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Field Screening for Shallow Gas in McKenzie County, North Dakota

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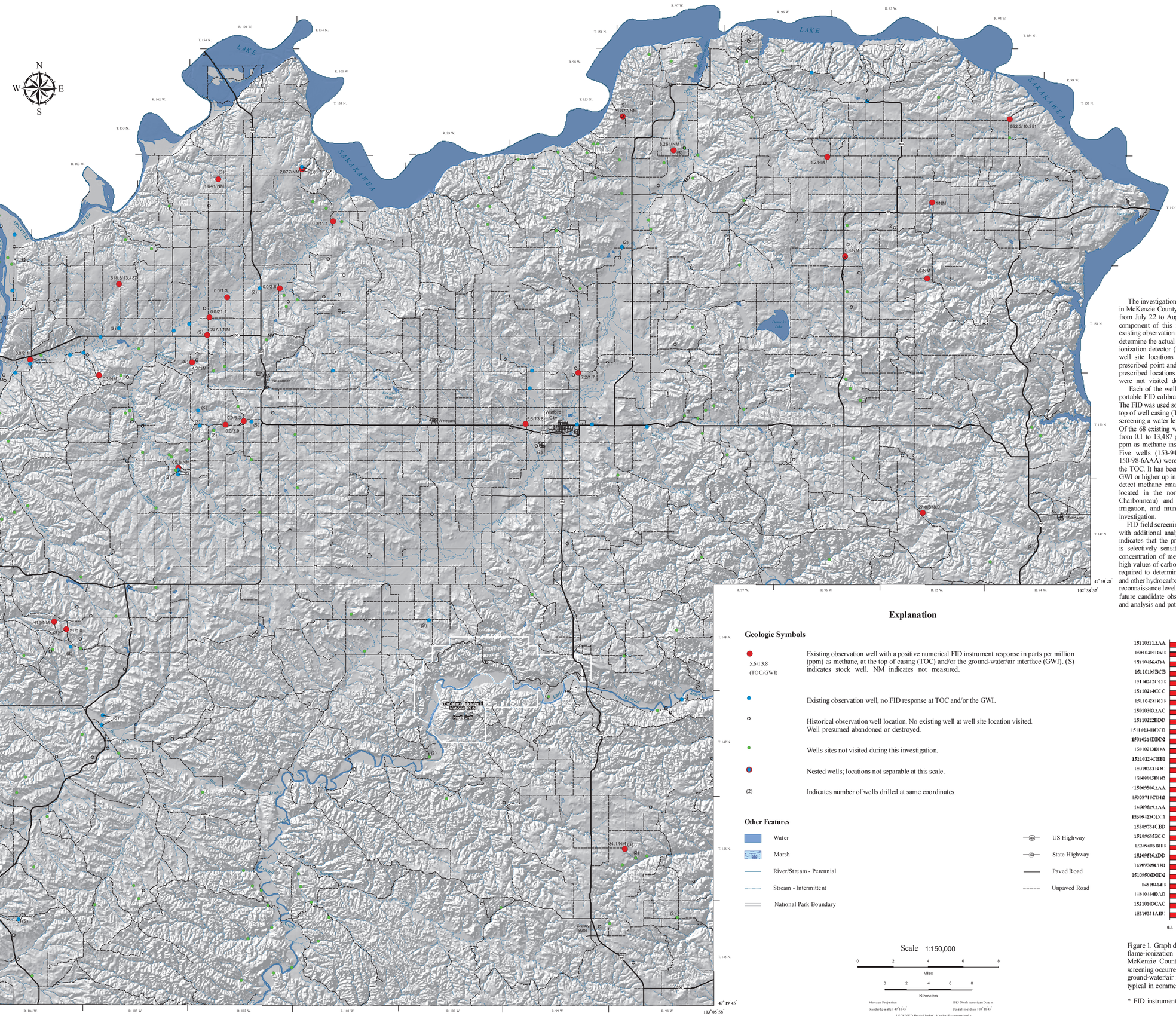

McKenzie County, North Dakota

The investigation of shallow natural gas occurences within existing ground-water wells in McKenzie County, North Dakota was conducted over a 23 non-consecutive day period from July 22 to August 27, 2009. Over 655 well sites were reviewed prior to the field component of this investigation. Of these, 379 wells sites, consisting of historic and existing observation and stock wells, were selected to be visited in the field in order to (1) determine the actual existence of the well, (2) to verify its location, and (3) perform flame-ionization detector (FID) field screening for possible shallow natural gas occurrences. 68 well site locations were verified to have a ground-water observation well at their prescribed point and were subsequently field screened. 39 wells were not found at their prescribed locations in the field and were presumed abandoned or destroyed. 163 wells were not visited due to access and/or time constraints.

Each of the wells were field screened for the presence of combustible gases using a portable FID calibrated to methane (100 ppm low-span or 10,000 ppm high-span) in air. The FID was used solely for field screening on all wells. FID response was collected at the top of well casing (TOC) and just above the groundwater/air interface (GWI). After field screening a water level reading within the well was collected using an electric well tape. Of the 68 existing wells field screened, 29 wells returned positive FID responses ranging from 0.1 to 13,487 ppm as methane (Figure 1; 39 wells showed no response (i.e., a 0.0 ppm as methane instrument reading) during field screening at both the TOC and GWI. Five wells (153-94-23CCC1, 150-99-15DDD, 149-95-9CDD, 151-103-11AAA, and 150-98-6AAA) were found to have detectable concentrations of methane emanating from the TOC. It has been observed in the field that it is more likely to detect methane at the GWI or higher up in the air column within a given well. It has been less typical to actually detect methane emanating from the TOC. The occurrence of FID responses tend to be located in the northern half of McKenzie County, coincident with surficial (e.g. Charbonneau) and shallow bedrock (e.g. Fox Hills) aquifers. Individual private, irrigation, and municipal water supply wells were not considered as a part of this investigation.

FID field screening is not a stand-alone analytical tool. It must be used in conjunction with additional analytical methods and procedures. A positive FID instrument response indicates that the presence of methane is highly likely at the well since the instrument is selectively sensitive to methane and is calibrated specifically to a predetermined concentration of methane in air. However, excessive moisture and low oxygen levels or high values of carbon dioxide can influence FID response. A confirmatory gas analysis is required to determine and quantify the absolute presence and concentration of methane and other hydrocarbons that may be present in conjunction with FID screening results. The reconnaissance level screening results presented here are intended to aid in the selection of future candidate observation well locations and or areas to conduct additional sampling and analysis and potentially focus future field investigative and exploration efforts.

Explanation

Geologic Symbols

- 5.6/13.8 (TOC/GWI) — Existing observation well with a positive numerical FID instrument response in parts per million (ppm) as methane, at the top of casing (TOC) and/or the ground-water/air interface (GWI). (S) indicates stock well. NM indicates not measured.
- Existing observation well, no FID response at TOC and/or the GWI.
- Historical observation well location. No existing well at well site location visited. Well presumed abandoned or destroyed.
- Wells sites not visited during this investigation.
- Nested wells; locations not separable at this scale.
- (2) — Indicates number of wells drilled at same coordinates.

Other Features

- Water
- Marsh
- River/Stream - Perennial
- Stream - Intermittent
- National Park Boundary
- US Highway
- State Highway
- Paved Road
- Unpaved Road

Scale 1:150,000

0 2 4 6 8 Miles

0 2 4 6 8 Kilometers

Mercator Projection — 1983 North American Datum
Standard parallel 47°1845 — Central meridian 103° 1845

USGS NED Shaded Relief - Vertical Exaggeration 9x

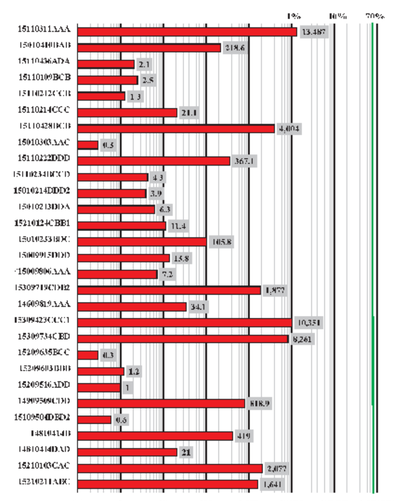

Figure 1. Graph depicting the relative relationship and absolute maximum values of flame-ionization detector (FID) instrument responses from selected wells in McKenzie County. FID results for each well are presented in order of field screening occurrence from top to bottom. Values shown are those reported from the ground-water/air interface (GWI) (as CH4 in ppm). The concentration of methane typical in commercial natural gas is highlighted by the vertical green line at 70%.

* FID instrument response collected from the top of well casing (TOC).

Cartographic Compilation: Elroy L. Kadrmas