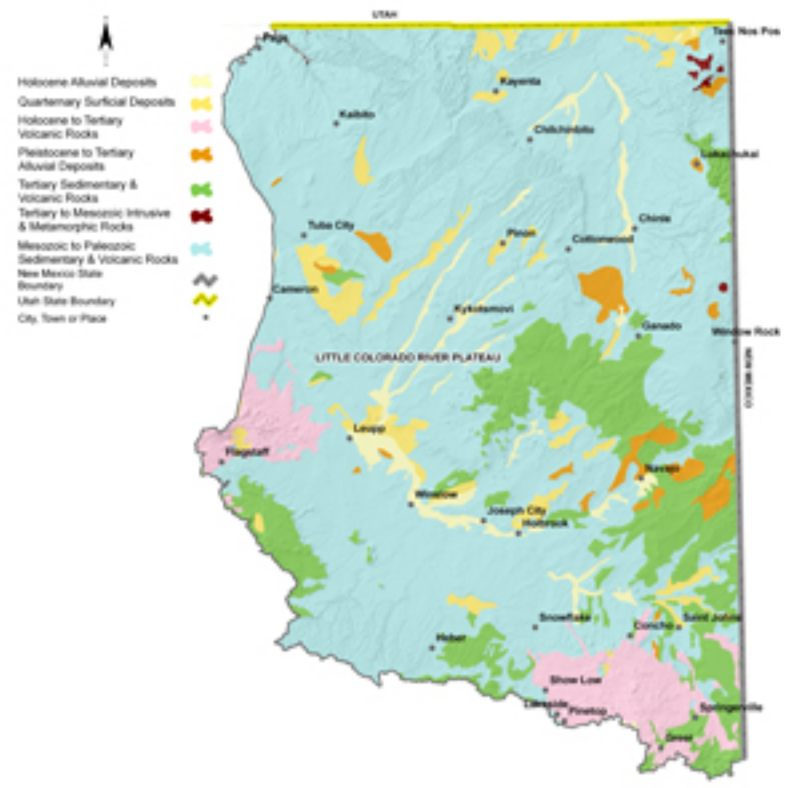
Hydrology of the Eastern Plateau Planning Area - Groundwater

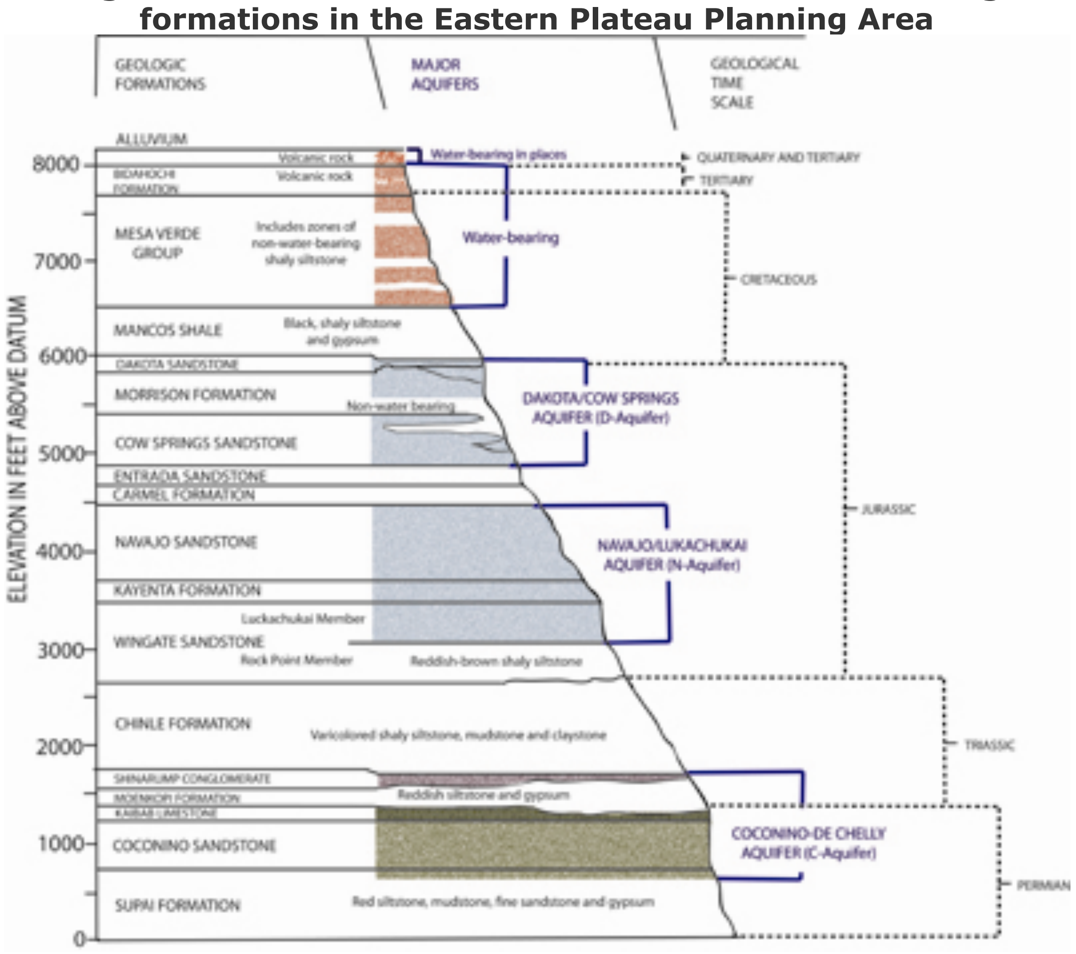
Figure 2.0-4: Geology of the Eastern Plateau Planning Area (Based on AZGS, 1988)



A significant portion of the planning area is underlain by Mesozoic to Paleozoic sedimentary and volcanic rocks (**Figure 2.0-4**) that form the area's regional aquifers. The sedimentary rocks consist of sandstones and limestones stacked on top of one another that are generally separated by low permeability shales and siltstones. The three largest regional aquifers are the D-, N-, and C-aquifers. Each has a very large areal extent within the basin and except for the D- and N- aquifers, there is little vertical hydrologic connection between them. These water-bearing formations gain thickness towards the center of the basin resulting in artesian conditions. Primary recharge areas are along the southern and eastern periphery of the planning area. It is estimated that there are about 508 million acre-feet (maf) in storage in Little Colorado River Plateau aquifers (ADWR, 1990a). **Figure 2.0-5** shows a generalized cross-section of the water- bearing formations of the planning area. In addition to these regional aquifers, several local aquifers are important groundwater sources. One of the most extensive is the Bidahochi aquifer in the east central part of the planning area, composed of tertiary sedimentary and volcanic rocks (See **Figure 2.1-7** for the location of large local and regional aquifers).

The C-aquifer is the largest and most productive aquifer in the planning area with an areal extent of 21,655 square miles. It is named for its primary water-bearing unit, the Coconino Sandstone. The C-aquifer extends from the Mogollon Rim in the south to an area west of the Little Colorado River and northeast into New Mexico. Water flow in the aquifer is generally in a west-northwest direction. Recharge to the aquifer is along the Mogollon Rim and on the Defiance Plateau (Hart and others, 2002). The major discharge from the C-aquifer is at Blue Springs along the lower Colorado River. ADWR (1990) estimated there was about 413 maf of C-aquifer water in storage in the planning area.

Figure 2.0-5 Generalized cross-section of water bearing formations in the Eastern Plateau Planning Area



Water levels measured in selected wells drilled in the C-aquifer varied in depth from 37 feet to almost 2,000 feet below land surface (bls) (**Figure 2.1-8**). Of the 24 wells measured in 2003-2004, 14 wells showed water level declines since 1990-1991. Most declines were between -1 to -15 feet, however declines of more than 30 feet were measured near Springerville and St. Johns in the vicinity of power plants, and near Flagstaff in the Lake Mary wellfield.

The C-aquifer is utilized as a water supply south of the Little Colorado River and along the southern edge of the basin by Flagstaff, Heber, Overgaard, Show Low, Snowflake and Concho. North of the river the C-aquifer is too deep to be economically useful, or is unsuitable for most uses because of high concentrations of total dissolved solids. In general, the water quality of the C-aquifer degrades with increasing distance from recharge areas and at increasing depths (USBOR, 2006).

The N-aquifer occurs north of the Little Colorado River and has an areal extent of 6,250 square miles. The Navajo and Wingate Sandstones are the main water-bearing units in the N-aquifer. Groundwater flow direction varies as shown in **Figure 2.1-7** and is generally south and west or north and west. The aquifer is generally unconfined but there are artesian conditions in the Black Mesa area and near Window Rock and much of the aquifer underlying the Hopi Reservation is unconfined (ADWR, 2008a). Natural recharge to the N-aquifer has recently been estimated at 2,600 to 20,246 AFA (OSM 2008). Water is discharged via springs, baseflow to streams and as underflow to drainages. N-aquifer storage estimates vary from 166 maf to 526 maf (ADWR, 1989; ADWR, 2008a).

Water levels measured in selected wells drilled in the N-aquifer vary in depth from 17 feet to 851 feet bls as shown in **Figure 2.1-8**. Water level changes between 1990-1991 and 2003-2004 varied in these measured wells (**see Figure 2.1-7**). Recent adjudication investigation on the Hopi reservation showed median well depths of 745 feet for claimed wells (ADWR, 2008a).

N-aquifer water quality is generally good and is a source of supply for the Navajo and Hopi Reservations. However, there are sites of uranium and heavy metal contamination due to past uranium mining and milling operations. Groundwater remediation activities are underway near Tuba City where a plume of groundwater contamination extends south and southeast of an uranium ore mill operation and 37 extraction wells convey water to an onsite treatment plant (DOE, 2008a)

The N-aquifer is utilized for mining operations at the Black Mesa Coal Mine operation. Until 2005, N-aquifer water was also used for the Black Mesa Coal Mine slurry pipeline that delivered coal to the Mohave Generating Station at Laughlin, Nevada. From the pre-mining period to 2003, the median water level decline was more than 23 feet in 26 wells and declines were approximately 72 feet for 12 wells in the confined part of the aquifer. (Truini, et al., 2005) To relieve impacts on the N-aquifer from pumping at Black Mesa, a proposal to use C-aquifer water withdrawn near Leupp was considered and a study undertaken that was completed in 2005 (Leake, et al., 2005). The Mohave Generating Station suspended operation in 2005, which has significantly reduced the need for N-aquifer withdrawals.

The D-aquifer overlays portions of the N- and C-aquifer in the planning area and is the smallest of the three regional aquifers. It covers about 3,125 square miles under the Navajo and Hopi reservations. The D-aquifer is composed of the Dakota, Cow Springs and Entrada sandstones. Flow direction is toward the southwest in the southern part of the aquifer and toward the northwest in the northern portion (**Figure 2.1-7**). Annual recharge is estimated at 5,392 acre-feet (GeoTrans and Waterstone, 1999). Recharge probably occurs along the eastern slope of Black Mesa where units of the aquifer outcrop (Lopes and Hoffman, 1997), and also locally along washes. There is some connection between the D-aquifer and the underlying N-aquifer and D-aquifer discharge also occurs via springs, baseflow to streams and as underflow along washes (ADWR, 2008a). ADWR (1989) estimated that there are 15 maf in storage in the D-aquifer.

Water level data from a well collected in 2003-2004 in the D-aquifer showed a depth to water at 271 feet bls and no water level decline since 1990-1991. Median water levels at 48 claimed wells on the Hopi reservation were 268 feet (ADWR, 2008a). Water quality is marginal to unsuitable for domestic use due to high concentrations of dissolved solids. Nevertheless, it is utilized in the north-central parts of the planning area for domestic use.

Local aquifers are important for domestic uses where the regional aquifers are too deep or have unsuitable water quality. Local aquifers include alluvial deposits


Little Colorado River near Springerville

that occur along washes and stream channels, including along the Little Colorado River and its tributaries, sedimentary and volcanic rocks of the Bidahochi and other formations and some sandstones. The Bidahochi formation forms a local aquifer in the central part of Apache and Navajo counties and south of Sanders. Most recharge to the Bidahochi aquifer probably occurs from direct precipitation. In the southeastern part of Navajo County, saturated basaltic rocks together with underlying sedimentary rocks are locally known as the Lakeside-Pinetop aquifer, which is an important supply for the area. The aquifer covers an area of about 16 square miles and is composed of two distinctive but hydrologically well-connected water-bearing zones (Overby, 2007). Undifferentiated sandstones west of Show Low along the Mogollon Rim and in the Springerville-Eagar area form aquifers that are also locally important supplies.

The City of Flagstaff has become more dependent on groundwater from several distinct aquifers. The aquifer in the vicinity of Flagstaff is complex and composed of sandstones, siltstones and limestones. Groundwater flow in the aquifer is poorly understood because of its depth and complex geologic structure. Recent geologic mapping indicate structural features such as faults and fractures that have important effects on the occurrence and flow of groundwater in this aquifer. Unconsolidated sediments and volcanic rocks in this area may also be waterbearing, but their areal extent is limited and yields are generally low. The Woody Mountain and Lake Mary well fields extract water from this aquifer. Water levels in these well fields show seasonal fluctuations and long-term declines due to pumping. (Bills and others., 2000) The San Francisco Peaks caldera, known as the Inner Basin, contains an aquifer that historically supplied much of the municipal water for the City of Flagstaff (Grahame and Sisk, 2002). In the Fort Valley area northwest of Flagstaff, a perched aquifer at a depth of a few hundred feet is utilized by individual land owners (Pinkham and Davis, 2002).

As shown in **Figure 2.1-9**, well yields are typically low (<100 gpm) north of the Little Colorado River, and higher in the south-central and southeast part of the planning area where wells encounter the C-aquifer. D-aquifer well yields are comparatively low, with yields up to 20 to 25 gpm reported (ADWR, 1989).

Groundwater quality data from selected sampling sites are shown in **Table 2.1-7** and mapped on **Figure 2.1-10**. The most frequently exceeded constituents, measured in order of greatest occurrence, were arsenic, radionuclides, thallium, lead and total dissolved solids (TDS). North of Highway 264, thallium and radionuclides were most frequently reported. Between Highway 264 and Interstate 40, the parameter most frequently exceeded at measured sites was arsenic. South of Interstate 40, arsenic and cadmium were the most frequently exceeded constituents.

For more information on Groundwater in the Eastern Plateau Planning Area see **Section 2.1.6 - Groundwater Conditions**

Click here to continue to Section 2.0.2 Hydrology - Surface Water Hydrology

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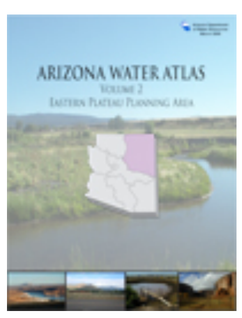

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References and Supplemental Reading for the Eastern Plateau Planning Area Overview