Hydrogeologic Analysis and Consumptive Use

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Choteau
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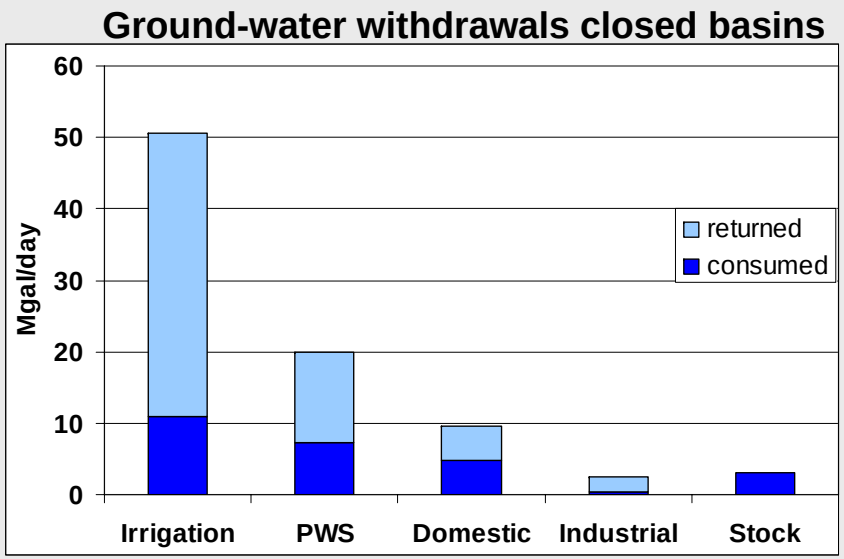
Consumptive Use

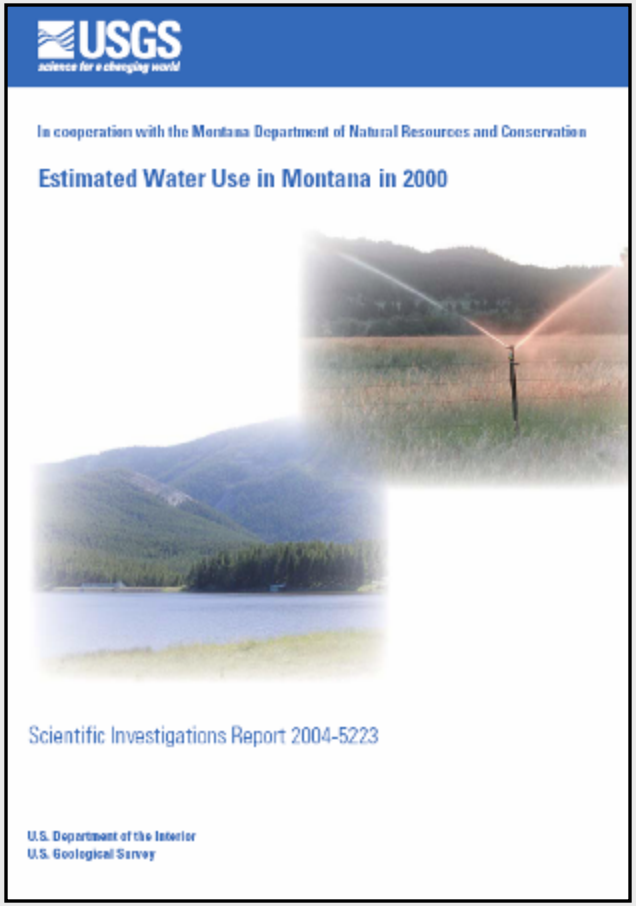
- That part of water withdrawn that is removed from the immediate water environment
  - evaporated, transpired, incorporated into products or crops, consumed by humans or livestock,
- Used in conjunction with hydrogeologic analysis to assess impacts to stream flow

Consumptive Use Varies

State wide *estimates:*

- **Irrigation – 21%**
- **Public Water Supply – 37 %**
- **Domestic – 100 % (10 – 50%)**
- **Industrial – 15 %**
- **Stock – 100 %**



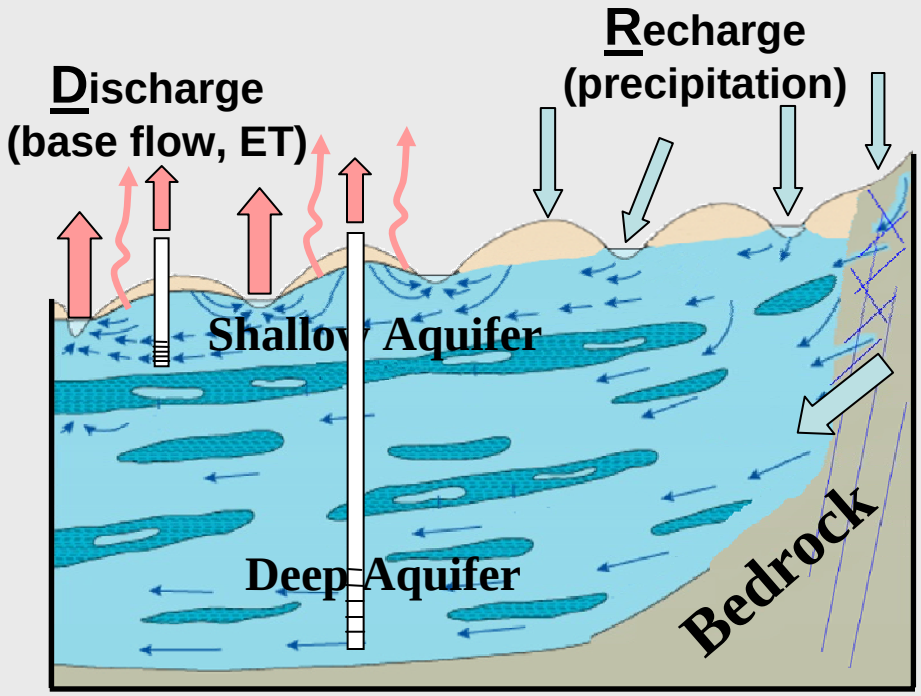


http://pubs.usgs.gov/sir/2004/5223/

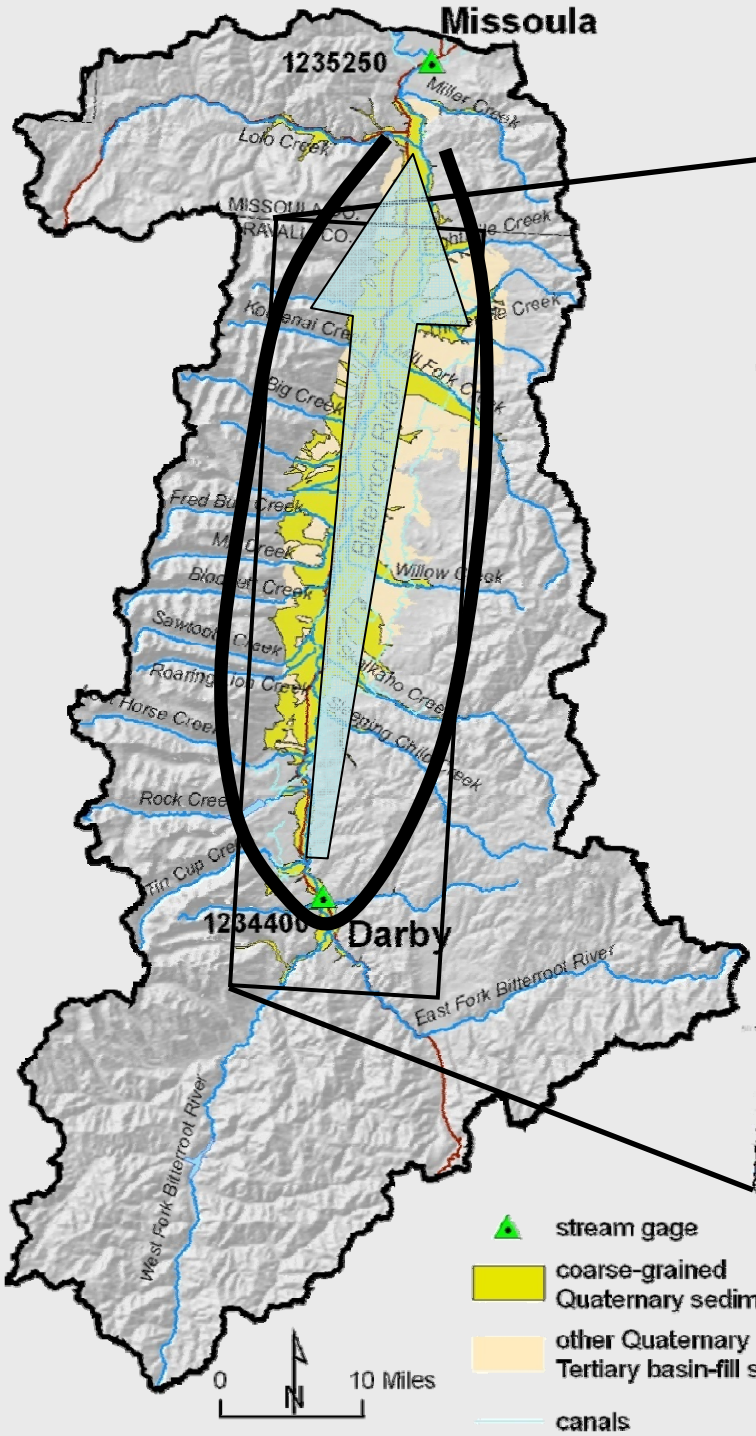
Hydrogeologic Analysis

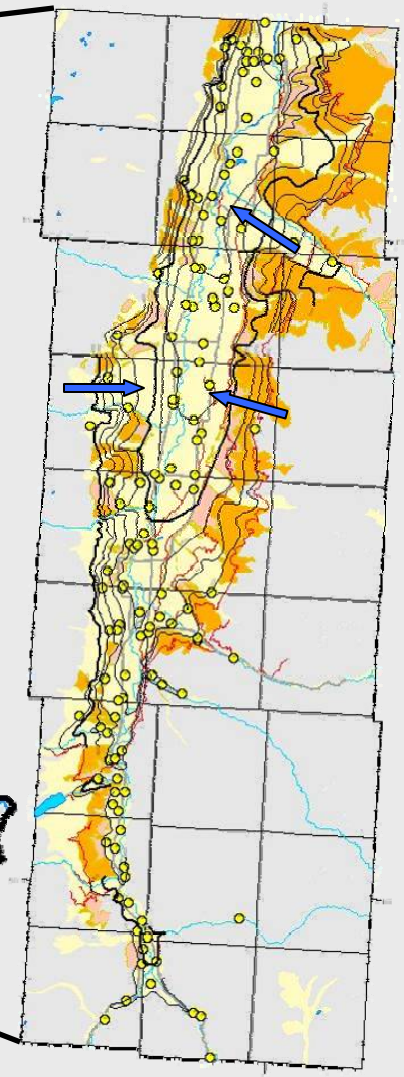
How much water is there? Where's it coming from and going to?
How will it respond to a stress?

- **Aquifer Boundaries**
  - Lateral extent (catchment area)
  - Vertical
- **Flow System**
  - Movement of water from recharge to discharge areas
- **System Capacity**
  - Aquifers store and transmit
- **Budgeting**
  - How much going in and out
    - $\mathbf{R} = \mathbf{D} +/- \triangle \mathbf{S}_{torage}$
  - Evaluate stresses
    - $\mathbf{P}_{umping} = \triangle \mathbf{D} +/- \triangle \mathbf{S}$
- **Scale**
  - Geographic
  - Temporal



Bitterroot Example

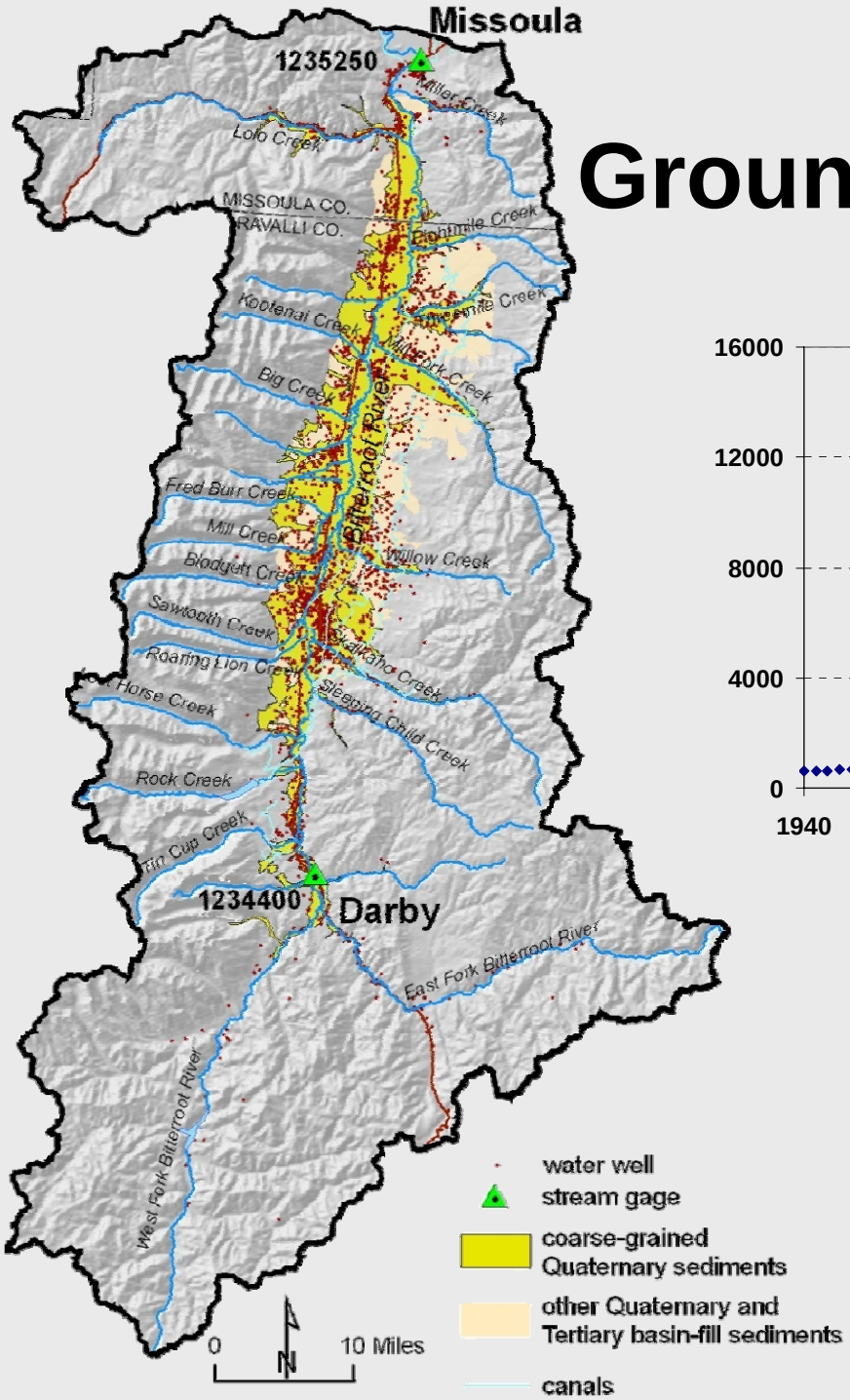




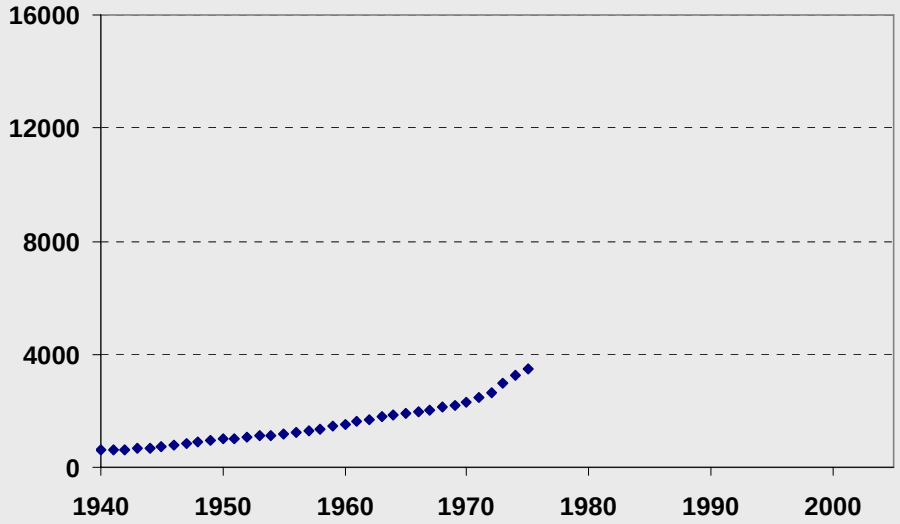
Ground-Water Resources

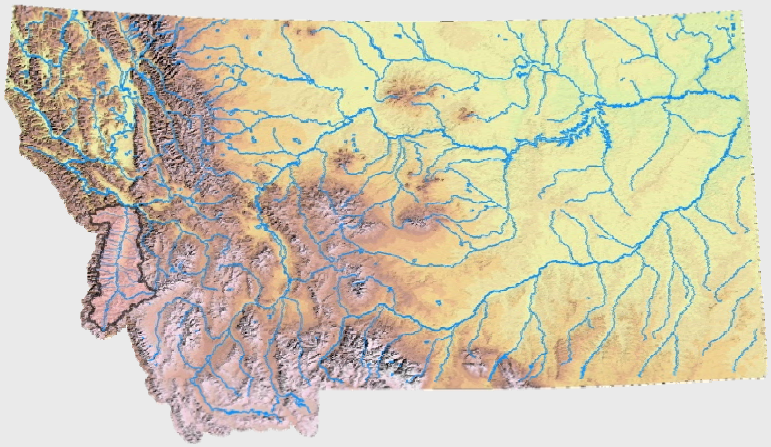
- **Basin-fill sediments up to 3,000 ft thick**
- **Shallow basin-fill:**
  - **Within 50 ft of ls**
  - **Unconfined**
  - **DTW: 2 – 40 ft**
  - **10 – 1,000 gpm**

Bitterroot Ground-Water Development

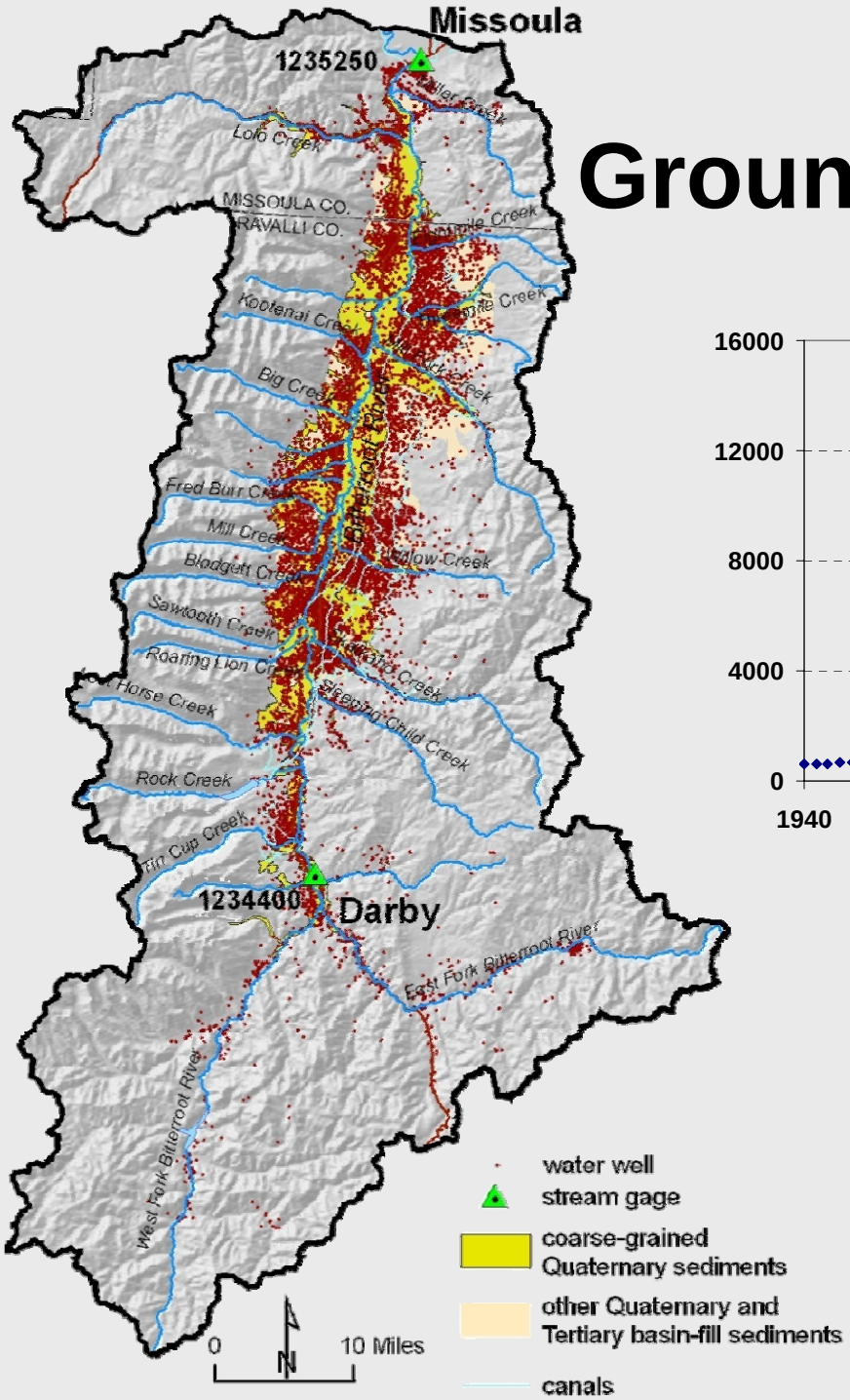


1975 number of wells: 3,500

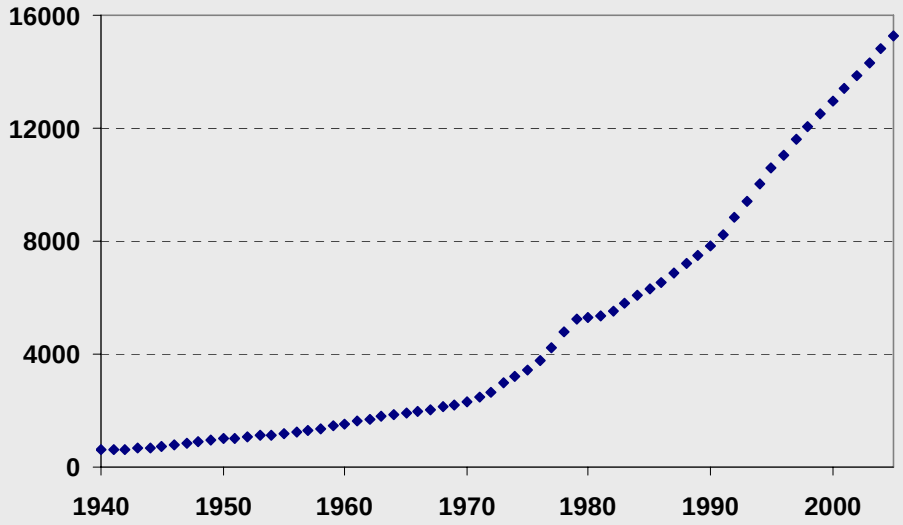




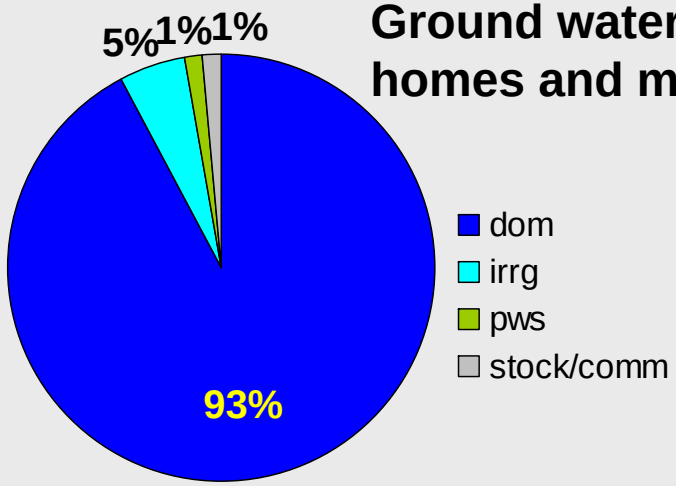
Bitterroot Ground-Water Development



2005 number of wells: 15,900



Ground water supplies most homes and municipalities



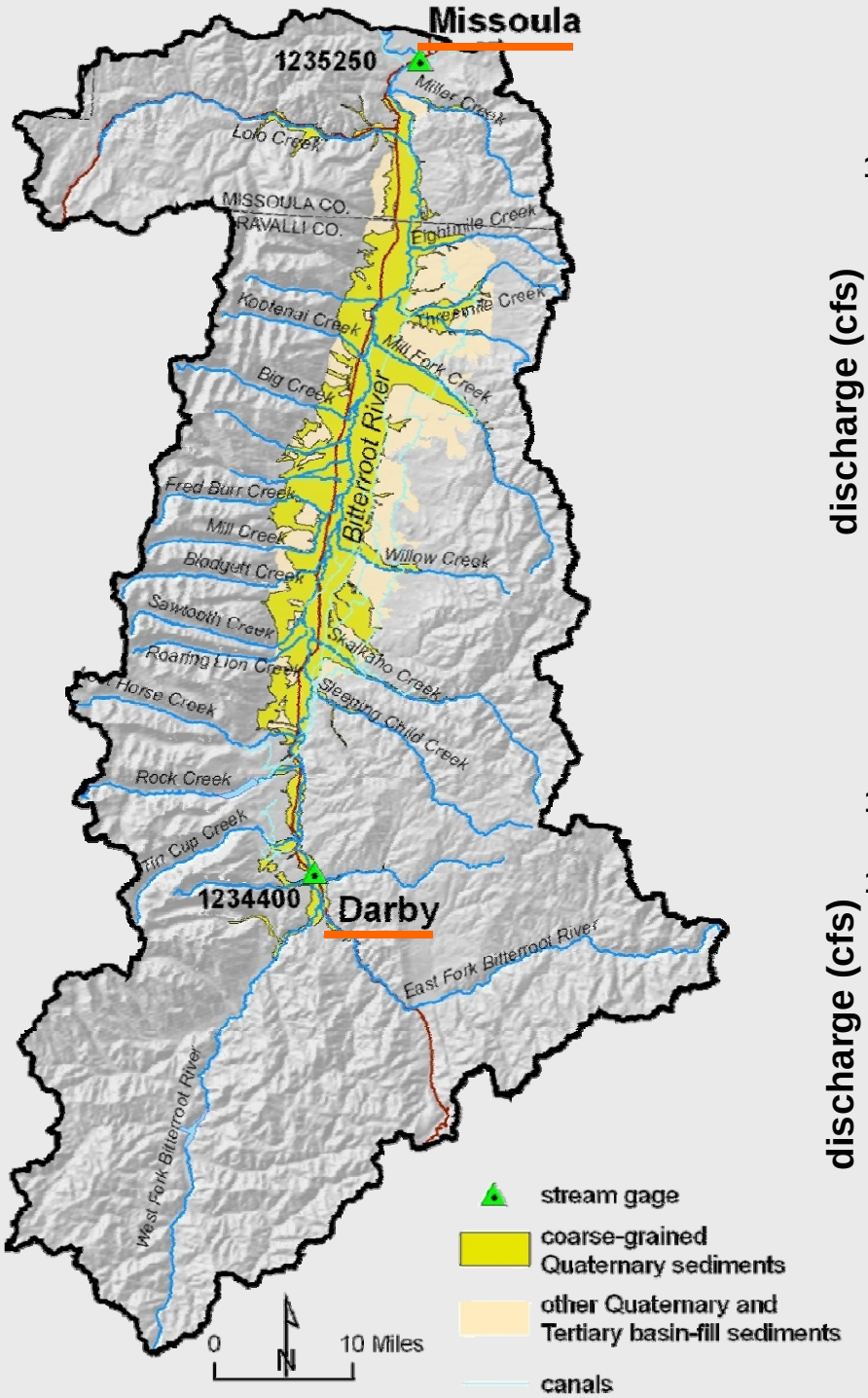
Has this development resulted in:

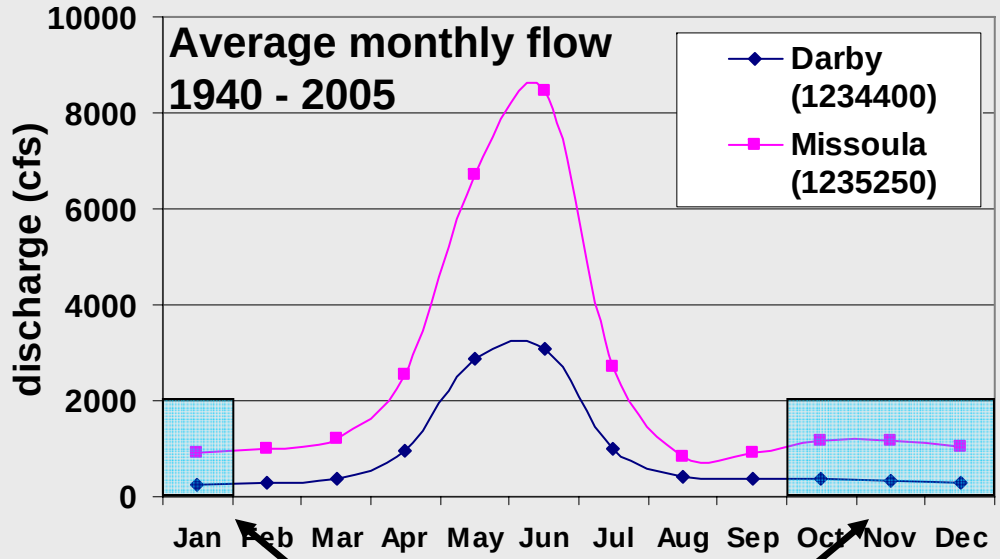
1) impacts to the Bitterroot?

2) ground-water depletion?

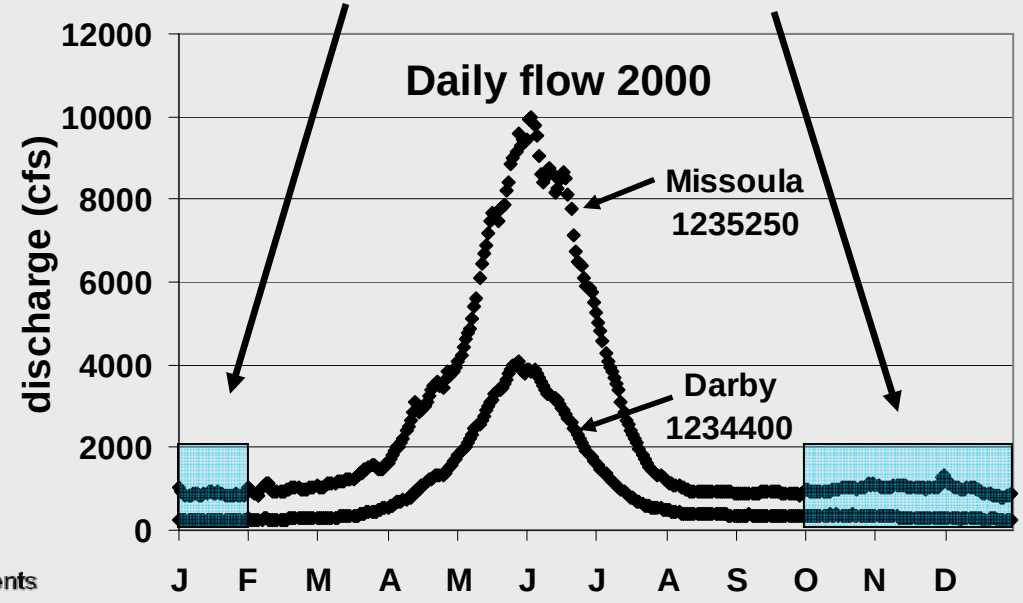
- Changes in baseflow
- Long-term water level data

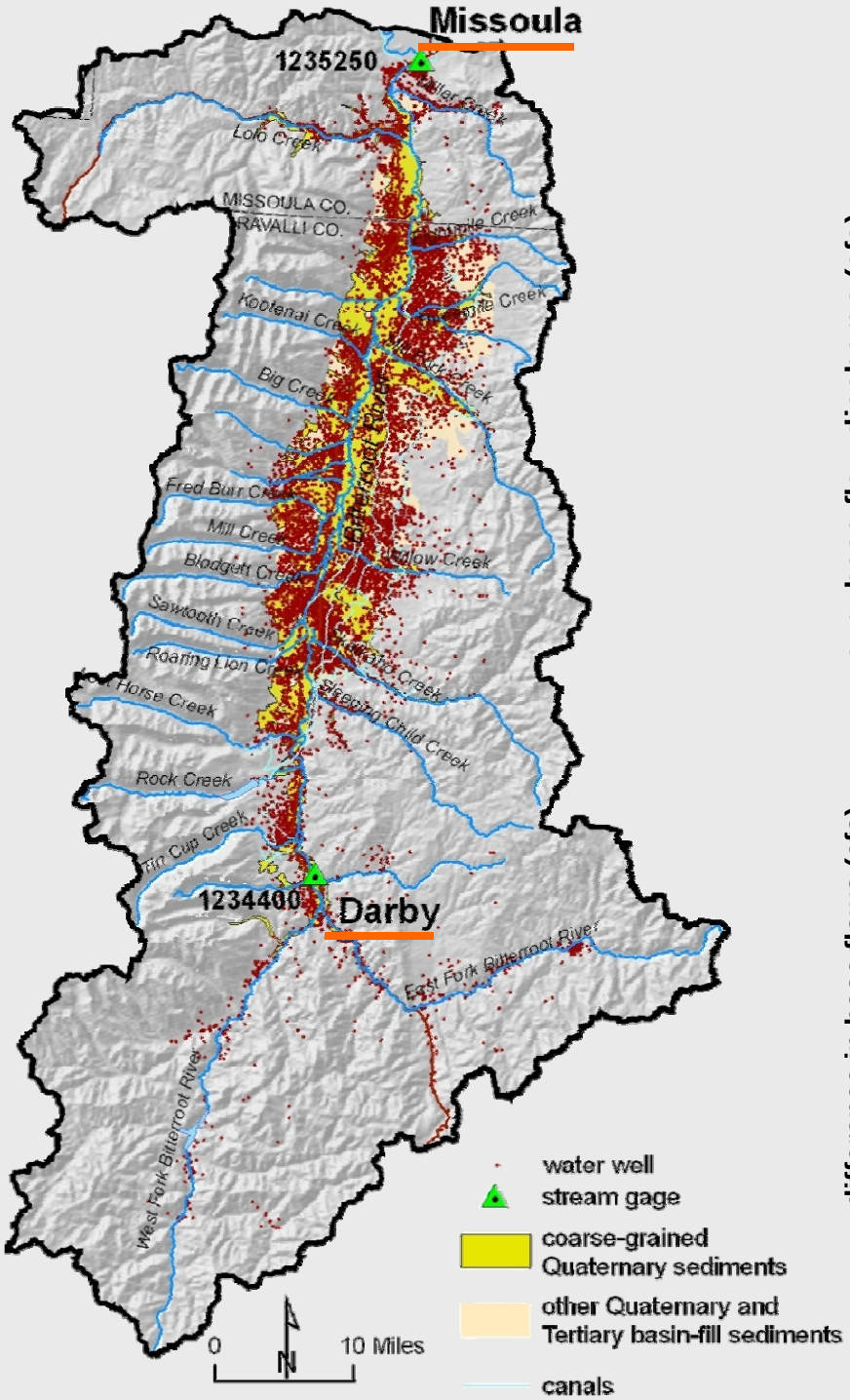
Stream Flow





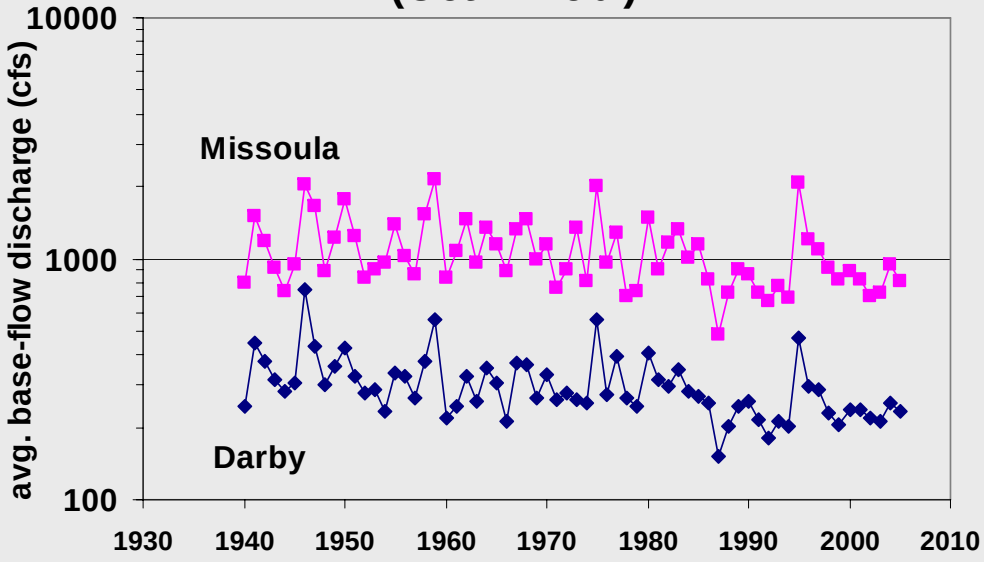
Baseflow Period

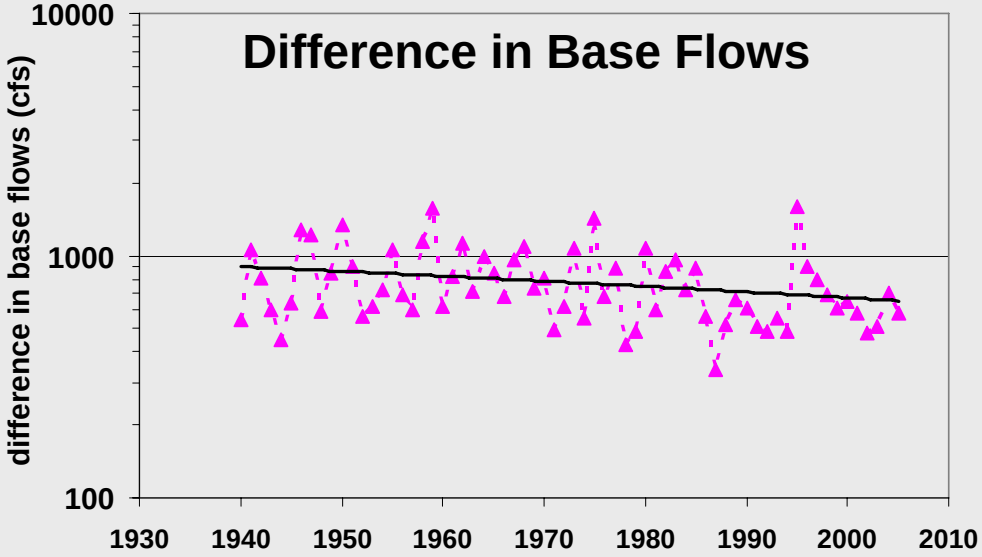




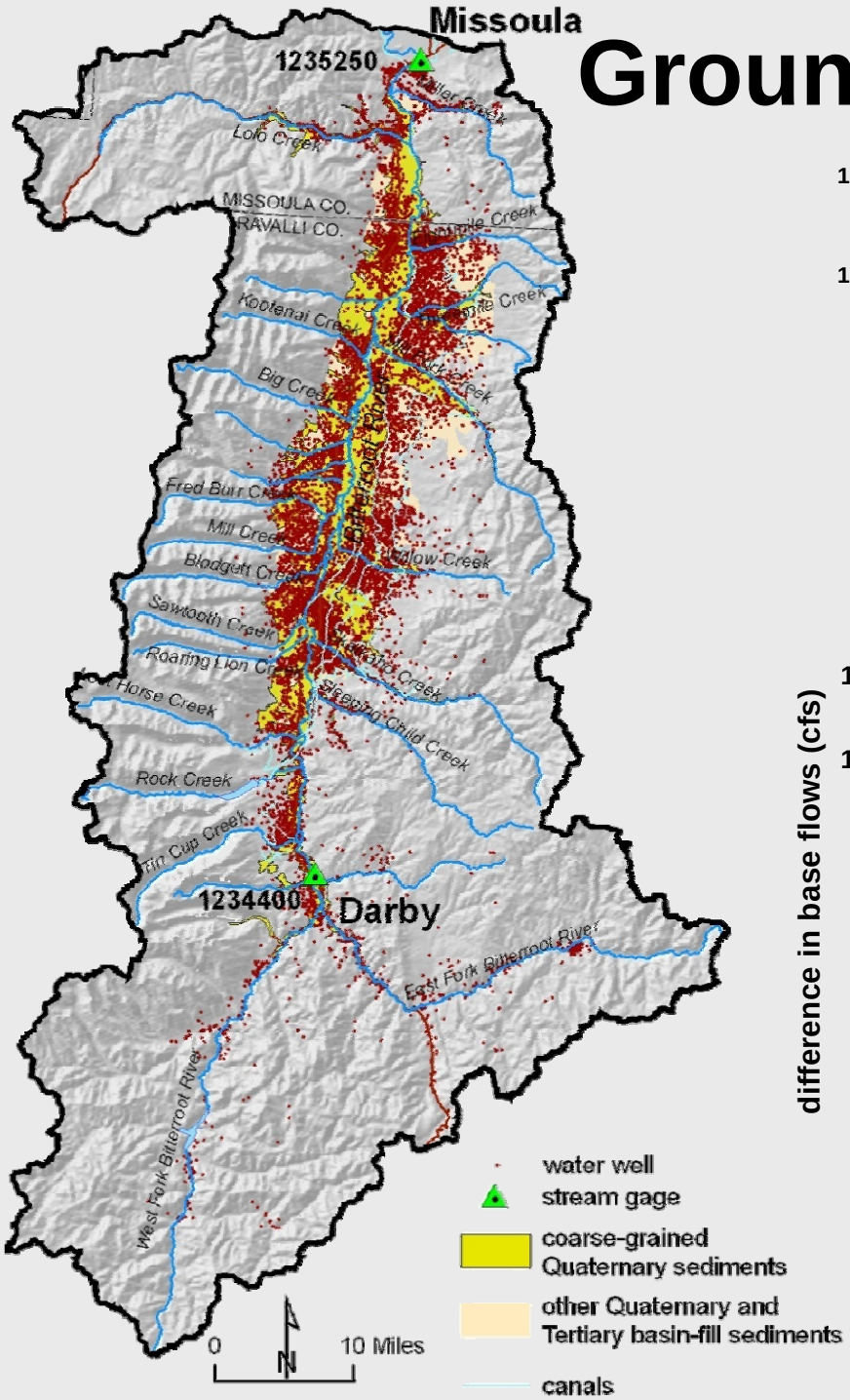
Base Flow

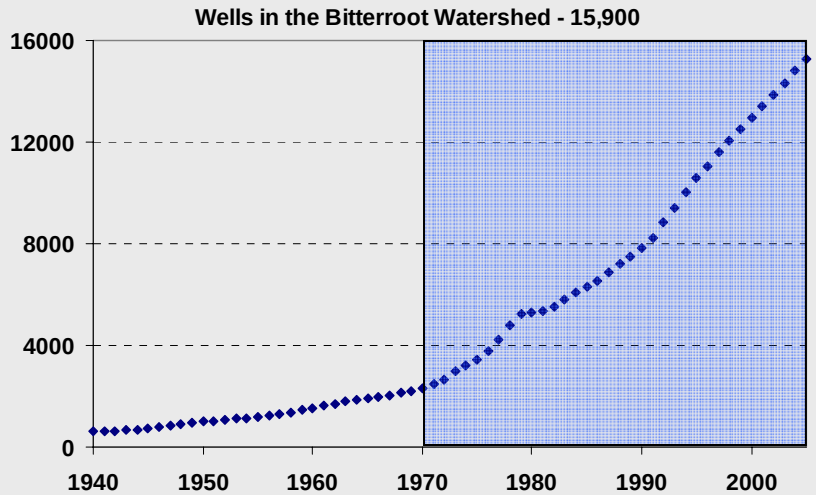
(Oct. – Feb.)

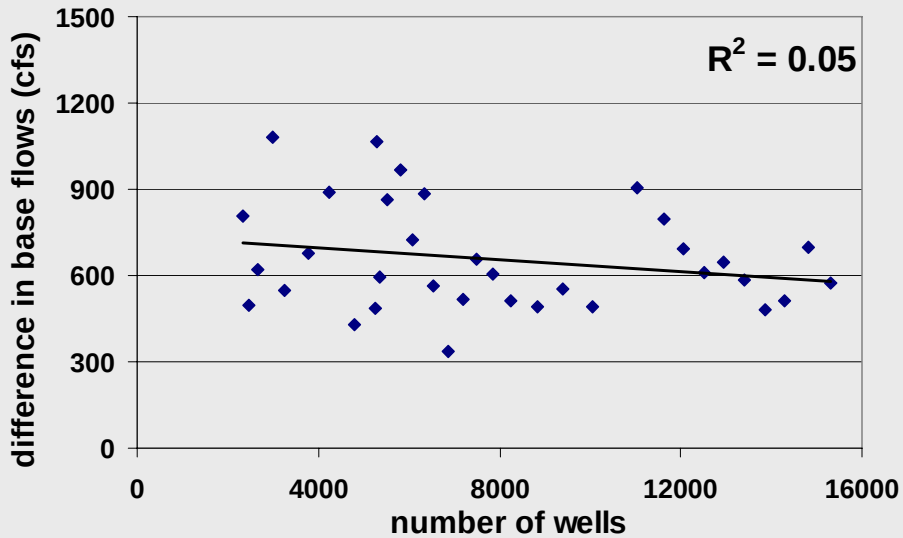




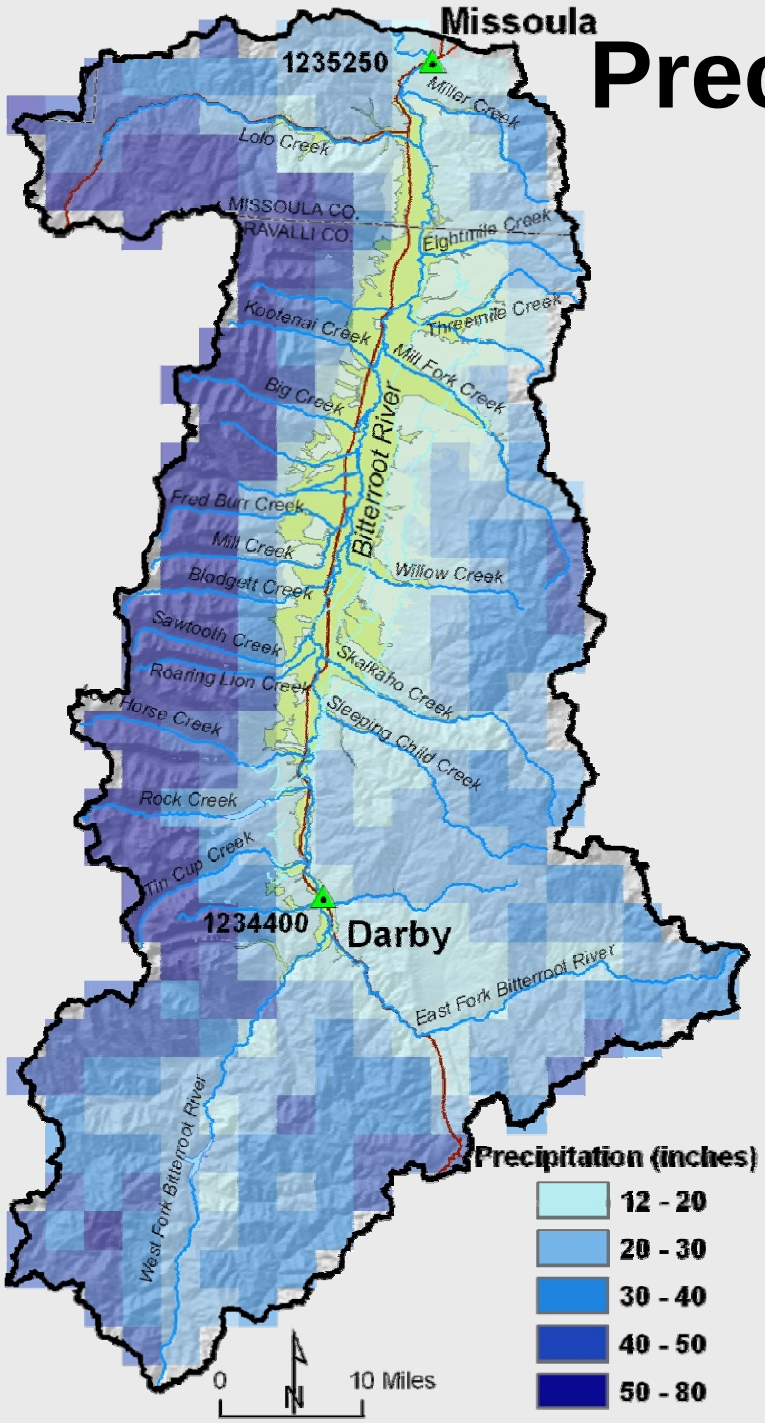
Ground-Water Development

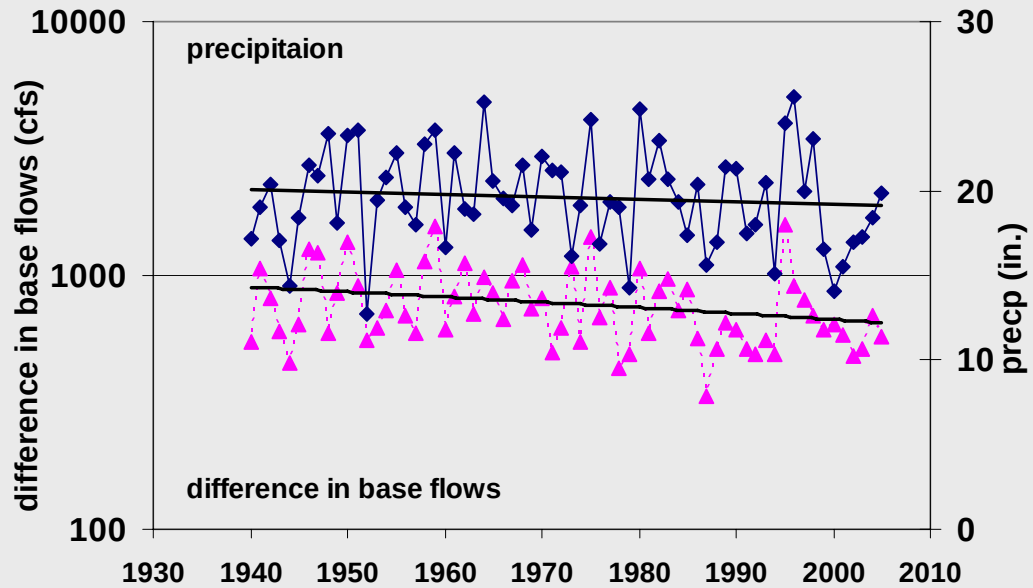


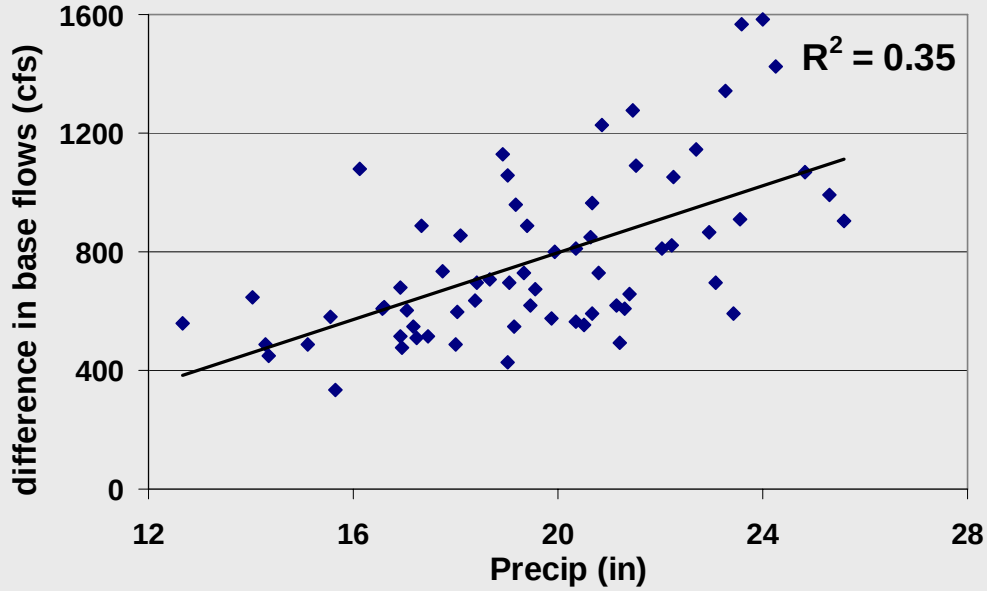




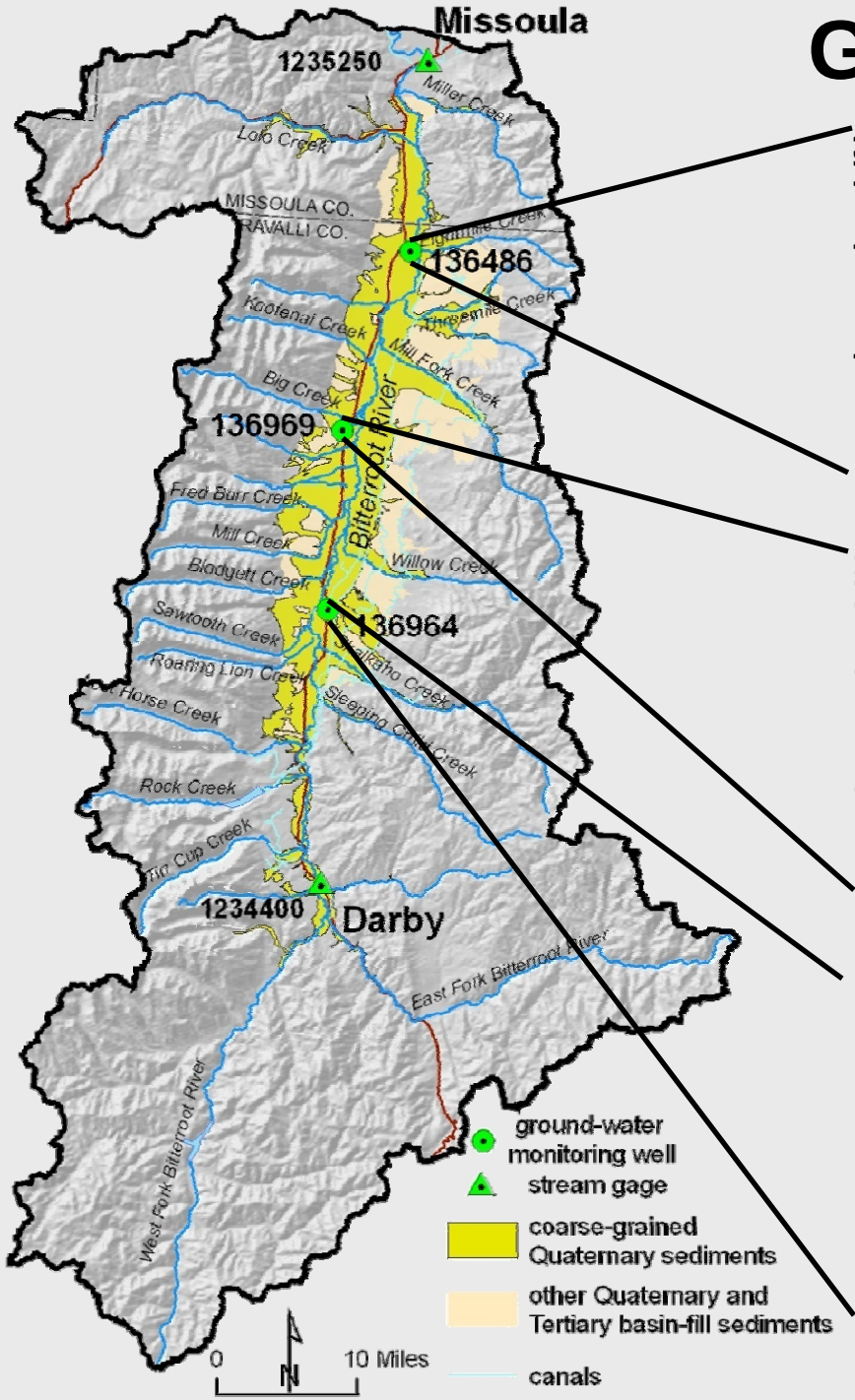
Precipitation and Base Flow

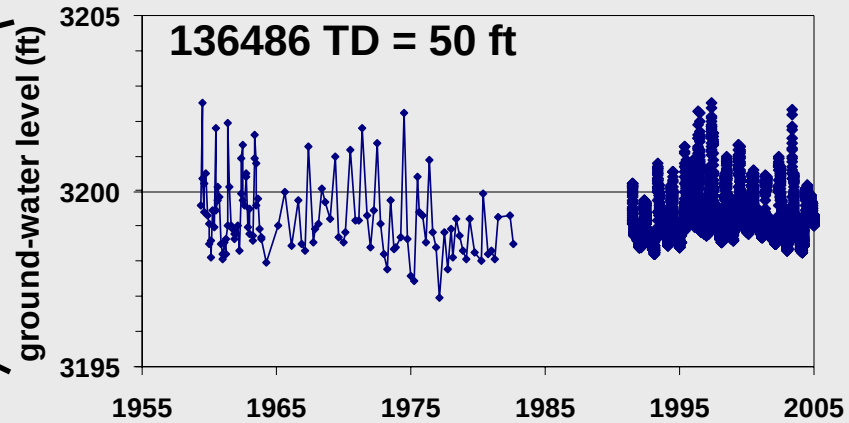


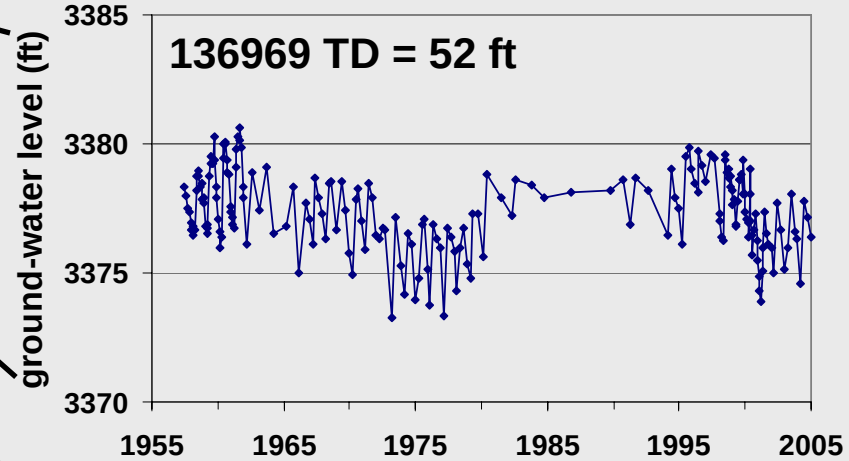


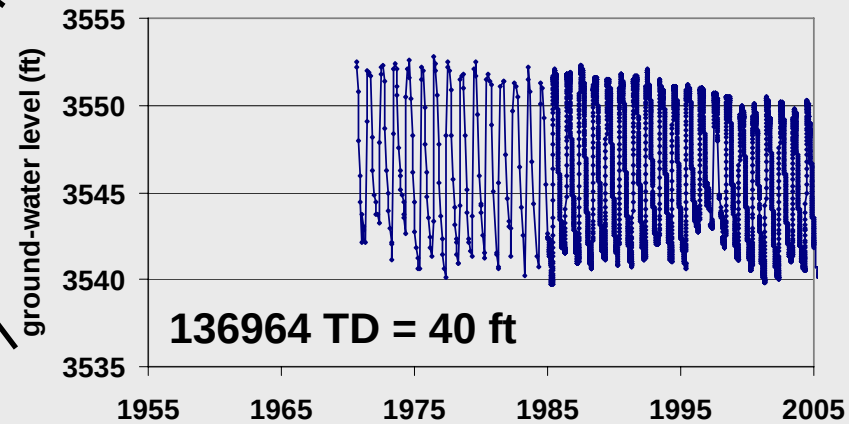


Ground-Water Storage

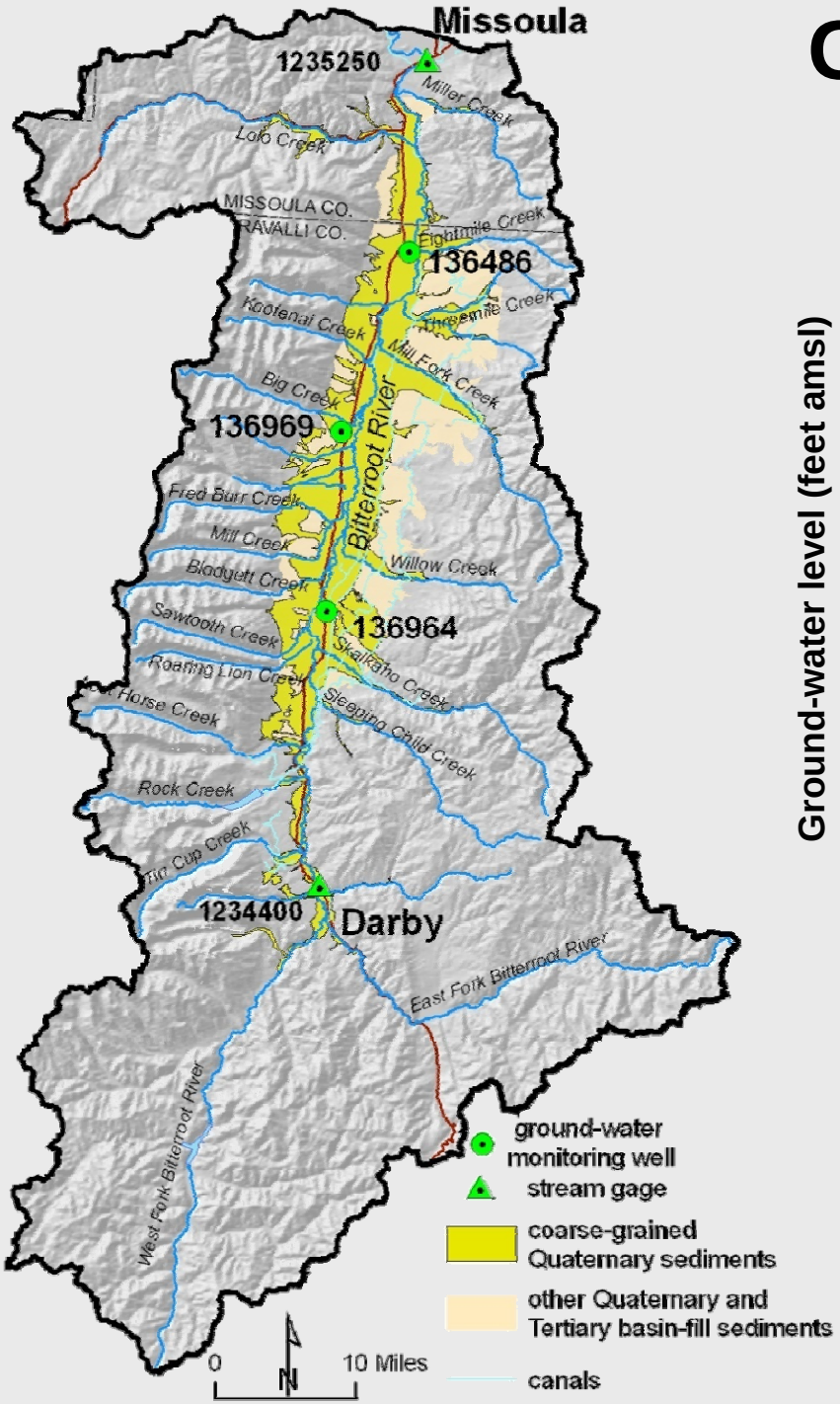




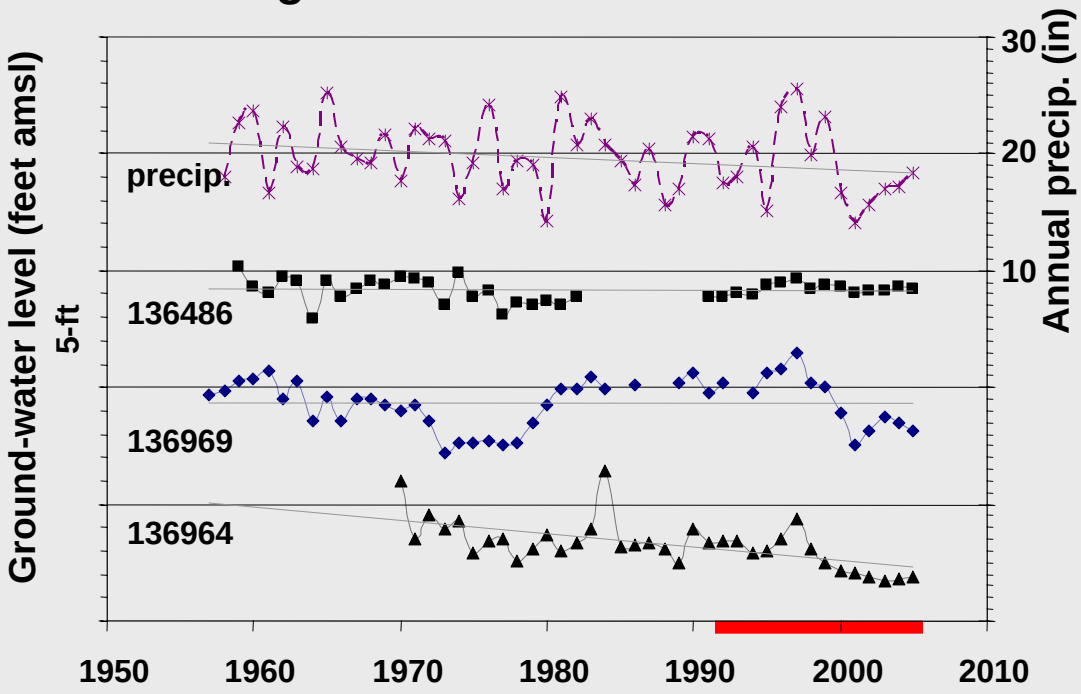




Ground-Water Storage

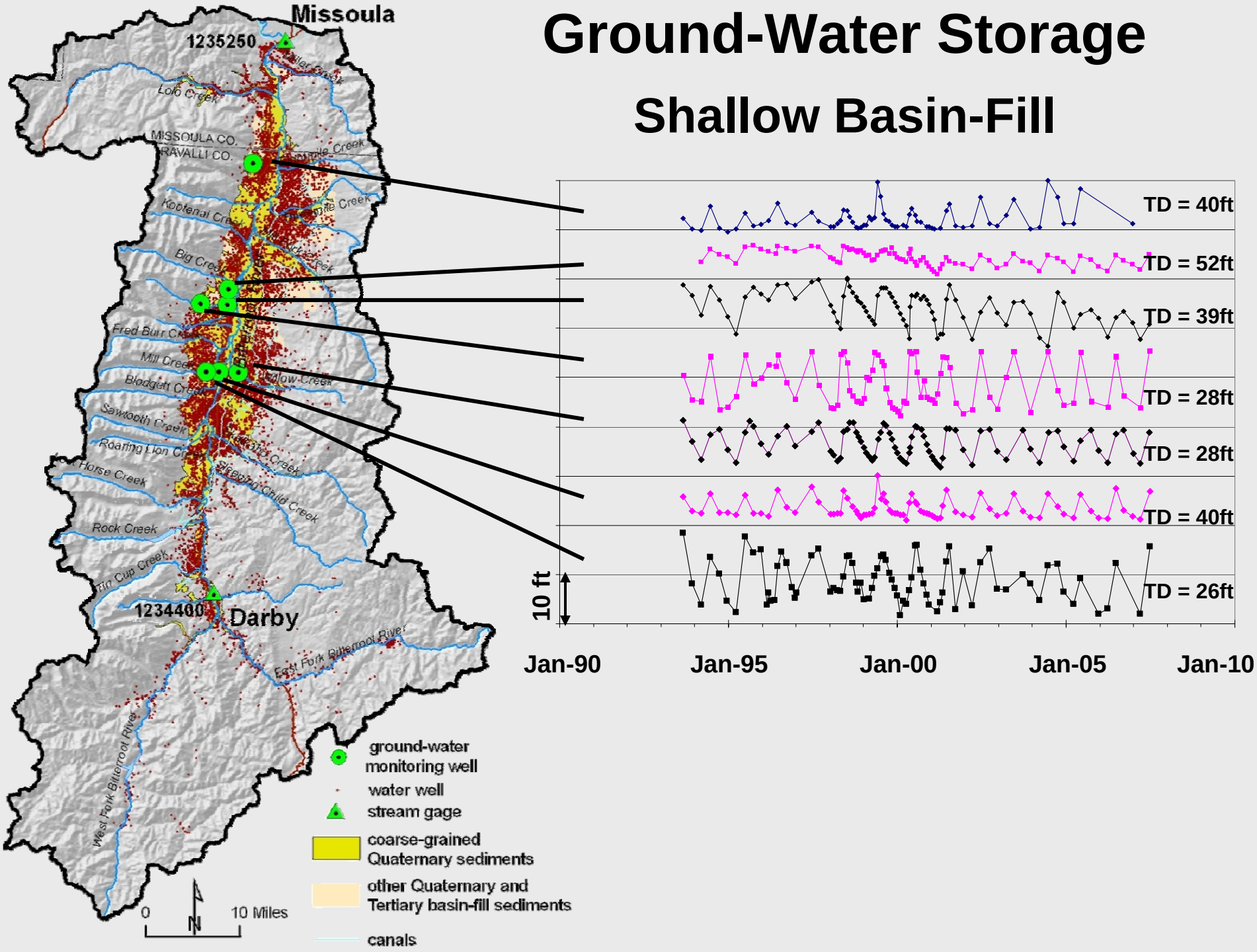


Average Annual Measurements

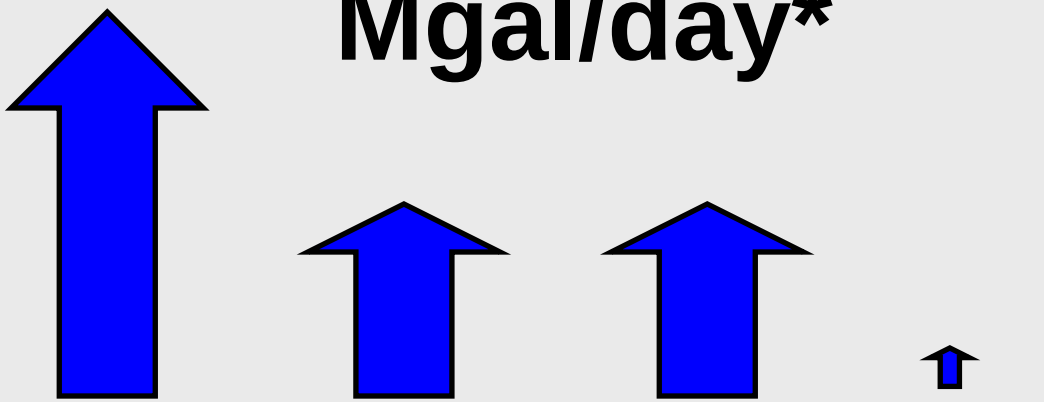


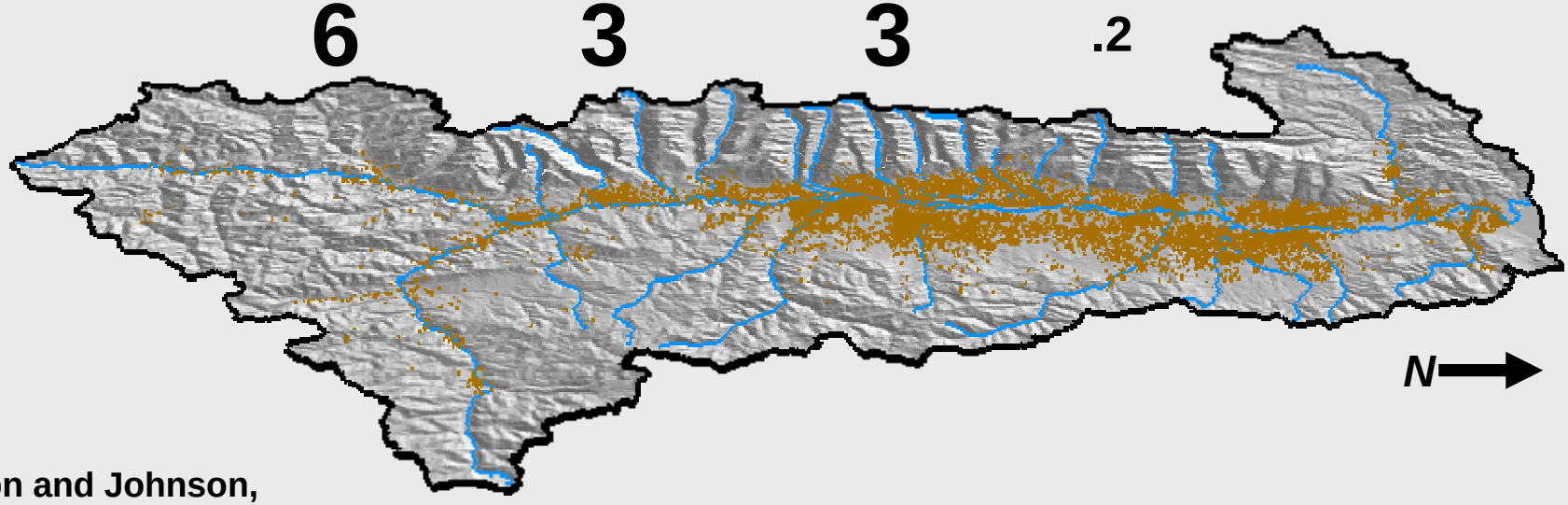
Ground-Water Storage

Shallow Basin-Fill



Ground-Water Withdrawals Mgal/day*

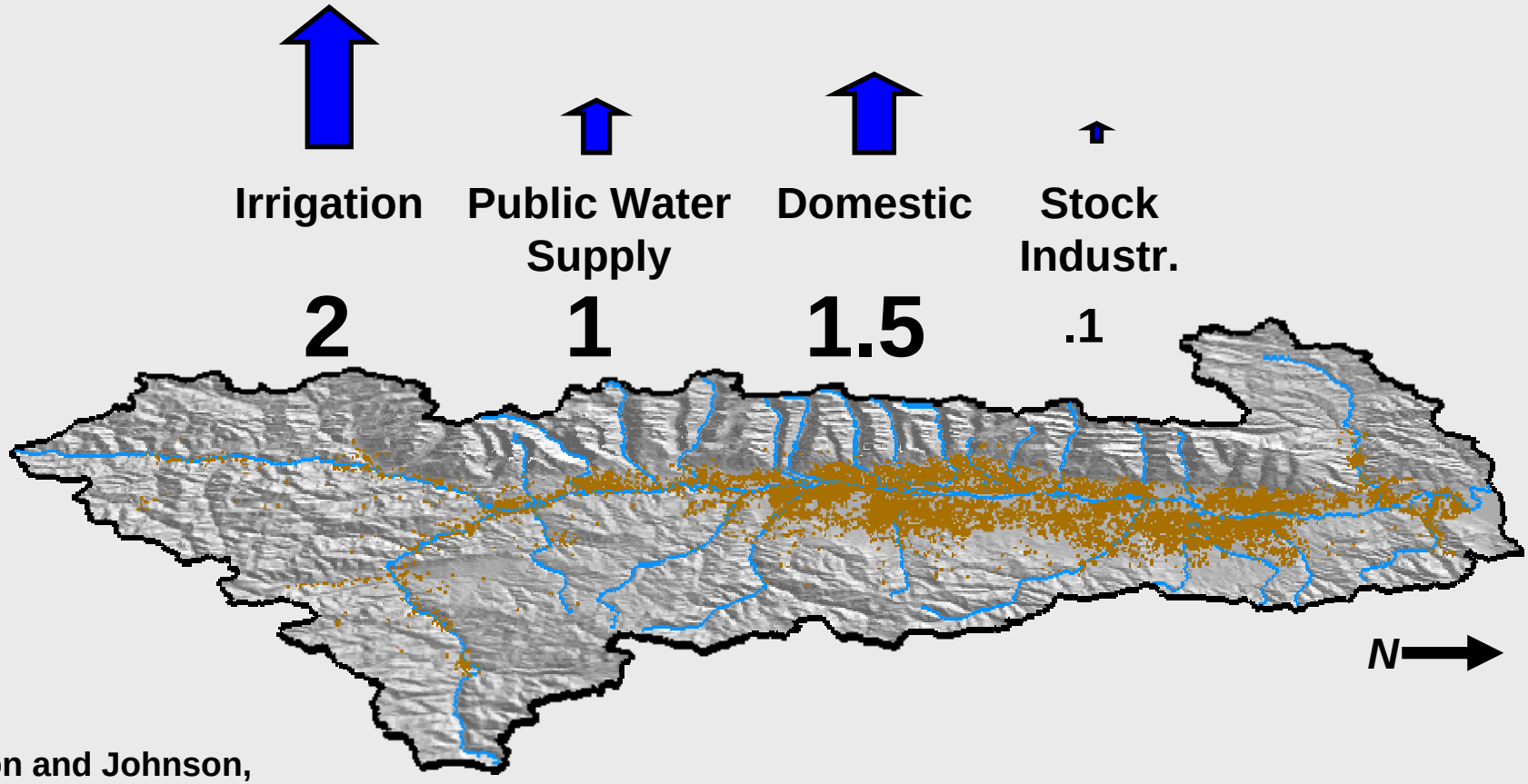




*Cannon and Johnson, 2004, Estimated water use in Montana in 2000,USGS SIR 2004-5223

4.6 Billion Gallons/yr

Ground-Water Consumed Mgal/day*

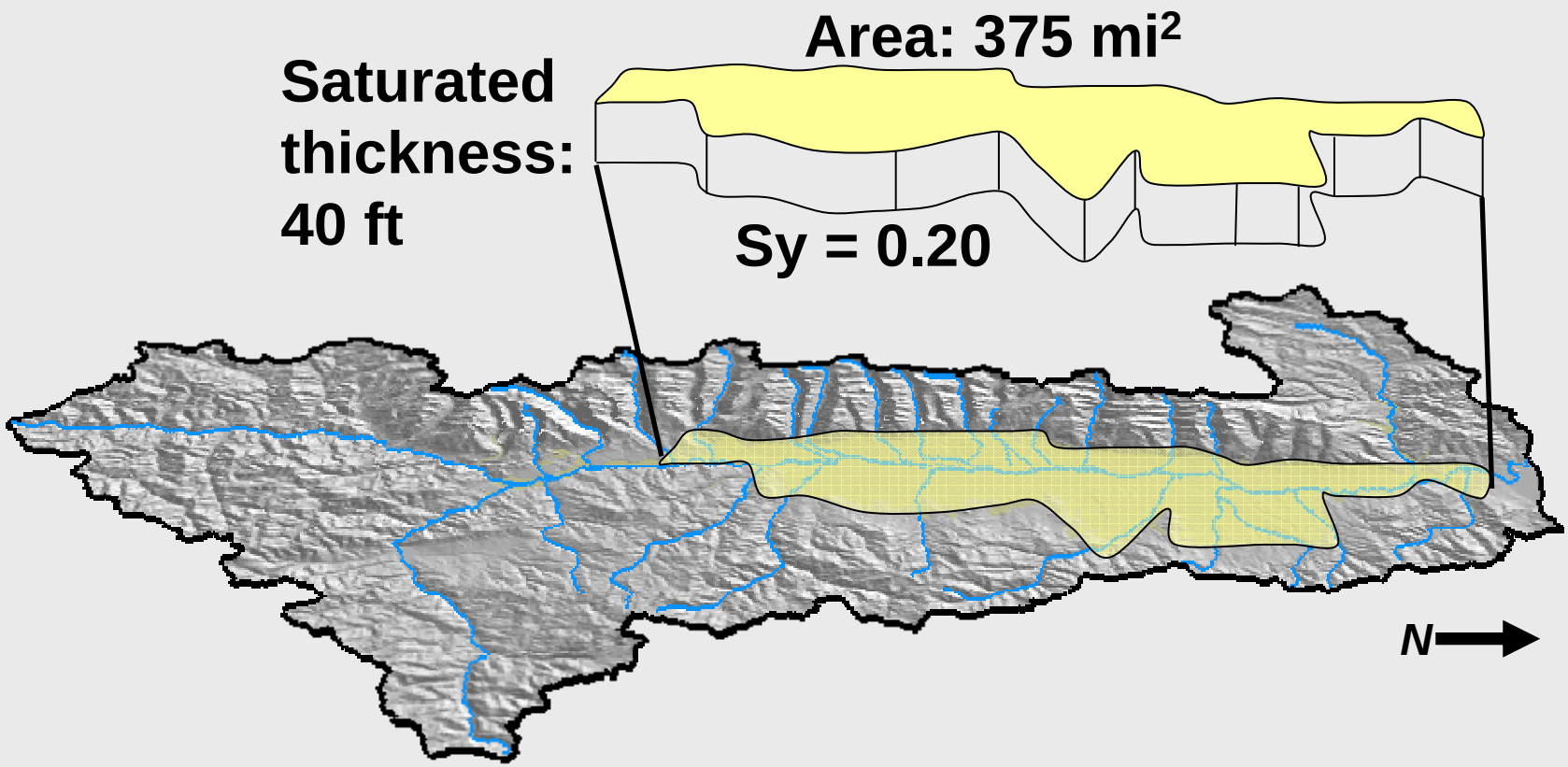


*Cannon and Johnson, 2004, Estimated water use in Montana in 2000,USGS SIR 2004-5223

1.6 Billion Gallons/yr

Ground-Water Storage shallow basin-fill

Volume = (area of the aquifer) x (saturated thickness) x (specific yield)

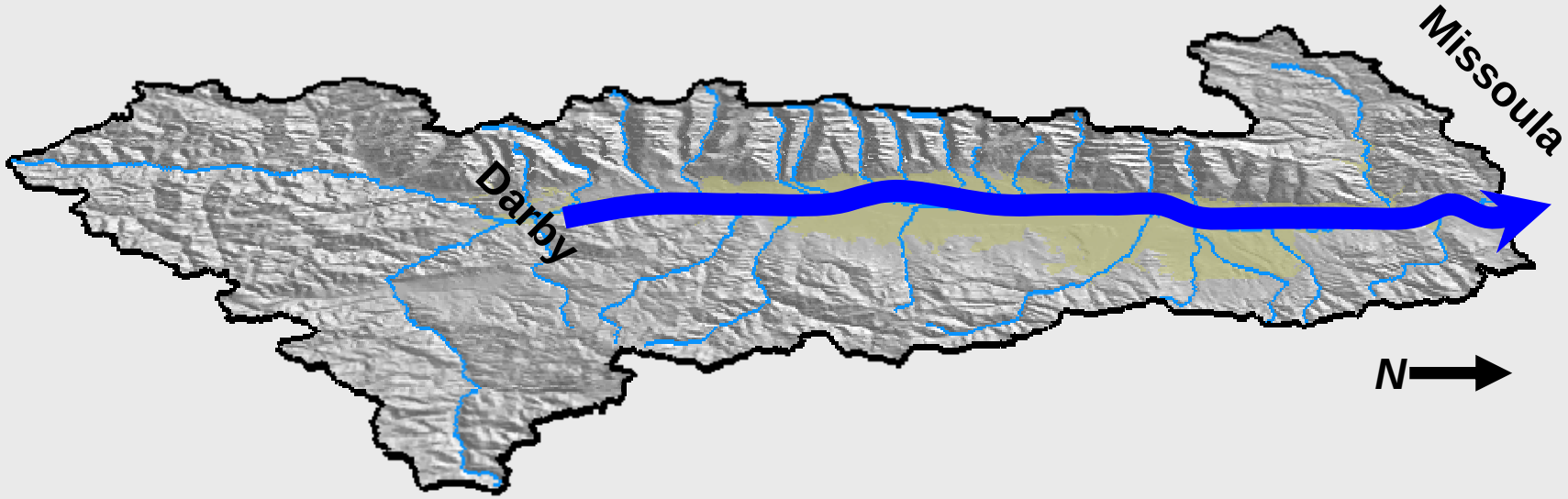


628 Billion Gallons

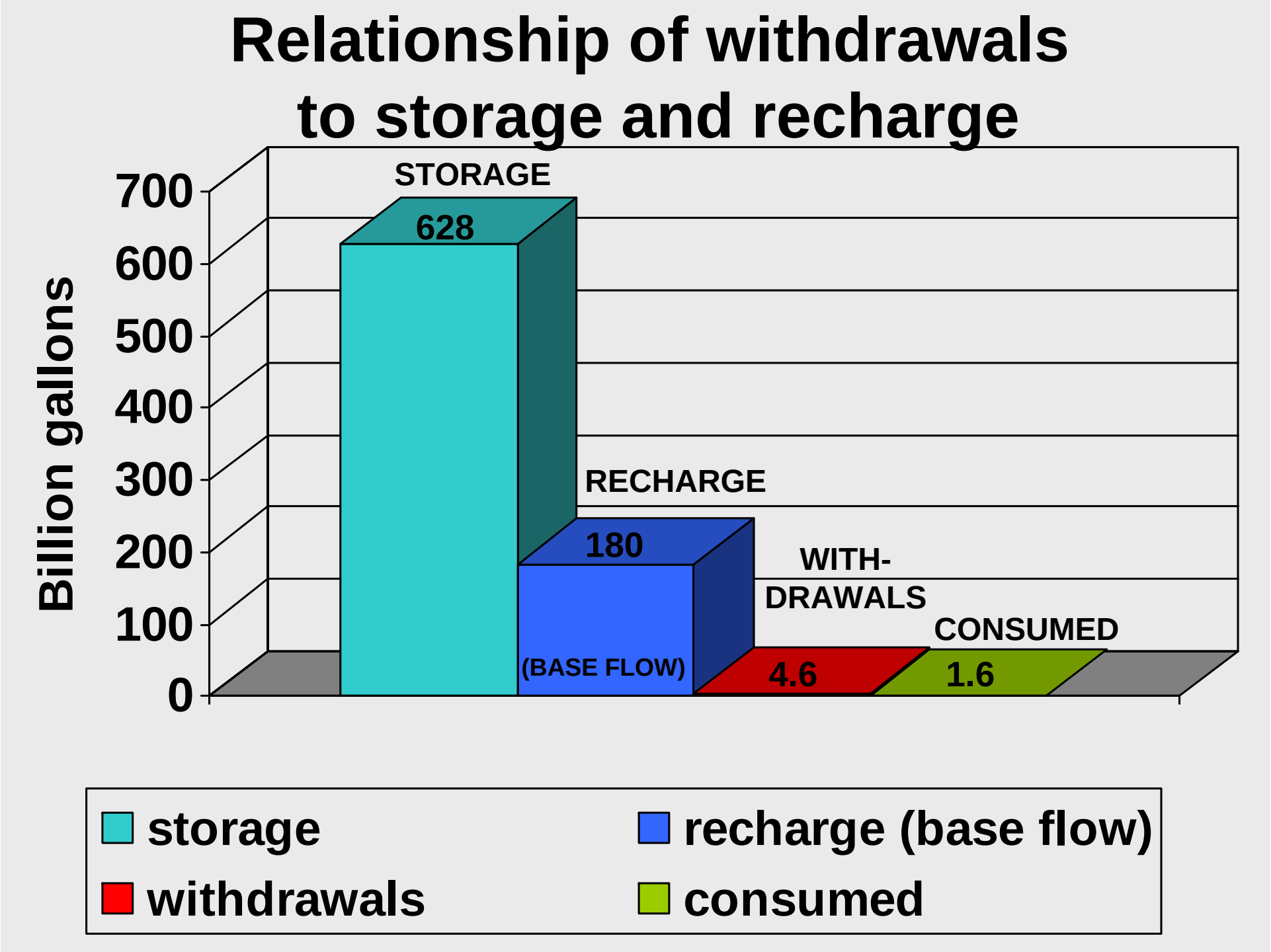
Ground-Water Recharge

Recharge to an aquifer* results in an equal amount of discharge to a stream

Average Base Flow Gain Between Darby and Missoula
775 cfs



180 Billion Gallons/yr


Relationship of withdrawals
to storage and recharge
Billion gallons
700
600
500
400
300
200
100
0
STORAGE
628
RECHARGE
180
(BASE FLOW)
WITH-
DRAWALS
4.6
CONSUMED
1.6
storage
recharge (base flow)
withdrawals
consumed

Bitterroot Summary

- Watershed scale analysis
  - May not pick up localized impacts
- Long-term changes
  - May not pick up seasonal impacts
- Addresses the basin-wide physical availability of water
  - May not address the legal availability of water

Hydrogeologic Analysis Summary

- Complexity will vary with problem and scale
  - Water budget provides a mean to assess availability
- Underpinned by good data
  - Mapping
    - Geologic
    - Hydrogeologic
  - Monitoring (systematic, long-term, on-going)
    - Ground-water levels
    - Stream flow
    - Climate data