instances the fire burned completely to the mineral soil layer. The July storm was of an unusual intensity, but we saw no evidence of accelerated erosion. Part of the reason for this is that the fire did not burn much, if any, of the vegetation on and in the active channels of Rhoads and Granite Creek. After the fire it was relatively easy to find the channels of these two creeks because that was where trees were still alive. From the upper gage site near the southern extremity of the fire to the most downstream evidence of water, the channels can be located by looking for green trees. The presence of water in these channels in late May surely set up micro-conditions that enabled these trees to survive. Because of this, these channels should stay relatively stable. What is unknown is whether, over time, floods will carve new channels in the heavily burned areas.

The aerial photography flown in 1987 is very useful for determining how the Rhoads-Granite Creek drainage works. Unfortunately, coverage of the Rhoads Creek portion is lacking - only a small part of the upper 1408 road is included and the highway crossing is not covered. Inspection of the photography shows the many flood channels in the drainage. One myth destroyed by the photography is the downstream distance that water flows above ground during normal flows. Photography of August 24, 1987, shows flowing water approximately 5 miles from the Alaska Highway, much further downstream than anticipated.

Earlier estimates placed the downstream point of flowing water approximately one mile below the upper gage site and six miles upstream of the lowest flowing water shown by the photography.

Another observation from the aerial photography is the effect of Tract A on flooding. During high flow events, water from Rhoads and Granite Creek flows through many channels in the forested area south of Tract A. When the flows reach Tract A, berm piles which are arranged perpendicular to the flow direct the water easterly toward the 1408 Road. As these channels near the 1408 Road, from the aerial photography erosion appears to worsen. Aerial photography of the area near the 1408 Road was not taken, but ground observations show erosion to be very bad adjacent to the road. If the flows from the forest channels could be redirected when they reach Tract A, erosion in Tract A and flood levels at the highway crossing could be reduced.

CONCLUSIONS

The fire that swept through the lower parts of the Rhoads-Granite Creek drainage in late May produced no identifiable impacts on flood levels or on erosion. Recording equipment in the field show levels from the mid-July rainstorm had an estimated 10 year return period. In the upper basin flows from this storm fell between the 10 and 25 years period flows estimated for the 1987 report. Flows at the highway site were much lower than those predicted by the flood model developed for

1987 report. One explanation for this is that when flood levels reach a certain stage they reenter the old channel of Granite Creek and other distributary channels and are lost to the system. If this explanation is correct, flooding from Rhoads-Granite Creek has little chance of introducing sediment into Clearwater Creek. Our knowledge of Rhoads-Granite Creek flooding will be enhanced by further gaging of the upper and lower sites, precipitation data collection, and observation of actual flood events.

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APPENDIX 1. Seasonal Precipitation and Discharge

Granite Mountain Precipitation, Summer 1987

Values in inches

Total= 22.1 inches

Maximum= 2.52

	May	June	July	August	September
1					
2		0.6		0.12	
3		1.32			0.12
4		0.84			
5	0.12	0.24			0.24
6					
7			0.12		1.08
8	0.12				0.36
9					0.12
10		0.12	0.12	0.12	0.12
11	0.12	0.24	1.08		0.12
12		0.24	0.72		0.12
13	0.12	0.12	0.36		0.24
14		0.36	2.52	0.48	0.12
15		0.6	0.24	0.6	
16		0.24		0.84	
17		0.12			0.12
18				0.12	
19				1.32	
20			0.24	0.12	
21		0.12	0.12	0.24	
22			0.12		
23		0.12			
24			1.08		
25		0.12	0.24		
26		0.12	0.12		
27			0.12		
28			0.24		
29			0.12	0.96	
30			0.24	0.24	
31			0.24	0.12	
Total	0.48	5.52	8.04	5.28	2.76

APPENDIX 1. Seasonal Precipitation and Discharge

Upper Granite Creek Discharge, 1987
Values in cubic feet per second
Total= 65.1 cfs
Maximum= 2850 cfs

	June	July	August	September
1		25.6	79.1	51.3
2		24.6	75.5	49.5
3		24.6	67.0	48.8
4		23.9	62.3	44.3
5		19.7	54.6	43.8
6		17.2	50.4	42.3
7		15.5	46.5	42.9
8		13.7	42.4	43.4
9		11.4	39.5	39.7
10		10.7	36.7	36.5
11		14.1	34.1	34.1
12		93.1	30.9	32.5
13		81.6	31.2	30.7
14		827	46.9	29.9
15		293	66.4	29.6
16		150	116	27.5
17		112	97.5	27.2
18		90.8	77.3	26.2
19		81.5	84.4	24.4
20		71.0	121	24.4
21		71.9	107	22.6
22	62.4	64.6	92.4	22.7
23	55.5	60.5	81.2	22.5
24	47.7	116	72.1	22.8
25	50.5	163	65.1	20.3
26	40.9	127	58.8	18.3
27	32.4	102	52.5	
28	28.6	89.2	52.6	
29	26.9	89.5	50.6	
30	26.1	90.6	72.1	
31		95.4	55.2	
Total	41.2	99.0	65.1	33.0