How Much Debris Down the Drainage?

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After logging and burning in 1955, debris in this western Oregon stream appeared to be stabilized . . .

until . . .

a single severe storm in December 1957 sluiced the channel depositing the debris far downstream.

By JACK ROTHACHER,
Pacific Northwest Forest and Range Experiment Station,
U. S. Forest Service, U. S. Department of Agriculture,
Portland, Ore.

Logging debris in stream channels ›s worried many people in recent ars. Although undisturbed streams ›ften contain considerable natural debris, it has accumulated over a long period of time and most of it is well stabilized. In contrast, residues from logging operations are added in a few months during low streamflow and do not become stabilized before peak flows occur during the following winter.

This bothersome aftermath of logging can be the source of log jams that not only prevent fish migration but often break up during high water and move downstream in a churning, destructive mass of logs, rocks, and mud. It is frequently recommended that logging debris be kept out of channels in which winter peak flows are apt to move the accumulated material.

Immediately, the question arises, "What size stream channel will carry sufficient flow during high water to cause trouble?" There is no simple answer. It depends on many things like amount and intensity of rainfall, size and shape of the drainage area contributing runoff, gradient of the ›hannel and roughness of the stream-1. During summer and fall when eamflow is reduced to a deceptive ›rickle, it may appear safe to leave logging refuse in a channel that in winter carries a destructive torrent.

How Much Rain?

A study of our flood storms can give us one clue to the amount of winter runoff carried by typical channels.

In the Douglas fir region, most timber is harvested in the mountainous country from the Cascade Range west to the Pacific Ocean, at elevations where precipitation approaches 100 inches annually. Flood-producing storms are generally of several days' duration, with only moderate-to-low intensities. Though intensity rarely exceeds one-half to three-quarters of an inch per hour, it is not uncommon to experience storms that produce six inches or more per day.

Several storms of this size have occurred on the H. J. Andrews Experimental Forest near Blue River, Ore., during a relatively brief period of six years. Two storms have been recorded totalling over six inches of rain per day, two over five inches, and two more over four inches. These heavy rains are generally associated with a series of storms that bring precipitation lasting from several days to a week or more.

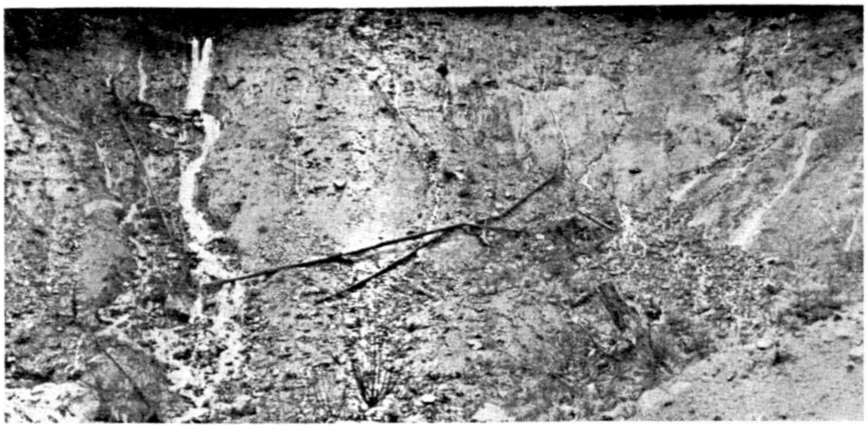
How Much Runoff?

Foresters and loggers who have lived in this heavy rainfall country for any length of time know how water literally squirts out of the road cuts from top to bottom after prolonged rains. All depressions, small and large, have standing water and, although there may be no general surface runoff under virgin forest conditions, temporary streams flow in every possible channel.

When this is the case, soils become saturated and water drains out of watersheds almost as fast as it is received as rainfall. A good example of this is shown by records of test watersheds on the Andrews Experimental Forest.

During the period December 18-20, 1957, a total of 12.51 inches of rain was recorded, with a maximum of well over six inches on the 19th (one-fourth inch per hour). An intensity of one inch per hour is about equal to a streamflow of one cubic foot per second (cfs) per acre. Thus, we would expect that one-fourth inch per hour (six inches per day) would yield a flow of almost ¼ cfs per acre if runoff equalled the rate of rainfall input.

The test watersheds gave a precise check on the amount of runoff actually produced by this storm. In one watershed, a 239-acre drainage covered with old-growth timber, the six-inch storm produced a peak flow averaging 48 cfs for several hours during the following day. For a watershed of this size, a maximum runoff of 48 cfs approximates 1/5 cfs per acre, which indicates that water flowed



AFTER PROLONGED RAINS, water literally squirts out of road cuts from top to bottom.

out of the watershed at about 80% of the rate at which rainfall was received.

It isn't unreasonable to anticipate storms producing runoff of 1/5 cfs or more per acre. The storm of December 19 is by no means the heaviest on record in the region. In fact, 12 to 14 inches of precipitation have fallen in 24 hours more than once in the Coast Range. And if snow melt adds to the flow of streams during these heavy rains, the rate of runoff can equal or exceed the intensity of rainfall.

What Size Channel?

We must determine the sizes of channels needed to carry various amounts of peak runoff flow. We can get a pretty good idea of channel size needed by calculating the cross sectional area of a stream at peak flow. To do this, we can employ a basic formula in hydraulics that says:

$$\text{Cross section area (sq.ft.)} = \frac{\text{Discharge (cfs)}}{\text{Velocity (ft. per sec.)}}$$

Since we already have an estimate of runoff during peak flows, it should be a simple matter to determine the channel size needed if we know the velocity of the flow. Here is where we run into a complication.

Average velocities are difficult to determine in natural streams where large boulders, logs, pools, and small waterfalls cause variation. In debris-filled streams we also have some damming causing small pools in which the stream slows down appreciably. Velocity then increases rapidly as the stream drops to the next pool. In well-defined and relatively clean channels, velocity increases as the water level rises, but such is not the case in debris-choked streams.

For purposes of illustration, we might assume a velocity of five feet per second (fps). By using this value in the formula and the figure we have already obtained for discharge (area x 1/5 cfs per acre), we can determine the cross section area of the channel needed. For example, let's take a 40-acre drainage. On the basis of experience and our set of conditions, we could expect a peak runoff of 8 cfs (40 x 1/5). Using the formula, we get:

$$\text{Area (sq. ft.)} = \frac{\text{Discharge (8 cfs)}}{\text{Velocity (5 fps)}} = 1.6 \text{ sq. ft.}$$

The following tabulation—based on assumptions of ¼-inch-per-hour rainfall intensity for long periods, 1/5-cfs-per-acre maximum streamflow, and a velocity of five feet per second—gives flow and cross section area of stream channels for a number of drainage sizes:

Area of drainage (Acres)	cfs	Cross section of stream (Square feet)
40	8	1.6
50	10	2
100	20	4
200	40	8
400	80	16
640	128	25.6

Cross Section Measurements

The cross section area of a stream can be expressed in various dimensions. Imagining a rectangular cross section (most stream sections are roughly parabolic), a stream with 1.6 square feet of cross section area might be 2 feet wide and 10 inches deep. Perhaps in most drainages up to 40 acres, which cannot be considered large, it might be considered safe to leave debris in the channel, following the general argument that large logs and debris in the streambed catch and hold silt.

From a square-mile drainage, we might imagine a stream eight feet wide and a little over three feet deep. That much water certainly would float and move logging debris of the size that normally accumulates in streambeds. Debris in these relatively small drainages may not move for several years, but when it does it builds a jam. The increased weight of water may eventually break the jam and cause damage downstream from lost fills, culverts, bridges, and undercut roads, and will rouse the ire of farmers who have to burn or remove the logging debris from their fields before they can plow the next spring—or the steelhead angler who finds his favorite fishing holes plugged with debris.

What is the Answer?

All this adds up to the conclusion that we have no precise answer to the question: "Where should logging debris be removed from streams?" On the basis of theoretical considerations, we can estimate the maximum amounts of water that a given watershed is capable of producing and depths that can be expected in the channel during high flow. As we learn more we can better estimate these maximum flows and how large a stream it takes to move logging leftovers.

One thing seems clear: We can be badly fooled by an innocent-looking summer trickle. If the stream is fed by a watershed larger than 40 acres, the wisest course would be to keep logs and chunks out of the channel, if possible, or remove them before the next winter flood flows do the job and maybe remove a road fill or bridge.

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