# SEDIMENT BUDGET OF A MIXED-USE, URBANIZING WATERSHED

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## INTRODUCTION

The Issaquah Creek basin is an urbanizing watershed of 144 square km in western Washington, where sediment aggradation of the main channel and delivery of fine sediment into a large downstream lake have raised serious local and regional concerns. The basin has many water quality problems that may be associated with erosion occurring throughout the watershed. The water quality of Lake Sammamish, located at the outlet of the basin, is degrading with time, and fine sediment entering the lake from the watershed is a likely source of phosphorus during periods of lake anoxia. Additionally, there are flood-prone areas in the basin, particularly along the mainstem of Issaquah Creek in downtown Issaquah, that may be exacerbated by channel aggradation and subsequent reductions in flow conveyance. Another potential in-channel concern is the effect of fine sediment on spawning gravel for the salmon species that occupy Issaquah Creek. A sediment budget was constructed for this mixed-use, rapidly developing watershed to evaluate the relative effects of land-use practices, including urbanization, on watershed-scale sediment supply and delivery. It also can be used to identify the major sources of sediment, and thus guide the most effective remedial measures.

## PREVIOUS STUDIES

Very few sediment budgets have been conducted in urban or urbanizing areas. The vast majority of sediment budgets in the literature are in forested or undeveloped drainage basins. Several studies have been conducted in forested Pacific Northwest drainage basins (Reid 1981, Madej 1982, Slaymaker 1993, Paulson 1997), where vegetated hillslopes are the dominant erosional features in the landscape. Of the few sediment studies conducted in urban areas, most have focused on one or more elements of sediment production, such as construction or channel-bank erosion resulting from urbanization (Wolman 1967, Wolman and Schick 1967, Trimble 1995, Trimble 1997). Other urban sediment studies have used sediment concentration measurements from catchment outlets to document the magnitude of upland sediment production from various land uses. While this information is useful to evaluate catchment-level changes, it is difficult to discern the significant sediment production processes from such aggregated data.

## METHODS

Sediment production was evaluated for the different land uses in the basin, which include urban development, construction, forest/timber harvesting, and landfill and gravel quarry operations. GIS (Geographic Information System) data were used to determine land use categories and areas, and to evaluate basin characteristics that should influence erosion and sediment-delivery potential. Within each land-use category, the sediment production and delivery processes associated with each general land use were evaluated using a combination of methods described in the geomorphologic and engineering literature.

## RESULTS

The current annual sediment production rate is estimated at 44 tonnes $km^{-2}$ $yr^{-1}$, relative to a pre-development estimate of 33 tonnes $km^{-2}$ $yr^{-1}$. The main sources of sediment in the basin are landslides (50%), channel-bank erosion (20%), and road surface erosion (15%) (Figure 1). Less significant sources of sediment included agriculture, construction, and landfill

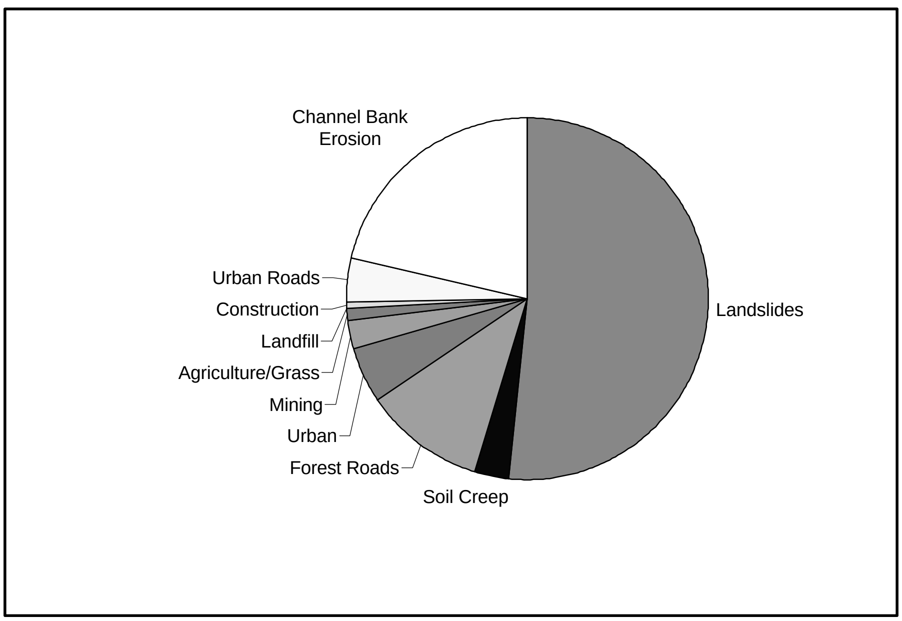


Figure 1. Relative Sediment Contributions from Different Land Uses/Processes

and gravel quarry operations.  Although the Issaquah Creek basin is developing, forest lands still occupy over 70 % of the basin area and produce the majority of sediment, where steep slopes contribute to a high landslide rate and efficient sediment delivery to the channel network.  Urban land uses account for only 18 % of the basin area and contribute very little sediment directly to the overall budget, because developed areas have only modest yields and a relatively small fraction of the basin is under construction at any given time.

## Sediment Size Fractions

Watershed managers have specific concerns related to the different size fractions of sediment delivered to the channel network, therefore, both fine and coarse sediment production processes were evaluated in this sediment budget.  Increased coarse sediment supply can lead to channel aggradation, whereas abundant fine sediment usually leads to a reduction in water quality. Fine sediment accounted for approximately 60 % of the total sediment production in the Issaquah Creek basin, primarily from landslides, gravel roads and channel bank erosion (Figure 2).  Landslides and channel bank erosion also contribute

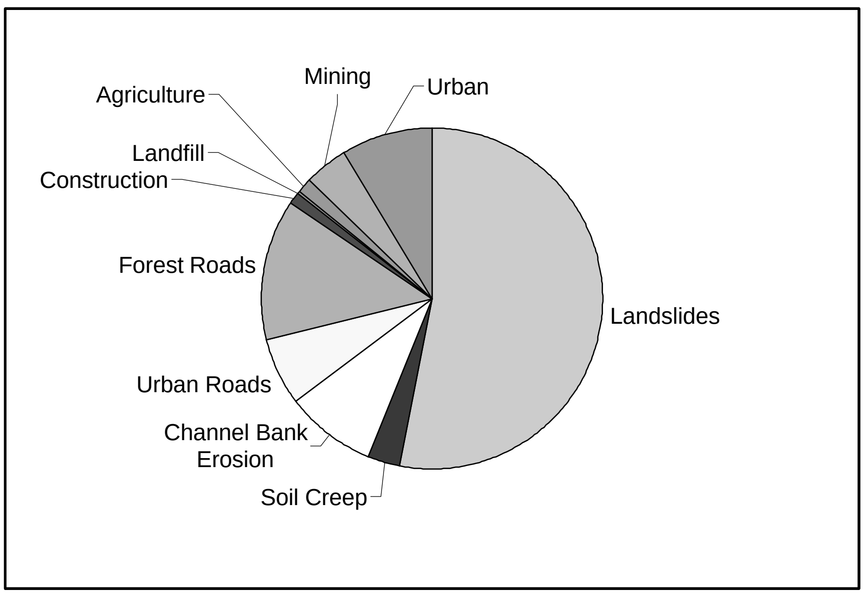


Figure 2.  Relative percentages of fine sediment from different land uses/processes

significant amounts of coarse sediment to the overall budget. Relative to the total sediment budget, urban land uses accounted for a greater percentage of fine sediment, indicating there are opportunities for better management of urban stormwater runoff.

## Balancing the Sediment Budget

A number of different approaches were taken to check estimates of upland sediment production in the basin, including an evaluation of depositional and erosional areas within the mainstem of Issaquah Creek, an evaluation of the growth of the Issaquah Creek delta into Lake Sammamish, and a comparison of these results with other studies.

### Erosional and Depositional Areas in Issaquah Creek

Historical bridge survey records within the City of Issaquah indicate a net channel aggradation (ranging from 7 to 30 mm) in Issaquah Creek. The bridge survey data compared favorably to calculated channel aggradation rates (6 to 12 mm per year) based on estimates of upland sediment production and downstream routing and transport in the mainstem of Issaquah Creek.

### Delta Growth Evaluation

The average annual growth rate of the Issaquah Creek delta into Lake Sammamish was estimated from a review of historical aerial photographs (1944 to 1995) to compare estimated rates of fine sediment production from the watershed. The growth rate was estimated to be approximately 2,600 tonnes/year, which compares to an estimated fine sediment input of 3,800 tonnes/year. Recognizing that a significant, though indeterminant, fraction of the fine sediment would be carried in suspension far out into the lake, these results are fully consistent with the sediment-budget calculation.

Comparison to Other Studies

In general, the calculated sediment production rate of 44 tonnes $km^{-2}$ $yr^{-1}$ for the Issaquah Creek basin is much less than rates calculated by others (Reid 1981, Madej 1982, Paulson 1997) for forested Pacific Northwest basins (which vary from 77 – 1800 tonnes $km^{-2}$ $yr^{-1}$). Regional urban sediment yields were reported at rates ranging from 10 to 35 tonnes $km^{-2}$ $yr^{-1}$ (City of Bellevue 1995).

## DISCUSSION

Based on current and pre-development estimates of sediment production rates in the Issaquah Creek basin, urbanization has increased basin-wide sediment production, primarily through channel bank erosion. Bank erosion resulting from channel enlargement, due to increased discharges, account for 20% of the total basin sediment budget and is a direct consequence of urbanization. More generally, channel bank erosion is probably the primary source of sediment in more urbanized watersheds. Trimble (1997) found channel bank erosion to be the primary source of sediment yield (67%) in San Diego Creek basin, a 50%-urbanized watershed in southern California. These results indicate yet another reason to mitigate impacts from stormwater runoff as rural areas are developed. Unlike more visible sources of sediment (such as construction runoff), channel enlargement is a process that can occur without much notice from human inhabitants until property is lost or structures are threatened.

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