COGCC Mamm Creek Area Cementing and Bradenhead Pressure Monitoring Practices

COGCC Hearing Informational Update

Broomfield

Monday, September 19, 2011

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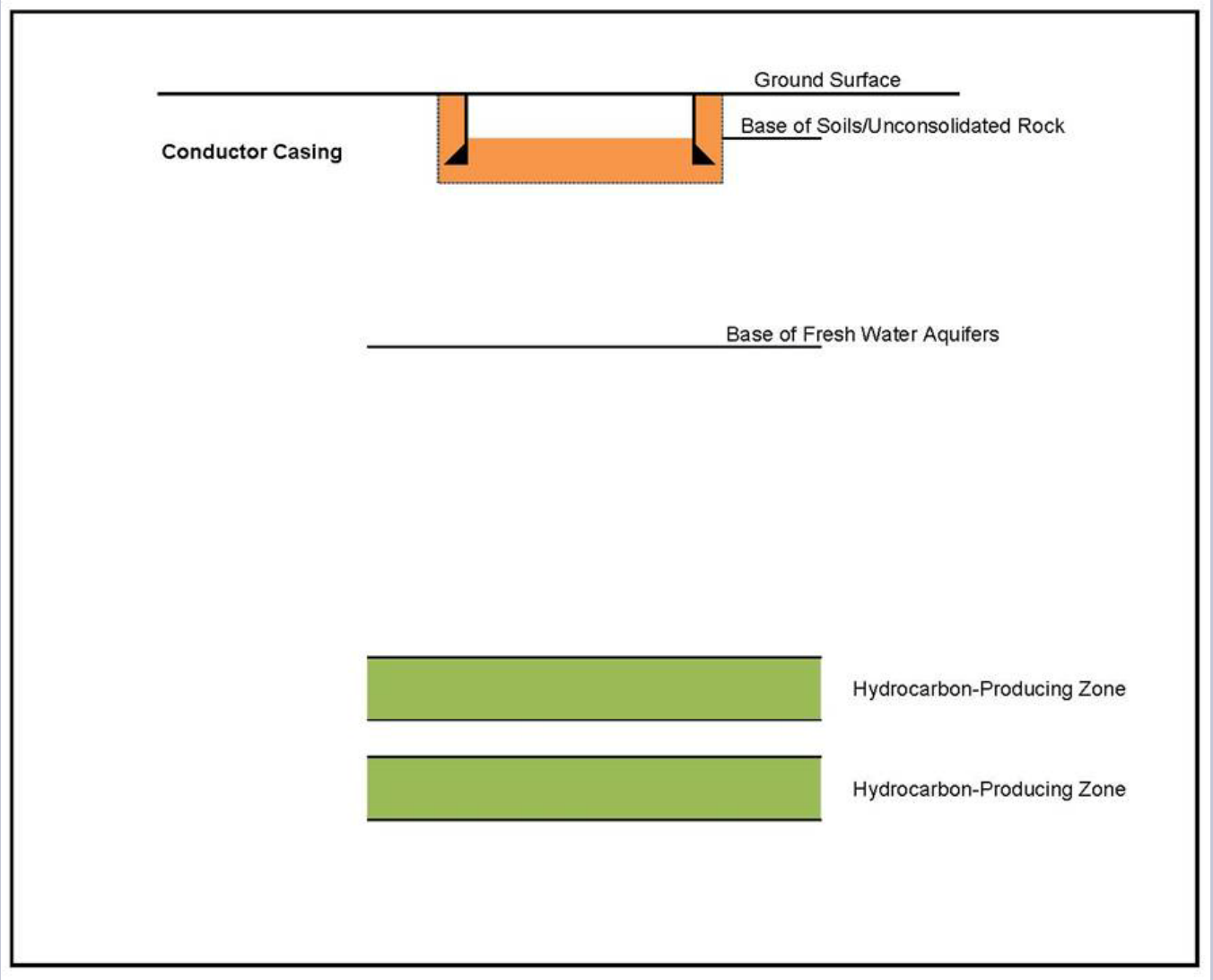
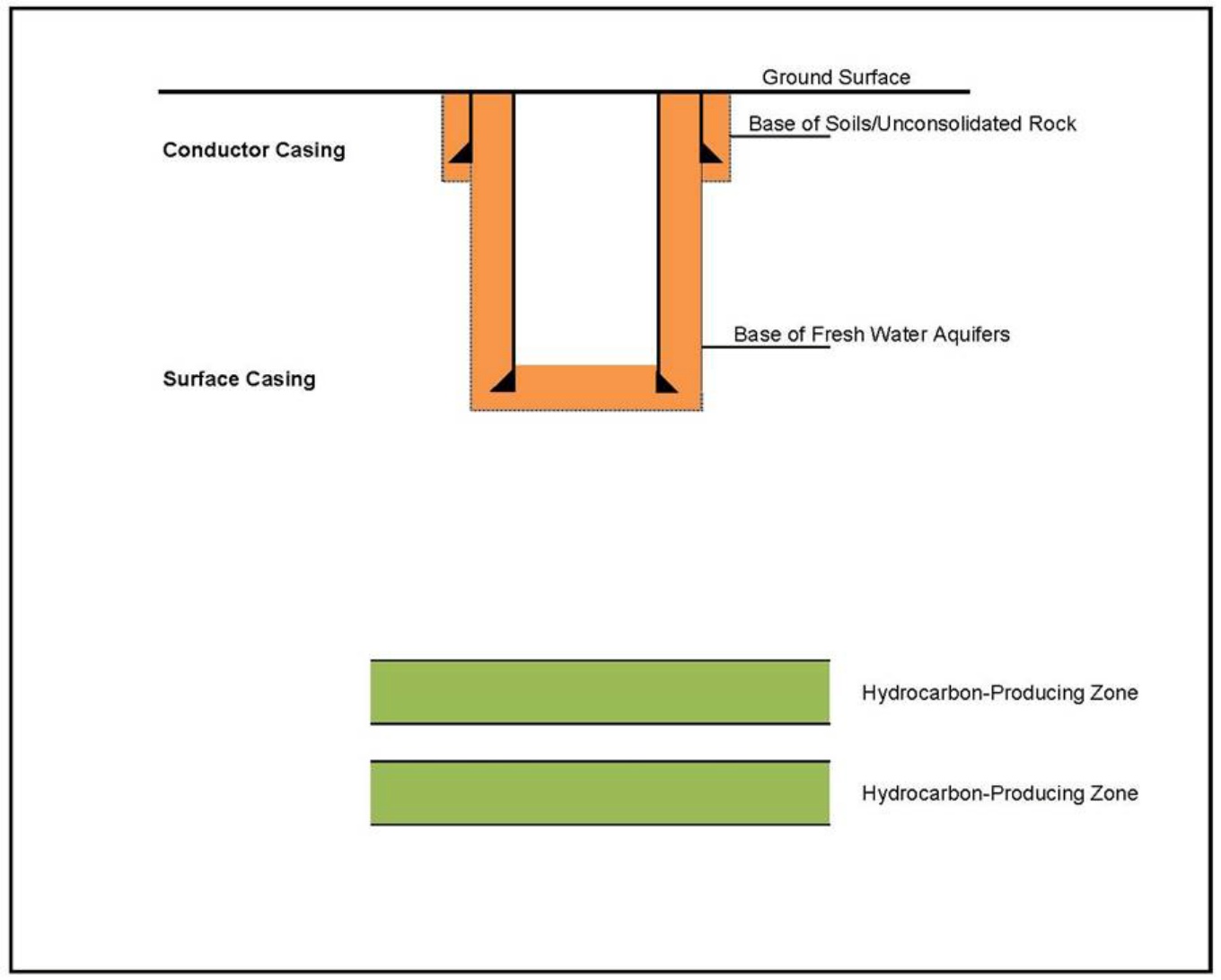
Presentation Outline

- General wellbore construction, definition of “bradenhead”annulus, and definition of policy areas.
- Mamm Creek Field geologic setting.
- Historical timeline.
- COGCC consultant report conclusions and recommendations.
- Available shut-in bradenhead pressure data.
- U.S. EPA cement evaluation results.
- Forward plan. This is an interim update. Work is on-going.

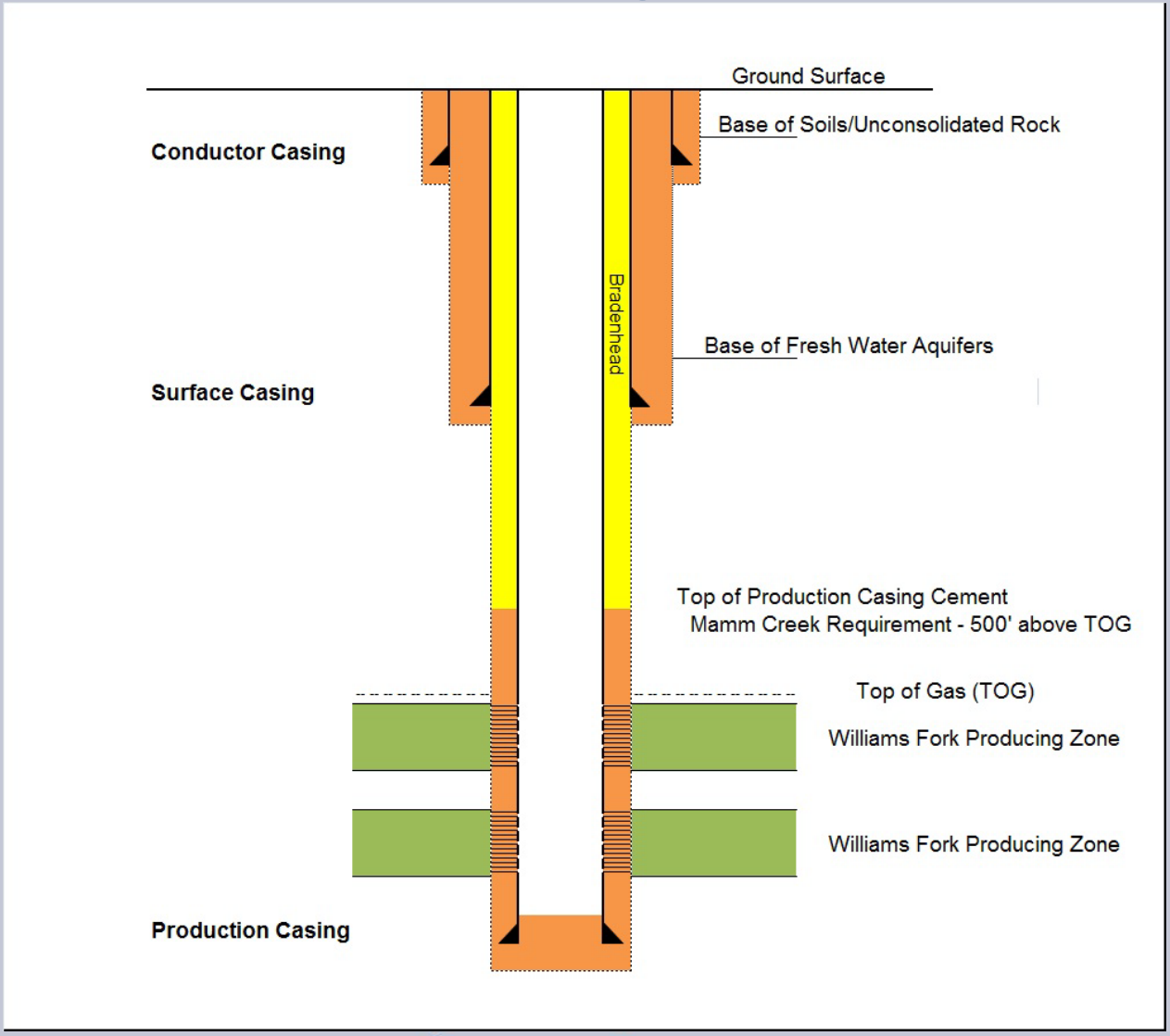
Casing and Cement Design (Conductor)



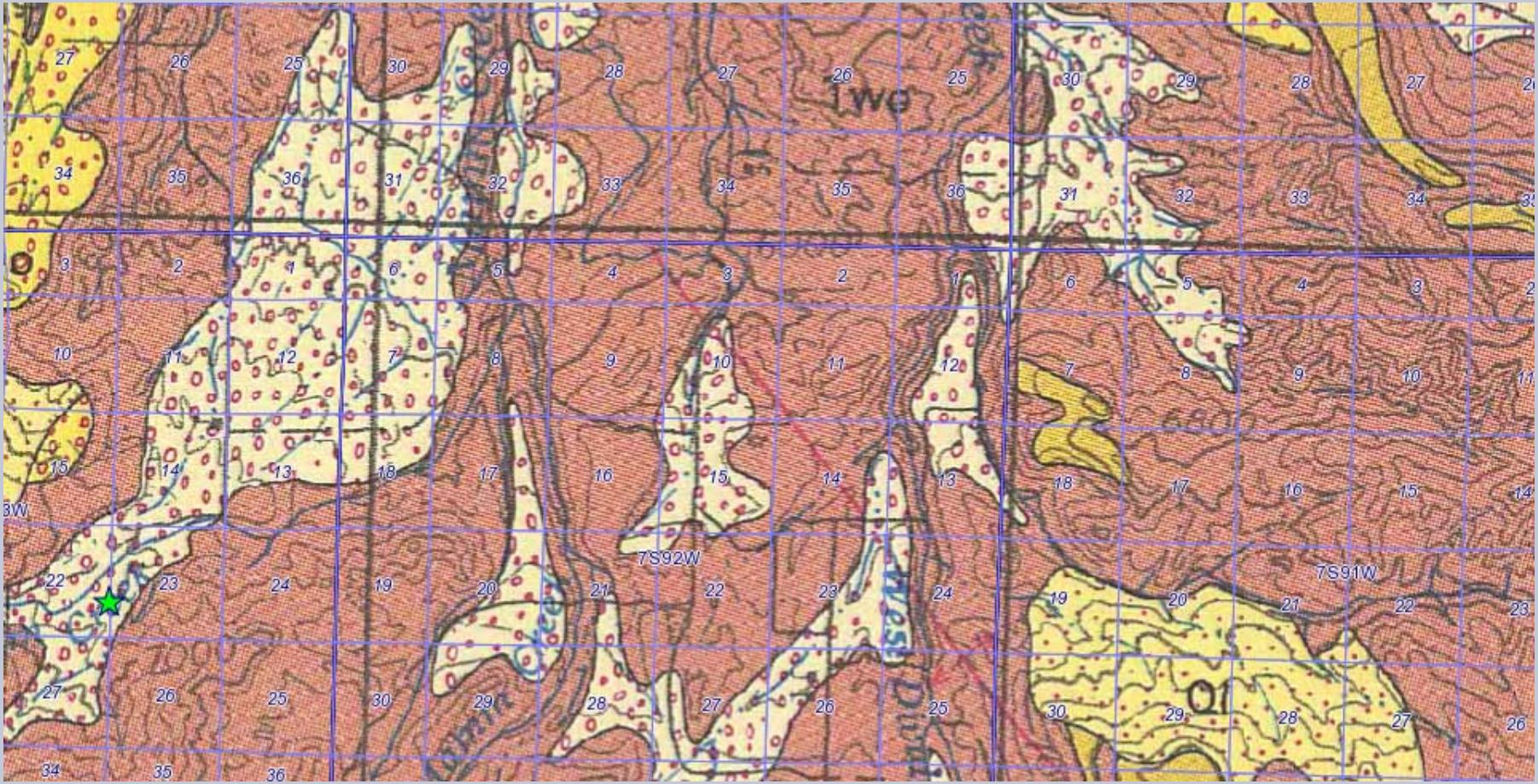
Casing and Cement Design (Surface)



Casing and Cement Design (Production)



Mamm Creek Field Surface Geology



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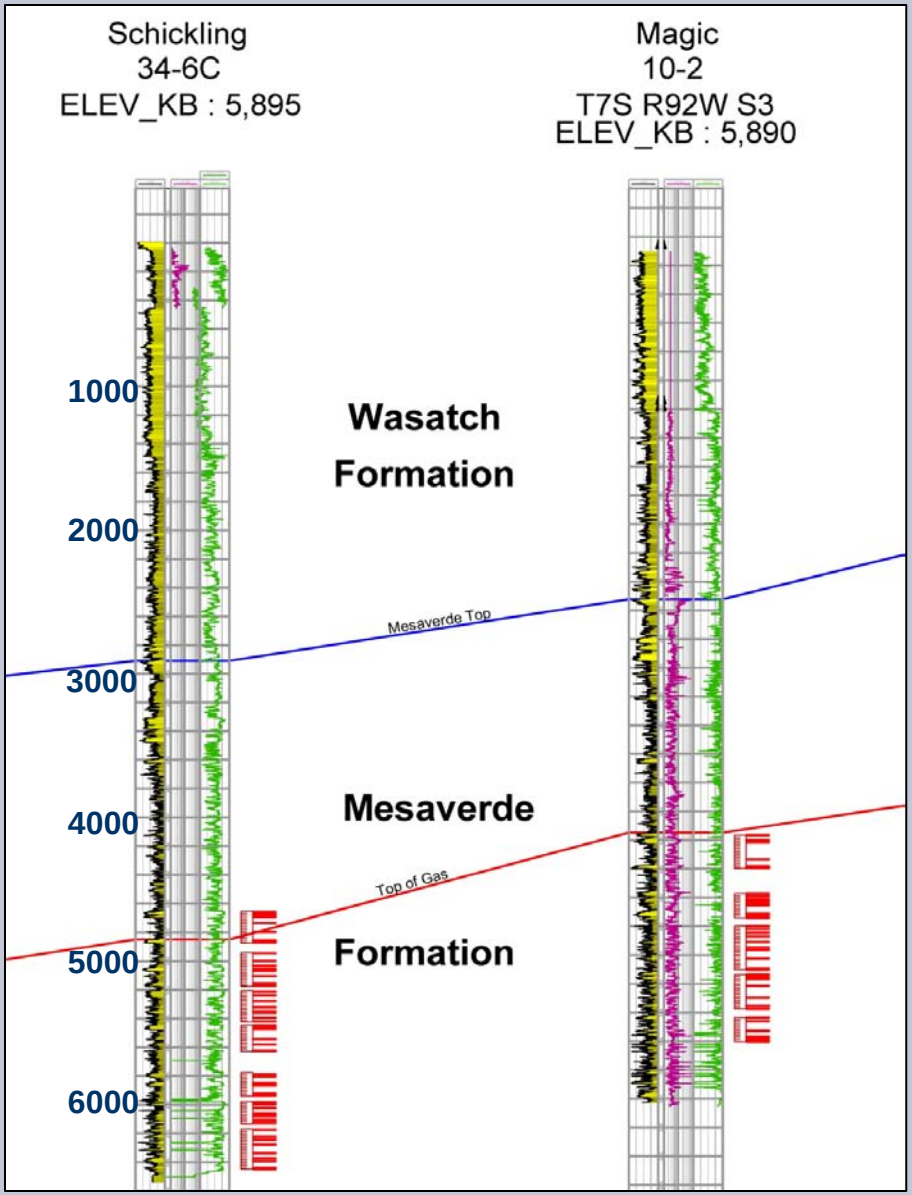
Mamm Creek Field Geologic Cross Section



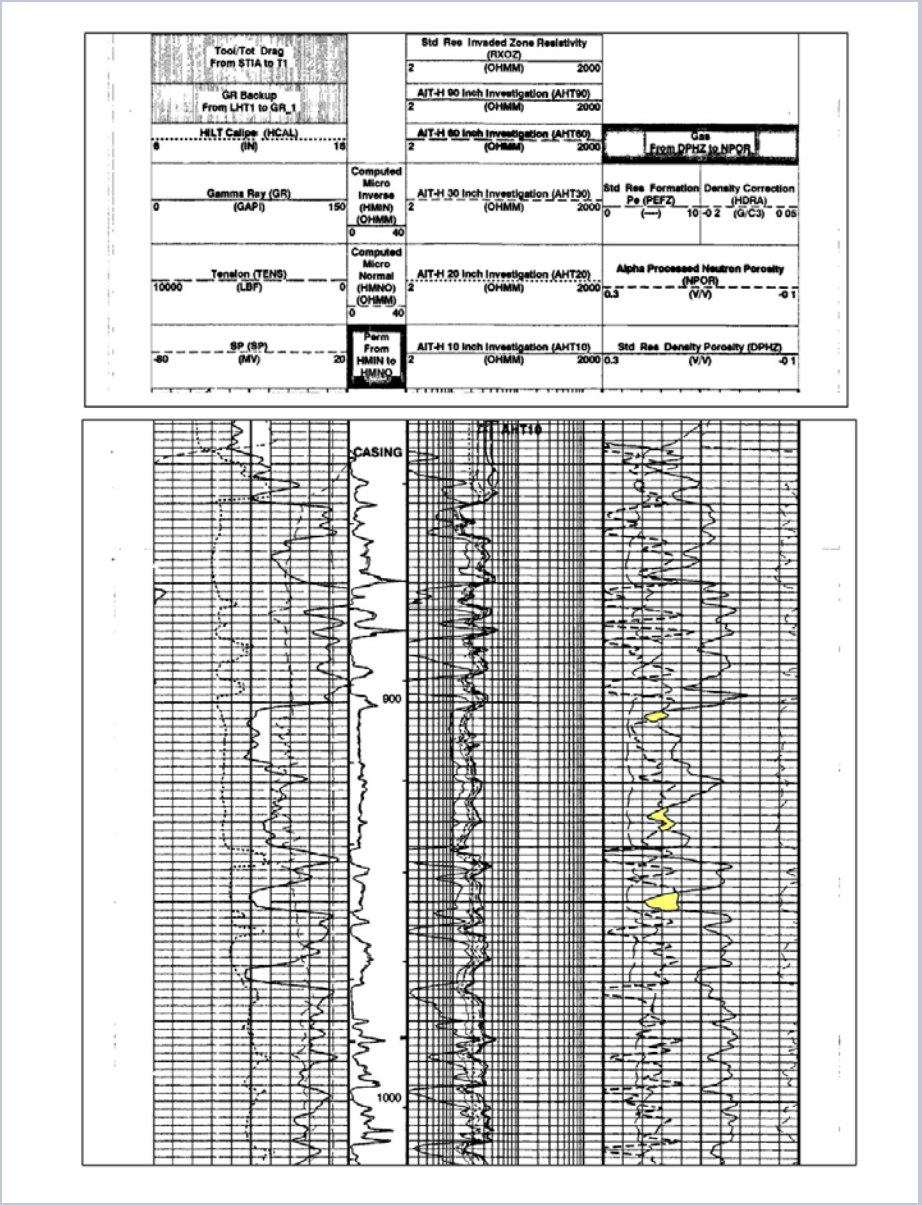
From: URS, PHASE I HYDROGEOLOGIC CHARACTERIZATION OF THE MAMM CREEK FIELD AREA IN GARFIELD COUNY
March 13, 2006

Shallow Wasatch Gas

API: 05-045-09148

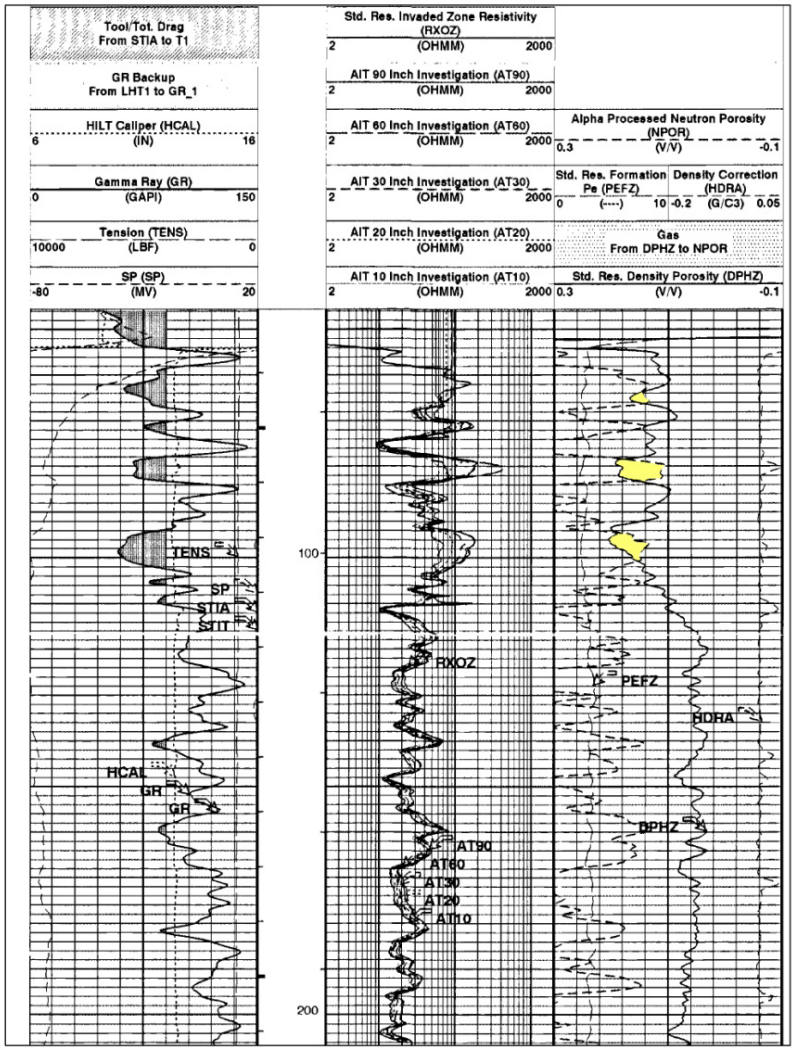
Gas presence indicated (does not confirm flow into annulus):

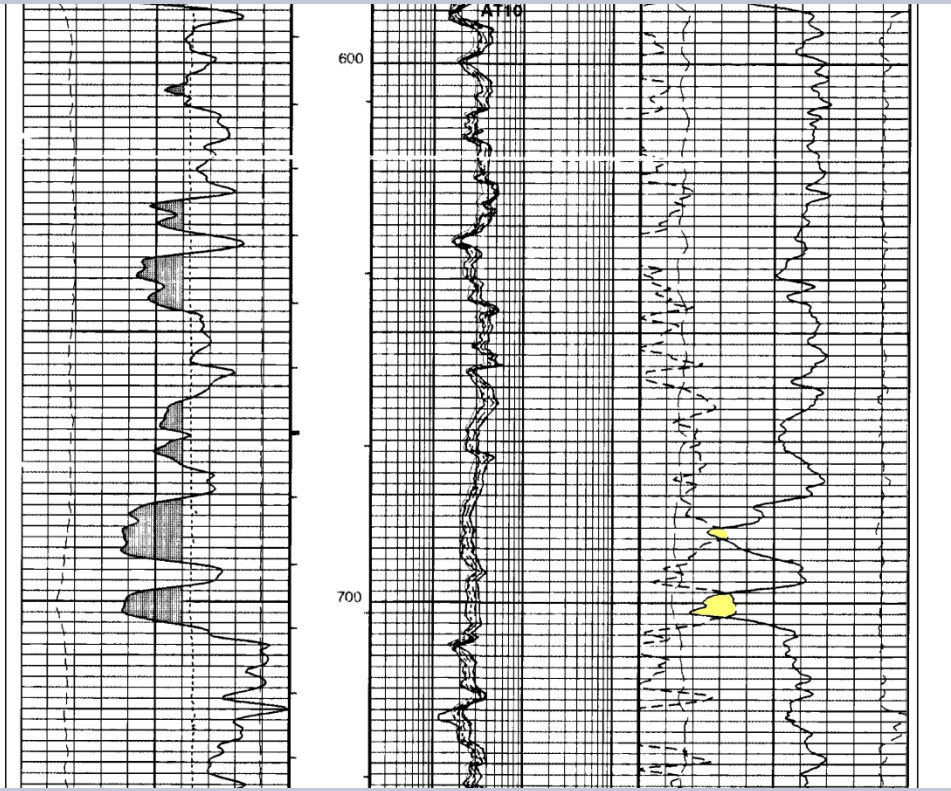
902’-05’
926’-32’
948’-52’



Shallow Wasatch Gas

API: 05-045-12515





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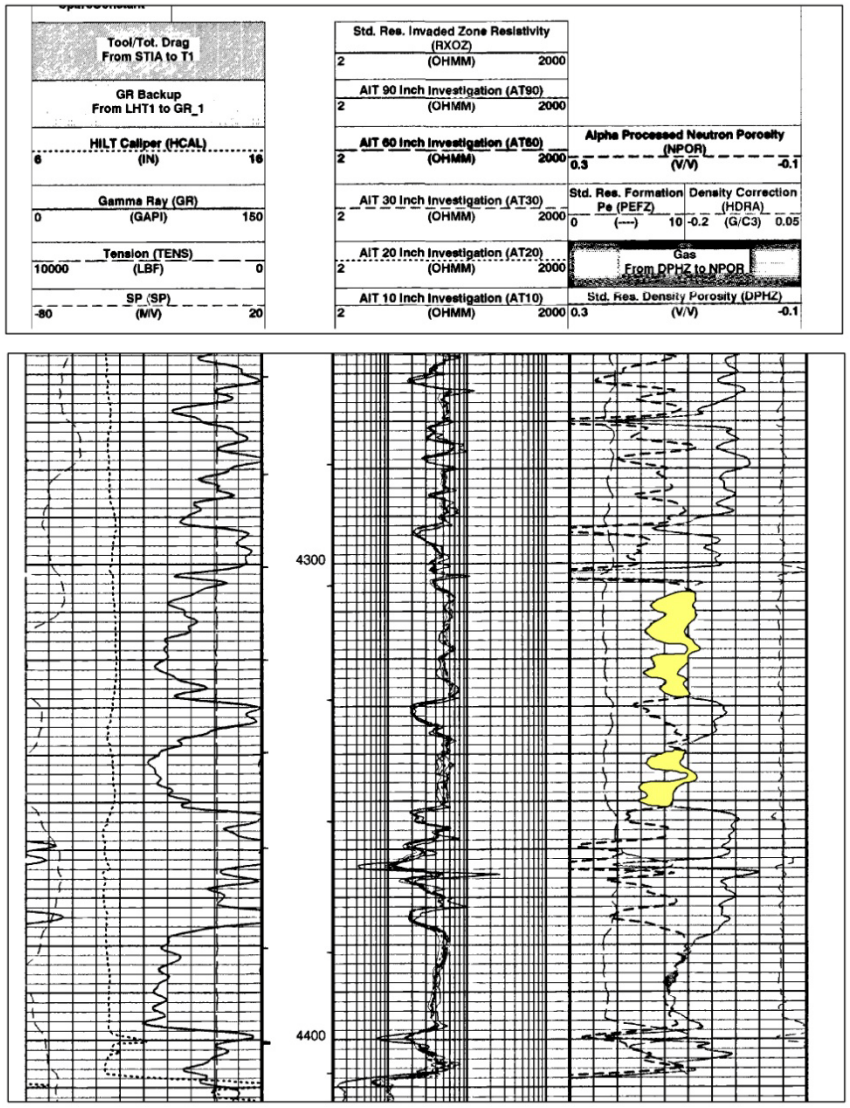
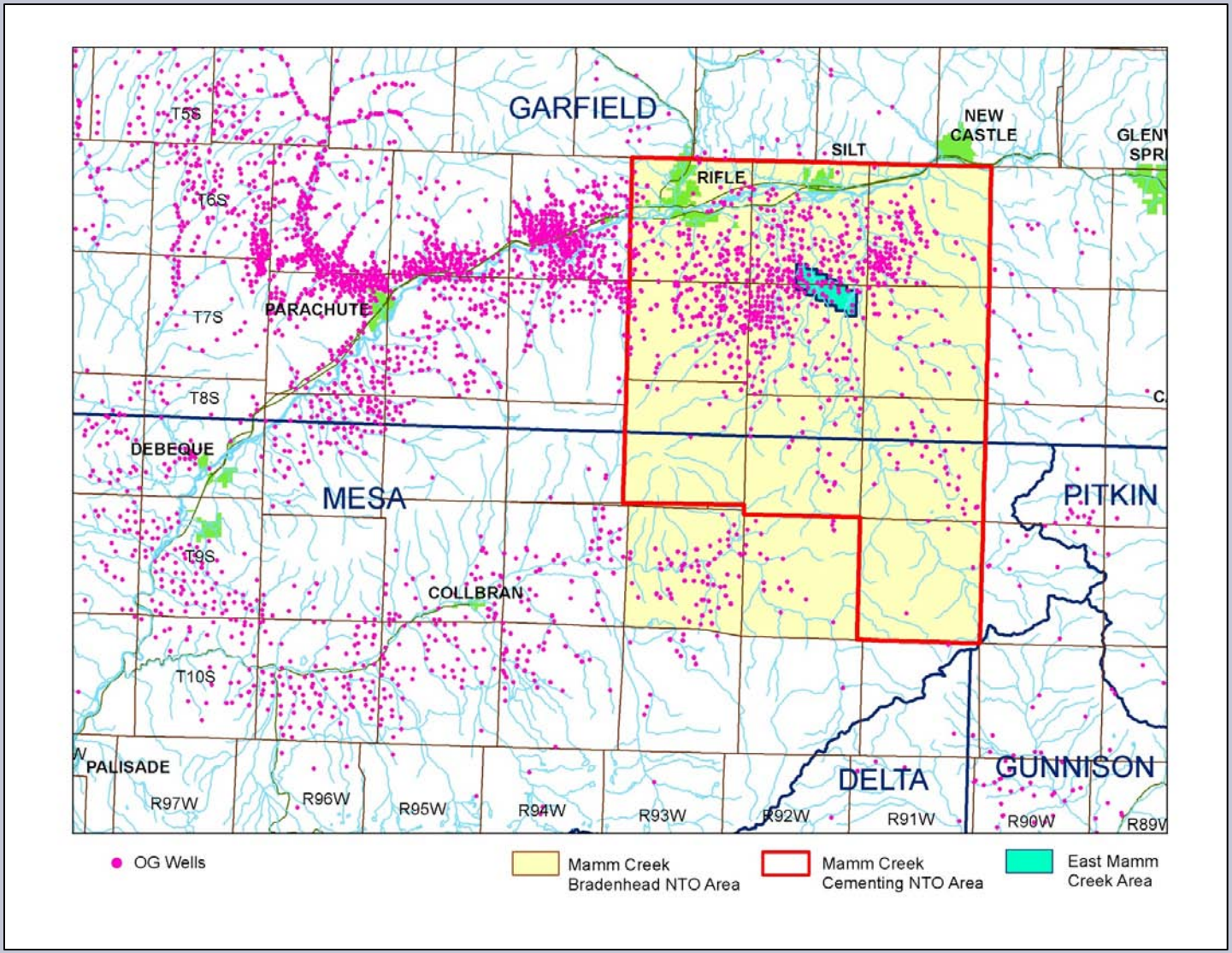
Williams Fork Gas Above "Commercial" Top of Gas

API: 05-045-12515



Mamm Creek Field Policy Areas



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Historical Timeline

- March 9, 2004: "Arbaney Event" on the P3 pad.
- March, 2004: West Divide Creek Gas Seep resulted from a primary cement job failure and subsequent shut-in bradenhead pressure build-up.
- July 23, 2004: Original Mamm Creek cementing Notice to Operators ("Cementing NTO") issued.
- February 9, 2007: Cementing NTO revised.
- Fall 2008: COGCC began to require Sundry Notices for requests to vent bradenhead gas. Undocumented venting had already been a common practice for several operators, likely dating back to at least 2004.

Historical Timeline (continued)

- February, 2009: COGCC began to request compositional and isotopic bradenhead and production gas analyses for selected venting requests.
- July 8, 2010: Bradenhead NTO issued.
- Winter 2010/2011:
  - EPA study commenced
  - COGCC consultant study commenced.
  - COGCC commenced review of gas sample analytical data and annual operator bradenhead pressure data submittals, which were required pursuant to the Bradenhead NTO.
  - Encana performed P3 pad pressure buildup study (required by COGCC).

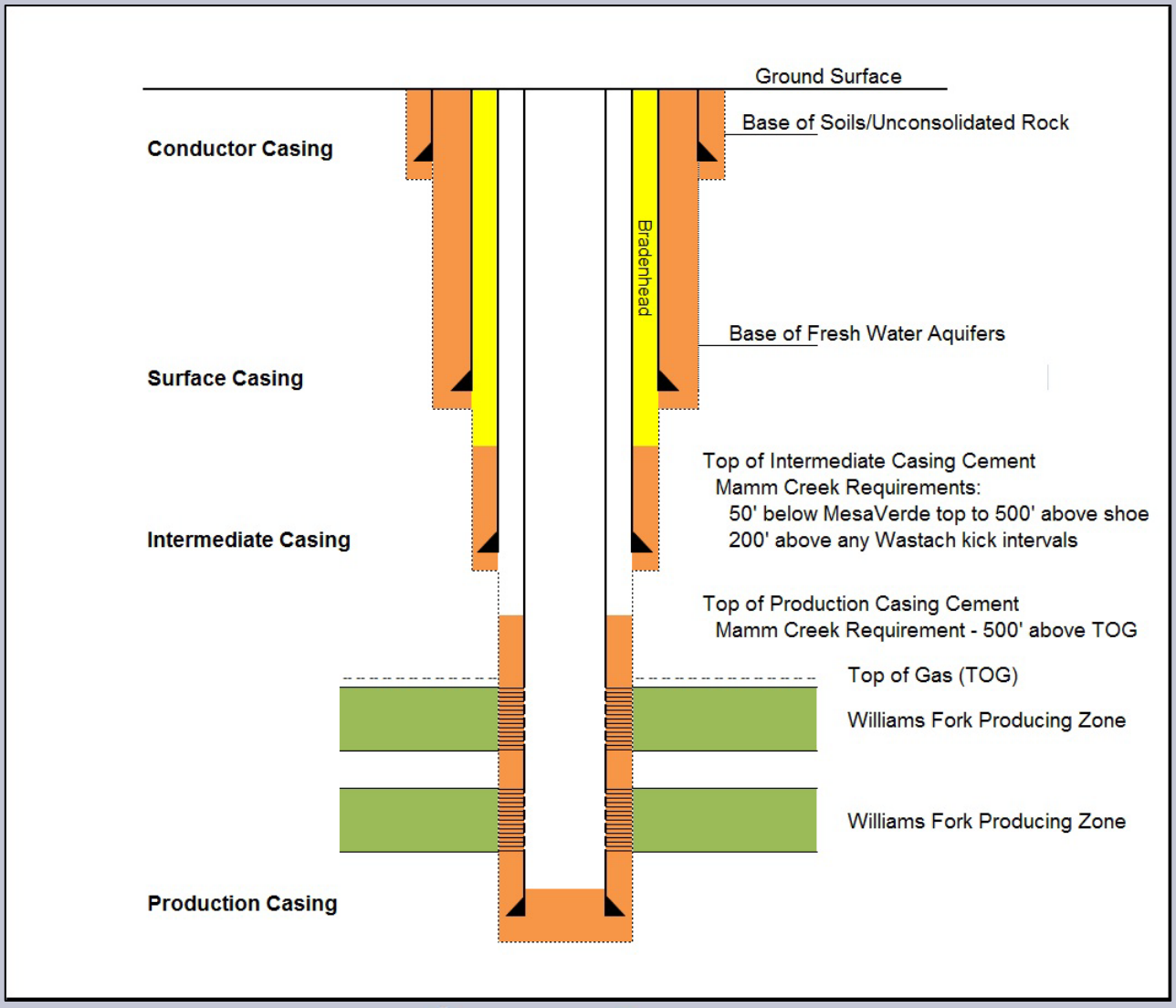
COGCC Cementing NTO
Field-Wide Requirements

- Production casing cement required 500’ above TOG. COGCC intends to modify this requirement to match BLM’s standard of 200’ above MVRD/OHCRK formation top. New requirement would be applied as COA’s on new APD’s.
- Bradenhead pressure, annular fluid makeup volume, cement bond logs, temperature logs required with Sundry Notice, Request to Complete.
- Monitor bradenhead pressure after cementing and during stimulation operations.

COGCC Cementing NTO
East Mamm Creek Area Requirements

- Surface casing setting depth must be 15 percent of the total vertical well depth or 500 feet below the total depth of any water well within a one-mile radius.
- Surface casing shoe formation integrity test (FIT) to 13.0 ppg equivalent mud weight.
- Intermediate casing must be set if the FIT fails.

EMCA Intermediate Casing



COGCC Bradenhead NTO

- Perform 7-day bradenhead shut-ins, and measure and report pressures annually by November 1.
- Mitigation or remedial requirements may be required by COGCC, based on a review of the testing results, and COGCC must approve proposed procedures.
- Keep bradenhead pressures below 150 psi.
- Use of combustors is encouraged, if feasible based on pressures and flow rates.
- Operators must comply with CDPHE-AQCD rules for atmospheric discharges of vented gas.

EMCA Report Conclusions and Recommendations Summary

- The East Mamm Creek Area (EMCA) Report finds COGCC Cementing NTO and Bradenhead Monitoring NTO have made significant improvements to drilling practices in the EMCA.
- The report also finds that updated SOP's by the operator have also made significant improvements.
- The report summarizes drilling and cementing operations for each well and pad in the evaluation area.
- The report includes several conclusions and recommendations for further improvement in the EMCA.

COGCC Conclusions and Recommendations

- Several recommendations were applied as COA's on recent drilling permits, including:
  - Surface hole logs for first well on the pad
  - Lost circulation and gas zone notices to COGCC while drilling
  - New method defined to determine TOG, based on mud log gas units
  - 50% centralizer standoff requirement
  - Submittal of daily drilling and stimulation reports
  - Environmental monitoring and baseline sampling
- COGCC will consider revising the Cementing NTO EMCA requirements to include these recommendations and operator best practices not currently covered in the NTO.

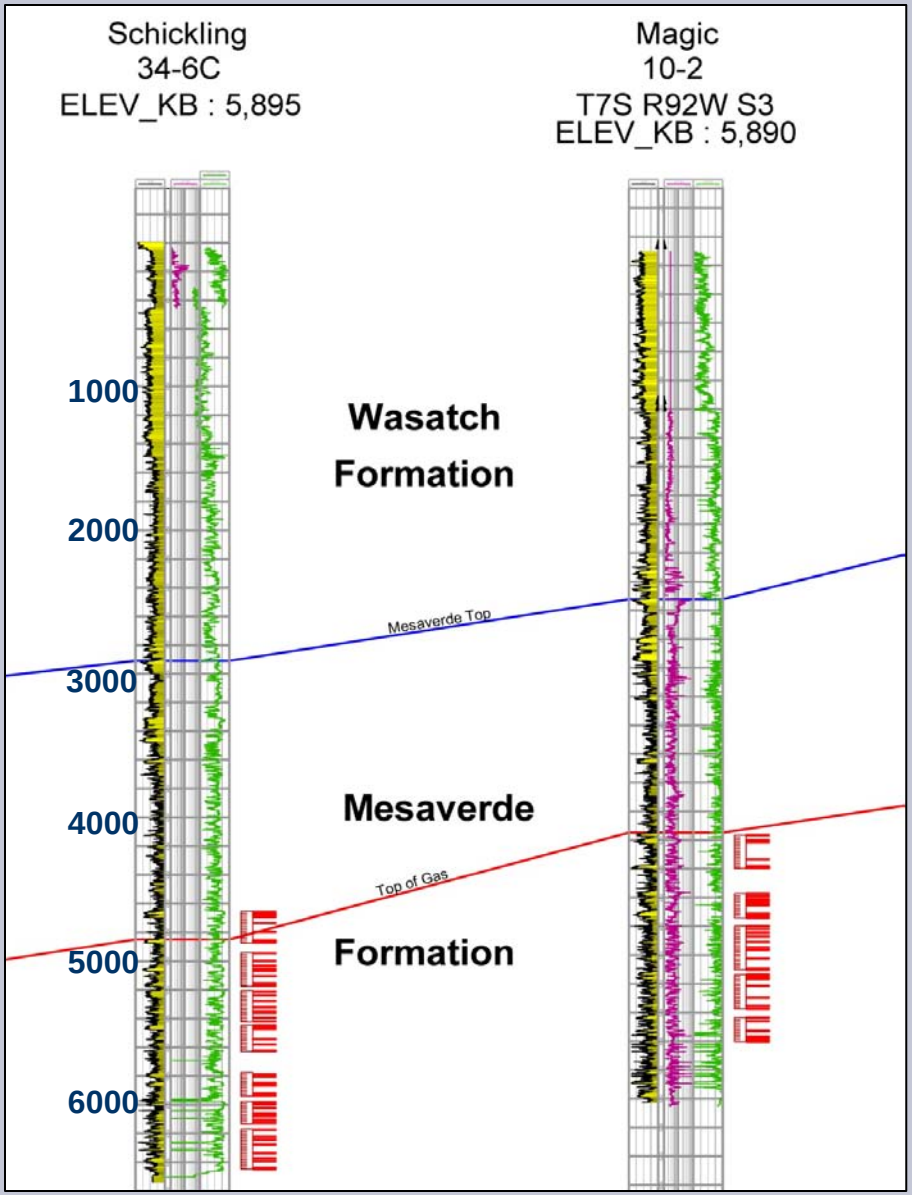
Encana Conclusions and Recommendations

- Slim holes resulting from intermediate casing installation and deviated wellbores, including surface holes, require rigorous engineering design for casing centralization and cementing to minimize gas flow potential in the annulus.
- Improved casing centralization programs and primary cement designs may also improve remedial cement performance when necessary.
- Use of more advanced LCM in cement slurries could provide superior performance, and limit cement fallback.
- In areas with lost circulation, lightweight cement slurries should be utilized.

Joint Conclusions

- Naturally-occurring shallow gas zones exist in the surface hole.
- The lenticular nature of gas-bearing sands make fluid losses and flows unpredictable.
- Definition of TOG is critical for TOC design. TOG can be in either the Williams Fork or the Wasatch Formation.

Mamm Creek Field Geologic Cross Section



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March 13, 2006

Joint Conclusions

- Depending on the cement design, the presence of bradenhead pressure alone does not reflect poor cement performance.
  - Monitoring bradenhead pressure over time is an effective method to evaluate the necessity of cement remediation.
  - Squeeze cementing efforts have reduced or eliminated bradenhead pressure.
- There is no evidence that hydraulic fracture stimulation has had an effect on cement sheath integrity or contributed to bradenhead pressure.
- Water well construction practices could be improved.

P3 Pad Findings in the EMCA Report

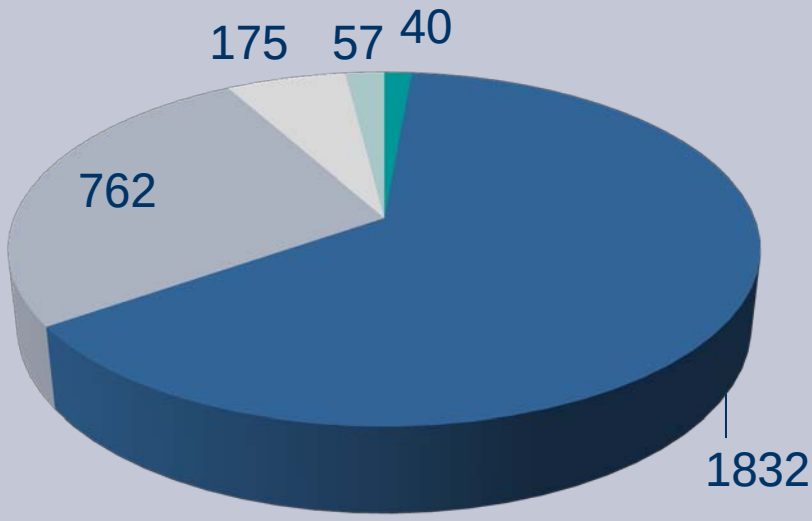
- Two pressure buildup events occurred while drilling the Magic 10-2 and Arbaney 3-15C wells in 2004. Some wells on this pad were subsequently remediated through squeeze cementing and installation of liners.
- COGCC Opinion: Pressures may have been high enough during drilling to break down the formation at the base of the surface casing in these wells.

Encana's P3 Pad Pressure Buildup Study (Winter 2010/2011)

- Pressure responses were observed in shallow groundwater while shutting in the bradenhead valves on the Arbaney 3-15C and Arbaney 3-16C wells.
- Dissolved gasses in the Dietrich and Moon water wells corresponded with bradenhead gas (shallow Wasatch, not deep Williams Fork production gas) in the Arbaney 3-15C and Arbaney 3-16C wells.
- Current Status: All bradenhead valves on the P3 Pad are currently left open to a combustor to mitigate pressure buildup.

COGCC Evaluation of Bradenhead Pressure Data

TOTAL WELLS	2867
Null value reported	40 (1%)
Zero pressure reported	1832 (64%)
1 psi to 74 psi	762 (27%)
75 psi to 149 psi	175 (6%)
150 psi or higher *	57 (2%)

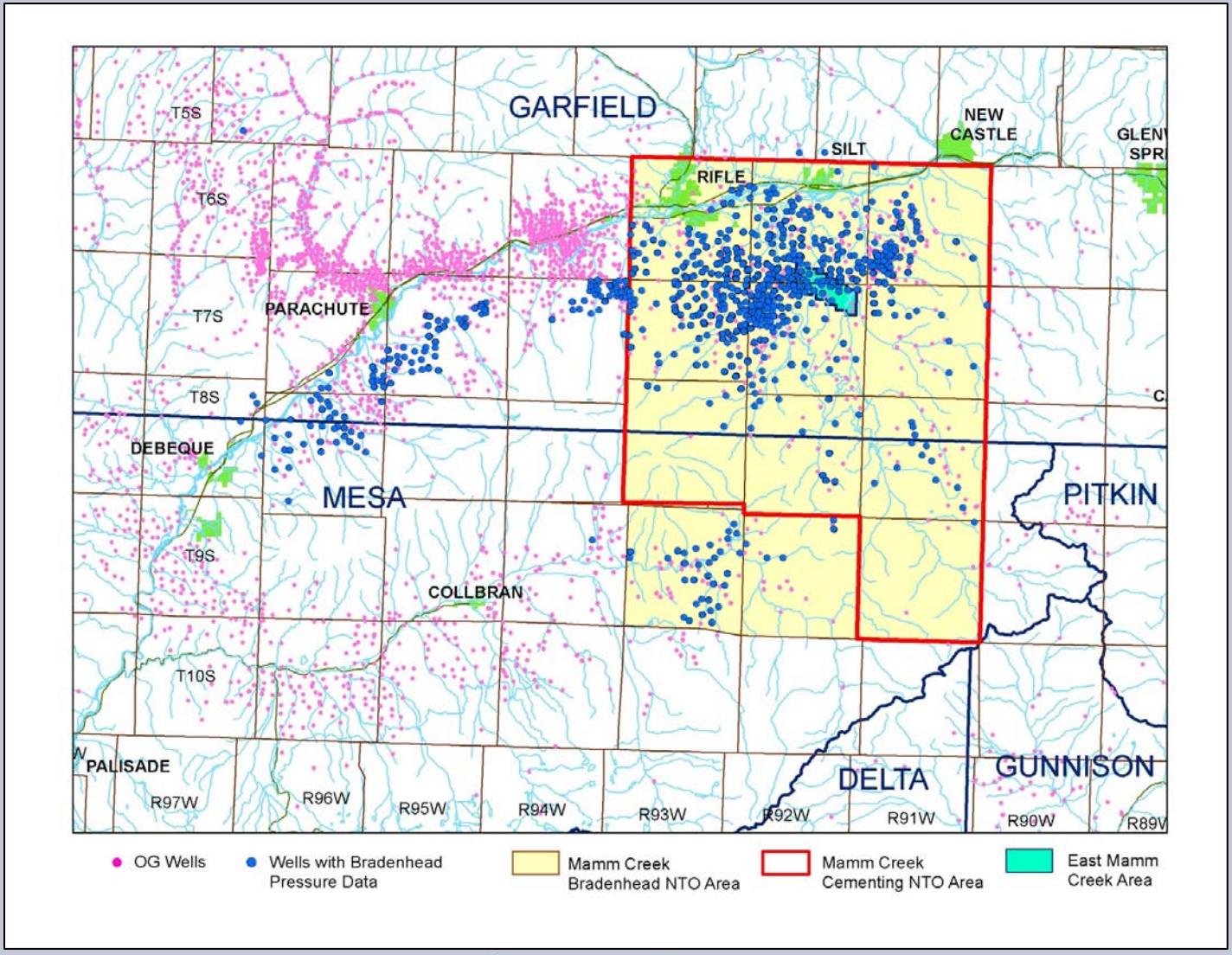


*** Based on detailed well-by-well reviews,12 wells currently recommended for cement remediation, increased monitoring, or testing to evaluate potential remediation**

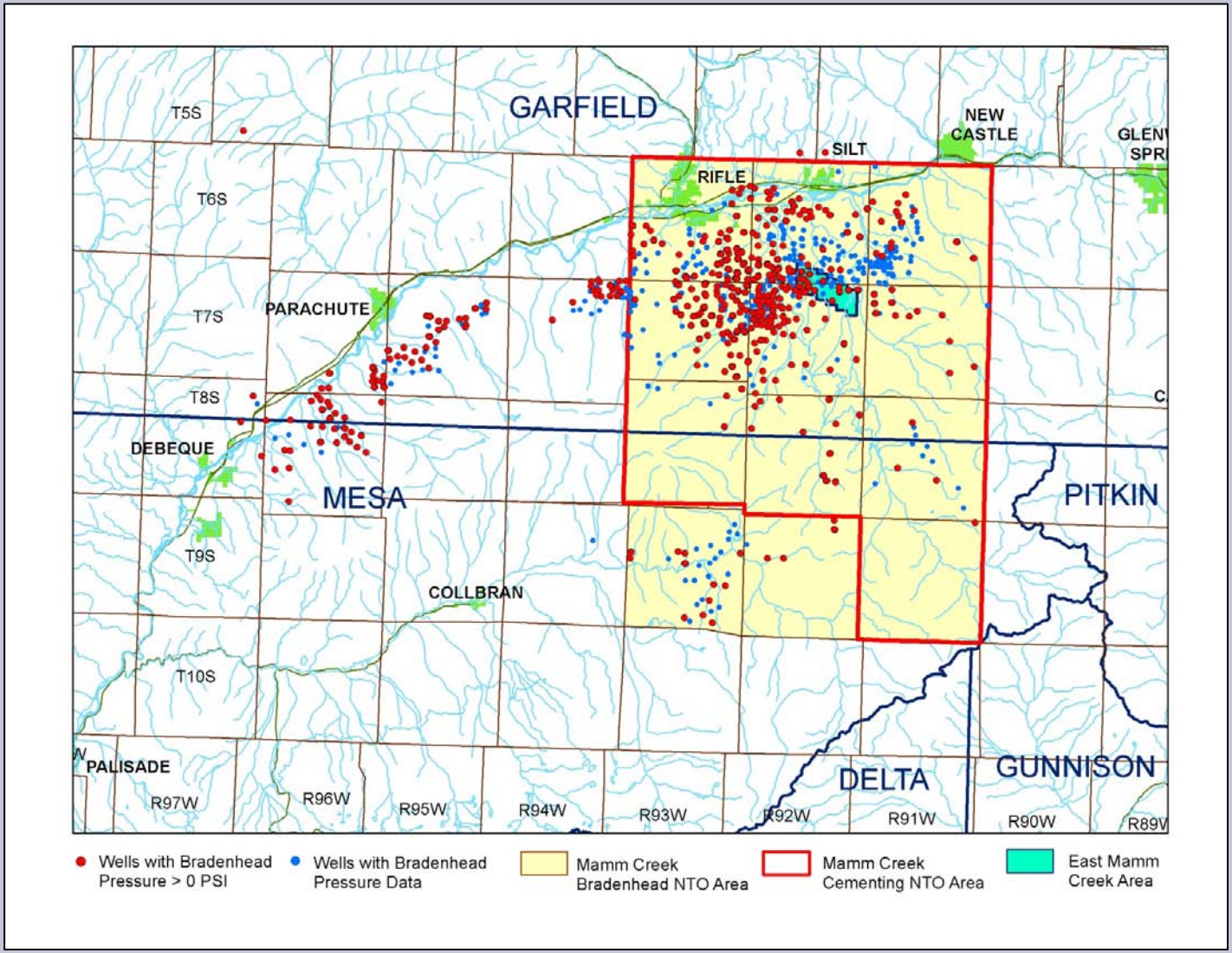
COGCC Evaluation of Bradenhead Pressure Data

- Wells with a bradenhead pressure equal to or exceeding 150 psi and wells exhibiting significant liquid flows were flagged for further evaluation.
- Detailed evaluations are being performed for flagged wells, including a review of casing and cement configurations, open-hole log reviews, and cement bond log reviews. Based on these evaluations, mitigation and remediation recommendations are being developed.

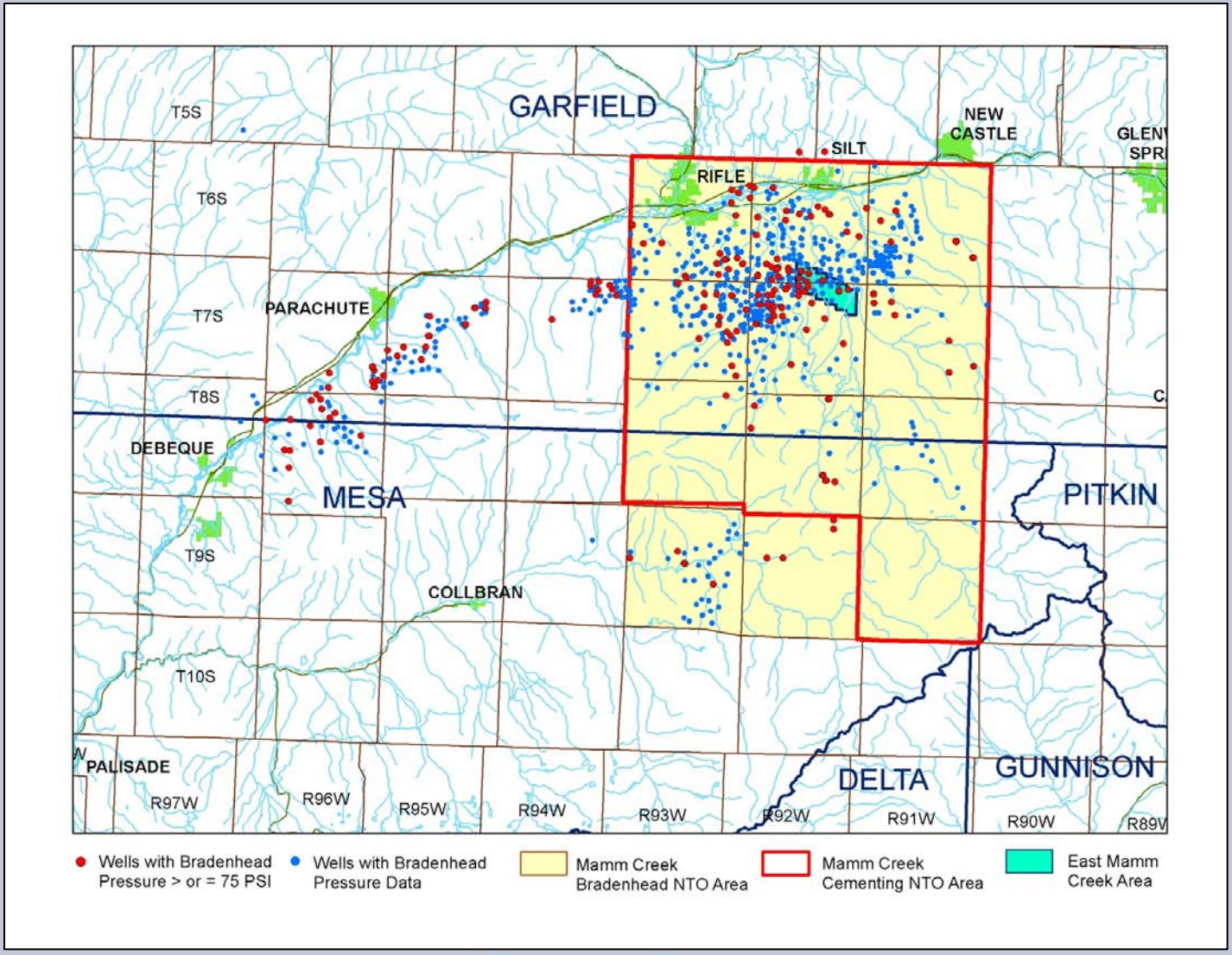
All Wells with Pressure Data



Wells with BH Pressure > 0 psi



Wells with BH Pressure >= 75 psi



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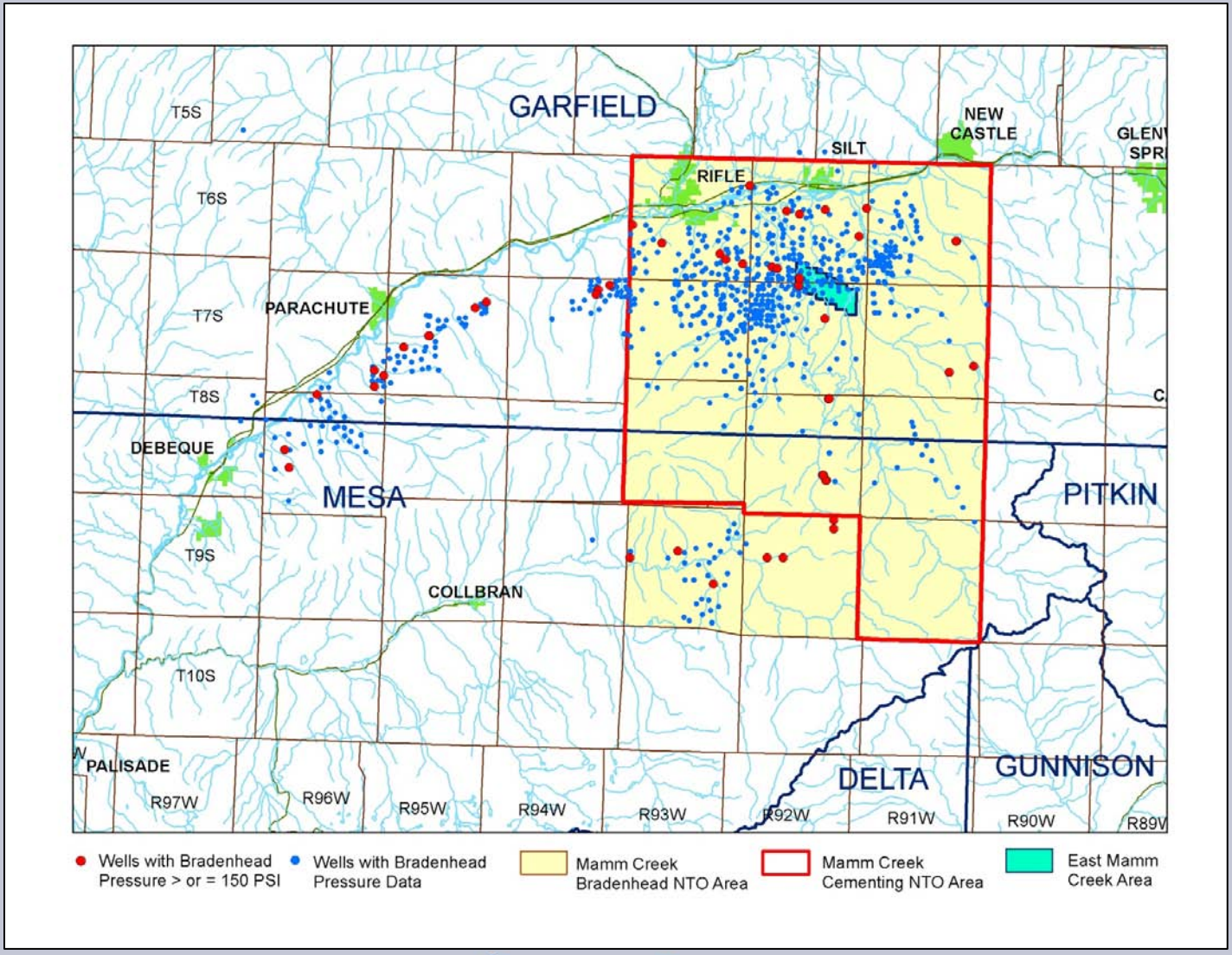
Wells with SI BH Pressure >= 150 psi



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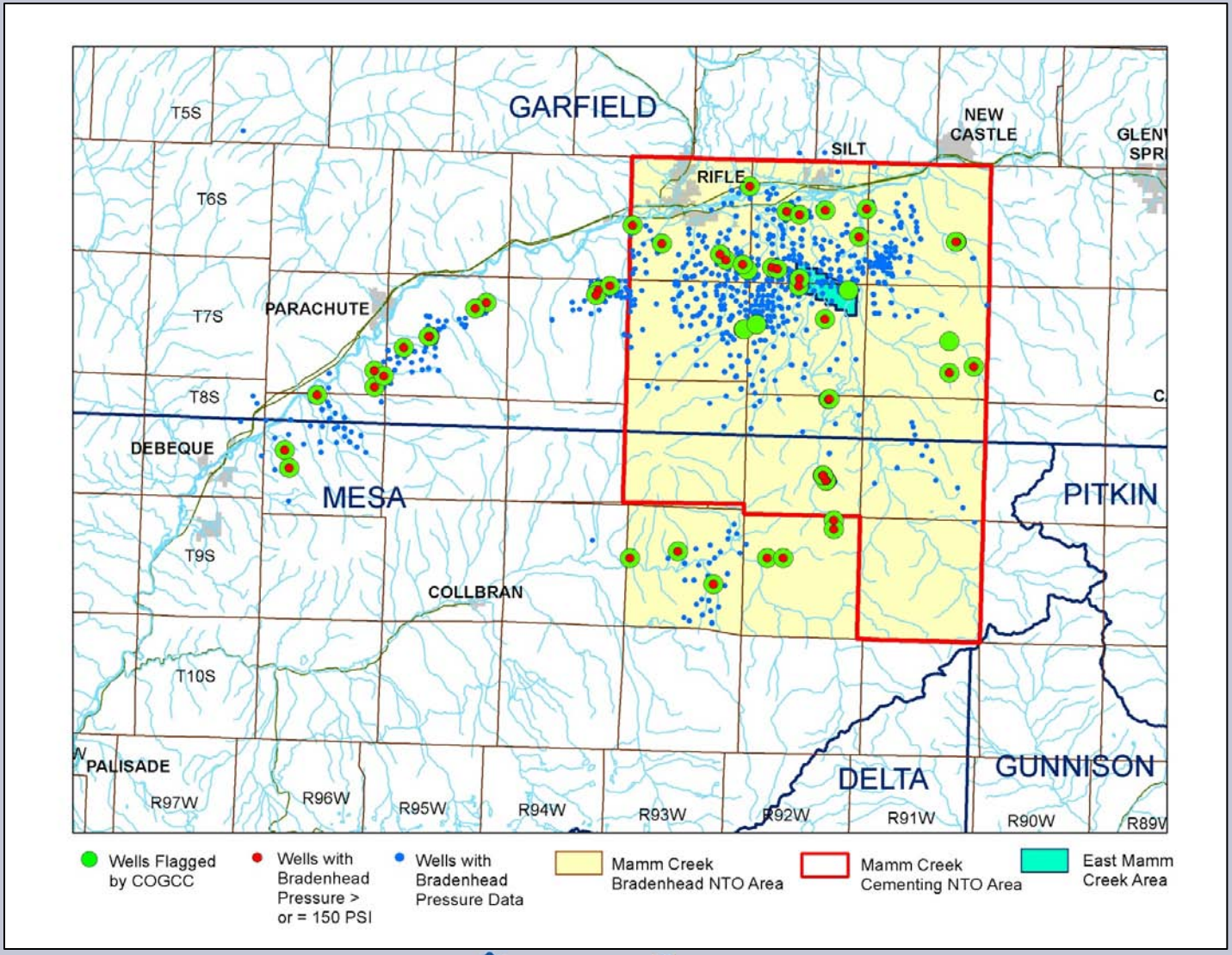
Wells Flagged for COGCC Evaluation



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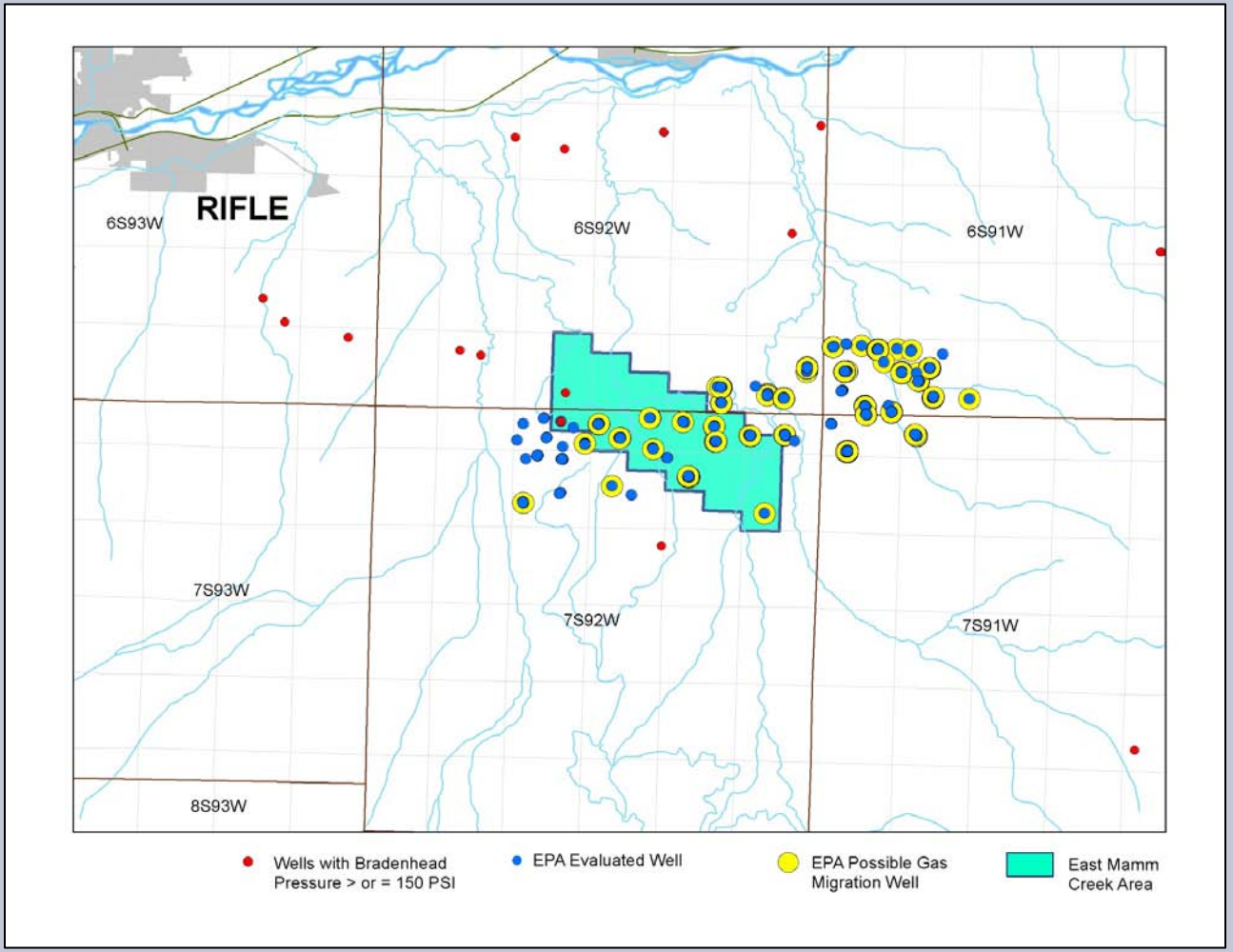
COGCC Evaluation of Gas Sample Analytical Data and Flow Rates

- COGCC is in the process of reviewing gas sample analytical data in an effort to determine the likely source of bradenhead gas (Williams Fork vs. Wasatch).
- Preliminary evaluations in several wells have supported results from COGCC's well-by-well reviews in many cases. However, in some cases the data appear to conflict with the results of the well-by-well reviews. Data analysis is on-going.
- COGCC continues to work with operators to estimate flow rates associated with venting bradenhead valves. The potential for use of low-flow residential meters has been discussed with one operator.

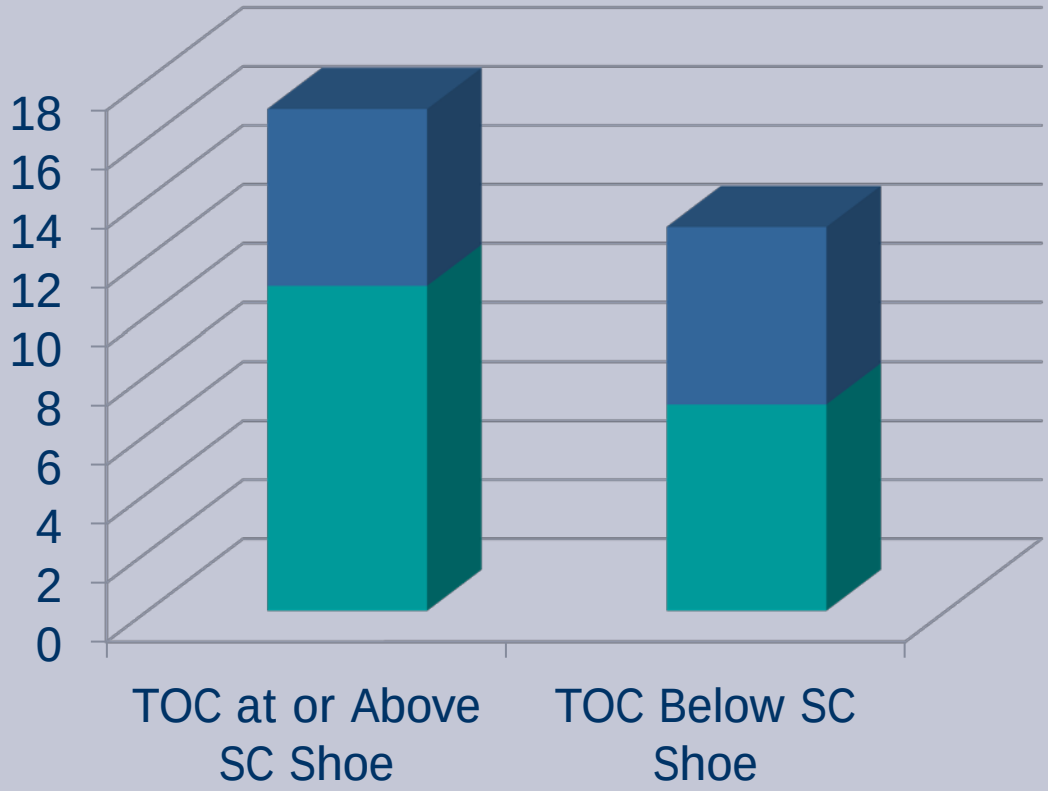
U.S. EPA Study

- Evaluated wells within and proximate to the East Mamm Creek Area, in response to recurring thermogenic impacts to three water wells in the area.
- Prepared summary tables to document well construction, open-hole log, and cement bond log data.
- Identified wells, that in U.S. EPA's opinion, have the potential for gas migration into shallow groundwater aquifers, based on gas occurrence and cement sheath quality.
- The U.S. EPA did not evaluate the presence and magnitude of bradenhead pressures in the flagged wells to confirm gas migration.

EPA-Evaluated Wells and Wells >= 150 psi SI BH Pressure

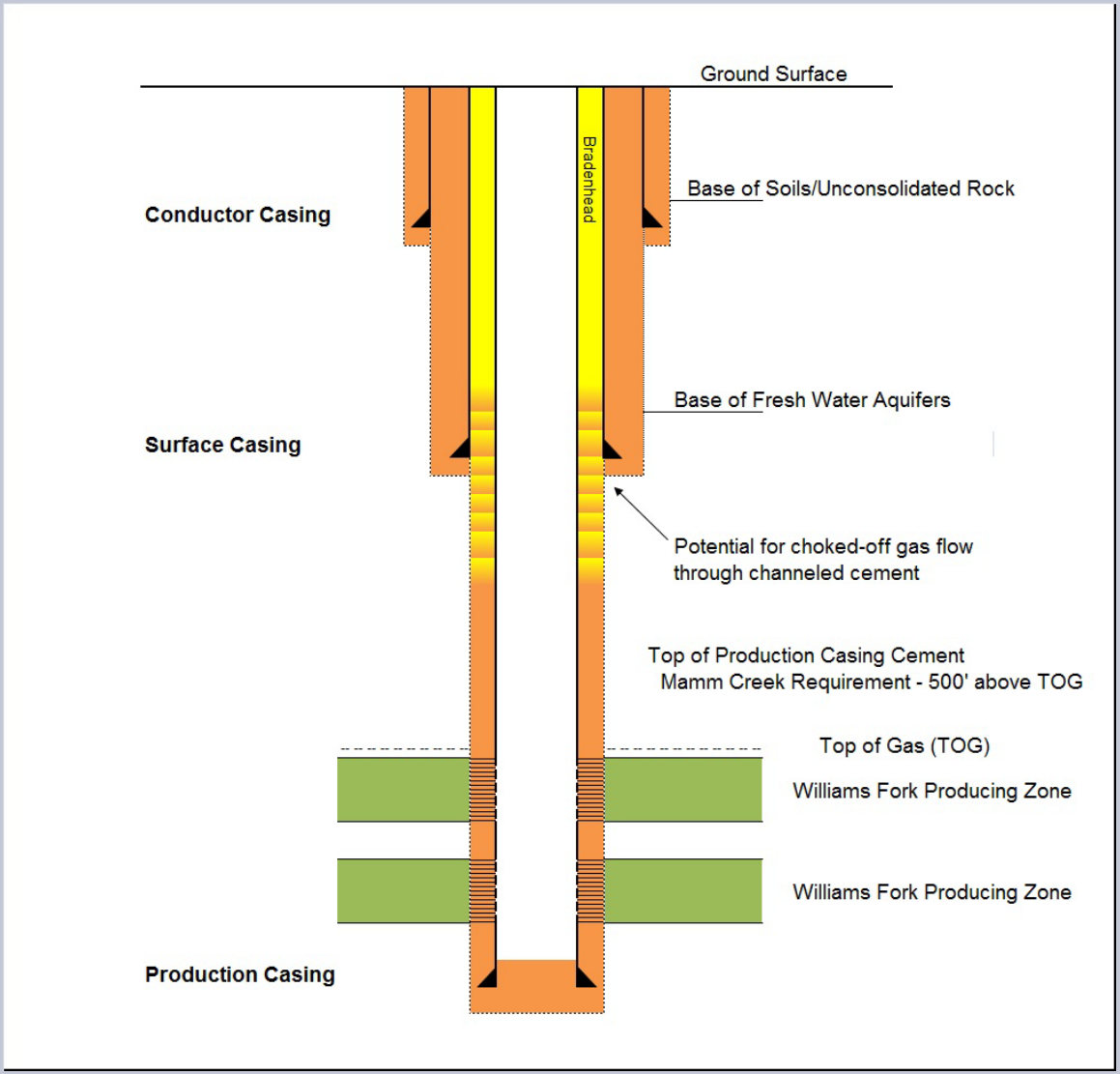


Encana Wells with SI BH Pressure equal to or greater than 150 psi

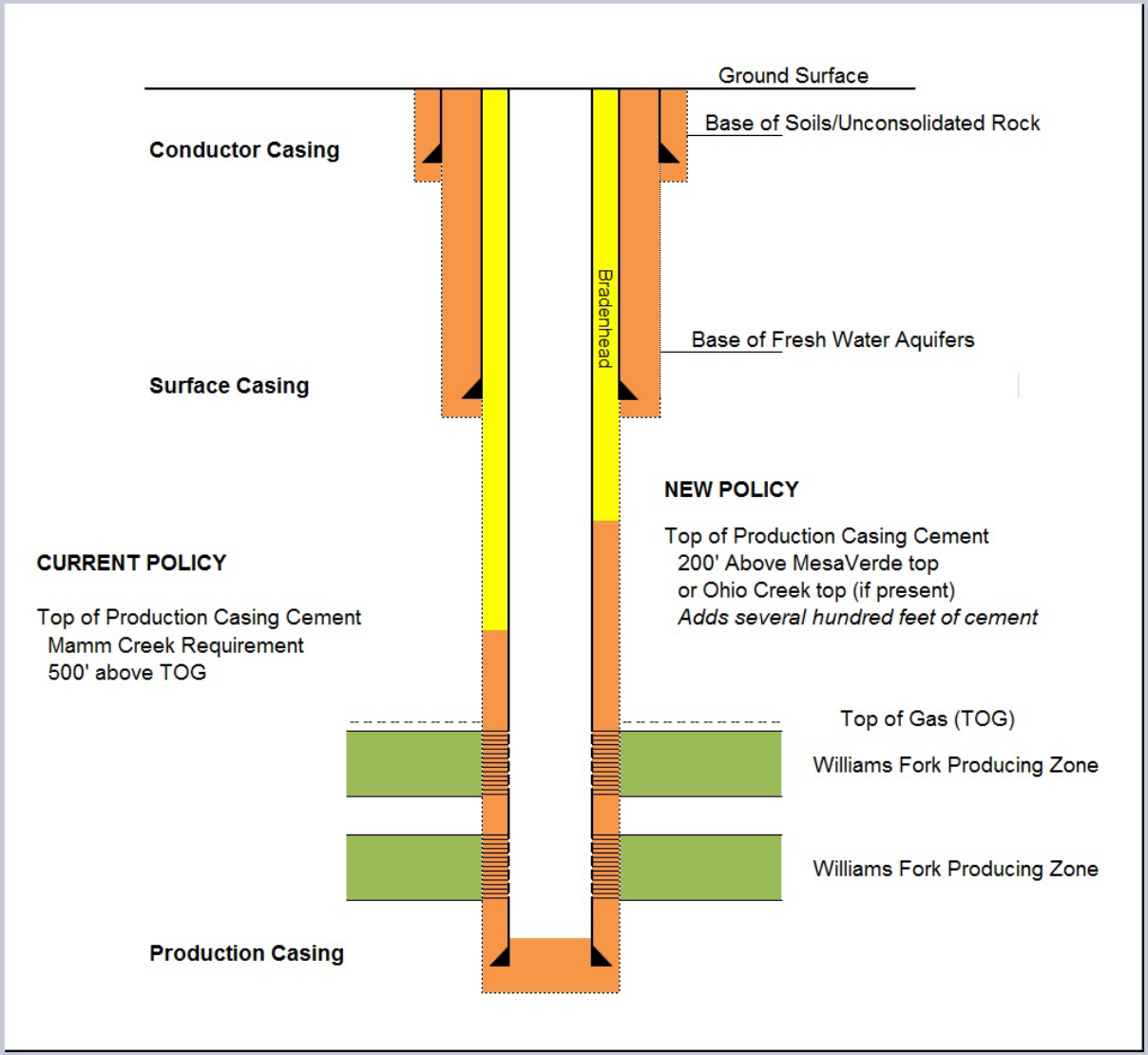


Detailed well-by-well evaluations for other operators besides Encana are in progress.

COGCC Concern with High TOC



New Cement Requirement



Next Steps

- Continue COGCC flagged well evaluations.
- Continue COGCC gas sample analytical evaluations.
- Update Cementing NTO to address COGCC consultant recommendations and consider consistency with some BLM standards. In the mean time, apply COA's to APD's, as necessary on a pad-by-pad basis.
- Evaluate adequacy of current NTO defined areas.
- Evaluate additional Bradenhead pressure submittals upon receipt (NTO areas and other areas)
- Continue discussions with CDPHE related to air permitting and control devices associated with venting.