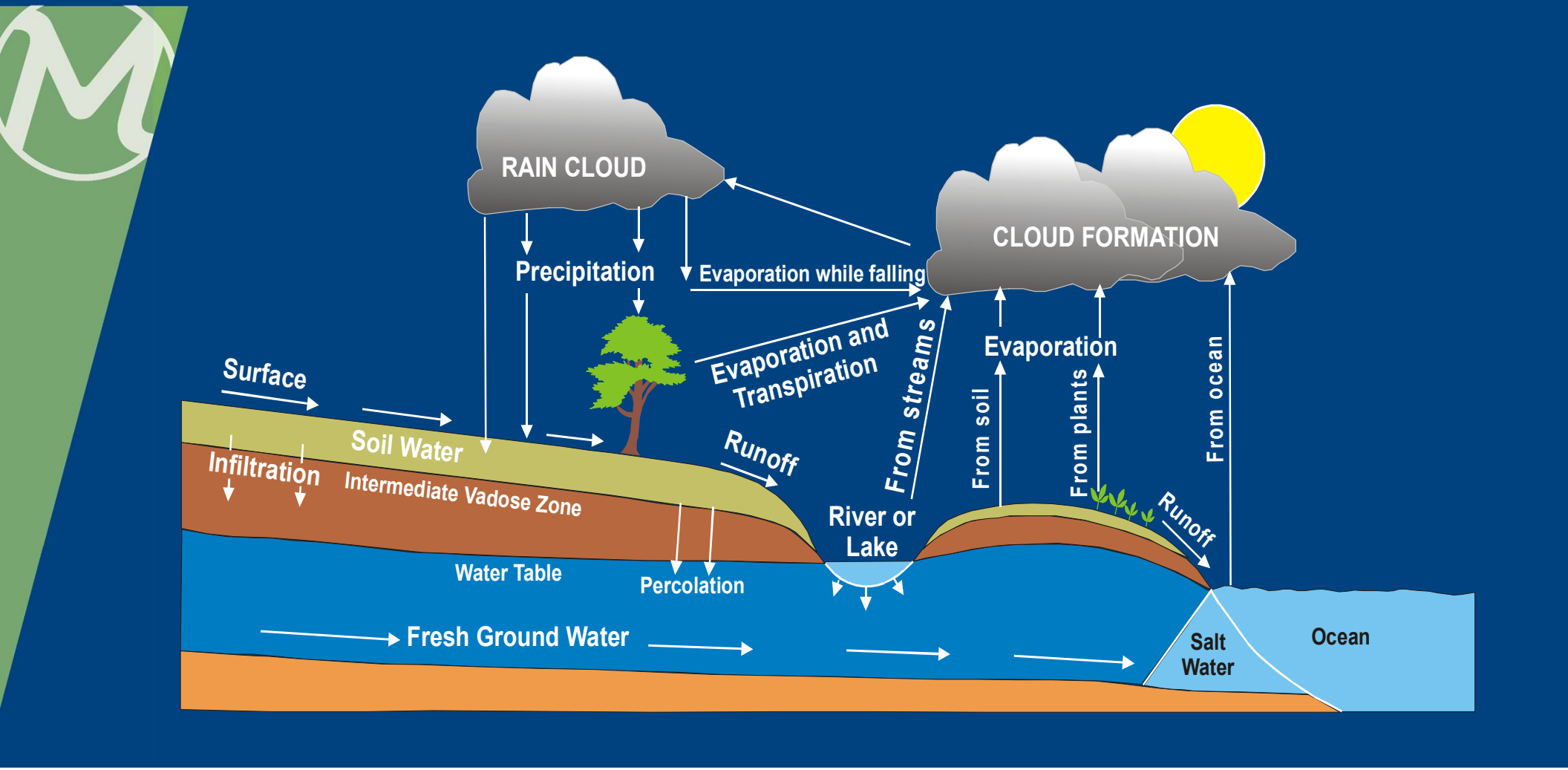
Evaluation of Extent and Reliability of Denver Basin Aquifer Resources

El Paso County, Colorado

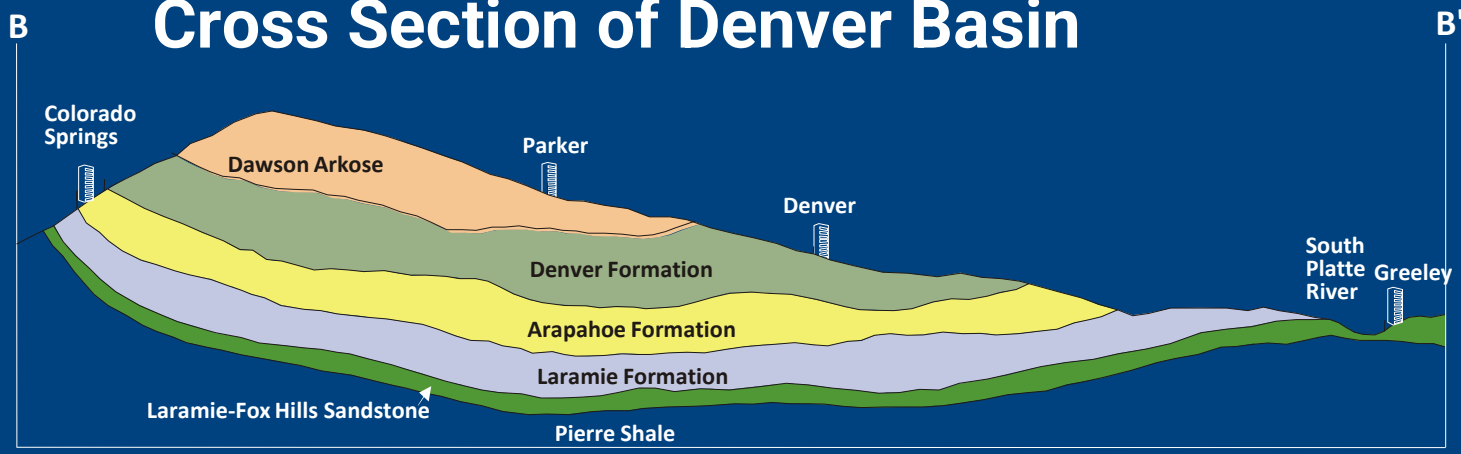
Planning and Community Development

LWS | moore engineering, inc.

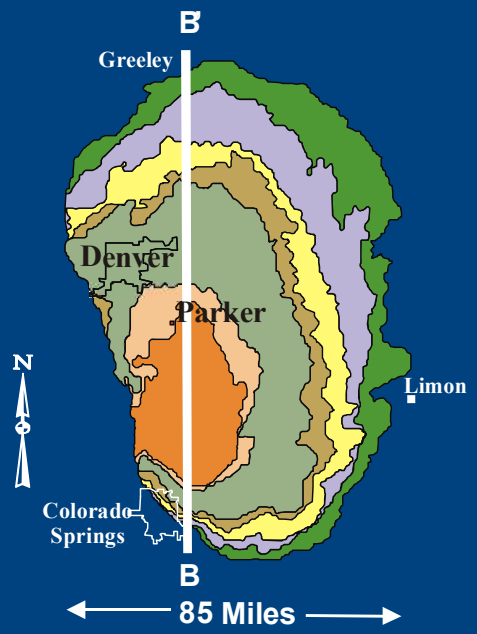
HYDROLOGIC CYCLE



Cross Section of Denver Basin



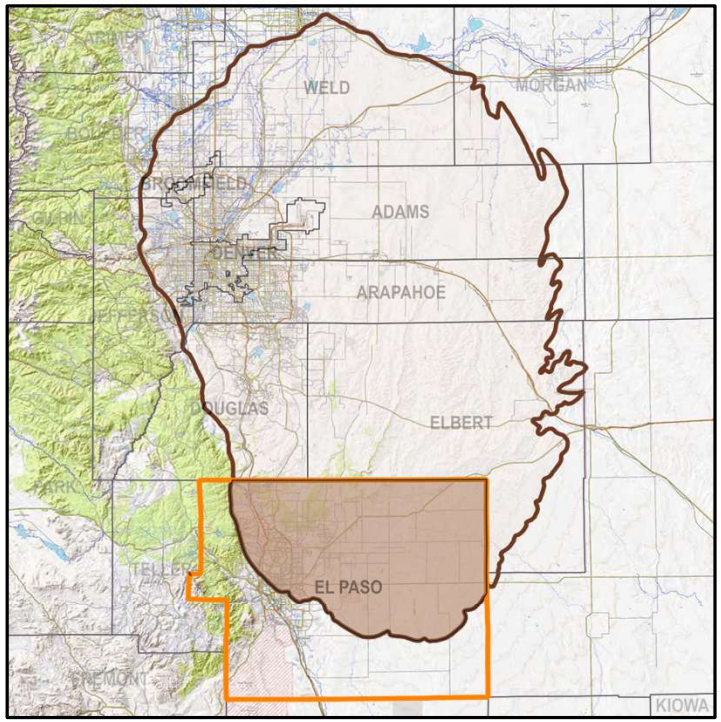
VERTICAL EXAGGERATION X32



RECOVERABLE VOLUME OF WATER IN STORAGE

DAWSON	27,000,000
DENVER	42,000,000
ARAPAHOE	80,000,000
LARAMIE-FOX HILLS	110,000,000
	TOTAL = 259,000,000

Denver Basin in El Paso County



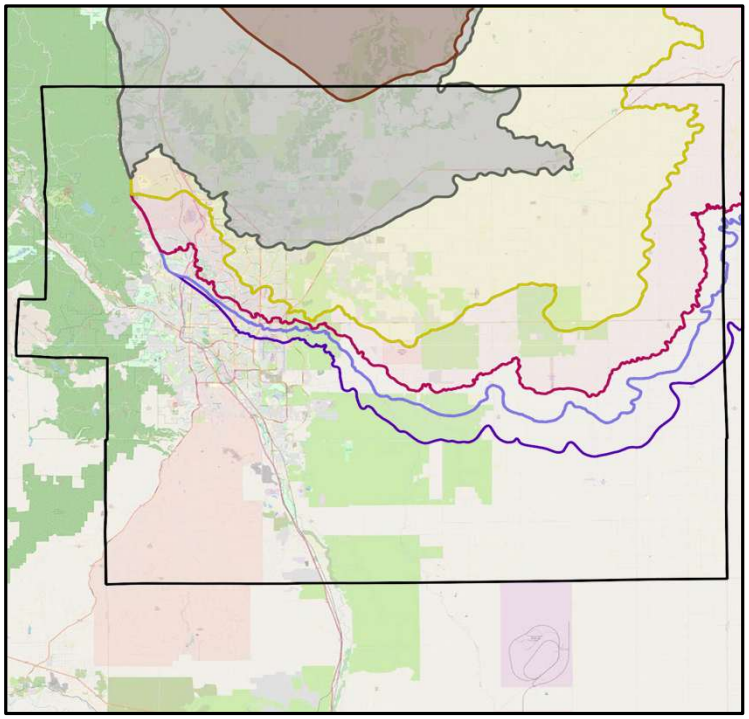
LEGEND

- Denver Basin Aquifer System
- El Paso County

0 10 20 mi

Note: Area calculations estimate 17% of the entire Denver Basin is located in El Paso County.

Areal Extent of Denver Basin Aquifers in County



LEGEND

- El Paso County
- Upper Dawson Aquifer
- Lower Dawson Aquifer
- Denver Aquifer
- Arapahoe Aquifer
- Laramie Confining Layer
- Laramie-Fox Hills Aquifer

N

Data Source: Paschke, S.S. (editor) 2011. Groundwater availability of the Denver Basin Aquifer System: U.S. Geological Survey Professional Paper 1770, Chapters A-C, 274 p.

Aquifer Hydraulic Conditions

- **Confined:** the aquifer water-bearing sediments are fully saturated and under pressure greater than atmospheric

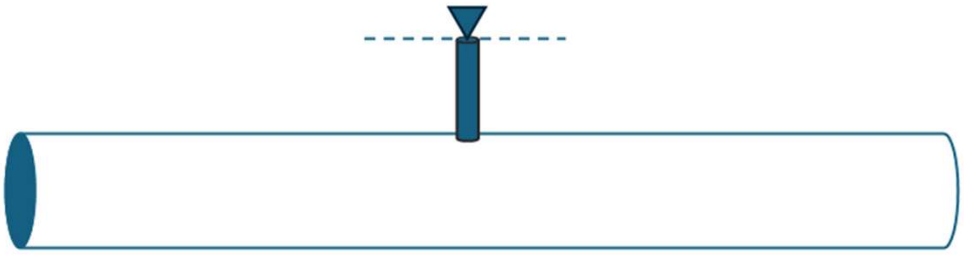
- **Partially confined:** the upper strata may not be under pressure but the lower strata remain under pressure since pumping has reduced water levels below the top of the aquifer

- **Unconfined:** all water-bearing strata are contained under atmospheric pressure

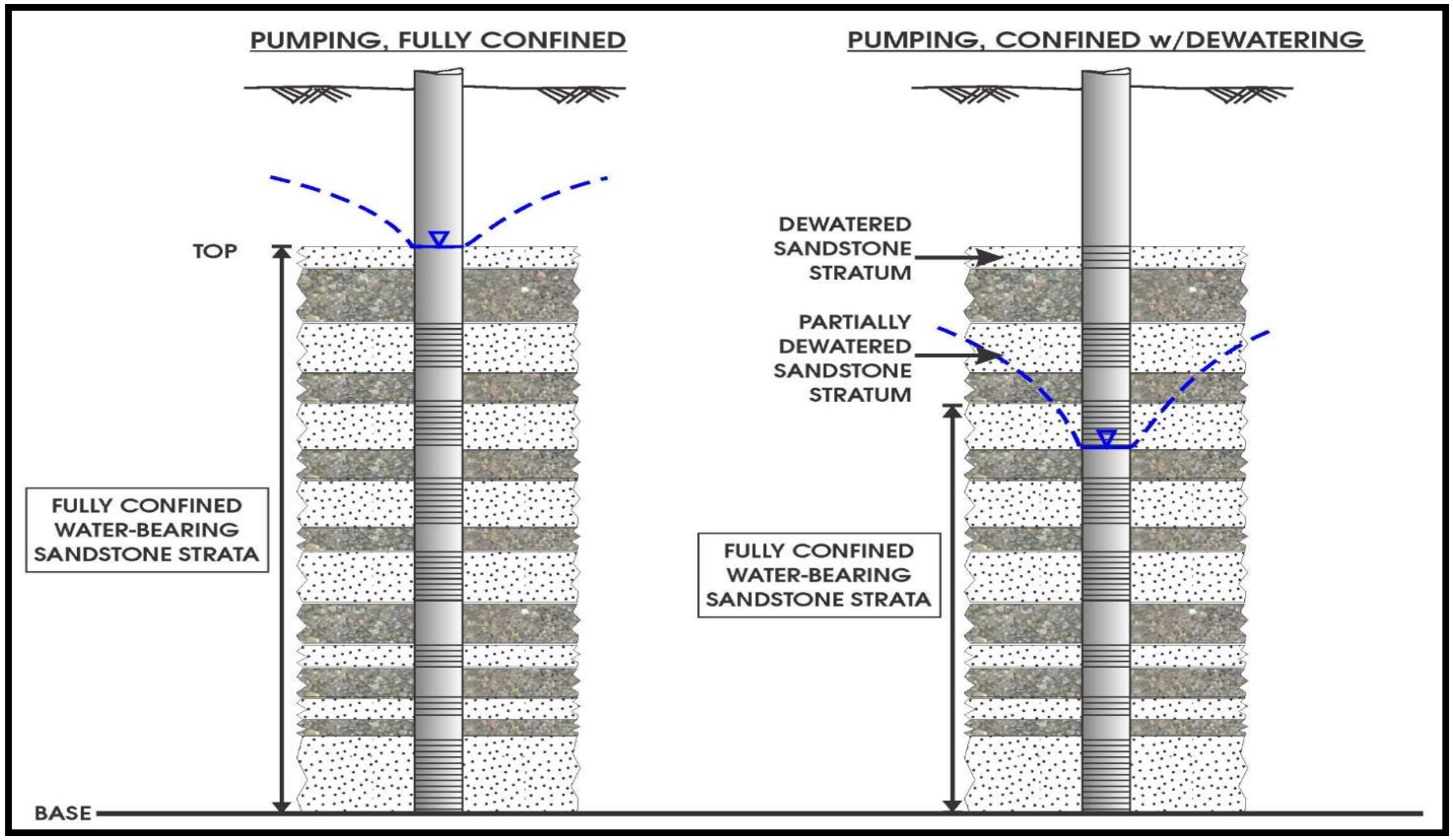
Unconfined vs. Confined Aquifer

Unconfined aquifer: pipe is full but not under pressure

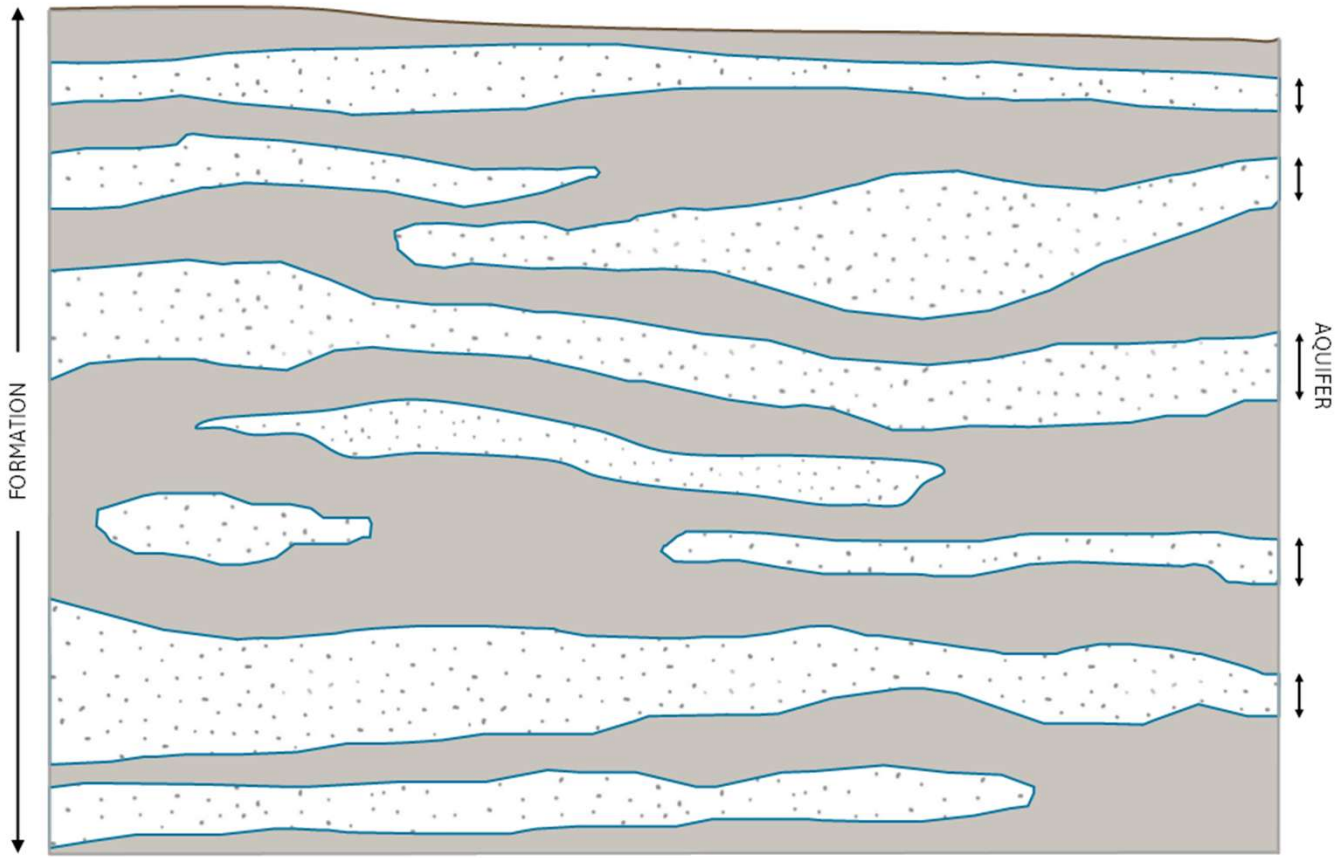
Confined aquifer: pressurized water distribution pipe



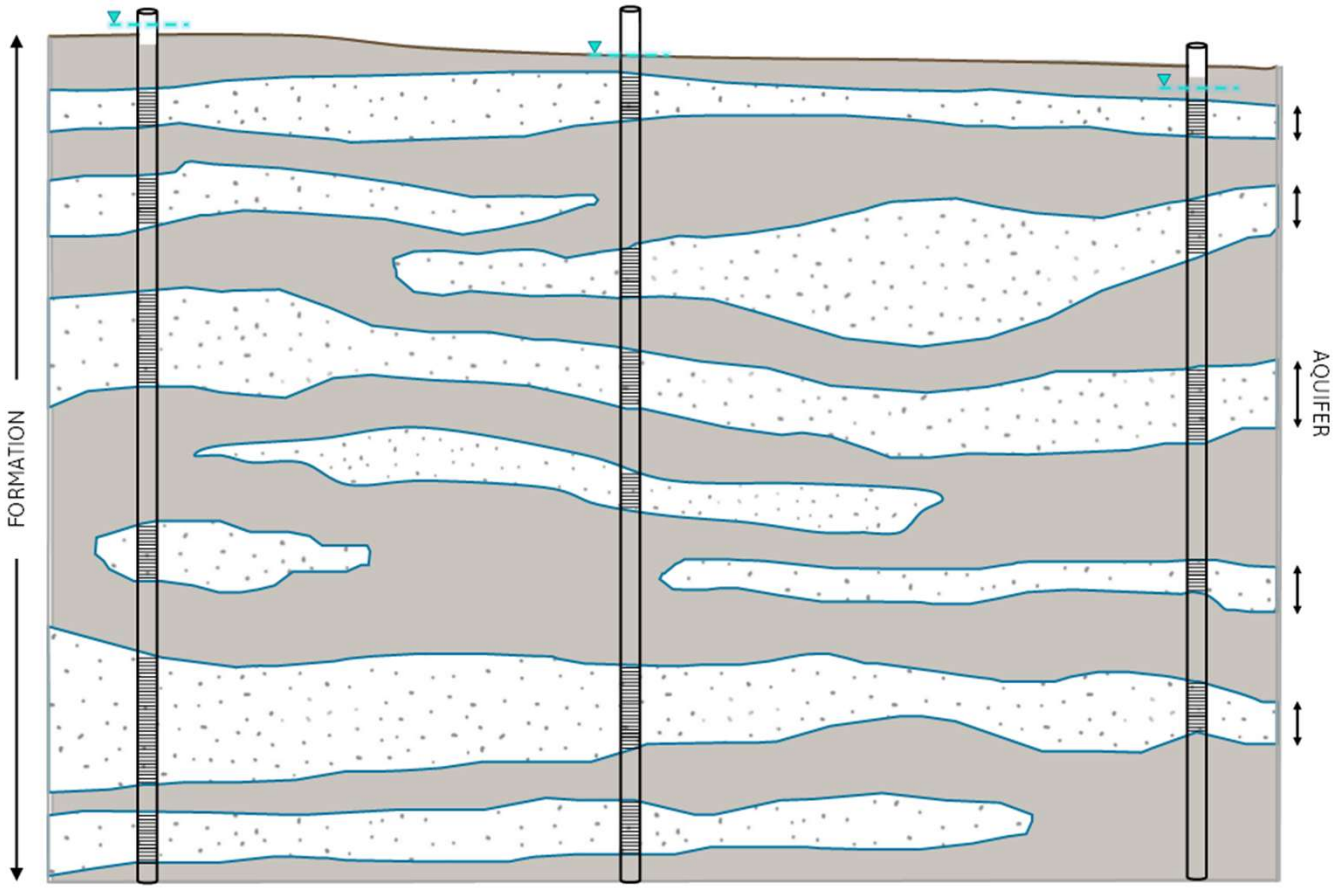
Confined Vs. Partially Confined Aquifer



Typical Denver Basin Stratigraphy



Heterogeneity in Denver Basin Aquifers



Denver Basin Statutory Allocation Formula

$$V = (A)(b)(S_y)/100$$

where,

V = annual allocation (acre-feet)

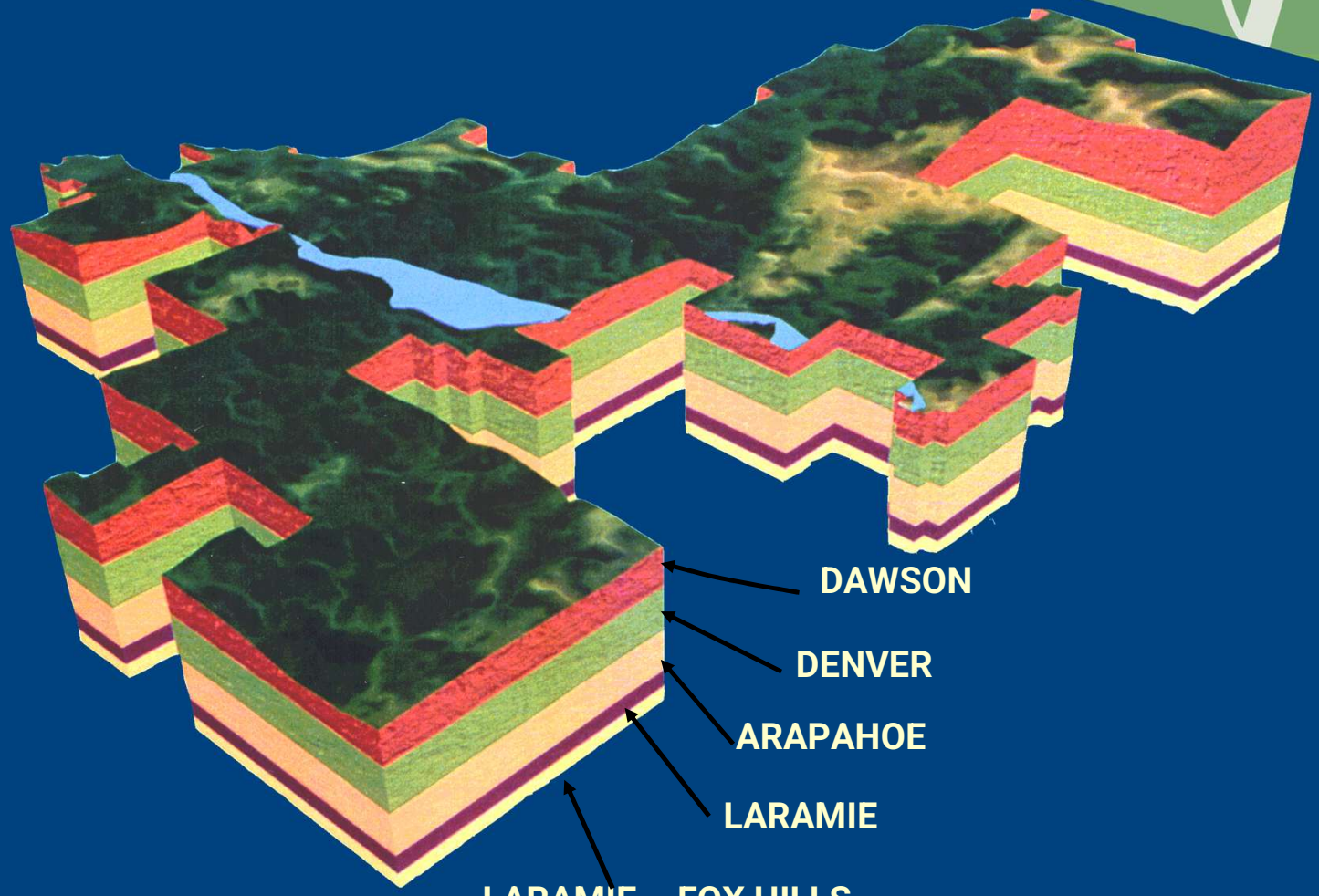
A = surface area (acres)

b = saturated thickness (feet)

S_y = aquifer specific yield (dimensionless)

*El Paso County has a 300-yr Rule, so these values would be divided by 3

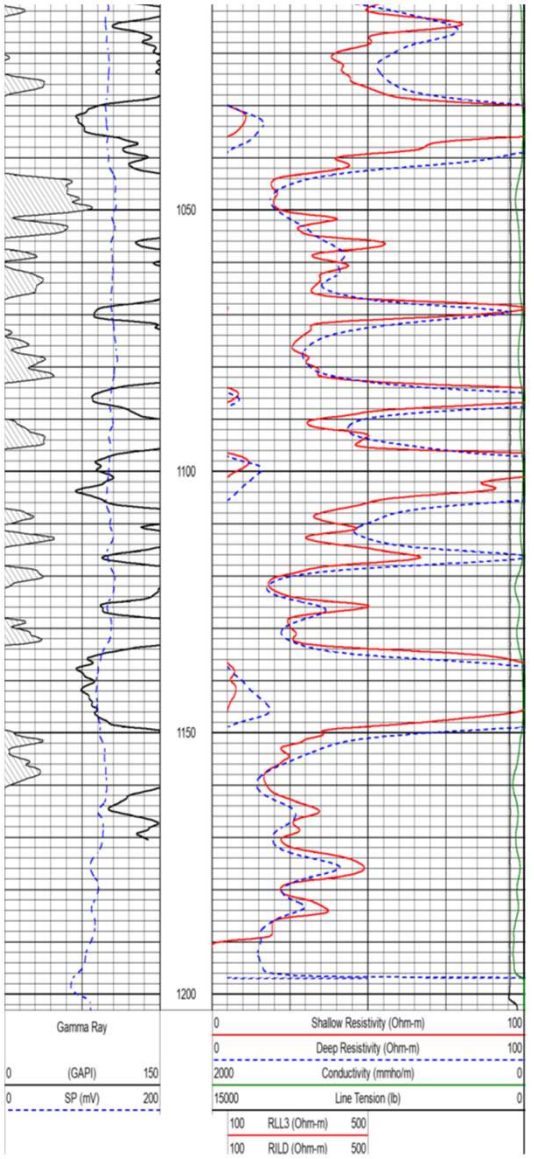
Appropriation of Denver Basin Water



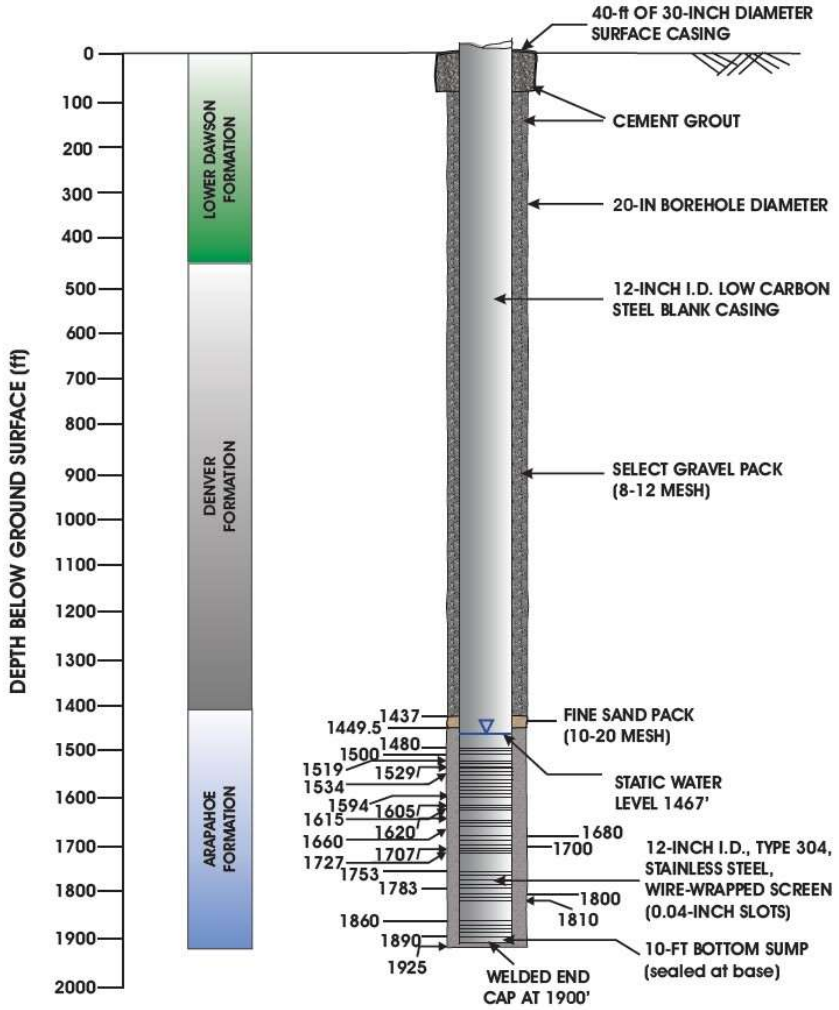
Simplifying Assumptions In Statutory Allocation Method

- There is one continuous sandstone unit in each aquifer
- That water-bearing sandstone is both horizontally continuous across the basin and is homogeneous
- No consideration for water contained under pressure in aquifers, i.e., the aquifers are fully unconfined
- All of these assumptions are demonstratively false and result in misleading conclusions

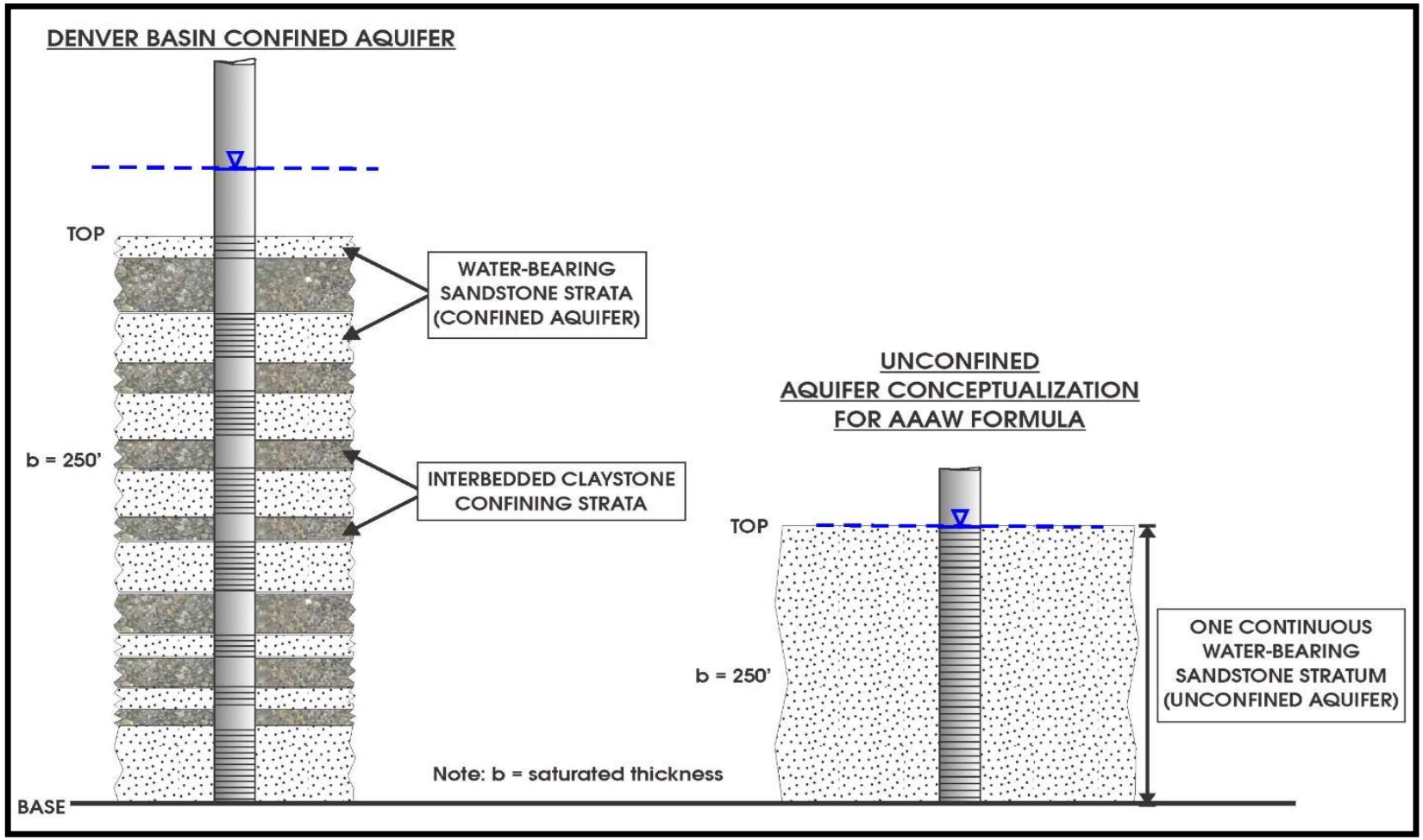
Interbedded Sandstone Units



Interbedded Sandstone Units



No Consideration of Pressurized Aquifers



Exempt vs. Non-Exempt Wells

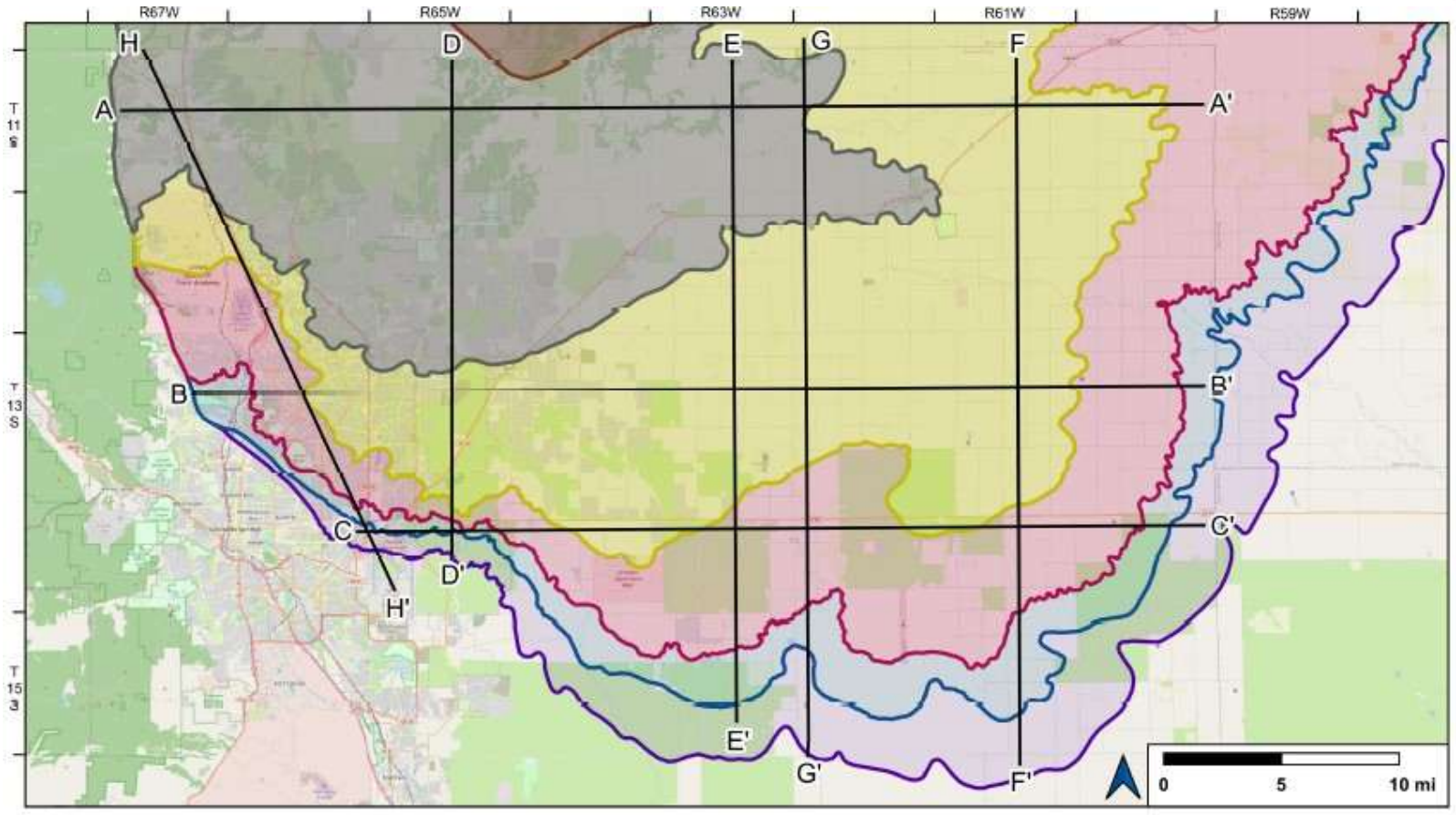
- Important to understand differences in types of wells and what uses can be permitted
- Non-exempt wells (CRS 37-90-137)
  - Large uses, e.g., municipal, commercial, industrial, irrigation
  - Primary focus of water allocation method
  - Nontributary/not-nontributary water
  - 600-ft spacing rule
- Exempt wells (CRS 37-92-602)
  - Small yield (15 gpm) residential wells
  - Domestic exempt wells on 35+ acre lots (expanded uses)
  - Commercial exempt wells

DENVER BASIN WATER RELIABILITY ANALYSIS

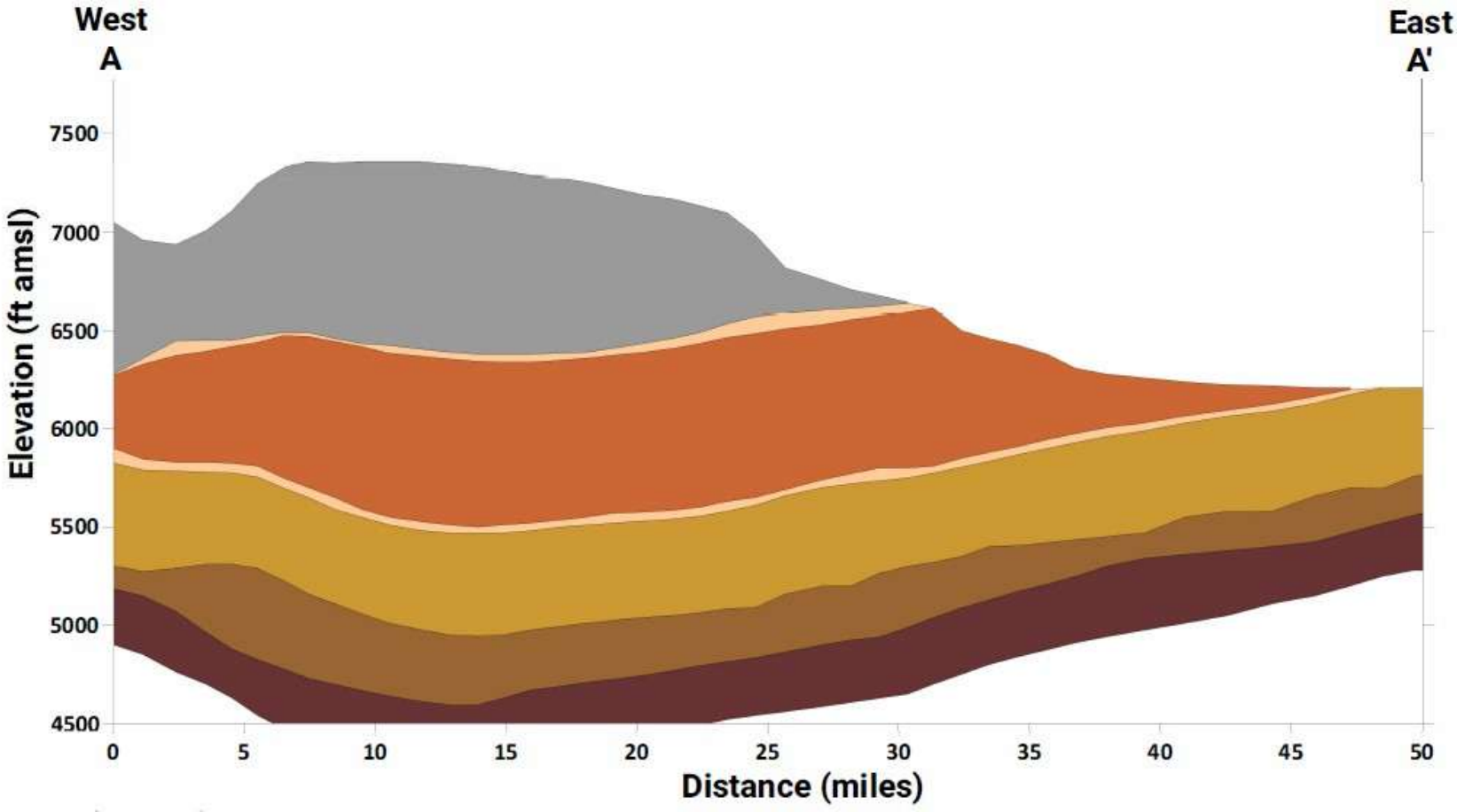
Study Assessment Factors

- Analysis of the structure of each of the Denver basin aquifers;
- Evaluation of the tops and bottoms of each aquifer along multiple north-south and west-east cross sections;
- Development of time series hydrographs of water level changes within the aquifers;
- Assessment of the hydraulic condition of each aquifer across the county, i.e., fully confined or partially confined, and how those aquifer conditions have changed over time;
- Assessment of areas that are potentially impacted by aquifer boundary conditions; and
- Assessment of the physical reliability of the Denver basin aquifers water supply.

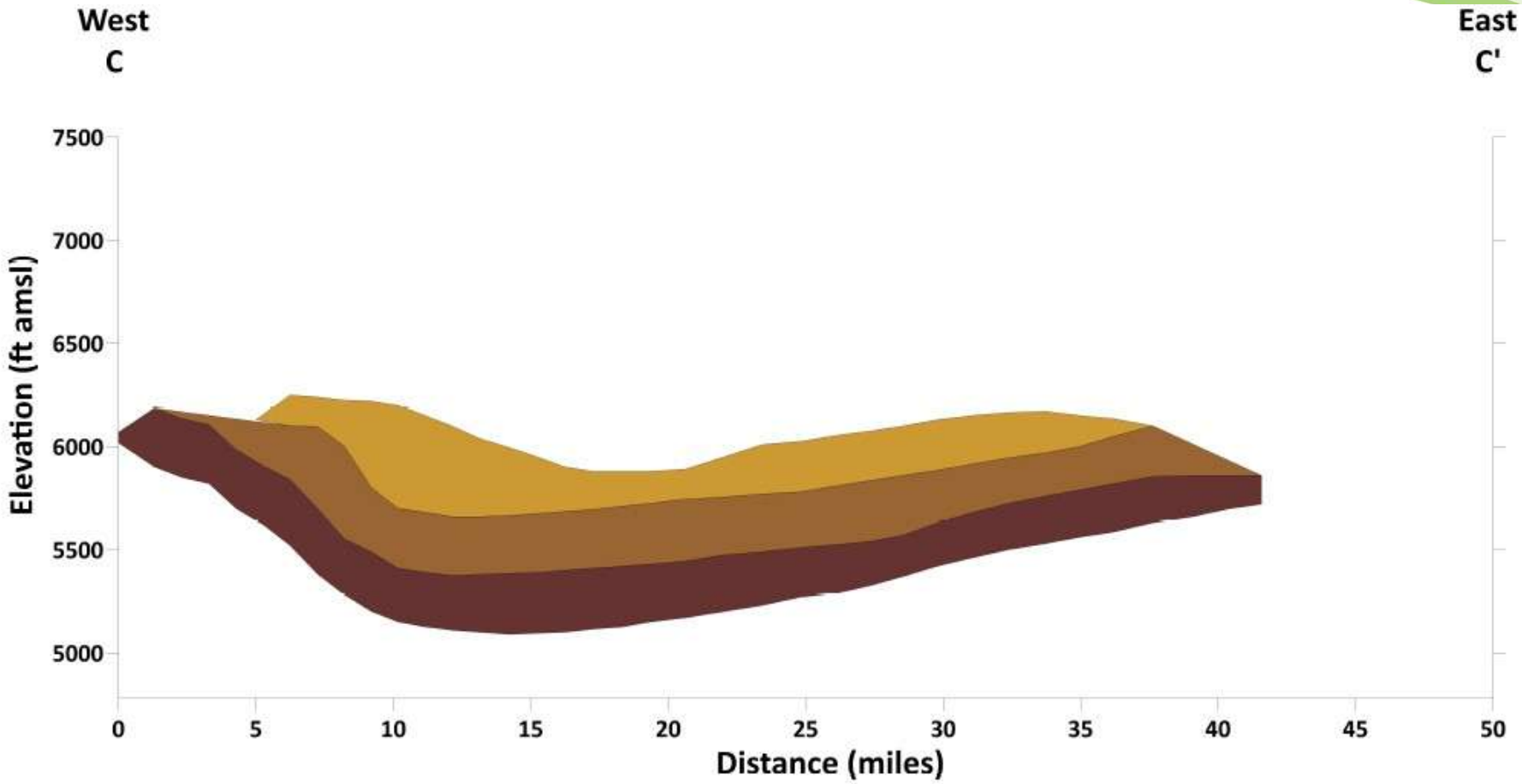
Denver Basin Cross-Sections



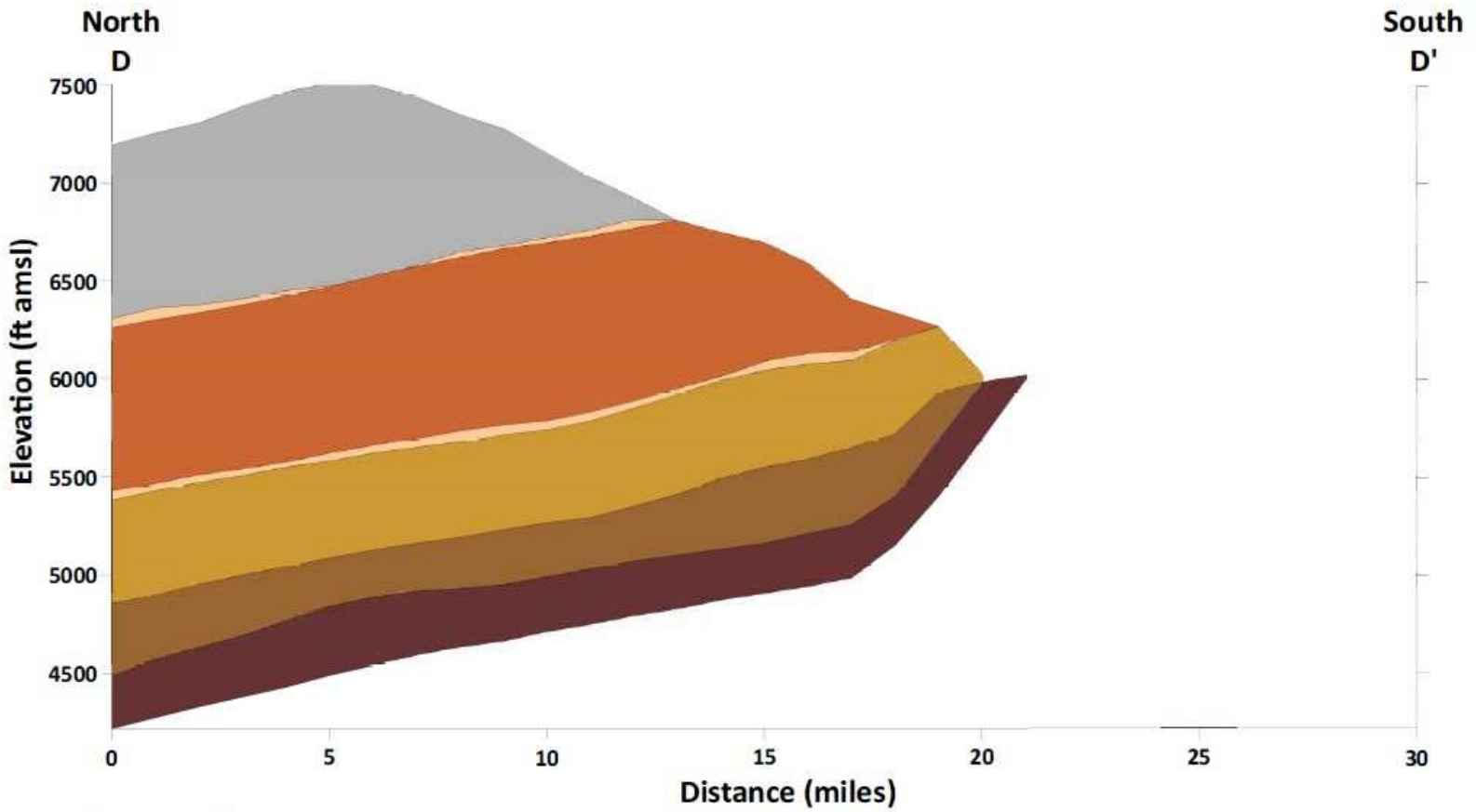
Cross-Section A-A’



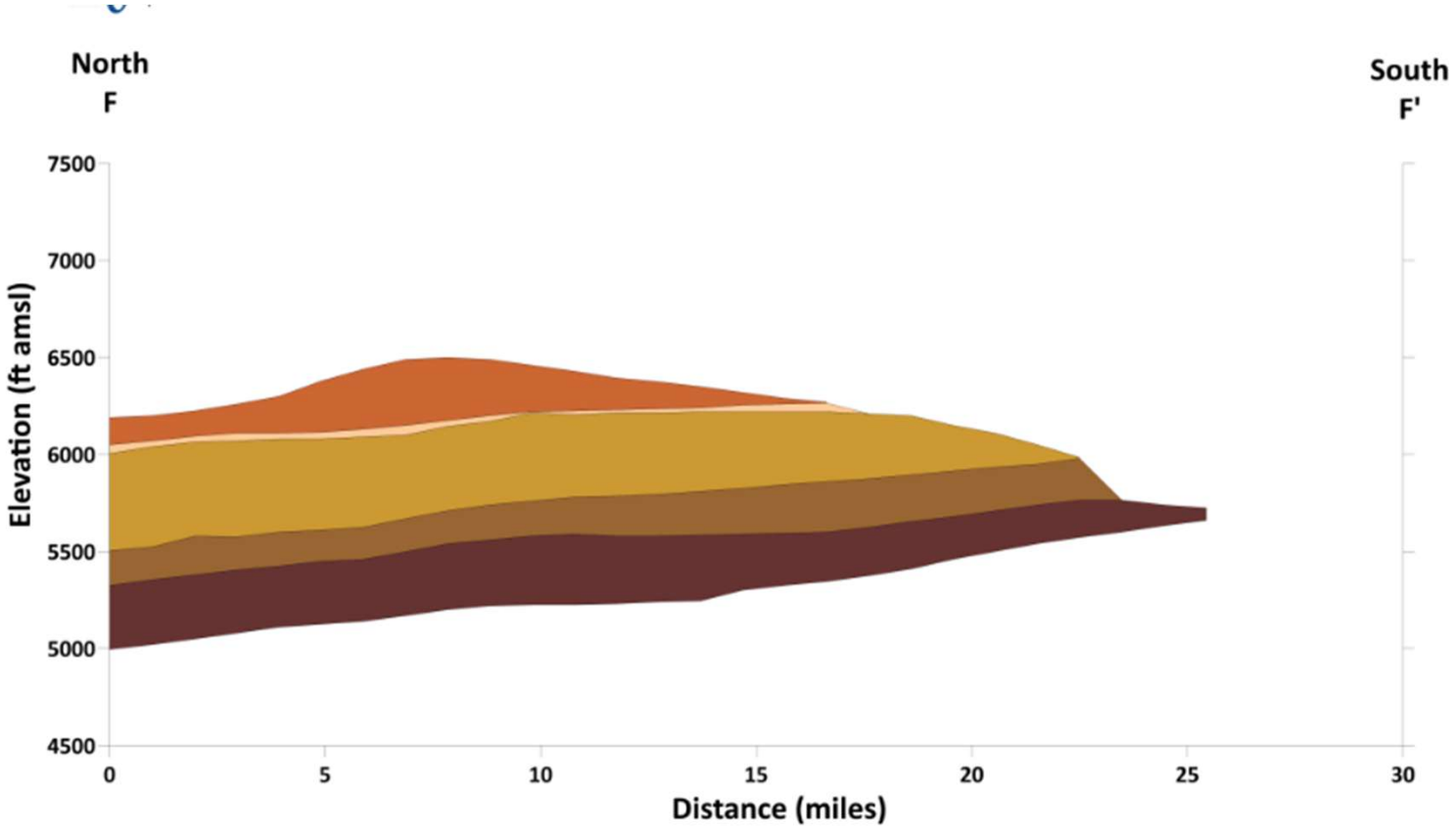
Cross-Section C-C’



Cross-Section D-D’

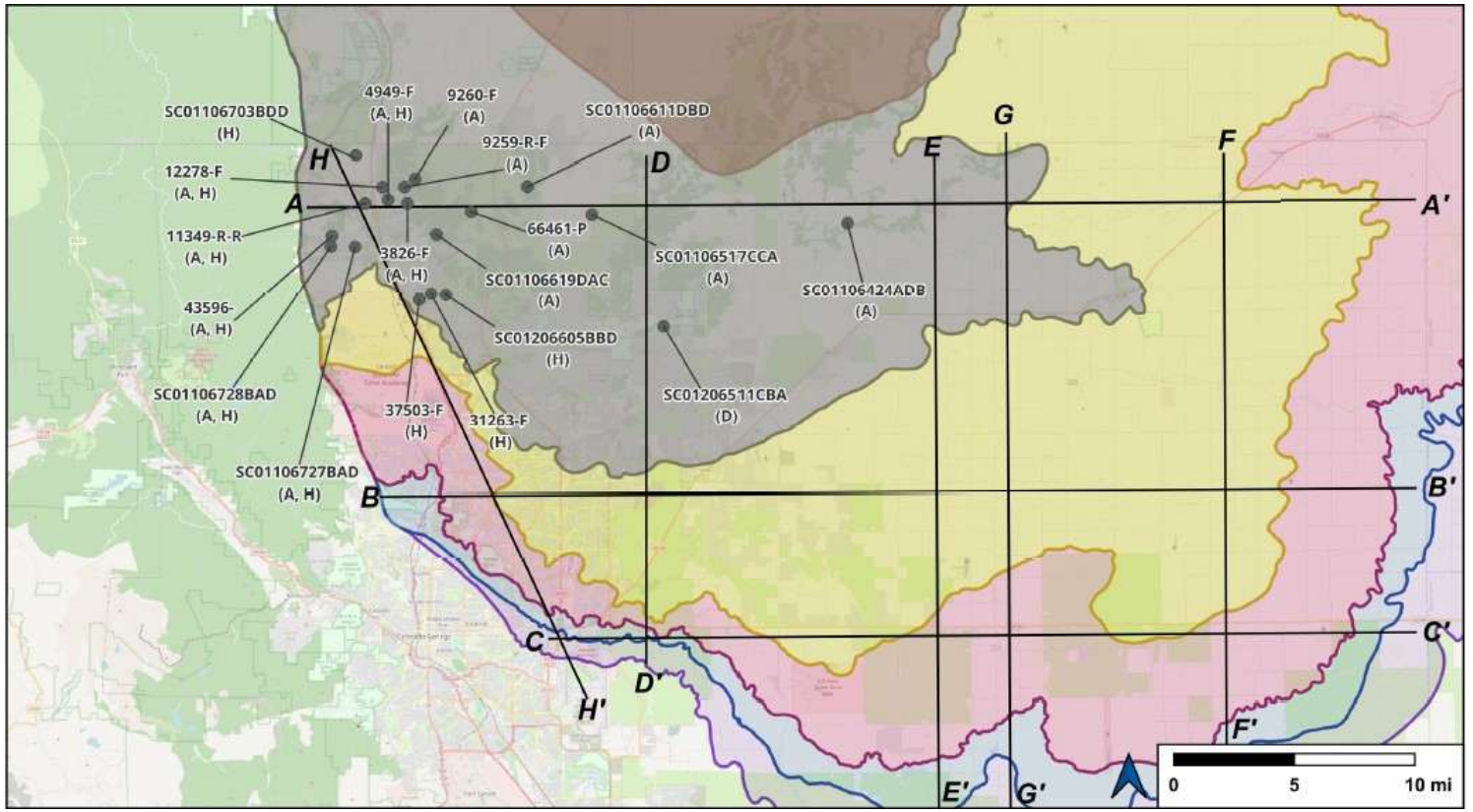


Cross-Section F-F

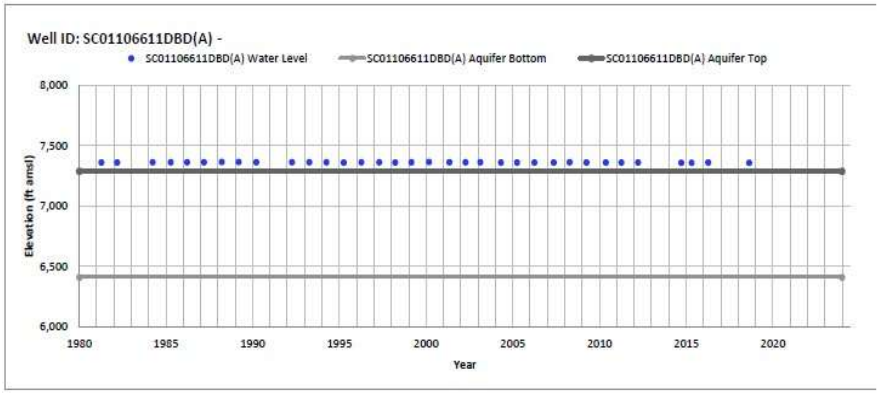


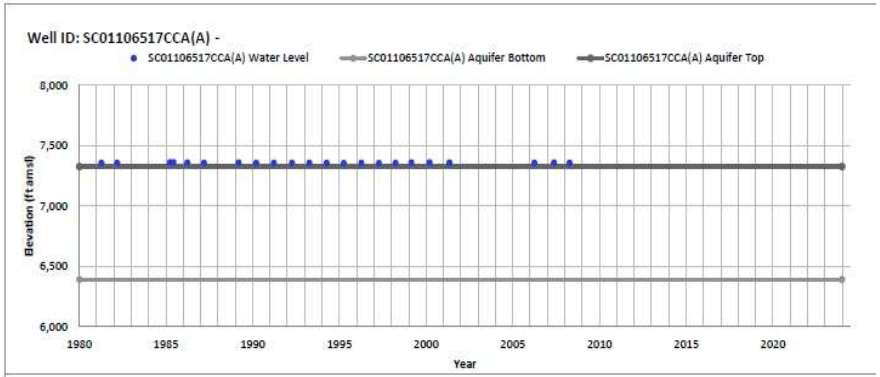
DAWSON AQUIFER

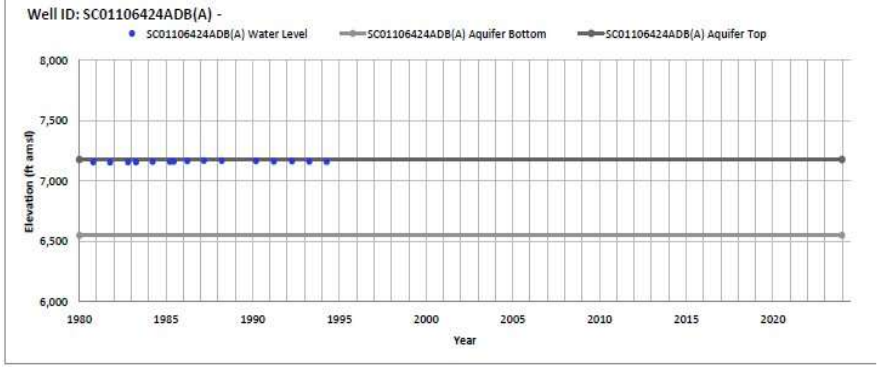
Dawson Aquifer Wells



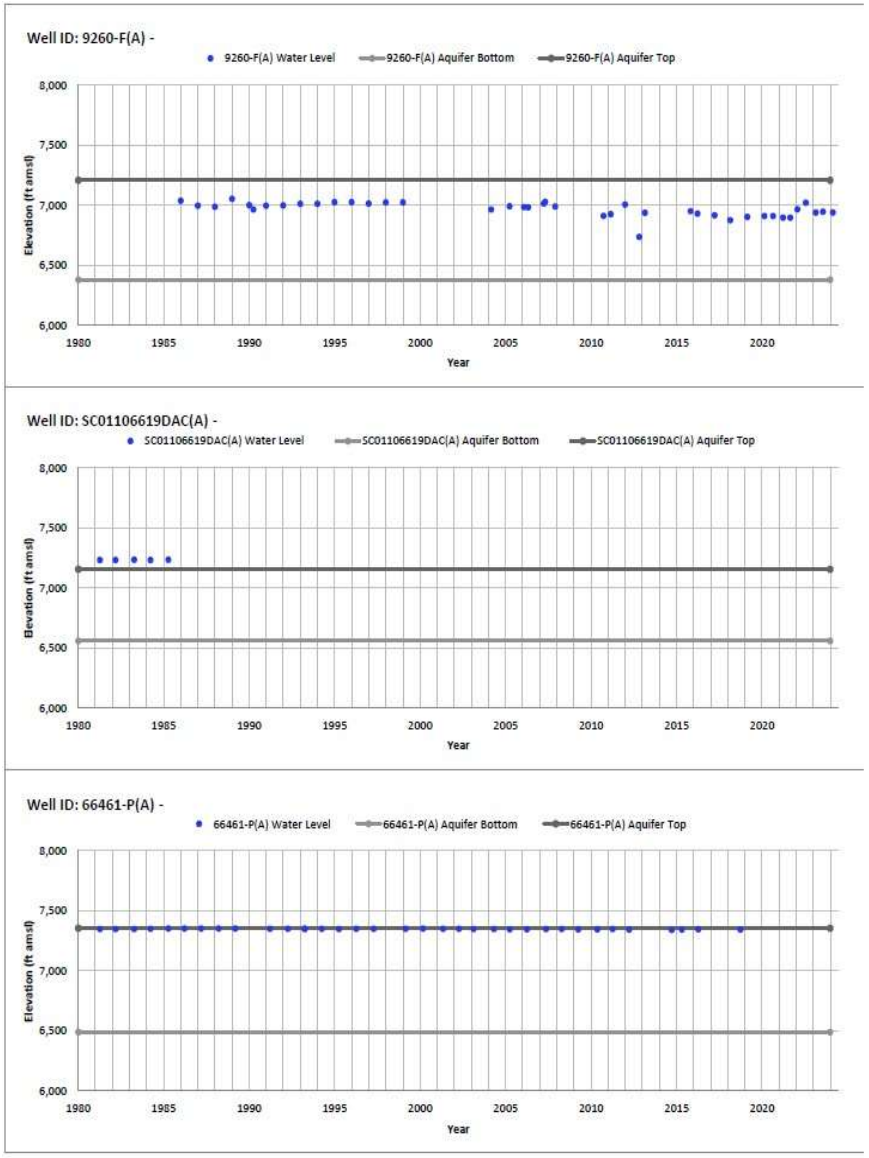
Dawson Aquifer Well Hydrographs



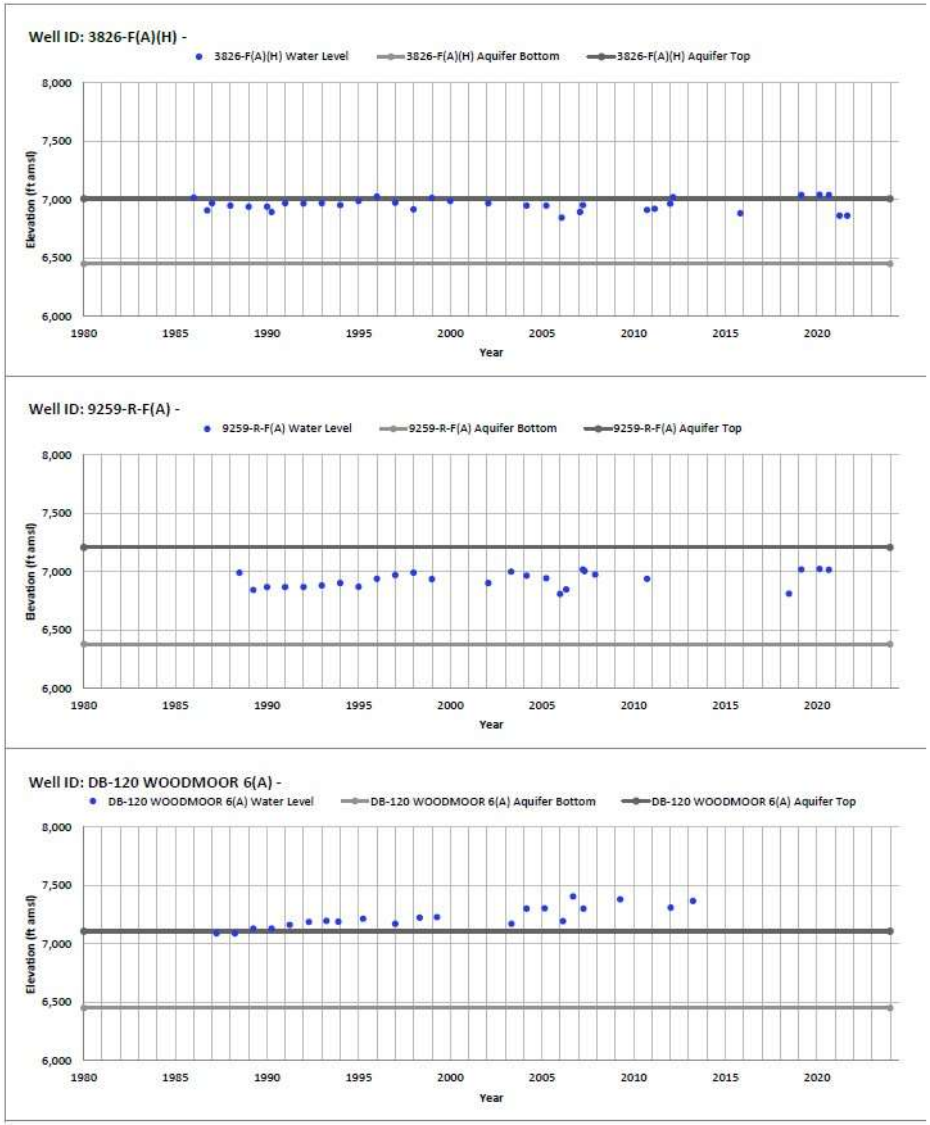




Dawson Aquifer Well Hydrographs



Dawson Aquifer Well Hydrographs

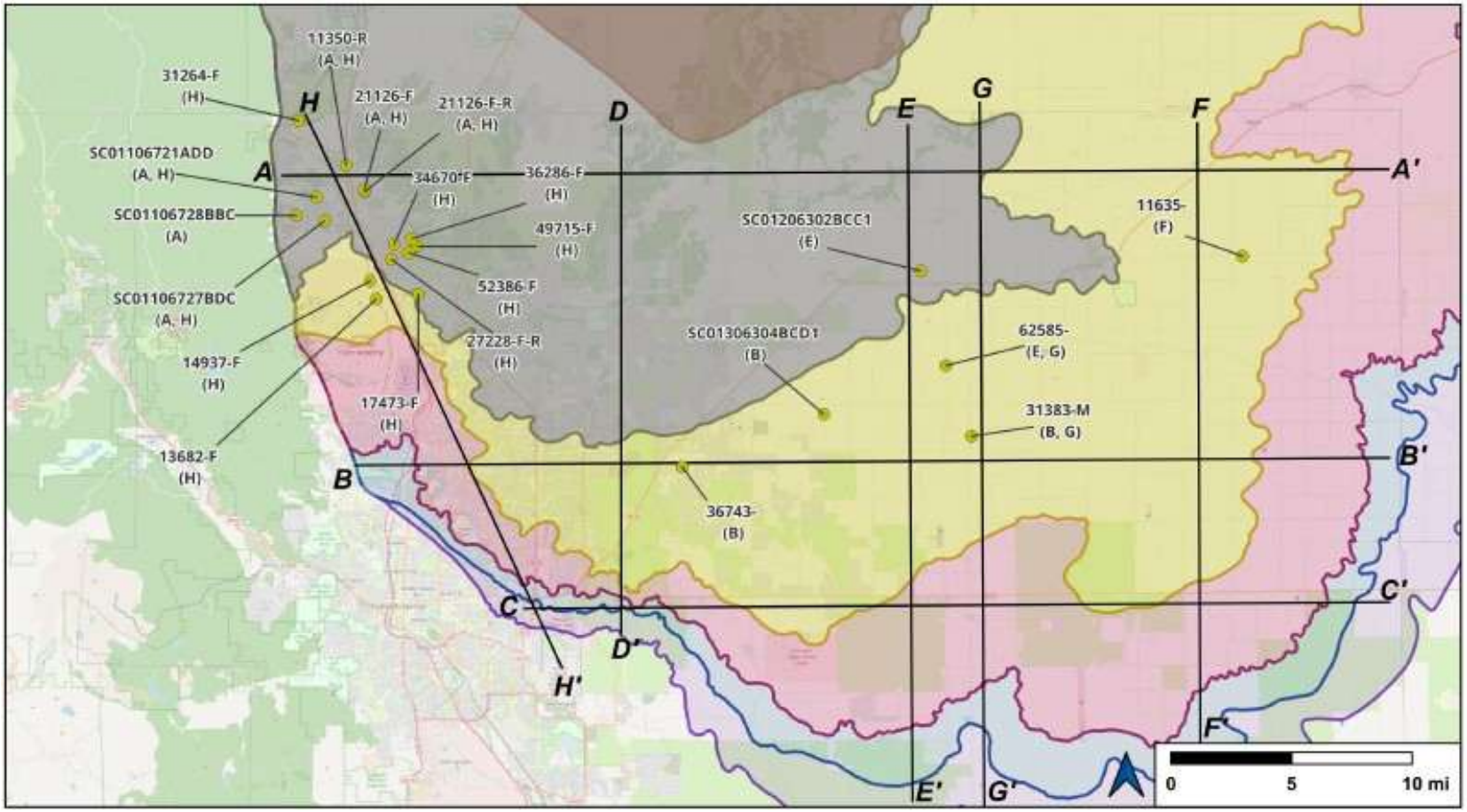


Dawson Aquifer Analysis

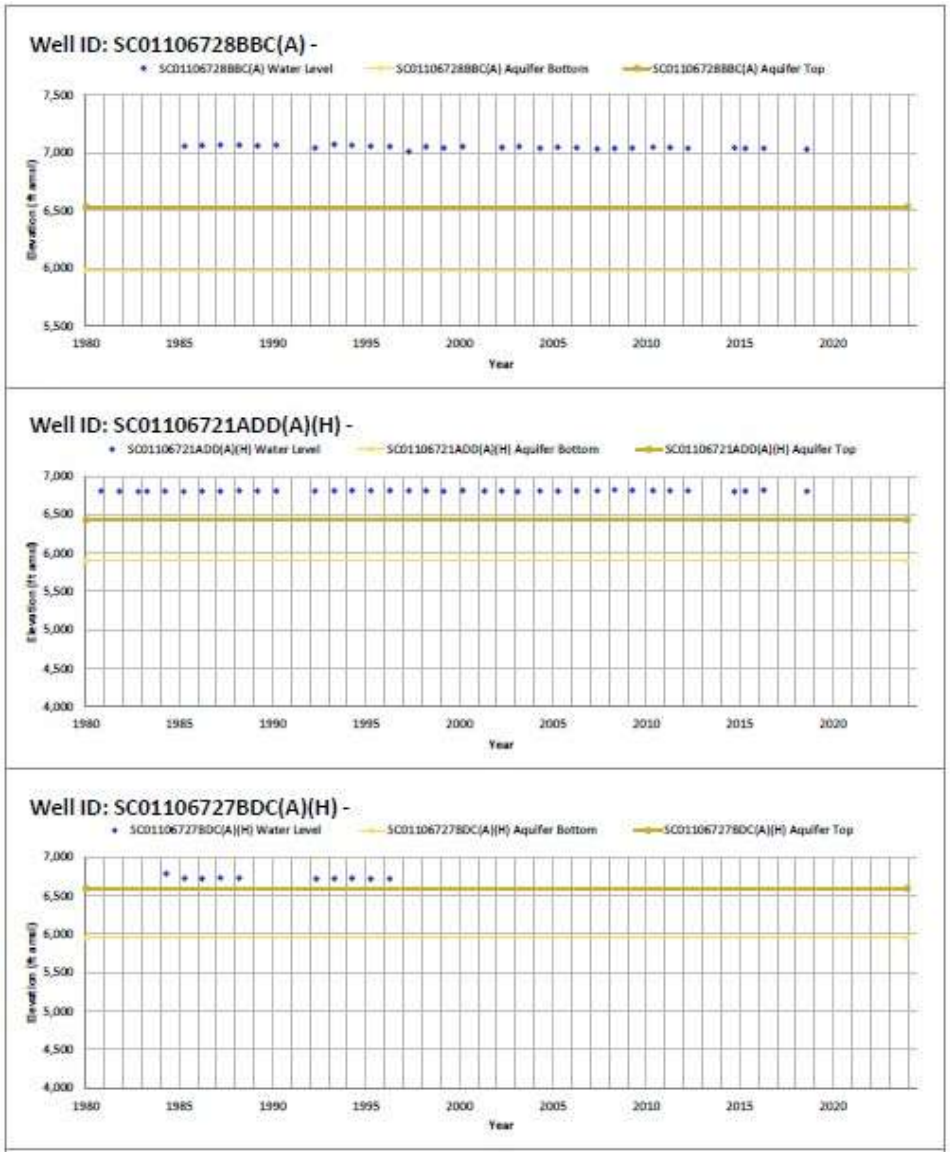
- Limited areal extent in northwestern portion of County
- Signs of dewatering in the aquifer
- Boundary conditions exist due to limited extent, which can limit well production
- Best suited for low yield exempt residential/commercial wells
- Higher production non-exempt wells should be limited and have significant well-to-well spacings
- Generally, the Dawson aquifer is not used extensively for large non-exempt uses

DENVER AQUIFER

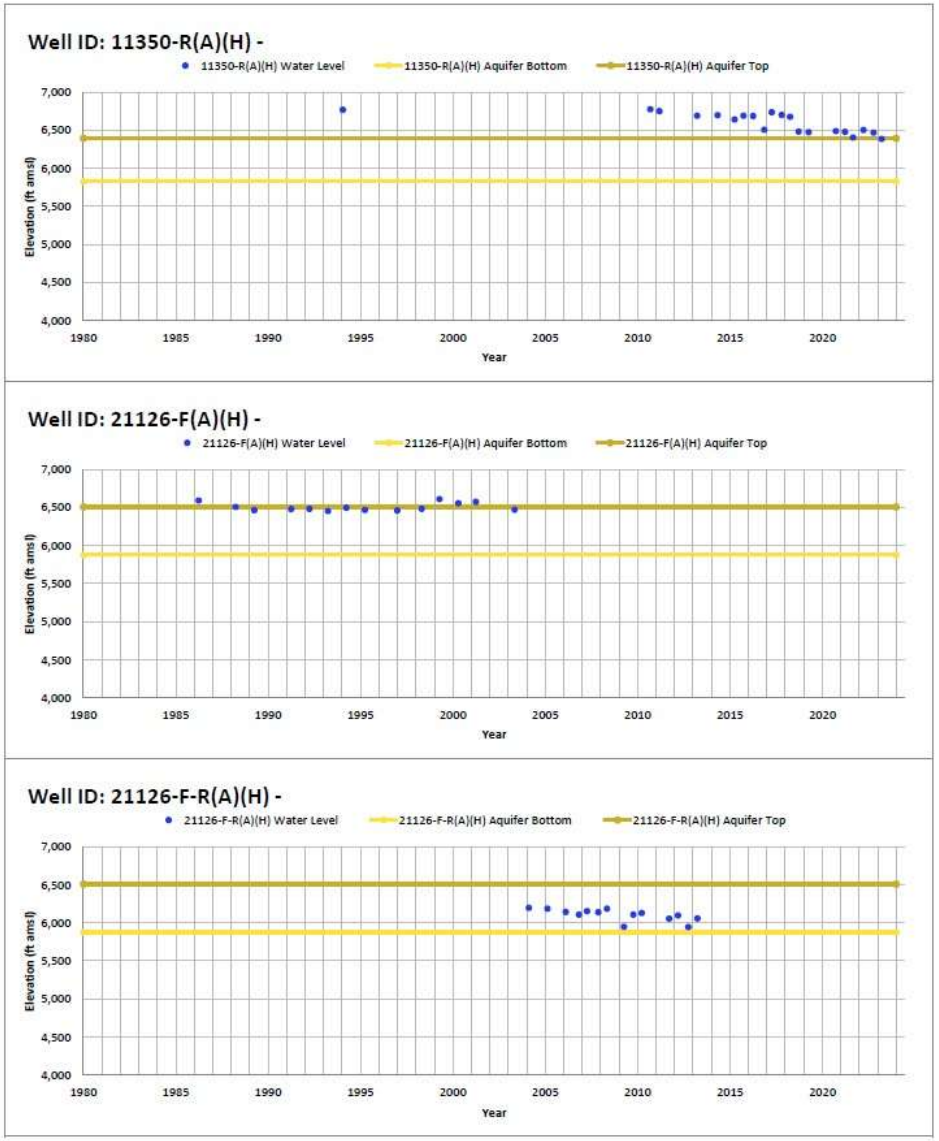
Denver Aquifer Wells



Denver Aquifer Well Hydrographs

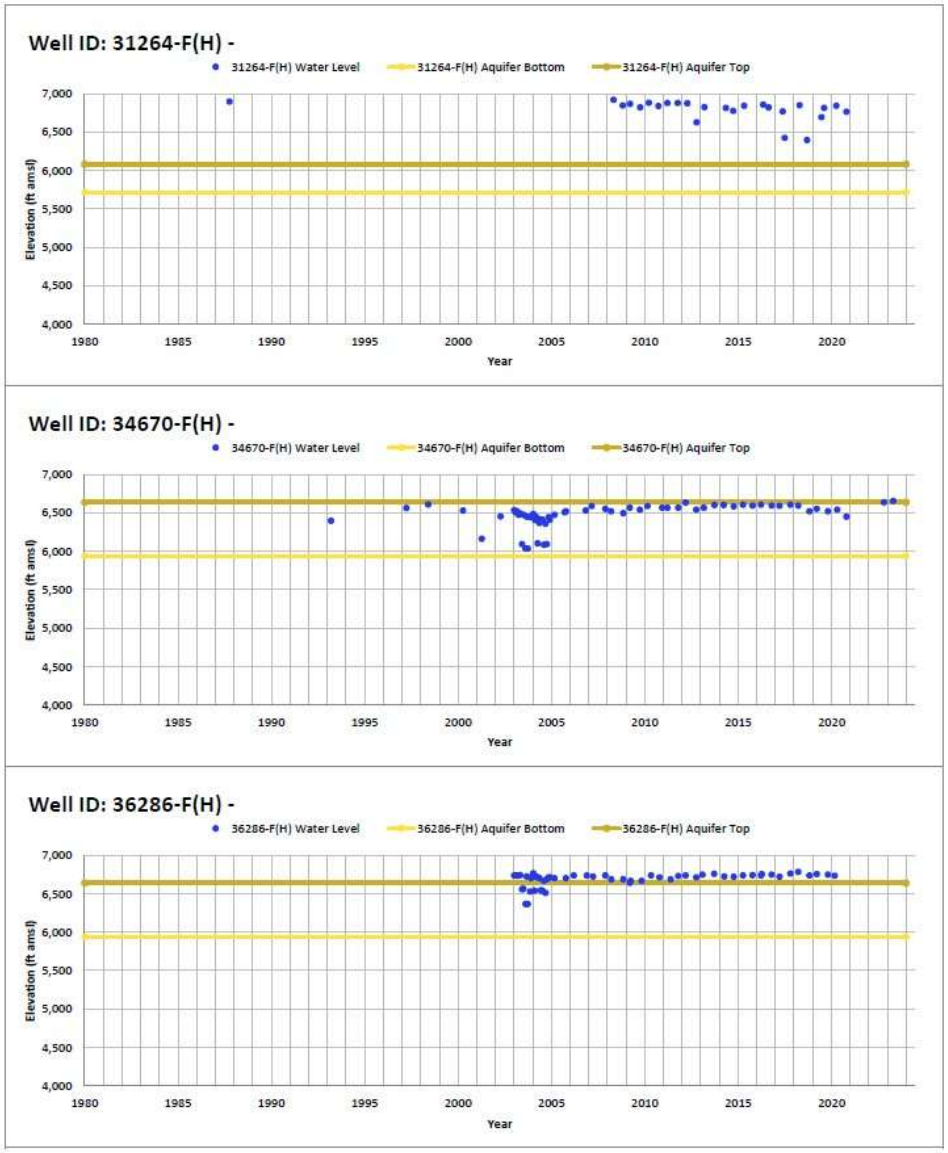


Denver Aquifer Well Hydrographs

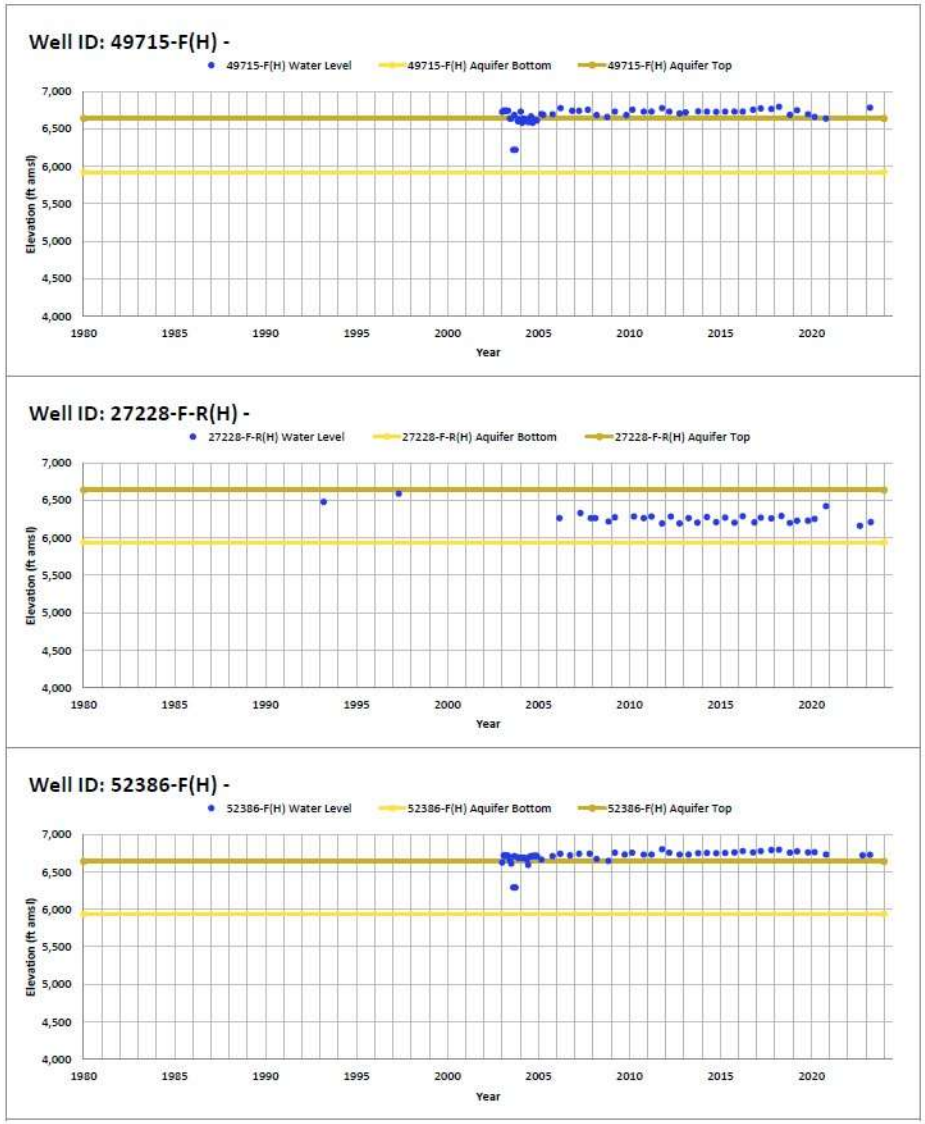


Denver Aquifer Well Hydrographs

DENVER AQUIFER WELL HYDROGRAPHS



Denver Aquifer Well Hydrographs

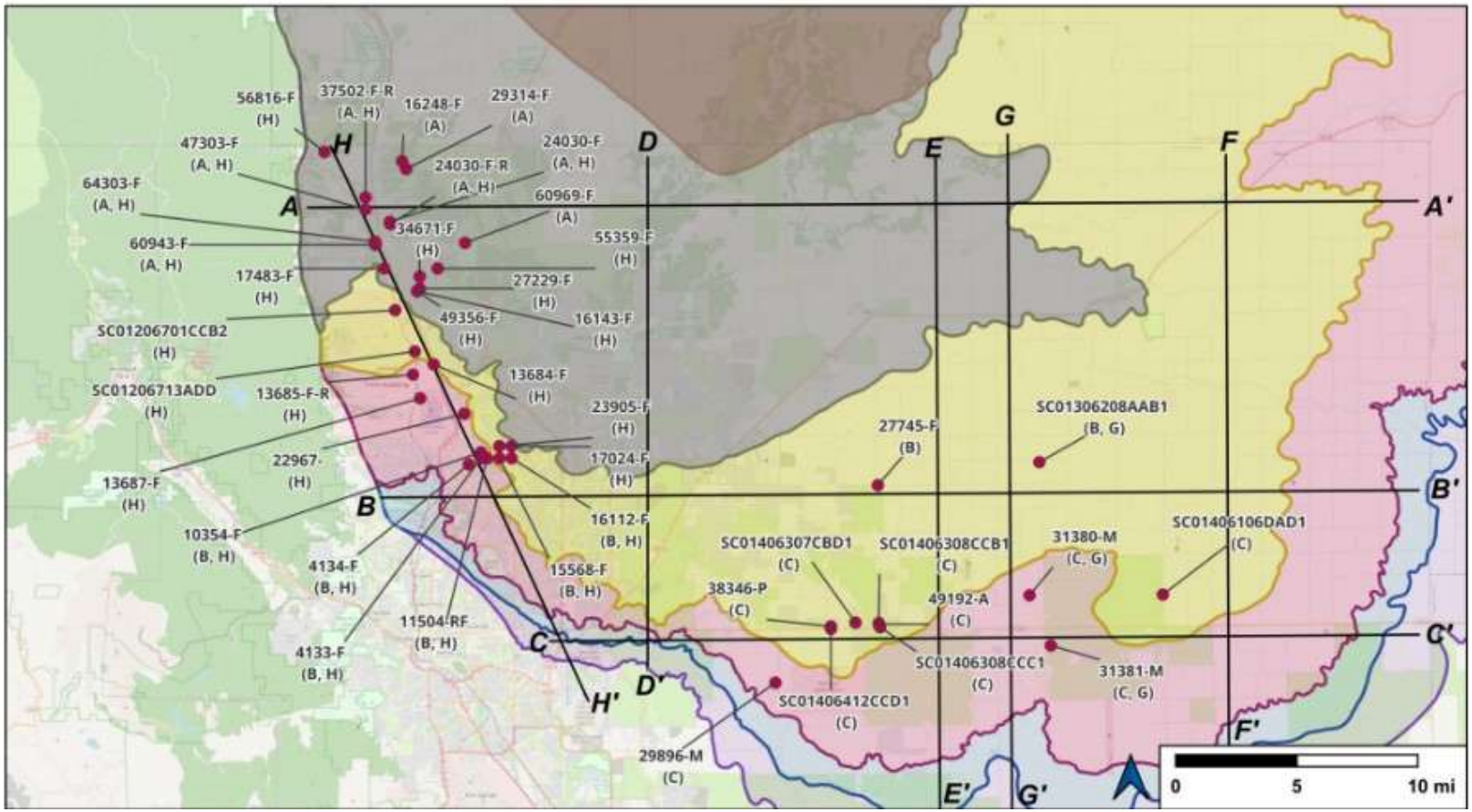


Denver Aquifer Analysis

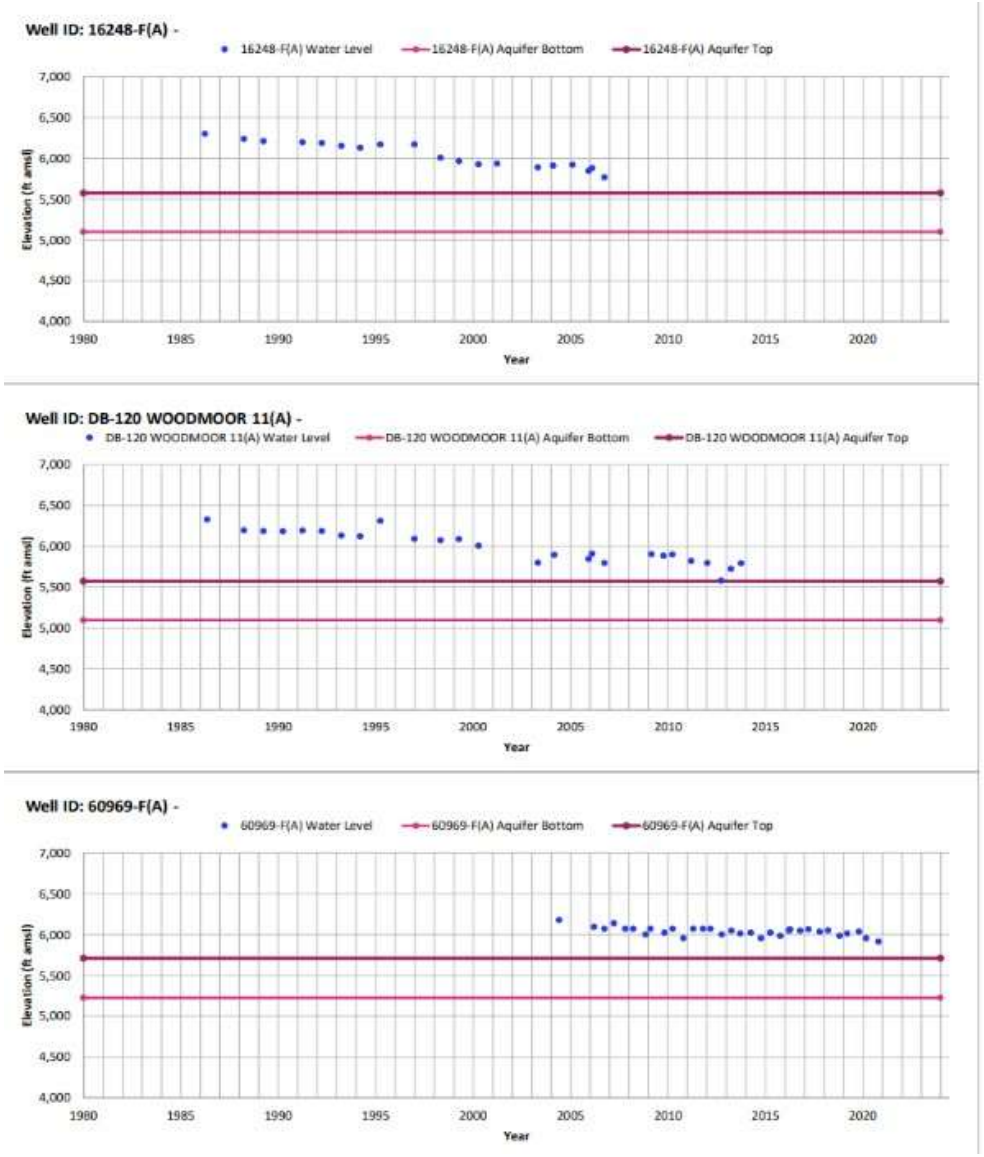
- Along with the Arapahoe aquifer, one of the two principal municipal production aquifers
- Some local dewatering of the upper formation in the most concentrated area of pumping in northwestern quadrant of County
- Aquifer only outcrops on southern edge of basin, extends further east beyond County line
- Considerable thinning to the east and south, but aquifer remains fully confined
- Thinning affects production capability of wells
- Viable, reliable source of water for residential and larger municipal/commercial uses

ARAPAHOE AQUIFER

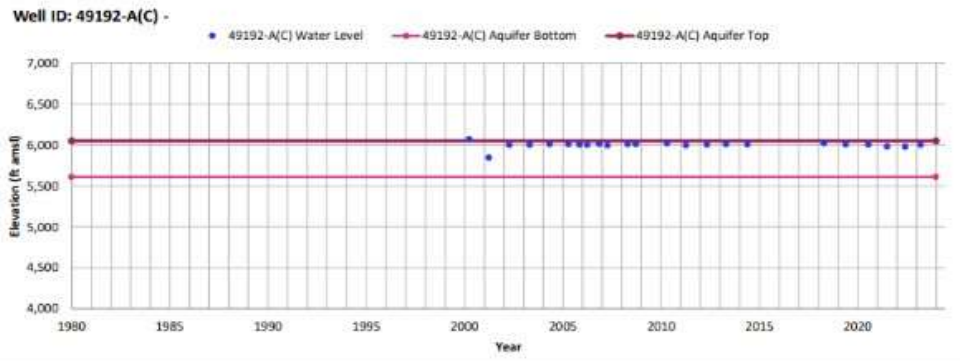
Arapahoe Aquifer Wells

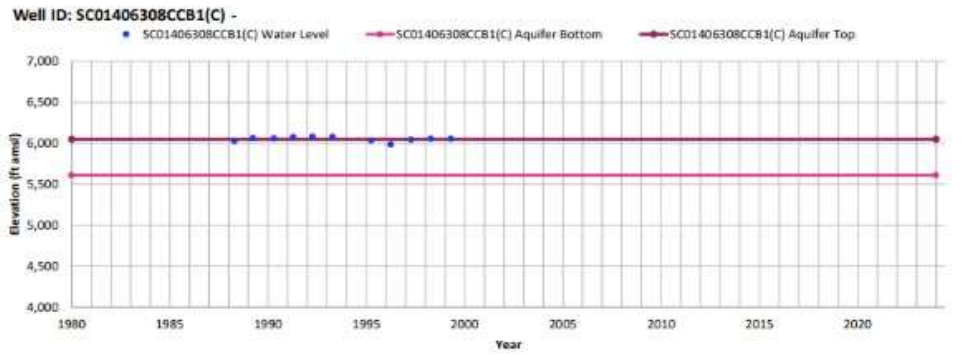


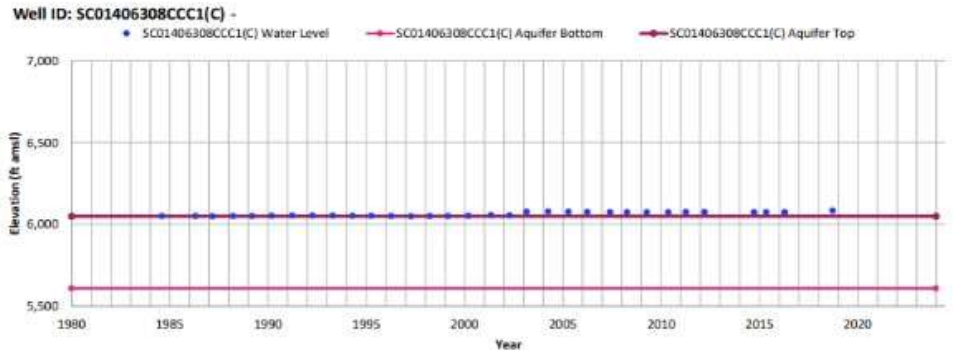
Arapahoe Aquifer Well Hydrographs



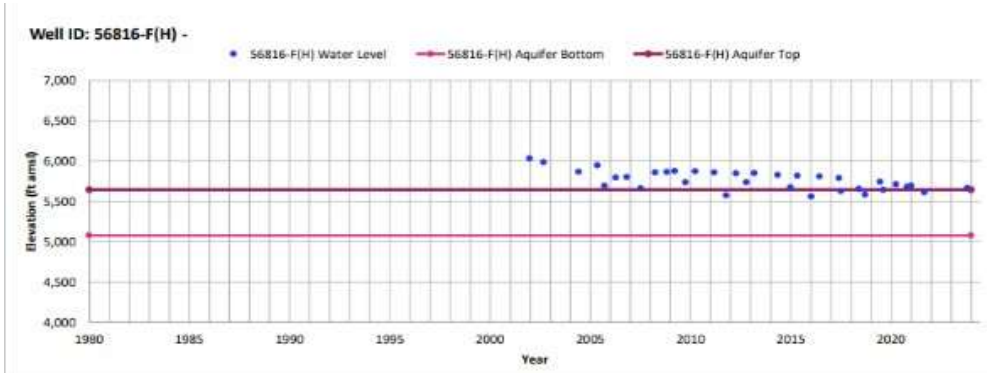
Arapahoe Hydrographs Aquifer Well

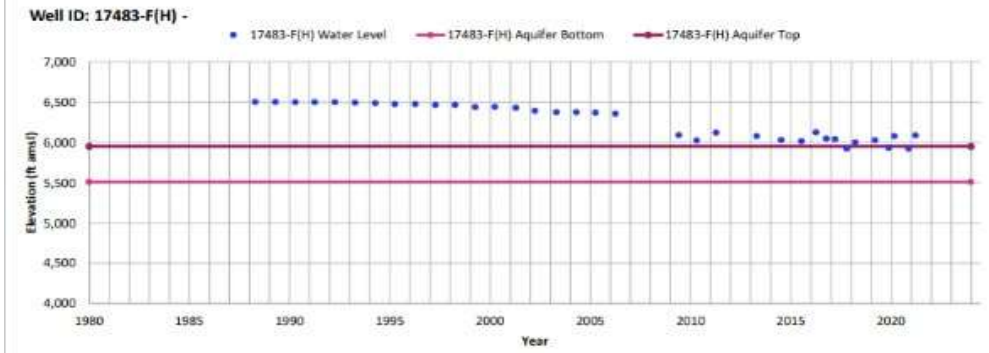


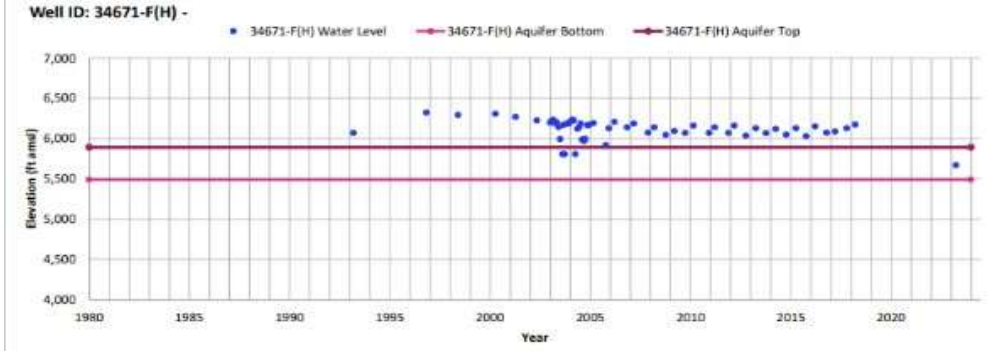




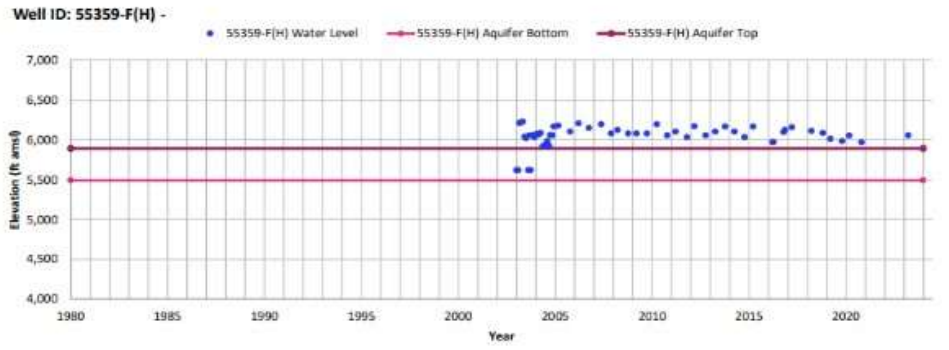
Arapahoe Aquifer Well Hydrographs

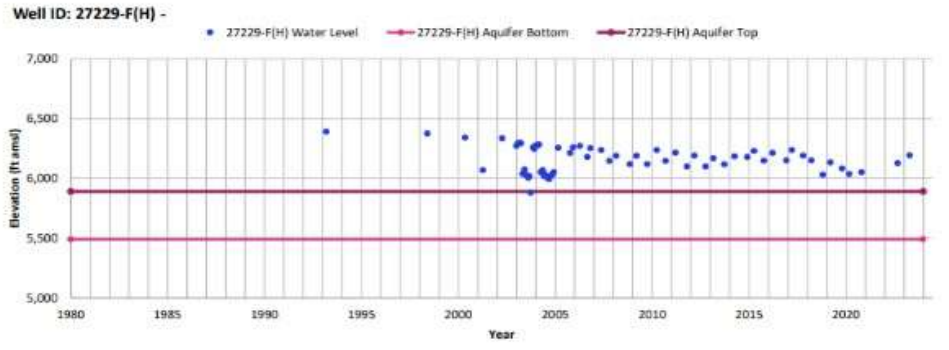


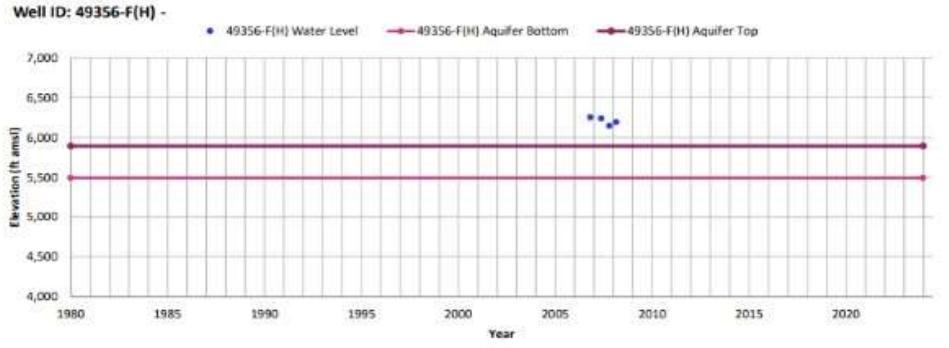




Arapahoe Aquifer Well Hydrographs

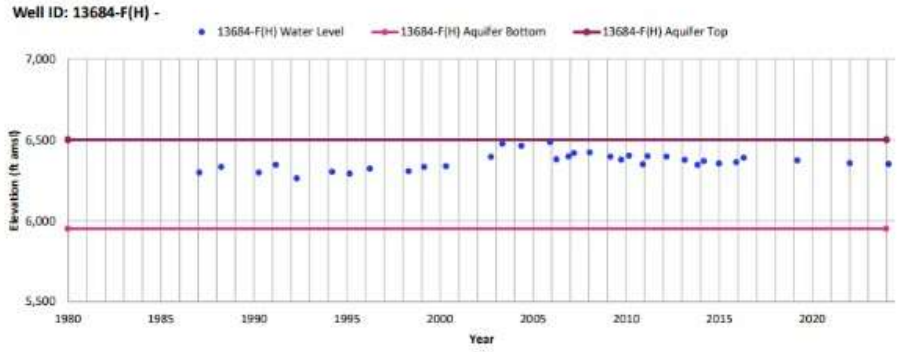


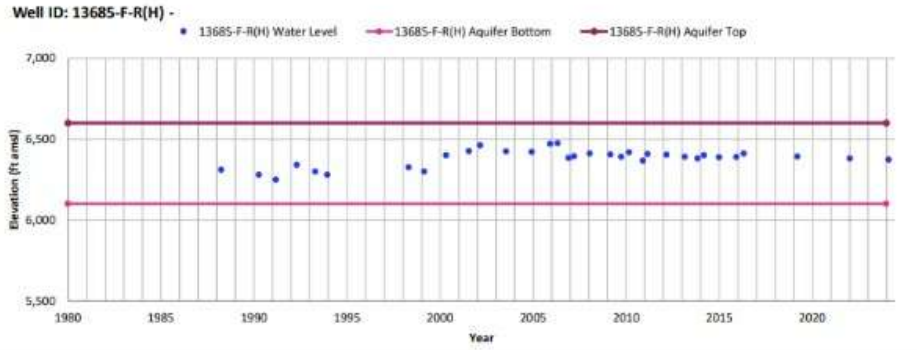


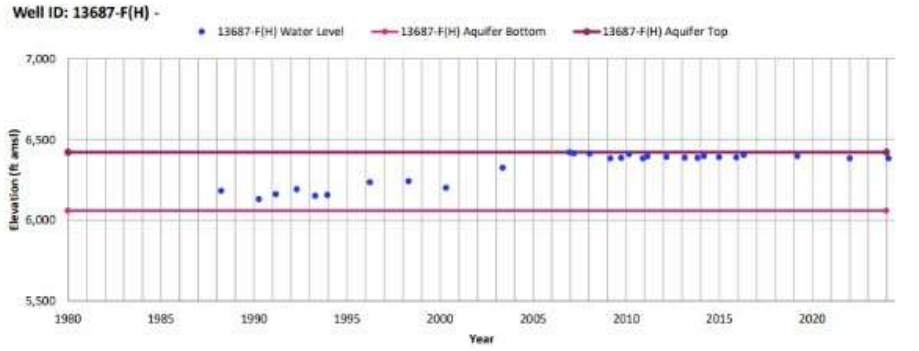


Arapahoe Aquifer Well Hydrographs

Arapahoe Aquifer Well Hydrographs





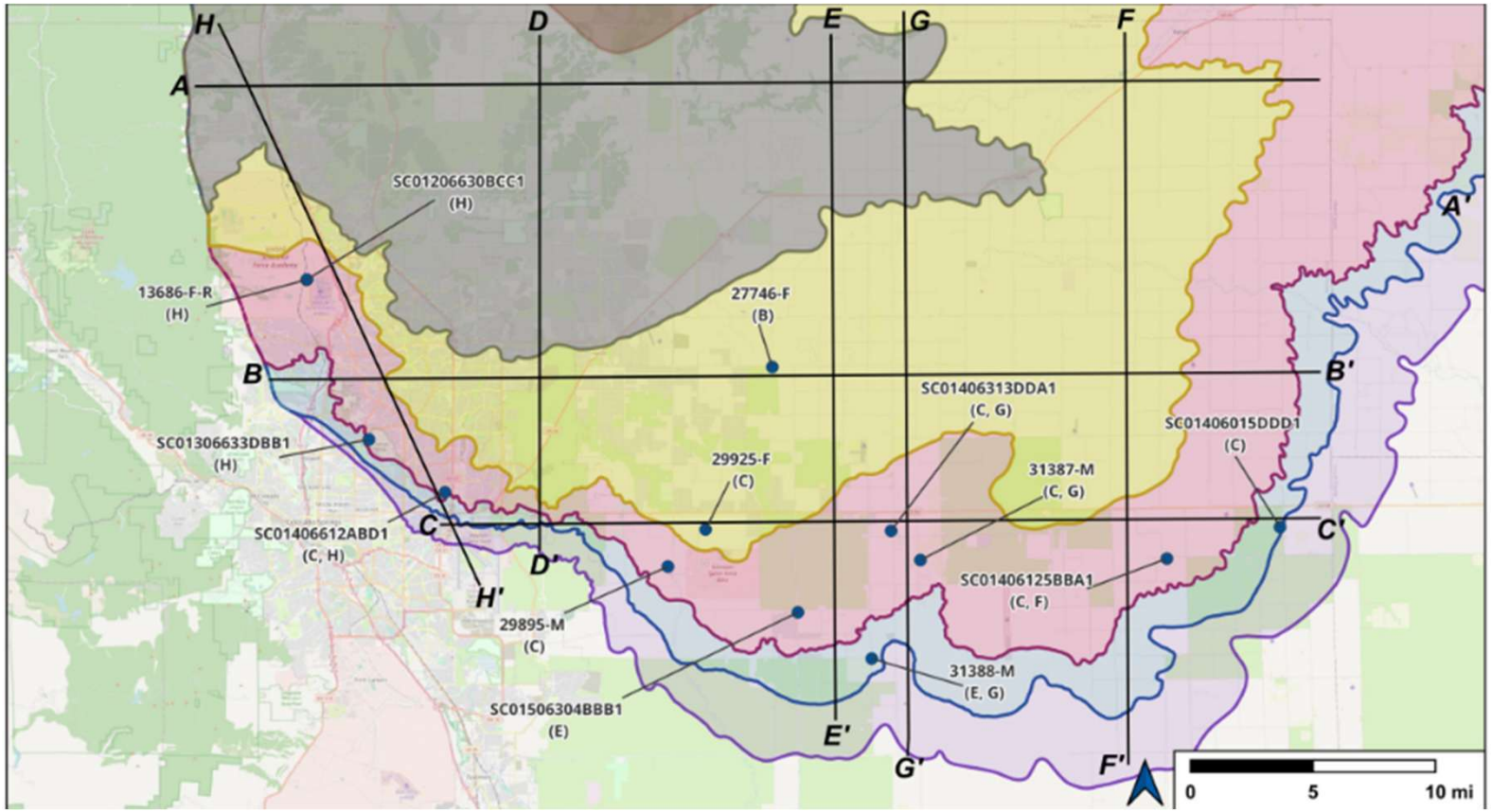


Arapahoe Aquifer Analysis

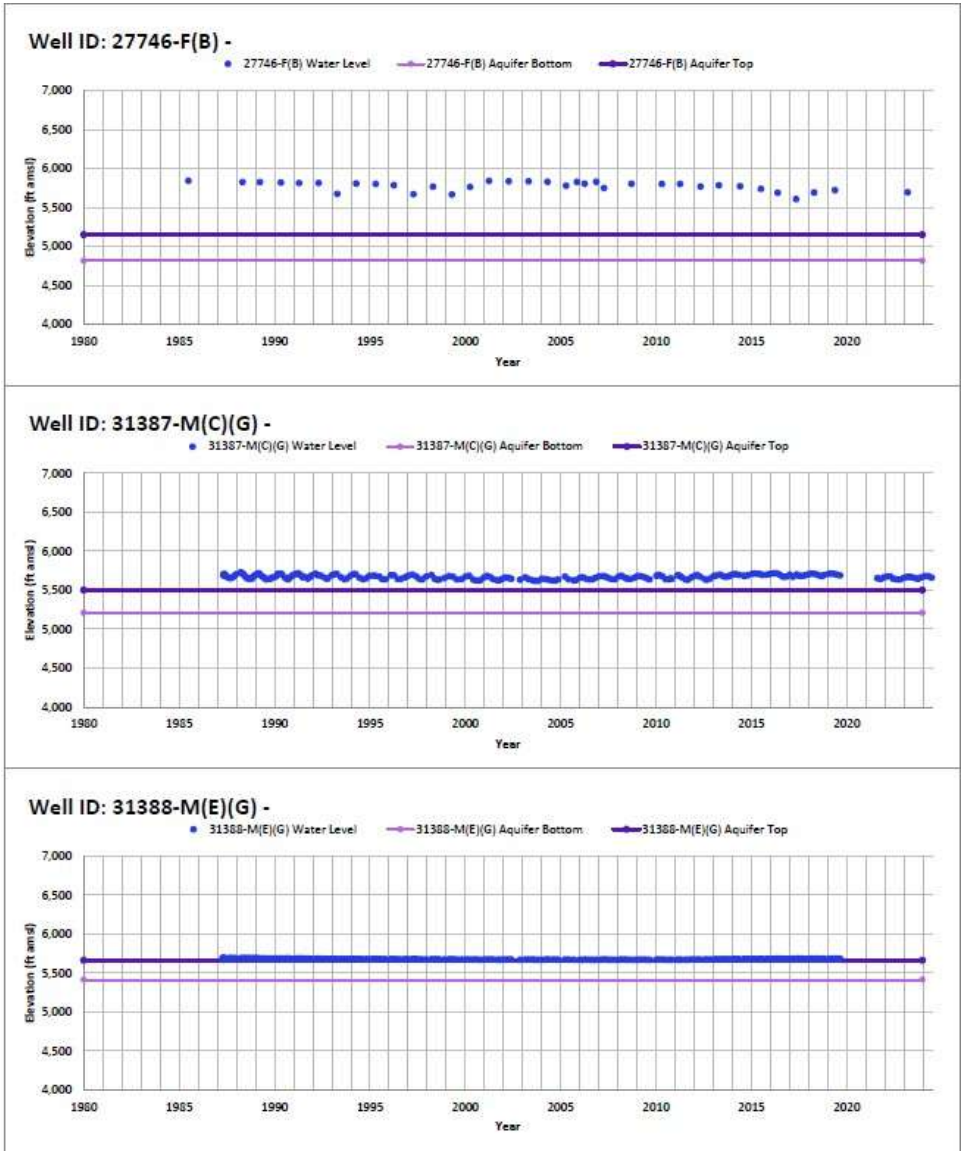
- Along with the Denver aquifer, one of the two principal municipal production aquifers
- Most relied on aquifer due to productivity and water quality
- Although most heavily used, the Arapahoe is still fully confined over much of the basin, including along the margins to the south and east
- Similar to the Denver, aquifer only outcrops on southern edge of basin, extends further east beyond County line
- Significant thinning of the aquifer to the south and east is limiting production of wells
- Viable, reliable source of water for residential and larger municipal/commercial uses

LARAMIE-FOX HILLS AQUIFER

Laramie-Fox Hills Aquifer Wells



LFH Aquifer Well Hydrographs



LFH Aquifer Well Hydrographs

LFH Aquifer Well Hydrographs

LFH Aquifer Well Hydrographs

Laramie-Fox Hills Aquifer Analysis

- Deepest aquifer, with several hundred feet vertical separation from Arapahoe aquifer
- Least developed aquifer due to depth (cost to develop) and water quality issues
- Fully confined in all areas of the County based on the available data
- Significant head above aquifer and general lack of declining water levels over time indicate good reliability of the water supply
- Viable, reliable long-term source of water for residential and larger municipal/commercial uses

Conclusions and Recommendations

- Based on available data, the Denver Basin aquifers appear to be viable, reliable long-term sources of water for residential and larger municipal/commercial uses
- Dawson aquifer has the most limited potential for larger non-exempt wells due to limited areal extent and some dewatering, as well as localized boundary conditions
- No evidence that would suggest the 300-yr Rule is too lenient relative to allowed use of Denver Basin aquifer water
- Based on information available through this study, we do not recommend policy or code changes related to how the County administers Denver Basin aquifer water use

LEGAL ISSUE WITH ALLOCATION PROCESS

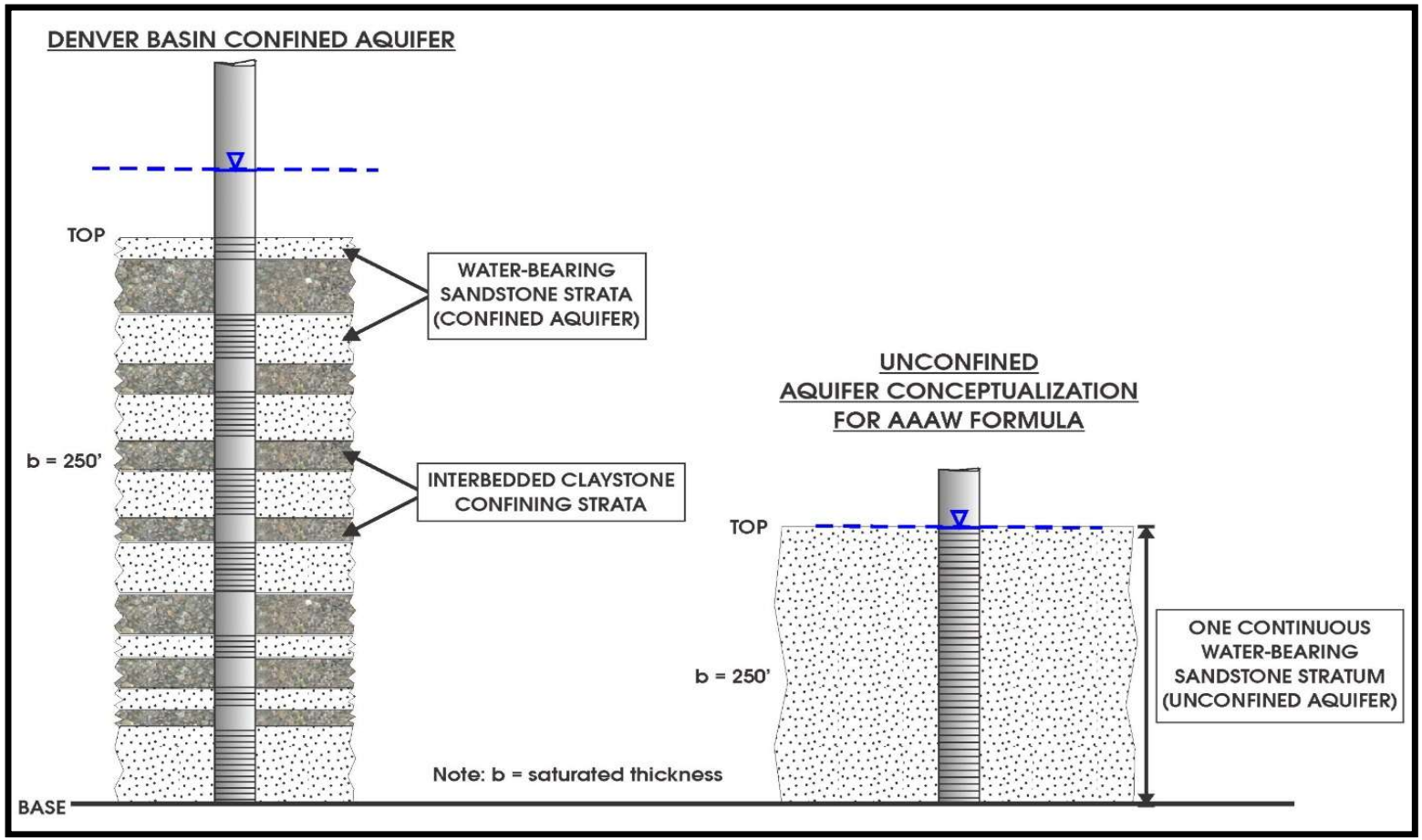
Laws Regarding Denver Basin Water

- **Ground Water Appropriation Act - 1969**
- First regulation of ground water relative to surface water impacts
- **Senate Bill 213**
- Established land ownership criteria
- Minimum useful 100-yr life
- **Senate Bill 5**
- Denver Basin Rules
- Nontributary / Not-nontributary
- Continued annual allocation approach
- Total Allowable Withdrawal (TAW)

Effect of TAW

- State Engineer's Office promoted TAW concept
- Lawsuit filed challenging the concept
- Still allows annual allocation methodology
- Instead of "minimum useful life" concept, there is a hard stop at 100 years of usage
- This applies whether there is usable water remaining in aquifer or not
- Doesn't account for significant water contained under pressure in aquifers
- Therefore, likelihood appropriations will be discontinued when aquifers can still provide viable water resources
- Supreme Court has affirmed the TAW concept

No Consideration of Pressurized Aquifers



Potential Discussion Issues

- Denver Basin hydraulics
  - Confined vs Unconfined
  - Heterogeneity
  - Boundary conditions
- Historical changes in Denver Basin aquifer water supply availability
- Well permitting status (exempt vs. non-exempt)
- Individual aquifer analyses
- Legal characteristics of Denver Basin aquifer water (NT vs NNT water)
- Allocation of water-historical and TAW
- County policies and code on Denver Basin use

Bruce A. Lytle, PE - (303) 350-4090
bruce.lytle@mooreengineeringinc.com
www.mooreengineeringinc.com