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Introduction

Atmospheric, surface and subsurface portions of the hydrologic system (Figure 1-1) are three dynamically linked water reservoirs having distinctly different time and space scales. The challenge is in understanding and measuring the dynamic interchange among these reservoirs, especially for interchanges with the subsurface. Most subsurface storage of water is in the groundwater reservoir, with a small amount of storage as soil moisture in the overlying unsaturated zone (see Basic Concepts Related to Groundwater Recharge/Discharge). While soil moisture is directly connected to the atmosphere and is an important storage reservoir for the energy associated with water (latent heat), simply because of its ease of exchange with the atmosphere, groundwater is the far more important storage reservoir for the water mass itself.

Fluxes to and from groundwater are called, respectively, recharge and discharge. Natural groundwater recharge has several origins. The most important of these are the flux of water across the water table from precipitation that percolates through the unsaturated zone, and the influx of water from a bounding or overlying surface water bodies including rivers, lakes, wetlands and the ocean. Natural groundwater discharge is the efflux of water from the groundwater reservoir to surface water, or to the land surface itself where, for example, it may return to the atmosphere through evaporation and transpiration. Natural recharge and discharge zones develop in response to the regional climatic and local topographic, hydrogeologic and biospheric conditions. Important anthropogenic sources of recharge and discharge include agricultural irrigation and drainage, respectively, infiltration basins and recharge/injection and pumping (e.g., water supply) wells.

The various recharge and discharge fluxes can be measured or estimated at a wide range of temporal and spatial scales. Uncertainties in the measurement methods and the related understanding in the process, and disparities in measurement and modeling scales, prevent adequate closure of the transient water balance at the spatial and temporal scales of interest to scientists, engineers, and decision makers. For example, *in situ* point measurements are representative of the point value of a flux but are inadequate for mapping larger regions of interest to planners, while regional chemical tracers and modeling techniques can provide estimates representative of larger areas but these are difficult to relate to local conditions at water supply and aquifer remediation sites. The challenge to closing the groundwater balance, and to estimating groundwater fluxes to or from other water reservoirs, is to integrate flux measurement and estimation techniques at multiple scales, with multiple types of data. These estimates would make effective use of models to map recharge and discharge fluxes over a wide range of spatial and temporal scales.

Estimates of recharge/discharge fluxes are needed at many different spatial scales in water budget studies of natural hydrologic systems, and in studies of systems impacted by agriculture, water supply, or contamination. Estimation and understanding of recharge and discharge rates are of importance when evaluating