

species composition and abundance can be observed among macroinvertebrate assemblages found in snags, sand, bedrock, and cobble within a single stream reach (Benke et al. 1984, Smock et al. 1985, Hury and Wallace 1987). This preference for conditions associated with different substrates contributes to patterns observed at larger spatial scales where different macroinvertebrate assemblages are found in coastal, piedmont, and mountain streams (Hackney et al. 1992).

Stream substrates can be viewed in the same functional capacity as soils in the terrestrial system; that is, stream substrates constitute the interface between water and the hyporheic subsurface of the aquatic system. The *hyporheic zone* is the area of substrate which lies below the substrate/water interface, and may range from a layer extending only inches beneath and laterally from the stream channel, to a very large subsurface environment. Alluvial floodplains of the Flathead River, Montana, have a hyporheic zone with significant surface water/ground water interaction which is 2 miles wide and 33 feet deep (Stanford and Ward 1988). Naiman et al. (1994) discussed the extent and connectivity of hyporheic zones around streams in the Pacific Northwest. They hypothesized that as one moves from low-order (small) streams to high-order (large) streams, the degree of hyporheic importance and continuity first increases and then decreases. In small streams, the hyporheic zone is limited to small floodplains, meadows, and stream segments where coarse sediments are deposited over bedrock. The hyporheic zones are generally not continuous. In mid-order channels with more extensive floodplains, the spatial connectivity of the hyporheic zone increases. In large order streams, the spatial extent of the hyporheic zone is

usually greatest, but it tends to be highly discontinuous because of features associated with fluvial activities such as oxbow lakes and cutoff channels, and because of complex interactions of local, intermediate, and regional ground water systems (Naiman et al. 1994) (**Figure 2.35**).

Stream substrates are composed of various materials, including clay, sand, gravel, cobbles, boulders, organic matter, and woody debris. Substrates form solid structures that modify surface and interstitial flow patterns, influence the accumulation of organic materials, and provide for production, decomposition, and other processes (Minshall 1984). Sand and silt are generally the least favorable substrates for supporting aquatic organisms and support the fewest species and individuals. Flat or rubble substrates have the highest densities and the most organisms (Odum 1971). As previously described, substrate size, heterogeneity, stability with respect to high and baseflow, and durability vary within streams, depending on particle size, density, and kinetic energy of flow. Inorganic substrates tend to be of larger size upstream than downstream and tend to be larger in riffles than in pools (Leopold et al. 1964). Likewise, the distribution and role of woody debris varies with stream size (Maser and Sedell 1994).

In forested watersheds, and in streams with significant areas of trees in their riparian corridor, large woody debris that falls into the stream can increase the quantity and diversity of substrate and aquatic habitat or range (Bisson et al. 1987, Dolloff et al. 1994). Debris dams trap sediment behind them and often create scour holes immediately downstream. Eroded banks commonly occur at the boundaries of debris blockages.