DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

Prepared in cooperation with the
DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT

Miscellaneous Field Studies
Map MF-515(Sheet 3 of 3)

PROCESS OF ACCELERATED EROSION IN THE SANTA CRUZ MOUNTAINS UPLANDS EROSIONAL PROVINCE

The drainage basins in the Santa Cruz Mountains uplands lie within a landscape that offers its primary resistance to accelerated erosion by supporting a protective vegetal covering. As this covering is removed either by natural processes or by the activities of man, friable colluvium and poorly consolidated bedrock are exposed on steep slopes to annually heavy rainfall. Where bedrock is exposed on channel banks, in roadcuts, and as a result of landsliding, much of it continues to disintegrate into transportable sediments. On steeper slopes, the regeneration of soil and forest cover is therefore hindered. Saturation of exposed slopes by rainfall activates further sliding and disintegration of rock, and runoff transports loose material downslope into stream channels.

As sediment reaches the stream channels, the channels must necessarily make hydraulic adjustments to accommodate the quantity and size of the sediment. An input of sediment to a given reach of channel decreases the extant capacity of the channel to carry a given flow; thus, the stream must either erode away the newly deposited sediment, enlarge its channel by eroding the banks, or overflow the banks in order to sustain a given flow rate. In a typical basin, each of these processes is occurring at different points along the stream, and is abetted by blockade of the channel by logs and brush. The responses of stream channels to these discontinuities are changes in slope, capacity, and form that will tend to transfer downstream both detrital inputs and their associated hydraulic effects. Accelerated erosion, then, affects not only a localized area, but also major segments of the stream system.

The geomorphic evidences for accelerated erosion persist throughout the Santa Cruz Mountains uplands province; however, precise data on rates of sediment yield are lacking. Logging, roadbuilding, and other activities of man that change the natural sediment system predate the beginning of systematic erosion measurement practices by more than a century. During this time, series of landscape alteration and erosion have occurred in virtually all parts of the province save some parks and scattered small drainage basins. However, the existing terrain reflects its recent geomorphic history and the nature of human activities with respect to erosion control. Where poorer practices have occurred, streams are incised into the valley floor alluvium. They are characterized by a deep, rectangular cross section having freshly exposed banks and a step-like profile brought about by the accumulation of debris behind log jams or other obstructions such as sediment deposits from landslides. In general, a greater amount of sediment reaches the stream channel than the stream can transport under normal conditions, and the channel assumes a localized unstable alluvial form. This form of channel, as opposed to a bedrock-controlled channel, is free to adjust its dimensions, shape, pattern, and gradient--often with adverse effects.

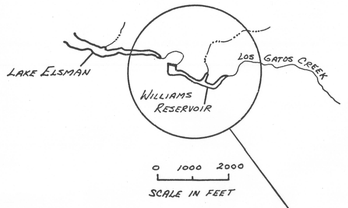
The natural drainage system is partly characterized by bedrock-controlled channels that are so confined between outcrops of rock that the bedrock material forming their bed and banks determines the morphology of the channel (Schumm, 1971, p. 4-22). Other natural channels are stable alluvial channels so adjusted to their natural setting that they accommodate normal water and sediment discharge without major alterations of the type described above. The stable alluvial channels are characterized by shallow, rectangular or U-shaped cross sections having moderately sloping, vegetated banks and a moderate to gentle gradient on an even profile. Sediment-transport rates are very low compared to those of unstable channels. Sediment yield from small, unaltered basins may, in fact, be negligible (except during periods of excessive flooding) principally because of the protection afforded by the natural vegetal covering.

SEDIMENT YIELD IN A BURNED AREA[1]

The effect of the removal of vegetation from the landscape by fire is demonstrated by excessive sediment yields measured for a fire-scarred basin on upper Los Gatos Creek. A severe fire in July 1961 burned over about 80 percent of a 5.25-square-mile drainage basin, destroying much of the vegetation. Subsequent erosion of the basin led to the deposition of about 104,000 tons of sediment in Williams Reservoir between 1961 and 1971, and the movement of much of this sediment was probably initiated during intense storms in October 1962 and January 1963. Trees growing on deltaic deposits that were not present before the fire were found to be 9 years old in 1971; thus, these deposits were likely formed soon after the fires. The expected rate of sediment deposition in the reservoir with vegetation in the drainage basin intact was calculated to be 47,000 to 76,000 tons during 1961-71; therefore, the increase in sediment deposition attributable to fire effects was 28,000 to 57,000 tons or about 530 to 1,100 tons per square mile per year.

The reservoir was constructed in 1895 and, according to R. M. Ritchey (oral commun., 1971), chief engineer of the San Jose Water Works, the reservoir was drained each summer prior to the fire in 1961. This practice apparently allowed the passage downstream of yearly accumulated sediments so that the reservoir capacity was not significantly diminished through the years. However, the rapid deposition of sediment subsequent to the fire obstructed the reservoir outlet gate, precluding the annual drainage, and the reservoir capacity was reduced by about 33 percent by 1971.

[1]Data and interpretations from Ritter and Brown, 1972.



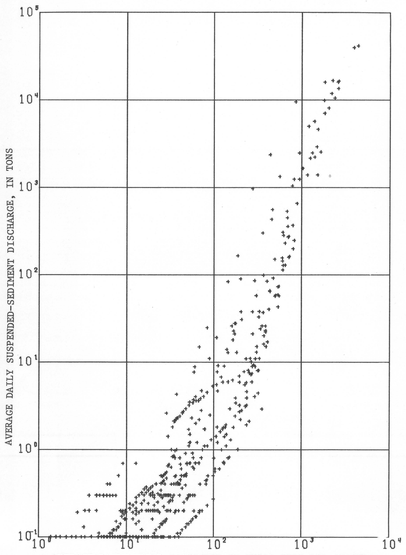
SEDIMENT DISCHARGE AND SEDIMENT YIELD

Quantitative information on the sediment system is derived primarily from sediment-discharge data collected at U.S. Geological Survey gaging stations and from reservoir sedimentation surveys. The relation between water discharge and sediment discharge at the Survey stations is shown in conjunction with a tabulation of annual water and sediment discharges. Sediment yield is converted into a landscape-denudation rate expressed as a uniform lowering of the land surface of the basin in inches. Obviously, no surface is lowered uniformly, but the denudation rate serves as a basis for comparing the general magnitudes of geologic change among subunits of the study area. The assumed unit weight of 100 pounds per cubic foot for in-place material is arbitrary and should be adjusted where precise data are available.

SUMMARY OF ANNUAL SUSPENDED-SEDIMENT AND WATER DISCHARGE, AND AVERAGE LOWERING OF LAND SURFACE

Coyote Creek near Gilroy, California
USGS station 11-1698.00 — Drainage area = 109 sq mi

Water year (ending Sept.30 of year listed)	Water discharge (acre-ft)	Suspended-sediment discharge (tons)	Suspended-sediment yield (tons/sq mi of drainage area)	Average basin-wide lowering of land surface (inches), assuming a unit weight of in-place material at 100 lbs/ft^3
1962	27,980	28,000	257	0.002
1963	53,700	100,000	917	.008
1964	7,550	4,000	36.7	---
1965	47,740	41,000	376	.003
1966	11,220	2,800	25.7	---
1967	69,270	78,560	721	.006
1968	3,300	140	1.3	---
1969	94,620	168,300	1,540	.013
1970	35,740	19,510	179	.002
Totals	351,100	442,300		.034



RELATION OF WATER DISCHARGE TO SUSPENDED-SEDIMENT DISCHARGE, COYOTE CREEK NEAR GILROY, CALIFORNIA

SEDIMENT YIELD FROM UNDEVELOPED UPLAND BASINS IN THE DIABLO RANGE

Sediment yield figures based on reservoir surveys of Pacheco Lake and sediment records at Coyote Creek near Gilroy show that erosion rates for the Diablo Range uplands are somewhat lower than rates measured in other upland regions of the study area for concurrent periods. The following concepts pertain to the characteristics of sediment yield from the Diablo Range uplands:

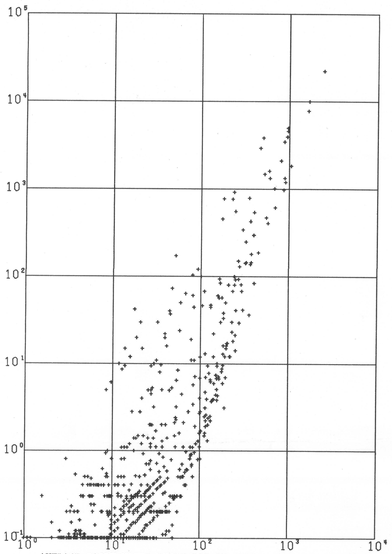
(1) Erosion that is characteristic of the land surface in its natural or generally undisturbed state is in a long-term equilibrium with the formation of erodible soil material.[1] This equilibrium is dynamic, and subject to the additional considerations given below, but is the assumed condition of the Diablo Range uplands. Grazing practices may have modified the erosional regime, but data to document the effects of grazing are lacking.

(2) Moderate flooding having expected recurrence intervals within the planned duration of man's activities and constructions in the stream system is of primary importance in the erosional regime of the Diablo Range uplands. These infrequent high flows in short periods of time may be expected to perform the geologic work of landscape denudation similar to that done by more constantly flowing streams for longer periods in other areas. Verification of this contention is not readily apparent using the existing sedimentation data. A spectrum of hydrologic events sufficient to define the expected range of sediment discharge in the long term has not been recorded, and the extension of records to include this spectrum is beyond the scope of this preliminary report.[2]

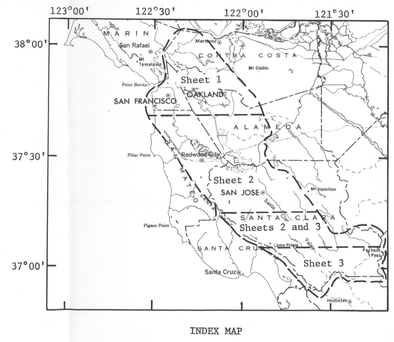
(3) Compared with other upland regions in the study area, the Diablo Range uplands are minimally affected by human activity. Suburban construction, roadbuilding, and the like can be expected to contribute to large increases in sediment yield unless extreme caution is exercised in landscape protection during development.

[1]Rare natural events cause periodic imbalances in this equilibrium, but the restoration of equilibrium (or the establishment of another set of equilibrium conditions) is the expected geologic norm. Severe flooding, severe drought, and major tectonic adjustments are included as significant modifiers of the erosional regime, and are generally beyond the scope of planning for erosional problems identified with man's use of the landscape.

[2]Streamflow records show anomalous flows during the 1956 and 1958 water years having the potential for carrying large amounts of sediment. The frequency of these flows and their sediment-carrying capacity will be calculated or estimated for the interpretive phase of this report.



RELATION OF WATER DISCHARGE TO SUSPENDED-SEDIMENT DISCHARGE, UVAS CREEK ABOVE UVAS RESERVOIR NEAR MORGAN HILL, CALIFORNIA

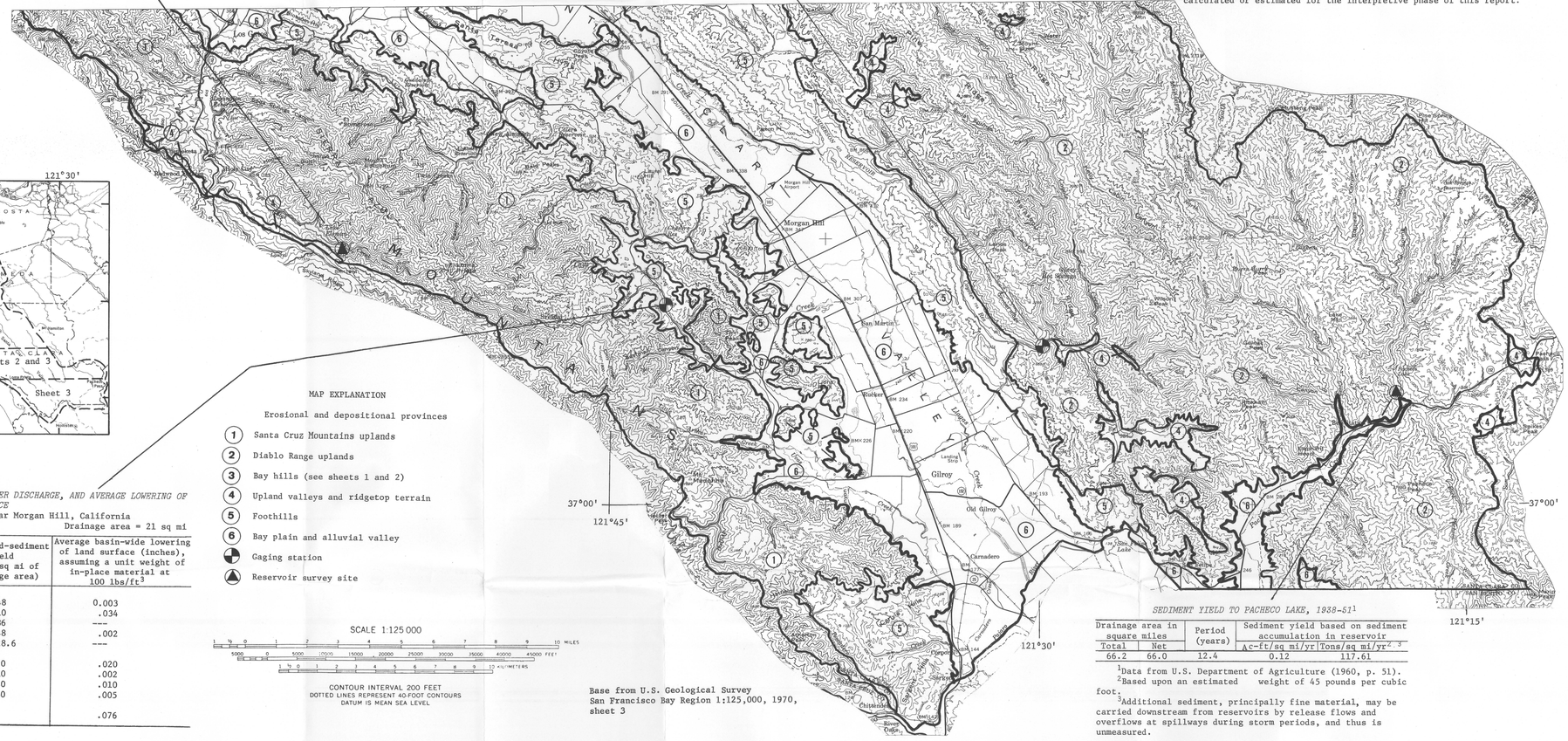


INDEX MAP

SUMMARY OF ANNUAL SUSPENDED-SEDIMENT AND WATER DISCHARGE, AND AVERAGE LOWERING OF LAND SURFACE

Uvas Creek above Uvas Reservoir near Morgan Hill, California
USGS station 11-1539.00 — Drainage area = 21 sq mi

Water year (ending Sept.30 of year listed)	Water discharge (acre-ft)	Suspended-sediment discharge (tons)	Suspended-sediment yield (tons/sq mi of drainage area)	Average basin-wide lowering of land surface (inches), assuming a unit weight of in-place material at 100 lbs/ft^3
1962	16,700	7,300	348	0.003
1963	35,710	82,200	3,910	.034
1964	6,230	600	286	---
1965	21,130	5,200	248	.002
1966	5,780	600	28.6	---
1967	42,350	48,130	2,290	.020
1968	6,560	4,400	210	.002
1969	38,280	23,880	1,140	.010
1970	21,340	12,190	580	.005
Totals	194,100	184,500		.076



SEDIMENT YIELD TO PACHECO LAKE, 1938-61[1]

Drainage area in square miles		Period (years)	Sediment yield based on sediment accumulation in reservoir	
Total	Net		Ac-ft/sq mi/yr	Tons/sq mi/yr[2, 3]
66.2	66.0	12.4	0.12	117.61

[1]Data from U.S. Department of Agriculture (1960, p. 51).
[2]Based upon an estimated weight of 45 pounds per cubic foot.
[3]Additional sediment, principally fine material, may be carried downstream from reservoirs by release flows and overflows at spillways during storm periods, and thus is unmeasured.

PRELIMINARY MAP OF EROSIONAL AND DEPOSITIONAL PROVINCES AND DESCRIPTIONS OF SEDIMENT-TRANSPORT PROCESSES IN THE SOUTH AND CENTRAL SAN FRANCISCO BAY REGION, CALIFORNIA

BY
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1973

Explanatory pamphlet accompanies map sheet