Ground Water Depletion in Helena Area Aquifers

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October 2017
Overview of Talk
- Purpose – Characterize Impacts from Exempt Well and Over-pumping
  - Helena Area Examples

Helena Area Surface and Ground Water
- Combined System
- General Conceptual Model
  - All Surface and Ground Waters Discharge to Lake Helena (Upward Vertical Gradient)
    - Upwelling into Lake Helena
  - Streams recharge aquifer
  - Irrigation Waters Recharge Aquifer

Issue - EXEMPT Wells
- Dewatering Example – Emerald Ridge
- Future developments – Unknown Impacts
- Impacts from PWS Pumping Wells

Depletion and Declining Water Levels
- Pumping/Withdrawals exceed Recharge
- Private (exempt) wells need replacement
Overview - Helena Area Local Aquifers

Helena Valley Aquifer (HVA)
- High Permeability & Yield, Valley Fill Sediments, Upward Vertical Gradient
- Recharge and Communication with area Streams and Irrigation Canals/Waters
  - Subsurface Recharge from Underlying Bedrock Units (Upward Gradient)
- Ca-Mg/HCO₃ Water Type

“Tertiary” Aquifers
- Underlying HVA as Clay Lenses, Dominated by Fine-grained sediments with sand/gravel lenses, Limited/Variable Yield
- Not Present at all locations
- “Deep” Aquifer in Valley, City of Helena Water Reserve, Eastgate Village
- TDS and Water Type Varies from Na-K/SO₄ to Ca-Mg/HCO₃

Bedrock Aquifers
- Granitic and “Belt” Sedimentary Rocks
- Underlying Tertiary, Shallow Soil Covers
- Variable Yield in Fracture Flow System
- Ca-Mg/HCO₃ Water Type
Helena Area Waters
Oxygen/Hydrogen Isotope Dataset

- Characterize Water by Major Ions AND Water Molecule Isotopes
  - Major Ions Not Discussed Here

Water Molecule
- Oxygen
- Hydrogen

Conservative Tracer from Recharge Source
- Stream
- Irrigation
- Precipitation
- Other

Central Valley – **Helena Valley Aquifer** surface and ground water system combined, locally recharged ground water.

Stream Recharge
- Irrigation Recharge

“Deep” ground waters, **Na-K/Bicarbonate-Sulfate** waters; different recharge source (wells in **Tertiary Strata** along valley margins)

Tertiary wells with mixed recharge sources, **Bedrock wells**, upgradient snowmelt recharge

Regulating Reservoir Well, Showing evaporation, Mixed Recharge from Helena Valley Regulating Reservoir and snowmelt

Evaporated waters – Lake Helena (surface water) and well near Water Ski Lake

Tertiary wells with mixed recharge sources, **Bedrock wells**, upgradient snowmelt recharge

- Meteoric Water Line
  - Surface Water
  - Drains
  - Ground Water
  - Piezometers
  - Emerald Ridge
  - South Valley "Tertiary"
  - North Hills (East side)
Ground Water Data

- Differentiate Irrigation (Missouri River) Waters from other Stream recharge
- “Lightest” in Tertiary Wells
  - Depletion is Occurring (Emerald Ridge)
  - Recharge Source Unknown?
Helena Area Ground Water Flow Map

- 50’ contour interval in bedrock and upgradient areas
- 10’ contour interval in valley
  - Higher Permeability in Helena Valley Aquifer
- Public Water Supply (PWS) Source Wells shown
- Data from monthly water level collection by LCWQPD
  - East Helena/METG
  - Subdivision Development Records
- Depletion (drawdown) Areas Indicated
  - Emerald Ridge
  - North Hills (West & East sides)
    - PWS and Exempt Wells
  - Eastgate Area
    - PWS and Exempt Wells
- Risk for New Developments
  - EXEMPT Wells dewatering
  - High Capacity PWS Wells

Geology of Aquifer Dictates Yield
Southwest Valley (Basement) Flooding Area

Flooding Increases Storage
- Seasonal Peaks Decline yearly,
- Link – Tenmile Creek Flows to Aquifer Recharge
  - Mountain Snowpack & Runoff link to HVA Recharge

Trend exists inside HVID Main Canal
- Irrigation Recharge Doesn’t “Fill” System each year
- Subsurface Recharge from Bedrock System

Annual Decrease in Aquifer Storage
- Decreasing snowpack and runoff may cause problems

2011 Flood Year
2014 High Precipitation/Runoff Year - Recharge

Graph showing ground water surface elevation and Tenmile Creek average daily flow at Rimini (cfs).
North Hills – Long Term Trends

- LCWQPD Mon Well (exempt well area)
  - TD 100', Sand & Gravel
- Dept. State Lands Well (near PWS area)
  - TD 208', Spokane Shale
- Private House Well (exempt well, near PWS)
  - TD 156', Spokane Shale
- Wells show pattern of general decline, reflecting climate (precipitation) patterns
North Hills
North Montana Corridor

Well GWIC# 64755
DNRC, Dept State Lands

- Public Water Supply Pumping Creates Drawdown (Cone of Depression)
  - New PWS, Impacts Immediate
  - PWS Reporting Yield Problems, Can’t Fill Storage Tanks
- Impacts Yields for Exempt Wells
  - Wells go dry, need to deepen or install replacement wells
- Continuous Depletion means problem is only getting worse – impacted area is expanding in size

North Hill Depletion/Drawdown

- 40’ – Static Water Level 1967
- 60’-70’ – Water Level 2010-2011

MBMG North Hills GWIP Study
Compare with Other Area Wells

- North at top
- South at Bottom

North of HVA, see long term trends

Wells in HVA, More Stable WL
In cross section

- **Geology**
  - South of Main Helena Valley Fault
  - Unnamed faults north of depletion — change from shallow bedrock to “Tertiary”
  - Additional fault on north side of Helena Valley Aquifer (not shown)
- **Multiple PWS means drawdown area may be larger — more complicated**
Emerald Ridge

- All “EXEMPT” Wells
- Developed 2004
  - Immediate Yield Problems
    - Replacement Wells
  - Initial Wells 225-300’ bgs
    - Now >750’
- Drawdown below level of Helena Valley Aquifer
  - Geologic Fault Seals aquifer from recharge
Depletion from Exempt Wells

Emerald Ridge - Water Level Hydrograph

Park Ground Surface Elevation (lowest elevation in subdiv)

March 15, 2004
Water Levels

Lake Helena Surface Elevation (Top of Valley Aquifer Water Table)

2013 Summer Irrigation Season Apr15-Oct1
2014 Summer Irrigation Season
2015 Summer Irrigation Season
2016 Summer Irrigation Season

Emerald Ridge
Cross Section (2014)

- Fault seals recharge from Valley Aquifer
- Distinctly Different Water Types (Chemistry)
- Water Isotope Data

Stiff Diagram Explanation

- Sodium (Na⁺) + Potassium (K⁺)
- Calcium (Ca²⁺)
- Magnesium (Mg²⁺)
- Chloride (Cl⁻)
- Bicarbonate (HCO₃⁻)
- Sulfate (SO₄²⁻)

Milliequivalent per liter
East Side of North Hills

- NaK/\text{SO}_4\) Water Chemistry to Emerald Ridge
- Water Isotope Data Similar to Emerald Ridge
- Limited Development/Growth (>20 acre parcels)

Steady, Consistent Decline in Water Levels
Southeast Helena Valley Eastgate Area

- Multiple Public Water Supply (PWS) Pumping Sources
  - Limited Monitoring Locations (Exempt Well)
- Summer Drawdown near Pumping Center (PWS Wells)
- Summer – Recharge from Irrigation Canal
  - Upgradient Drawdown – lower than downgradient wells
- Cone of Depression Estimated
- New Canyon Ridge Subdivision - >100 New Exempt Wells
  - Where will Recharge Come from?

Southeast Helena Valley Drawdown

Wells Near HVID Canal
Water Levels Rise during Irrigation Season

Summer Drawdown/Depletion
Upgradient from Irrigation Canal

See similar trend to SW Valley Wells
- increase in high precip years
- irrigation waters don’t fill to same level each year


- **Helena Valley Aquifer** — “Tertiary” Sediments
  - High Permeability Aquifer, High Yields
- **Drawdown from Static Water Levels**
  - Levels present when well was installed
- **Recharge from Helena Valley Irrigation Canal**
- **Partial Recovery in Winter** (see hydrograph)
  - Not Reaching Level of Previous Years
Conclusions

• Combined drawdown from Exempt Wells can be significant
  – Emerald Ridge – all exempt wells
    • Followed regulatory process to develop, hard to know
  – Other areas with similar geologic conditions BEWARE
• Impacts from development of high volume pumping sources (e.g. PWS supply wells) not always well understood.

• Obvious – overpumping from aquifers leads to drawdown/depletion
  – Combined effects from Exempt wells, or High Volume pumping wells
• Less Obvious – Helena Valley Aquifer shows declining water levels linked to changing precipitation patterns (and stream runoff patterns)
• Helena Area “Tertiary” Wells – use isotope data to characterize risk?

• Policy
  – Impacts of PWS Well Pumping not always well understood
  – EXEMPT Wells – need more data/site specific studies showing impacts
    • Models are good, but real examples are better for public to understand
    • If problems suspected, then start a regular WATER LEVEL DATA COLLECTION program (data can be used later for model calibration)
  – Water Resource Community – Get Data to characterize problems
    • Need to start developing long-term SUSTAINABLE solutions (e.g Managed Aquifer Recharge)
Questions/Discussion?

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Helena Valley from Divide (view East)