Section C

Hydrology

Introduction

This section provides the available hydrologic data for the Noyo WAU and some analysis of the bed mobility in response reaches of the WAU. The Noyo 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 Noyo 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.

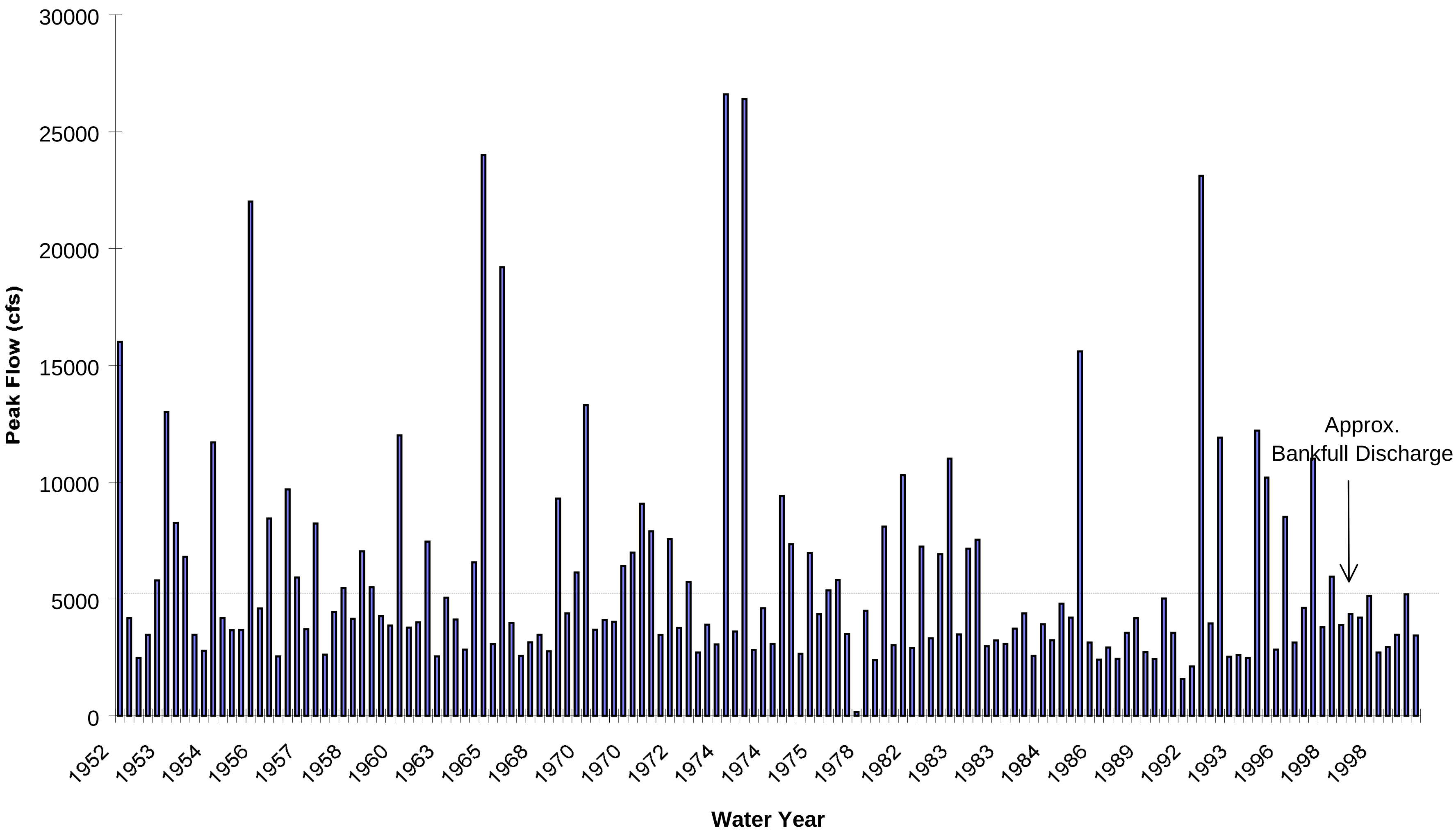
Peak Flows for the Noyo River

The peak flow information was collected by the United States Geological Survey (USGS) gage 11468500, Noyo River at Fort Bragg, from water year 1952-1998 (1998 is preliminary data). All peak flows greater than base flow (2100 cfs) are shown over the period of record (Figure C-1). To estimate the recurrence interval of the flood events of the Noyo River the USGS annual peak flow series was used. The time frame of the peak flow information collected was from 1951-1998. An extreme value type I distribution (Gumbel, 1958) was fitted to the data to calculate the recurrence interval. Table C-1 shows the estimated recurrence interval for peak discharges in the basin.

Table C-1. Flood Recurrence for Peak Flows of the Noyo River.

Recurrence Interval (years)	Peak Discharge (cfs)
1.1	1329
2	7491
5	13120
10	16850
25	21550
50	25050
100	28500

Figure C-1. High Peak Flows (above base flow) for Noyo River, 1952-1998



Using the peak flow record from 1952-1998, the flood of record is 1974 (26,600 cfs) considered to be greater than a 50 year event for the Noyo River (Table C-1). In the last decade alone there has been 1 storm around a 30-40 year recurrence (1993), 1 storm greater than a 5 year recurrence (1995) and 6 storms greater than bankfull discharge (approx. >2 yr. recurrence). This indicates a high number of extreme storms occurring within the last decade. The high occurrence of these extreme storms in the last decade suggests that the Noyo WAU has been subjected to stressful hydrologic conditions, possibly creating a greater incidence of landslides, road failures or surface erosion than previous decades.

Throughout the last 40-50 years in the Noyo WAU there have been numerous large flood events (>2 year recurrence, Figure 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.

Hydrologic Change due to Forest Management

Hydrologic change of the size of peak flows, the discharge at low flows, or annual water yield can be affected by forest harvesting. Forest harvesting influences these parameters by: changes in evapotranspiration from removal of vegetation, increased surface run-off from compacted soil surfaces of skid trails and roads, changes in snow accumulation from openings created by vegetation removal, and loss of interception from vegetation removal. The extent or magnitude of the hydrologic change is influenced by the parameter changed, and the physical and geographical characteristics of the watershed where the changes occur.

Change in size of peak flows, the highest instantaneous discharge of a hydrologic event, from forest harvest has long been a source of misunderstanding and public concern. The misunderstanding comes from the belief that vegetation removal increases the amount of water available for stream flow thus the peak flow must be increased as well. The first premise of this statement is correct. Annual water yield has been found to increase following forest harvest (Harr et. al., 1979; Keppeler and Ziemer, 1990; Rothacher, 1970). However, the annual water yield increase does not equate to an increase in the peak flow.

Current research shows possible cumulative effects from increased peak flows from forest harvest in rain-on-snow dominated areas (e.g. 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; Ziemer, 1998). Typically the largest peak flows, in rain dominated watersheds of coastal California, occur during the winter months when soil moisture is at its highest. Evapotranspiration levels during the winter are at the lowest and the intervals between storms are short. Therefore during the winter the water available for stream flow is not strongly affected by vegetation differences and the largest peak flows are not increased. Research conducted in watersheds which have had forest harvesting typically show increased peak flows in the fall, when soil water storage is depleted, but do not discern peak flow increases in the largest winter floods (Ziemer, 1981; Wright et. al., 1990; Rice et. al., 1979; Rothacher, 1973). This is significant when considering that the peak flows of interest for road design, channel formation, and sediment transport are the events with a 50-year recurrence interval, the largest flow events.

Water yield is typically increased following forest harvest. This increase is typically short lived, effects diminish after 5 years (Keppeler and Ziemer, 1990), due to re-growth of vegetation following harvest. Unfortunately the increased water yield is not of great utility to water managers or fishery concerns. This is because the timing of the augmented yield is not when the demand for greater water yield is needed, in the summertime. Secondly, that portion of the flow increase which did increase during the summer diminished rapidly following forest harvest, due to new vegetation demands (Keppeler and Ziemer, 1990).

Low flow is similar to water yield in that summer low flows tend to increase following forest harvest but diminish within 5 years (Keppeler and Ziemer, 1990), due to re-growth of vegetation following harvest. A slight decrease in low flows is observed after 5 years due to the new water demands of the regenerated forest following forest harvest (Keppeler and Ziemer, 1990). The impact of changes of low flows to summertime stream ecology are not known. However, it might be assumed that increased low flow in the summer provides more water for summer fish and macroinvertebrate use and stream temperature reductions. While a decrease in summer low flows would lower the amount of fish and macroinvertebrate habitat and facilitate higher stream temperatures. However, in both scenarios the summer low flow would need to be increased or decreased substantially, something which does not appear to occur.

The Mendocino Redwood Company (MRC) ownership in northern California does not receive any significant snow accumulations which could contribute to rain-on-snow events. The hydrology of the watersheds in the MRC ownership will always be a consideration to the company especially during intensive watershed analysis. However, due to the lack of rain-on-snow event occurence on the MRC ownership no standards for hydrologic change due to forest harvest are considered necessary.

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 1.5, moderate bed mobility potential was assigned to ratios greater than 1 and less than 1.5, and low bed mobility potential was assigned to ratios less than or equal to 1.

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. The bed mobility was calculated at permanent stream cross section survey locations. The D_{50} value calculated from this equation is compared to the actual observed D_{50} of the cross for determination of bed mobility potential. The results of the bed mobility potential calculations are presented in Table C-2.

Table C-2. Bed Mobility Potential for Channel Segments of the Noyo WAU.

Stream Name	Segment ID# (cross sec.)	Observed D50 (mm)	Predicted D50 (mm)	Predicted/ Observed Ratio	Bed Mobility Potential
Noyo	1(1)	45	3	0.07	Low
Noyo	1(2)	22	4	0.19	Low
Noyo	1(3)	51	5	0.09	Low
Noyo	1(4)	48	4	0.09	Low
NF Noyo	159(1)	41	14	0.35	Low
NF Noyo	159(2)	34	10	0.29	Low
NF Noyo	159(3)	57	14	0.25	Low
Marble Gulch	23(1)	55	21	0.37	Low
Marble Gulch	23(2)	44	15	0.35	Low
Marble Gulch	23(3)	52	14	0.27	Low
Marble Gulch	23(4)	49	24	0.49	Low
Middle Fork NF Noyo	153-2(1)	45	19	0.42	Low
Middle Fork NF Noyo	153-2(2)	35	24	0.68	Low
Middle Fork NF Noyo	153-2(3)	35	22	0.63	Low
Hayworth Creek	104(1)	53	20	0.37	Low
Hayworth Creek	104(2)	53	21	0.39	Low
Hayworth Creek	104(3)	60	23	0.38	Low
Hayworth Creek	106(1)	90	10	0.11	Low
Hayworth Creek	106(2)	44	13	0.30	Low
Hayworth Creek	106(3)	92	14	0.15	Low
Hayworth Creek	118(1)	42	20	0.47	Low
Hayworth Creek	118(2)	86	35	0.40	Low
Hayworth Creek	118(3)	47	28	0.60	Low
Hayworth Creek	118(4)	58	26	0.45	Low

see Section E - Stream Channel Condition module for channel segment locations.

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.

All of the sampled reaches of the Noyo WAU have low bed mobility potential and are assumed to be well armored and not influenced by small changes in peak discharges or sediment supply. The low potential sites could still have problems with scour potential or changes in sediment supply and transport. Also low bed mobility might occasionally occur in 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.

Literature Cited

Dietrich, B. 1997. Personal communication about predicted grain size mobility and critical shear stress.

Gumbel, E.J. 1958. Statistics of extremes. Columbia University Press, New York.

Harr, D. 1981. Some characteristics and consequences of snowmelt during rainfall in western Oregon. Journal of Hydrology, 53: 277-304.

Harr, D., R.L. Fredriksen, and J. Rothacher. 1979. Changes in streamflow following timber harvest in southwestern Oregon. United States Forest Service Res. Pap. PNW-249. 22 p.

Keppeler, E. and R. Ziemer. 1990. Logging effects on streamflow: water yield and summer flows at Caspar Creek in northwestern California. Water Resources Research, 26(7) 1669-1679.

Phillip Williams and Associates, Ltd. 1996. Garcia River gravel management plan. Prepared for Mendocino County Water Agency, Ukiah, California.

Rice, R., F. Tilley, and P. Datzman. 1979. A watershed's response to logging and roads: South Fork of Caspar Creek, California. United States Forest Service Res. Pap. PSW-146.

Rothacher, J. 1970. Increase of water yield following clearcut logging in the Pacific Northwest. Water Resources Research, 6(2) 653-658.

Washington Forest Practice Board. 1995. Standard methodology for conducting watershed analysis. Version 3.0. WA-DNR Seattle, WA.

Wright, K.A., K. Sendek, R. Rice, and R. Thomas. 1990. Logging effects on streamflow: storm runoff at Caspar Creek in northwestern California. Water Resources Research, 26(7) 1657-1667.

Ziemer, R. 1981. Storm flow response to road building and partial cutting in small streams of northern California. Water Resources Research, 17(4) 907-917.

Ziemer, R. 1998. Flooding and stormflows. In: Proceedings of the Conference on Coastal Watersheds: The Caspar Creek Story. USDA, United States Forest Service Pacific Southwest Research Station Gen. Tech. Rep. PSW-GTR-168. pp 15-24.