SECTION 8

FIGURES

8.0 SUMMARY OF MAJOR FINDINGS

Given the extensive base of information obtained and reviewed for the study area, it is feasible to draw many scientifically based conclusions regarding the hydrology and hydrogeology of the study area. Please note that many of these findings center on the Mesaverde Formation, since this report was prepared in the context of the potential development of natural gas wells in the study area that would be located in this formation.

8.1 Dominance of Surface Water in Study Area

A key finding is that the hydrology and hydrogeology of the study area is driven by surface water. The northern half of the study area and especially the Grand Mesa area is surface water rich, with substantial annual precipitation and numerous large lakes and wetlands atop the Grand Mesa. USGS gauging data for the period of record show that streams which flow off the south face of the Grand Mesa (some of which are shown on Figure 1) collectively convey an average of over 150,000 acre-feet annually. Over 99 percent of the water used to irrigate the approximately 26,000 acres of crops and pasture in the study area is supplied by surface water. Approximately 97 percent of all of the decreed absolute flow water rights in the study area are associated with surface diversions (ditches). Water wells represent only 0.1 percent of all of the adjudicated flow rights in the study area (many small capacity domestic wells are permitted with the State Engineer's Office but do not have decreed water rights). Municipal water systems are based predominantly on surface water. The documents reviewed indicate that no municipal systems rely on Mesaverde Formation water wells.

Stream flows are seasonal, with peak flows normally associated with snowmelt in May-June and low baseflows throughout the winter. In general, surface water quality is good, and many beneficial uses (aquatic life, water supply, agriculture, recreation) are supported. Wetlands and ponds are common, especially atop the Grand Mesa, in riparian zones, and downslope from springs and seeps. Springs and seeps are found in all of the geologic formations evaluated in the report. Most of them issue from unconsolidated deposits underlain by bedrock, and are primarily recharged by surface or near-surface sources. Spring water quality varies widely.

The amount of groundwater use in the study area is very small by comparison to surface water use. Wells can draw water from: a) shallow, unconsolidated colluvial and/or alluvial deposits, b) deeper bedrock formations or c) a combination of the two. Most of the water wells in the study area are completed in alluvium or glacio-fluvial materials (Brooks and Ackerman 1985). Figure 20 provides a conceptual comparison of two types of wells completed in the Mesaverde Formation.

The origin of water sources can often be established from water chemistry measurements. Alluvial/colluvial waters and bedrock waters typically have distinctive chemical "signatures." This water chemistry signature technique was used to demonstrate that many Mesaverde Formation water wells in the study area are recharged by overlying unconsolidated (alluvial/colluvial) deposits.

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Mesaverde Well

WHERE FORMATION HAS:

1) SIGNIFICANT SECONDARY PERMEABILITY,
2) PERMEABLE OVERLYING DEPOSITS AND
3) SURFACE WATER SOURCES.

Well Characterized by:

- SUBSTANTIAL SURFACE WATER/SHALLOW GROUNDWATER CONTRIBUTION AND ASSOCIATED WATER CHEMISTRY
- RELATIVELY GOOD PUMPING RATE
- USUALLY SUITABLE FOR POTABLE CONSUMPTION.

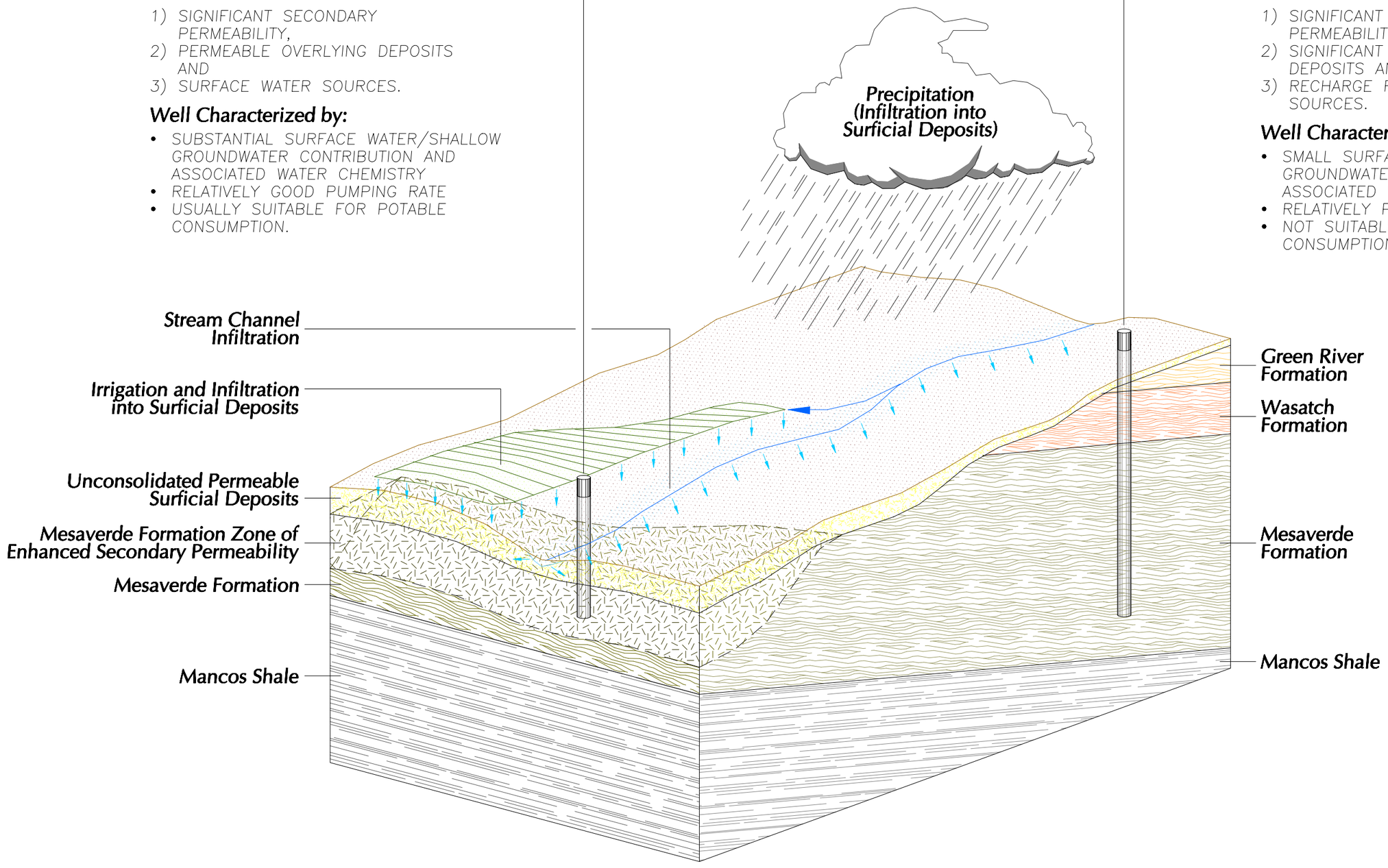
Mesaverde Well

WHERE FORMATION DOES NOT HAVE:

1) SIGNIFICANT SECONDARY PERMEABILITY,
2) SIGNIFICANT PERMEABLE OVERLYING DEPOSITS AND
3) RECHARGE FROM SURFACE WATER SOURCES.

Well Characterized by:

- SMALL SURFACE WATER/SHALLOW GROUNDWATER CONTRIBUTION AND ASSOCIATED WATER CHEMISTRY
- RELATIVELY POOR PUMPING RATE
- NOT SUITABLE FOR POTABLE CONSUMPTION WITHOUT TREATMENT.



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DETAIL	KAL
CHECK	JEJ/GDW
DATE	1/31/03
SCALE	NTS

CONCEPTUAL COMPARISON OF TWO BASIC MESAVERDE FORMATION WATER WELL TYPES IN STUDY AREA

FIGURE 20

8.2 Mesaverde Formation Water

The bedrock formation of primary interest in the study area is the Mesaverde Formation. In general, the Mesaverde Formation transmits very little water in the study area, due to its very low permeability. Although water is present in localized portions of the Mesaverde Formation, it is not a regional aquifer. For example, Brooks (1983) states: "The Mesaverde Formation in the study area transmits little groundwater because of the negligible transmissivity of the 1,300 feet of fine-grained sandstone, coal and shale comprising the formation." The Colorado Division of Minerals and Geology (1991) report entitled *Cumulative Hydrologic Impact Study of the Tongue Creek Watershed* states: "The Mesaverde does not typically have productive aquifers in this area due to poor lateral continuity, inappropriate petrology or poor recharge topography." Many other references make statements to this effect.

Analyses provided in this report indicate that there are 36 wells in the study area which appear to draw water exclusively from the Mesaverde Formation and 27 wells which are partially supplied by this formation. These wells withdraw, conservatively, about 20 acre-feet of Mesaverde Formation water per year. To put 20 acre-feet into perspective:

- More than 60,000 acre-feet of irrigation water is typically used annually in the study area.
- Roughly 1 million acre-feet of precipitation falls on the study area annually, on average.
- Cumulative streamflows in the study area, excluding the North Fork Gunnison River, exceed 150,000 acre-feet annually, on average.
- Total municipal water use—the vast majority of which is provided by surface water sources—is orders of magnitude higher than Mesaverde Formation groundwater use.

- Two garden hoses running constantly for a year would produce about 20 acre-feet of water. The flow of the typical garden hose is roughly 6 to 10 gpm (AWWA 1975).

The general lack of Mesaverde Formation water in the study area is also demonstrated by water production data for seven oil/gas wells from the Colorado Oil and Gas Conservation Commission and Amoco (now BP/America). Specifically, the average daily water production rate for these seven oil/gas wells is about 1 gpm. The observed water production rate of 1 gpm is also low by comparison to water production rates for other oil/gas fields in the Rocky Mountain Region. For example, observed water yields of 30 gpm (or higher) per well in the Powder River Basin, Wyoming are not unusual. Based on review of records at the Colorado State Engineer's Office, permitted Mesaverde water wells in the study area have pumping rates ranging from about 1 to 20 gpm.

The available evidence indicates that most of the Mesaverde Formation domestic wells in the study area have three factors present:

- The Mesaverde Formation has relatively high localized permeability due to such factors as faults, fractures, historic burning in the coal zones, weathering, etc.
- Overlying or adjacent unconsolidated surface deposits are permeable and recharge the Mesaverde Formation.
- A stream, irrigation ditch and/or other surface water source recharges the permeable unconsolidated surface deposits overlying the Mesaverde Formation.

These factors are present near Cedaredge. This is a major reason that about two-thirds of the total number of permitted Mesaverde Formation water wells in the study area are located near Cedaredge. The remainder are scattered along the North Fork Gunnison River and Anthracite Creek. Mesaverde Formation water wells are not distributed uniformly throughout the study area.

Many of the Mesaverde Formation water wells in the study area would no longer be viable if the overlying surficial deposits were "stripped away" or if the overlying surface flows were removed. Their recharge source would be gone, and without surface water contributions, most Mesaverde Formation water wells would have high TDS concentrations, making water quality unacceptable for most uses.

As the monitoring programs described in this report continue, the water resources database will expand. Consequently, periodic updates to this report may be necessary. Although this report defines and describes water resources in the study area, it does not evaluate the potential impacts to these resources of proposed natural gas wells—this subject will be addressed by the U.S. Forest Service and U.S. Bureau of Land Management in their on-going environmental analysis.