Potential Impacts of Oil & Gas Development on Ground Water Resources: Middle Rio Grande Basin Hydrogeology & Vulnerability to Impacts from Fracking

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Introduction

- NM has large reserves of fossil fuel resources including oil, gas, and goal
- Oil & gas development is important to the NM economy
- Much misunderstanding about the role of water in development
- Public concern about impacts of oil & gas development on water resources
  - Water resources required for exploration & development
  - Water produced during development (produced water)
  - Impacts on ground water, seismic events, others

Previous Presentation

- Focused on drilling technologies & water use
  - Water use for drilling
  - Water use for fracking
    - Chemical constituents in frack fluids
  - Water produced during oil recovery
    - Frack flowback
    - Produced water

Previous Conclusions - 1

- Fracking coupled with horizontal drilling has revolutionized oil & gas production in U.S.
  - Has enabled development of formations that previously were inaccessible (shales, tight sands, coal)
  - Has increased productivity of existing formations
  - Increased productivity with fewer wells
- But fracking become a lightning rod that has produced very emotional opposition from some members of the public
- Oil & gas industry has extensive experience with process
  - Originally with vertical wells
  - More recently with horizontal wells
- Fracking technology is well understood and potential failure mechanisms leading to loss of integrity

Previous Conclusions - 2

- Principal threats to water resources from fracking are those associated with conventional oil & gas development
  - Spills, leaks, accidents associated with surface operations
  - Transportation and disposal of produced water
- Little evidence that fracking has contaminated ground water resources, nevertheless, management & regulatory programs are needed to assure protection of resources.

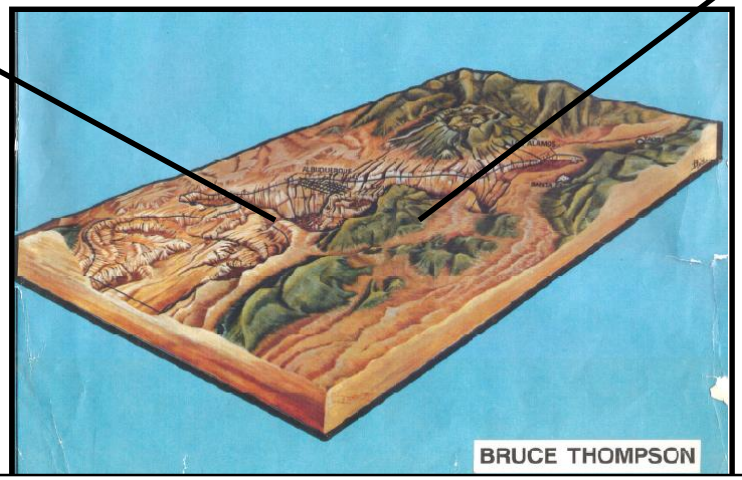
Current Presentation

- Questions were raised regarding proposed exploration & production well in western Sandoval County by SandRidge Exploration & Development, LLC and the threat this development might pose to ground water resources in the Middle Rio Grande

- Objectives of this presentation
  - Summarize hydrogeology of MRG basin in context of potential contamination from oil & gas exploration & development
  - Summarize of SandRidge Project
  - A bit about ground water contaminant transport
- Present concluding thoughts on vulnerability of ground water resource to contamination

Hydrologic View of Albuquerque Ground Water Basin < 1985

- Ground water resources equivalent to Lake Superior
- Unconsolidated sediments to >10,000 ft deep
- High quality water throughout entire basin



Cover of notebook for 1985 Committee for developing ground water vulnerability & protection plan

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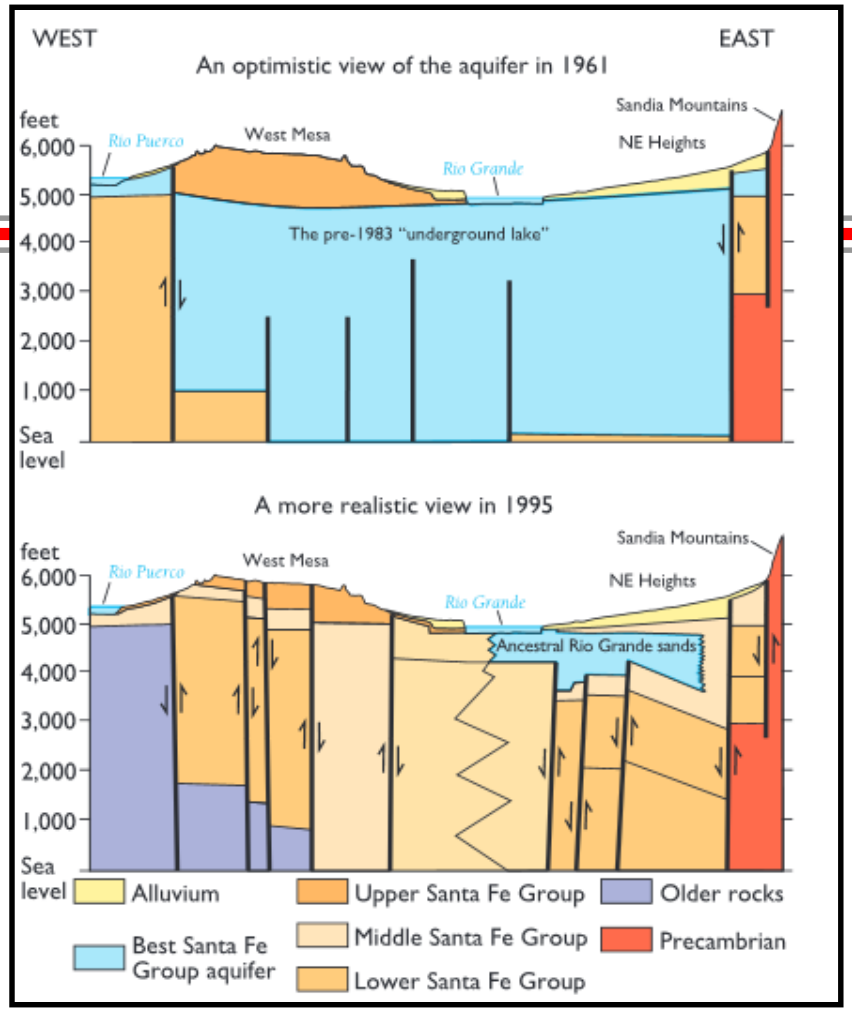
Actually Basin is Much More Complicated

- Notable contributors to knowledge
  - Kelly Summers, 1st hydrogeologist employed by CABQ
  - John Hawley, NMBGMR, contracted to prepare detailed conceptual model of basin (Hawley & Haase, 1992)
  - Mike Kernodle et al., USGS, developed 3-D ground water model that is basis of that used today (Kernodle et al., 1994)

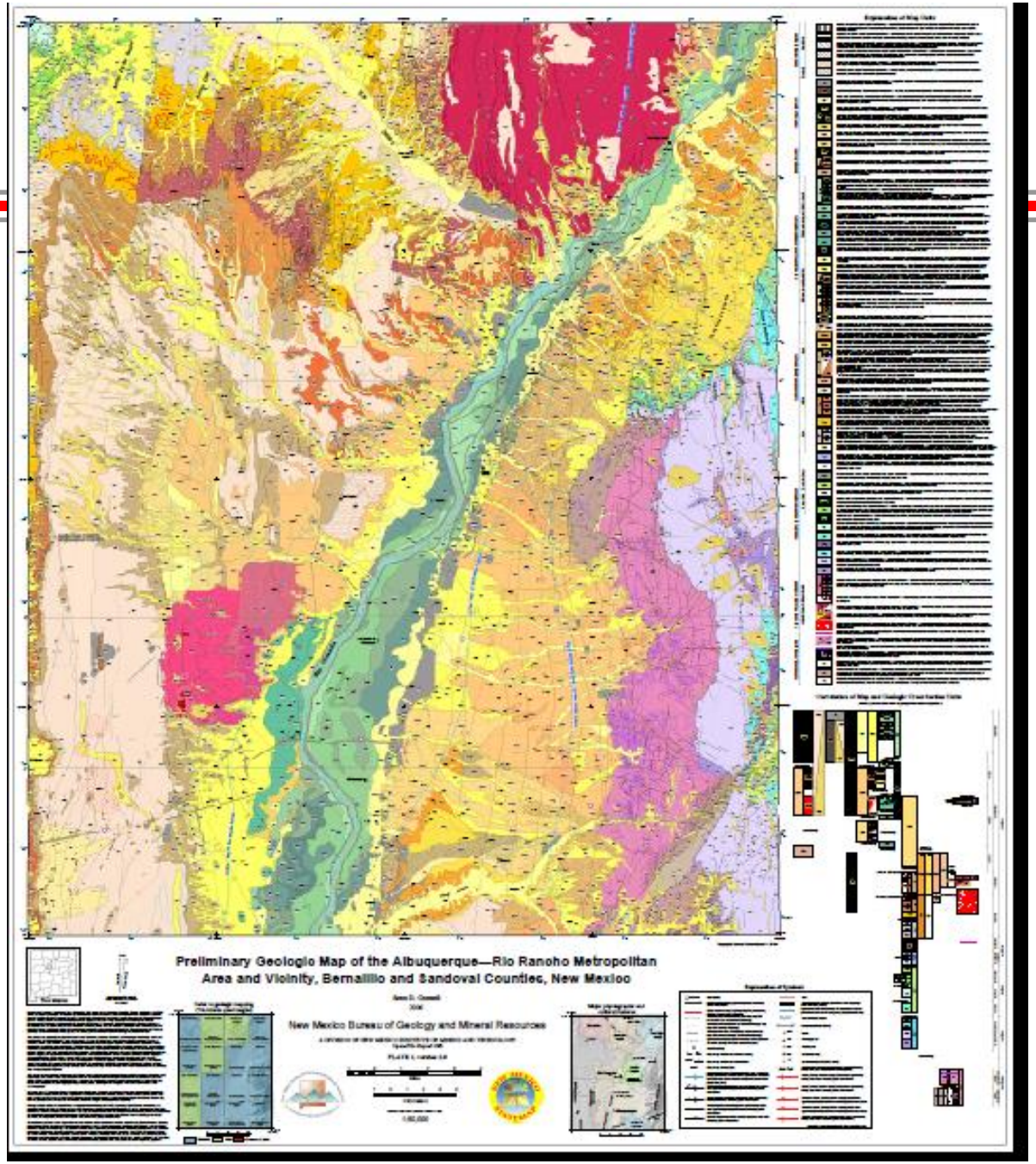
- New knowledge:
  - Aquifer heads were falling rapidly
  - Aquifer was subject to severe over draft (~50 KAF/yr)
  - Much less recharge from river & mountain front than originally thought
  - Glover-Ballmer equation not valid
  - Horizontal stratification: K_H ~ 500 K_V



Johnson, P., (2009), NMBGMR, Decision Makers Conference

Pretty Maps!

(Connell, 2008)



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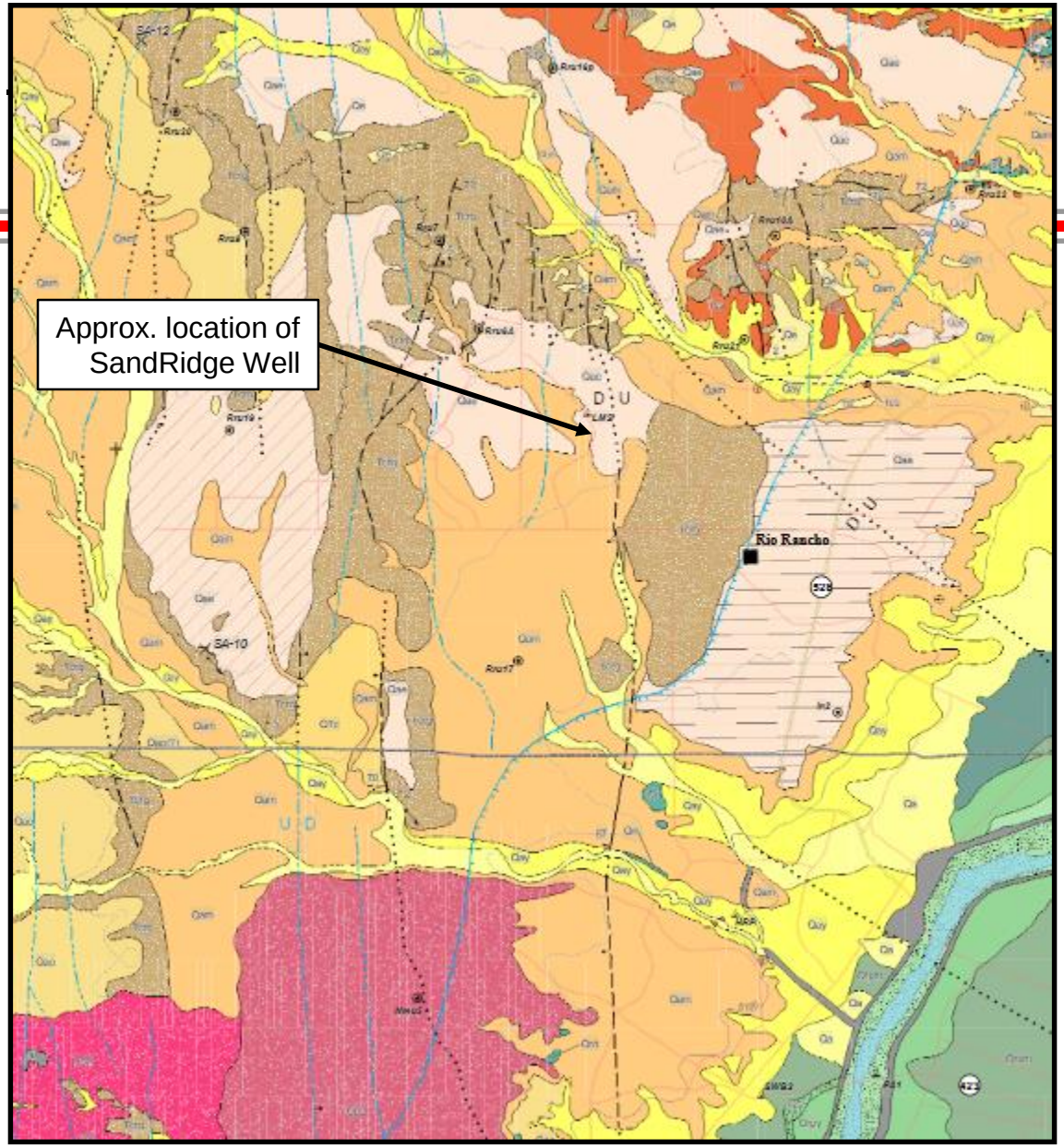
Geology of Sandoval Co.
(Connell, 2008)



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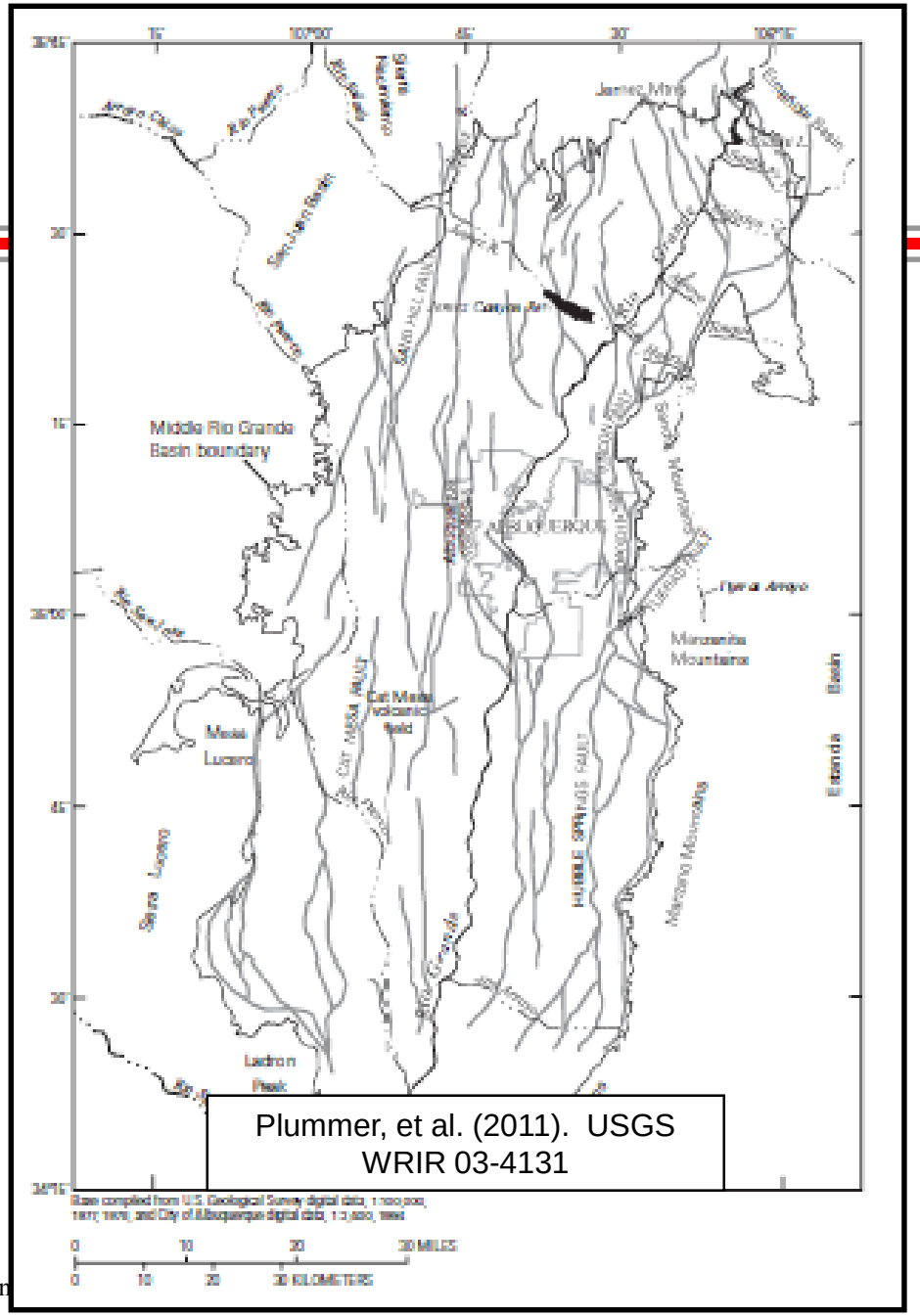
Lots of Faults

- Faults have major influence on direction of ground water flow
- Major influence on ground water quality



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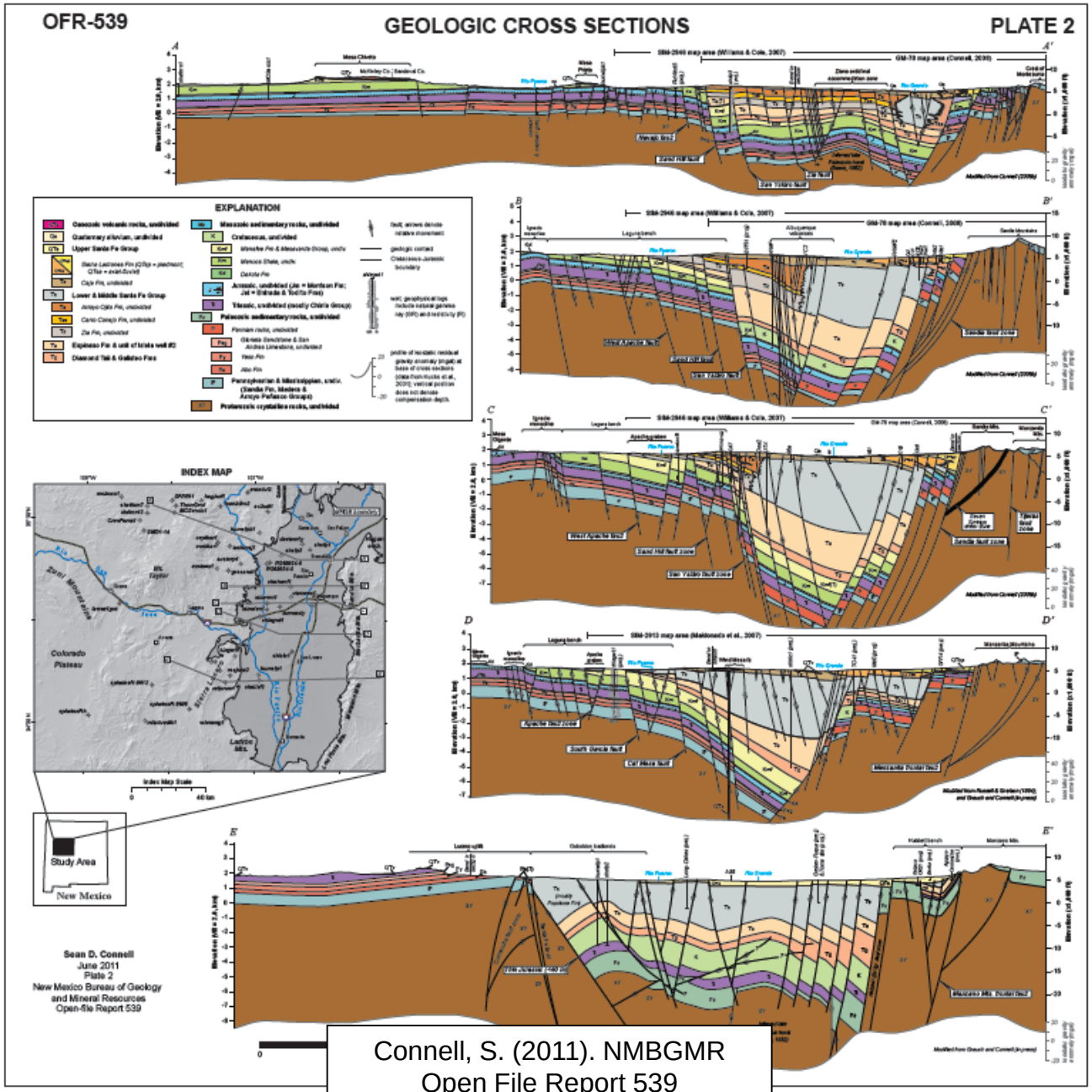

Connell, S. (2011). NMBGMR Open File Report 539

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Hydraulic Properties Vary Widely

(Kernodle et al., 1994)

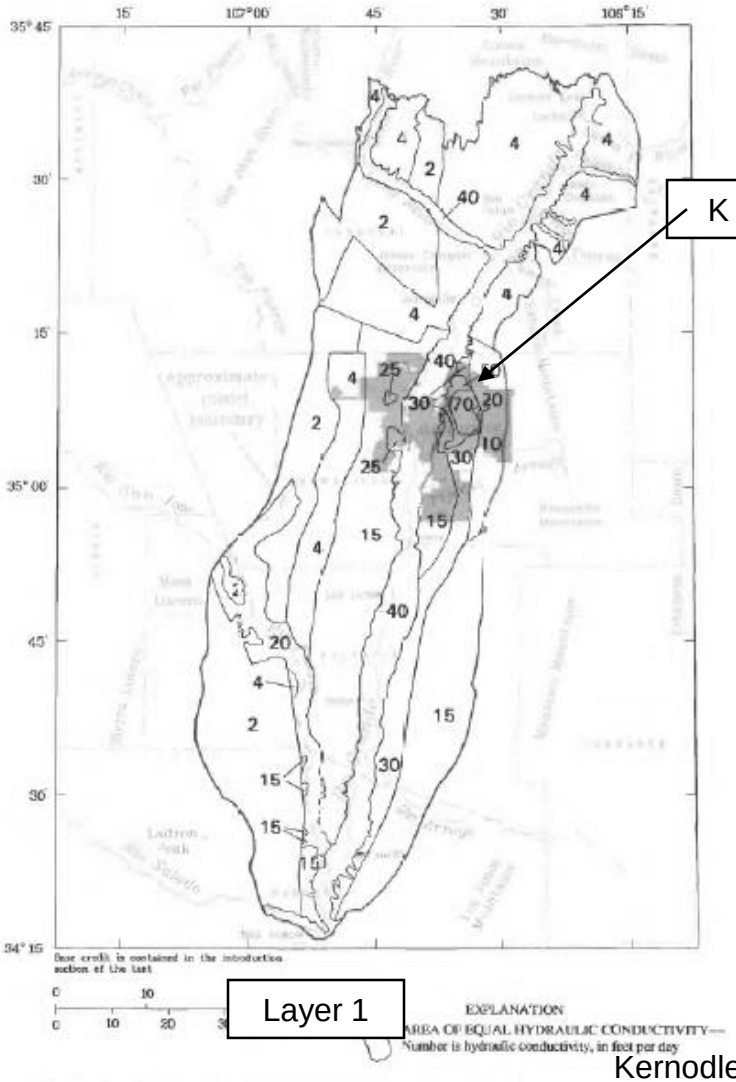

Figure 7.—Distribution of hydraulic conductivity from which hydraulic conductivity in model layer 1 was calculated.

K = 70 ft/d

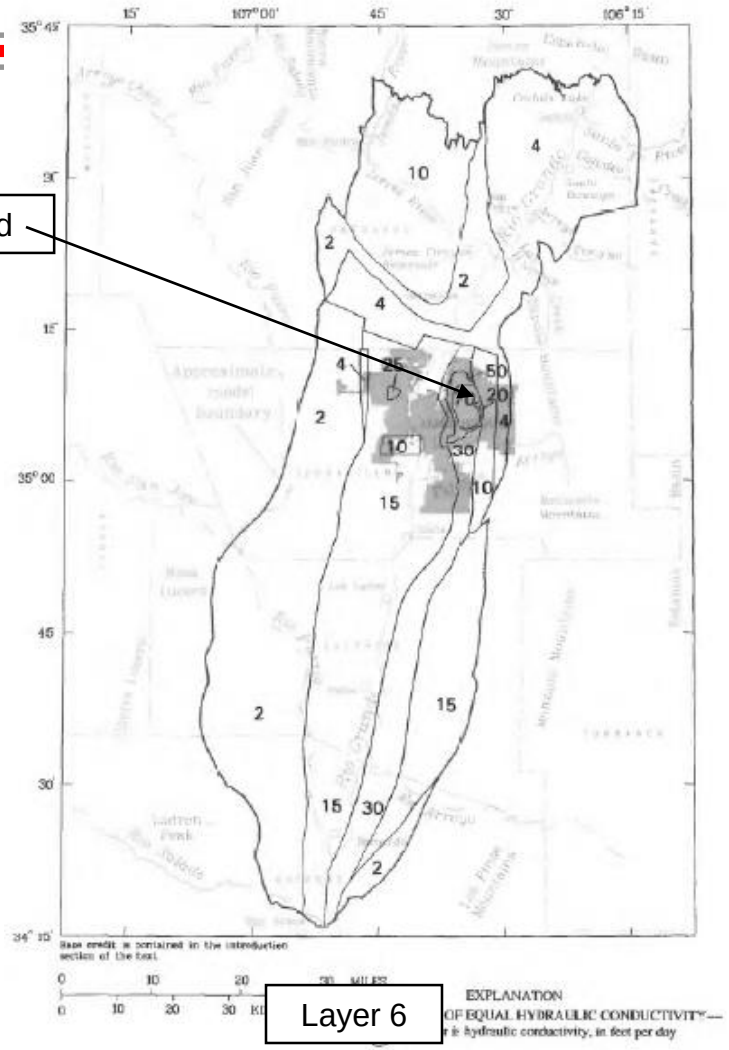

Figure 12.—Distribution of hydraulic conductivity from which hydraulic conductivity in model layer 6 was calculated.

Kernodle et al., (

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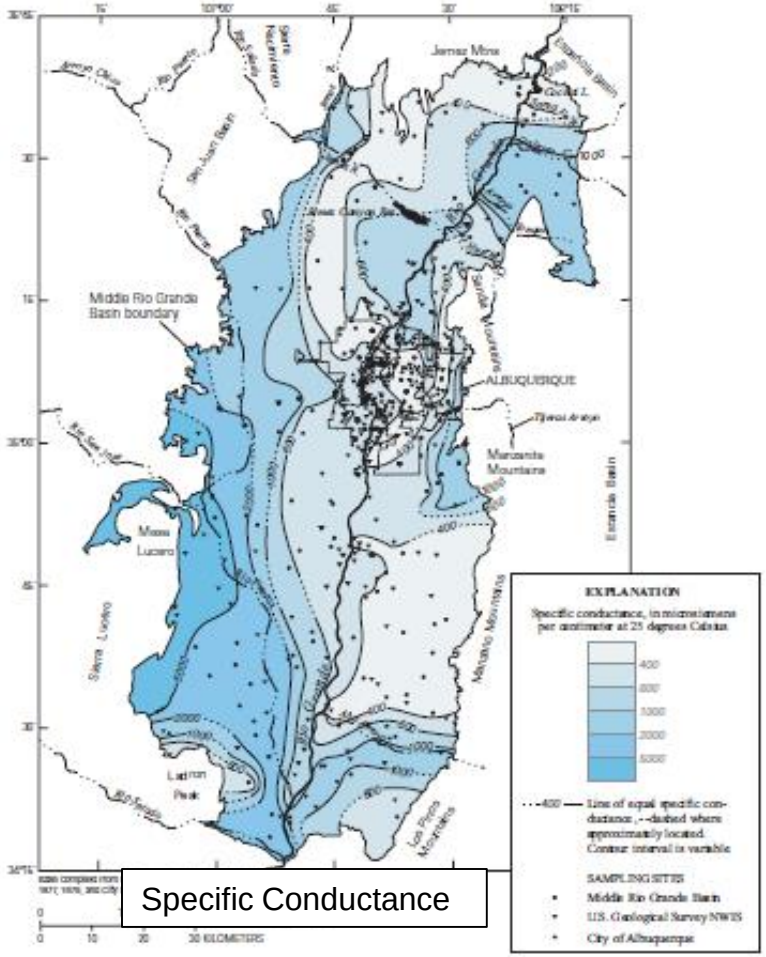
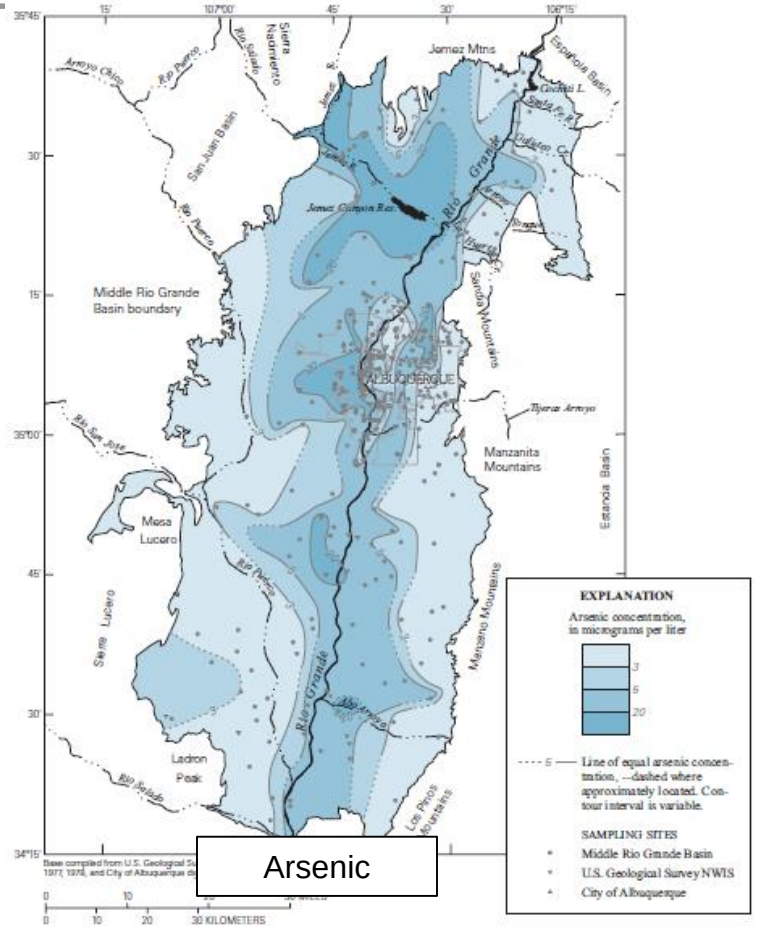
Ground Water Quality in MRG Basin

(Plummer et al., 2004)



Specific Conductance



Arsenic

Summary of Hydrogeology Related to Regional Water Supply in Western Sandoval County

- Hydrogeology is very heterogeneous, both vertically & horizontally
  - Low hydraulic conductivity
  - Numerous north/south faults limit east/west flow
  - Horizontal stratification limit vertical flow
  - Hydraulic gradients are flat in western Sandoval County due to little ground water development
  - Proximity to faults limits potential value of ground water resource
- Poor water quality due to As, Mo, V, TDS & other parameters

Proposed

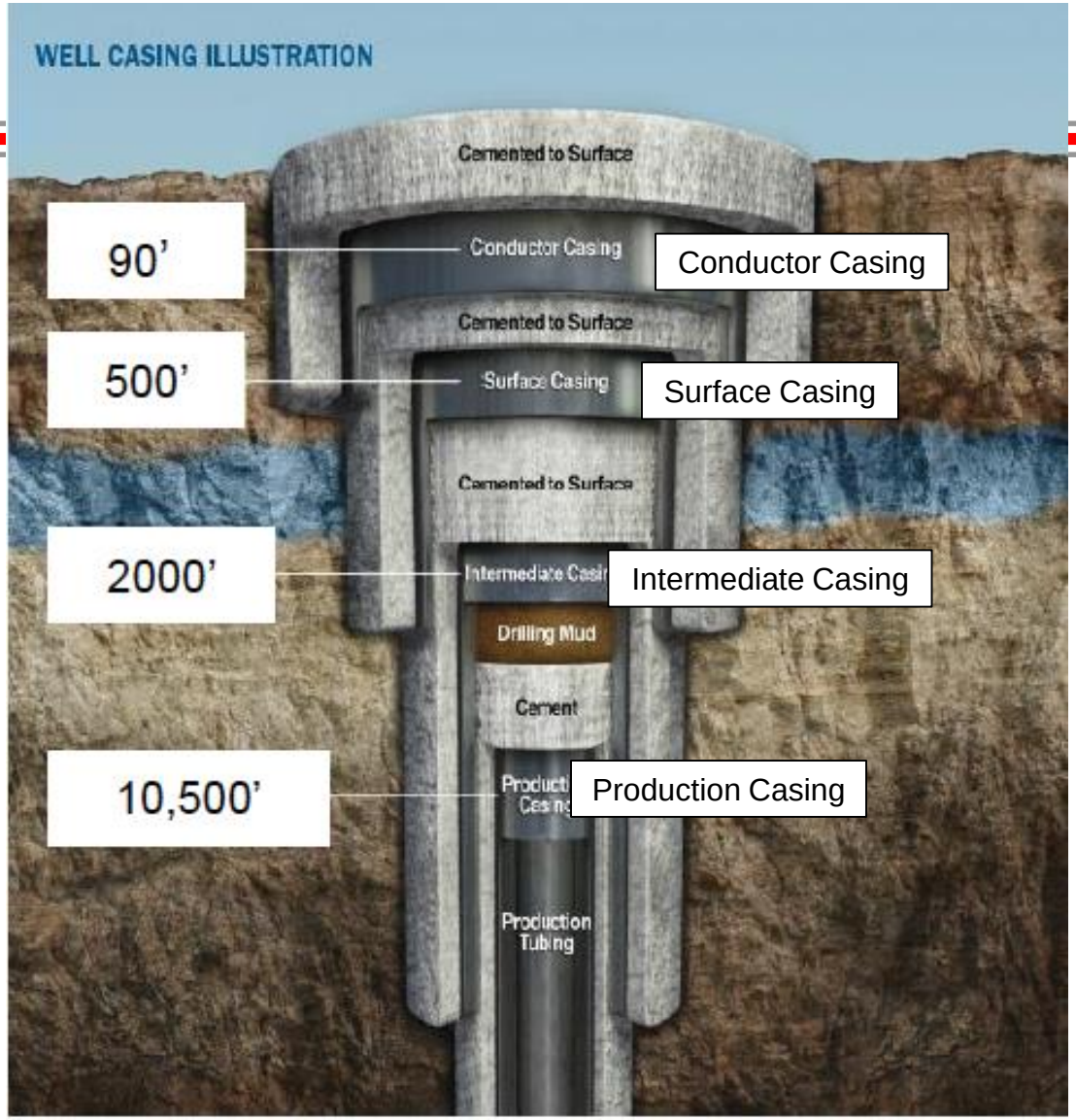
Proposed SandRidge Project

(From application materials submitted to Sandoval Co.)

- Site is 5.7 mi west of Rio Rancho city limits
- Exploration & possible development
- Full capacity:
  - < 500 bbls/d oil
  - < 2 M ft^3/d gas
  - < 1000 bbls/d produced water
- Oil, gas & water to be transported by truck
- Fracking may be used during development
- Water for drilling is 10,000 bbls (400,000 gal)
  - Purchase water from Rio Rancho

Well Construction

- Conservative design to limit risk of contamination
- Maximum depth ~10,500 ft

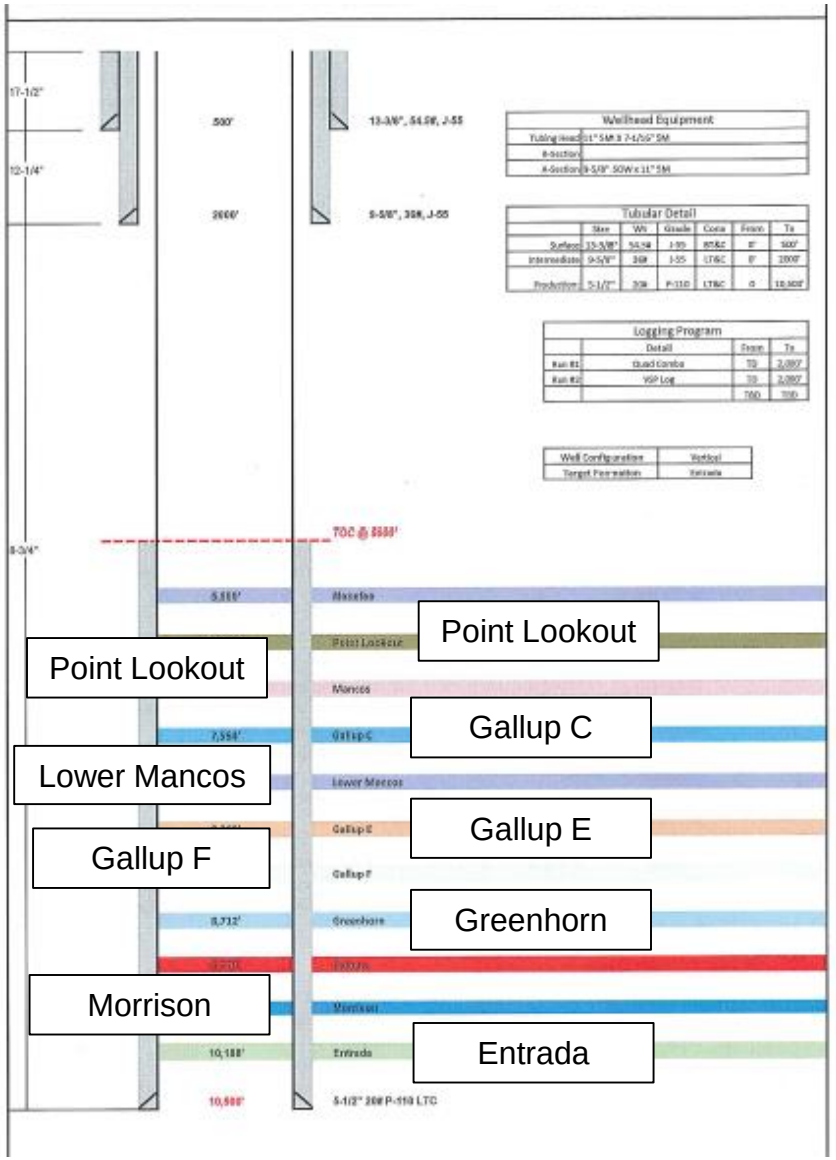


Depths

- Primary Targets
  - Gallup F – 8468 ft
  - Gallup E – 8268 ft
  - Lower Mancos – 7805 ft
  - Gallup C – 7584 ft

- Secondary Targets
  - Entrada – 10188 ft
  - Morrison – 9100 ft
  - Dakota – 8770 ft
  - Greenhorn – 8712 ft

- Base of treatable water – 2000 ft



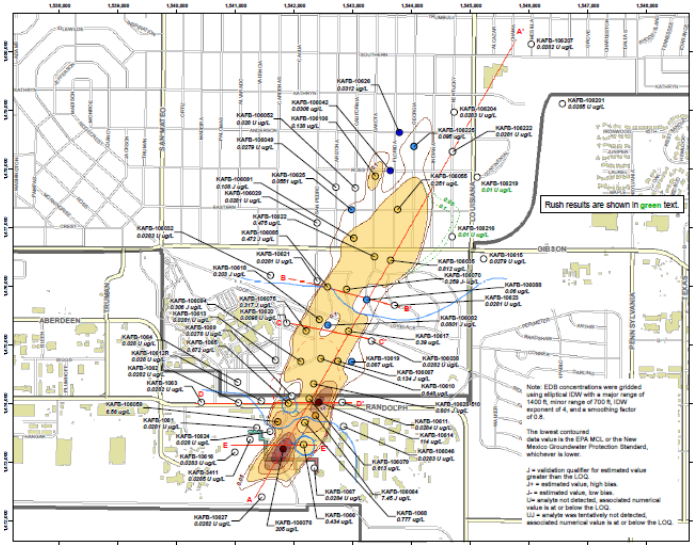
Contaminant Transport

- Ground water moves very slowly. Velocity depends on gradient, hydraulic conductivity, & porosity. Use values from Kernodle et al. (1994)
  - K = 2 ft/d, gradient ~2 ft/mile, η (porosity) ~0.2
  - GW velocity = 1.4 ft/yr

$$v = \frac{K}{\eta}\frac{dh}{dL}$$

- Compare to KAFB fuel plume
  - K = 70 ft, gradient ~ft/mile, η ~0.2
  - GV velocity = 190 ft/yr
  - Note: Plume ~6,000 ft long, time > 30 yrs

    $v \leq 200$ ft/yr



Nature of Possible Contaminants

- Hydrocarbons:
  - Strongly adsorbed to soil
  - Biodegradable
  - Little likelihood of persistence or rapid migration
- Fracking chemicals
  - Not considered toxic
- Produced water
  - To be disposed at facility near Lindrith (~100 miles)

Neighboring Wells?

Permit No.	Diversion (AF/yr)	Well Depth (ft)	Water Depth (ft)	Distance (ft)
RG 06745 POD14	24000	1922	1090	3353
RG 26259X2	1875	1505	1128	3690
RG 26259 X4		1475	1093	1340
RG 26956 POD1	0			3120
RG 37634 POD1*	3	112	13	3219
RG 06745 POD14	0	1922	1090	3353
RG 66531*	3			953
RG 70045*	3	3517	288	160

* Private Domestic Well

Concluding Thoughts

- In considering threat that oil & gas exploration & development presents to water resource need to consider
  - Nature of exploration & development
    - Type of drilling (horizontal vs vertical)
    - Details of well construction & QA/QC procedures
    - Transportation issues: oil, gas, water
    - Waste storage & disposal method
  - Ground water resource
    - Hydrogeology, especially hydraulic properties
    - Quality of ground water
    - Proximity to receptor wells
  - Nature of potential accidents & contaminants
    - Spills, leaks
    - Environmental & toxicological behavior of contaminants

References

- Connell, S.D. (2008). Geologic map of the Albuquerque-Rio Rancho metropolitan area and vicinity, Bernalillo and Sandoval Counties, New Mexico, Geologic Map 78, NMBGMR, NM Tech, Socorro, NM
- Connell, S. (2011). Preliminary study of the geologic framework of the Colorado Plateau-Middle Rio Grande Basin transition, New Mexico., Connell, NMBGMR Open File Report 539, NM Tech, Socorro, NM 58 p.
- Hawley, J. Haase, S. (1992). Hydrogeologic Framework of the Northern Albuquerque Basin, Open File Report 387
- Johnson, P., (2009), Water Natural Resources, and the Urban Landscape Decision-Makers Field Guide 2009 Decision Makers Conference,
- Kernodle, J.M., McAda, D.P., Thorn, C.R. (1994). Simulation of Ground-Water Flow in the Albuquerque Basin, Central New Mexico, 1901-194, with Projections to 2020, USGS Water-Resources Investigations Report 94-4251, Albuquerque, NM
- Plummer, L.N., Bexfield, L.M. Anderholm, S.K., Sanford, W.E., Busenberg, E. (2004). Geochemical Characterization of Ground-water Flow in the Santa Fe Group Aquifer System, Middle Rio Grande Basin, New Mexico, USGS Water-Resources Investigations Report 03-4131, Albuquerque, NM