Problem 25

During heavy rain, a section of a mountainside measuring 2.5 km horizontally, 0.80 km up along the slope, and 2.0 m deep slips into a valley in a mud slide. Assume that the mud ends up uniformly distributed over a surface area of the valley measuring 0.40 km × 0.40 km and that mud has a density of 1900 kg/m^3. What is the mass of the mud sitting above a 4.0 m^2 area of the valley floor?

Solution

Multiply the density by the volume of the mountainside section to get the mass of mud.

$$m = \rho V = \frac{1900 \text{ kg}}{1 \cancel{\text{m}^3}} \times \left(2.5 \cancel{\text{km}} \times \frac{1000 \cancel{\text{m}}}{1 \cancel{\text{km}}}\right)\left(0.80 \cancel{\text{km}} \times \frac{1000 \cancel{\text{m}}}{1 \cancel{\text{km}}}\right)(2.0 \cancel{\text{m}}) = 7.6 \times 10^9 \text{ kg}$$

Divide this mass by the surface area of the valley to get the mass per unit surface area.

$$\frac{m}{A} = \frac{7.6 \times 10^9 \text{ kg}}{\left(0.40 \cancel{\text{km}} \times \frac{1000 \text{ m}}{1 \cancel{\text{km}}}\right)\left(0.40 \cancel{\text{km}} \times \frac{1000 \text{ m}}{1 \cancel{\text{km}}}\right)} \approx 4.8 \times 10^4 \ \frac{\text{kg}}{\text{m}^2}$$

Multiply this mass per unit surface area by 4.0 m^2 to get the mass of mud on this surface area.

$$4.0 \cancel{\text{m}^2} \times \frac{7.6 \times 10^9 \text{ kg}}{\left(0.40 \cancel{\text{km}} \times \frac{1000 \cancel{\text{m}}}{1 \cancel{\text{km}}}\right)\left(0.40 \cancel{\text{km}} \times \frac{1000 \cancel{\text{m}}}{1 \cancel{\text{km}}}\right)} = 1.9 \times 10^5 \text{ kg}$$