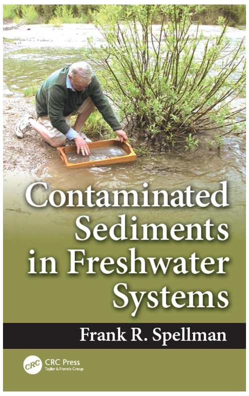

Contaminated Sediments in Freshwater Systems

Frank R. Spellman

Physical Sediment Damage

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Frank R. Spellman
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9 Physical Sediment Damage

Soil erosion is the most serious and prevalent disease of the land.

USDA (1954)

INTRODUCTION

Natural erosion causes about 30% of the total sediment in the United States, but human activities account for the remaining 70%. Physical sediment damage contributes to contaminated sediments in freshwater systems simply due to their presence. Earlier we stated that sediment is defined as solid material that is being transported or has been moved from its site of origin by air, water, gravity, or ice. We also defined erosion as the detachment and movement of rock or mineral materials by wind, moving water, ice, gravity, or other agents. When we discuss sediment damage of any type—physical, biological, or chemical—it is important to keep in mind the source of the material under discussion. In this book, and throughout the current discussion, for purposes of evaluation sediment and erosion damages are separated into two categories, as shown in Figure 9.1: (1) direct damages, and (2) indirect damages. Direct damages result in primary impairment of manmade properties, facilities, and utilities. Indirect damages are secondary damages related to or resulting from primary or direct damages. Computations of monetary damages are the responsibility of environmental economists. Ecology and environmental specialists are expected to supply the data on physical damages that environmental economists need for such calculations. In some instances, such as in cleanup costs, sediment damages can be estimated only in monetary terms, in which case geologists and environmental economists should jointly decide who should estimate such damages. Thorough knowledge of the use of information by environmental economists and close coordination with environmental economists are necessary to avoid collection of unnecessary data.

SEDIMENT DAMAGE

Damage to properties, facilities, and utilities as a result of sediment in transit or sediment deposition is considered to be sediment damage and/or contamination. Figure 9.2 illustrates and the following explanation describes the types of sediment damage.

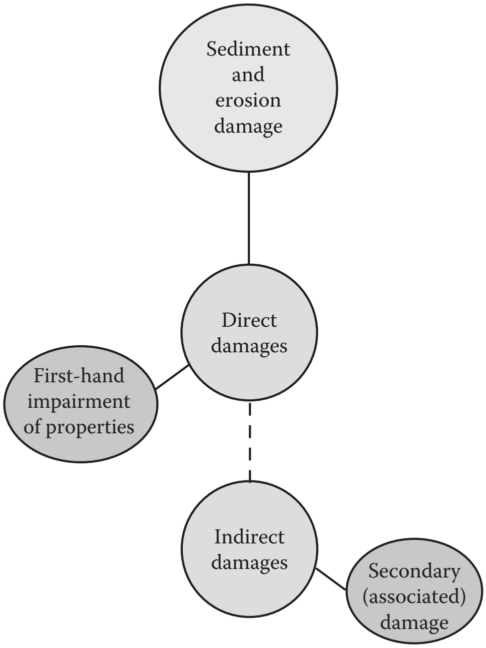

FIGURE 9.1 Direct and indirect damages resulting from sediment and erosion damages.

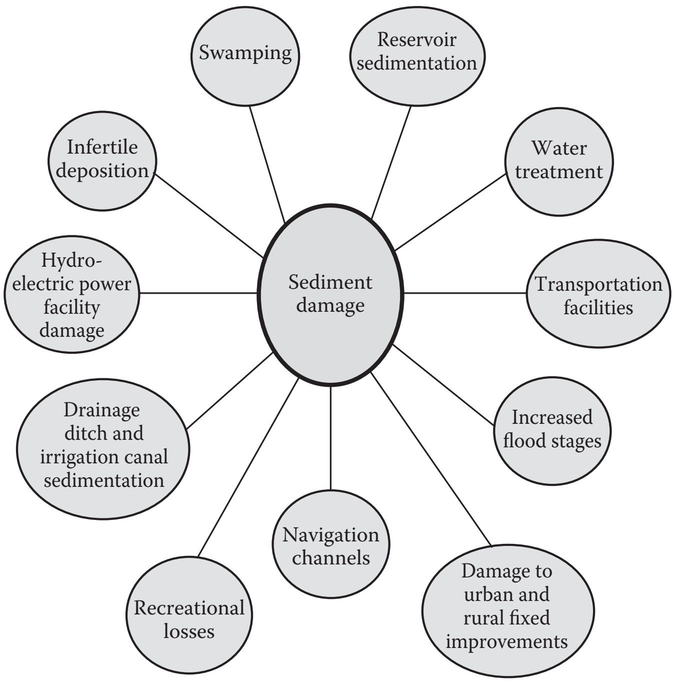

FIGURE 9.2 Types of sediment damage.

Infertile Deposition

Relatively infertile modern sediment may be deposited on floodplains or on colluvial soils. Modern sediment results from culturally accelerated erosion. It may take various forms, such as over-bank splays, fans, or vertical accretion deposits. Infertile sand or gravel deposits commonly cause this type of damage, but silts and clays derived from subsoil erosion, if low in nutrient elements, are also harmful in some areas. General principles of stream and valley sedimentation, criteria for recognition of modern valley deposits, and the relationship of stream and valley sedimentation of flood-control problems were outlined by Happ et al. (1940). The degree of damage by deposition of infertile materials depends on the type of material, the depth of deposit, and the rate of deposition, as well as on the productivity of the land in its original state. As an example, consider two areas of silt loam floodplain soils that have been damaged by sand. One has been damaged by a deposit of 16 inches of sand added gradually, at the rate of an inch each year for 16 years. It has been possible to mix the sand with the surface 8 inches (plow depth) of soil each year. Therefore, although the productive capacity of the soil has diminished to 50% of the original capacity, it is still in production. In contrast, the other area has received a deposit of only 8 inches of sand, all of which was deposited in a year. Under normal practices, there would not be much mixing of this sand with the old soil below. Unless special treatment is used, it might be taken out of production and for all practical purposes lost to cultivation.

Swamping

Swamping is any impairment of lateral or vertical drainage or floodplain soils due to sediment deposits. Swamping may be caused by the filling of stream channels with sediment, which raises the water table; by the formation of natural levees by modern sediment deposits, which prevents proper surface drainage; or by deposition of fine-grained sediment upon floodplain soils, which results in puddling or a reduction of permeability and prevention of internal drainage. Although swamping is a direct result of deposition, it is evaluated as a separate damage. Swamping often affects extensive areas of floodplains, and in its most serious form it will make formerly good cropland unfit for agricultural use.

Reservoir Sedimentation

Deposition of sediment in reservoirs results in a loss of the storage capacity required for water supply, power, recreational, irrigation, flood control, and other purposes. As a result, the services dependent upon such capacity are impaired. Damage to natural lakes is included in this category as well as artificial reservoirs.

Water Treatment

It is rather ironic that state-of-the-art water treatment processes include sand filtration as a unit process to ensure that the water is cleansed to the extent possible. Sand filtration is extremely important in ensuring the removal of *Giardia lamblia* and *Cryptosporidium* oocysts. Traditional, small-scale water treatment processes are usually good enough to ensure adequate and safe water treatment, but when *Giardia* or *Cryptosporidium* could be present traditional methods of water treatment are not adequate to ensure the removal of these disease-causing protozoans. So, what is the irony here? Simply, the irony is that water treatment systems spend considerable amounts of time and money to remove sand—which, if part of the process, is otherwise vital to filtration in the unit process—and other sediment from surface water or reservoir inlets because of blockage problems. It is a damage in this text because it is considered preventable.

Hydroelectric Power Facility Damage

After a power reservoir is completely filled with sediment, the power plant no longer has reserve, or carryover, storage and must depend on run-of-the-river flow entirely. Although this may greatly reduce the amount of power that can be generated, most power plants continue to operate under these circumstances on a reduced power output basis. At this stage, new sediment damage may occur. Coarse materials may move out of the silted-up reservoir, through the intake, and into the turbines. This causes excessive wear on the turbines, runners, and other equipment and necessitates more frequent overhaul and replacement.

Damage to Transportation Facilities

Sediment deposits damage highways and railways by collecting in ditches and culverts and on roadways and by filling and constricting channels beneath bridges. Roadway sediments become surface runoff and eventually make their way into surface water bodies.

Drainage Ditch and Irrigation Canal Sedimentation

Drainage ditches, irrigation canals, and floodways are usually vulnerable to sedimentation because of the low grades developed. As they become filled with sediment, and often with vegetative growth, they lose their capacity to transport water. This results in more frequent overflow of floodways and drainage ditches. These overflows may raise the water table adjacent to drainage ditches or impair the effectiveness of lateral outlets. Silting of irrigation canals reduces the amount of water that may be delivered to irrigated areas at critical times, resulting in a loss of crop production.

Damage to Navigation Channels

When navigation channels, pools, and harbors become shoaled because of sediment deposits, movement of vessels may be limited to high water periods or halted entirely.

Increased Flood Stages

When stream channels become clogged with sediment and floodplains are raised by sediment deposits, flood crests for the same discharges are constantly forced to higher elevations and floodwater damage increases. The damage may be caused by several conditions. If the floodplain is bounded by low terraces and the channel and floodplain are aggrading at approximately the same rate, increasing flood damage will take place on the terraces, but not on the floodplain, except in the case of buildings or other fixed installations. If the channel is aggrading at a faster rate than the floodplain, then there will be increasing floodwater damage on both the floodplain and terraces. If the channel is enlarging at a rate equal to the rate of floodplain aggradation, no increase in floodwater damage will take place on either the floodplain or terraces. Figure 9.3 illustrates these various conditions.

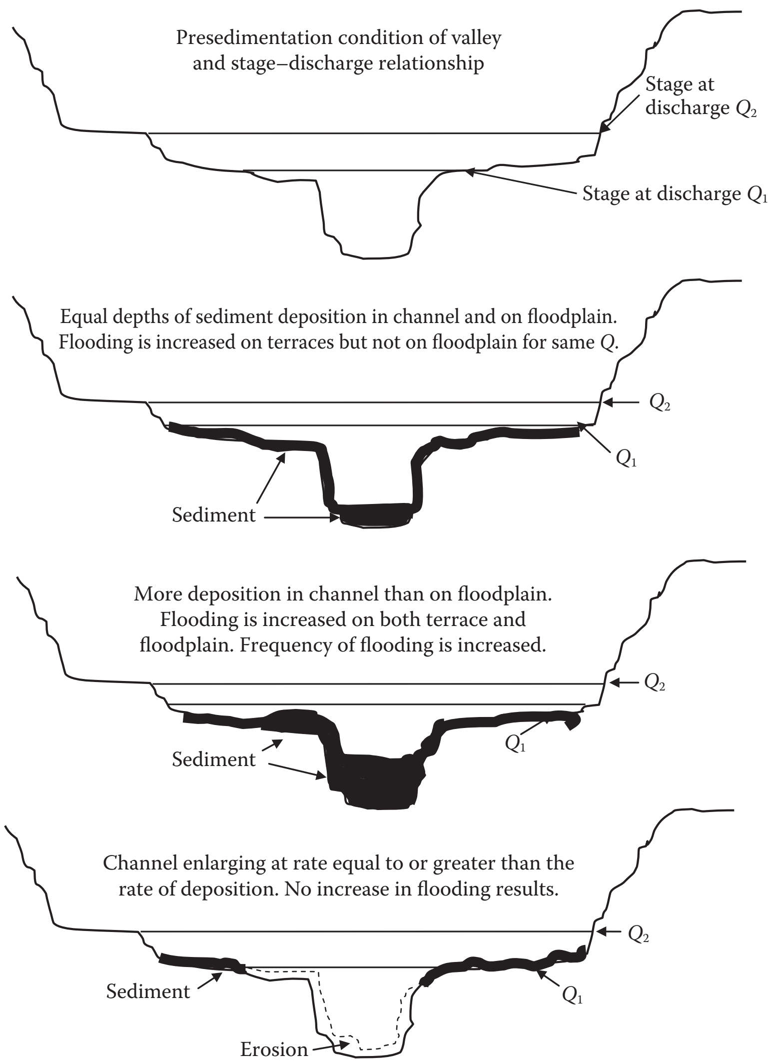

FIGURE 9.3 Interrelation between sedimentation and flood stages. (From USDA, Ge*ologic Investigations for Watershed Planning*, Technical Release No. 17, U.S. Department of Agriculture, Washington, DC, 1996.)

Damage to Urban and Rural Fixed Improvements

After most floods, deposits of sediment are found on streets and in homes, factories, sewers, wells, and other places where they cause damage due to the cost of removing this sediment or cleaning and replacing equipment and materials.

Recreational Losses

Sediment may cause the impairment of recreational values, such as damage to fish, wildlife, and recreational facilities (e.g., beaches, bathing facilities).

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