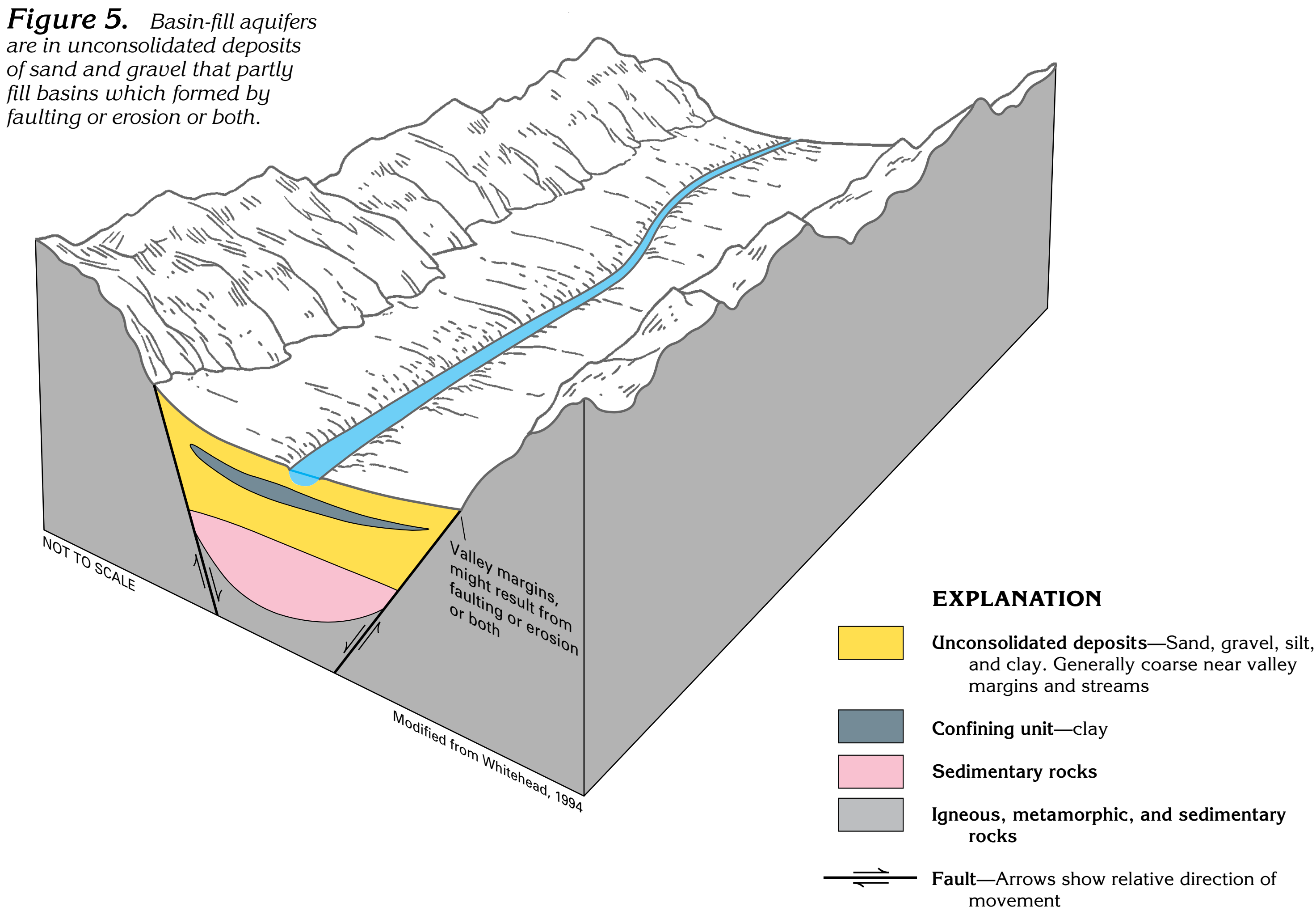
Unconsolidated sand and gravel aquifers

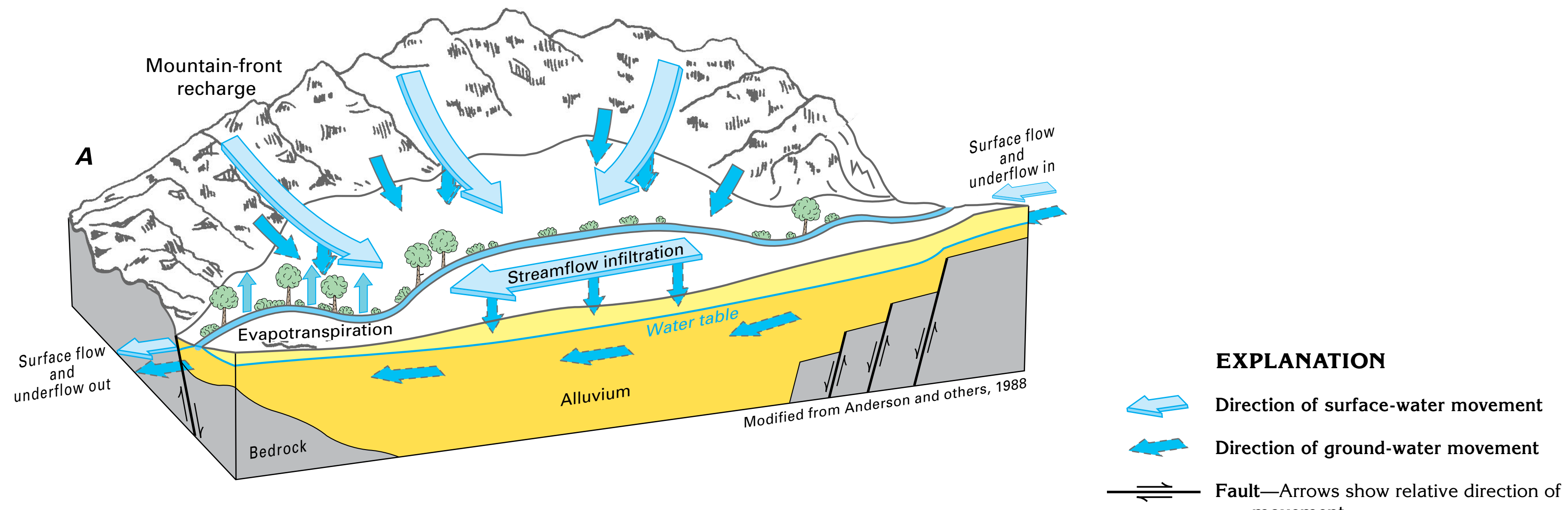
INTRODUCTION

The unconsolidated sand and gravel aquifers shown in **figure 4** can be grouped into the following three categories: basin-fill aquifers, referred to as valley-fill aquifers in many reports; blanket sand and gravel aquifers; and glacial-deposit aquifers. A fourth type, called stream-valley aquifers, is located beneath channels, floodplains, and terraces in the valleys of major streams. The stream-valley aquifers are not shown on **figure 4** because they are too small to map accurately at the scale of the figure. The most important stream-valley aquifers are mapped in the descriptive Atlas chapters.

All the unconsolidated sand and gravel aquifers are characterized by intergranular porosity and all contain water primarily under unconfined, or water-table, conditions. However, each of the four categories occupies a different hydrogeologic setting. Examples of each category are used to illustrate these differences.

Figure 5. *Basin-fill aquifers are in unconsolidated deposits of sand and gravel that partly fill basins which formed by faulting or erosion or both.*





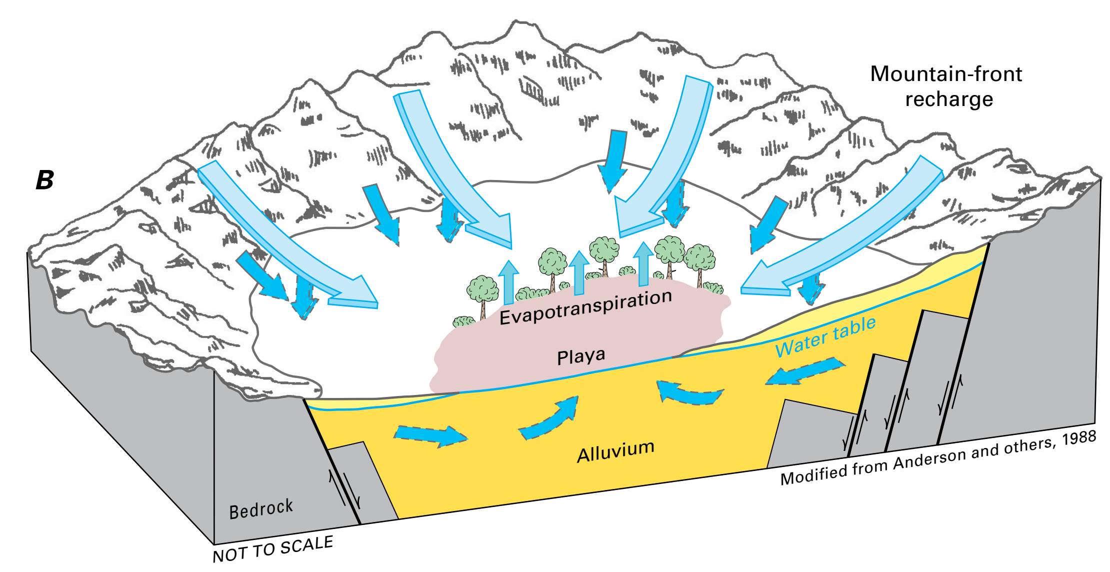


Figure 6. *Basin-fill aquifers in open basins (A) are hydrologically connected by through-flowing streams and ground-water underflow. Closed basins (B) discharge only through evapotranspiration, mostly at playas or lakes near the basin centers. Both types of basins receive recharge primarily from infiltration of flow from streams that originate in the surroun-ding mountains.*

BASIN-FILL AQUIFERS

Basin-fill aquifers consist of sand and gravel deposits that partly fill depressions which were formed by faulting or erosion or both (**fig. 5**). These aquifers are also commonly called valley-fill aquifers because the basins that they occupy are topographic valleys. Fine-grained deposits of silt and clay, where interbedded with the porous sand and gravel, form confining units that retard the movement of ground water. In basins that contain thick sequences of deposits, the sediments become increasingly more compacted and less permeable with depth. The compacted, lithified deposits form sedimentary rocks. The basins are generally bounded by low-permeability igneous, metamorphic, or sedimentary rocks.

The sediments that comprise the basin-fill aquifers mostly are alluvial deposits, but locally include windblown sand, coarse-grained glacial outwash, and fluvial sediments deposited by streams that flow through the basins. The alluvial deposits consist of sediments eroded by streams from the rocks in the mountains adjacent to the basins. The streams transported the sediments into the basins and deposited them primarily as alluvial fans at the base of the mountains. The coarser sediment (boulders, gravel, and sand) was deposited near the basin margins and finer sediment (silt and clay) was deposited in the central parts of the basins. Some basins contain lakes or playas (dry lakes) at or near their centers. Windblown sand might be present as local beach or dune deposits along the shores of the lakes. Deposits from mountain, or alpine, glaciers locally form permeable beds where the deposits consist of outwash transported by glacial meltwater. Sand and gravel of fluvial origin are common in and adjacent to the channels of through-flowing streams. Basins in arid regions might contain deposits of salt, anhydrite, gypsum, or borate, produced by evaporation of mineralized water, in their central parts.

The hydrogeologic setting of a typical basin generally is one of two types: open (**fig. 6*A***) or closed (**fig. 6*B***). Recharge to both types of basin is primarily by infiltration of streamflow that originates as precipitation which falls on the mountainous areas that surround the basins. This recharge, called mountain-front recharge, is intermittent because the streamflow that enters the valleys is intermittent. As the streams exit their bedrock channels and flow across the surface of the alluvial fans, the streamflow infiltrates the permeable deposits on the fans and moves downward to the water table. In basins which are located in arid climates, much of the infiltrating water is lost by evaporation or as transpiration by riparian vegetation (plants on or near stream banks).

Open basins contain through-flowing streams (**fig. 6*A***) and commonly are hydraulically connected to upstream or downstream basins or both. Some recharge might enter an open basin as surface flow and underflow (ground water that moves in the same direction as streamflow) from an adjacent upstream basin, and recharge occurs as streamflow infiltration from the through-flowing stream. Before development, water discharges from an open basin largely by evapotranspiration within the basin but also as surface flow and underflow into downstream basins. After development, most discharge is by withdrawals from wells.

No ground-water or surface-water flow leaves closed basins (**fig. 6*B***). Streamflow and ground-water movement are from the basin boundaries toward a lake or playa usually located near the center of the basin. Predevelopment discharge in the closed basins was by evaporation and transpiration from the lake or playa area; in developed closed basins, discharge is primarily through wells.

Some basins are bounded or underlain by permeable bedrock such as carbonate rocks or fractured crystalline rocks. Where such rocks surround a basin, some ground water can enter and leave the basin through the permeable bedrock. Some carbonate rocks are highly permeable and might be cavernous where they have been partially dissolved by circulating ground water. Several basins might be hydraulically connected, especially where they are underlain by carbonate rocks, so that water moves through and between the basins as a regional or subregional ground-water flow system. In southeastern Nevada, for example, major flow systems that are described in Atlas chapter B extend for as much as 250 miles in basin-bounding carbonate rocks, and the flow mostly discharges to large springs.

Examples of basin-fill aquifers discussed in the Atlas include the Basin and Range aquifers of chapters B, C, and H; the Rio Grande aquifer system of chapters C and E; the Pacific Northwest basin-fill aquifers of chapters B and H; and the Northern Rocky Mountains Intermontane Basins aquifer system of chapters H and I. Some basin-fill aquifer systems, such as the Central Valley aquifer system described in chapter B and the Puget-Williamette Lowland aquifer system described in chapter H, are in extremely large basins.

BLANKET SAND AND GRAVEL AQUIFERS

Widespread sheetlike aquifers that consist mostly of medium to coarse sand and gravel are collectively called blanket sand and gravel aquifers in this report. These aquifers mostly contain water under unconfined, or water-table, conditions but locally, confined conditions exist where the aquifers contain beds of low-permeability silt, clay, or marl. Where stream-valley alluvial aquifers, that also consist of sand and gravel, cross the blanket sand and gravel aquifers, the two types of aquifers are hydraulically connected and the stream-valley alluvial aquifers are not mapped separately.

The blanket sand and gravel aquifers largely consist of alluvial deposits. However, some of these aquifers, such as the High Plains aquifer, include large areas of windblown sand, whereas others, such as the surficial aquifer system of the southeastern United States, contain some alluvial deposits but are largely comprised of beach and shallow marine sands.

Except for the Seymour aquifer in north Texas, which is underlain by low-permeability rocks, the blanket sand and gravel aquifers partly overlie, and are hydraulically connected to, other aquifers. Where they are in contact with aquifers in older rocks, the blanket sand and gravel aquifers store water that subsequently leaks downward under natural conditions to recharge the deeper aquifers.

The High Plains aquifer is the most widespread blanket sand and gravel aquifer in the Nation. This aquifer extends over about 174,000 square miles in parts of eight States and four Atlas segments (**fig. 7**). The principal water-yielding geologic unit of the aquifer is the Ogallala Formation of Miocene age, a heterogeneous mixture of clay, silt, sand, and gravel that was deposited by a network of braided streams which flowed eastward from the ancestral Rocky Mountains. Because it consists largely of the Ogallala Formation, the High Plains aquifer has also been called the Ogallala aquifer in many reports. Dune sand is part of the High Plains aquifer in large areas of Nebraska and smaller areas in the other States (**fig. 7**). This permeable dune sand quickly absorbs precipitation, some of which percolates downward to the water table of the aquifer.

Figure 7. *The High Plains aquifer is the largest blanket sand and gravel aquifer in the Nation and extends over about 174,000 square miles in parts of eight States.*