Sediment Transport Trends in Watersheds West of San Francisco Bay

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1. Main Point

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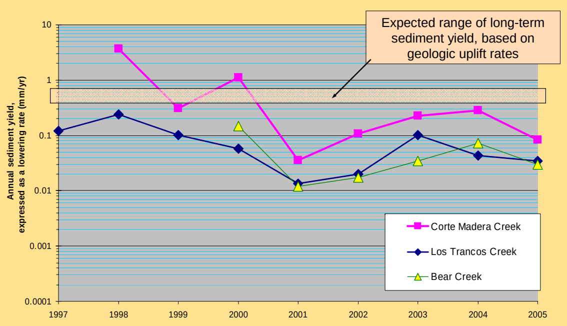
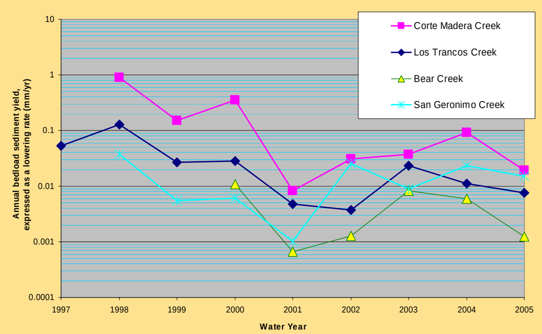
Sediment production and its eventual deposition is a major concern for fishery health and the maintenance of reservoirs and downstream channels. Multi-year measurements of sediment transport in several regionally-significant watersheds draining the eastern slopes of the San Mateo Peninsula provide a basis for assessing both short- and long-term inter-annual variations in transport rates and establish a framework for comparing spatial differences in these rates. Comprehensive data sets for Corte Madera Creek and Los Trancos Creek are reviewed and analyzed in light of underlying geomorphic and hydrologic considerations for the entire period from the last substantial ENSO event in Water Year 1998 through Water Year 2005. Simultaneous quantification of bedload and suspended load in conjunction with ongoing stream gaging at these sites shows total annual sediment loads that vary over several orders of magnitude within each watershed. Comparisons are made with similar data sets collected for Bear Creek (in the same watershed), the Gazos Creek watershed draining the western slopes of the Peninsula, and for San Geronimo Creek in western Marin County, demonstrating order of magnitude differences on an inter-watershed basis. Additionally, annual transport rates are expressed as landscape lowering rates to place the data in the context of the geologic-timescale uplifting that frames overall sediment generation and movement in these systems.



Annual sediment yield from three San Mateo Peninsula Creeks. Since water year 1998, sediment yields have decreased markedly, mainly due to annual rainfall patterns, which have lead to lower average annual flows and lower peak flows since 1998. This has implications for how much sediment is delivered to estuaries and lakes.



Annual bedload sediment yield from four Bay Area creeks. Bedload follows most of the same patterns as total sediment yield; bedload is usually less of the total sediment load than suspended load. San Geronimo Creek follows a slightly different pattern for water years 2002 to 2005; this may be be due to spatially differing rainfall patterns from the north bay to the peninsula.

2. Project Background

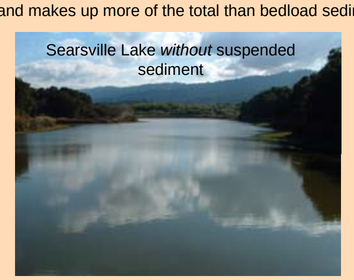
Recent sediment budgeting using transport monitoring in the Bay Area by Balance Hydrologics, 1998-2005

Long-term geologic uplift rates

Geologic uplift rates can be used as an indicator of long-term landscape lowering rates or rates of sediment yield. Investigations that have been carried out have estimated the uplift of the central Santa Cruz Mountains to be approximately 0.5 mm/year, using geologic datums over the last 125,000 to 1,000,000 years (Gianluca Valensise, Institute Nazionale de Geofisica, Italy). So we would expect long-term erosion rates to be equivalent to about 0.5 mm/year.

Suspended sediment vs. bedload sediment

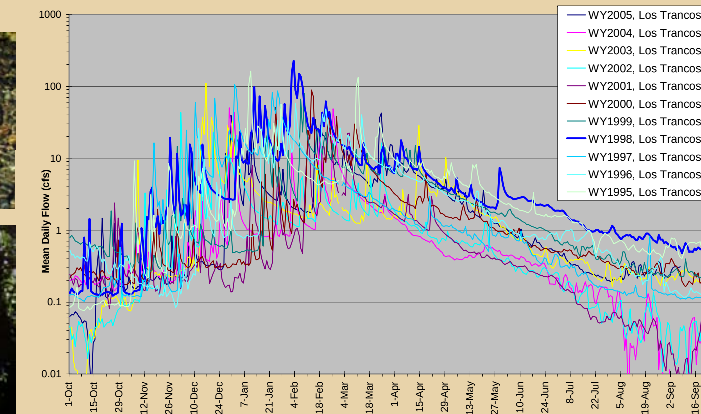
Following convention, we distinguish two types of sediment in transport, each measured during storms using specific samplers and methods, approved by the Federal Interagency Sedimentation Program. Bedload sediment is supported by the bed of the stream; it rolls and saltates along the bed, commonly within the lowermost 3 inches of the water column. Movement can be either continuous or intermittent, but is generally much slower than the mean velocity of the stream. In these creeks, bedload consists primarily of coarse sands and gravels. Suspended sediment is supported by the turbulence of the water; it is transported at a velocity approaching the mean velocity of flow. Generally, in the Santa Cruz Mountains, suspended sediment consists primarily of fine sands, silts, and clays, and makes up more of the total than bedload sediment.



3. Methods

Method steps:

1. manual flow measurements
2. manual sediment-transport measurements
3. construct flow hydrograph from datalogger record at 15-minute intervals
4. construct sediment-discharge rating curves from measurements
5. apply sediment-discharge curves to the flow hydrograph at 15-minute intervals
6. add up daily and annual totals



Daily flow hydrographs, Los Trancos Creek. Flow hydrographs form the basis for calculating sediment yield. Eleven years are shown, highlighting year-to-year differences in flow patterns such as peak flows and overall wetness.

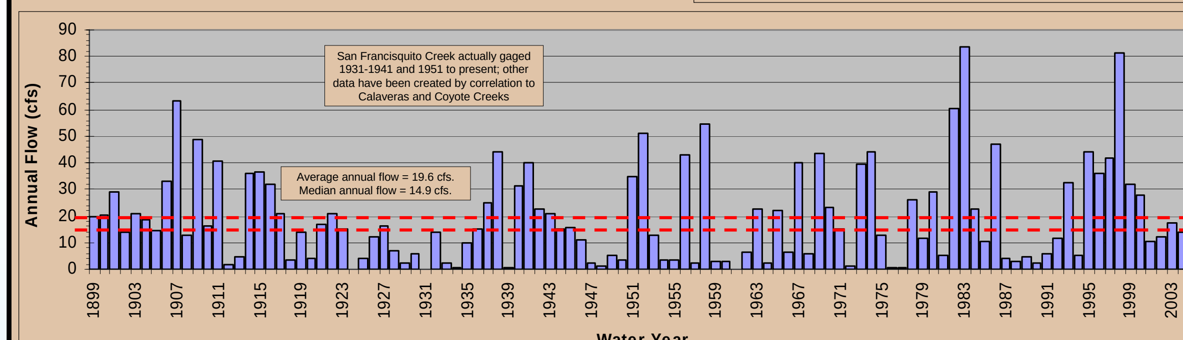
4. Data/Results

Questions that the data may help us answer:

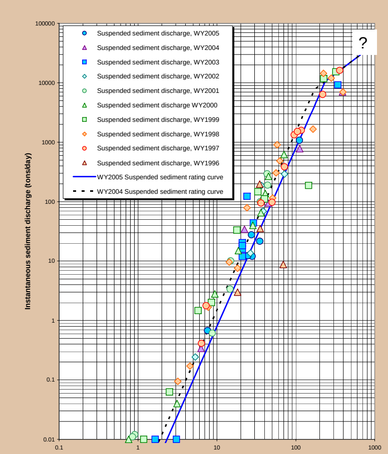
What are the main reasons for the year-to-year sediment yield patterns? Do sediment transport rates change, or are higher sediment totals just due to more flow during wetter years? Which is more important, total flow for the year, or the size of the peak flow?

When was the last comparable period of high sediment yield?

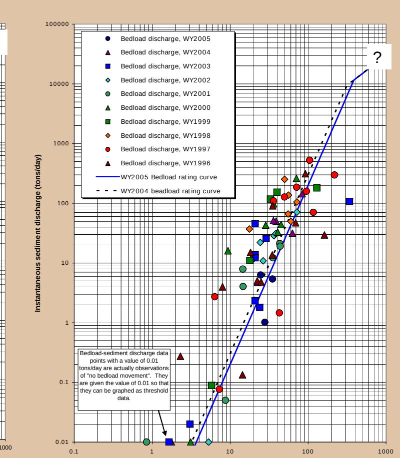
How does sediment yield during these recent years compare to the long-term average? The long-term historically and the long-term geologically?



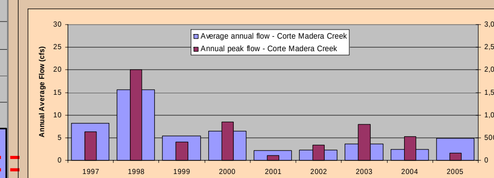
Extended flow chronology: San Francisquito Creek at Stanford Golf Course: water years 1899 to 2005. Note the degree to which streamflow was unusually high during water years 1995 to 2000. This is also the period during which Balance has monitored sediment discharge in the watershed, so we would expect sediment totals from this period to be above the long-term average.



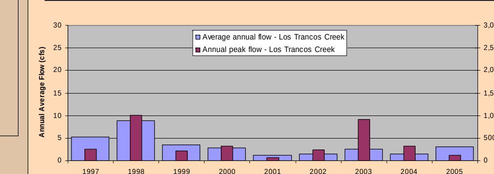
Measurements of suspended-sediment transport rates and estimated rating curve: Corte Madera Creek at Westridge Dr., water years 1996-2005.



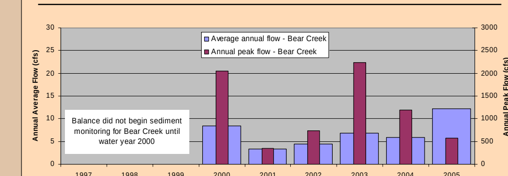
Measurements of bedload-sediment transport rates and estimated rating curve: Corte Madera Creek at Westridge Dr., water years 1996-2005.



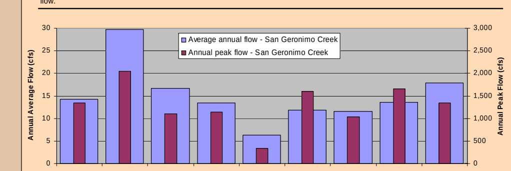
Corte Madera Creek: annual average flows and peak flows. Both of these factors influence watershed sediment yield. Some years, like 1997, have a high average flow, but a low peak flow. Some years, like 2003, have a low average flow, but a high peak flow.



Los Trancos Creek: annual average flows and peak flows. Both of these factors influence watershed sediment yield. Some years, like 1997, have a high average flow, but a low peak flow. Some years, like 2003, have a low average flow, but a high peak flow.



Bear Creek: annual average flows and peak flows. Both of these factors influence watershed sediment yield. Some years, like 2005, have a high average flow, but a low peak flow. Some years, like 2003, have a low average flow, but a high peak flow.



San Geronimo Creek: annual average flows and peak flows. Both of these factors influence watershed sediment yield. Some years, like 1997, have a high average flow, but a low peak flow. Some years, like 2003, have a low average flow, but a high peak flow.

5. Conclusions

1. Even though sediment *totals* have declined since 1998, we have not seen large declines in sediment discharge as a function of flow since 1998.
2. Year-to-year sediment yield seems to be mainly due to both: a) the size of the peak flow (generates sediment sources), and b) the amount of streamflow (ability to transport sediment from those sources).
3. The unusually wet period starting in water year 1995 has resulted in high sediment yields; the last comparable period of consistently high streamflow (and therefore high sediment yields) occurred from 1906 to 1911.
4. Although sediment yield in water year 1998 was well above the long-term geologic average, most of the years since then have been near or below the long-term average.