WORKING PAPER NO. 10

COLUMBIA RIVER BASIN PROJECT
For Water Supply and Water Quality Management

SEDIMENT PRODUCTION RATING
WILLAMETTE BASIN, OREGON

Date: January 1, 1962	DISTRIBUTION
Prepared by WEB	Project Staff ____
Reviewed by ______	Cooperating Agencies ____
Approved by ______	General ____

U. S. DEPARTMENT OF HEALTH, EDUCATION AND WELFARE
Public Health Service
Region IX

Division of Water Supply and Pollution Control
570 Pittock Block
Portland 5, Oregon

This working paper contains preliminary data and information primarily intended for internal use by the Columbia River Basin Project staff and cooperating agencies. The material presented in this paper has not been fully evaluated and should not be considered as final.

SEDIMENT PRODUCTION RATING
WILLAMETTE BASIN
OREGON

INTRODUCTION

Based on the experience gained in rating the Umpqua Basin streams, the work was extended north into the adjacent Willamette Basin on areas of similar geology, climate, cover, and land use. Here there is less available information from sediment sampling, and the rating estimates are necessarily subjective. Some earlier estimates are available from studies by the U. S. Forest Service Flood Control Surveys, the USDA Willamette Basin Agricultural Program report, and the Corps of Engineers.

SUMMARY AND CONCLUSIONS

The high mountain portions of the basin occupying highly permeable lava formations not subjected to extensive development and use have the lowest sediment production rating. This is characteristic of the headwaters of the McKenzie, Santiam, and Clackamas Rivers draining the Cascades on the east side of the basin.

For entire watersheds, the Tualatin Valley at the extreme north end of the basin, the Long Tom, Luckiamute and Mary's Rivers draining the Coast Ranges, and the Calapooya River draining the Cascade foothills have the lowest ratings.

The Molalla River watershed has the highest rating, due to recent extensive road building and the channel disturbance caused by last year's flood.

Over-all rating for the entire Willamette Basin is "moderate".

A prime source of sediment is bankcaving in the deep alluvial soils along the main watercourses in the valley. The several large multipurpose dams built on all the major tributaries - and on several of the minor ones - effectively stop large volume sediment movement from the upper parts of the basin. They also regulate flow and thus tend to reduce the amount of high flow season bankcutting in the lower watercourses, though the competence or sediment-carrying capacity of the regulated streams may be increased.

DESCRIPTION OF THE BASIN

The Willamette River Basin is roughly rectangular in shape, about 80 miles wide east to west, and 150 miles long north to south. Total area is 11,200 square miles. The basin lies between the Cascade Range on the east, from which flow the major tributaries, and the Coast Range on the west. The southern rim of the watershed abuts the Umpqua Basin. The Willamette River, formed by the confluence of the Coast Fork, the Middle

Fork, and the McKenzie River in the vicinity of Eugene, flows north in a broad low valley to its junction with the Columbia at Portland.

The rugged Cascade Mountains, composed primarily of igneous rocks, occupy nearly half the basin area. Major streams from the Cascades feeding the Willamette River are the Middle Fork, the McKenzie, the Santiam and the Clackamas. Lesser tributaries feeding in from the Cascade foothills include the Mohawk, the Calapooya, and the Molalla. Elevations in the Cascades range up to 10,000 feet at Mt. Jefferson and the Three Sisters. The valley is filled with debris from ancient glaciers of the Cascades, and covered with recent alluvium brought down by the Cascade tributaries.

The less rugged Coast Range on the west is composed largely of sedimentary rocks, and occupies about one-eighth of the basin area. Elevations range up to 4,000 feet on Mary's Peak in the center of the western rim. Tributaries feeding from the Coast Range include the Long Tom, Mary's River, the Luckiamute, Rickreall Creek, the Yamhill, and the Tualatin River.

There are wide variations in soil conditions, from the unstable soils developed in the mountains on old volcanic mudflows, to the stable soils developed on the valley floor alluvium. Major soil groups include recent alluvial or floodplain soils, old valley fill soils, residual hill and mountain soils developed from sedimentary rocks, and residual hill and mountain soils developed from igneous rocks.

Cultivated cropland, both irrigated and nonirrigated, occupies about 1,400,000 acres on the valley floors, benches, and lower foothills. (1) Rangeland, with brush and weed and grass cover, occupies about 550,000 acres in a belt around the edges of the valleys. Forest, covering 70 per cent of the basin, occupies the foothills and mountains; 85 per cent of the forest is Douglas-fir type, with subalpine mixt conifer type at the higher elevations, and with hardwoods along the streams and on some of the lower hills. The forest zone includes the important tributary watersheds that feed the Willamette River. Other land in the basin amounts to about 280,000 acres; it includes urban areas, roads, and rocky barrens. Water surface in streams and lakes totals about 35,000 acres within the basin.

The climate is temperate, with dry warm summers and mild wet winters. In the mountains the bulk of the precipitation is snow; average annual total is about 80 inches. Valley areas receive average amounts from 35 to 45 inches; nearly all as rain. Rainfall rates as great as an inch in one hour are rare.

Streamflow is variable from season to season and from tributary to tributary. Streams draining the high Cascades show the greatest yield, while those draining the inside of the Coast Range show the lowest yield. Total flow of the Willamette River at its mouth is estimated to average 22,000,000 acre-feet annually. Peak winter flow for the high month equals one-fifth of the average annual, while late summer minimum flow is but one-eightieth of the average annual. Tributary streams show similar ranges. Half the time the month of high flow is December or January; for low flow, September. Annual variation around the average ranges from a low of about 60 per cent to a high of more than 150 per cent. The bulk of the streamflow is derived from the forested mountain watersheds; the McKenzie and Santiam Rivers contribute more than a third of the total yield though they drain less than a quarter of the basin. Major floods have been experienced about once in eight years on the average; present flood hazard is far less because of control afforded by dams on principal tributaries.

Ownership of basin lands is 38 per cent Federal (mainly National Forest), 2 per cent State, County and Municipal, and 60 per cent private. Nearly all of the public land and a bit more than half of the private is in forest. It is used for lumber production and recreation and some grazing. Private land includes three-fourths of the range and all of the cropland.

Land use has influenced sediment production. Development of access roads, logging, heavy grazing use, and cultivation - particularly with clean-tilled winter fallow - all have disturbed the soil and led to increased erosion. Nevertheless, indications are that more than half the total sediment movement in the Willamette River has come from bankcutting (2) in the lower courses of the streams. Dams in the middle and upper channels of many of the tributaries act as effective traps for sediment.

RELATED STUDIES BY OTHER AGENCIES

Flaxman and High (3), reporting on studies by the Forest Service and the Corps of Engineers, noted sedimentation rates ranging from 53 to 286 tons per square mile in the major streams, up to 800 tons per square mile in the minor tributaries. They cited also a Soil Conservation Service study of the record erosion in February, 1949, showing maximum soil losses up to 60,000 tons per square mile and assuming that 80 per cent of the soil loss became stream sediment.

Lowest rates of average annual sediment production were found in the Coyote Creek, Long Tom River and the Tualatin River watersheds. The McKenzie River watershed was almost as low. Highest rate was found in the Luckiamute River [1/] watershed, more than twice as high as any others reported, and six times as high as the lowest.

1/ Three years suspended load sampling at a valley station; average 780 tons per square mile per year including the record year 1949. Bank-caving and winter erosion of clean-tilled fields may be largely responsible; the present survey of the watershed showed conditions to be good and the soils well stabilized.

Sixteen years of dredging in Portland Harbor at the mouth of the Willamette removed 11,800,000 tons of sediment. This amounts to 66 tons per year per square mile of contributing watershed.

SURVEY METHODS

The field survey was made by observations while traveling through the country, with particular attention to stream channel conditions. As many watershed slopes and stream channels were checked as could be conveniently reached by car. Areas were rated (as to sediment production) "very low", "low", "moderate", "high", or "very high", depending on signs of surface erosion on the watershed, landslides and slumps, disturbance by road-building, etc., and on the apparent stability of the channels and the amount and kind of sediment in the channels. For example, a stable channel was assumed to be one that had a bottom shingled with rocks supporting a wide variety of plant and animal life - evidence of little or no scour - and banks protected by well-established brush and tree cover; this was taken to indicate low sedimentation.

Field notes were made on subwatershed maps. The notes cited specific problem areas and causes, as well as classes of sediment production rating. In the office these notes were checked against available information from other agencies, and the ratings of the areas sampled were extrapolated by checking aerial photographs to other areas of similar cover and topography and appearance.

Weighting the sediment production rating classes by applicable areas as determined from the field notes and the aerial photos gave a weighted average rating class for each tributary watershed. These in turn were combined into area-weighted averages to determine the average sediment production rating for the whole Willamette Basin.

SURVEY FINDINGS

Timber access roads, dam construction, burned area erosion, landslips in old volcanic mudflow ~~windflow~~ formations, and flood scour in channels are the principal sources of sediment in the upper watersheds. Bankcaving and erosion of clean-cultivated farmland are also important sediment sources along the lower reaches of the streams. In a few places logging operations were directly responsible for increased sedimentation, but any adverse effects of logging generally were overshadowed by the effects of access road construction. These were at their worst on Willamette National Forest lands in the Blue River watershed tributary to the McKenzie River.

Effects of the Hehe burn in the Fall Creek watershed and the Sardine Creek burn in the North Santiam watershed are still noticeable. Quantities of unstabilized debris in the stream channels provide a continuing sedimentation hazard, although cover vegetation is coming back on the watershed slopes.

Dam construction and road relocation on the Hills Creek, Cougar, Green Peter, and Carmen-Smith projects are causing massive soil disturbance and a large immediate sedimentation hazard. This type of soil disturbance is just beginning on the Foster and Wiley Creek dam projects on the South Santiam River. This should be greatly reduced on completion of the projects.

Landslip effects are particularly noticeable in the Clackamas drainage and in parts of the North Santiam drainage. In a few cases they are aggravated by road construction, but in many instances the slumping is directly into stream channels from undisturbed slopes. Sheep Creek and other small adjacent drainages at the head of the South Santiam are underlain by highly unstable mudflow and cinder deposits that are constantly in motion, slumping into channels and providing a heavy sediment load.

Scouring of channels by the floods of the winter 1960-61 was particularly severe in the Molalla drainage and in one or two small tributaries to the North Santiam River. The effects of the 1955 flood in Salt Creek are still obvious, though clean-up work and slow natural stabilization processes have resulted in considerable improvement.

On Thomas Creek and Crabtree Creek in Linn County tributary to the South Santiam River, improvement work for flood control done this year will temporarily increase sediment yields. River gravels were dragged out of the stream channel and used to build up the banks to avoid further bank-cutting and to afford freer flow. Fine material disturbed by the operation will be carried out by high flows this winter, but the channels should be stabilized fairly well afterward. In one place the work was done on the inside of a curve, but not on the outside; the vertical channel bank on the outside is still subject to cutting and caving at times of high flow. Some harm to fisheries resulted from the timing of the work, as eggs in the gravel were dug up. Spawning beds, however, are still available to anadromous fish.

The Calapooya drainage was given a low rating because of the excellent condition of the streambed gravels in the middle reaches and the lack of any signs of serious soil disturbance in the upper watershed. Even the excessive disturbance of the channel below Holley by machinery removing rock and gravel for highway construction created only minimum turbidity. The streambed still appears to be in good shape for spawning steelhead to use.

The Tualatin River draining the hills west of Portland was also rated "low", surprisingly enough, for its watershed occupies an intensively developed area. The topography is not too rough, the climate is moderate, and the soils quite stable. Soil movement is limited despite extensive suburban development, intensive agriculture, and logging.

Ratings applied to the various subwatersheds of the Willamette Basin are as follows:

Watershed	Sediment Production Rating
Tualatin River	low
Yamhill River	low to moderate
Luckiamute-Mary's River	low
Long Tom River	low
Coast Fork Willamette River	low to moderate
Middle Fork Willamette River	low 1/
Mohawk-McKenzie River	moderate to high 1/
Calapooya River	low
Santiam River	moderate 1/
Molalla-Pudding River	high
Clackamas River	low to moderate

1/ Temporary disturbance from dam construction very high, but other dams serve as sediment traps below.

Over-all sediment production rating for the whole Willamette Basin would be "moderate", despite the "low" rating given the great bulk of the area. Since most of the larger tributary streams are dammed at from one to several places, a large part of the rating is attributable to the rather extensive bankcaving through the main valley.

Sediment production ratings may be interpreted as follows:

Rating Class	Average Sediment Load in ppm of
S Slight or very low	under 50
L Low	50 to 150
M Moderate	150 to 500
H High	500 to 1500
VH Very high	1500 plus

DISCUSSION

Though there are specific problem areas in the Willamette Basin beyond the few already cited, the types of problem seem more important. Of most widespread occurrence and greatest significance, and probably the most easily improved is the sediment contribution from timber access road construction. If present practices continue as the timber harvest proceeds, sediment production will increase markedly. However, application of present knowledge to avoid and control movement of soil into channels could bring about a reduction of sedimentation from the present road network and prevent any large future increase as the road network expands. The same statement applies to logging operations also. In neither case is there any need to suffer the amount of sedimentation damage now occurring; it can be prevented or minimized.

Flood effects, tremendous as they are when they occur, are felt sufficiently infrequently to have any great over-all effect. The same is true for the effects of fire. Both are occasionally locally severe, with effects that taper off in a few years. Fire protection holds burned area down, and channel cleanup reduces the sedimentation hazard in flood-ravaged channels. Dams recently built or now under construction will modify flood flows in the lower tributary stream courses and in the Willamette River and reduce bankcutting from flood scour. At the same time they will trap much of the sediment moving down into them.

Sedimentation from mudflow and similar unstable soil and rock formations will continue to occur. However, its effects can be reduced by avoiding unstable areas in road building. Soils mapping on forest areas is proceeding, and before long the unstable areas will be marked out so that they can be located and avoided much of the time.

Preservation of stable channel conditions and reduction of excessive turbidity and sedimentation is desirable to maintain fish habitats as well as to maintain water quality. According to Cordone and Kelly (4), "...even small amounts of sediment may be harmful (and) may well result in gradual destruction of the majority of our streams...the bulk of the damage is unnecessary. It can be prevented with known land use methods, often with little or no additional expense. Much of it is the result of carelessness."

RECOMMENDATIONS FOR IMPROVEMENT

On public lands, major improvement in reducing sediment production will follow implementation by the land-managing agencies of their excellent policy statements for protection of water resources. Failures to live up to policy are due to one-sided pressures from a part of the public, to lack of interest in and understanding of watershed and stream protection requirements, and to inadequate job supervision. A continuing education program both for the public - to equalize pressures - and for agency personnel - to develop needed skills and interest - is strongly indicated. Much tighter supervision of on-the-ground jobs at the lowest levels, and of contracting operators, to ensure compliance with policy requirements is also necessary on a continuing basis.

Physical measures applicable to any forest land for protection or rehabilitation of watersheds are well known and well documented, though unfortunately not well enough applied. Professional society (5), inter-agency group (6), State (7), and Federal agency (8), (9) publications, as well as Federal agency operating manuals set forth clearly what situations are harmful and what measures to apply. The publications listed are only a few of many, but they are readily available here and now. Measures for agricultural and range land are also well known but not everywhere applied. Any County Agent can furnish information on agricultural practice to prevent erosion and conserve soil and water.

Highway planning and construction agencies, both State and Federal, need to take an interest in the effects of their work on water resources, and to pay attention to State law which should govern their operations. Protection for watersheds and water resources must be built into the highway system, starting with planning and including adequate financing. The common practices of diverting road drainage directly into streams, dumping excess cut materials into channels or where it can erode into channels, constricting and changing water courses, all without regard to downstream effects on water or to effects on fisheries and recreation, are contrary to State law and are economical only to the immediate highway construction job.

Specifically, in all work on the land it is necessary to avoid undue soil disturbance or denudation, to avoid dumping debris of any kind into streams, to keep oil and pesticides and fertilizers from draining into streams, to avoid working in stream channels or along channel banks with heavy equipment, and to preserve the natural conditions of the riparian habitat as far as possible. In roadbuilding this means laying out locations that involve the least cut and fill, the least direct disturbance of channels, and the least opportunity for rapid drainage into channels. In the timber harvest this means high-lead cable logging uphill rather than tractor logging downhill, leaving protective strips along streams, avoiding yarding across streams, location of landings away from streams, clean-up of slash that does get into channels, and application of soil stabilization measures such as seeding temporary cover crops on disturbed soil or installing drainage diversions in skidtrails and temporary roads. In agriculture it means cultivation along the contour, sodding to stabilize drainage ways, cover crops for fields in winter fallow or underneath orchards, and care in the application of chemicals for whatever purpose. In grazing it means keeping livestock numbers at a level consistent with maintenance of sufficiently dense vegetation cover to protect the soil and with maintenance of soil tilth and infiltration rates.

Dam construction necessarily involves extensive channel disturbance and temporary increases in stream turbidity and sedimentation regardless of the season in which the work is done. After construction, the dams effectively trap and stop sedimentation, and the control of streamflow they afford is beneficial in reducing bankcutting downstream. Other channel work may cause much less disturbance if done during the low water season - sometimes the only season in which it can be done - but may harm the fisheries resource if spawning beds are disturbed during the August to January period when eggs and fry are still in the stream bottom gravels. Such work should be done as early as possible in June or July.

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