

Natural Gas Explosions in Hutchinson, Kansas: Locating Abandoned Brine Wells by High- resolution Magnetic and Electromagnetic Survey

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Kansas Geological Survey

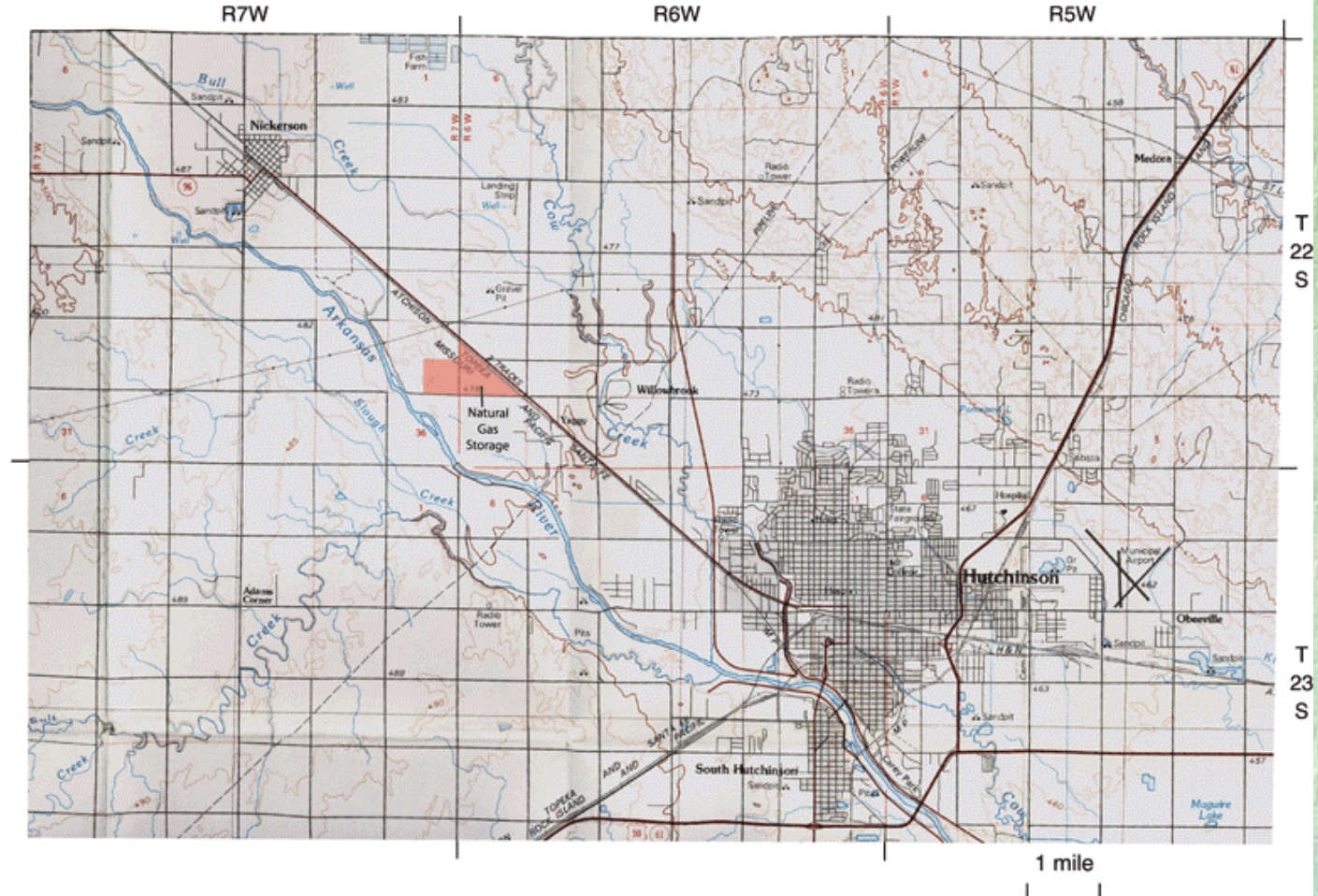
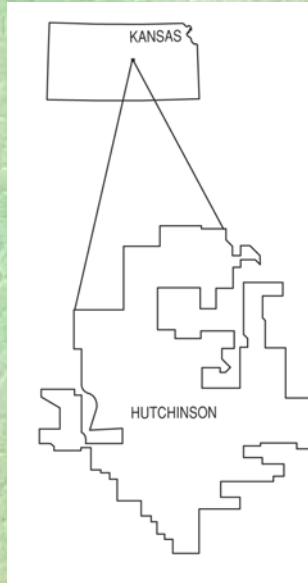
The University of Kansas

Stephen L. Williams

The City of Hutchinson

**GSA North-Central Section 37th Annual Meeting
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From KGS Web Site



The natural gas is suspected to have come from a leak at the Yaggy underground gas storage facility, ~7 miles northwest of Hutchinson.

Gas leaking to surface

Sketch depicting brine well and cavity (from Lomenick, 1972)

Solution mining schematics (from Myers et al., 1972)

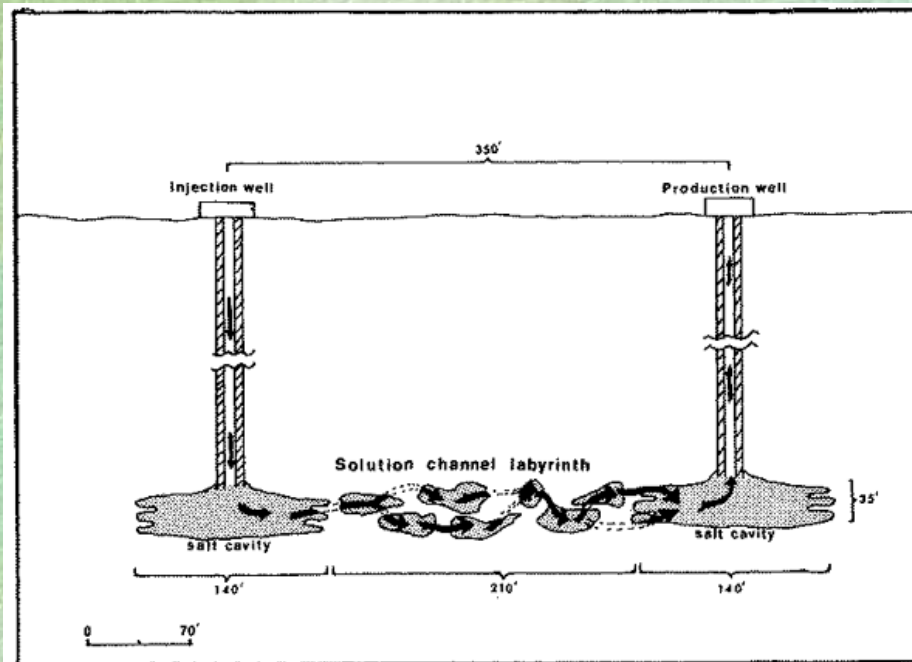
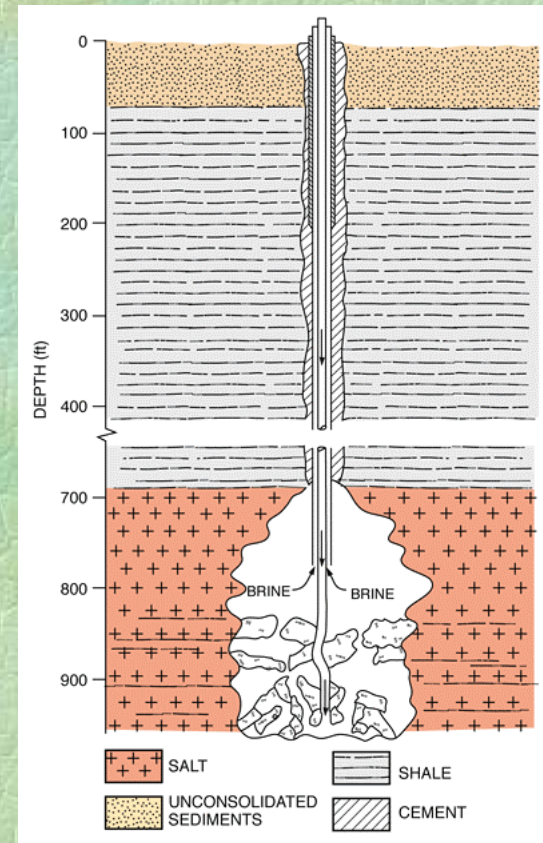


Figure 3. Merging of salt cavities.



Methodology

Record signals from a known well.

Compare the signals with data acquired in an assigned area.

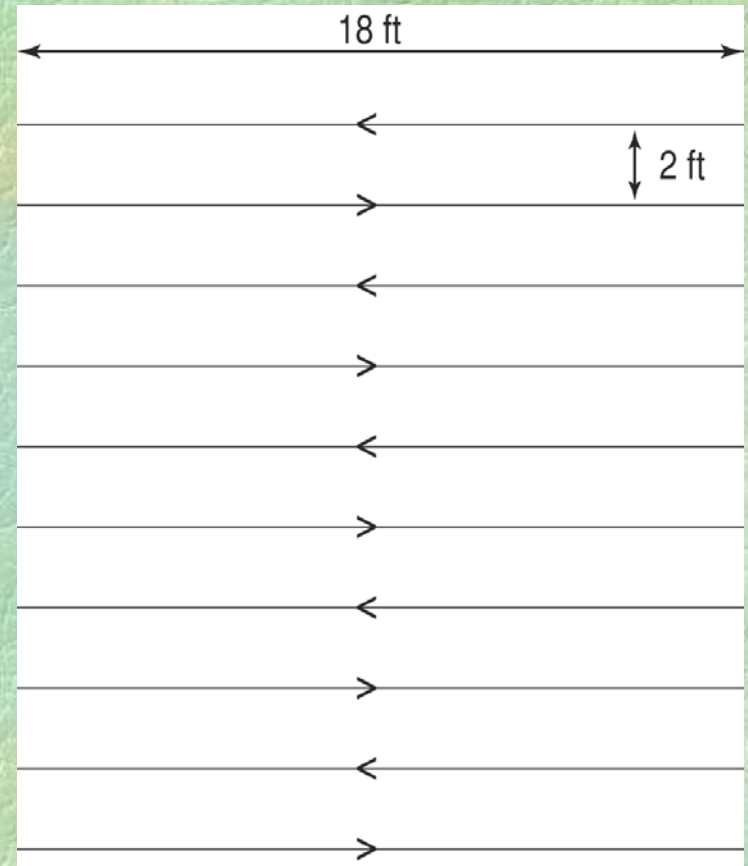
Signals from abandoned wells are dependent on a physical size of wells, buried depth, surrounding materials, and most importantly, calibration of an individual instrument, so the information from a known well was essential for properly interpreting anomalies.

EM instrument GEM-2

Survey pattern



Measuring the induced (secondary) EM field in the unit of parts per million (ppm) relative to the primary EM field. Three frequencies were selected: 2430 Hz, 7290 Hz, 18270 Hz.



EM signature at Well C8

2430 Hz in Phase

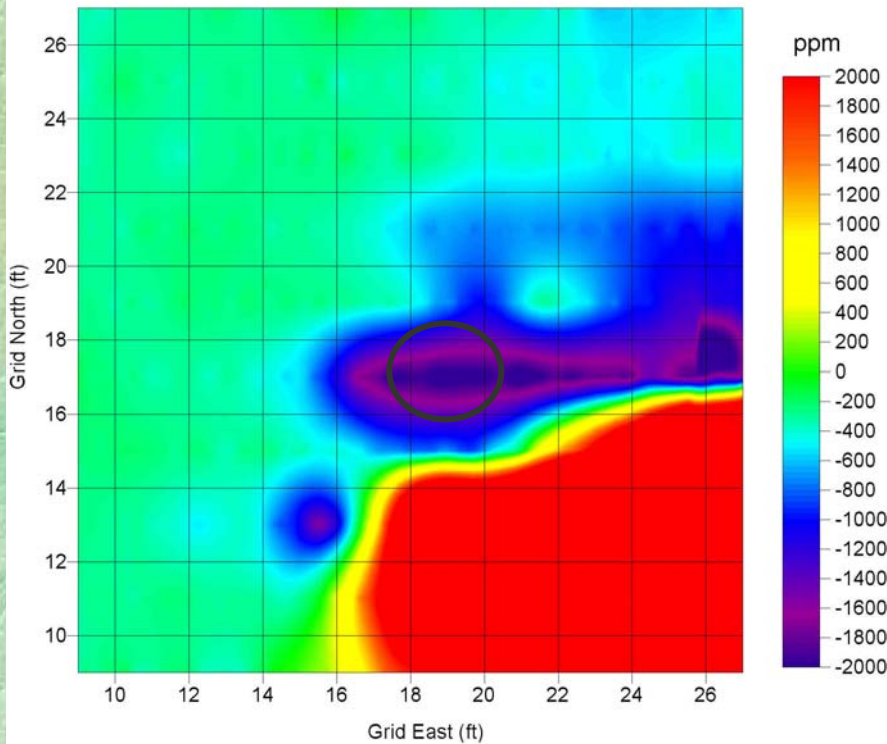


Figure 5a

2430 Hz Quadrature

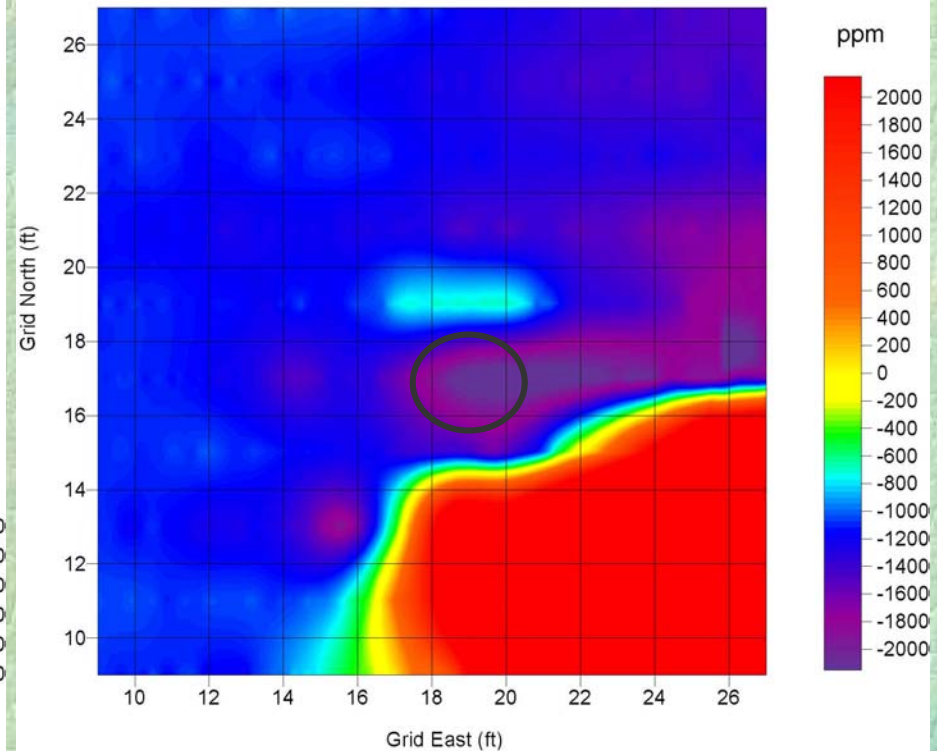
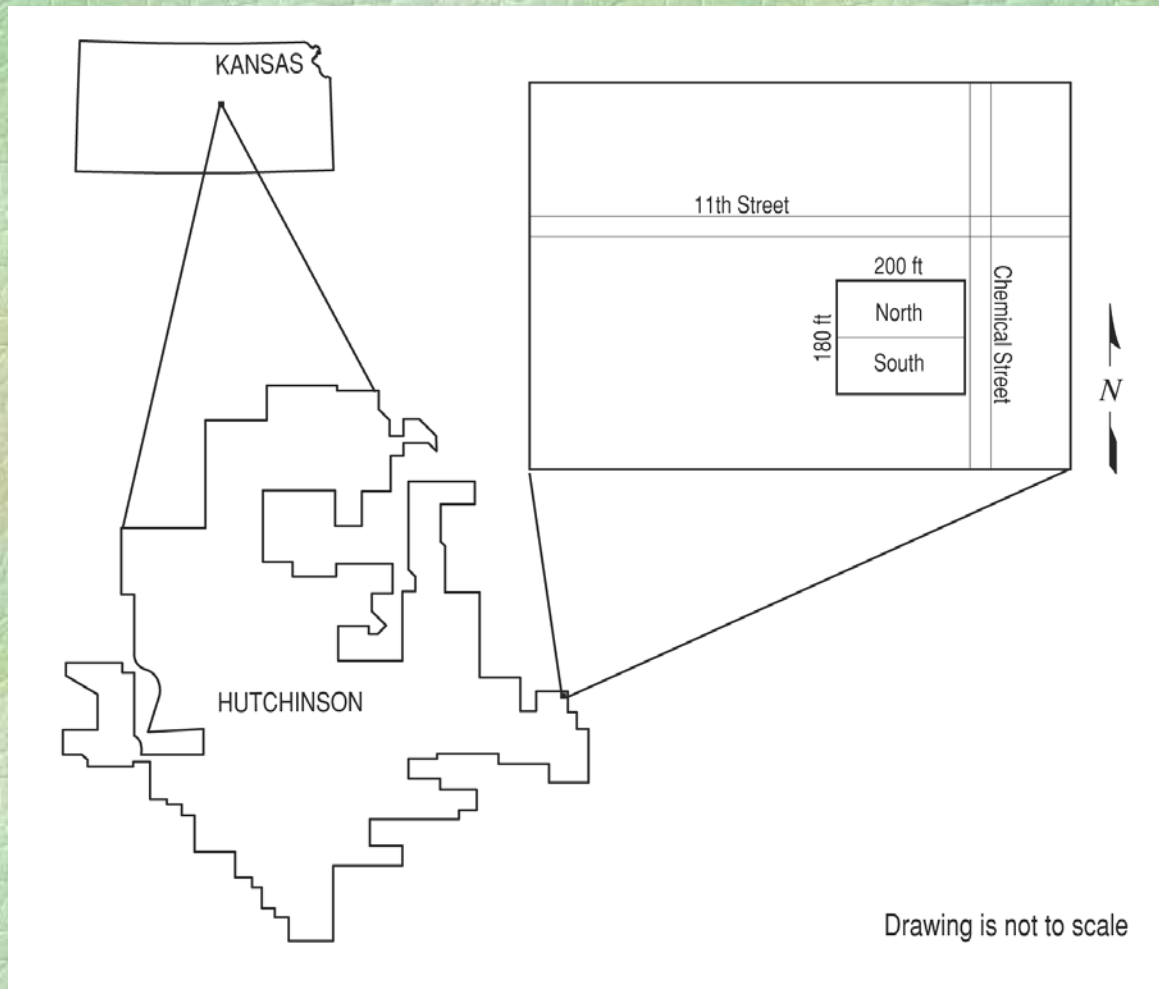


Figure 5b

Site map of EM survey



2430 Hz in Phase

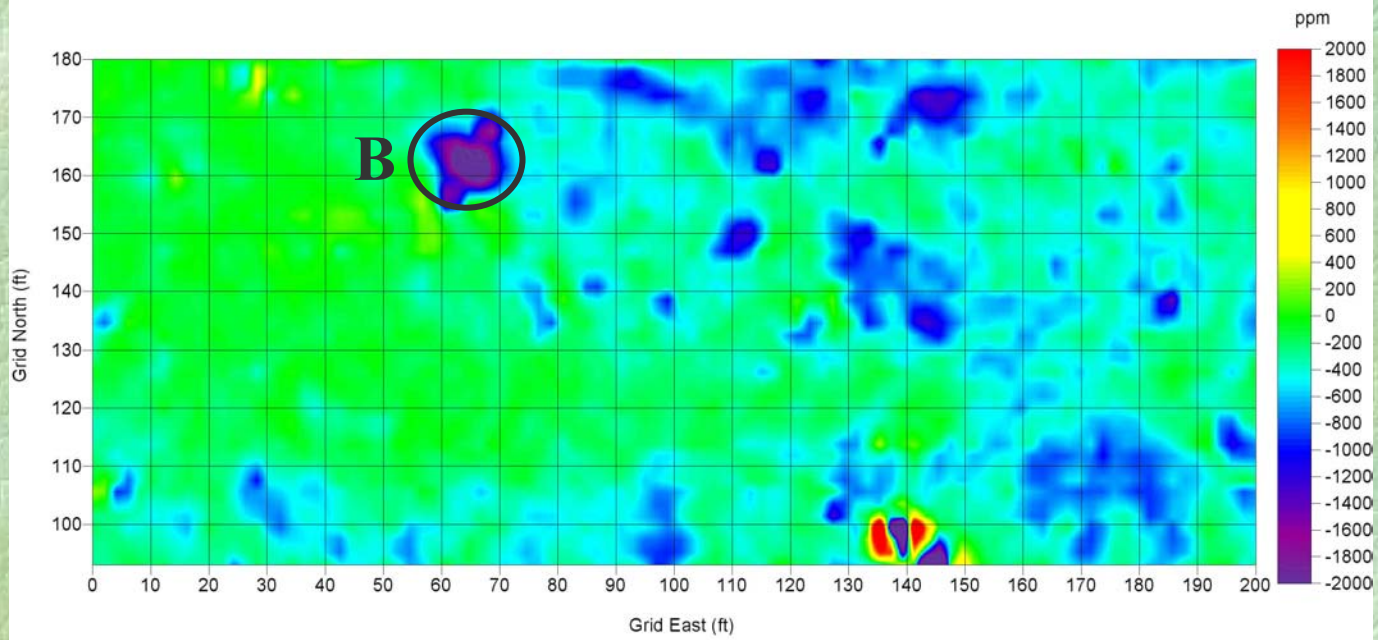


Figure 8a

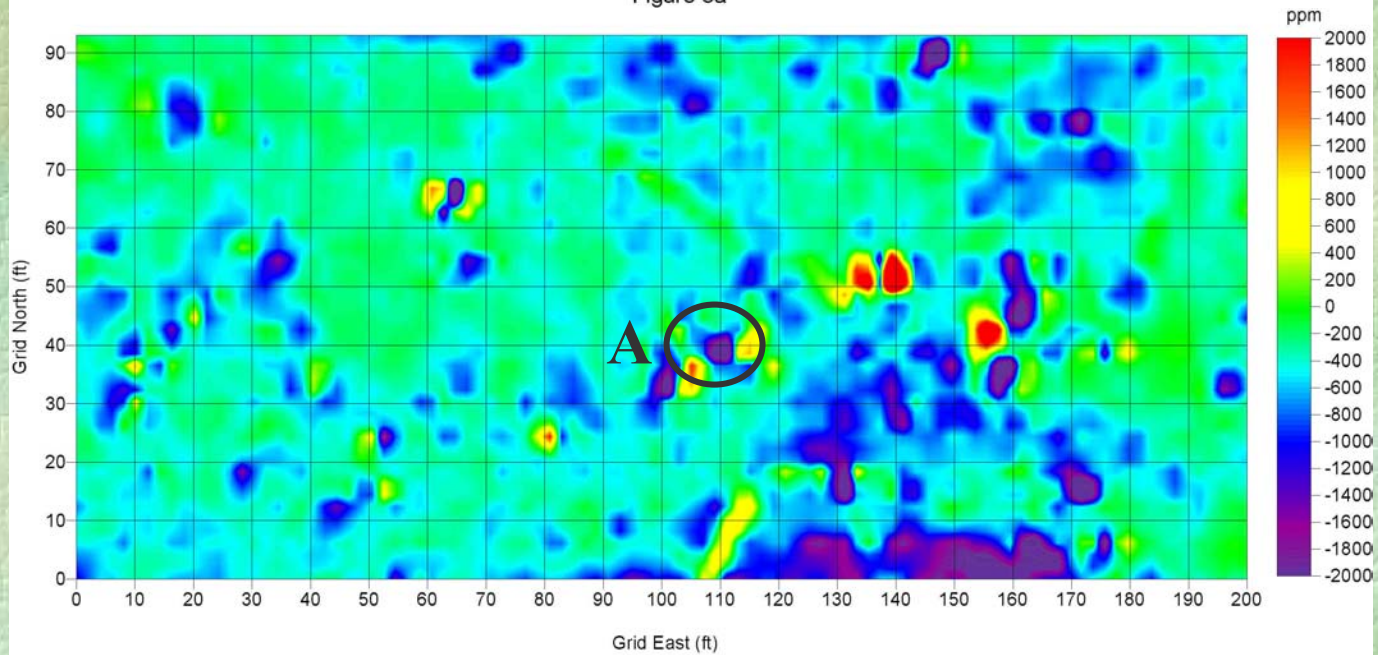


Figure 7a

March
2001

2430 Hz Quadrature

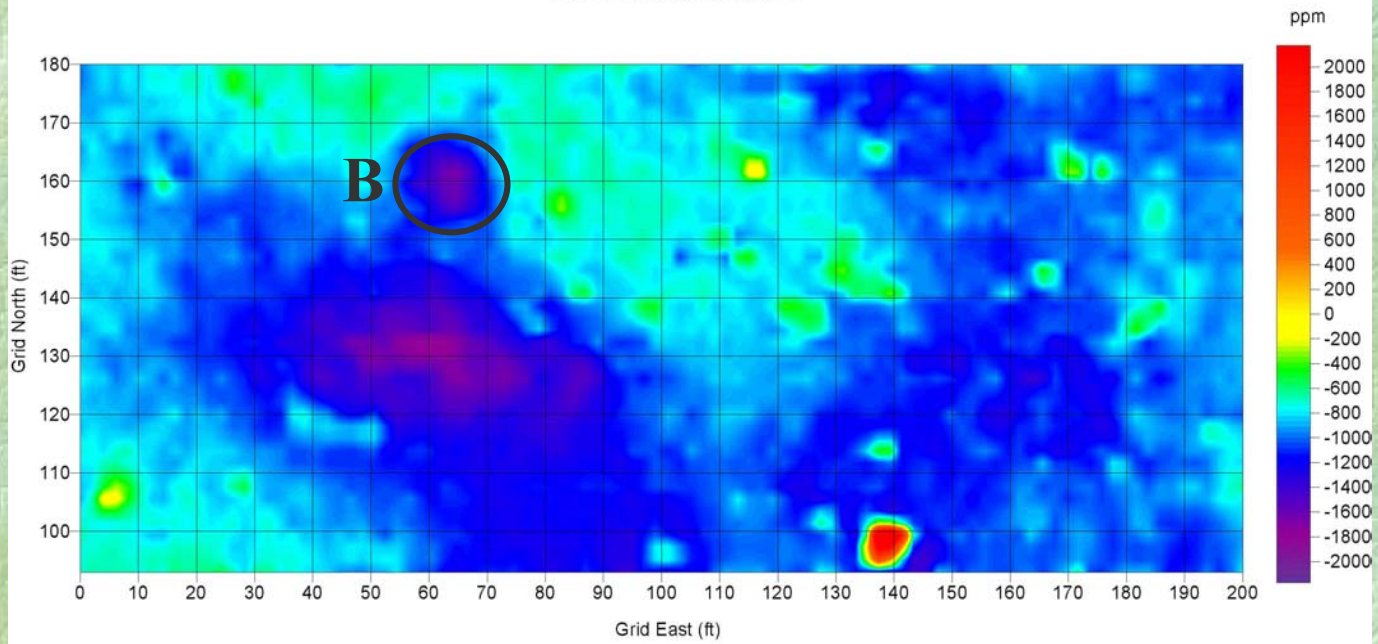


Figure 8b

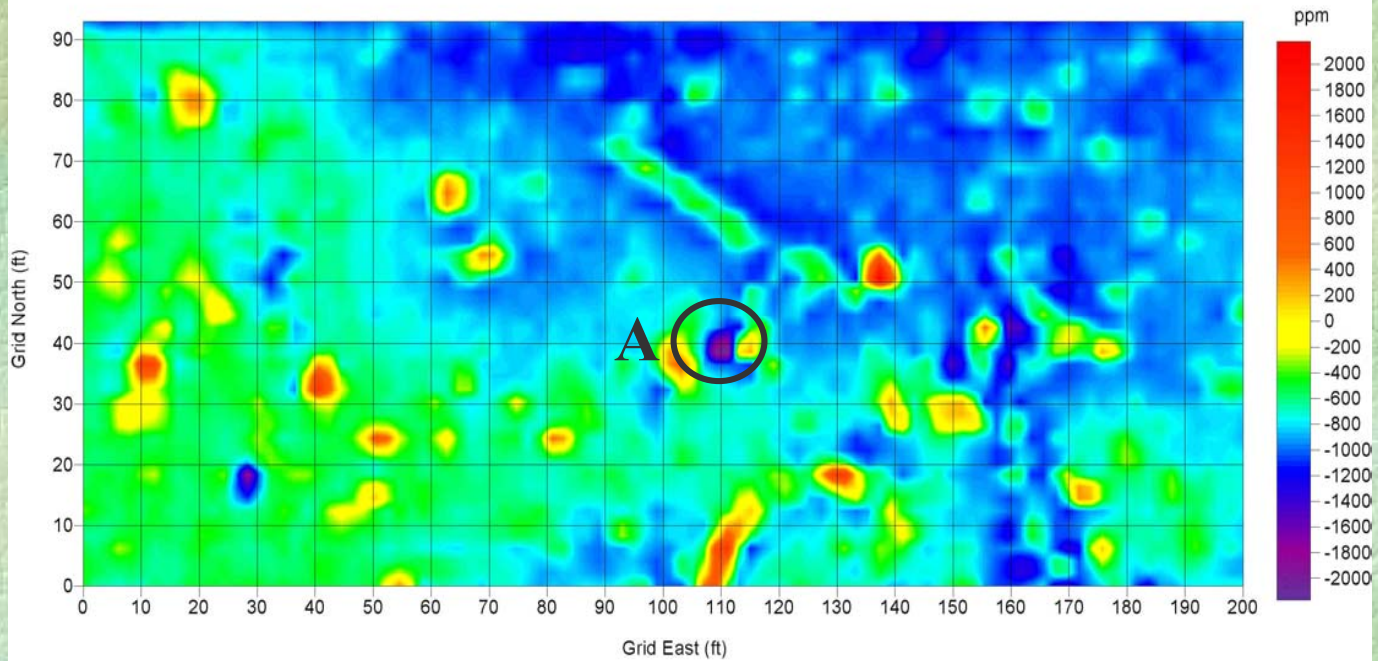
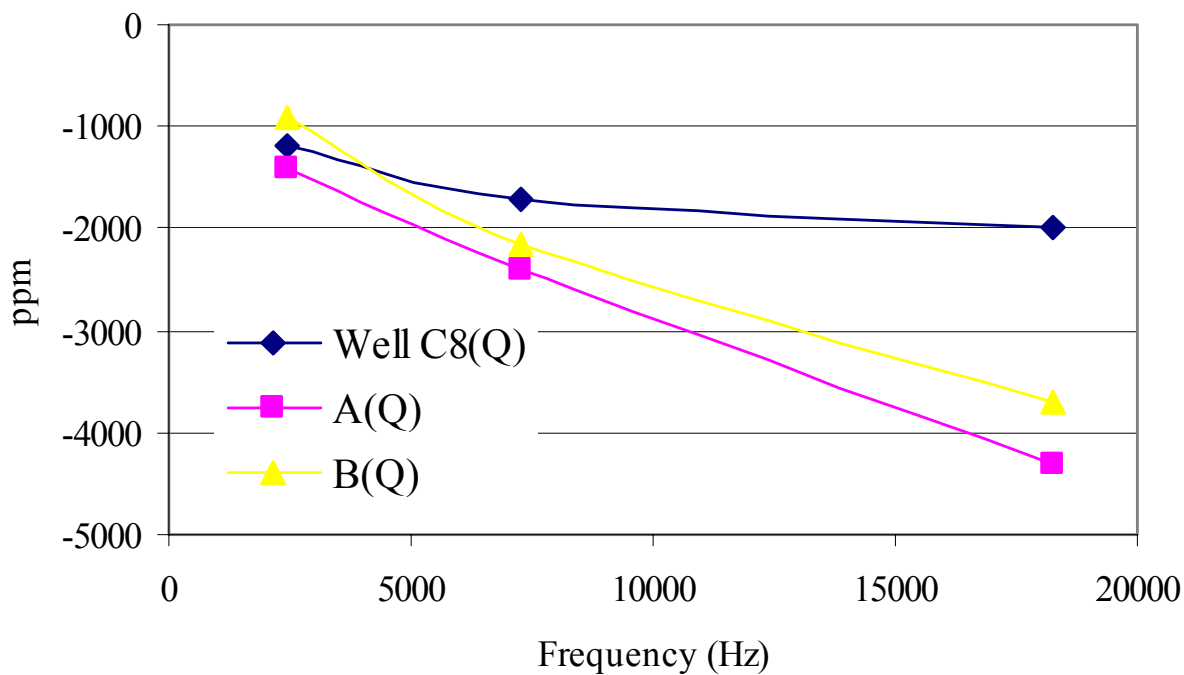
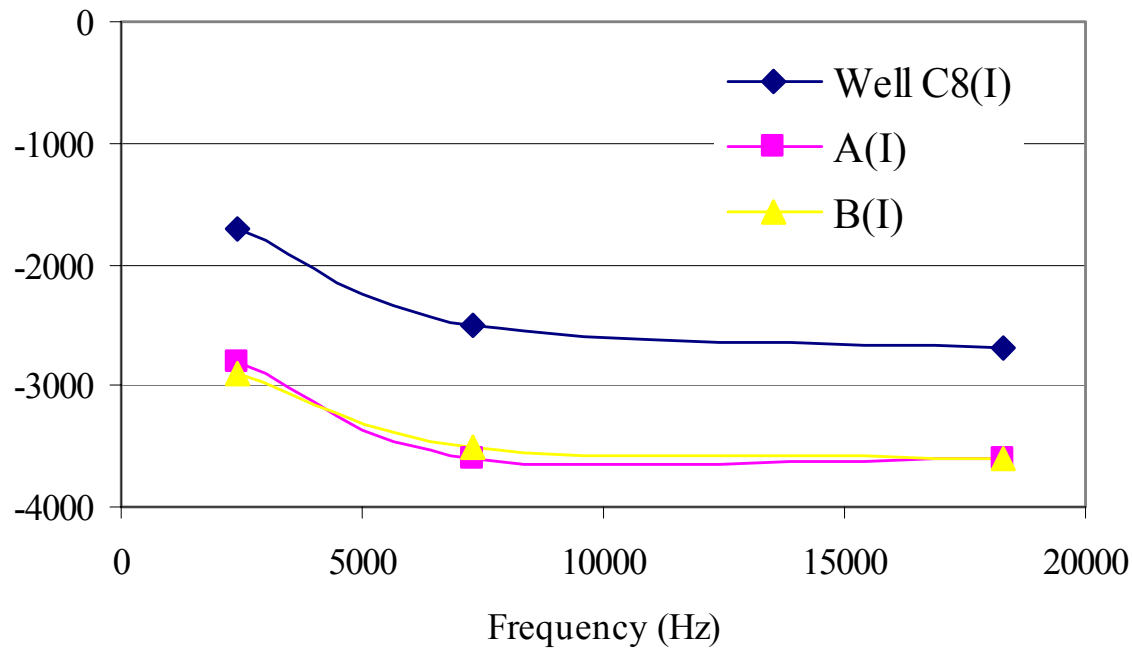


Figure 7b

March
2001

In-phase spectrum

Quadrature spectrum

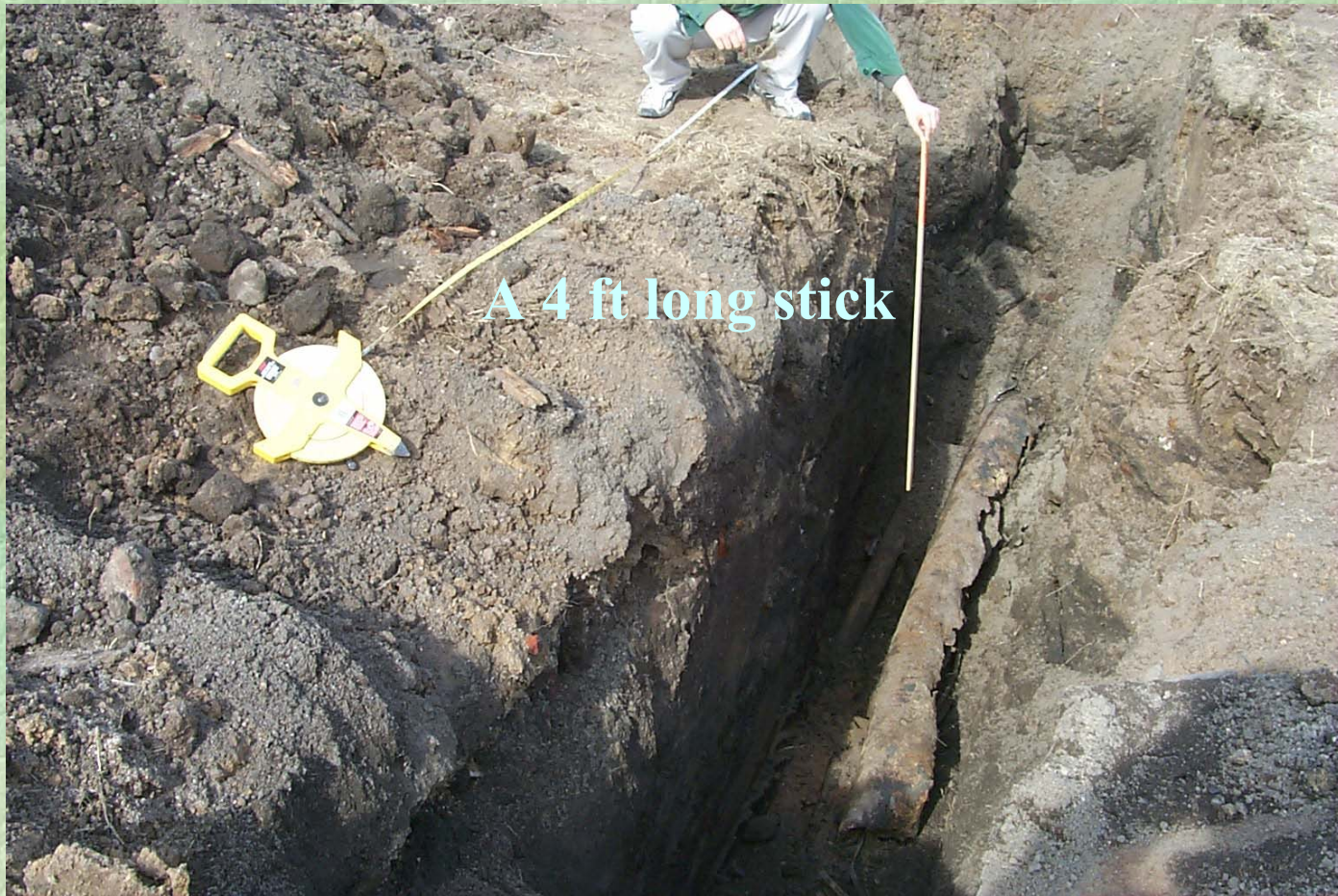


**Source of an anomaly
at location A (110, 40)**



It is 4 inches in diameter and buried 5 ft in depth and surrounded by sandy soils, clay, and gravel.

Source of an anomaly at location B (65, 161)



Conclusions on EM method

Feasibility: An uncapped abandoned brine well 4 inches in diameter and buried 5 ft deep in Hutchinson was found by a GEM-2

A key: Get a signature from a known well

Investigation depth: As deep as 20 ft by a GEM-2 in the Hutchinson area

Main challenge: Signature recognition

High-resolution magnetic survey

Data acquisition

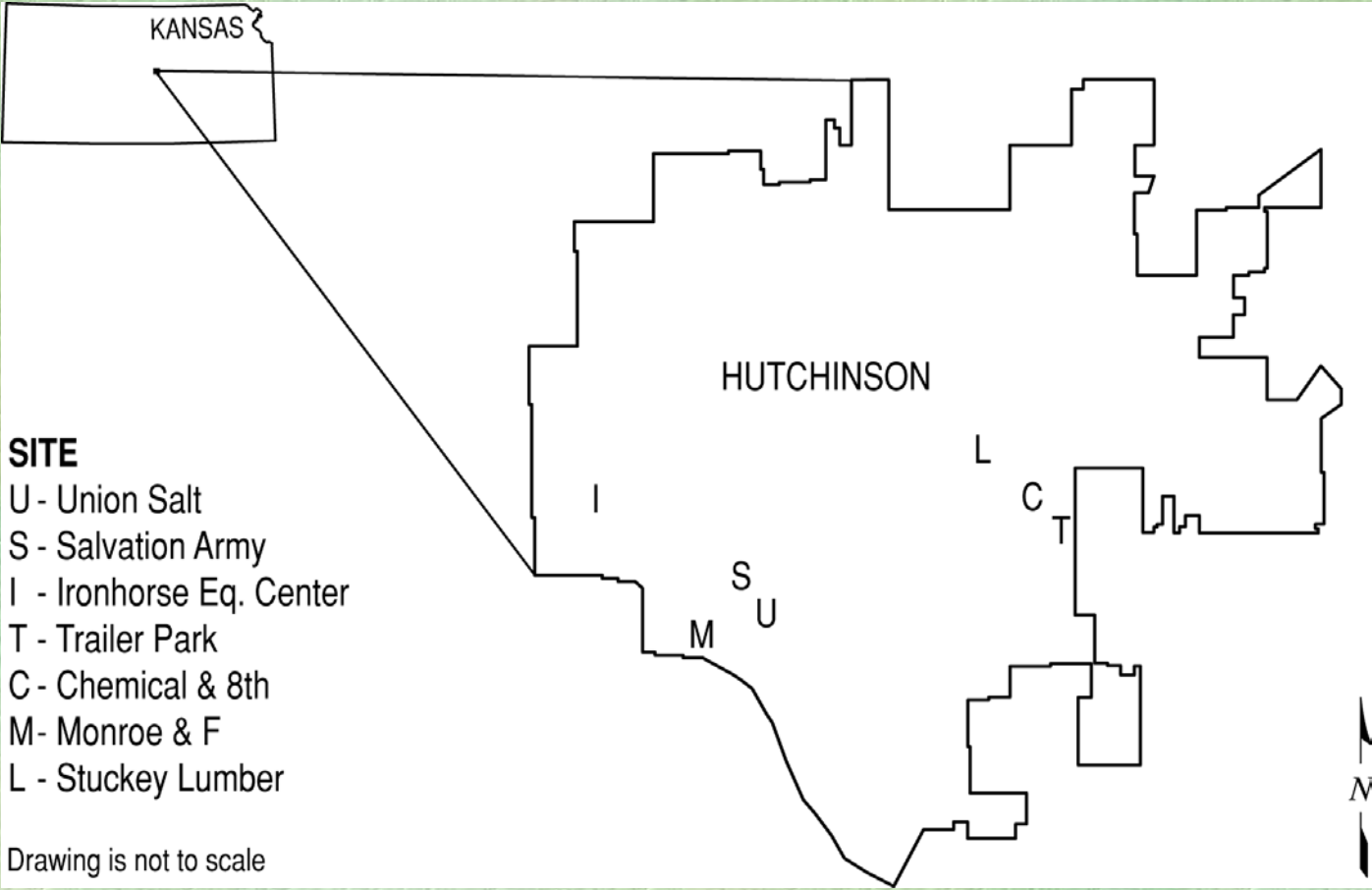
- ☛ Total area surveyed: **512,000 ft²**
- ☛ Line spacing: **3 ft**
- ☛ Data density along a survey line:
2.3 measurements/ft (10 readings/second)
- ☛ Total line length: **35 miles**

Defining grids

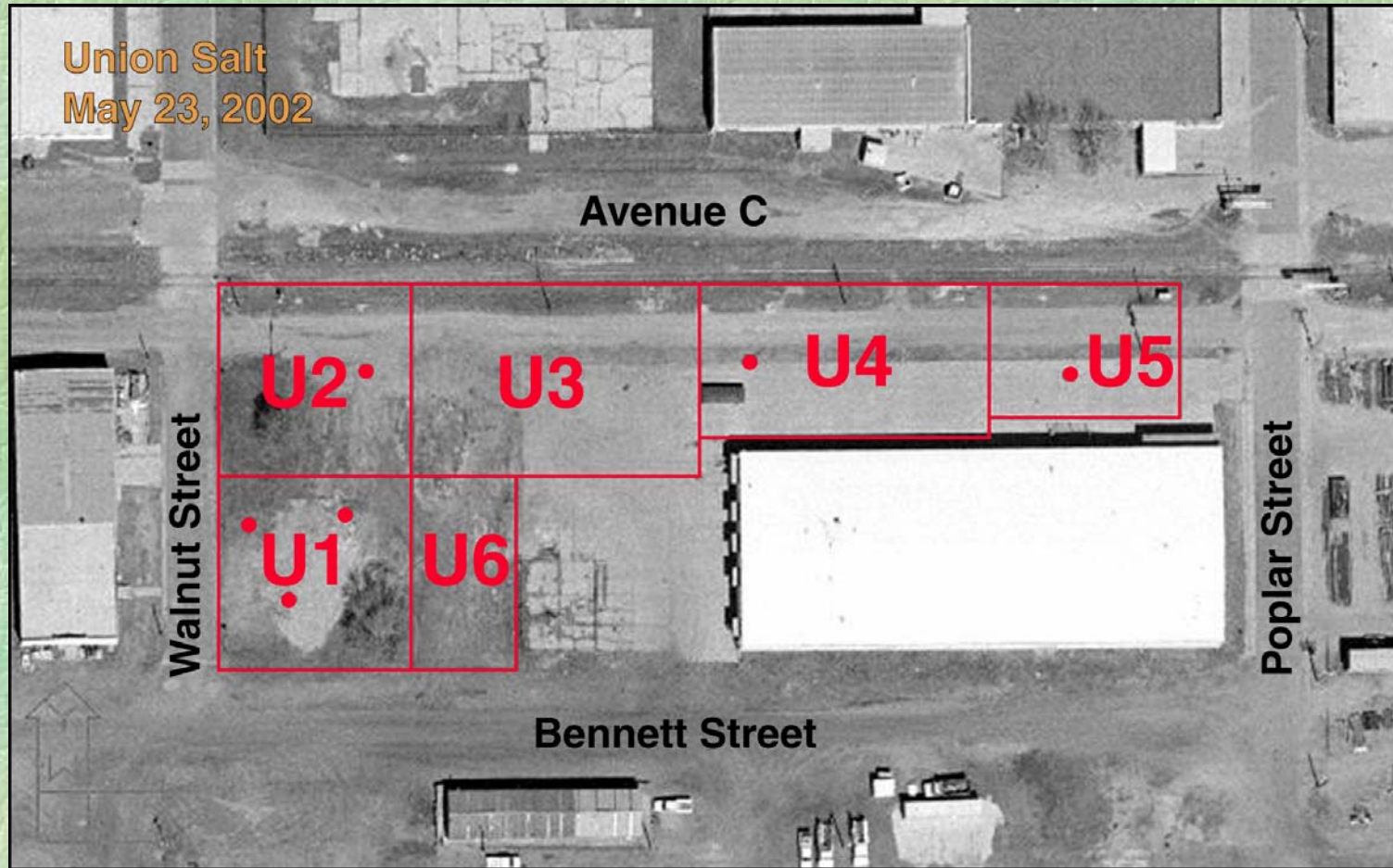


Survey areas were defined by **100 ft by 100 ft** grids. Horizontal accuracy of grids: **± 0.5 ft**. Dave and Gang are surveying.

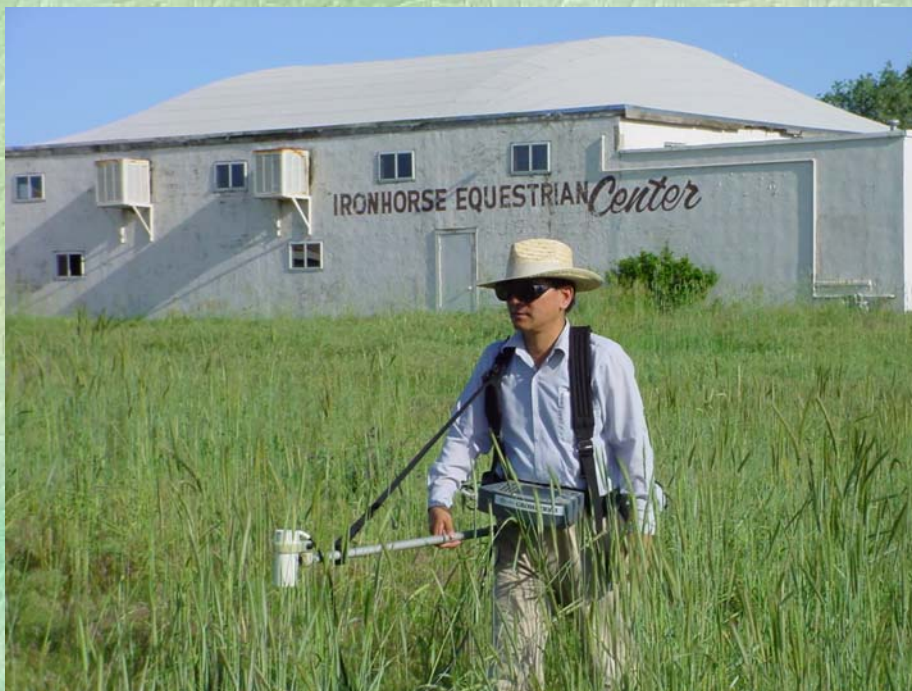
Site map



Union Salt



Magnetometer G858



Continuously recording the total component of the geomagnetic field. Accuracy of reading: 0.1 nT

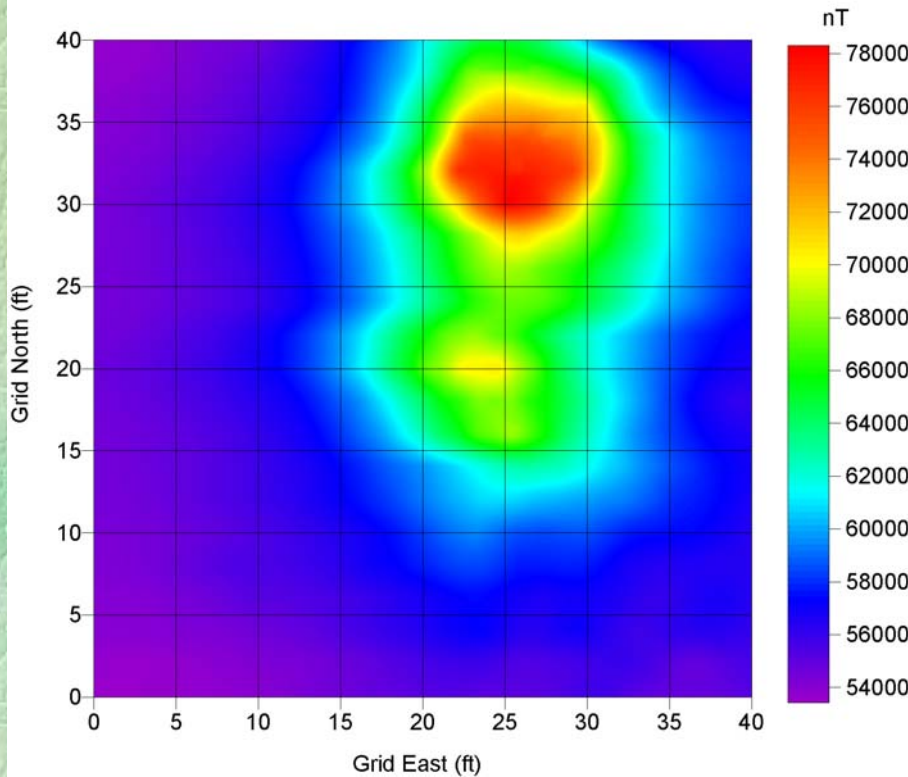
Data processing

- ☛ **Assign field geometry**
- ☛ **Correct sensor locations**
- ☛ **Adjust data dropouts**
- ☛ **Grid data into 1 ft × 1 ft grids**
- ☛ **Display results in a color scale that enhances anomalies**

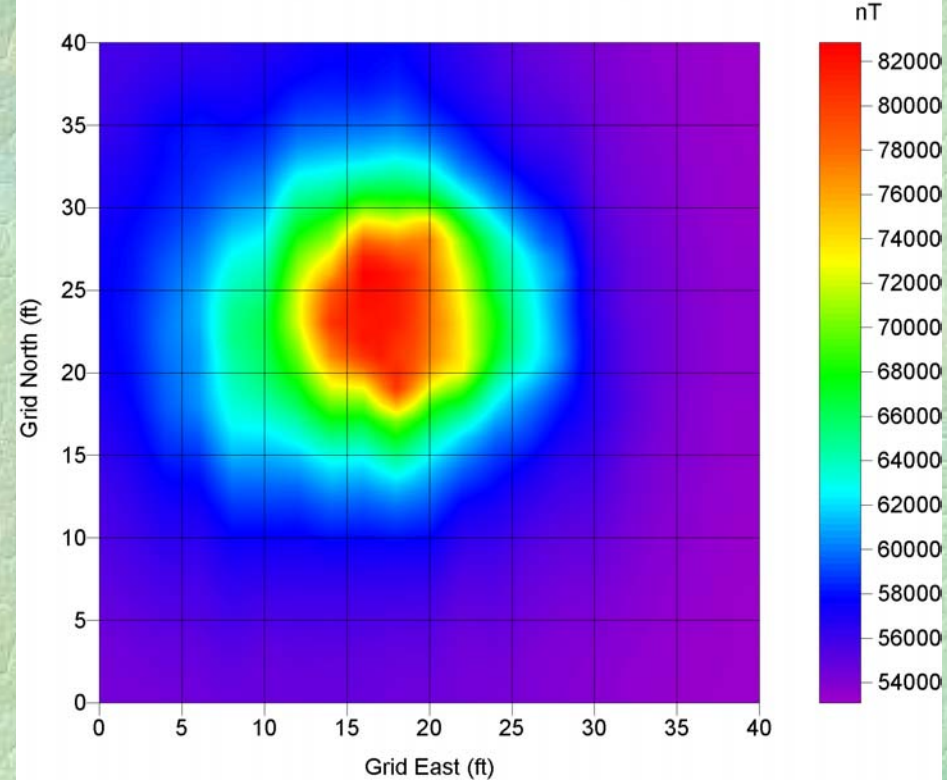
- ☛ **Correlate an anomaly with signals of the known well**
- ☛ **Invert an anomaly**

Magnetic signals from Wells C8 and C13

Total Field Component of Magnetic Anomaly at well C8

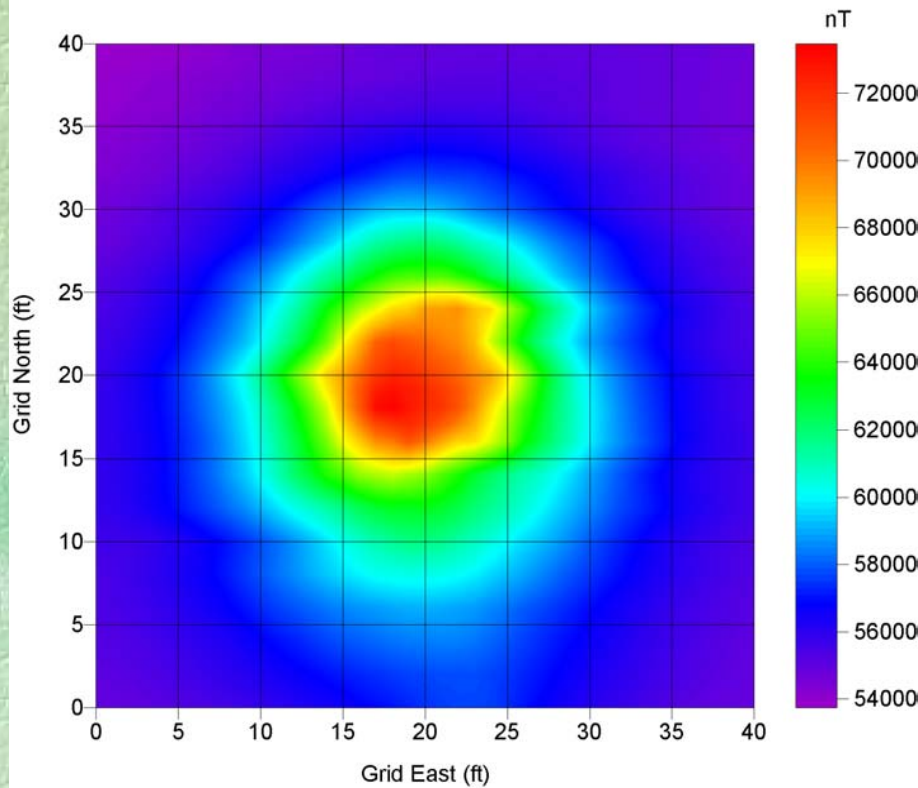


Total Field Component of Magnetic Anomaly at well C13



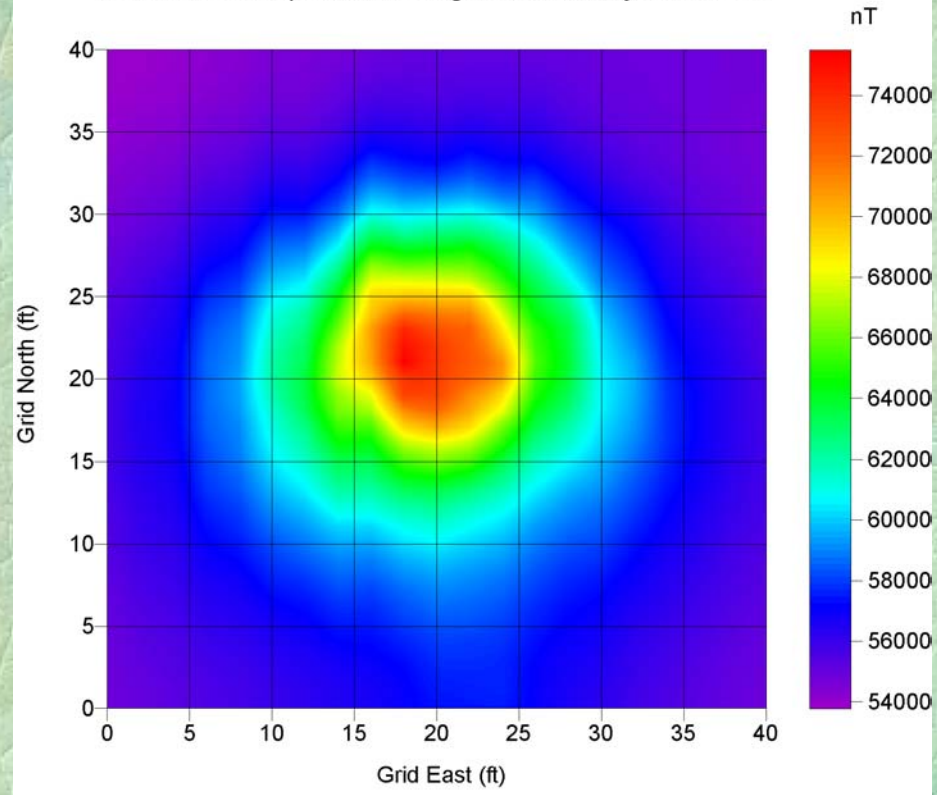
Magnetic signals from Well C4

Total Field Component of Magnetic Anomaly at well C4



Survey line in the east-west direction

Total Field Component of Magnetic Anomaly at well C4



Survey line in the north-south direction

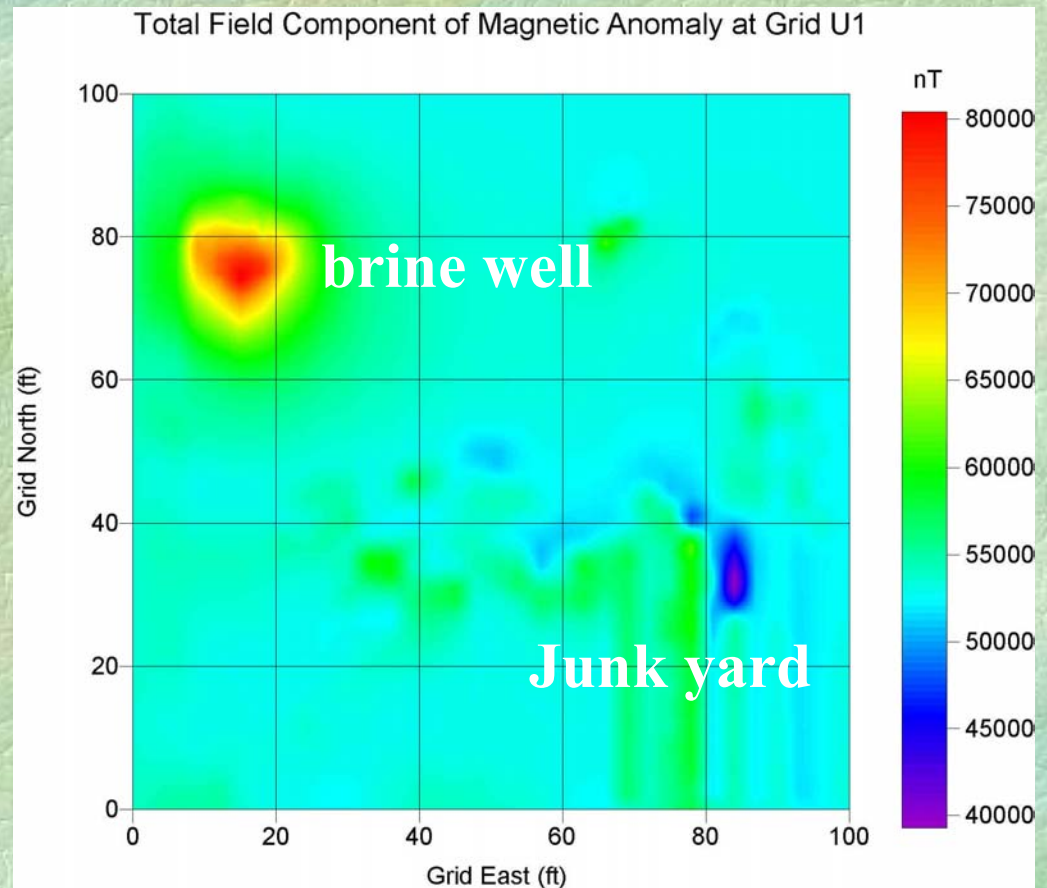
Findings from 21 anomalies

- ☞ **A. Five identified 8-inch brine wells**
- ☞ **B. Three 2.5-inch water wells**
- ☞ **C. One probable 1.5-inch water well**
- ☞ **D. One 4-inch vertical pipe**
- ☞ **E. One probable 4-inch gas pipe**

- **Five identified brine wells**

1. At Union Salt, Walnut Street, between Avenue C and Bennett (two blocks south of City Hall)

Grid 1, an anomaly at (15, 75)



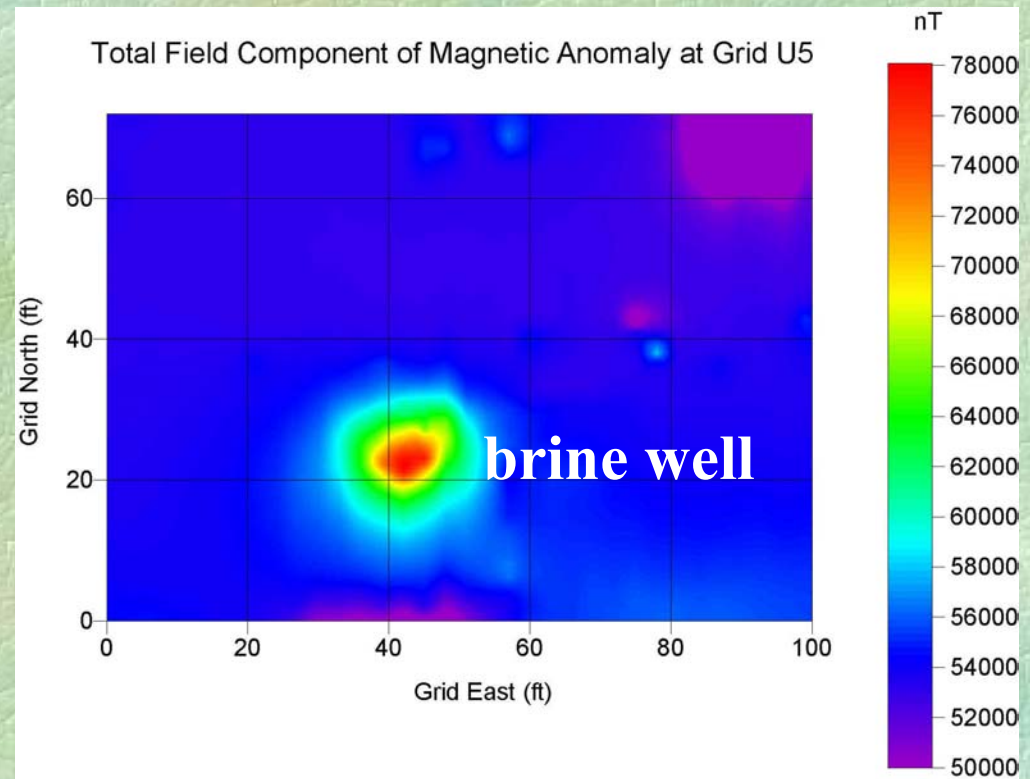
An 8-inch brine well uncovered at (15, 75)



Depth to the top of the well is 1 ft. The length of field note book is 7.5 inch. Mike is checking the well.

2. At Union Salt, Walnut Street, between Avenue C and Bennett (two blocks south of the City Hall)

Grid 5, an anomaly at (42, 23)



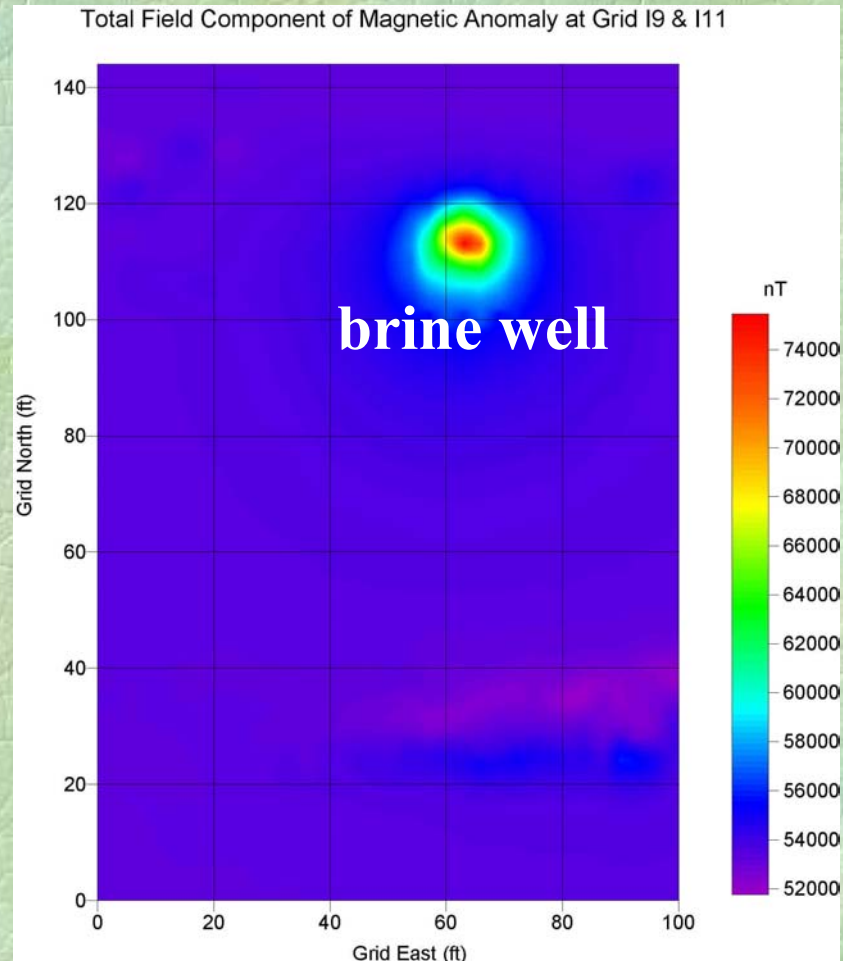
An 8-inch brine well uncovered at (42, 23)



Depth to the top of the well is 1 ft. The well was under 6 inches of concrete. Rick is taking notes.

3. At Ironhorse Equestrian Center, southeast of the intersection of Nickerson and Hendricks Streets

Grids 9 & 11, an anomaly at (63,114)



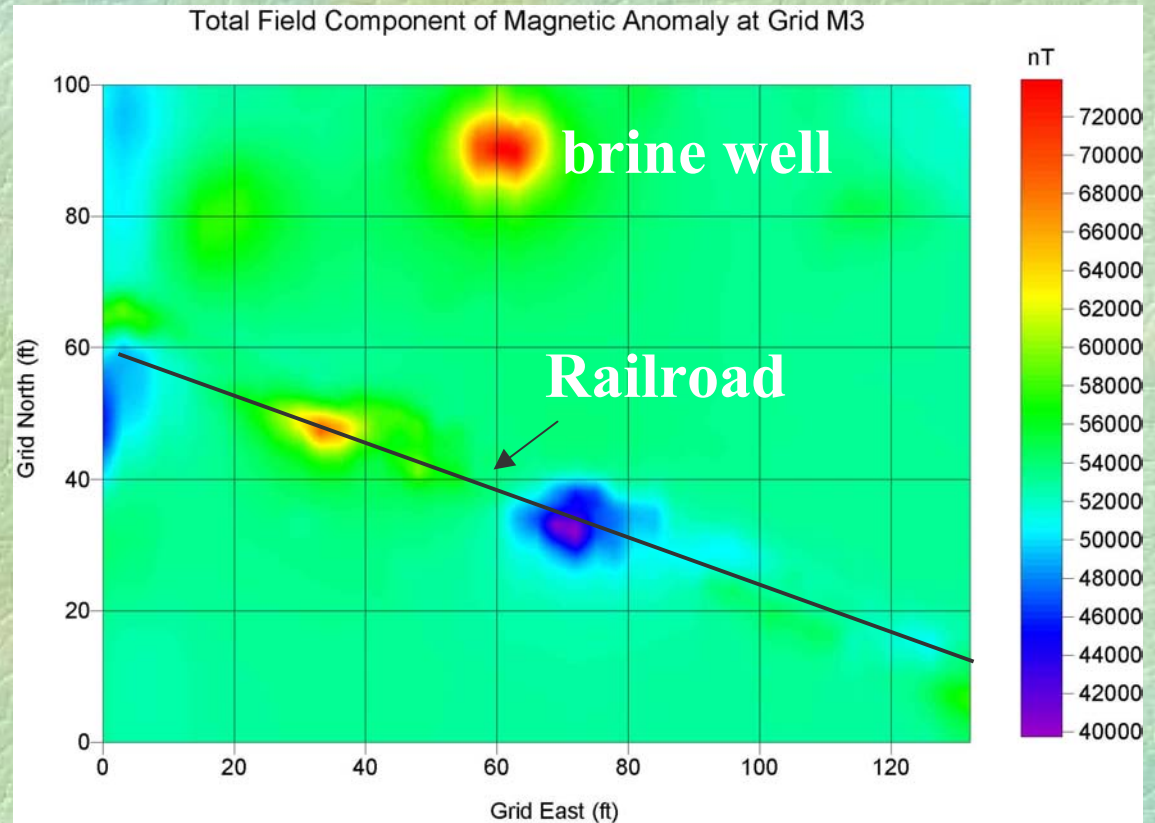
An 8-inch brine well uncovered at (63, 114)



Depth to the top of the well is 4.5 ft. Mike is checking the well.

4. On Monroe Street, at the intersection with Avenue F

Grid 3, an anomaly
at (62, 90)



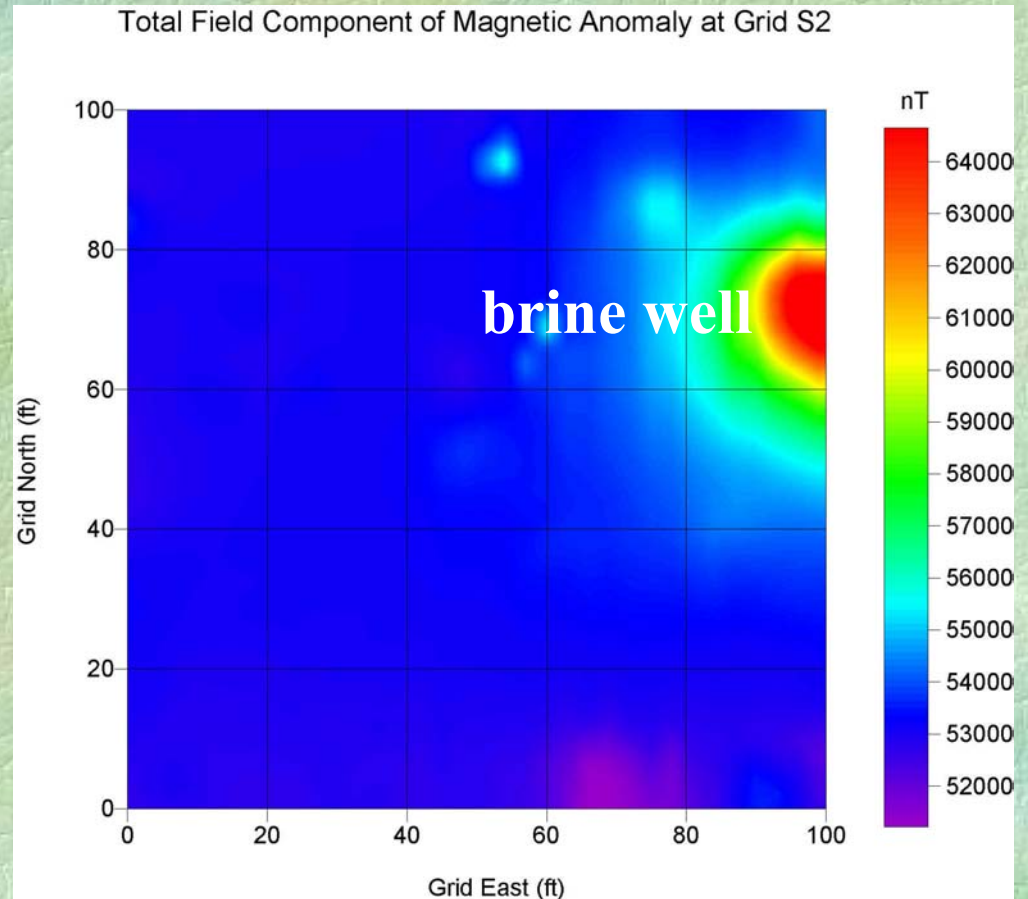
An 8-inch brine well uncovered at (62, 90)



Depth to the top of the well is 2 ft. The well was covered by 1 ft of asphalt pavement.

5. In Salvation Army Eagle Park, Main Street, between Avenues B and C

**Grid 2, an anomaly
at (100, 72)**



An 8-inch brine well uncovered at (100, 72)



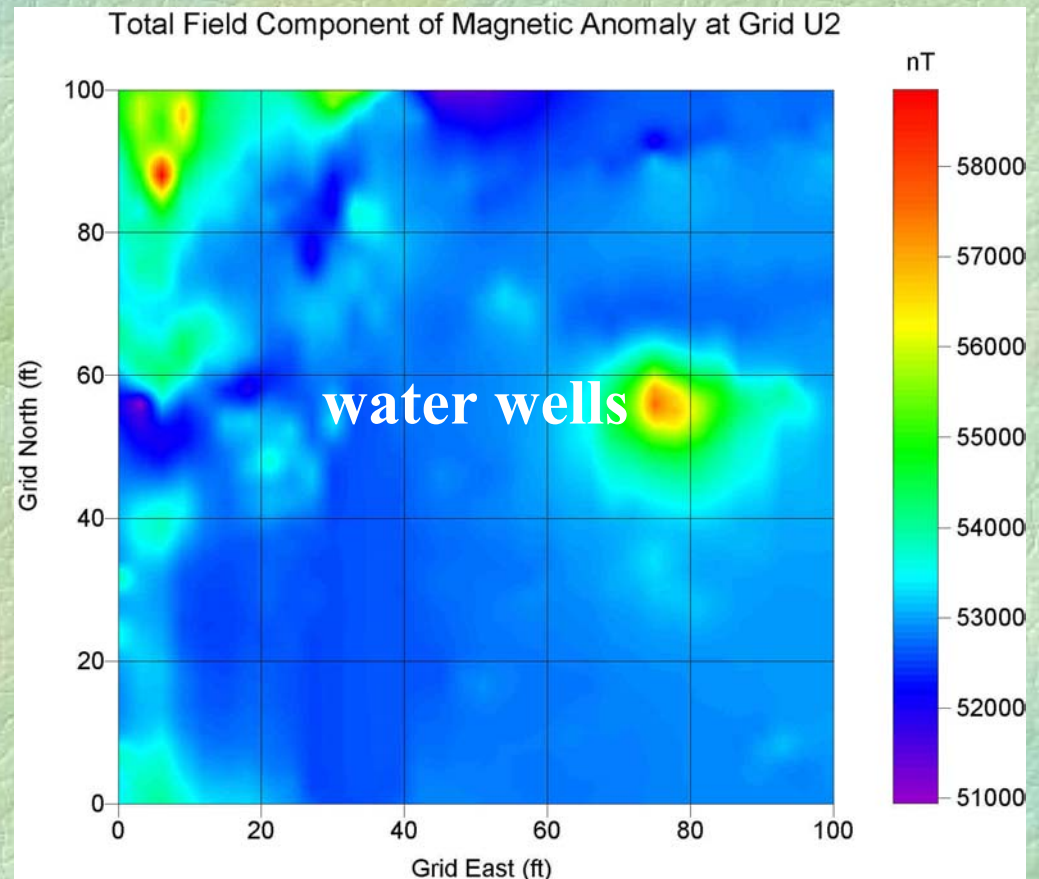
Depth to the top of the well is 7 ft. There was some oil in the well.



B. Three water wells

1. At Union Salt, Walnut Street, between Avenue C and Bennett (two blocks south of City Hall)

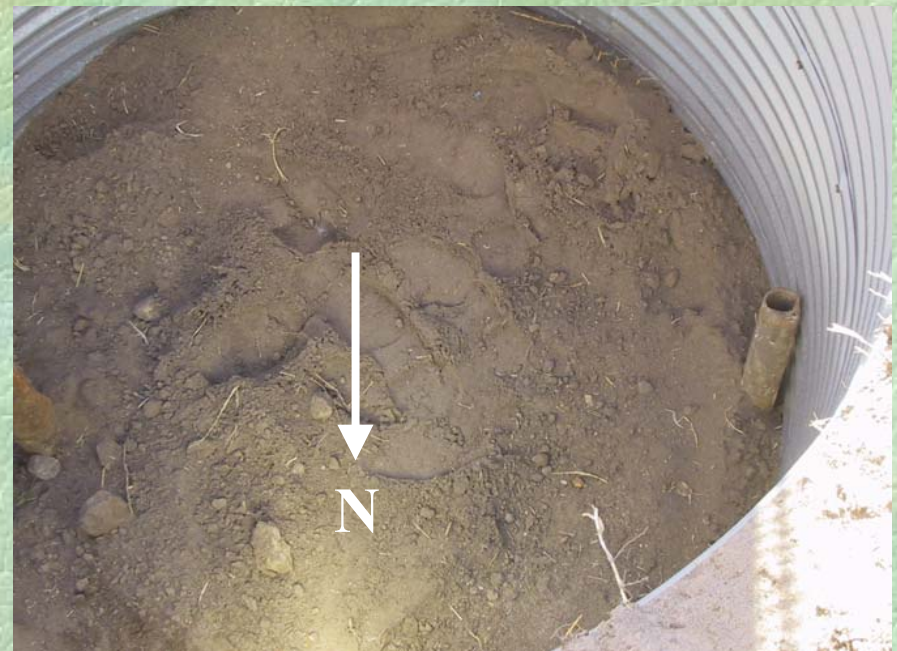
**Grid 2, an anomaly
at (76, 55)**



Two 2.5-inch water wells uncovered at (76, 55)



The original well

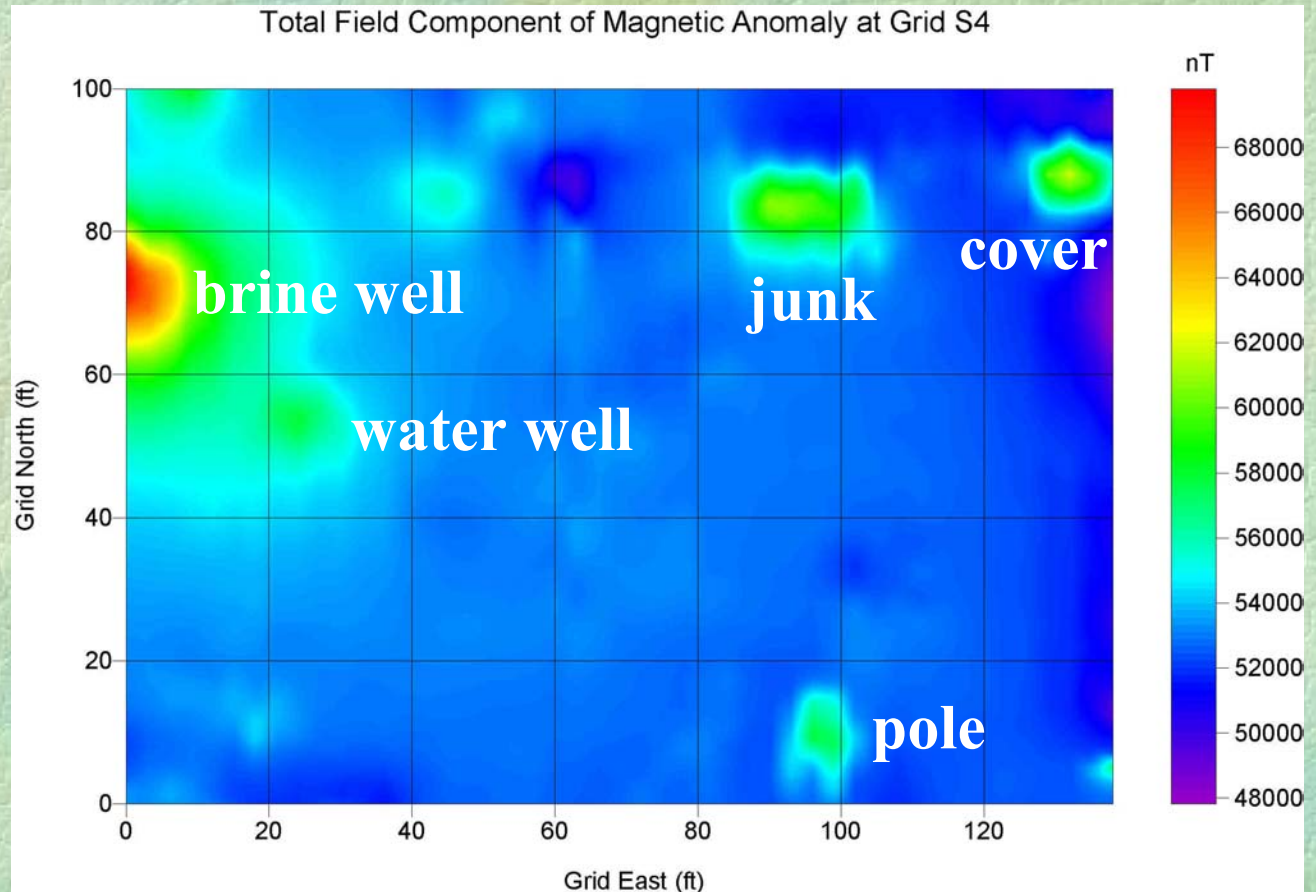


A new well (3'-9" due east of the original well) found during plugging

Depth to the top of the water wells is 4 ft.

2. In Salvation Army Eagle Park, Main Street, between Avenues B and C

Grid 4, an anomaly at (23, 55)



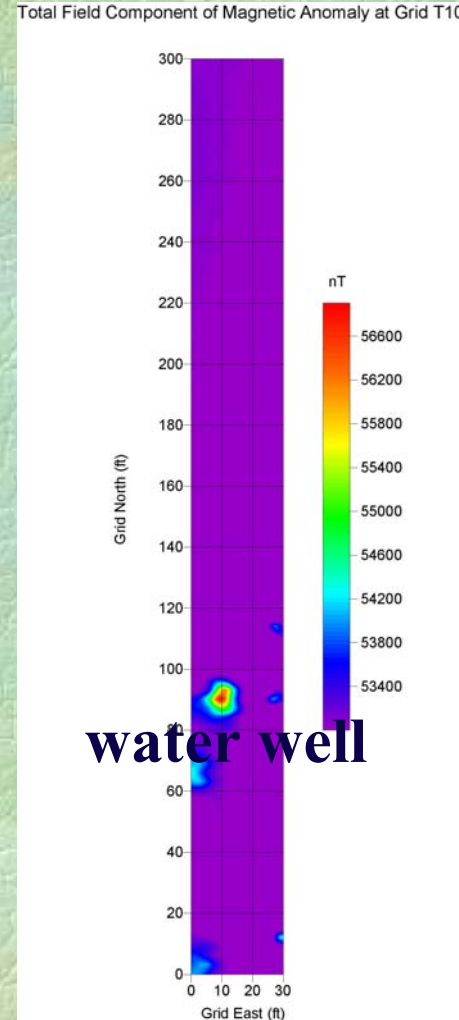
A 2.5-inch water well uncovered at (23, 55)



Depth to the top of the water well is 2 ft. Jianghai is checking the well.

3. On Grand Street (150 ft north of the intersection of Grand and Bell Streets)

Grid 10, an anomaly at (10, 90)



A 2.5-inch water well uncovered at (10, 90)

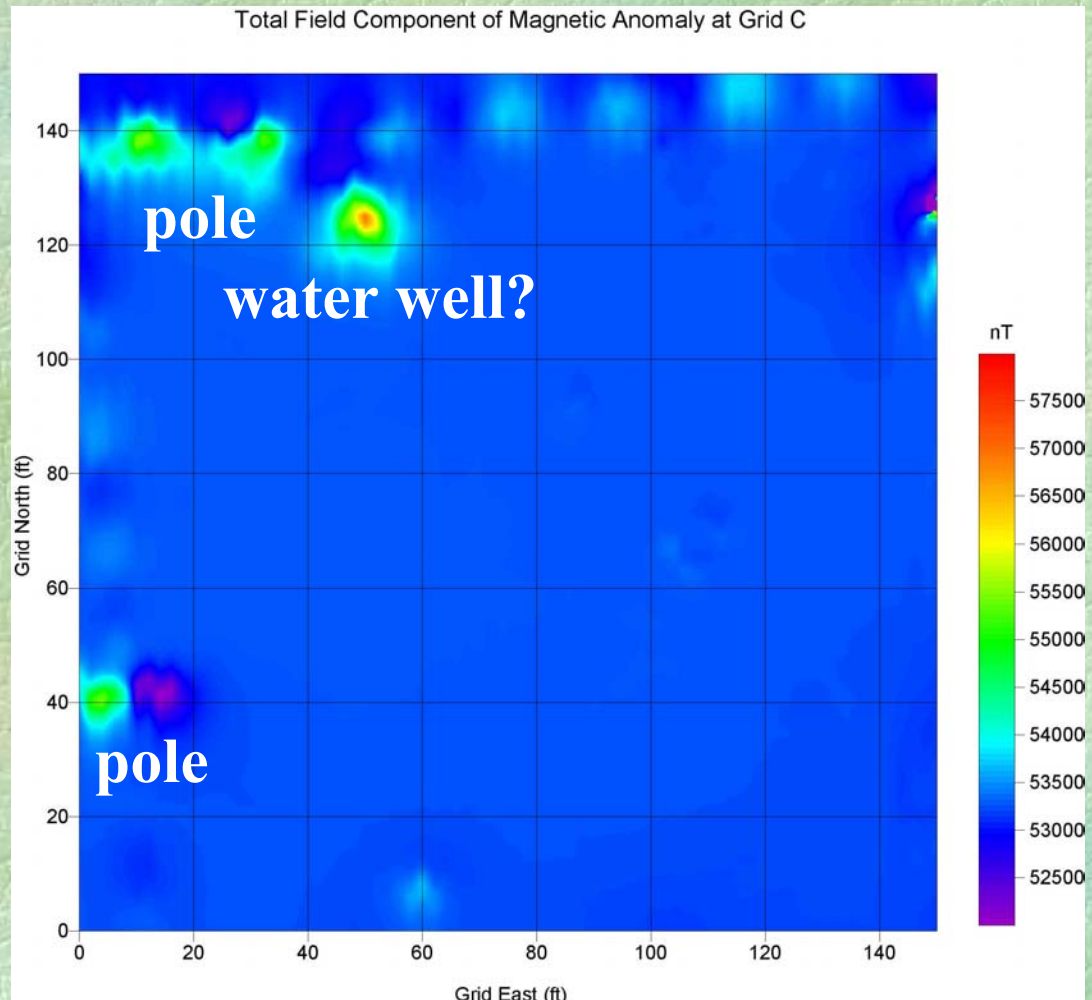


Depth to the top of the water well is 1 ft.

C. One probable water well

At 8th and Chemical Street

Grid 1, an anomaly
at (50, 123)



A 1.5-inch pipe uncovered at (50, 123)

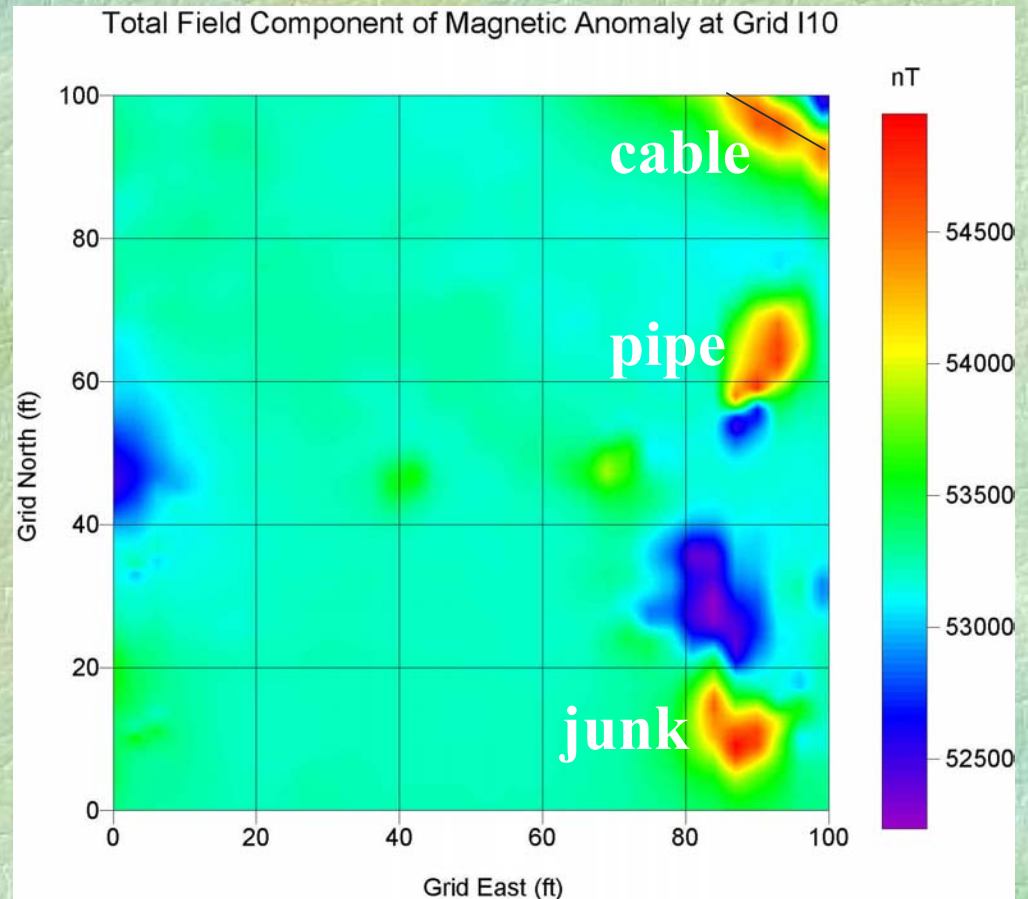


Depth to the top of the (water?) well is 1 ft. Kyle and Sihao are checking the well.

D. One vertical pipe

At Ironhorse Equestrian Center, southeast of the intersection Nickerson and Hendricks Streets

Grid 10, an anomaly at (92, 62)



A 4-inch pipe uncovered at (92, 62)

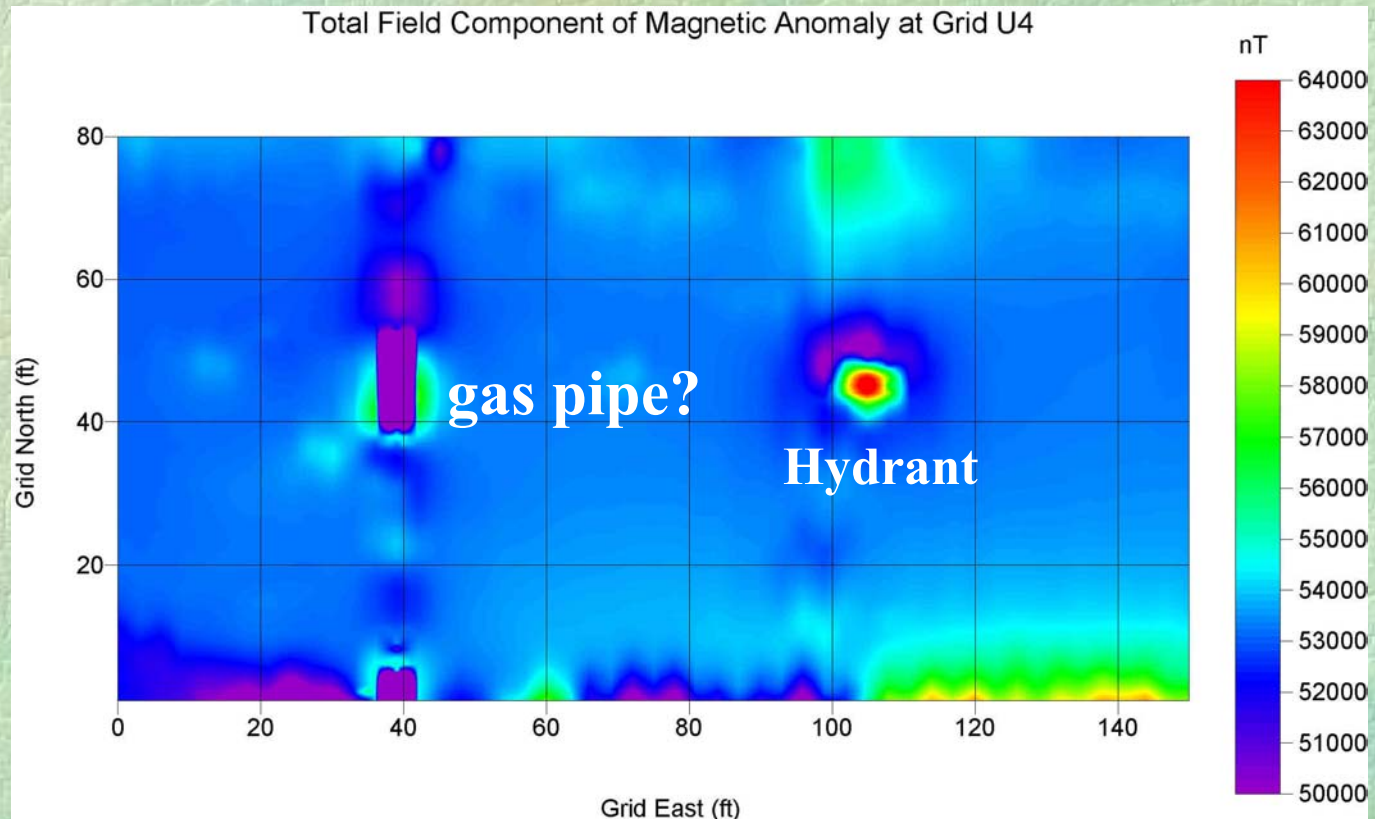


Depth to the top of the 5-ft long pipe is 2 ft.

E. One probable gas pipe

At Union Salt, Walnut Street, between Avenue C and Bennett (two blocks south of City Hall)

Grid 4, an anomaly at (36, 40)



A 4-inch pipe uncovered at (36, 40)



Depth to the top of the pipe is 1 ft. The pipe was under 6 inches of concrete and may be a gas pipe (Mike in the photo).

Conclusions on magnetic method

- ☛ The high-resolution magnetic method: **efficient** and **effective** in locating buried abandoned brine wells in the City of Hutchinson, Kansas.
- ☛ **Signature recognition**
 1. Monopole shape
 2. Over 12,000 nT: a well with an 8-inch steel case
Over 2,000 nT: a 2.5 or 4-inch pipe
 3. The half-width: 5 to 7 ft

Acknowledgements

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- ☛ *Reg Jones* and *his crew* of the City of Hutchinson
- ☛ *Ross Johnson* of Geometrics, Inc.