Turning to Ground Water: An Engineering Perspective

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Overview

- Introduction
  - Ground Water Definitions
  - Brief History of Ground Water Legislation
- Physical Classifications of Ground Water
- Hydrogeology
- Legal Framework / Jurisdiction
- Ground Water Supply Planning
- Considerations

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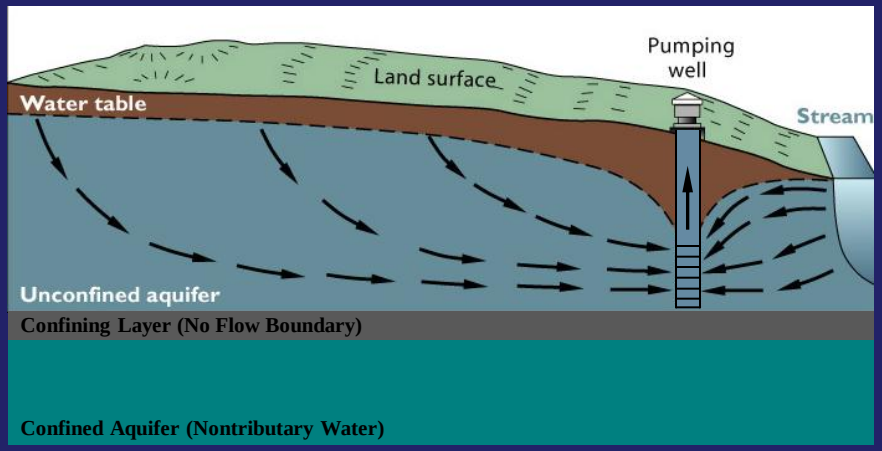
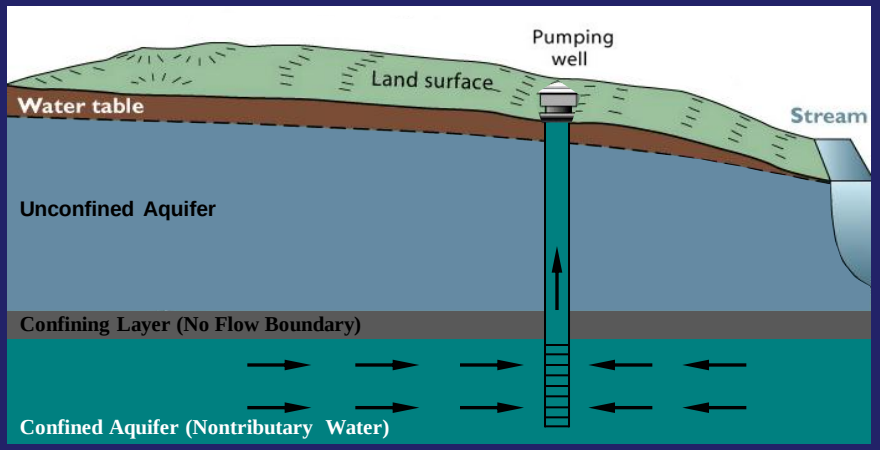
Ground Water Definitions

- Doctrine of Prior Appropriation
- Tributary Ground Water
- Nontributary Ground Water





Modified from Ground Water Atlas of Colorado, Colorado Geological Survey, 2003

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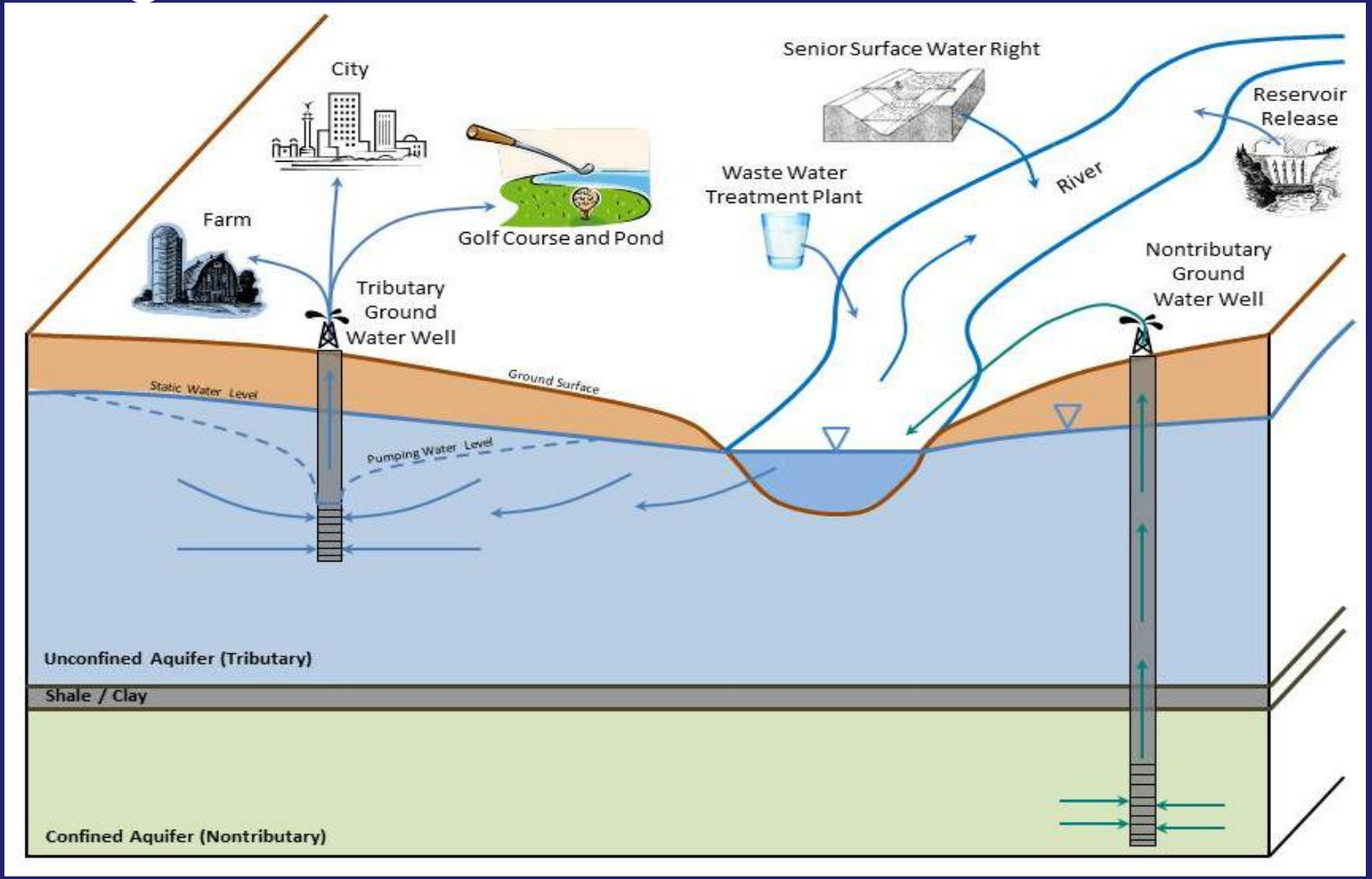
Ground Water Definitions

- Well Augmentation Plan



Introduction - Brief History of State Ground Water Legislation

- 1876 Colorado Admitted to the Union
  - Colorado Constitution declares prior appropriation doctrine as basis for allocation of State waters
- 1879 Water Commissioners and First Water Districts Established by Legislature

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Introduction - Brief History of State Ground Water Legislation

- 1957 – the "Colorado Ground Water Law"
  - Required well permits
  - Established Ground Water Commission and framework of Designated Basins
- 1965 Act / HB 1066 "Colorado Ground Water Management Act"
  - Established integrated surface water and ground water administration
  - Gave SEO authority to evaluate use of ground water and deny well permits

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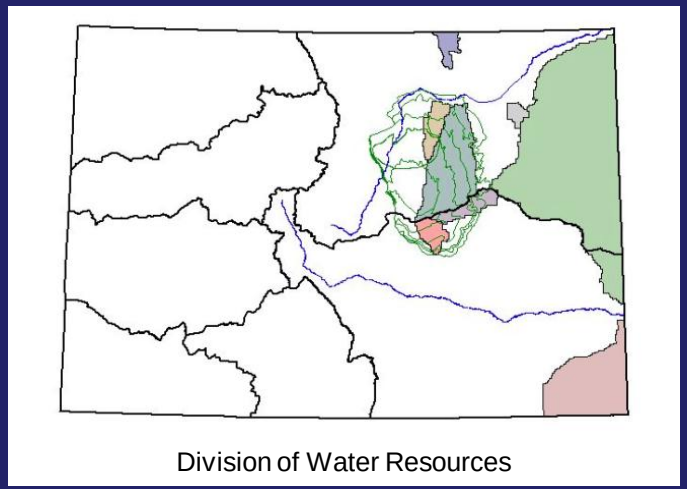
Ground Water Definitions

- Designated Ground Water Basins
  - Defined by the Ground Water Commission
  - In areas not adjacent to a continuously flowing natural stream
  - Ground water withdrawals have constituted the principal water usage for a least 15 years
  - Administered outside priority system



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Introduction - Brief History of State Ground Water Legislation

- 1969 - Water Rights Determination and Administration Act of 1969
  - Tributary ground water shall be administered according to the doctrine of prior appropriation
  - Augmentation plans may be decreed to allow out-of-priority diversions, if sufficient replacement water is provided in time, location and amount

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Introduction - Brief History of State Ground Water Legislation

- 1972 – HB 1042
  - Established “Exempt Wells:” Presumption of non-injury for some uses
- 1973 – Senate Bill 213
  - Allocation of nontributary water based upon overlying land area and 100-year aquifer life

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Introduction - Brief History of State Ground Water Legislation

- 1985 – Senate Bill 5
  - Confirmed allocation based on overlying land
  - Caused State Engineer to develop Denver Basin Rules
  - Created provisions including:
    - Banking
    - Well fields

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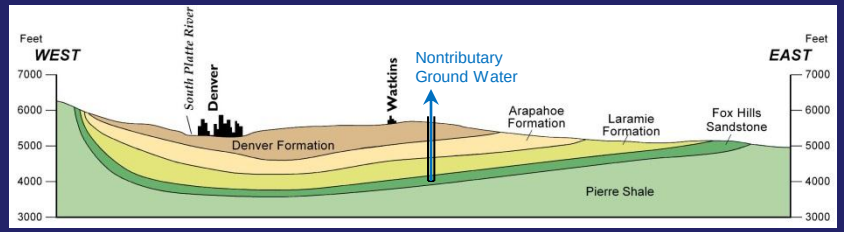
Introduction - Brief History of State Ground Water Legislation

- SB5 - Nontributary Ground Water
  - Located outside the boundaries of *Designated Ground Water Basins*, the withdrawal of which will not, within 100 years of continuous withdrawal, deplete the flow of a natural stream at an annual rate greater than 0.1-percent of the annual rate of withdrawal
    - E.g. 1000 af/yr pumping, <1 af/yr depletion after 100 years of pumping



Division of Water Resources

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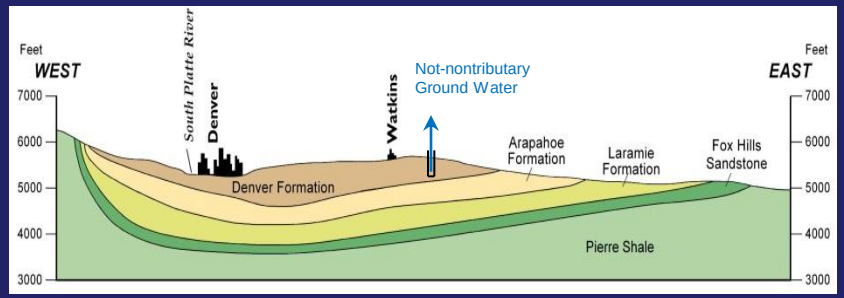
Ground Water Definitions

- SB5 - Not-nontributary Ground Water
  - Located within the Denver Basin that is outside the boundaries of *Designated Ground Water Basins*, the withdrawal of which will, within one hundred years, deplete the flow of a natural stream at an annual rate greater than one-tenth of one percent of the annual rate of withdrawal



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Introduction - Brief History of State Ground Water Legislation

- 1989 – SB120
  - Gravel pits that expose tributary ground water administered as wells
  - Gravel pit substitute water supply plans

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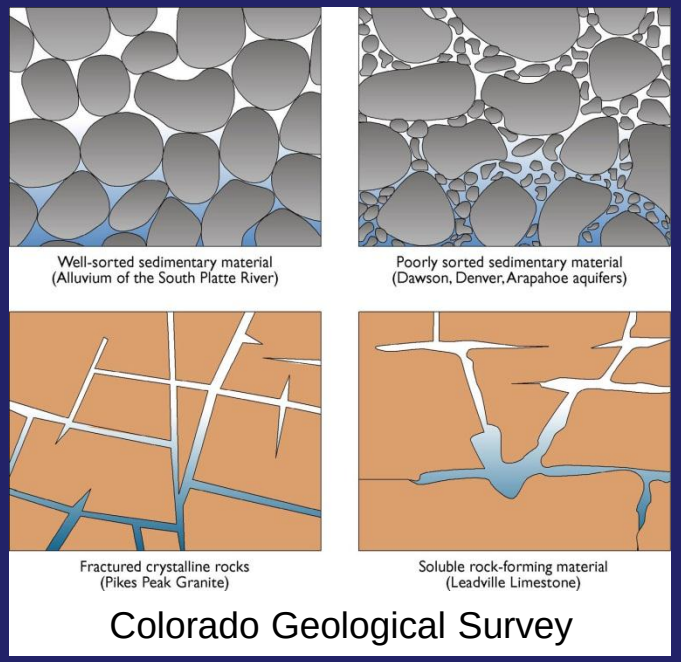
Physical Classifications of G.W.

- General Types of Aquifers
  - Alluvial
  - Sedimentary Bedrock
  - Hard Rock Bedrock
- Effect of Geologic Factors on Ground Water Flow



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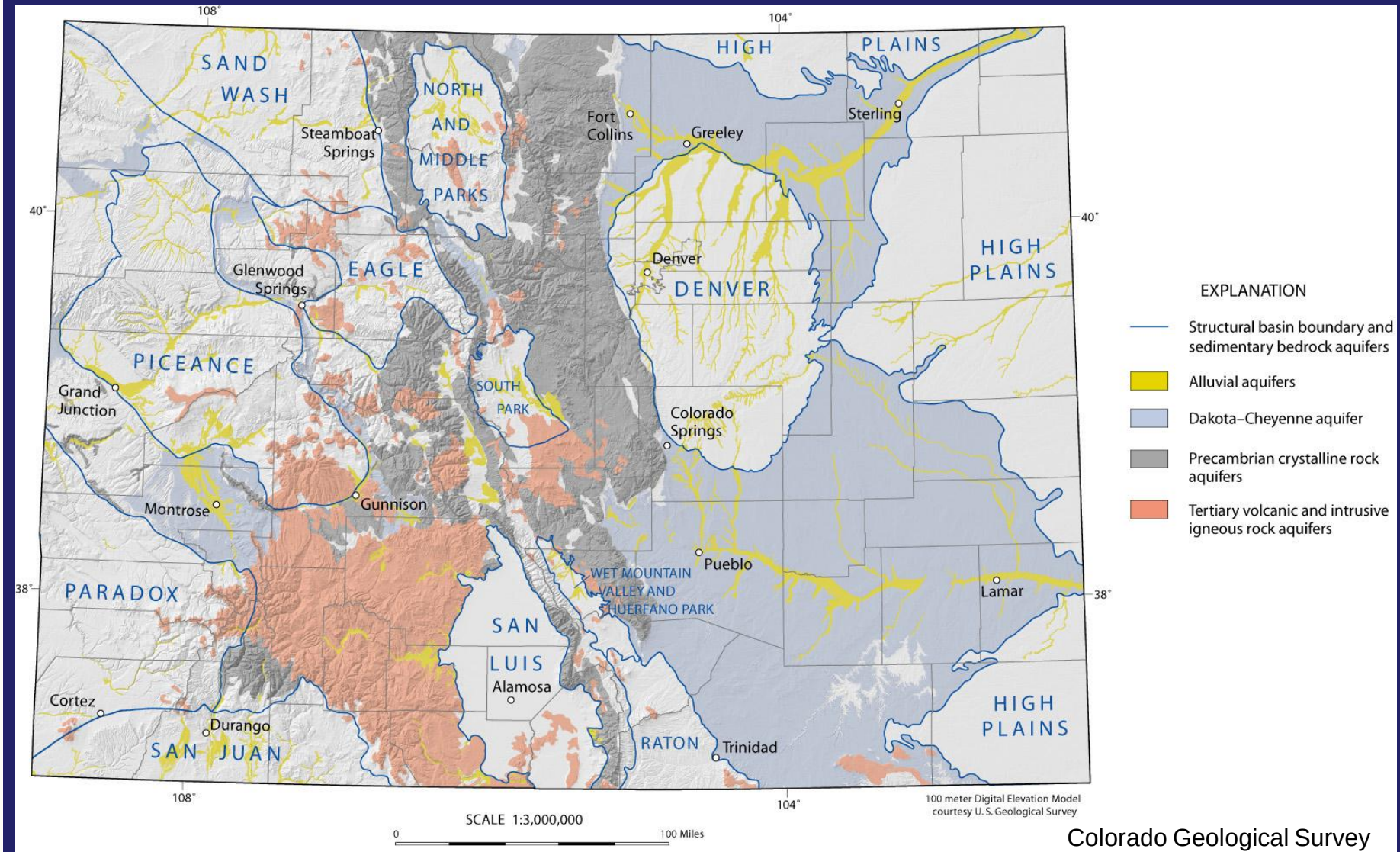
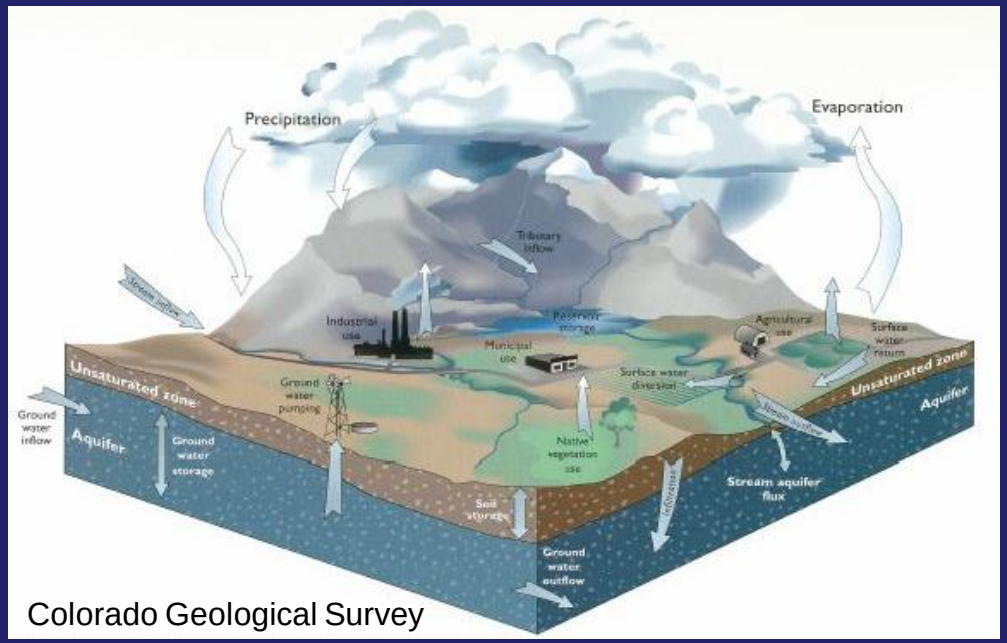
Physical Classifications of G.W.



Colorado Geological Survey

Physical Classifications of G.W.

- Alluvial Aquifers
  - Tributary
  - Specific yield (10% to 25%)
  - E.g. South Platte River Alluvial Aquifer



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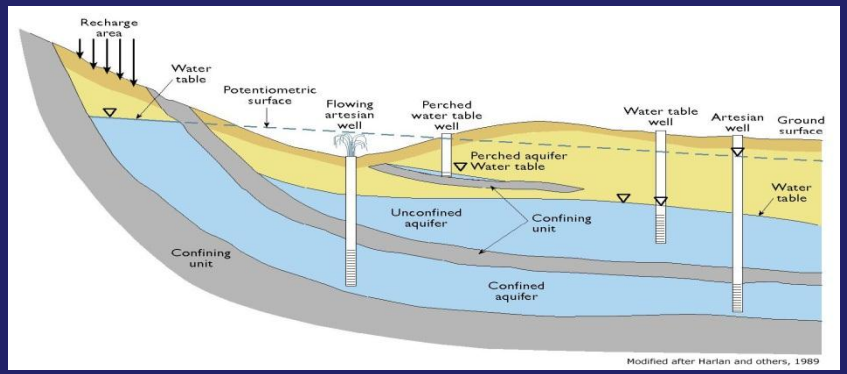
Physical Classifications of G.W.

- Sedimentary Bedrock Aquifers
  - Tributary / Not-nontributary / Nontributary
  - Specific yield (10% to 20%)
  - Artesian “confined” aquifers
  - Specific storage (0.01% to 0.1%)
  - E.g. Denver Basin aquifers
  - Aquifer Storage Recovery (ASR)



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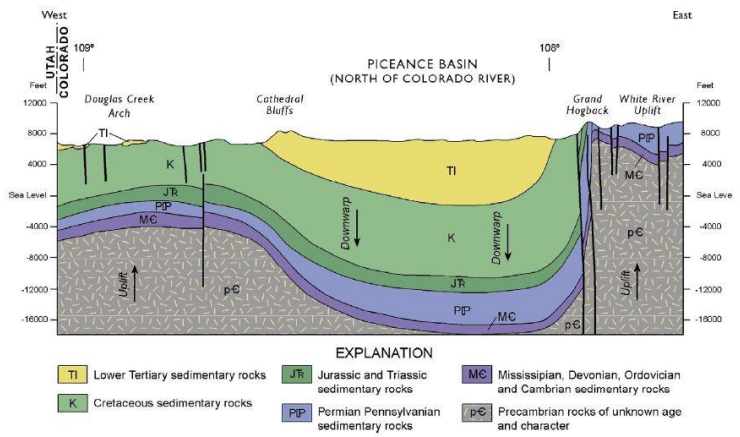
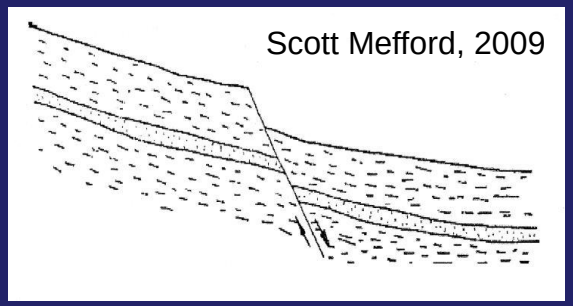
Physical Classifications of G.W.

- Sedimentary Bedrock Aquifers (cont.)
  - Structural features
    - Dipping beds
    - Faults
    - Fractures

Colorado Geological Survey





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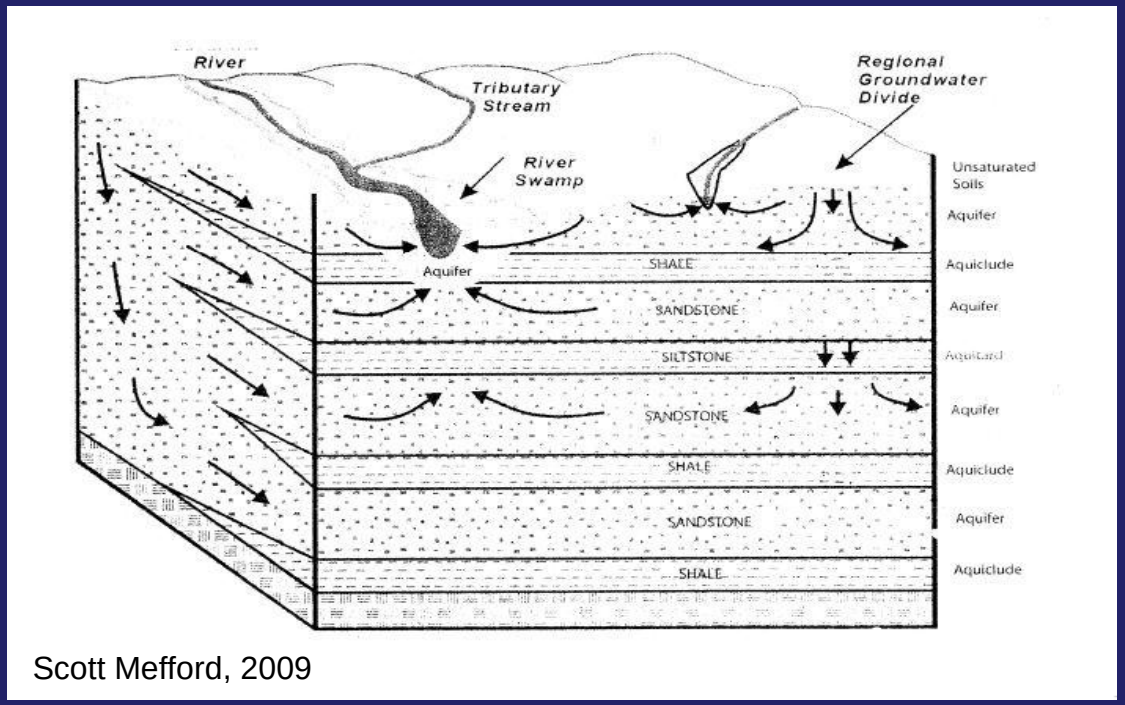
Physical Classifications of G.W.

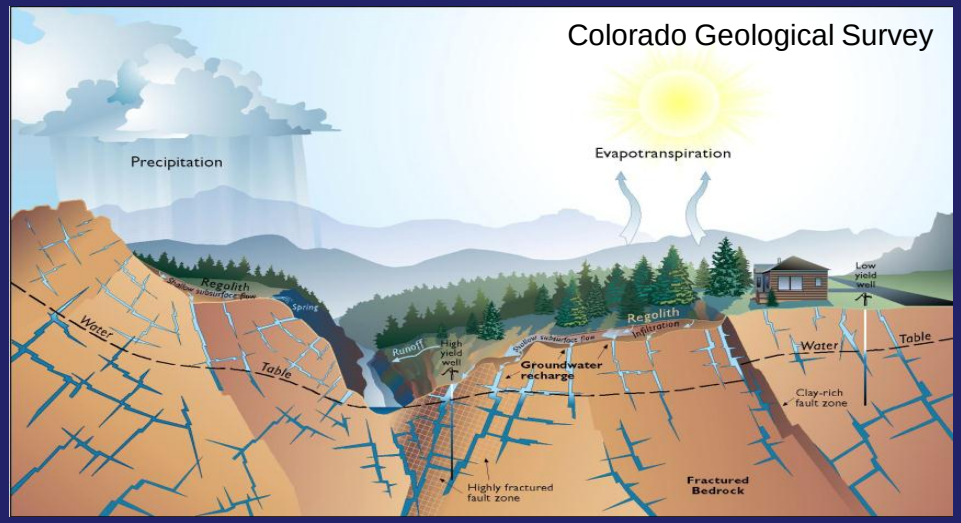
- Sedimentary Bedrock Aquifers (cont.)
  - Stratigraphy
    - Sandstone
    - Siltstone
    - Shale



Scott Mefford, 2009

Physical Classifications of G.W.

- Hard Rock Bedrock Aquifers
  - Tributary
  - Fractured rock
  - Fracture permeability (“secondary”)
  - E.g. Summit County, West Jefferson County



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Hydrogeology

- Determining well yield
- Timing and location of stream depletions
- Impacts and injury to wells and streams
- Water quality
- Challenges

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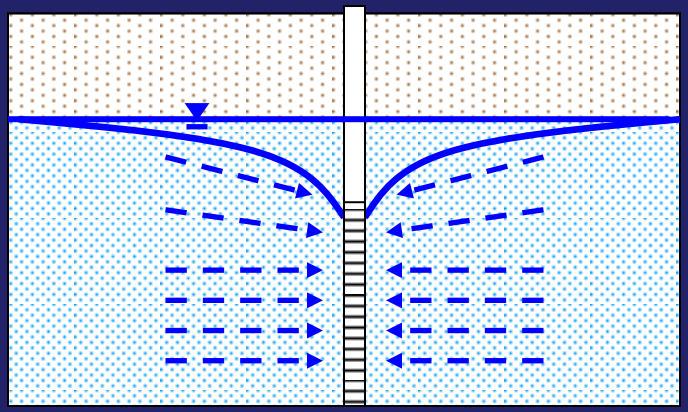
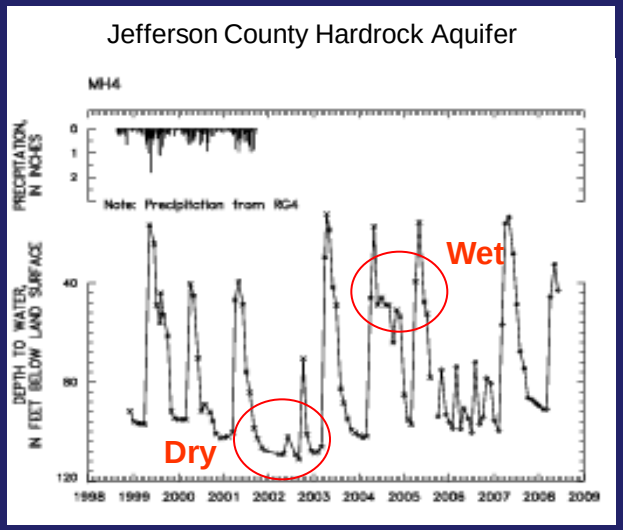
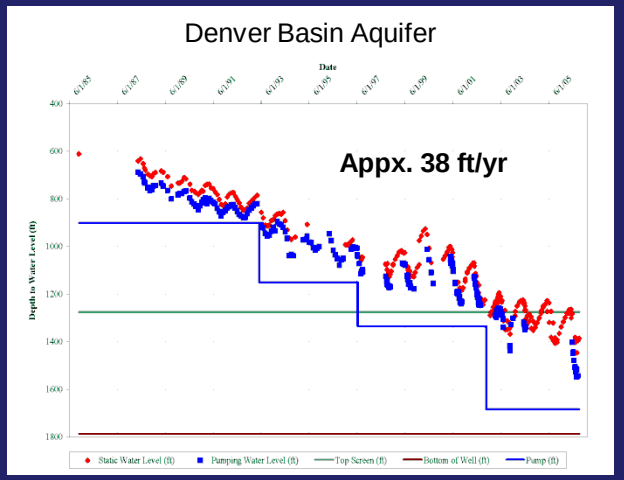
Hydrogeology

- Determining Well Yield
  - Pumping test
  - Analytical methods
  - Ground water levels
    - Recharge
    - Drought and seasonality





Thanks to Roy Laws



Hydrogeology

- Timing and location of stream depletions
  - Determine point of connection
  - Modeling methods to determine timing
    - Glover Equation
    - MODFLOW Model
  - Augmentation plans
    - Post-Pumping Depletion
    - Unit Response Factor
    - Stream Depletion Factor

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Hydrogeology

- Evaluating injury and replacement
- Impacts and injury to wells and streams
  - Stream depletions
    - 100-percent of well pumping results in stream depletion
    - Variables
      - Conductance (transmissivity), specific yield, distance from well to river, hydraulic connection
  - Well-to-well interference
    - Water levels
  - Water quality

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Hydrogeology

- Challenges
  - Limited data (uncertainty)
  - Expensive to collect data (well construction cost)
  - Ground water can't be seen; difficult to directly measure
  - Challenge to manage, administer within prior appropriation doctrine

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Ground Water
Legal Framework / Jurisdiction

- Water Court
  - Decrees water rights and augmentation plans
- Division of Water Resources
  - Administers water use, water rights and augmentation plans
  - Approves Substitute Water Supply Plans
  - Issues well permits
    - Exempt
    - Non-Exempt (Fee Wells, including gravel pits)
    - Headgate wells

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Ground Water
Legal Framework / Jurisdiction

- County Regulations
  - Zoning
- Colorado Department of Public Health and Environment
  - Public water supply approval
  - Injection approvals
- EPA, Others

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Ground Water Supply Planning

- Considerations for ground water supplies
- Components of successful ground water planning

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Considerations for Ground Water Supplies

- Considerations
  - Economically accessible
  - Locally available
  - Drought tolerant
  - Water quality (natural filtration)
  - Supply adequacy and sustainability

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Components of successful planning

- Hydrogeology (is ground water available?)
  - Estimate demand
  - Prove supply (drill & test wells, water quality, sustainability)
  - Hard rock environments are unpredictable
- Regulatory framework
  - Water Rights (develop legal supply)
  - Division of Water Resources (State Engineer's Office)
  - CDPHE
  - County Regulations
- Facilities Planning and Infrastructure
  - Individual wells vs. centralized systems
  - Treatment

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Ground Water Considerations

- Location
- Limitations and sustainability
- Alternatives / economics
- Analytical methods
- Impacts
- What is injury?
- Unknowns

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