SECTION C

HYDROLOGY

INTRODUCTION

This section provides the available hydrologic data for the Garcia WAU and some analysis of the bed mobility in response reaches of the WAU. The Garcia WAU does not receive any significant snow accumulations which could contribute to rain-on-snow events. Current research shows possible cumulative effects from increased peak flows from forest harvest in rain-on-snow dominated areas (Harr, 198l). However, in rain dominated areas increases in large stream peak flows from forest harvesting are not found (Ziemer, 1981; Wright et. al., 1990). The Garcia WAU is in a rain dominated area in the temperate coastal zone of Northern California therefore analysis on peak flow hydrologic change was not considered necessary

Peak Flows for the Garcia River

The peak flow information was taken from the Garcia River Gravel Management Plan (Philip Williams and Assoc., 1996). Hydrologic data was collected by the United States Geological Survey (USGS) gage 11467600 from 1962-1983. The gaged period of record at the Garcia River USGS gaging station was extended using a synthesis of data from a continuous gaging record for the nearby Navarro River (Philip Williams and Assoc., 1996). The peak flood discharges greater than a 2-year recurrence interval are presented in Table C-1.

Table C-1. Peak Flow Discharges for the Garcia River greater than a 2-year Recurrence Interval (from Philip Williams and Assoc., 1996)

Date	Peak Discharge (cfs)
1952	19,400
1955	26,300
1963	23,900
1964	26,100
1966	28,700
1969	20,800
1970	26,600
1973	19,300
1974	30,300
1986	28,038
1993	20,350
1995	37,000

Using the synthesized record from 1952-1995, the flood of record is 1995 (37,000 cfs) considered to be close to a 50 year event for the Garcia River (Table C-2). Before the 1995 flood, the second highest flood is the 1974 event (30,300 cfs). To estimate the recurrence interval of the flood events of the Garcia River the USGS annual peak flow series was used. The time frame of the peak flow information collected was from 1962-1983. An extreme value type I distribution (Gumbel, 1958) was fitted to the data. Table C-2 shows the estimated recurrence interval for peak discharges in the basin.

Table C-2. Flood Recurrence for Peak Flows of the Garcia River.

Recurrence Interval (years)	Peak Discharge (cfs)
2	14000
5	22000
10	27000
25	34000
50	39000
100	44000

Throughout the period of modern forest management in the Garcia WAU, post 1950, there have been numerous large flood events (>2 year recurrence, Table C-1). These flood events have the capacity to re-shape river or stream channels and transport large sediment loads. The meteorological events which created these large floods also can be assumed to be a major contributor to the erosion and mass wasting delivered to the watercourses in the WAU.

Bed Mobility Analysis

Bed mobility analysis is used to determine whether the bed particles of the streambed (usually represented by D_{50}) are likely to be transported at a given flow. The predicted bed particle size is then compared to the measured particle size to assess whether or not the bed material is likely to be mobilized for the bankfull flow (Version 3.0, Washington Forest Practices Board). The ratio of predicted particle diameter to the actual particle diameter provides a measure of bed mobility potential. Bed mobility is high if the ratio is much greater than 1 and low if the ratio is less than 1.

Uncertainty associated with the use of bedload transport equations is relatively high, differing field conditions can produce a range of results. Even with the greatest care in calculating a predicted D_{50}, there is still considerable margin for error. Because of this a range of values is probably most appropriate for assigning sensitivity ratings. For this analysis high bed mobility potential was assigned to ratios greater than 2, moderate bed mobility potential was assigned to ratios between 0.75 and 2, and low bed mobility potential was assigned to ratios less than 0.75.

The median grain diameter at which the streambed is entrained can be calculated by:

$$D_{50} = \rho_w g R S/(\rho_w - \rho_s) 0.047 g$$

where ρ_w is the density of water, ρ_s is the density of the grain particle material (assumed to be 2.65 g cm^{-3}), g is the acceleration of gravity, 0.047 is a constant defining the critical shear stress (i.e. Shield's number)(Dietrich, pers. comm.), R is the hydraulic radius, and S is channel slope. The hydraulic radius was approximated by bankfull depth, which was observed during the stream channel assessment. The D_{50} value calculated from this equation is compared to the actual observed D_{50} from pebble counts performed in the summer of 1997 for determination of bed mobility potential. The results of the bed mobility potential calculations are presented in Table C-3.

Table C-3. Bed Mobility Potential for Channel Segments of the Garcia WAU, 1997.

Channel Segment Name	Segment Number*	Observed D_{50} (mm)	Predicted D_{50} (mm)	D_{50} Ratio (pred./obs.)	Bed Mobility Potential
Garcia River	1	32	14	0.43	Low
Garcia River	2	28	11	0.39	Low
Garcia River	3	12	30	2.53	High
South Fork Garcia	84	38	33	0.87	Moderate
South Fork Garcia	86	19	56	2.95	High
South Fork Garcia	83	7	22	3.09	High
South Fork Garcia	85	12	37	3.05	High
Upper South Fork Garcia Tributary	101	28	38	1.35	Moderate
Fleming Creek	111	38	28	0.74	Low
Upper South Fork Garcia Tributary	102	38	58	1.52	Moderate
No Name Creek	53	38	46	1.21	Moderate
Rolling Brook	19	77	46	0.59	Low
Unnamed Trib. (Buehler)	149	77	75	0.97	Moderate
Unnamed to South Fork	90	38	38	1.00	Moderate
Unnamed (Buehler)	150	109	98	0.90	Moderate

* - see Stream Channel Module for channel segment locations.

One channel segment of the main stem Garcia River and all but one channel segment of the South Fork Garcia River have high bed mobility potential. The remainder of response reaches have low to moderate bed mobility potential. The high bed mobility potential site on the main stem of Garcia River has a slightly steeper slope than the rest of the main stem, thus it would be expected to have a coarser bed. Our observations show a finer bed (D_{50} = 11 mm), which given the steep slope of channel segment creates a high potential for the bed to scour or transport sediment to downstream reaches. The channel segments of the South Fork Garcia River have a finer bed then what is predicted for them. The channel of the South Fork is currently aggraded. The high sediment supply currently present in the South Fork's channel has resulted in a finer bed, which has higher mobility.

Bed mobility tends to be directly proportional to scour, and thus provides an index of scour potential of the bed (Version 3.0, Washington Forest Practices Board). Bed mobility also tends to be directly proportional to sediment supply, and may reflect large supplies of sediments supplied either naturally or from accelerated erosion in the watershed. Low bed mobility may indicate that the channel bed is inherently stable and not subject to scour; on the other hand, it can also mean the channel has been scoured of finer materials by large floods.

For the high mobility potential sites of the Garcia WAU the likelihood of greater scour can be beneficial. Aggraded channels could regain pool habitat, channel diversity and remove excess sediment. However, downstream effects may not be favorable because of increased sediment delivery. Also, the finer bed particles could be indicative of a larger problem of increased erosion delivered from forestry practices in the WAU. This could keep the bed particles fine and in a state of high mobility, creating greater sediment transport, impacting downstream areas. These areas need to be monitored over time to properly assess the significance of the bed mobility and particle sizes.

The remaining response reaches analyzed for bed mobility with moderate bed mobility potential are better interpreted in the Stream Channel Module and Sediment Budget Module of this report. The moderate potential sites could indicate the beginning of problems with scour potential or changes in sediment supply and transport. However, moderate mobility potential could indicate no problem or be indicative of a channel recovering from previous high sediment impacts. The interactions between sediment supply, present and past channel conditions, and bed mobility all must be considered. Stream channel segments which show low bed mobility potential are assumed to be armored and not influenced by small changes in peak discharges or sediment supply.

Literature Cited

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