East North Hills Groundwater Hydrology

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Introduction/Why We’re Here

• Local Citizens Group Showed Concerns over Groundwater Depletion from Residential Growth
  – Hydrograph(s) shows declining water levels
  – Requested LCWQPD petition DNRC for a Controlled Ground Water Area

• Previous Studies – MBMG 2006; MBMG 2012
  – Temporary Controlled Ground Water Areas (CGWA)
    • “North Hills” Areas
    • focus – west side of area (where the growth/population is)

*Note – copies of reports are available at MBMG website*
LCWQPD Study

• Focus – East Side of North Hills
  – North of HVID Canal
• Supplement Data from previous studies
  – Water Levels
  – Water Quality
  – Water Isotopes
  – Geology of Aquifer
  – Groundwater Temperature
• Evaluate feasibility of CGWA Proposal
  – Boundaries?
Basic Hydrology and Hydrologic Cycle

• Hydrologic Cycle – all water is connected
  – Evaporation, condensation in clouds
  – Precipitation and Infiltration/Runoff

• With respect to Groundwater and Study
  – Only a finite amount of groundwater available
Background Info

- **Groundwater Depletion** – long term decline in water levels **from pumping**.
  - Not related to changing precipitation patterns

- **Aquifer** – geologic underground layer which transmits water
  - “usable” quantities, high permeability, yields
  - **Unconfined** – water table surface
  - **Confined** – “artesian” pressure, surface rises above top of aquifer

- **Water Balance**
  - Water in (recharge) = water out (discharge)
  - Equals water available for use

- **North Hills Area**
  - Recharge from **precipitation** in higher elevations
  - Infiltration is main/only groundwater recharge
  - HVID Canal in downgradient area
Concepts to East North Hills Area

- Recharge from precipitation.
- Groundwater flows south towards Lake Helena
- HVID Canal – adds water to downgradient area only
- MBMG Model (2012) – rain amount sufficient for water needs
  - Things are a little different than modeled conditions

From MBMG, 2012. Figure 10 – Schematic North-South Geologic Cross Section

North Hills (Recharge Area)

Bedrock Aquifer

Pediment

Tertiary Aquifer

Helena Valley Aquifer

Study Area

Groundwater Flows To South towards Lake Helena

Helena Valley Fault

“Tertiary” Climbing Arrow Fm

HVID Canal

Lake Helena

Helena Valley Alluvium

Bedrock

Alluvium

“Tertiary” Climbing Arrow Fm

Argillite Bedrock

Coarse-Grained Tertiary Sediments
Water Levels

- **Hydrograph**
  - Graph showing changes in water levels over time

- **Types (still same graph)**
  - Depth to groundwater surface
  - Elevation of groundwater surface
Note on Water Level Measurements

- **Term – *Static Water Level*** – depth to water
  - No drawdown from pumping
  - Reported on well logs (MBMG-GWIC)
- **Term – *Drawdown***
  - How much water levels falls from static during pumping
- **Regular measurements by hand**
  - Potential for non-static results
  - LCWQPD Program – monthly measurements
- **Dataloggers – frequent measurements**
  - Sensors (pressure transducers)
  - Sonic sensors at wellhead
Note on Water Level Measurements

- Information from Datalogger and regular measurements
  - Drawdown from normal pumping
  - Low Yield Aquifers – recovery takes time
    - Extended period of time for return to static levels
  - Connect line at “peaks” to get “static” hydrograph

- East North Hills Study Area
  - “Aquifer” is clay-rich with sand seams providing water
    - Climbing Arrow Formation
  - Limited yield and permeability

![Water Level Measurements Graph](image)
Water Levels and Groundwater Flow

- Elevation of water surface
  - Vs. depth to groundwater below surface
- Contours made like topography
  - Interpolate between wells with data
  - But surface may be different than land surface
- Water flows perpendicular (90°) to contours

Groundwater Flow Direction
2019 Water Level Program

- Identify wells with data from previous projects
  - Collect monthly data to see how water levels have changed over time
  - Monthly to account for seasonal trends

- Dataloggers
  - Transducers placed into two bedrock wells
  - Well-n-tel sonic water level datalogger provide data from one location.

Remember link to precipitation – “wet” years more recharge “dry” or “drought” years less
Water Levels and Hydrographs

- 10 location on map with data from 2004-2005
- Elevations from high to low
Water Levels and Hydrographs

• Upgradient Well
  – TD 48’,
  – No change – rising WL
Water Levels and Hydrographs

- **3 Wells**
  - TD 178', same
  - TD 192', same
  - TD 324', same
Water Levels and Hydrographs

- 2 wells
  - TD 420’, drawdown 20’
  - TD 390’, same
Water Levels and Hydrographs

- Downgradient 4 wells
  - TD 259’, same
  - TD 420’, same
  - TD 350’, 10’ drawdown
  - TD 254’, same
Hydrograph Information

- Do we see changes in water levels since 2004?
  - Generally No
  - Slight drawdown in 2 wells
    - 10’ over 15 years

What drawdown do we see?
- Change in “Storage”

Concept - **Groundwater Storage**

Clay rich aquifer
- Holds water in small pores – not available for pumping
- Slowly released over time

Difference between recharge and discharge
- Some aquifers have excess “storage” built up over time
- Pumping (discharge) exceeds natural recharge

- Aquifer may have “extra” water from prehistoric times
  - Recharge exceeds discharge
Aquifers in Study Areas

- Geology (rock type) determines aquifer properties
  - Clay-rich aquifer system – most of East North Hills
  - Climbing Arrow Formation (MBMG, 2017)
    - Sand/gravels seams in mostly clay/silt aquifer
    - Low yields
    - Confined conditions
  - “Bedrock” wells – variable yields but generally good.
    - At surface in west side of study area
      - Water Table, unconfined aquifer
    - Beneath clay-rich system in central part of area
      - Confined conditions
  - Sand & Gravel wells – south side of study area
    - “Shallow” wells, water table (unconfined) system
Aquifer Delineation and Geology

• Geology determines aquifer properties
  – Yield
• Ogs – Tertiary
  – Climbing Arrow Fm
    • Clay rich
    • Sand seams
    • Low yields
  – BEDROCK present beneath Climbing Arrow Fm
• Bedrock
  – Fracture flow
  – Variable Yields

(will come back to Geology later in presentation)
Bedrock Wells

- MBMG Pumping Well
  - Bedrock at surface, TD 360'
  - WL falls, STORAGE
- Potable well into bedrock
  - TD 420’, Clay/shale to 380’
  - Argillite (bedrock) at 380’-420’
Bedrock Wells - 2019

- Two different recharge sources
  - West well – surface bedrock/recharge
  - East well – 300’ of clay over bedrock

- Different Aquifers
Summary of Hydrograph Conclusions

• Water Levels are generally stable
  – Limited drawdown in 2 wells attributed to storage

• Bedrock aquifer
  – Different when exposed at surface
    • “Water Table”, Unconfined
  – Beneath clay-rich sequence
    • Confined
Water Quality (Major Ions)

- Major ions to characterize water “type”
  - Example, “hard” water, “soft” water, etc
  - Process/Method applied to >500 sites in area

- Major ions comprise 99% of dissolved solids
  - Reflect geology/minerals of aquifer
  - Water quality type can change with time in subsurface
  - With geology, can link to trace elements (e.g. arsenic, uranium)

**Stiff Diagram**

Size of polygon reflect Total Dissolved Solids (TDS)

- Sodium ($\text{Na}^+$) + Potassium ($\text{K}^+$)
- Calcium ($\text{Ca}^{2+}$)
- Magnesium ($\text{Mg}^{2+}$)
- Iron ($\text{Fe}^{3+}$)
- Chloride ($\text{Cl}^-$)
- Bicarbonate ($\text{HCO}_3^-$)
- Sulfate ($\text{SO}_4^{2-}$)
- Carbonate ($\text{CO}_3^{2-}$)

**Sample Dates**

- April
- August
- October

All sampling in 2010

Results plotted in meq/L
Chemistry Conclusions

• See Differences across study area
  – Some areas with same chemistry

• Bedrock wells – different aquifers
  – Different chemistry

• North of Helena Valley Fault – High TDS
  – Different Aquifer Properties
• Oxygen and Hydrogen in water molecules
• “Conservative” *tracer* since it doesn’t change with water quality
  – But can have “mixed” values, from mixed recharge sources
• Allows *tracing* from recharge (precipitation, stream or irrigation waters)
  to discharge (well or spring)
Graph of Groundwater Isotope Data

- Irrigation Waters
- Stream Waters
- Groundwater
  - Bedrock
  - HVA
  - “Tertiary” areas
Water Isotopes

• Takeaway
• Different Recharge Sources
  – Different from valley
• See HVID Recharge
Water Isotope data

Bedrock Wells

Clay Rich Aquifer Wells

HVID Water

North HV Fault??

Helena Valley Fault
Water Isotope Conclusions

- Areas with different water isotopes
  - Different recharge sources
- Clay Rich Aquifer area
  - “lightest” results
- Bedrock area
  - “heavier” results
- Irrigation Canal Recharge to south side
- Area north of Helena Valley Fault different
Ground Water Temperature

- Another "Tracer" for groundwater—snowmelt recharge cold
- Average water temperature 1-2°C above mean annual temperature (8°C)
- Ground water temperature increases with depth at Geothermal Gradient
  - 1.8°C/100m (0.0055°C/ft) in "normal" areas (higher in volcanic locations)

Geothermal Gradient
Ground Temperature Increases with Depth

(Heath, 1983)
Study Area Ground Water Temperature

- Wells from North Hills, Scratchgravel Hills
  - Show “normal” geothermal gradient
  - Groundwater Temperature 8°C at surface

Warm water means recharge from depth, like hot springs

“Bedrock” Wells – Local Recharge; Mixed Recharge gives cooler temps
Groundwater Temperature Conclusions

• Warm/heated water shows upwelling of groundwater
  – Recharge from below, not above
  – East side of Study Area
    • Bedrock waters beneath Climbing Arrow unit
• “Cool”/normal temperature water in bedrock
  – Local recharge from precipitation

• Separate Factors influence water in different areas

• Anecdotally hear of warm/hot waters near and north of **Helena Valley Fault**
  – Local groundwater system separate
Aquifer Delineation and Geology

- Geology determines aquifer properties
  - **Yield**
- Ogs – Tertiary
  - Climbing Arrow Fm
    - Clay rich
    - Sand seams
    - Low yields
  - BEDROCK present beneath Climbing Arrow Fm
- Bedrock
  - Fracture flow
  - Variable Yields

(Same map we saw before)
Geologic Cross Section A-A’
West – East

Geology determines aquifer properties – Yield

- Ogs – Tertiary – Clay rich – Sand seams – Low yields
- Bedrock – Fracture flow – Variable Yields
View North – Geologic Cross Section A-A’

- **East to West**: 3400’ to 4000’
- **West**: A
- **East**: A’

**Bedrock (Argillite)**

- North of Helena Valley Fault
- Water Level below Lake Helena (3650’)
- Different Aquifer system here

**“Tertiary” Climbing Arrow Formation**

**Bedrock – Limestone Shales**

**Warm Water Recharge from Bedrock**

**Elevation (ft msl)**
- 4000’
- 3900’
- 3800’
- 3700’
- 3600’
- 3500’
- 3400’
Complex Geology
- Multiple Faults
- Fault orientation at depth

Different Geologic Formations

Water table is lower
- Need to drill deeper...

View West – Geologic Cross Section
Lake Helena (South) to Holter Lake (North)
Summary of Data Conclusions

• Water Levels
  – No Depletion Observed
    • Some declining water levels from storage

• Water Chemistry and Isotopes
  – Differences in Study Area
  – Different in bedrock/deep/clay-rich aquifer

• Water Temperature
  – Local Recharge into Bedrock
  – Clay-Rich sequence, “deep” aquifer recharge (warm waters)

• Geology – Different Aquifer Systems
  – Bedrock Aquifers – recharge locally
  – Clay rich aquifers – warm water, recharge from base
  – **Helena Valley Fault** separates aquifer types
    • Little Data, Deep groundwater north of fault
• Bedrock Aquifers surrounding “Tertiary” Aquifer
  – Tertiary clay-rich Climbing Arrow Formation
    • Poor yields, recharge from base to deep
  – Surface recharge to bedrock, shallow Tertiary aquifers
  – Recharge to Tertiary Aquifers from bedrock across fault

• Yields and Depletion
  – Bedrock provides best yields, may need to drill to depth
  – Depletion not observed
    • Would see break in slope of declining water level wells

• Groundwater Divide not at Drainage Divide
  – Aligns with some of Helena Valley Fault / Complex System
  – Flow appears to Align with “Tertiary Channel) to northeast
    • Water Quality, Isotopes similar
    • Recharge to Clay-rich sediments upward from base
Conclusions

• Climbing Arrow Formation major local aquifer
  – Poor aquifer, low yields, recharge
• Groundwater available at depth in bedrock in East North Hills
  – Area South of Helena Valley Fault
  – Water much deeper, but still available in bedrock

• (Temporary) Controlled Ground Water Area
  – No basis to develop, water levels stable
  – No need to determine/propose boundaries

• Next Steps
  – Continue WL monitoring program at selected locations
  – Looking for Resident wells to monitor (& Sample) North of Helena Valley Fault
Questions/Discussion?

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Project Report (est. Dec 2019) will be available at
http://www.lccountymt.gov/health/water.html

Helena Valley from Divide (view East)