REDWOOD CREEK

1975 SEDIMENT STUDY

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INTRODUCTION

In April 1975, Winzler and Kelly Water Laboratory released its 1973-1974 Redwood Creek Sediment Study (Winzler and Kelly, 1975)[1] which contained the findings of a sediment and clay mineralogy study performed in the Redwood Creek Basin during the rainy season of 1973 and 1974. This report is a continuation of the original study and focuses primarily on the sediment transport characteristics of Redwood Creek and several of its mid-reach tributaries (figure 1). Considerable effort, however, was also directed toward answering questions we received on the original report concerning several aspects of the clay mineralogy work used to identify soil types and sediment sources.

To facilitate review, this report has been divided into three major sections: stream sediment monitoring, which contains narrative and graphical descriptions of the storm events monitored; a clay mineralogy section which presents additional data and discussion on the mineralogic characteristics of the basin's soils and sediments; and a final section containing the findings and conclusions derived from the data found in the study. Appendix A contains the data from which the graphical analyses were made of the parameters measured during the synoptically monitored storm events.

1. Winzler and Kelly Water Laboratory. April, 1975. "1973-1974 Redwood Creek Sediment Study." Winzler and Kelly Consulting Engineers, Water Laboratory, Post Office Box 1345, Eureka, California 95501.

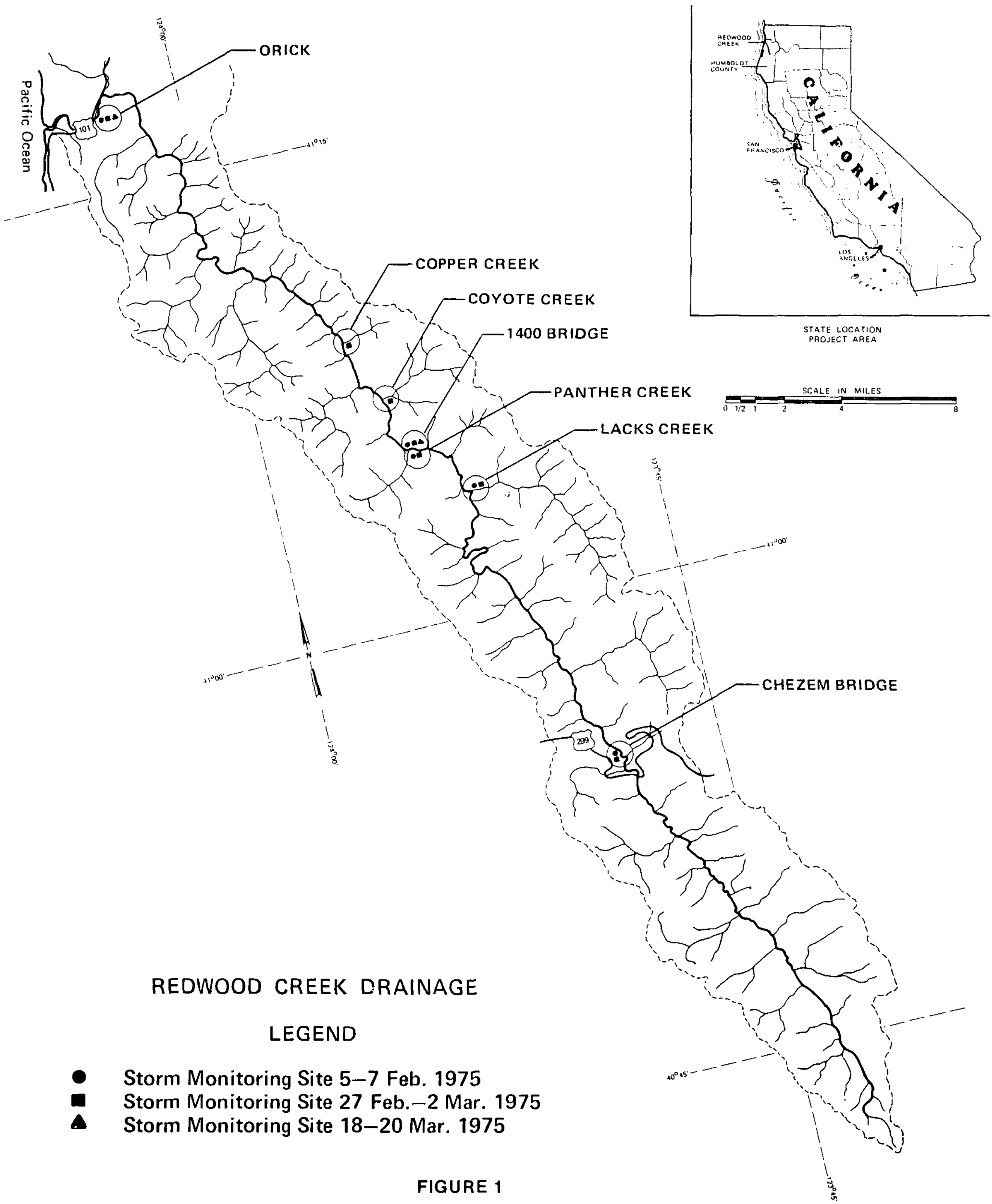

ORICK
Pacific Ocean
101
41°15'
124°00'
COPPER CREEK
COYOTE CREEK
1400 BRIDGE
PANTHER CREEK
LACKS CREEK
41°00'
CHEZEM BRIDGE
299
40°45'
123°45'
REDWOOD CREEK
HUMBOLDT COUNTY
CALIFORNIA
SAN FRANCISCO
LOS ANGELES
STATE LOCATION
PROJECT AREA
SCALE IN MILES
0 1/2 1 2 4 8
REDWOOD CREEK DRAINAGE
LEGEND
● Storm Monitoring Site 5–7 Feb. 1975
■ Storm Monitoring Site 27 Feb.–2 Mar. 1975
▲ Storm Monitoring Site 18–20 Mar. 1975

FIGURE 1

STREAM SEDIMENT MONITORING

The three storms monitored during the 1974-1975 season varied considerably in intensities and durations. The first two storms never fully developed and as a result the stream response was limited. Monitoring activity during the first two storms was terminated due to a lack of sufficient rainfall rather than by the completion of a hydrologic event. The third storm generated stream flows so intense, on the order of flows measured during the 1964 flood, that monitoring activities were limited to the recessional period. Additionally, the intense flows and extremely high water levels which occurred during that storm restricted monitoring to just the main stream of Redwood Creek. However, the monitored storm periods did provide valuable information on the flow and suspended sediment characteristics of the measured streams.

Storm I

5-7 February 1975

Rainfall during this storm event was very localized within the basin. For example, on the 6th of February Valley Green received 0.06 inches and the Prairie Creek Ranger Station a trace; both stations are at a low elevation in the Basin. In the upper basin at Okane the U.S. Weather Bureau recorded 0.4 inches on the 6th of February, while at our station at Panther Creek only 0.09 inches were recorded on the same date between 1700 hours and 2340 hours. Immediately above our station at The Simpson Timber Company station, on the ridge dividing the Redwood Creek and Little River drainages, a total of 1.42 inches were recorded on the 6th of February. Rainfall continued in this sporadic fashion until the monitoring was terminated on the 7th of February.

TABLE I
Basin Precipitation
Storm I

Station	Time Interval	Precip. [inches]
Prairie Cr Ranger Sta*	5-7 Feb 1975	0.95
Valley Green**	5-9 Feb. 1975	2.07
Redwd Cr at Panther Cr	1700 6 Feb to 0900 7 Feb 1975	0.12
Okane***	5-7 Feb 1975	2.00
800 and K&K****	5-6 Feb 1975	2.92

*California Dept. of Parks and Recreation Data
**Arcata Redwood Company Data
***U.S. Weather Bureau Data
****Simpson Timber Company Data

The rainfall rate was fairly uniform during the measured period low in the basin, and was most intense on the 5th of February, high in the basin.

Streamflow

Streamflow in Redwood Creek was generally recessional from the initiation of monitoring on the 5th until approximately 0800 on the 6th, at which time all three stations experienced an increase in stream flow. The streamflow peaked at the Chezem Bridge station (Chezem) at approximately 1700 cfs (cubic feet per second) at about 2130 on the 6th. Streamflow at the 1400 Bridge Station (1400), located at the confluence of Redwood and Panther Creeks, exhibited a peak flow of about 2900 cfs approximately ten hours later than at Chezem. The flow in Redwood Creek at Orick was still increasing when the monitoring was terminated at 0900 on the 7th, when a high flow reading of approximately 2800 cfs was measured (figure 2).

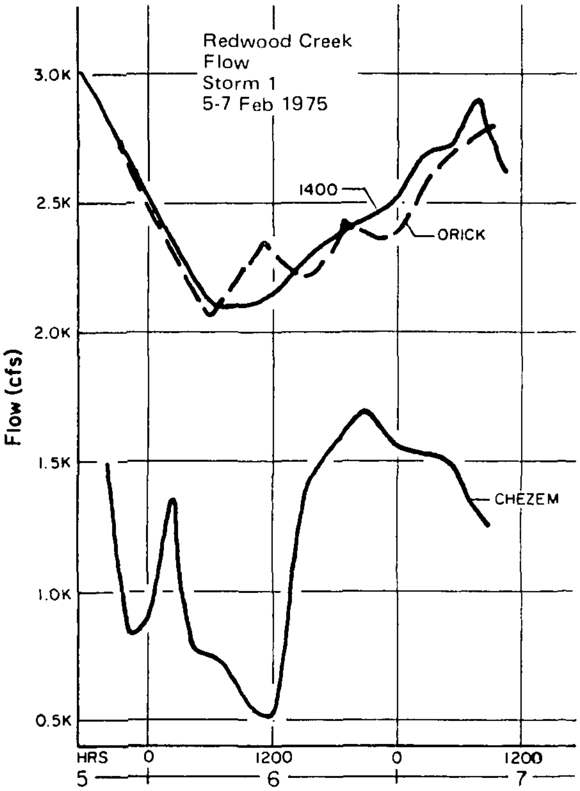


FIGURE 2

The two tributary streams monitored during this period experienced quite different flow patterns during the event. Panther Creek, measured at its confluence with Redwood Creek, had a fairly even flow rate during the event, ranging from 39 to 67 cfs (figure 3), and exhibited a small flow peak at approximately 1600 on the 6th of February. In contrast, Lacks Creek, which has a 17.5 square mile drainage (nearly three times that of Panther Creek), showed considerably more variation in flow during the same period (figure 3). Lacks Creek more closely mimicked the flow patterns found in Redwood Creek, exhibiting a low flow at about 0800, 6 February 1975, and peak flows around 1800 hours of the same day. Stream flow in Lacks Creek varied from a low of about 280 cfs to a high of about 400 cfs. The higher degree of variability in the Lacks Creek flow is thought to be due primarily to the rainfall pattern of the storm within the basin and the differing aspects of the two drainages, as Lacks Creek flows generally north-northwest while Panther Creek flows northeast. It is recognized that other factors, such as drainage shape and size, would produce differences in the flow regime, but it was felt that such other influences played a lesser role in this particular instance.

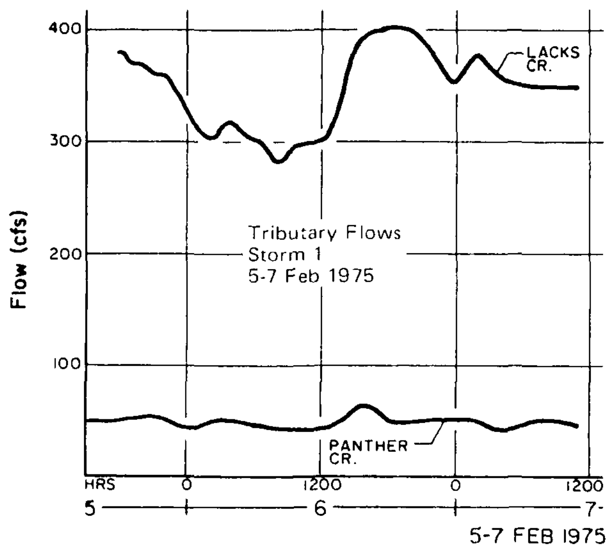


FIGURE 3

Turbidity

Turbidity is included as a parameter of note in the storm monitoring program only because the turbidity values tend to mimic, in a general sense, changing flow and sediment conditions. No attempt was made to correlate turbidity to sediment concentration as this is possible only under very limited stream and sediment conditions.

With these limitations in mind, the curve generated by turbidity values in Redwood Creek, in a general sense, followed the same pattern exhibited by flow during this period (figure 4).

Suspended Sediment Characteristics

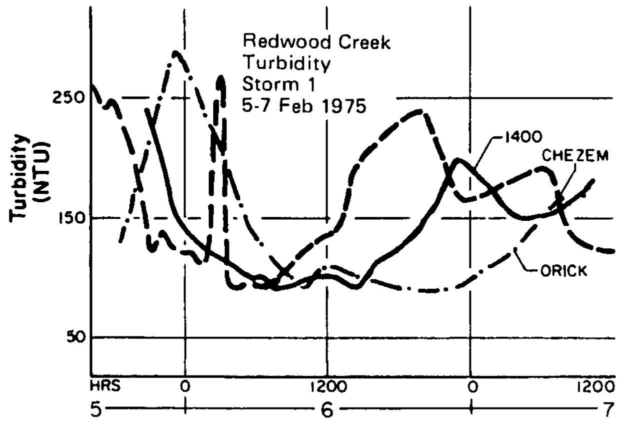


FIGURE 4

The absolute values for all three stations ranged from slightly under 100 NTU's (Nephelometric Turbidity Units) to highs of between aproximately 250 and 300 NTU's. The greatest fluctuation was noted at the Chezem station, with the values at Orick exhibiting the least variation.

There was a dramatic difference between the turbidity of the two tributaries monitored (figure 5). The turbidity in Panther Creek, which flowed extremely clear during the entire period, never exceeded 3 NTU's. Lacks Creek varied from a high turbidity of approximately 160 NTU's to a low of less than 20 NTU's. The turbidity differences between Lacks and Panther Creeks reflect not only differences in soil types, aspects, slopes, basin size, steepness, and land-use, but also differences in runoff patterns.

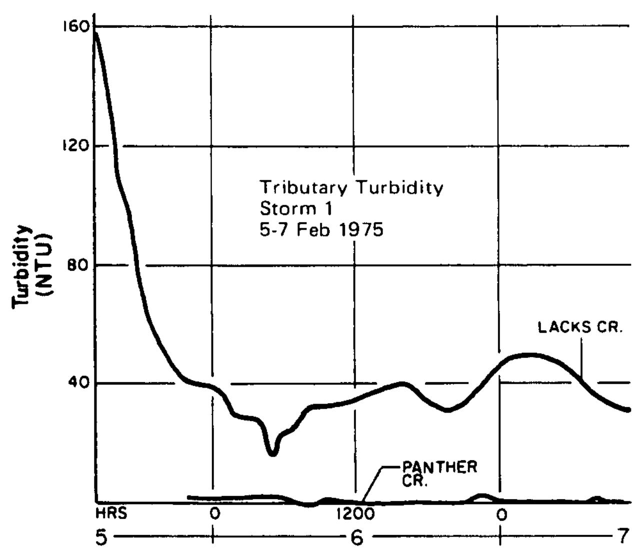


FIGURE 5

The primary thrust of our Redwood Creek synoptic sampling was to obtain the data necessary to define the sediment transport characteristics of Redwood Creek and selected tributaries in order to be able to draw conclusions as to the various sediment production rates.

Suspended sediment concentrations in Redwood Creek generally decreased during the initial phase of the stream monitoring to the low values obtained near mid-day on the 6th of February, when they began increasing. Sediment concentrations decreased during the early morning hours of the 7th and continued to decrease until monitoring was discontinued (figure 6). The stations at the Chezem Bridge and at the 1400 Bridge both show considerable fluctuation in the sediment concentrations,reflecting the greater degree of turbulence at these stations. The Orick station, low in the basin, shows very little fluctuation and more uniformly depicts changing suspended sediment concentration with varying flow conditions.

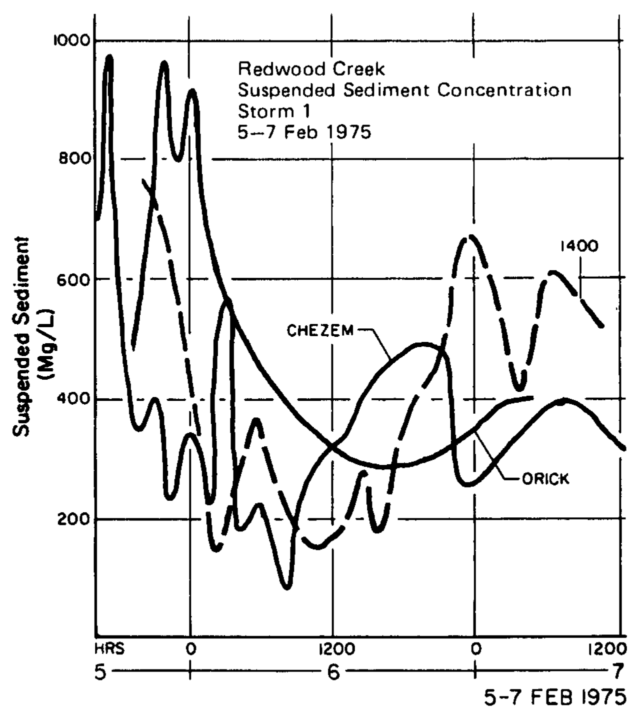


FIGURE 6

Suspended sediment concentrations in Panther Creek showed virtually no response to the storm, with all suspended sediment concentration values remaining less than 2 mg/l (milligrams per liter). In general, the suspended sediment concentrations followed the flow pattern in Lacks Creek with decreasing flows corresponding with decreasing suspended sediment concentrations. Individual suspended sediment peaks deviated somewhat from the flow conditions with sediment peaks both preceding and following flow peaks (figure 7).

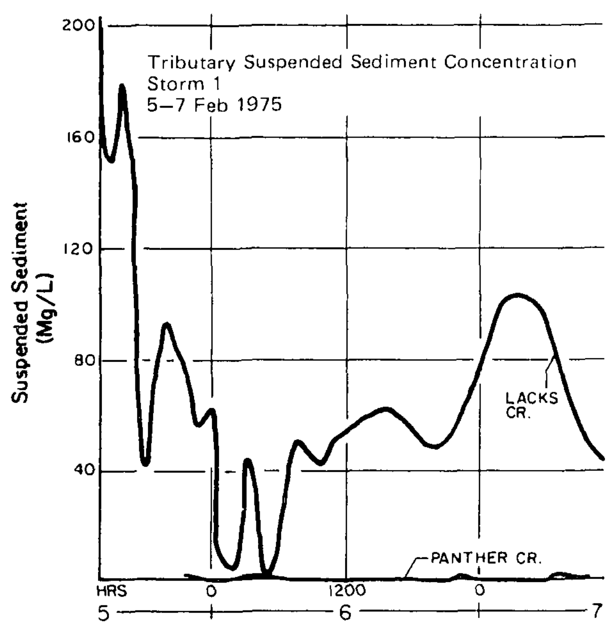


FIGURE 7

Instantaneous suspended sediment loads for Storm I in Redwood Creek are plotted in figure 8. These values reflect the increased flow at the downstream stations with correspondingly higher sediment transport rates. It is interesting to note that there appears to be a three to four hour lag time in sediment peaks between the station at the Chezem and the station at the 1400 Bridges. The higher transport rate at the 1400 station toward the end of the event reflects the lag time between that station and the station at Orick.

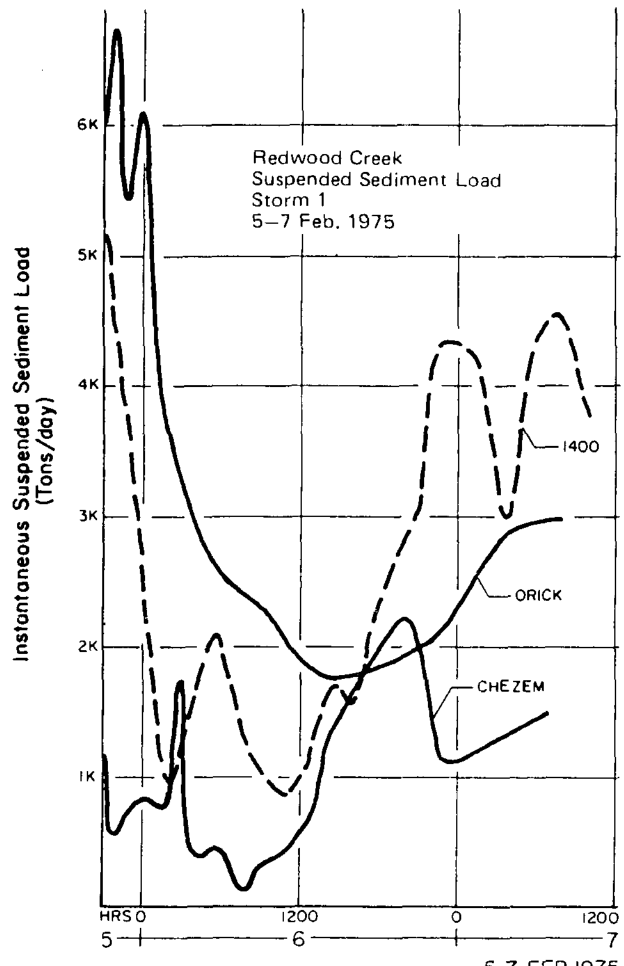


FIGURE 8

The high instantaneous suspended sediment transport rate for Panther Creek was 0.25 tons per day. Lacks Creek showed considerable fluctuation in instantaneous transport rates, with sediment transport rates varying from slightly over 100 tons per day to low values of approximately 2 tons per day (figure 9).

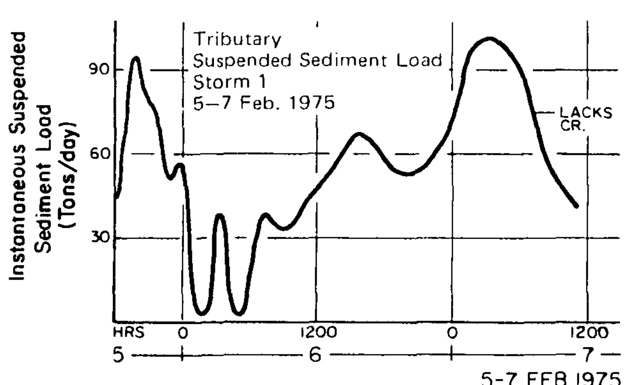


FIGURE 9

A Comparison of Suspended Sediment Transport Rates Per Unit Area for Storm I

Figure 10 depicts the suspended sediment transport rates at all the monitored stations, based upon an instantaneous transport rate per square mile of drainage area. Various sized drainages which have like erosional rates or characteristics should have sediment transport rates on a per-square-mile basis which are similar. However, it can be seen from figure 10 that the sediment transport rate for Redwood Creek at all of its stations is considerably higher than those of the two measured tributaries. The sediment transport rate for Redwood Creek tends to be higher in the upper basin, particularly during the last half of the monitored period.

The average transport rates and total tons of suspended sediment transported for the synoptic period are shown in the following table. The highest average suspended sediment transport rate for the storm was recorded at the 1400 Bridge station, which is somewhat anomalous as the Chezem station would predictably be higher since it is the uppermost station monitored.

TABLE II
Suspended Sediment Transport
Storm I

Station	Monitored Period [Hours]	Average Suspended Sediment Transport Rate [Tons/day/mile^2]	Total Suspended Sediment Transported [Tons/mile^2]
Redwood Creek,			
Chezem Bridge	34	15	21
1400 Bridge	37	18	28
Orick	35	11	16
Lacks Creek	41	3.1	5.3
Panther Creek	36	0.008	0.012

As Panther Creek did not exhibit a notable flow response to the monitored storm, a comparison of the sediment transport rate of Panther Creek with that of Redwood Creek would not be valid. However, when comparing the sediment transport rate of Lacks Creek with that for Redwood Creek at Orick, we find that Redwood Creek at Orick has a rate 3.5 times the transport rate of Lacks Creek. It is surprising, but consistent with our previous work, to find sediment production rates for the entire basin higher than those found for individual tributary streams.

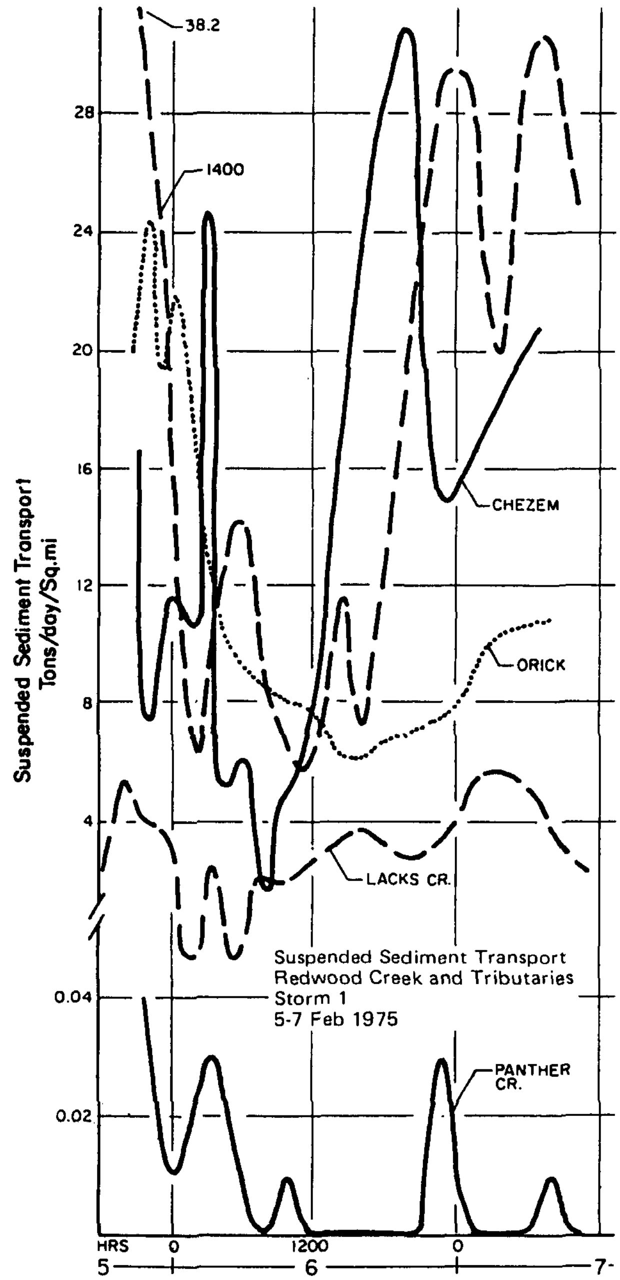


FIGURE 10

5-7 FEB 1975

Storm II

The predicted storm intensity did not develop and after three days of monitoring essentially baseline conditions, monitoring was terminated.

Precipitation throughout the Basin during the Storm II period, 27 February 1975 to 2 March 1975, was quite uniform with the exception of the rainfall recorded at the Simpson Timber Company rain gauge located on the ridge dividing the Redwood Creek and Little River drainages (800 and K&K), where nearly twice the rainfall was recorded compared to the other stations. The following table lists rainfall totals recorded at different locations within the Basin.

TABLE III
Basin Precipitation
Storm II

Station	Time Interval	Precip. [inches]
Prairie Cr Ranger Sta*	27 Feb.-2 Mar. 1975	1.60
Valley Green**	27 Feb.-2 Mar. 1975	1.58
Redwood Creek at Panther Creek	1650, 27 Feb.-1305, 2 Mar. 1975	1.74
Redwood Cr at Chezem	1 Mar.-2Mar. 1975	1.12
Okane***	27-28 Feb. 1975	0.50
800 and K&K ****	26 Feb.-2 Mar. 1975	3.56

*California Dept. of Parks and Recreation Data
**Arcata Redwood Company Data
***U.S. Weather Bureau Data
****Simpson Timber Company Data

Streamflow

Flow conditions in Redwood Creek were essentially baseline flows early in the storm, decreasing slightly until the river at the Chezem station began exhibiting an increase in flow at approximately noon on the 1st of March (figure 11). As no measurements were made at Orick between 1715 hours on the 1st and 1240 hours on the 2nd, that portion of the charted flow line is shown as a dashed line. Flow at the Chezem station increased until approximately 0800 on the 2nd of March when it peaked at 1550 cfs. Flow increases were measured at both the 1400 and Orick stations at approximately 1700 on the 1st of March. Flow continued to increase until the monitoring was abandoned on the afternoon of the 2nd of March. High flows measured in Redwood Creek were 2160 cfs at the 1400 Bridge and 2940 cfs at Orick.

Tributary flows displayed virtually no response to the basin rainfall until the afternoon of the 1st of March, when Lacks Creek, Coyote Creek, and to a lesser extent Copper Creek had a slightly increased flow rate (figure 12). Panther Creek did not show any increased flow over the entire monitored period. Lacks, Coyote, and Copper Creeks, which are all tributaries on the northeasterly side of the Redwood Creek Basin, displayed similar flow patterns. As in Storm I, Lacks Creek flow fluctuated considerably more than did the flow in the other monitored tributary streams. High flows monitored were 150 cfs in Lacks Creek, 110 cfs in Coyote Creek, 54 cfs in Panther Creek, and 45 cfs in Copper Creek.

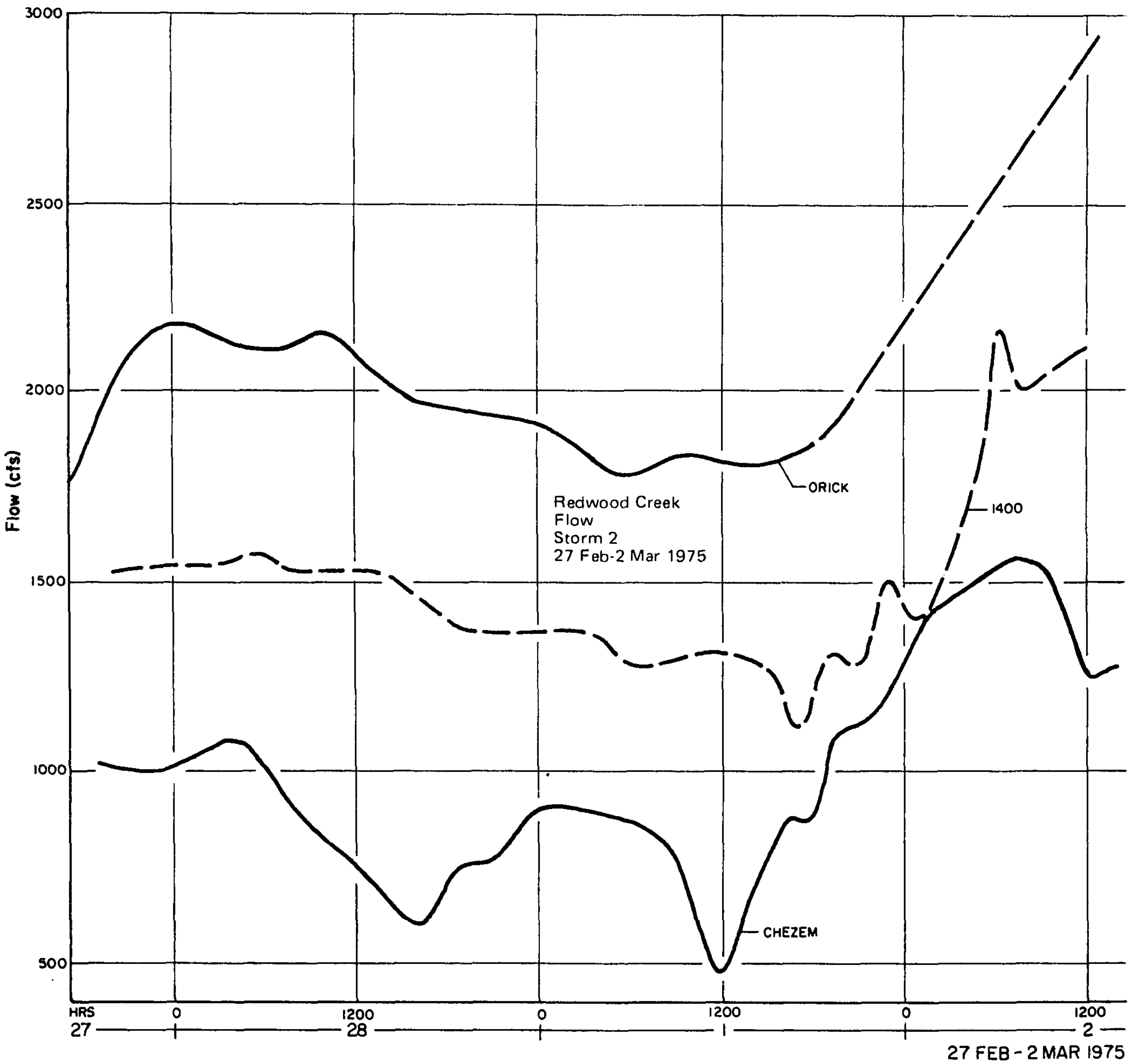


FIGURE 11

Stream Turbidity

Turbidity values in Redwood Creek were very uniform during most of the monitored period until the evening of March 1st when the stream at both the Chezem and 1400 stations exhibited dramatic increases (figure 13). Turbidity values increased from approximately 70 NTU's to peaks of 440 and 360 at the Chezem and 1400 stations, respectively.

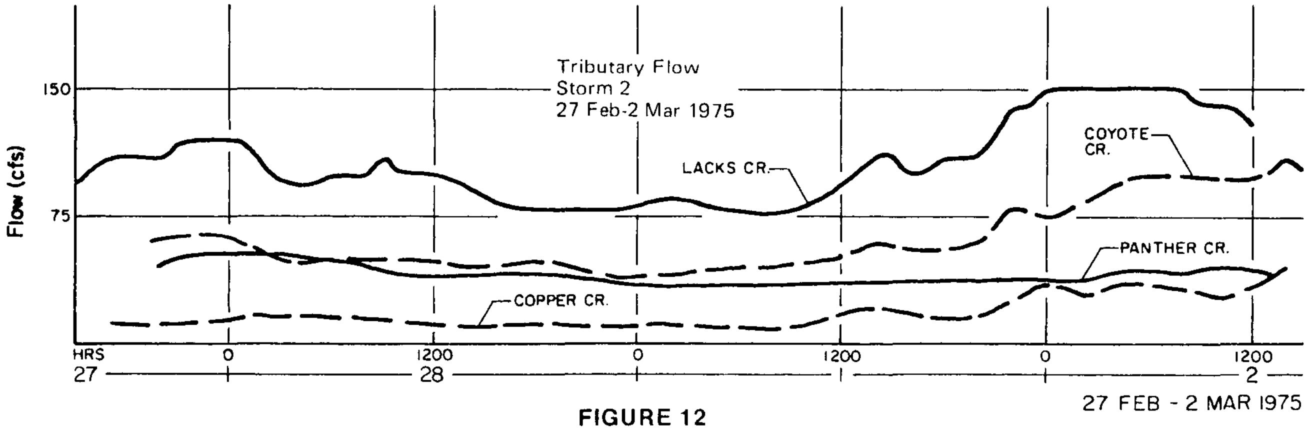


FIGURE 12

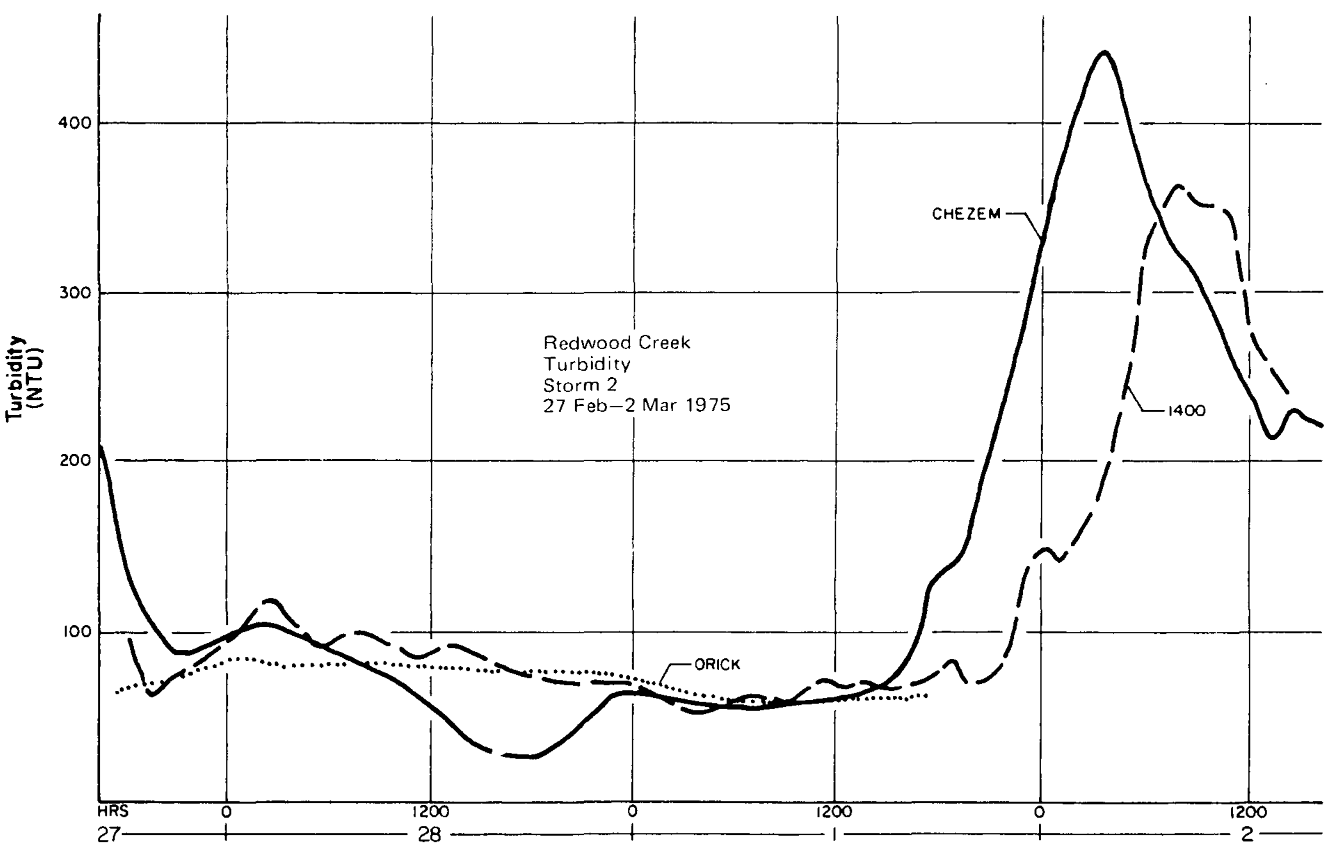


FIGURE 13

Tributary turbidity trends were quite interesting for the monitored period. Panther Creek again was not turbid during the measured period, with turbidity values of less than 6 NTU's (figure 14). However, the final sample taken in Panther Creek increased to 18 NTU's from the previous sample, which was 2.3 NTU's. Of the other tributaries measured, Lack's Creek, which had the highest flow and the greatest variation in flow, had the lowest absolute turbidity values and the least fluctuation in turbidity. The turbidity patterns of Copper and Coyote Creeks were very similar to one another, with Copper Creek having the highest peak value of 220 NTU's.

Suspended Sediment Characteristics

During the synoptic it was discovered that the crew working at the Chezem Bridge was concentrating the sediment samples when transferring the samples to laboratory bottles. Those samples known to have been concentrated were discarded.

In our previous work in Redwood Creek we had obtained our sediment samples by grab sampling methods, which generated considerable criticism of our report. Therefore during this synoptic period an attempt was made to obtain a rough correlation between the sediment concentrations obtained by

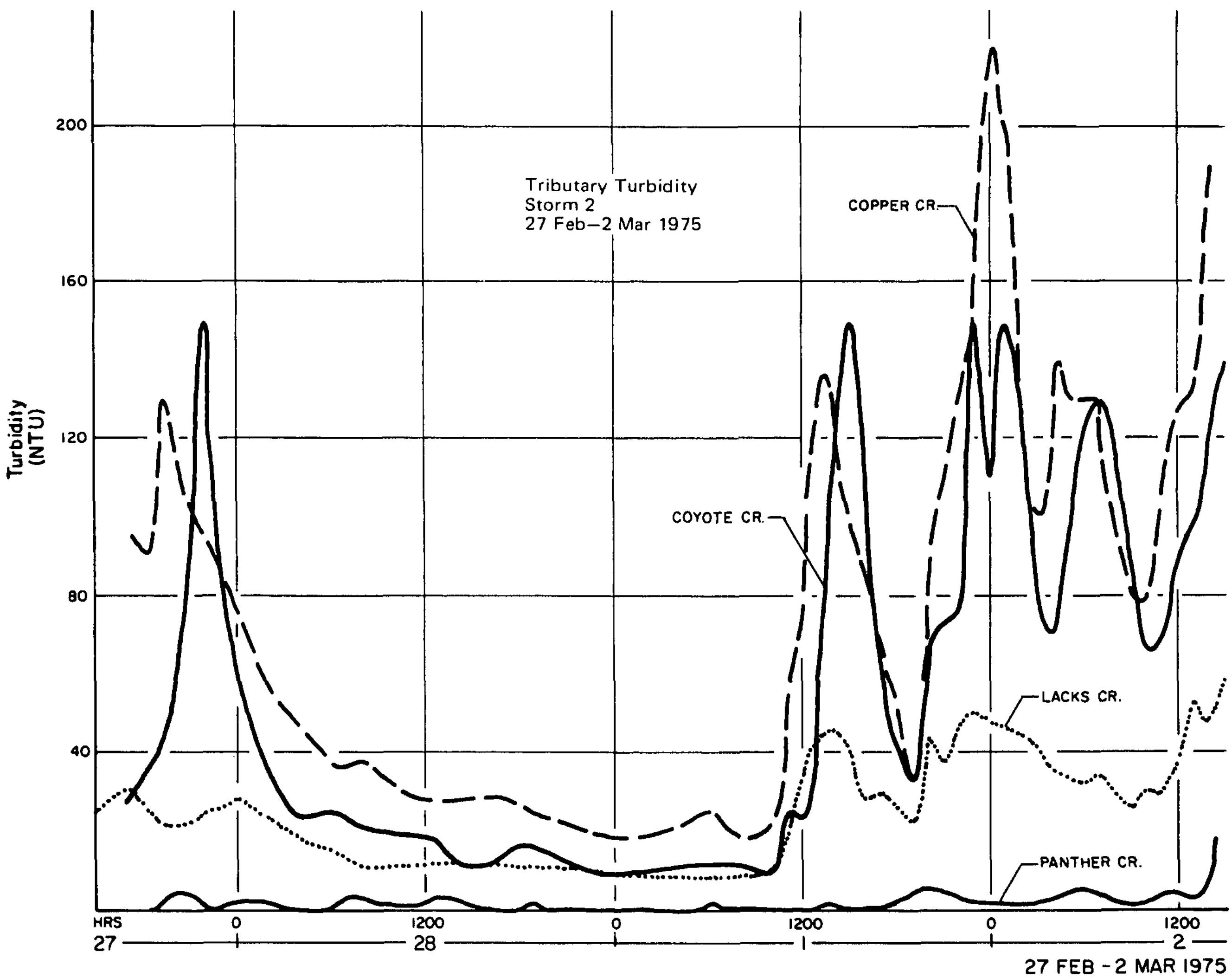


FIGURE 14

grab samples and those obtained by depth integrated means. Figure 15 shows the sediment concentrations obtained by using both techinques. The grab samples had a 27 percent lower average sediment concentration than did the depth integrated samples. This average percent difference is misleading, since the two methods agree fairly well during stable flow conditions, which occurred over much of the measured period, and did not agree under increasing flow conditions which occurred towards the end of the monitored period. At the time of the last sampling there was increased flow and the depth integrated sample showed a dramatic increase in suspended sediment; however, the grab sample results indicated a decrease in sediment concentrations.

This very cursory investigation of the differences in sediment concentrations obtained by the two methods would indicate that no linear correlation between the two methods exists and that the variation between the two methods would depend upon such influences as varying turbulence, water depth, sampling location, particle size of the suspended material and stream velocity. It should be noted that the differences between the two techinques would be generally greater in Redwood Creek than in the tributary

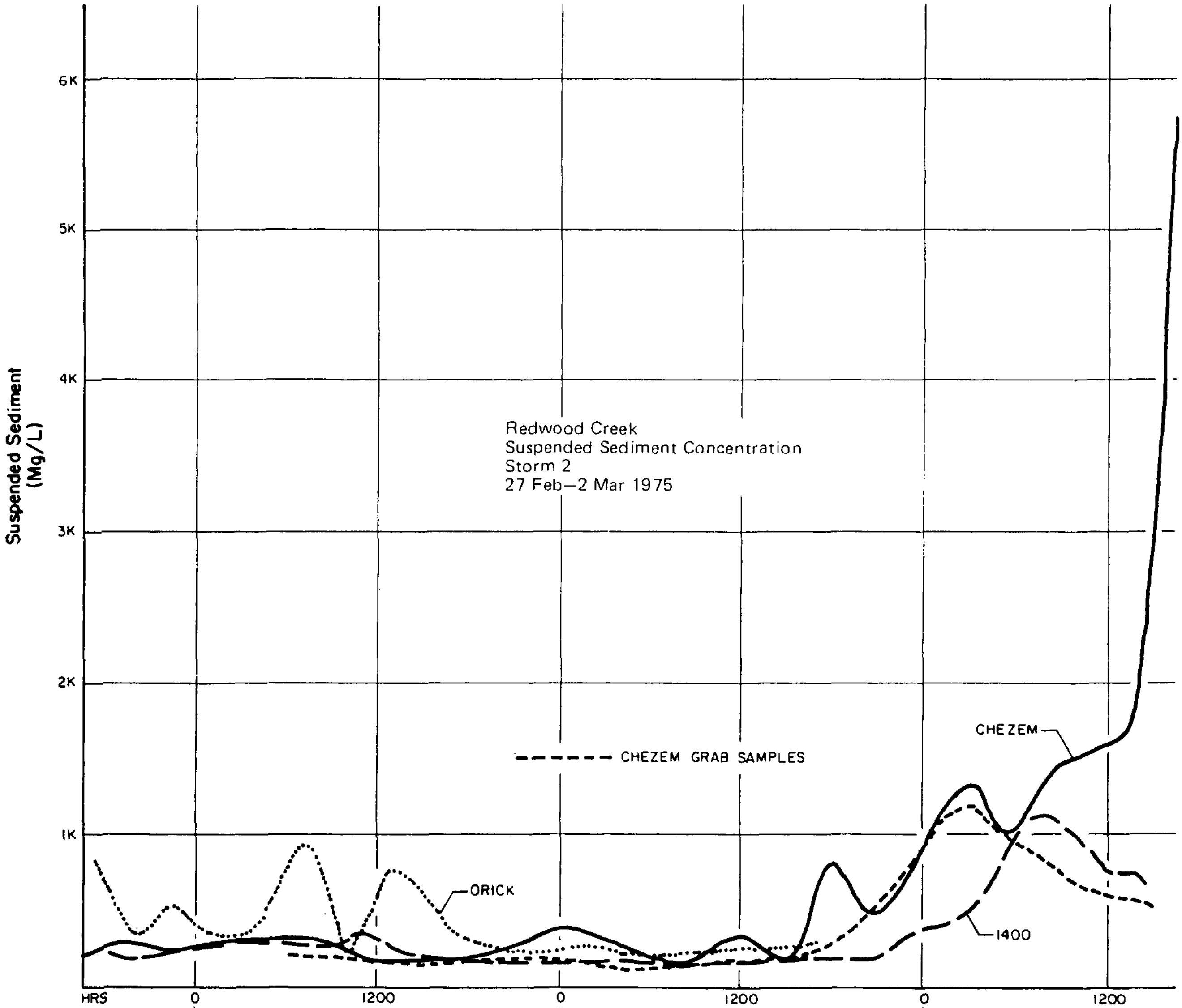


FIGURE 15

streams, primarily because of the greater depth in Redwood Creek with the possibility of a more marked sediment concentration gradient than in the tributary streams. The generally higher degree of turbulence in steep, short tributary streams tends to make them more vertically homogeneous with respect to sediment concentration.

Redwood Creek suspended sediment concentrations were very stable during most of the monitored period until approximately 1600, 1 March 1975, with some fluctuation in sediment concentration noted at Orick (figure 15).

Suspended concentrations increased at both the Chezem and 1400 stations beginning at approximately 1600 and 2100 hours, respectively, on the 1st of March. Two small sediment concentration peaks measured at the Chezem station at approximately 1800 and 0300 hours were detected at about 2400 and 0700 at the 1400 Bridge station, indicating a four to six hour lag time. The sediment concentration decreased at the Chezem Bridge site from the small peak concentration which occurred at about 0300 hours until 0500 hours, at which time it increased until the monitoring was terminated at about 1600 hours on the 2nd of March. Due to the lag time

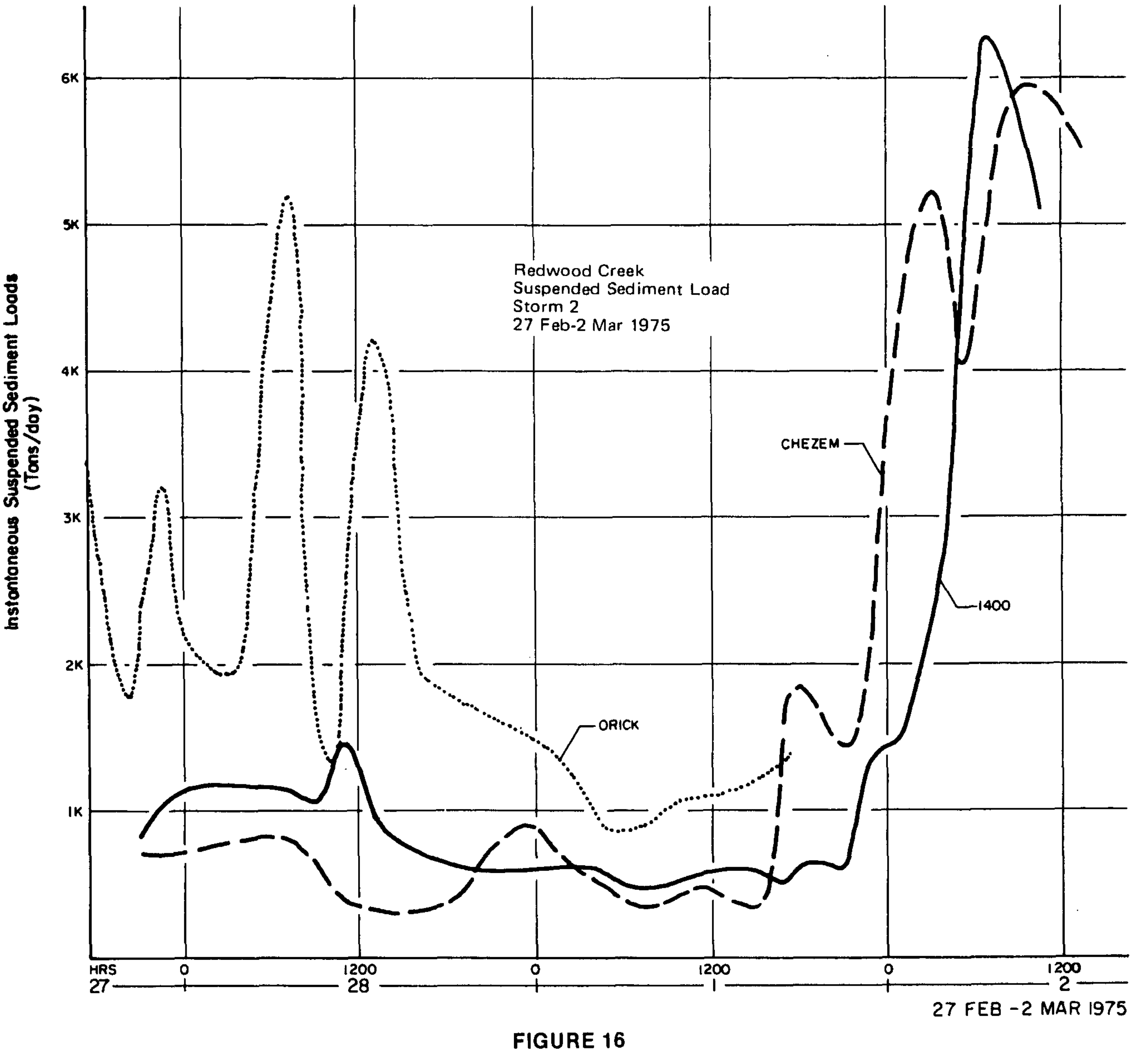


FIGURE 16

between the Chezem and the 1400 Bridge stations, sediment concentrations at the 1400 Bridge decreased until the monitoring was terminated.

Figure 16 depicts suspended sediment loads as measured at the three Redwood Creek stations during Storm II. The primary difference between the

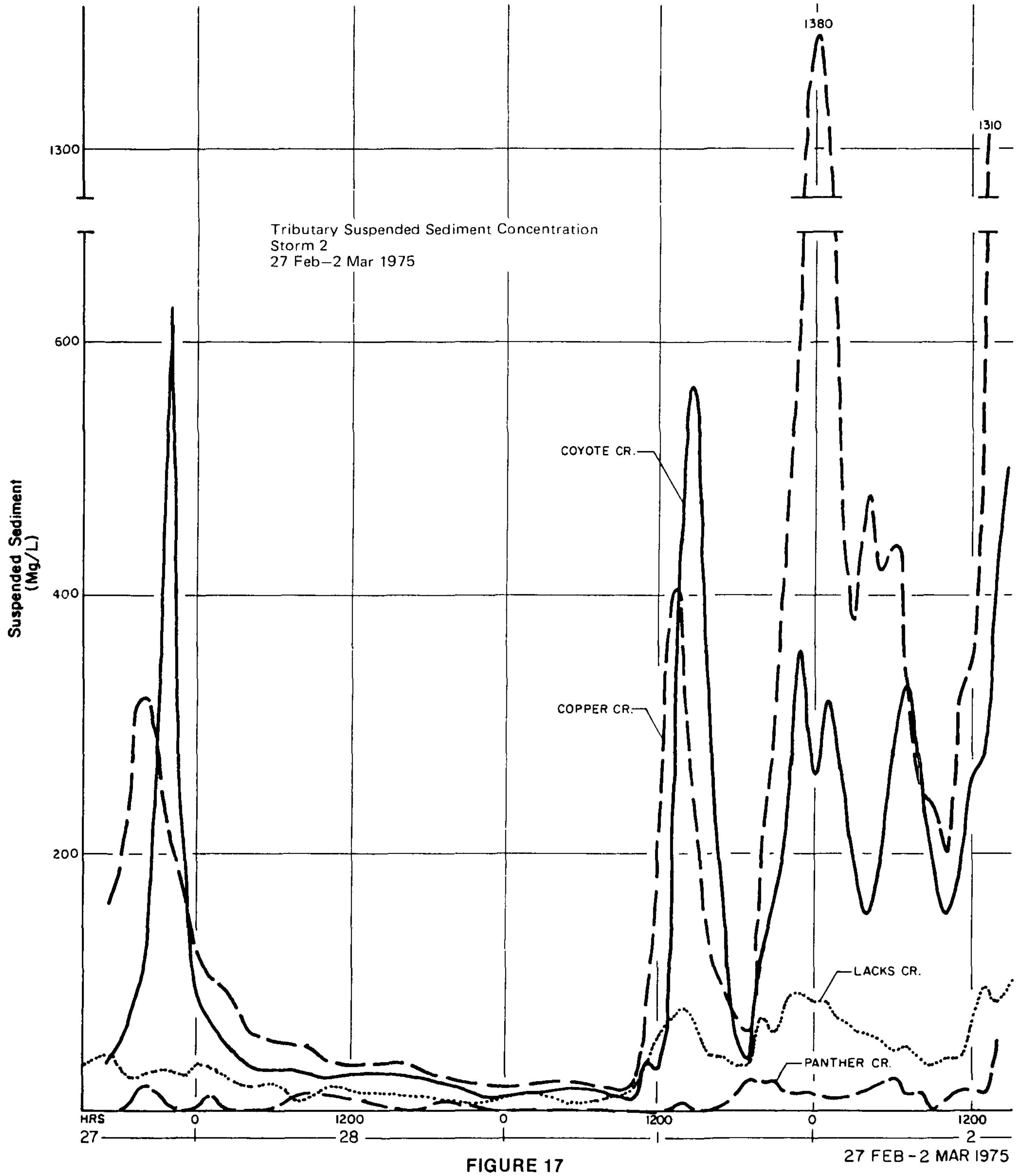


FIGURE 17

concentration curves and the curves depicting sediment load is that the magnitude of sediment transported is evident in the latter. During the first portion of the event the sediment transport rates were logically ordered with Redwood Creek at Orick transporting the greater amount. During the latter stage of the event it appears that the upper station, Chezem, has the greatest transport rate, which probably reflects the lag time experienced between the Chezem and 1400 Bridge stations. Had the monitoring been continued, the suspended sediment load at the 1400 Bridge station would be expected to increase to reflect the peak last measured at the Chezem station.

Tributary Suspended Sediment Concentrations

It is interesting to note that the tributary which had the highest flow, Lacks Creek, had lower sediment concentrations than either Copper or Coyote Creeks (figure 17). While the tributary flow regimes did not exhibit much response to the rainfall received, the sediment concentrations, particularly in Coyote and Copper Creeks, exhibited considerable response, with peak concentrations occurring during the initial and final stages of the monitored period. Both Copper and Coyote Creeks experienced extreme variations in sediment concentrations, with ranges of from less than 20 to 1380 mg/l in Copper Creek, and from less than 10 to 630 mg/l in Coyote Creek. Lacks Creek had a maximum suspended sediment concentration of approximately 100 mg/l and Panther Creek had a maximum concentration of approximately 55 mg/l.

Tributary Suspended Sediment Loads

Suspended sediment transport rates in the measured tributaries were extremely stable (except for a single peak which occurred in Coyote Creek at approximately 2200 hours, 27 February 1975) from the initiation of monitoring until approximately 1200 hours, 1 March 1975 (figure 18). At that time, all tributaries, except for Panther Creek, began to exhibit increases in suspended sediment transport rates. Of particular note is the fact that Copper Creek, which had the lowest tributary flow measured, had sediment transport rates consistently higher than Lacks Creek, and two peak rates higher than all measured tributaries.

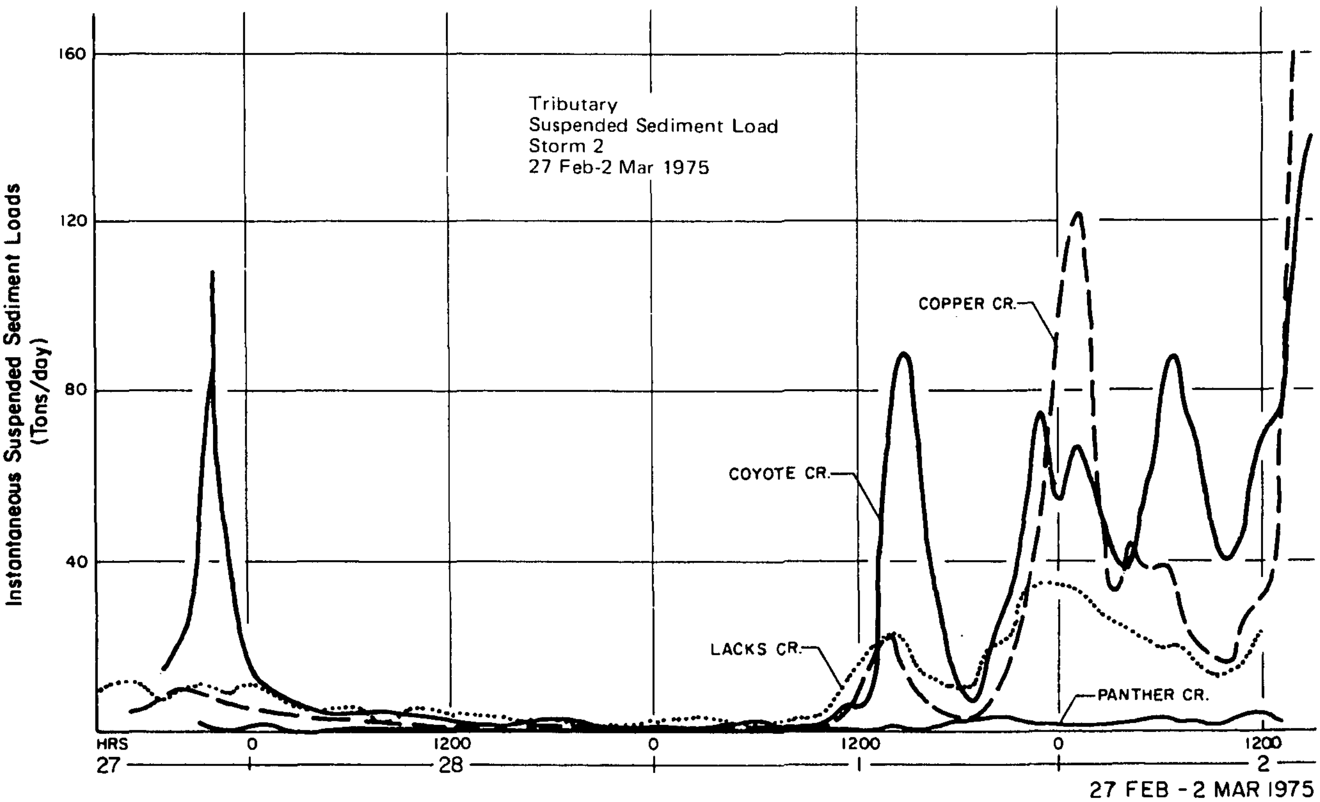
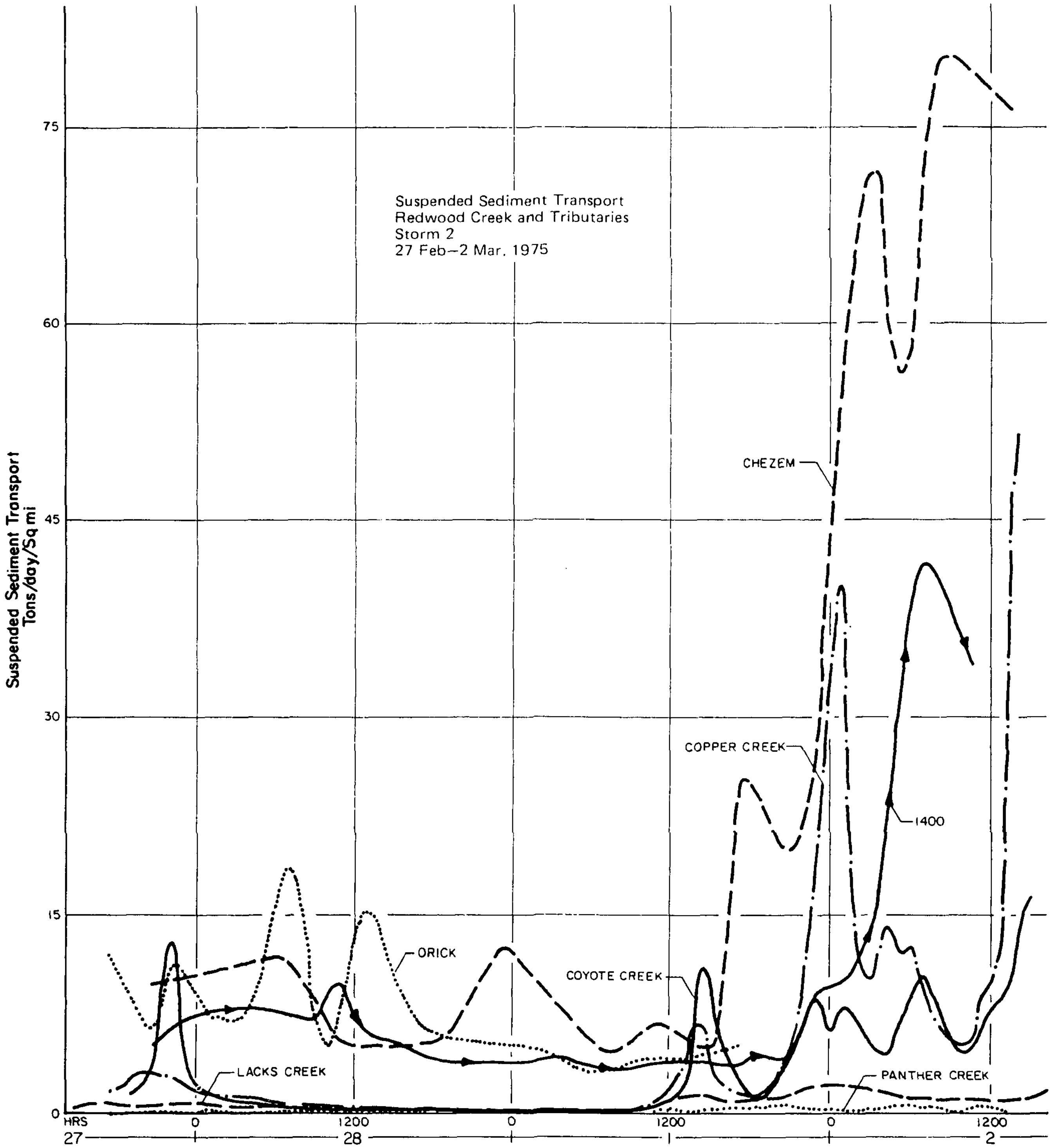


FIGURE 18



Suspended Sediment Transport
Redwood Creek and Tributaries
Storm 2
27 Feb–2 Mar. 1975
Suspended Sediment Transport
Tons/day/Sq mi
75
60
45
30
15
0
CHEZEM
COPPER CREEK
1400
ORICK
COYOTE CREEK
LACKS CREEK
PANTHER CREEK
HRS
0
1200
0
1200
0
1200
27
28
1
2
27 FEB –2 MAR 1975

FIGURE 19

A Comparison of Suspended Sediment Transport Rates Per Unit Area for Storm II

Figure 19 depicts the instantaneous suspended sediment loads per square mile in Redwood Creek and the measured tributaries for Storm II. During the stable streamflow periods, the Redwood Creek sediment load fluctuated considerably more than did the tributary stream sediment loads. The sediment load fluctuation in Redwood Creek is an anomalous condition as it would be expected that the tributary streams would experience more fluctuation. The reasons for this anomaly have not been determined. The ranking of the streams by amount of sediment transported is in agreement with our previous findings except for Copper Creek and to a limited extent Coyote Creek. As in our previous study, Redwood Creek, particularly high in the basin, had a greater transport rate per square mile of drainage area than did the tributaries. While Coyote Creek had generally higher instantaneous transport rates than either Lacks or Panther Creeks, the rates were, with two exceptions, considerably lower than those values found for Redwood Creek. Copper Creek, on the other hand, exhibited sediment transport rates during the latter portion of the monitored period equal to or higher than those found in Redwood Creek at the 1400 Bridge station.

The following table lists the average suspended sediment transport rates and the total suspended sediment transported at the various stations during Storm II.

TABLE IV
Suspended Sediment Transport
Storm II

Station	Monitored Period [hours]	Average Suspended Sediment Transport Rate [Tons/day/mile^2]	Total Suspended Sediment Transported [Tons/mile2]
Redwood Creek			
Chezem	64	23	61
1400 Bridge	61	9.0	23
Orick	48	7.4	15
Copper Creek	69	4.5	13
Coyote Creek	68	3.0	8.5
Lacks Creek	69	0.58	1.7
Panther Creek	64	0.12	0.32

The suspended sediment transport rates and total amounts of sediment transported for the three stations in Redwood Creek follow the orders expected in that the upper basin had the highest rate, the mid-basin carried an intermediate amount, and the total basin station at Orick exhibited the lowest transport rate and the lowest total sediment transported on a per unit basis.

The results obtained for the tributary streams' sediment transport rates are the reverse of what would be expected. All of the tributary transport rates are less than for the main stream of Redwood Creek, with the transport for Redwood Creek at Orick being 1.6 to 62 times greater than the rates found on the measured tributary streams. Upper Redwood Creek, which would be expected to have sediment transport rates on the same order of magnitude as those of the tributaries, had sediment transport rates which ranged from 5 to 192 times greater than those of the tributary streams.

Copper Creek is particularly noteworthy of discussion as it had the lowest measured streamflows of all tributaries monitored, and had the highest sediment transport rate. The history of Copper Creek reveals that virtually all of the commercial timber in its watershed has been harvested over the past 21 years. Additionally, approximately 50 percent of the watershed was clearcut between 1969 and 1971 to remove residual trees left from earlier cuttings and to harvest the remaining virgin stands. The watershed is roughly 40 percent prairie and 60 percent timberland, with the prairie land concentrated along the ridge lines. The clearcut harvesting operations during the 1969 through 1971 period were concentrated near or adjacent to the creek. Because all of the harvesting was completed prior to current timber harvest regulations becoming effective, no stream-side buffer strips were left and heavy equipment operations were conducted immediately adjacent to the creek. Combined with the percentage of the watershed that has been clearcut, this singles out Copper Creek as one of the more severely treated watersheds within the Redwood Creek Basin from a sediment production viewpoint. With this kind of harvesting history, Copper Creek would be expected to have one of the highest sediment production rates within the Basin, certainly much higher than the main stream of Redwood Creek. However, as the figures in Table IV indicate, sediment production rates for Redwood Creek during Storm II were (compared to Copper Creek) higher by a factor of 5.1 at the Chezem station, 2.0 at the 1400 station, and 1.6 at Orick. Copper Creek did have the highest suspended sediment transport rate of the tributaries measured, with a transport rate 1.5 times that of Coyote Creek, 7.8 times that of Lacks Creek, and 38 times that of Panther Creek. The differences in sediment transport rates are certainly significant and are undoubtedly due to a large degree to the differing histories of land use within the watersheds. However, in order to make a determination of the major cause for the differences in sediment production rates, it is necessary to be able to assess the significance of other watershed differences, such as watershed size, drainage patterns, stream gradients, geology, soils, and vegetative cover. As these parameters are normally assessed after a calibration period initiated prior to harvesting and road building activity, it is not now possible to state to what extent the 38-fold difference in sediment production between Panther and Copper Creeks is due to man's activities and to what extent it is due to the natural differences between the watersheds.

Storm III

Storm III was an extremely intense storm which produced flows in Redwood Creek on the same order as those measured during the devastating floods of 1964. Conditions were so hazardous and stream flows so intense that monitoring stations could only be established on Redwood Creek. Even in Redwood Creek flow was so intense that our gauging equipment was inadequate to measure flow until after the storm peaked. Therefore, all sediment and flow data collected during this storm are recessional. The initiation of our monitoring at Orick occurred approximately two hours after the storm peak, which was measured by the U.S. Geological Survey at 1300, 18 March 1975.

Precipitation

Precipitation was intense basin-wide during this event. Generally, the greatest amounts of rainfall in the basin were recorded on 18 March, with the exception of the station at Valley Green, which recorded its peak precipitation on 17 March. The following table lists the rainfall totals recorded during the period.

TABLE V
Basin Precipitation
Storm III

Station	Time Interval	Precip. [inches]
Prairie Cr Ranger Sta*	16-20 Mar 1975	8.88
Valley Green**	17-20 Mar 1975	8.17
Redwd Cr at Panther Cr	16-19 Mar 1975	13.85
Okane***	17-20 Mar 1975	9.30
800 and K&K****	17-20 Mar 1975	12.85

*California Dept. of Parks and Recreation Data
**Arcata Redwood Company Data
***U.S. Weather Bureau Data
****Simpson Timber Company Data

The rainfall data indicates the same general effects noted in earlier storms, except for the station at Okane, which had a precipitation total similar to stations low in the basin. The station at Okane indicates that even in a high-intensity area-wide storm there can be a considerable variation in the local rainfall pattern.

Streamflow

As mentioned earlier, extreme flows were encountered in Redwood Creek during the course of this synoptic event. The high flow measured was 50,600 cubic feet per second at Orick at 1500, 18 March 1975, approximately two hours after the storm crest had passed (figure 20). The highest flow previously recorded in Redwood Creek was 50,500 cfs on 22 December 1964. These flows rapidly attenuated and by 1500, 19 March 1975, the flow at Orick had decreased to 18,000 cubic feet per second. Due to a flow obstruction at the 1400 Bridge, measurements at that station did not commence until approximately 0630, 19 March. The flow at the 1400 Bridge was well past peak volumes and was receding at a comparatively gradual rate by the time flow measurements were able to be initiated.

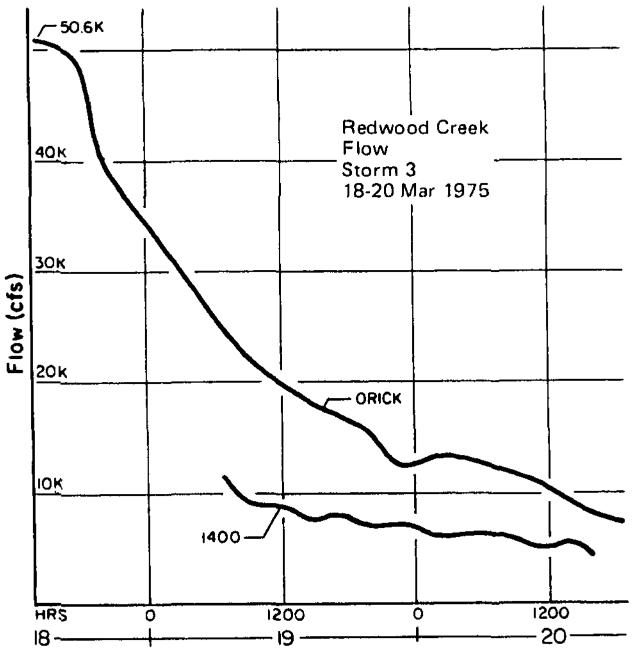


FIGURE 20

Turbidity

The pattern for the turbidity curve at Orick mimics that of the flow curve very closely, with little fluctuation (figure 21). Turbidity patterns at the mid-reach station, 1400 Bridge, while following the general flow pattern, showed considerable variation. The high turbidity values measured were 2,000 and 2,600 NTU's at Orick and the 1400 station, respectively. The differences between the two curves, degree of fluctuation, again points out the turbulence differences between the stations, the turbulence being much greater at the 1400 Bridge station.

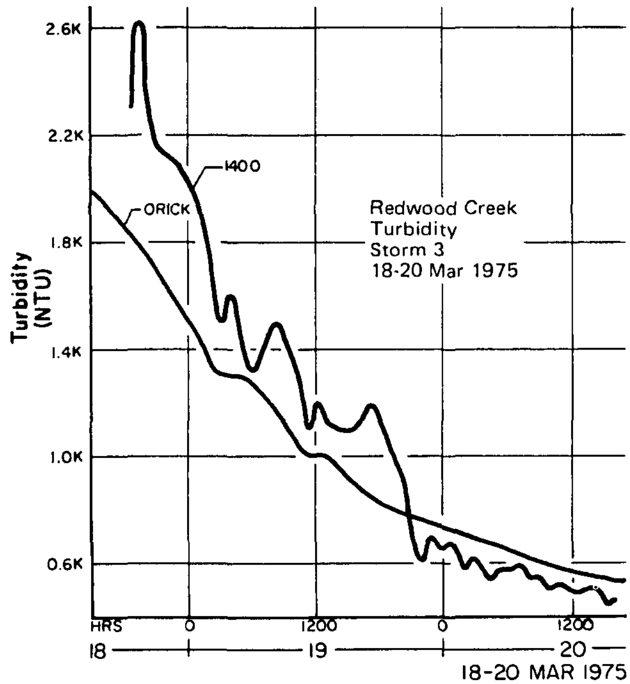


FIGURE 21

Sediment Characteristics

Figures 22, 23, and 24 depict sediment concentrations, suspended sediment load and suspended sediment load per square mile, for the two stations in Redwood Creek. Particularly noteworthy are the extreme values determined for sediment discharge during this recessional portion of the storm. The high instantaneous value obtained at Orick was 1,120,000 tons per day. The following table lists the transport rates and suspended sediment transported during the monitored period.

TABLE VI
Suspended Sediment Transport
Storm III

Redwood Creek	Monitored Period [hrs]	Average Suspended Sediment Transport Rate [Tons/day/mile2]	Total Suspended Sediment Transported [Tons/mile2]
1400	31.4	216	283
Orick	49.8	938	1950

The reason for the reversal in transport rates at the two stations from the previously monitored storms, that is, the higher rate at Orick rather than at the 1400 Bridge, is probably that the station at 1400 Bridge could not be monitored during the flood flows.

Unfortunately, conditions did not allow the monitoring of tributary flows so that a unique opportunity was lost that would have enabled the comparison of sediment transport rates between tributaries and between the tributaries and Redwood Creek under extreme storm conditions. However, the storm did provide sediment information on the recessional characteristics of Redwood Creek after a major storm. Also, it provided us with a chance to compare our field results with those obtained by the U.S. Geological Survey, since they measured the peak flow at Orick. The USGS obtained a flow measurement of 50,200 cfs at 1300, 18 March 1975, which compares quite favorably to the reading of 50,600 cfs which we obtained at 1500, 18 March 1975. The two flow measurements differ by only 0.7 percent, which is particularly noteworthy considering the extremely adverse conditions under which the flow determinations were made.

In view of the fact that it has been postulated that the sediment peak in Redwood Creek lags the flow peak, it is interesting to note how closely the sediment and flow peaks coincide (figures 20 and 22.)

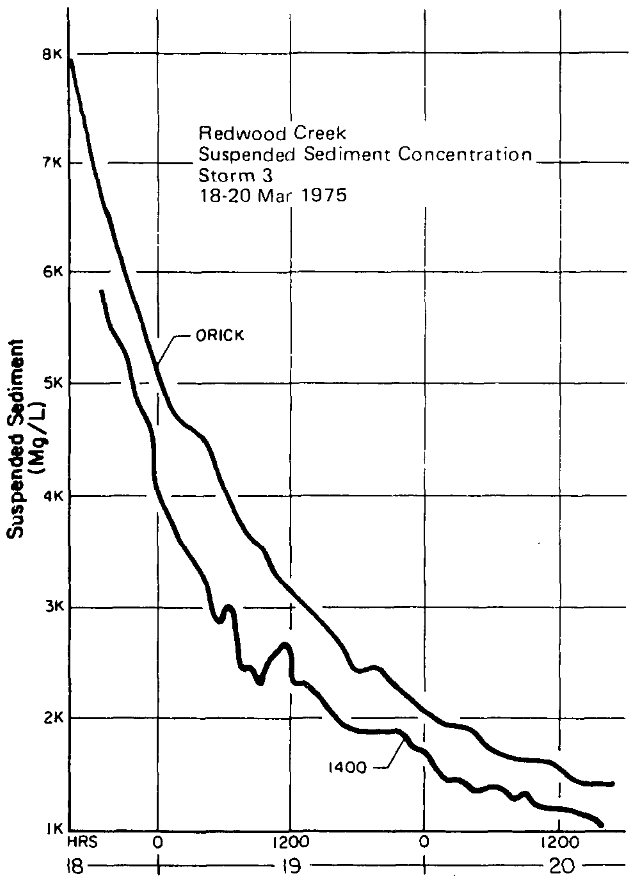


FIGURE 22

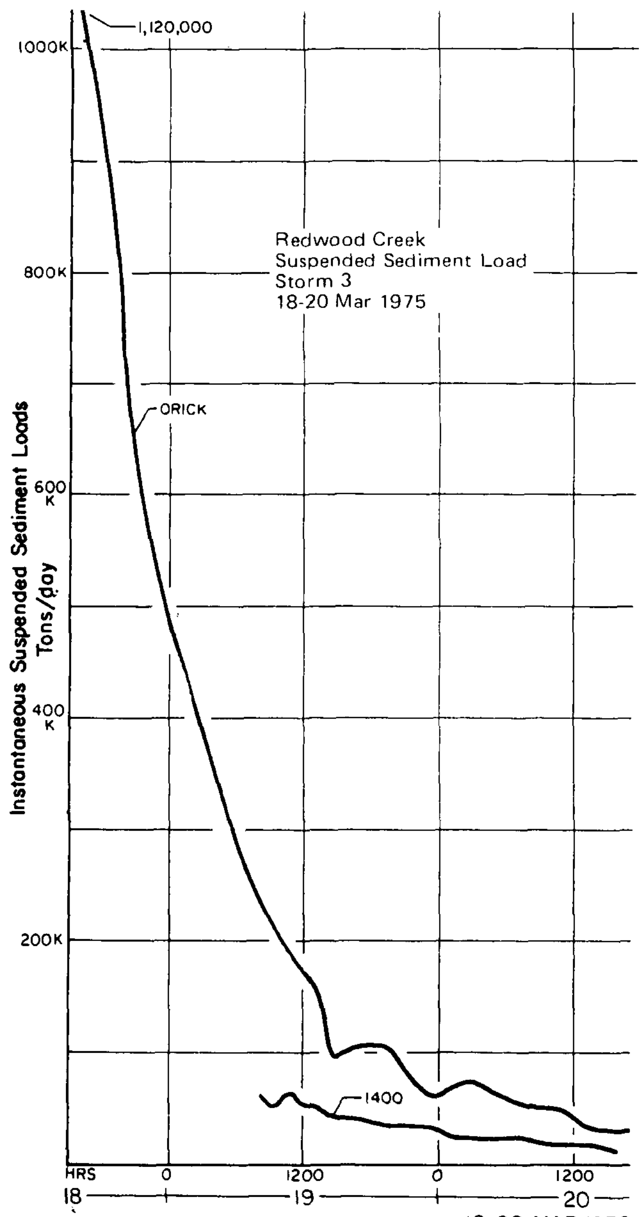
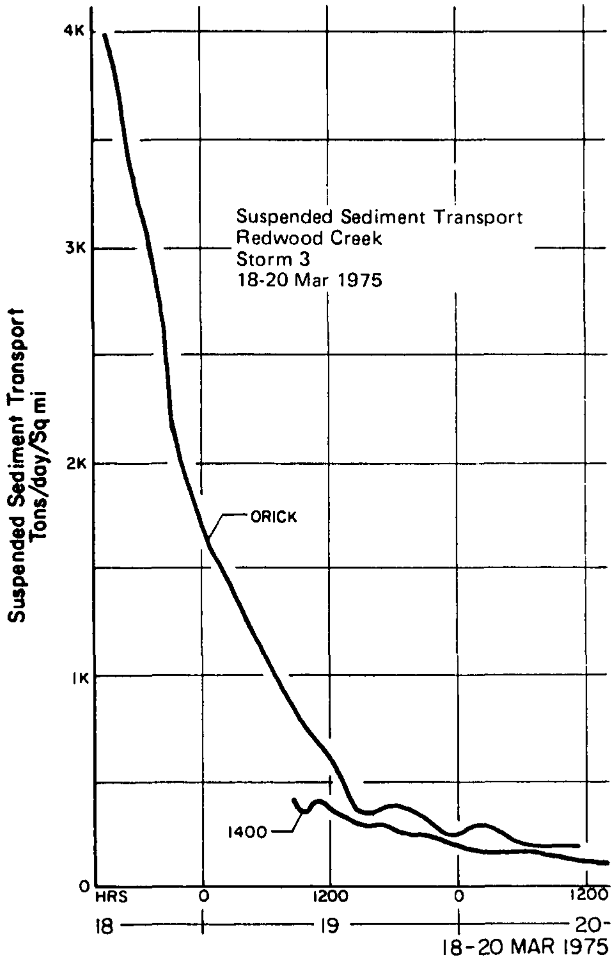


FIGURE 23



Suspended Sediment Transport
Redwood Creek
Storm 3
18-20 Mar 1975
Suspended Sediment Transport
Tons/day/Sq mi
4K
3K
2K
1K
0
ORICK
1400
HRS
0
1200
0
1200
18
19
20-
18-20 MAR 1975

FIGURE 24

CLAY MINERALOGY

M.E. Harward, C.T. Youngberg

Floodplain Deposits From Redwood Creek

Background

Evidence obtained from Winzler and Kelly's 1973-1974 sediment studies indicated that the large number of streamside slides throughout the length of Redwood Creek are principal sources of sediment. This conclusion was based on the fact that X-ray diffraction patterns of samples from slides, suspended sediments, streambed deposits, and floodplain deposits sampled at a depth of 20-24 inches were all similar. It was assumed that samples from this depth in the floodplain near Orick represented materials deposited prior to settlement and initiation of cultural activities on the watershed. The data indicate the importance of phenomena involving unstable landscapes and suggest that similar sources have contributed materials over time in the past and will continue to do so in the future.

The assumption that the sample of the Kerr soil from the 20-24 inch depth represented material deposited prior to logging activities seemed reasonable, but the validity of the assumption needed to be verified. Our understanding of the processes occurring in the watershed would be improved by examination of the nature of sediments in the floodplain. Specifically, we needed to know how samples from lower depths in the floodplain (presumed to represent older deposits) compare with materials in present slides. Accordingly, deposits from the floodplain of Redwood Creek were examined in the spring and summer of 1975.

General Procedures

A series of samples from three sites on the floodplain of Redwood Creek near Orick was obtained by C.T. Youngberg and George Wingate. Deposits were exposed with the aid of a backhoe. Horizons were described and samples taken from major horizons at each site (Table VII). Excavations at two of the three sites were over 16 feet in depth and resulted in exposure of gravels which underlie deposits of sand, silt, and clay. At the third site, descriptions and sampling were discontinued at the 13 1/2 foot depth due to danger from cave-in. However, the deposits examined at the third site were similar to those found at the other two sites.

TABLE VIII

ORICK FLOODPLAIN SAMPLING
(Description by C.T. Youngberg of Sites Examined and Samples Obtained)

Site 1—Near Base of Hill		**Sample No.**
0-12"	Very dark gray granular loam;	
12-20"	Very dark to dark gray **sandy loam** with lenses of more clayey material;	
20-40"	Dark gray **clay loam**, non-sticky, slightly plastic, smeary, abundant fresh micas;	
40-48"	Dark gray **clay loam** moderate fine subangular blocky structure, many pores in aggregates, old wood present;	OR-1
48-60"	Dark gray, with olive yellow mottles **clay**, moderate medium columnar and large blocky structure, firm slightly sticky and slightly plastic, old wood at lower boundary;	OR-2*
60-79"	Olive gray **fine sandy loam**, non-sticky, non-plastic, abundant mica;	OR-3
79-95"	Dark olive gray **medium sand** abundant fresh minerals (mica);	OR-4*
95-115"	Olive gray **coarse sand**, abundant mica and quartz;	OR-5
115-135"	Very dark gray **medium sand**, abundant mica and quartz;	OR-6*
135-160"	Very dark gray **coarse sand**, abundant mica and quartz;	OR-7
160-199"	Very dark gray **gravelly coarse sand**, abundant mica and quartz, ground water table at 184"	OR-8*
199" +	Gravel	

Site 2—Midway on West Line Toward Redwood Creek		
0-8"	Very dark gray granular **loam**;	
8-14"	Very dark gray **very fine sandy loam**;	
14-33"	Very dark gray **light clay loam**, weak fine subangular blocky structure, many old tree roots at boundary;	
33-43"	Olive gray **clay**, moderate fine subangular blocky structure, many fine pores in aggregates, firm, sticky, plastic;	OR-9
43-74"	Gray, with olive gray mottles, **clay**, weak coarse columnar structure, firm, sticky, plastic;	OR-10

74-106"	Dark olive gray fine sand with pockets of clay;	OR-11*
106-122"	Very dark gray **medium sand**, abundant fresh minerals (mica);	OR-12
122-151"	Dark gray **clay loam** with dark reddish brown mottles, firm, slightly sticky, slightly plastic;	OR-13*
151-182"	Very dark gray **coarse sand**, abundant mica and quartz;	
182-196"	Very dark gray gravelly **very coarse sand**, abundant quartz and mica, groundwater table at 182"	
196" +	Gravel	

Site 3—Southwest of Site 2, Adjacent to Grove of Spruce & Brush, 30' from Large Spruce [51 years old]

0-10"	Very dark gray granular **loam**, very friable, non-sticky, slightly plastic, smeary;	
10-19"	Dark gray **loam**, weak medium granular, non-sticky, slightly plastic, smeary;	
19-36"	Alternate bands of dark gray **medium and fine sand** (3 bands medium, 2 bands fine) very friable, smeary;	
36-44"	Dark olive gray **loam**, massive, friable non-sticky, slightly plastic, smeary, abundant mica;	OR-14
44-48"	Very dark gray, with strong yellowish red mottles, **loam**, weak medium subangular blocky structure with many pores in aggregates, friable, non-sticky, slightly plastic, smeary abundant mica;	OR-15
48-55"	Olive **light clay**, weak medium subangular blocky structure with abundant pores in aggregates, friable, slightly sticky, plastic, smeary;	OR-16
55-66"	Dark gray **heavy loam,** massive, friable, non-sticky, slightly plastic, smeary, moderate abundance of mica	OR-17
66-76"	Very dark gray **medium sand** with abundant light colored minerals (salt and pepper) very friable;	OR-18
76-84"	Dark gray **fine sandy loam**, massive, very friable, non-sticky, slightly plastic, many fresh minerals, slightly smeary;	OR-19
84-132"	Dark gray **fine sand**, massive, very friable non-sticky, non-plastic, many fresh minerals;	OR-20*
132-152"	Black **medium sand**, massive, very friable, many light colored minerals	
152-156"	Very dark gray, with dark reddish brown mottles, **sandy clay loam**, massive firm, slightly sticky, slightly plastic abundant fresh minerals;	OR-21*
156-164"+	Blue gray, with strong yellowish red mottles, clay, massive, firm slightly sticky, plastic, mottled appearance resulting from weathering of gravels, some hard cores present in some weathering gravels.	OR-22*

*Samples used for X-ray diffraction analysis

Samples were sealed in plastic bags in a field-moist condition and then eight of these were selected to represent the range of deposits at the three sites. These samples were submitted to Dr. R. Jones of the University of Hawaii for X-ray diffraction analysis. The methods of preparation were the same as those used previously in the 1973-1974 study. The less than 325 mesh fractions (less than 50 microns or the silt plus clay) were separated for analysis in order to compare with previous samples of suspended sediments and slides in the watershed. The characterization treatments and criteria for interpretations of the occurrence of phyllosilicates were as described in the previous study (Winzler and Kelly, 1975).

Four of the horizon samples were selected for age dating by radio-carbon (C^{14}) techniques. A sample from one of the lower horizons at each site was taken to provide estimates of the age of these lower deposits and to obtain some idea of how similar they were to one another. In addition, a sample from a horizon higher up in the profile was analyzed for one of the sites.

Results

The X-ray diffraction patterns from all samples contain strong peaks corresponding to approximately 14.2, 10, and 7.1 Å (figures 25 and 26, Table VIII). The lines were essentially unaffected by solvation, ion saturation or heat, except for the 550° heat treatment (Table VIII). Behavior of the samples in response to the imposed treatments establishes the presence of well-crystallized chlorite and mica (Table IX).

TABLE VIII

Intensities (peaks-background) of X-ray diffraction peaks after characterization treatments of subsoil samples from floodplain of Redwood Creek near Orick.

Sample #	Site #	Depth (inch)	Mg-sat'n and air dry 14 + A	10 + A	7 + A	K-sat'n 550°C 14 + A
OR-2	1	48-60	640	340	800	394
OR-4	1	79-95	544	516	1148	520
OR-6	1	115-135	688	648	1440	488
OR-8	1	160-199	768	875	1744	728
OR-11	2	74-106	720	672	1176	384
OR-13	2	122-151	608	552	1184	568
OR-20	3	84-132	396	416	790	576
OR-21	3	152-156	272	176	552	520

TABLE IX

Clay minerals identified from X-ray diffraction patterns of subsoil samples from floodplain of Redwood Creek near Orick.[1]

Sample	Chlorite	Chloritic Intergrade	10Å Mica	Vermiculite	Inter-stratified	Kaolin[2]
OR-2	S		S		W	
OR-4	S		S			
OR-6	S		S			
OR-8	S		S			
OR-11	S		S			
OR-13	S		S			
OR-20	S		S			
OR-21	S		S			

[1]S = Strong M = Moderate W = Weak
[2]Kaolinite is possible but doubtful in all samples.

The similarity in nature and locations of peaks on the patterns indicates that the mineralogy is similar for all samples. There is essentially no difference in the patterns regardless of location or depth. This is true even though the samples from different layers represented different textures (particle size distributions).

The patterns for floodplain samples were compared with those obtained previously for samples of slides and suspended sediments from Redwood Creek. The patterns for floodplain samples were like those obtained for present slides and suspended sediments on Redwood Creek. In most cases for both floodplain and slide samples, the 14 Å chlorite line is more intense than the 10Å mica line, while the 002 (7Å) chlorite line is more intense than the 001 (14Å) (Table X).

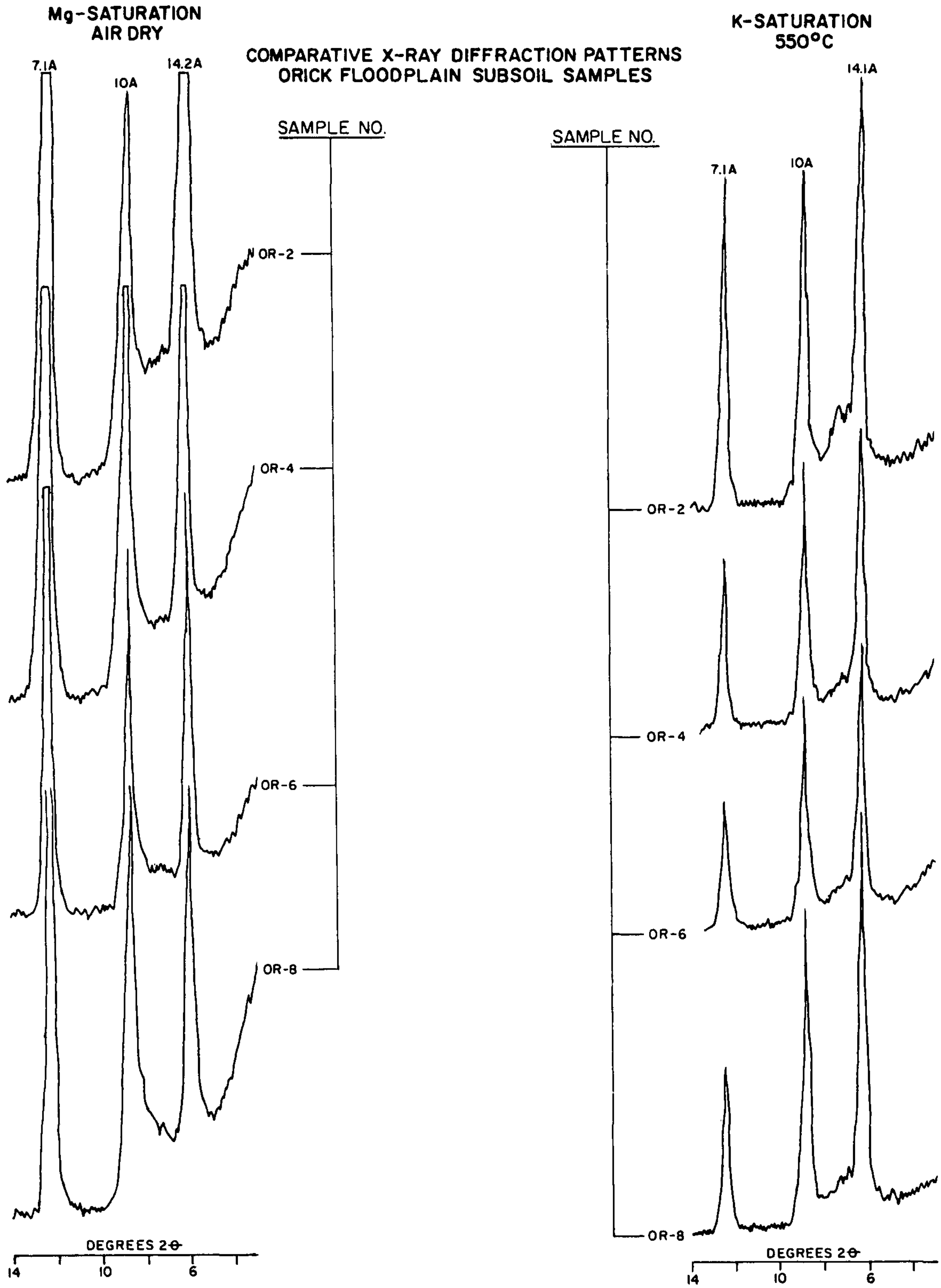
TABLE X

Ratios of intensities of X-ray diffraction peaks after characterization treatments of subsoil samples from floodplain of Redwood Creek near Orick.

Sample#	Site #	Depth (inch)	Mg-sat'n and air dry 10 + /14 +	7 + /14 +	K-sat'n 550°C 7 + /14 +
OR-2	1	48-60	0.53	1.25	0.77
OR-4	1	79-95	0.95	2.11	0.58
OR-6	1	115-135	0.94	2.09	0.49
OR-8	1	160-199	1.14	2.27	0.43
OR-11	2	74-106	0.93	1.63	0.65
OR-13	2	122-151	0.91	1.95	0.24
OR-20	3	84-132	1.05	1.99	0.13
OR-21	3	152-156	0.65	2.03	0.14

Further, there was a marked decrease in the intensity of the 7Å line and an increase in intensity of 14Å line after heating to 550°C. This indicates similar kinds of chlorite minerals in all samples. One would have great difficulty distinguishing unlabeled patterns for current slides from those of deep deposits in the floodplain (figures 25, 26, and 27).

Throughout the previous (1973-1974) and the present study, "long scan" diffraction patterns over the range 2° to 64° two theta were routinely obtained. However, the data over the shorter range from 2° to 14° two theta were sufficiently conclusive for "finger-print" purposes to eliminate the need for examination of other HKL lines on the diffraction patterns. This range contains the usual (001) peaks of the major types of phyllosilicate minerals and, in conjunction with various imposed characterization treatments, the minerals can be identified. However, because of the importance of the study of floodplain deposits and present slide material, and in order to minimize any chance for error or misinterpretation, the X-ray patterns obtained with an auto-focus sample holder were examined over the range from 2° to 64° two theta. These patterns for all eight floodplain samples and the samples from



Mg-SATURATION
AIR DRY
7.1A
10A
14.2A
COMPARATIVE X-RAY DIFFRACTION PATTERNS
ORICK FLOODPLAIN SUBSOIL SAMPLES
SAMPLE NO.
OR-2
OR-4
OR-6
OR-8
DEGREES 2θ
14
10
6
K-SATURATION
550°C
14.1A
7.1A
10A
SAMPLE NO.
OR-2
OR-4
OR-6
OR-8
DEGREES 2θ
14
10
6

FIGURE 25

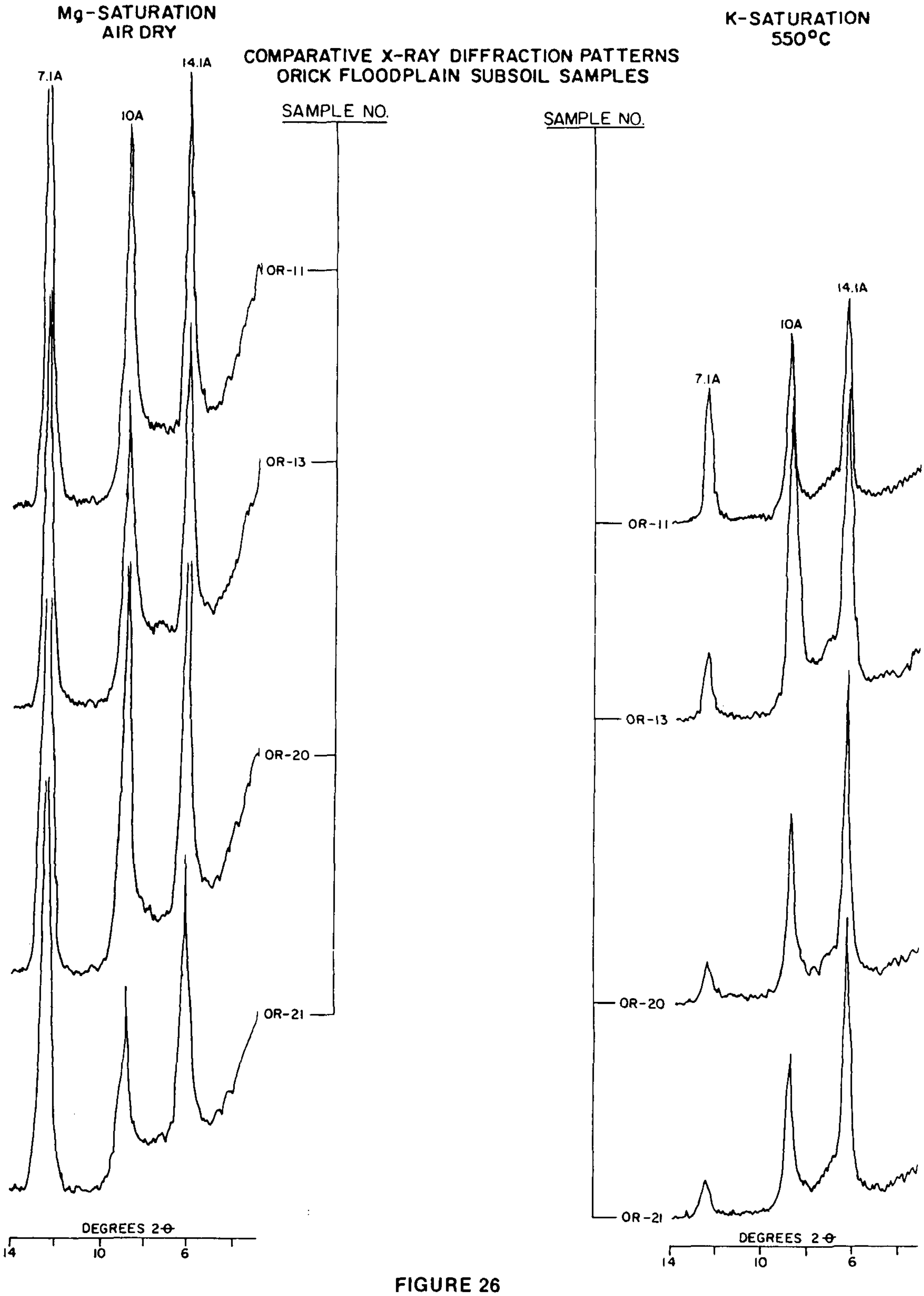

Mg-SATURATION
AIR DRY
K-SATURATION
550°C
COMPARATIVE X-RAY DIFFRACTION PATTERNS
ORICK FLOODPLAIN SUBSOIL SAMPLES
SAMPLE NO.
SAMPLE NO.
7.1A
10A
14.1A
OR-11
OR-13
OR-20
OR-21
DEGREES 2-θ
14
10
6

FIGURE 26

COMPARATIVE X-RAY DIFFRACTION PATTERNS

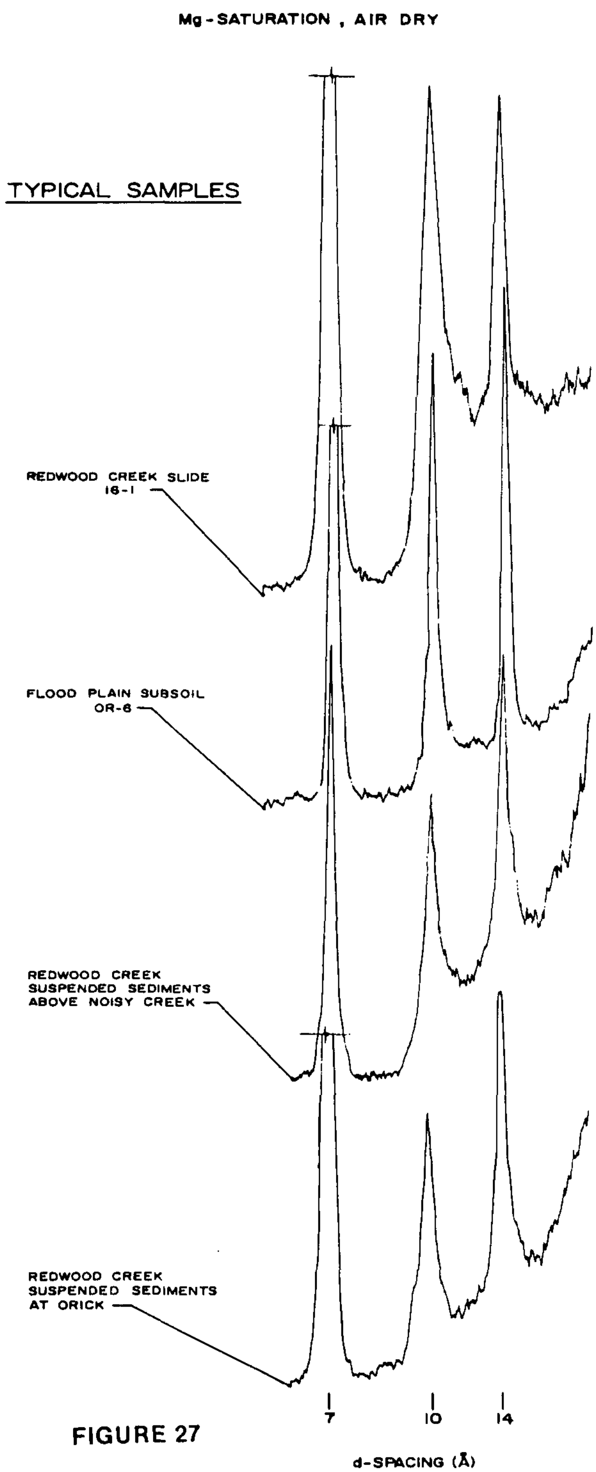


FIGURE 27

present-day slides all contain the same diffraction peaks. The similarity between the patterns for a present-day slide at the head of Simpson operations and the 10 to 12 1/2 foot depth in the floodplain is amazing (Figure 28). As many as 30 different lines can be matched up on both patterns. These "finger-print" patterns were similar for **all** slide and floodplain samples and these two patterns (Figure 28) are typical of the group. Not all long-scan patterns are reproduced here, since to do so would be redundant.

The similarity of the deposits at the three floodplain sites, and the similarity in phyllosilicates in all layers examined, indicate that similar material from the watershed has been the predominant source of floodplain sediments. The similarity in X-ray patterns for floodplain sediments and current slides strongly indicates that the slides in similar soils and geologic formations are the dominant sediment sources. These data reinforce the conclusions obtained from the 1973-1974 study of Redwood Creek. Most of the slides occur on the Kerr Ranch Schist. There is little doubt that this formation has been the origin of most of the sediments in the floodplain. (We do not know the basis for selecting Kerr as the series name for the soil on the floodplain, but in view of the relationship to the Kerr Ranch Schist, it is appropriate.)

Similarity of Deposits Over Time : Age of Deposits

Matching of as many as 30 different diffraction lines leaves little doubt that floodplain sediments are the same as materials in present-day slides. The question follows as to whether these floodplain deposits are of recent origin, i.e., following man's initiation of cultural practices. The deep floodplain excavations revealed the presence of gravels, most likely deposited during prior climatic conditions involving greater streamflow or a lower sea level. The end of the last major period of glaciation (Wisconsin age) was about 10,000 years ago. Regardless of whether or not the criterion of glaciation or lower sea level is used, it appears that the lower deposits just above the gravel contact are probably several thousand years old.

The question of age of deposits was discussed with Dr. LaVerne Kulm, a marine geologist at Oregon State University who has studied sedimentary deposits in the ocean and estuaries of the northwestern United States. He felt our approach and assumptions were reasonable, but he added a word of caution about the effects of meandering of streams in coastal estuaries. He felt that the lower deposit samples would either be fairly young or fairly old, but not likely intermediate. If the lower layers were young, this would indicate cutting followed by deposition of new material during meandering; if the lower layers were old, they would unambiguously indicate stratiographic deposits over time. The similarity of layers and occurrence of clay minerals regardless of site or layer suggest similar sources over time and that the lower layers are indeed old. However, it was decided to use C^{14} analysis on total carbon as a means of determining age and verifying our interpretations.

Four samples were dated by Teledyne Isotopes using C^{14} analyses. The age of all samples was found to be between 3500 and 5000 years (Table XI). These ages are minimal since any "modern" carbons associated with plant roots or leaching of organic compounds from upper horizons would lead to underestimates of age. Consequently, the data indicate that the deposits are older than 3500 years.

TABLE XI

Radiocarbon age dates for samples from the floodplain of Redwood Creek near Orick.

Sample No	Site	Depth Sample	Age [Years before Present]
OR-8	1	160-199"	3,520 ± 340
OR-10	2	43-74"	3,905 ± 230
OR-13	2	122-151"	4,730 ± 240
OR-21	3	152-156"	4,820 ± 330

Conclusion

The long scan X-ray analysis of a sample from a present-day slide on Redwood Creek and a sample from the 10-12½ foot depth in the floodplain gave the same diffraction peaks, indicating that the samples came from similar materials (sources) (figures 27 and 28). The samples differ by more than 4,700 years, as established by radiocarbon age dating. This, coupled with the knowledge of the large number of slides, flows, etc., throughout the length of Redwood Creek, makes the conclusion inescapable that mass wasting has been the principal source of sediment over considerable time.

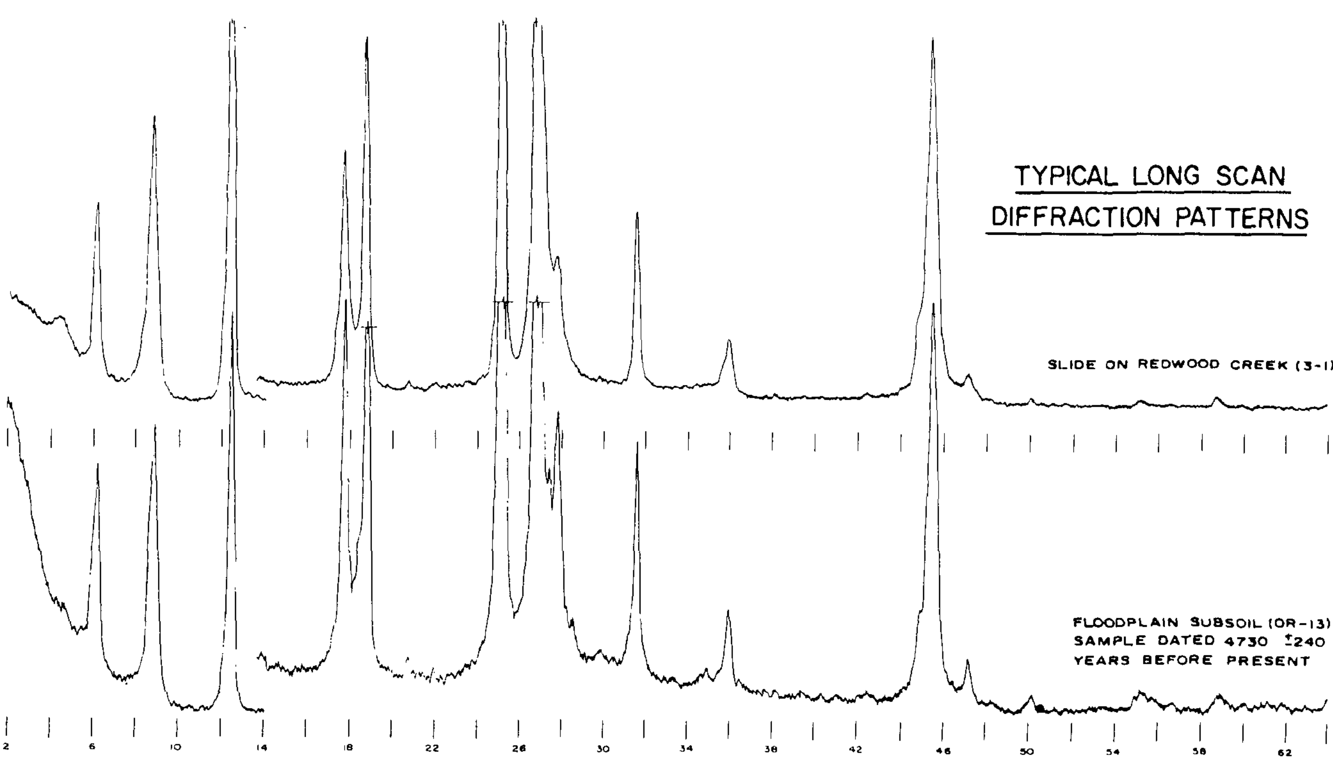


FIGURE 28

Quantitative Measurement of Soil and Slide Material in Suspended Sediments

Background

X-ray diffraction analyses were used as "fingerprint" techniques to determine that the Kerr Ranch Schist was a major source of sediments in Redwood Creek (Winzler and Kelly, 1975). This determination was possible because the samples of soil horizons and geologic formations were sufficiently different from each other to permit the identification of suspended sediments. The suspended sediments and deposits in the streambed of Redwood Creek gave X-ray patterns which contained the same diffraction peaks as material in streamside slides on the Kerr Ranch Schist. These patterns were different from samples of the major soils of the watershed; this was especially true for surface soil samples. The only soil samples which did correlate with the suspended sediments were from the lower horizons of the Masterson series. This soil is developed on the Kerr Ranch Schist and it is very unstable, i.e., it is the soil/geologic formation where many of the slides occur. The study clearly indicated that mass wasting by slides, flows, bank cutting, etc. in the Kerr Ranch Schist was the predominant source of sediment in Redwood Creek. It also established that the processes were deep seated rather than surficial such as sheet and rill erosion. To the extent that erosion of surface soils contributed sediments, the amounts were too small to be detected in the presence of the overriding influence of slide material.

These data raised a question on the lower limits of detection of surface soil materials. We were asked "how much of another component could be present before it would be observed on the diffraction pattern?" In order to respond to this question, a series of experiments was conducted in the fall-winter of 1975.

General Methods

Bulk horizon samples of some of the common soils of the watershed and a slide on the banks of Redwood Creek were obtained. The Atwell soil was used since it is believed to be generally unstable and might be expected to contribute sediments. The Hugo soil was selected since it represents a common soil formed on the Franciscan Formation. A surface sample of the Masterson soil was used since it occurs on the Kerr Ranch Schist and is the one on which streamside slides commonly occur.

The general procedure involved mixing slide materials with different proportions of soil materials. The silt and clay fractions (less than 50 micron) were first separated. The desired components were then added together on a weight basis and thoroughly mixed and suspended in water by shaking. Mixtures were recovered by centrifugation and subsamples were subjected to X-ray diffraction analyses. The characterization treatments were the same as those used in the previous (1973 - 1974) study. The proportions of soil to slide material were increased until the soil component could be detected from the pattern. The characterization treatments which were most sensitive to the soil component were used to determine the minimum detectable amount. Generally, the potassium saturation or potassium saturation plus heat treatments were most sensitive.

Results

The minimum amounts of soil which could be recognized in the presence of the slide material are given in Table XII.

TABLE XII

Limits of Detectability of Soil Components in the presence of slide materials on Kerr Ranch Schist.

Soil Sample	Minimum Amount of Soil Which Can Be Recognized in the Presence of Slide Material [% on dry weight basis]
Masterson A1 (surface horizon)	25
Hugo A1 (surface horizon)	25
Hugo B (a subsoil horizon)	20
Atwell A1 (a surface horizon)	50
Atwell B2 (a subsoil horizon)	15

The ability to detect other soil components in the presence of slide material in suspended sediments depends on how different the suites of clay minerals are. Those samples which contained clays like those in the slide were most difficult to recognize while those distinctly different could be recognized most readily. Four of the five samples gave minimum detectable amounts in the range of 15 to 25%. In one of the five cases, the minimum was 50%.

Conclusion

In areas which have been or are undergoing active logging, Hugo and Masterson are the dominant soil series. If surficial erosion was a major source of suspended sediment, these surface materials would have been recognized in the X-ray diffraction patterns. Since these materials were not observed in the samples of suspended sediments from Redwood Creek during the previous study, the amounts present were **less than 25%**. These data confirm the previous interpretations that surficial erosion is not the source of a major portion of the sediment in Redwood Creek. Rather, streamside slides and the banks of the main channel of Redwood Creek are the predominant sources of sediment.

DISCUSSION OF FINDINGS

Because the results of this study bear on the findings of our **Redwood Creek Sediment Study, 1973-1974**, the findings of the 1973-1974 study are stated, commented upon, and then restated, if necessary, incorporating appropriate modifications resulting from the subsequent data derived from this current study.

1973-1974 Finding

Suspended sediment samples in Redwood Creek well above timber harvesting activity were mineralogically the same as samples taken near the mouth of Redwood Creek at Orick.

This finding should be amended by inserting the word "current" before timber harvesting activity. We recognize that large-scale harvesting activity occurred in the upper basin mainly during the 1950's, which certainly had some effect on the sediment load for the upper basin. However, the samples were taken above all current activity and any effect due to past logging would have certainly been ameliorated over the ensuing twenty or so years. Aerial observation and ground inspection further indicates that there are no recent large scale clearcut areas above our sampling point in the upper basin. The modified finding is as follows:

Modified Finding

Suspended sediment samples in Redwood Creek well above current timber harvesting activity were mineralogically the same as samples taken near the mouth of Redwood Creek at Orick.

1973–1974 Finding

X-ray diffraction patterns for suspended sediment, streambed sediment, slides along Redwood Creek, and deposited floodplain soil near Orick are essentially the same. All of them contain well-crystallized mica and chlorite.

A considerable amount of additional work was conducted in the floodplain near Orick to further characterize the depositional soil. The results of X-ray diffraction analysis on samples taken at three locations in the Orick floodplain confirm the original conclusion that the deposited material is essentially the same as the material derived from streamside slides and currently being transported and deposited by Redwood Creek. Therefore, no modification is necessary to the original conclusion.

1973–1974 Finding

The subsoil of the Masterson soil has mineralogy like the stream sediment and slides. The slides have developed predominantly on the Kerr Ranch Schist. Kerr Ranch Schist is also the parent material for the Masterson soil. The predominant soil adjacent to Redwood Creek and its tributaries is also Masterson.

This conclusion was sufficiently established during the first year's work, and no further work was deemed necessary.

1973-1974 Findings

The mineralogy of surface horizons of the Masterson soil is different from the suspended and deposited sediment found in Redwood Creek. The similarity of the Redwood Creek sediment to the subsoil and not the topsoil suggests that the dominant geomorphic processes are deep-seated, occurring in the soil parent material rather than the solum.

Other representative soils of the Redwood Creek watershed have clay mineral suites which differ from the slide and sediment material. Although these soils could contribute to the sediment load of Redwood Creek, the amounts are not sufficient to be detected in the presence of the predominant suite of chlorite and mica from the Masterson subsoil.

Legitimate criticism of these conclusions was brought to our attention regarding the amount of material from other soil series and from surface soils that could be masked in the X-ray diffraction analysis by the presence of the Masterson parent or subsoil material. It was determined that the Masterson or Hugo surface soil material would be recognized if present in amounts of 25% or greater. As the surface material was not present in those amounts, it can be concluded that the dominant material present in the suspended and deposited sediment found in Redwood Creek is derived from the Masterson subsoil. This reinforces our conclusion that the dominant geomorphic processes are deep seated, occurring in the soil parent material rather than in the solum, and no modifications are required for the above two findings.

1973-1974 Finding

The clay mineralogy of sediment being transported by Redwood Creek at the present time does not differ significantly from sediment deposited at depths in the floodplain near Orick, indicating deposition prior to man's activity in the Basin. Geomorphic processes and sediment sources appear to have been similar through at least the last several hundred years. The same processes will continue in the future regardless of the changes in the land management of the watershed.

The above finding very conservatively suggested that soil samples taken at depths, based upon the professional judgment of the study team members, represented deposition prior to man's activity in the basin. The finding was conservatively worded as we did not have any "hard" data available as to the actual age of the sampled sediment. Subsequent radiocarbon age dating of sediment at various depths in the floodplain has established that the sediment dates from 3,520 ± 340 to 4,820 ± 330 years before present. This more accurate dating of the deposited material, combined with X-ray diffraction analysis, which indicated that the material is essentially the same as material derived from the streamside slides and being currently transported and deposited by Redwood Creek, allows the finding to be modified to read:

Modified Finding

The clay mineralogy of sediment being transported by Redwood Creek at the present time does not differ significantly from sediment deposited at depths in the floodplain near Orick, indicating deposition prior to man's activity in the Basin. Geomorphic processes and sediment sources appear to have been similar through at least the last 3,000 years. The same processes will continue in the future regardless of the changes in the land management of the watershed.

1973-1974 Finding

The amounts of suspended sediment in upper Redwood Creek [well above current timber harvesting operations] are in the same orders of magnitude as in the lower portions of the stream. The upper watershed is a significant source of sediment.

All of the additional sediment data collected from Redwood Creek during the 1975 study period supports the above finding. The suspended sediment transport rate on a per-square-mile basis was higher at the Chezem station than at Orick during both Storms I and II. The U.S. Geological Survey study findings also support the above conclusion in that they found that "Suspended sediment concentrations and load per unit area for Redwood Creek near Blue Lake are apparently about equal to those at Orick." (Janda, page 176a, October 1975).[2] No modification of the original finding is warranted.

1973-1974 Finding

The contribution of sediment from individual tributary streams is insignificant compared to the load carried by Redwood Creek.

During Storm I, Lacks and Panther Creeks contributed approximately 2.1 percent of the sediment carried by Redwood Creek at Orick. The same tributaries constitute 8.7 percent of the total Redwood Creek drainage area. During Storm II, Lacks, Panther, Copper and Coyote Creeks contributed approximately 3.5 percent of the sediment carried by Redwood Creek at Orick. Those monitored tributaries constitute 12.9 percent of the total Redwood Creek drainage area. While a sediment contribution of from 2.1 to 3.5 percent of the total sediment transported by Redwood Creek may not be insignificant, those percentages in light of the size of the contributing drainage areas certainly do not indicate that the measured tributaries are major or dominant sources of

2. Janda, Richard J., Nolan, K. Michael, Harden, Deborah R., and Coleman, Steven M. October, 1975. "Watershed Conditions in the Drainage Basin of Redwood Creek, Humboldt County, California, as of 1973." U.S. Geological Survey, Open-File Report 75-568, Menlo Park, California.

suspended sediment. Our data, Tables II and IV, agree with a finding of the U.S. Geological Survey study (Janda, October 1975) which stated on Page 180:

"However, during the observed storms, even the most heavily logged tributaries appear to have suspended sediment concentrations and loads that even on a per-square-mile basis are lower than those of Redwood Creek itself (Winzler and Kelly 1975; Iwatsubo and others, 1975)".

The original finding should be modified to reflect the additional data as follows:

Modified finding

Not only are the contributions of sediment from measured individual tributaries significantly less than the sediment loads carried by Redwood Creek, but the suspended sediment contribution from even the most heavily logged tributaries is less on a per-square-mile basis than the suspended sediment load carried by Redwood Creek.

1973—1974 Finding

The upper watershed is undergoing stream bank cutting and channel scour while a large section of the stream in and near Redwood National Park is undergoing deposition, particularly that area through the Tall Trees Flat. This appears to be in response to stream gradient.

No additional work has been attempted to further establish the above hypothesis as the assumption was drawn from the observable physical characteristics of the Redwood Creek Basin.

1973-1974 Finding

Based upon sediment composition and the number and location of slides, mass movement phenomena represent the dominant geomorphic response to processes within the Redwood Creek Basin. Streamside slides are the principal source of sediment within the Basin.

All of the work that we have conducted and all of the work conducted by others, that we are aware of, indicates that the main stream of Redwood Creek has sediment transport rates greater than its measured tributaries, including even the most heavily logged tributaries. As the sums of the individual contributions of tributaries do not add up to the whole of the Redwood Creek transport, there must be other major sources of sediment supply to the main channel. What are the other possible sources? Sheet erosion and streamside mass wasting are the only other processes of which we are aware that could contribute sediment directly to Redwood Creek. Surficial erosion contributes less than 25 percent of the total sediment from all sources; therefore, sheet erosion directly to Redwood Creek can be discounted as a major sediment supply. The major sources then must be mass wasting processes that feed sediment directly to Redwood Creek. Our X-ray diffraction data has identified the slide material, Masterson subsoil, as the predominant component of the sediment being carried by Redwood Creek. The U.S. Geological Survey study team determined that various reaches of Redwood Creek have from 41 to 68 percent actively eroding streambanks with 56 percent of the streambanks along the entire stream being actively eroded (Janda, October 1975).

Many of the streamside slides lining the stream are discretely distinguishable only from the air or on aerial photographs where the crown scarps can be recognized. At stream level, the bank erosion between slides makes it extremely difficult to recognize individual slides, which appear as continuous streamside scars.

As bank erosion and streamside slides contribute the same material, we, perhaps erroneously, did not distinguish between these processes in our original finding. Based upon the foregoing and in an effort to be more concise, the original finding should be modified as follows:

Modified Finding

Streamside mass wasting phenomena, including such processes as sliding, slumping, creeping and bank cutting, are the principal sources of sediment to Redwood Creek and its tributaries, accounting for as much as 75 percent of the sediment carried by Redwood Creek.

1973-1974 Finding

Owing to the general occurrence of erodible slide materials along Redwood Creek and its tributaries, sediment influx to the Creek is not readily attributable to point sources, either in terms of specific slide locations or tributary input.

Our continuing studies and observations in the Redwood Creek Basin have reconfirmed the finding that no single tributary or slide contributes a significant sediment input. For example, if the sediment load for Copper Creek, which had the highest measured tributary sediment transport rate, were removed from Redwood Creek, the decrease in sediment transported by Redwood Creek at Orick would be less than 1 percent. As subsequent study confirmed our original finding, no modification is necessary.

Appendix

STORM DATA

REDWOOD CREEK
Chezem Bridge Station
Storm I
5-7 February 1975

Date	Time	Flow [cfs]	Suspended Sediment [Mg/L]	Turbidity [NTU]
2-5	1615		540	260
2-5	1710		980	240
2-5	1800		560	250
2-5	1910		340	220
2-5	2000		350	190
2-5	2007	1490		
2-5	2110	1140	390	120
2-5	2200	860	230	140
2-5	2210	810		810
2-6	0006	910	340	120
2-6	0020	920		
2-6	0056	1050	290	120
2-6	0145	1230	230	110
2-6	0220	1360		
2-6	0300	1150	570	270
2-6	0400	830	170	90
2-6	0413	760		
2-6	0500	750	190	90
2-6	0605	740	220	100
2-6	0620	730		
2-6	0705	700	150	90
2-6	0805	640	67	100
2-6	0905	580	210	110
2-6	1000	520	260	120
2-6	1010	510		
2-6	1200	500		
2-6	1308	810	340	140
2-6	1445	1240	410	200
2-6	1525	1420		
2-6	2005	1680	490	240
2-6	2040	1710		
2-6	2305	1590	250	160
2-6	2335	1570		
2-7	0440	1510		
2-7	0645	1370	400	190
2-7	0833	1250		
2-7	0900		390	130
2-7	1210		320	120

REDWOOD CREEK
1400 Bridge Station
Storm I
5-7 February 1975

Date	Time	Flow [cfs]	Suspended Sediment [Mg/L]	Turbidity [NTU]
2-5	1730	3010		
2-5	2040	2760	770	240
2-5	2225	2630		
2-5	2315	2570	480	150
2-6	0105	2420		
2-6	0200	2360	150	120
2-6	0415	2190	290	110
2-6	0430	2170		
2-6	0545	2130	370	100
2-6	0700	2090	280	100
2-6	0730	2080		
2-6	0800	2090	220	90
2-6	1000	2120		
2-6	1100	2130	150	100
2-6	1210	2130		
2-6	1240	2160	180	100
2-6	1410	2260		
2-6	1440	2270	280	90
2-6	1600	2320	170	110
2-6	1630	2340		
2-6	1845	2390	390	130
2-6	2100	2450	460	160
2-6	2245	2500	640	200
2-7	0005	2530		
2-7	0115	2630	600	180
2-7	0215	2710		
2-7	0335	2700	410	150
2-7	0500	2690		
2-7	0530	2730	580	150
2-7	0800	2900	580	160
2-7	1000	2640	530	180
2-7	1005	2620		

REDWOOD CREEK
Orick Station
Storm I
5-7 February 1975

Date	Time	Flow [cfs]	Suspended Sediment [Mg/L]	Turbidity [NTU]
2-5	1830		450	130
2-5	2010	2780		
2-5	2050	2720	760	210
2-5	2200	2620	960	250
2-5	2300	2540	790	290
2-6	0010	2450	920	280
2-6	0530	2080	470	140
2-6	0545	2060		
2-6	0730	2160	410	110
2-6	1000	2310	360	92
2-6	1050	2360		
2-6	1150	2320	300	110
2-6	1435	2210	290	100
2-6	1450	2200		
2-6	1850	2410	290	92
2-6	2250	2350	330	92
2-7	0315	2630	400	120
2-7	0745	2770	400	170

LACKS CREEK
Storm I
5-7 February 1975

Date	Time	Flow [cfs]	Suspended Sediment [Mg/L]	Turbidity [NTU]
2-5	1400		200	160
2-5	1500		150	140
2-5	1600		180	110
2-5	1700		150	96
2-5	1745	380		
2-5	1800	380	40	68
2-5	1900	370	75	58
2-5	2000	370	94	50
2-5	2100	360	82	45
2-5	2200	360	71	40
2-5	2300	340	55	40
2-6	0005	330	63	40
2-6	0100	310	4.1	37
2-6	0200	300	2.9	29
2-6	0300	310	44	28
2-6	0400	320	38	29
2-6	0500	310	0.7	15
2-6	0600	300	12	24
2-6	0700	300	44	26
2-6	0800	280	51	32
2-6	0900	290	44	33
2-6	1000	300	42	32

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2-6	1100	310	52	34
2-6	1200	310	55	35
2-6	1600	400	62	40
2-6	2000	400	47	30
2-7	0005	350	75	47
2-7	0200	380	100	50
2-7	0600	350	95	44
2-7	0800	350	67	35
2-7	1100	350	43	30

PANTHER CREEK
Storm I
5-7 February 1975

Date	Time	Flow [cfs]	Suspended Sediment [Mg/L]	Turbidity [NTU]
2-5	1515	48		
2-5	2135	52	1.8	2.0
2-6	0005	42	0.7	1.5
2-6	0315	49	1.4	1.8
2-6	0545	46	0.7	1.4
2-6	0700	44	<0.1	<1
2-6	0800	43	<0.1	<1
2-6	0940	42	0.7	1.2
2-6	1140	39	<0.1	<1
2-6	1400	48	<0.1	<1
2-6	1600	67	<0.1	<1
2-6	1830	44	<0.1	<1
2-6	2100	48	<0.1	<1
2-6	2215	50		
2-6	2245	50	1.4	3.0
2-7	0130	53	<0.1	<1
2-7	0400	40	<0.1	<1
2-7	0600	46	<0.1	<1
2-7	0800	49	0.7	1.0
2-7	0900	50		
2-7	1000	48	<0.1	<1
2-7	1045	46		

REDWOOD CREEK
Chezem Bridge Station
Storm II
27 February - 2 March 1975

Date	Time	Flow [cfs]	Suspended Sediment [Mg/L]	Turbidity [NTU]
2-27	1630		210	210
2-27	1830		280	120
2-27	1900	1020		
2-27	2100	1010	260	85
2-27	2250	1000		
2-28	0130	1040	280	110
2-28	0135	1040	260	100

(Continued)

REDWOOD CREEK
Chezem Bridge Station
Storm II (continued)

Date	Time	Flow [cfs]	Suspended Sediment [Mg/L]	Turbidity [NTU]
2-28	0436	1080		
2-28	0615	990	320	90
2-28	0620	990	300	88
2-28*	0620	990	230	80
2-28	0800	900		
2-28*	1100	790	190	65
2-28	1100	790	180	65
2-28	1200	750		
2-28*	1500	640	160	62
2-28	1615	600		
2-28*	1900	760	160	63
2-28	1900	760	210	29
2-28	2035	760		
2-28	2325	890	380	65
2-28*	2325	890	160	68
3-1	0115	910		
3-1*	0330	900	130	63
3-1	0450	880		
3-1*	0715	840	120	53
3-1	0715	840	150	54
3-1	0810	830		
3-1	1100	550	320	57
3-1	1150	470		
3-1	1510	790	160	68
3-1*	1515	800	160	67
3-1	1610	880		
3-1	1730	870	770	130
3-1*	1730	870	260	90
3-1	1740	870		
3-1*	1915	1080	360	150
3-1	1930	1120		
3-1	2100	1120	470	200
3-1*	2100	1120	500	210
3-1	2125	1120		
3-2	0015	1260		
3-2*	0100	1360	1080	340
3-2	0130	1420		
3-2	0215	1430	1280	420
3-2*	0315	1440	1210	450
3-2	0325	1440	1330	440
3-2	0415	1480	1210	430
3-2	0510	1510	990	390
3-2*	0510	1510	1010	400
3-2	0520	1520		
3-2	0820	1550	1380	320
3-2	0825	1550		
3-2	0910	1530		
3-2*	1010	1440	670	250

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Date	Time	Flow [cfs]	Suspended Sediment [Mg/L]	Turbidity [NTU]
3-2	1220	1240		
3-2	1320	1260	1620	210
3-2	1410	1280		
3-2*	1445		540	220
3-2	1615		5760	220

*Grab Samples

REDWOOD CREEK
1400 Bridge Station
Storm II
27 February - 2 March 1975

Date	Time	Flow [cfs]	Suspended Sediment [Mg/L]	Turbidity [NTU]
2-27	1820		240	100
2-27	1930		200	64
2-27	2010	1530		
2-27	2105	1530	200	75
2-27	2315	1540	270	90
2-27	2345	1540		
2-28	0045	1540	280	100
2-28	0245	1540	280	120
2-28	0305	1540		
2-28	0535	1580	270	90
2-28	0548	1590		
2-28	0723	1530	270	100
2-28	0727	1530		
2-28	0855	1530	250	95
2-28	0934	1530		
2-28	1100	1520	360	85
2-28	1315	1510	220	92
2-28	1330	1500		
2-28	1610	1450	180	80
2-28	1630	1440		
2-28	1855	1380	160	70
2-28	1920	1370		
2-28	2250	1360		
2-28	2320	1360	160	70
3-1	0250	1380		
3-1	0320	1360	170	53
3-1	0610	1270		
3-1	0620	1270	140	60
3-1	0900	1290	140	57
3-1	0910	1290		
3-1	1020	1310	160	67
3-1	1100	1320		
3-1	1135	1310	160	72
3-1	1245	1300	160	67
3-1	1300	1290		
3-1	1340	1290	170	70
3-1	1445	1280	170	65

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3-1	1506	1280		
3-1	1545	1220	160	67
3-1	1700	1100	170	70
3-1	1745	1180	190	75
3-1	1900	1310	180	83
3-1	1952	1300	180	68
3-1	2100	1280	170	68
3-1	2200	1390	250	85
3-1	2300	1500		
3-1	2320	1490	350	140
3-2	0115	1400	380	140
3-2	0335	1620	540	780
3-2	0400	1650		
3-2	0440	1800	730	240
3-2	0600	2080	1010	320
3-2	0622	2160		
3-2	0655	2110	1100	340
3-2	0805	2000	1130	360
3-2	0900	2030	1060	350
3-2	1030	2080	910	350
3-2	1121	2110		
3-2	1140	2110		
3-2	1200		750	280
3-2	1305		760	260
3-2	1415		700	240

REDWOOD CREEK
Orick Station
Storm II
27 February - 2 March 1975

Date	Time	Flow [cfs]	Suspended Sediment [Mg/L]	Turbidity [NTU]
2-27	1700	1760		
2-27	1730	1800	820*	65
2-27	2025	2040	320	72
2-27	2045	2070		
2-27	2230	2160	550*	77
2-28	0045	2180	350*	85
2-28	0305	2130		
2-28	0340	2130	340*	80
2-28	0710	2110	910*	82
2-28	0730	2110		
2-28	1000	2160	230	81
2-28	1305	2030	770*	79
2-28	1700	1950	350*	76
3-1	0130	1890	270	69
3-1	0535	1770	180	60
3-1	0930	1860	210	59
3-1	1350	1800	240	62
3-1	1715	1840	280	63
3-2	1240	2940	3880*	78

*Gravel in sample

COPPER CREEK
Storm II
27 February - 2 March 1975

Date	Time	Flow [cfs]	Suspended Sediment [Mg/L]	Turbidity [NTU]
2-27	1700	11		
2-27	1715	11	160	95
2-27	1815	11	200	91
2-27	1915	11	310	130
2-27	2015	11	320	110
2-27	2115	12		
2-27	2215	13	210	92
2-28	0020	16	110	73
2-28	0125	17		
2-28	0220	16	94	54
2-28	0320	16		
2-28	0415	16	58	45
2-28	0520	16		
2-28	0615	15	54	35
2-28	0720	15		
2-28	0815	14	50	37
2-28	0915	12		
2-28	1015	12	38	31
2-28	1115	12		
2-28	1210	11	36	28
2-28	1305	11		
2-28	1410	10	37	28
2-28	1512	10		
2-28	1615	10	37	29
2-28	1715	10		
2-28	1815	10	29	26
2-28	1915	10		
2-28	2200	10		
3-1	0155	10		
3-1	0210	10	20	19
3-1	0540	8.2		
3-1	0610	8.1	20	25
3-1	0830	7.8		
3-1	0835	7.9	16	18
3-1	1000	10	17	21
3-1	1005	10		
3-1	1100	15	71	45
3-1	1200	17	180	73
3-1	1300	18	390	130
3-1	1355	20	390	130
3-1	1500	18	220	100
3-1	1600	17	130	84
3-1	1605	16		
3-1	1700	15	99	66
3-1	1800	13	69	53
3-1	1900	13	59	32
3-1	2000	14	200	94
3-1	2100	20	290	110
3-1	2200	26		

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3-1	2215	28	480	140
3-1	2300	31	630	150
3-2	0005	35	1040	220
3-2	0015	36		
3-2	0100	33	1380	200
3-2	0215	27	450	130
3-2	0300	30	380	100
3-2	0405	34		
3-2	0415	34	480	140
3-2	0500	34	420	130
3-2	0605	33		
3-2	0615	33	440	130
3-2	0700	32	340	130
3-2	0800	32	250	96
3-2	0900	30	240	80
3-2	1000	27	200	80
3-2	1100	30	320	110
3-2	1200	33	340	130
3-2	1300	39	470	130
3-2*	1400	45	1310	190

*Gravel in sample

COYOTE CREEK
Storm II
27 February - 2 March 1975

Date	Time	Flow [cfs]	Suspended Sediment [Mg/L]	Turbidity [NTU]
2-27	1700		38	27
2-27	1800		48	33
2-27	1900	60	86	37
2-27	2000	62	120	55
2-27	2100	63	280	80
2-27	2200	64	630	150
2-27	2300	63	220	90
2-28	0005	62	87	60
2-28	0045	62		
2-28	0200	54	59	35
2-28	0400	49	32	23
2-28	0600	50	32	25
2-28	0800	49	31	21
2-28	1000	50	26	19
2-28	1020	50		
2-28	1200	48	29	19
2-28	1400	46	11	12
2-28	1600	47	12	11
2-28	1800	48	26	17
2-28	2200	40	11	10
3-1	0200	42	13	10
3-1	0600	44	17	12
3-1	1000	48	7.0	9.0
3-1	1100	50	38	25
3-1	1200	52	30	23

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3-1	1300	57	78	43
3-1	1400	61	480	110
3-1	1500	58	550	150
3-1	1600	56	290	120
3-1	1800	56	62	43
3-1	1900	57	40	33
3-1	2000	58	120	65
3-1	2100	69	160	74
3-1	2200	81	220	74
3-1	2300	78	360	150
3-1	2400	75	260	110
3-2	0100	79	320	150
3-2	0200	83	270	130
3-2	0300	88	190	90
3-2	0400	93	150	70
3-2	0500	98	200	89
3-2	0600	100	270	120
3-2	0700	100	330	130
3-2	0800	98	270	120
3-2	0820	97		
3-2	0900	97	180	90
3-2	1000	97	150	65
3-2	1100	97	180	68
3-2	1200	97	260	88
3-2	1300	100	270	98
3-2	1400	110	370	120
3-2	1500	100	500	140

LACKS CREEK
Storm II
27 February - 2 March 1975

Date	Time	Flow [cfs]	Suspended Sediment [Mg/L]	Turbidity [NTU]
2-27	1500	94	33	24
2-27	1700	110	42	31
2-27	1800	110	32	27
2-27	1900	110	25	24
2-27	2000	110	29	21
2-27	2100	120	30	22
2-27	2200	120	32	25
2-27	2300	120	26	25
2-28	0005	120	37	28
2-28	0100	120		
2-28	0200	100	29	23
2-28	0300	95		
2-28	0400	94	17	18
2-28	0500	94		
2-28	0600	98	21	15
2-28	0700	100		
2-28	0800	100	7	11
2-28	0900	110		
2-28	1000	100	18	12
2-28	1100	100		

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2-28	1200	98	16	11
2-28	1300	96		
2-28	1400	91	13	12
2-28	1500	86		
2-28	1800	80		
2-28	2200	78	5.0	9.8
3-1	0200	86	13	8.5
3-1	0600	76	5.0	8.6
3-1	1000	80	17	9.9
3-1	1200	96	57	35
3-1	1300	100	69	44
3-1	1400	110	79	46
3-1	1500	110	64	40
3-1	1600	100	40	28
3-1	1700	100	42	29
3-1	1800	110	35	26
3-1	1900	110	32	22
3-1	2000	110	72	44
3-1	2100	120	61	37
3-1	2200	140	88	47
3-1	2300	140	91	50
3-2	0005	150	83	47
3-2	0100	150	84	46
3-2	0200	150	68	44
3-2	0300	150	65	42
3-2	0400	150	57	35
3-2	0500	150	55	33
3-2	0600	150	45	32
3-2	0700	150	49	34
3-2	0800	150	40	29
3-2	0900	140	33	25
3-2	1000	140	38	30
3-2	1100	140	41	29
3-2	1200	130	66	37
3-2	1300		95	53
3-2	1400		86	48
3-2	1500		100	59

PANTHER CREEK
Storm II
27 February - 2 March 1975

Date	Time	Flow [cfs]	Suspended Sediment [Mg/L]	Turbidity [NTU]
2-27	1820		<0.1	<1
2-27	1935		18	3.6
2-27	1955	49		
2-27	2105	50	15	3.4
2-27	2220	51		
2-27	2248	51	<0.1	<1
2-27	2315	52	<0.1	1.0
2-28	0045	53	12	2.1
2-28	0130	54		
2-28	0245	52	<0.1	1.0
2-28	0400	51		

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2-28	0535	50	<0.1	<1
2-28	0648	50		
2-28	0723	47	10	3.4
2-28	0859	40		
2-28	0903	40	13	1.6
2-28	1108	38		
2-28	1315	40	7.0	2.6
2-28	1410	41		
2-28	1610	41	<0.1	<1
2-28	1855	40	7.0	1.2
2-28	2330	36	<0.1	<1
3-1	0330	34	<0.1	<1
3-1	0630	36	<0.1	1.0
3-1	0900	33	<0.1	<1
3-1	1020	36	<0.1	<1
3-1	1130	36	<0.1	<1
3-1	1245	37	<0.1	<1
3-1	1341	37	7.0	1.6
3-1	1445	36	<0.1	<1
3-1	1900	37	24	4.5
3-1	1945	39	22	5.3
3-1	2100	38	23	5.0
3-1	2140	37		
3-1	2200	37	13	3.1
3-1	2325	36	13	2.6
3-2	0110	36	8.0	1.5
3-2	0145	36		
3-2	0335	40	13	2.1
3-2	0500	43	16	3.8
3-2	0600	42	21	5.1
3-2	0700	41	12	2.8
3-2	0800	42	15	1.5
3-2	0900	43	<0.1	1.0
3-2	1040	44	15	3.2
3-2	1200	43	16	4.1
3-2	1300	42	12	2.3
3-2	1415		53	18

REDWOOD CREEK
1400 Bridge Station
Storm III
18-20 March 1975

Date	Time	Flow [cfs]	Suspended Sediment [Mg/L]	Turbidity [NTU]
3-18	1845		5700	2300
3-18	1900		5820	2600
3-18	2000		5350	2600
3-18	2100		5240	2200
3-18	2200		4760	2100
3-18	2300		4600	2100
3-19	0001		3850	2000
3-19	0100		3820	1900
3-19	0200		3480	1700

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3-19	0300		3440		1500	
3-19	0410		3240		1500	
3-19	0410		3250	3220 Avg.	1500	1600 Avg.
3-19	0410		3160		1800	
3-19	0510		2840		1400	
3-19	0605		3030		1300	
3-19	0710		2410		1400	
3-19	0730	10300				
3-19	0830	9360	2450		1500	
3-19	0930	8630	2240		1400	
3-19	1015	8690	2510		1300	
3-19	1125	8790	2680		1100	
3-19	1220	8440	2280		1200	
3-19	1315	8080	2310		1100	
3-19	1410	7870	2210		1100	
3-19	1520	7600	2060		1100	
3-19	1715	8090	1900		1200	
3-19	1815	7620	1910		1100	
3-19	1915	7150	1870		1000	
3-19	2020	7040	1880		900	
3-19	2200	6880	1880		600	
3-19	2300	6930	1730		700	
3-20	0005	6990	1740		660	
3-20	0100	6480	1500	1530 Avg.	660	670 Avg.
3-20	0100	6480	1560		680	
3-20	0200	5930	1440		580	
3-20	0300	6020	1450		620	
3-20	0415	6140				
3-20	0430	6150	1340		540	
3-20	0515	6170	1370		580	
3-20	0615	6200	1400		580	
3-20	0710	6100	1380		600	
3-20	0810	6000	1290		540	
3-20	0825	5970				
3-20	0910	5700	1330		540	
3-20	1000	5400	1210		500	
3-20	1100	5200	1220		520	
3-20	1215	4980	1200		500	
3-20	1310	5230	1200		500	
3-20	1415	5520	1130		500	
3-20	1510	4920	1140		440	
3-20	1555	4490	1060		460	

REDWOOD CREEK
Orick Station
Storm III
18-20 March 1975

Date	Time	Flow [cfs]	Suspended Sediment [Mg/L]	Turbidity [NTU]
3-18	1500	50600	8200	2000
3-18	1924	48100	6500	1800
3-18	2110	39800	5800	1700
3-19	0130	33700	4700	1400
3-19	0300	31600	4600	1300
3-19	0500	28800	4300	1300
3-19	0730	25300	3700	1200
3-19	0930	22500	3500	1100
3-19	1100	20900	3200	1000
3-19	1315	19300	3000	1000
3-19	1500	12300	2800	910
3-19	1755	16500	2400	850
3-19	1945	15500	2500	800
3-19	2130	13100	2300	780
3-19	2345	10000	2100	760
3-20	0155	13700	2000	720
3-20	0400	13300	1900	700
3-20	0615	12000	1700	640
3-20	0830	11600	1600	630
3-20	1100	11000	1600	590
3-20	1332	7980	1400	550
3-20	1650	8130	1400	540