

Managing Metallic and Electrical Interference in EM Surveys

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Introduction

- Recognizing Interference
 - Effects on Type of Equipment
- Interference Strategies
- Distribution of Data and Statistics
- Examples

Interference and EM Sensors

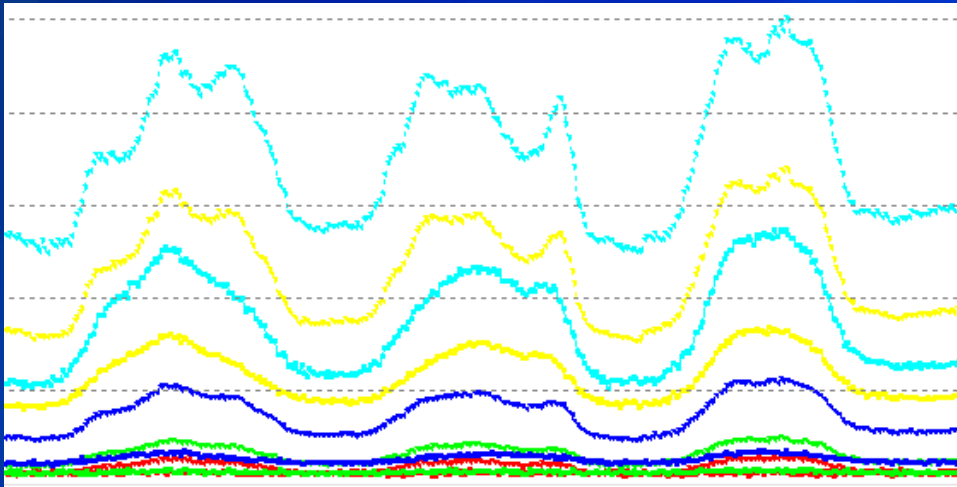
- Metallic or Electrical Interference
 - Occurs when sensor too close to interfering source
 - Vertical or horizontal
- Geophex GEM2
 - Interference increases with decreasing depth
 - Longer frequency – more penetration
 - Greater horizontal spread
- Geonics EM31 Affected More Than EM38
 - EM31 operates at lower frequency

Highly Positive Spikes

- Metallic or Electrical Interference
 - Only concerned with very high positive spikes
- Geophex GEM2
 - Proprietary conductivity algorithms
 - Low negative values automatically converted to zero or very small positive
- Geonics EM31 or EM38
 - Can get negative conductivity values
 - Manually convert to zero

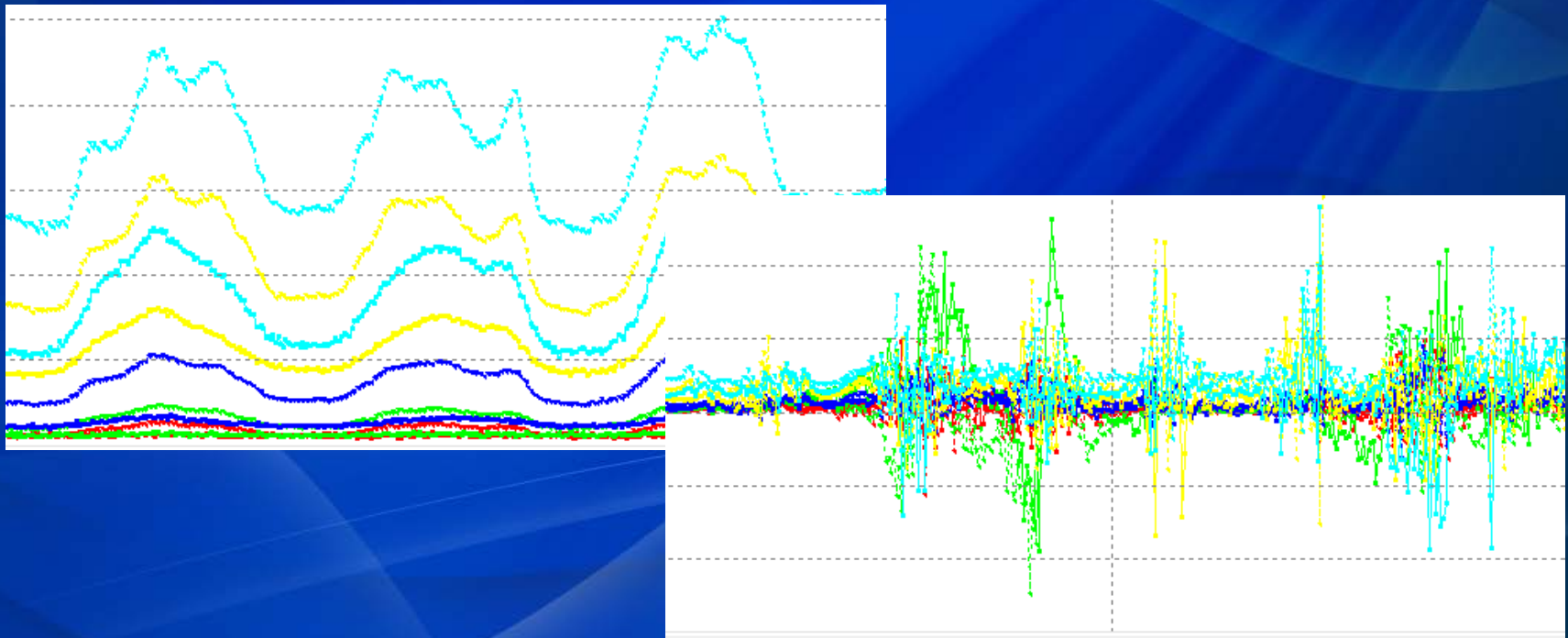
GEM2 Data

- Geophex Algorithm Creates Conversion Graph
 - Very useful for identifying quality of data



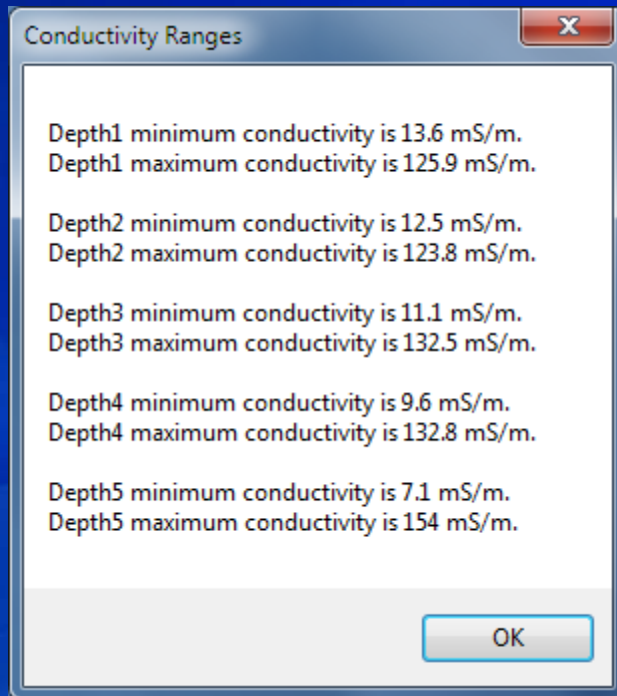
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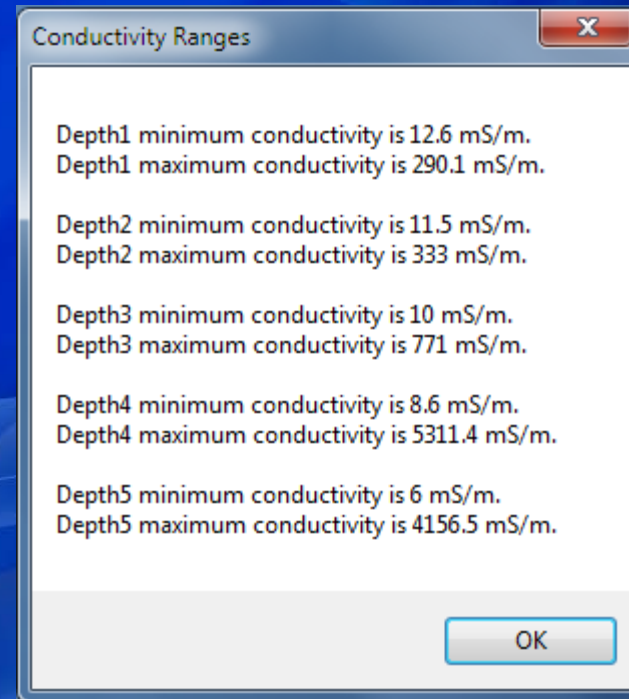
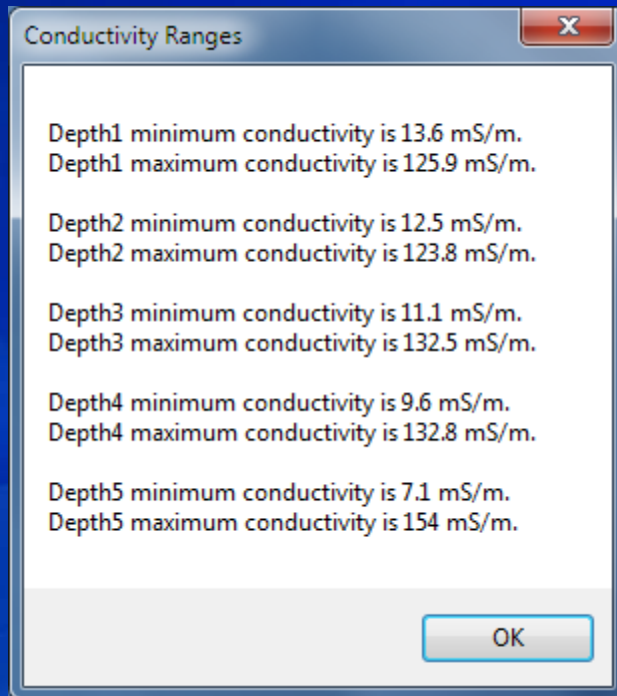
Max Min Data

- Maximum Conductivities
 - Should be of same magnitude



Max Min Data

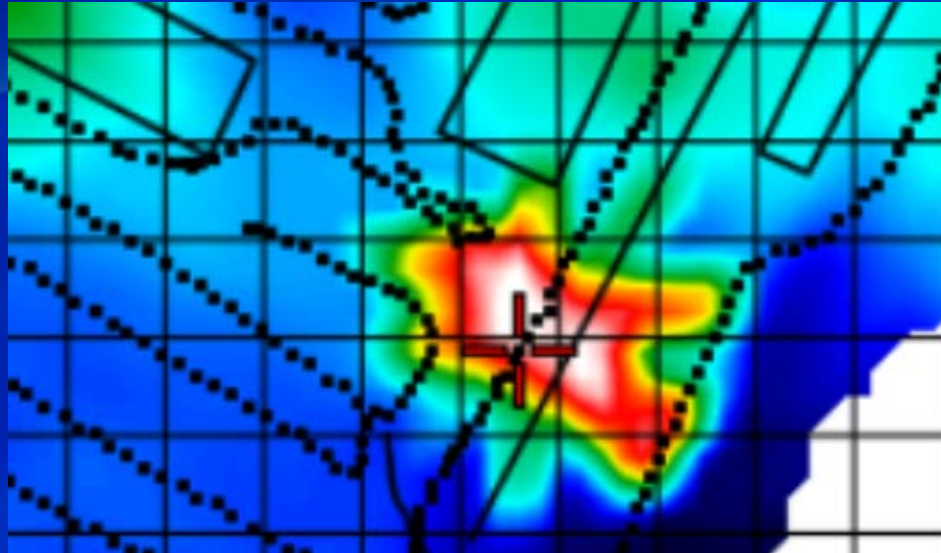
- Maximum Conductivities
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Interference Strategies

- Two Types of Interference
 - Point source – tanks, metal buildings, fences
 - Widespread – cathodic, electrical, metallic
- Management of Interference
 - Do Nothing
 - Least useful approach
- Define and Deal with Outliers
 - Remove Outliers

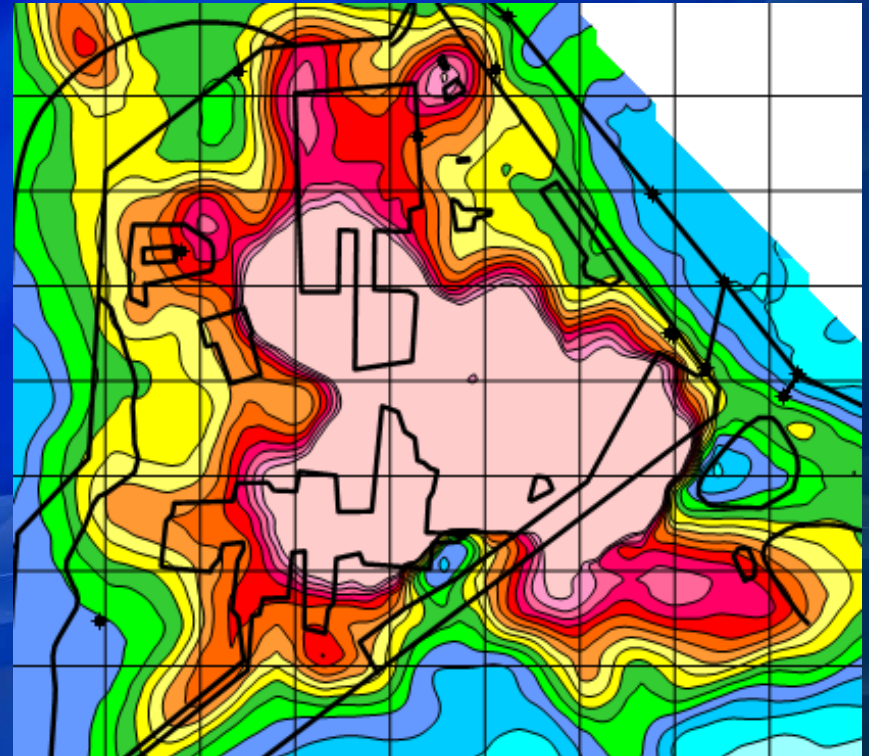
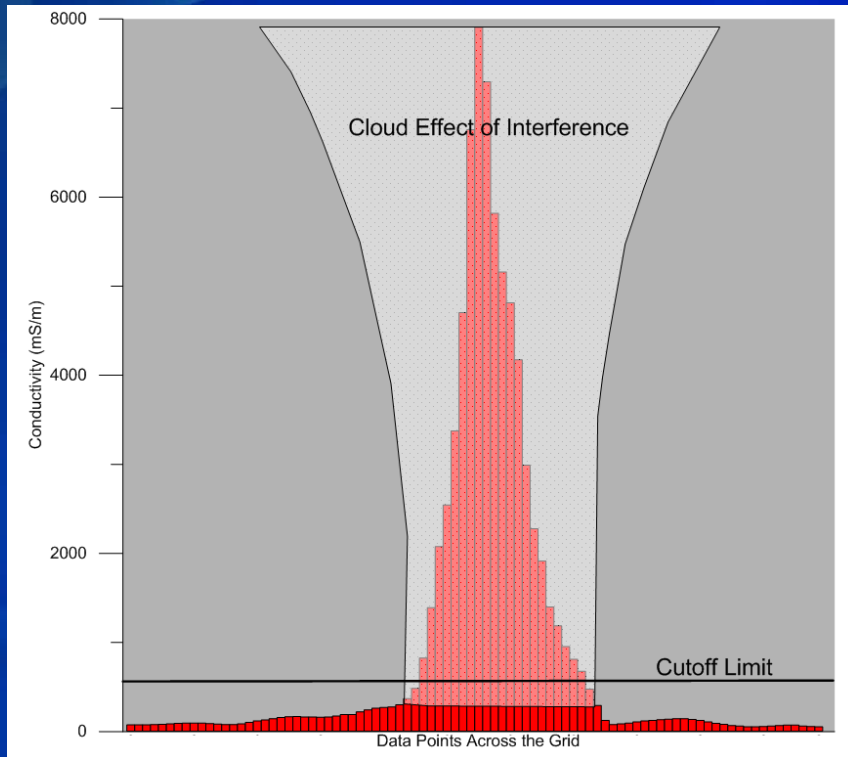
Point Source Removal of Data



A334 | 212510

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
329	212505	12/20/2013	454661.21	5887936.5	450	1	10	2	0	-4170	80.7	-4350	809	-3740	2840	1540	7610	3680
330	212506	12/20/2013	454661.85	5887937	450	1	10	2	0	-4160	412	-4310	1190	-3240	3120	1940	7720	4160
331	212507	12/20/2013	454661.85	5887937.7	450	1	10	2	0	-4580	-227	-5070	524	-4360	2490	564	7500	2930
332	212508	12/20/2013	454662.33	5887938.1	450	1	10	2	0	-3780	445	-3780	1220	-2600	3260	3220	7660	5250
333	212509	12/20/2013	454662.7	5887938.8	450	1	10	2	0	-1910	864	-1900	1490	-949	3200	4500	7540	6720
334	212510	12/20/2013	454662.94	5887939.3	450	1	10	2	0	17500	6570	18700	5700	21100	5760	27600	8470	29200
335	212511	12/20/2013	454663.41	5887940.0	450	1	10	2	0	42500	10300	44500	8270	47500	7200	54200	8700	55200
336	212512	12/20/2013	454663.81	5887940.9	450.1	1	10	2	0	86900	9840	88900	8620	92800	8530	100000	10700	101000
337	212513	12/20/2013	454664.57	5887941.3	450.1	1	10	2	0	25100	7870	26600	7170	30100	7490	37700	10400	39900
338	212514	12/20/2013	454664.47	5887942.2	450.1	1	10	2	0	333	1980	579	2440	2130	3940	8030	7910	10600
339	212515	12/20/2013	454665.09	5887942.8	450.2	1	10	2	0	-2280	1170	-2200	1840	-902	3800	5100	8130	7570
340	212516	12/20/2013	454665.11	5887943.7	450.2	1	10	2	0	-3830	169	-3900	1040	-2810	3040	2730	7630	5170
341	212517	12/20/2013	454665.73	5887944.2	450.2	1	10	2	0	-3620	291	-3780	1100	-2640	3080	2790	7780	5340
342	212518	12/20/2013	454665.99	5887945.1	450.2	1	10	2	0	-3610	257	-3890	1020	-2770	3020	2750	7620	5210

Widespread Interference



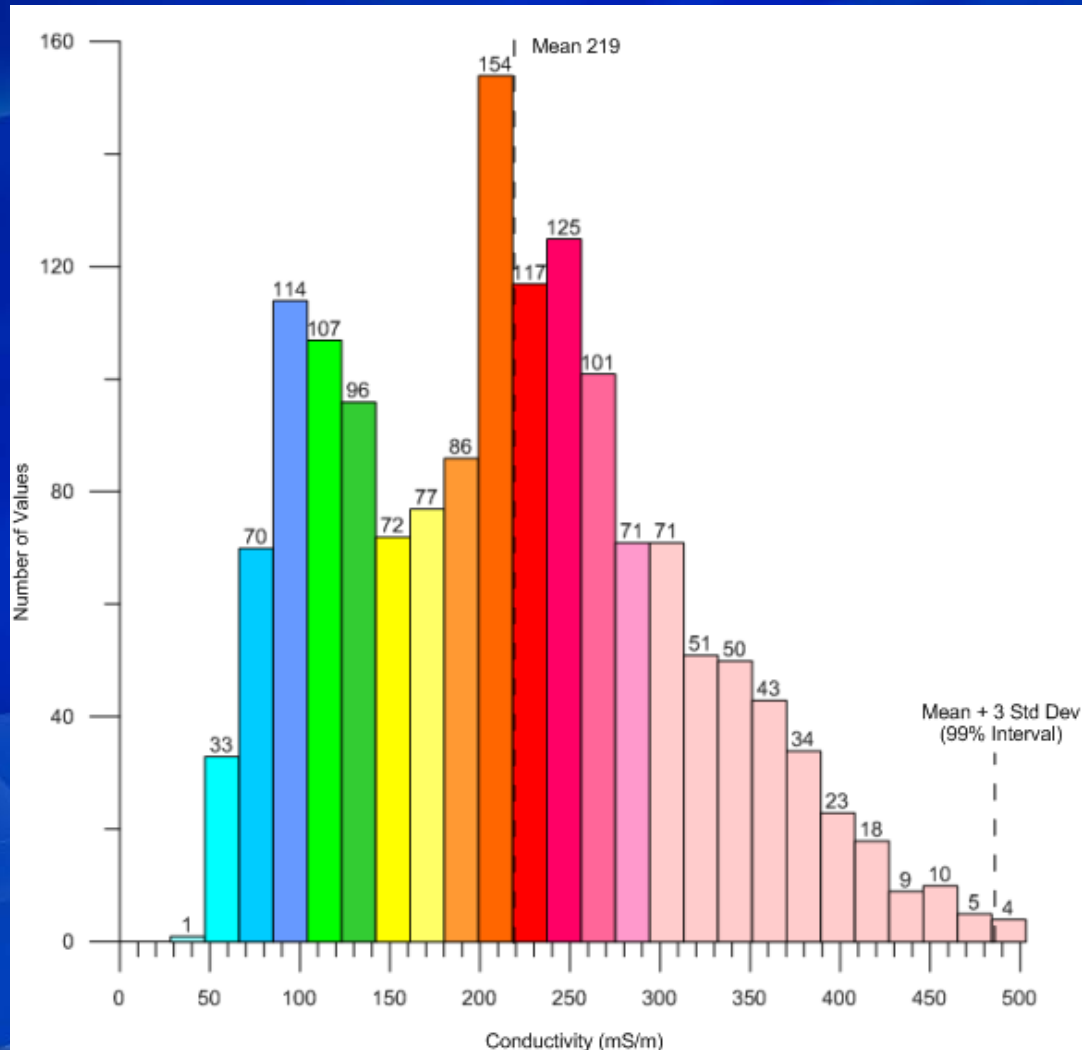
Widespread Interference

- Large Facilities or Power Lines
 - Metallic – above or below ground
 - Electrical – cathodic, cables, power lines
- Filter to Transform Maximum Values
 - To more reasonable values
 - Define rule based cutoff limit
- Fourier Transformation on Raw Data
 - Traditional method
- Statistical Filter on Final Data

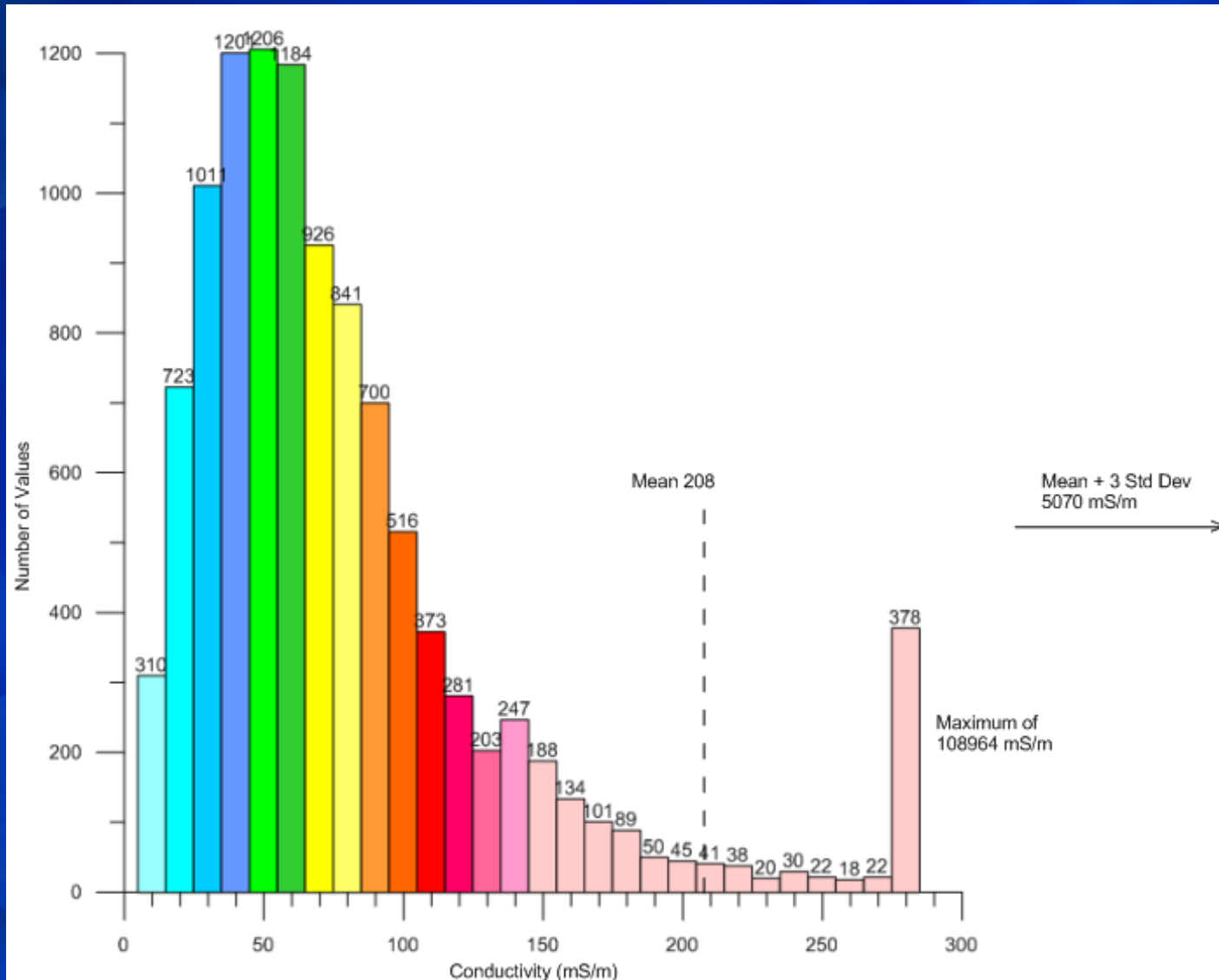
Fourier Transformation (FT)

- Reducing Signal Spikes
 - Traditional method for signal processing of raw data
 - Many published routines, programs
 - Complex mathematics – integral of sine & cosine
- Geophex GEM2
 - Proprietary conductivity algorithms
 - Difficult to implement FT
 - Effects of FT on conductivity unknown
 - trial and error
- Statistical Filter on Final Data Preferred

Distribution of Natural Salinity



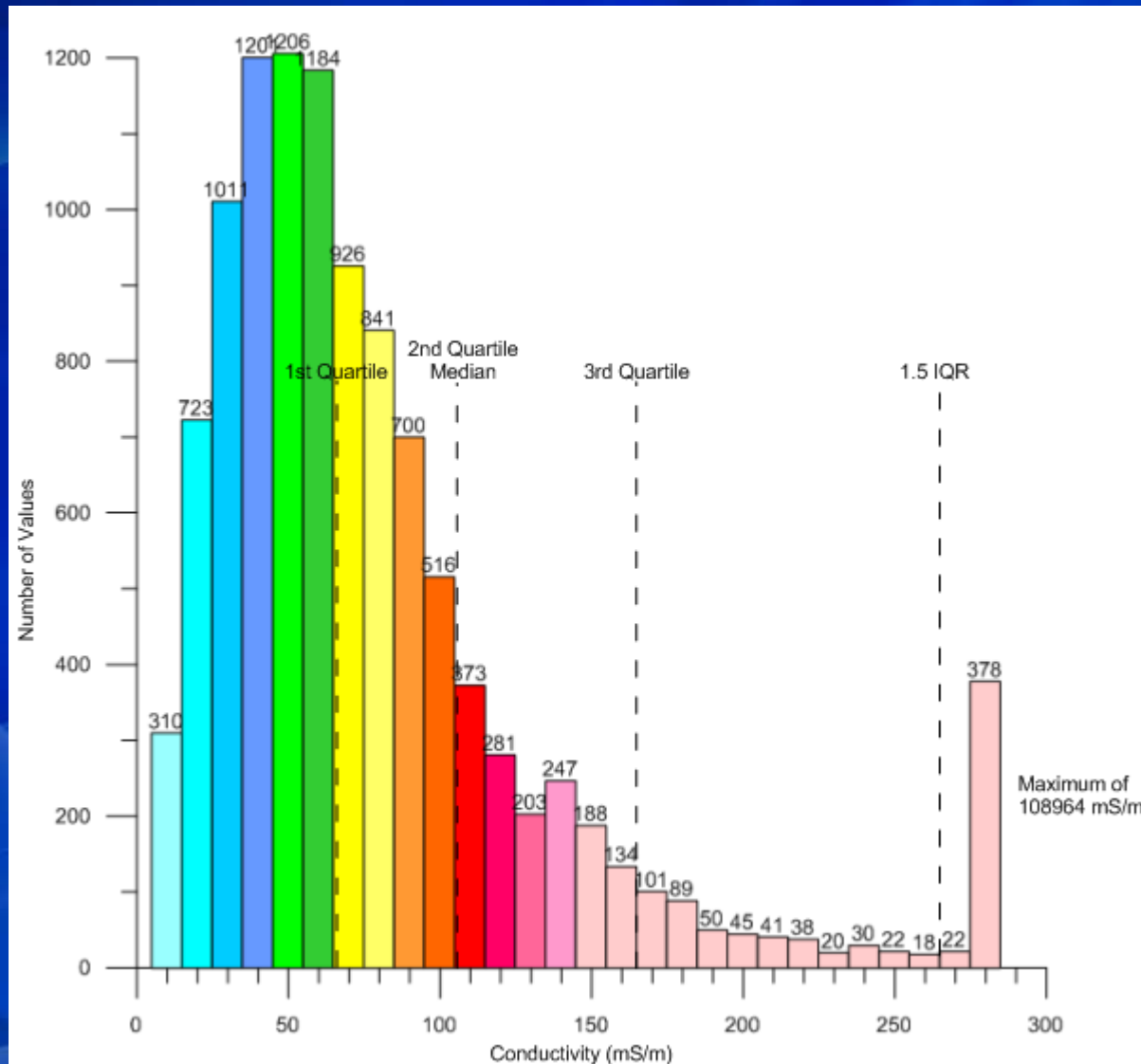
Data Distribution with Interferences



Statistics for Interference

- EM Data is Positively Skewed
 - Arithmetic mean is meaningless
- Median Values Based on Frequency
 - Median – 2nd Quartile
- Tukey's Rule for Outliers - 1977
 - InterQuartile Range (IQR)
 - 3rd Quartile – 1st Quartile
 - 3rd Quartile + 1.5 * IQR

Data Distribution with Interferences



Statistical Approach to Conductivity

- Tukey's Rule - 3^{rd} Quartile + $1.5 * \text{IQR}$
- Variable Factor for Multiplier
 - Varies from 0 (very restrictive) to 6 (non-restrictive)
- Multiplier Decreases with Depth
 - Filter becomes more aggressive with lower frequencies
- Iterative procedure
 - Start with weak filter, move on to stronger filter
 - Creative process until conductivity “looks” right

Output from Modified Tukey's Filter

- Expectations of Filter
 - Transform very high positive anomalies to more reasonable values
 - 3^{rd} Quartile + $0.75 * \text{IQR}$ (IQR Max)

Depth	1st Qrt	Median	3rd Qrt	IQR Max	Maximum	IQR Multiplier
0.5 m	73	106	149	244	4506	1.25
1 m	78	115	163	269	4671	1.25
3 m	71	111	161	251	15250	1.0
5 m	66	106	165	239	108964	0.75
7 m	55	94	161	241	34257	0.75

Exceptions to the Rule

- Situations Where Filter Does Not Work
 - Coarse textured subsoils with very low conductivity
 - Quartile values are zeroes
 - Must use arithmetic mean or delete data

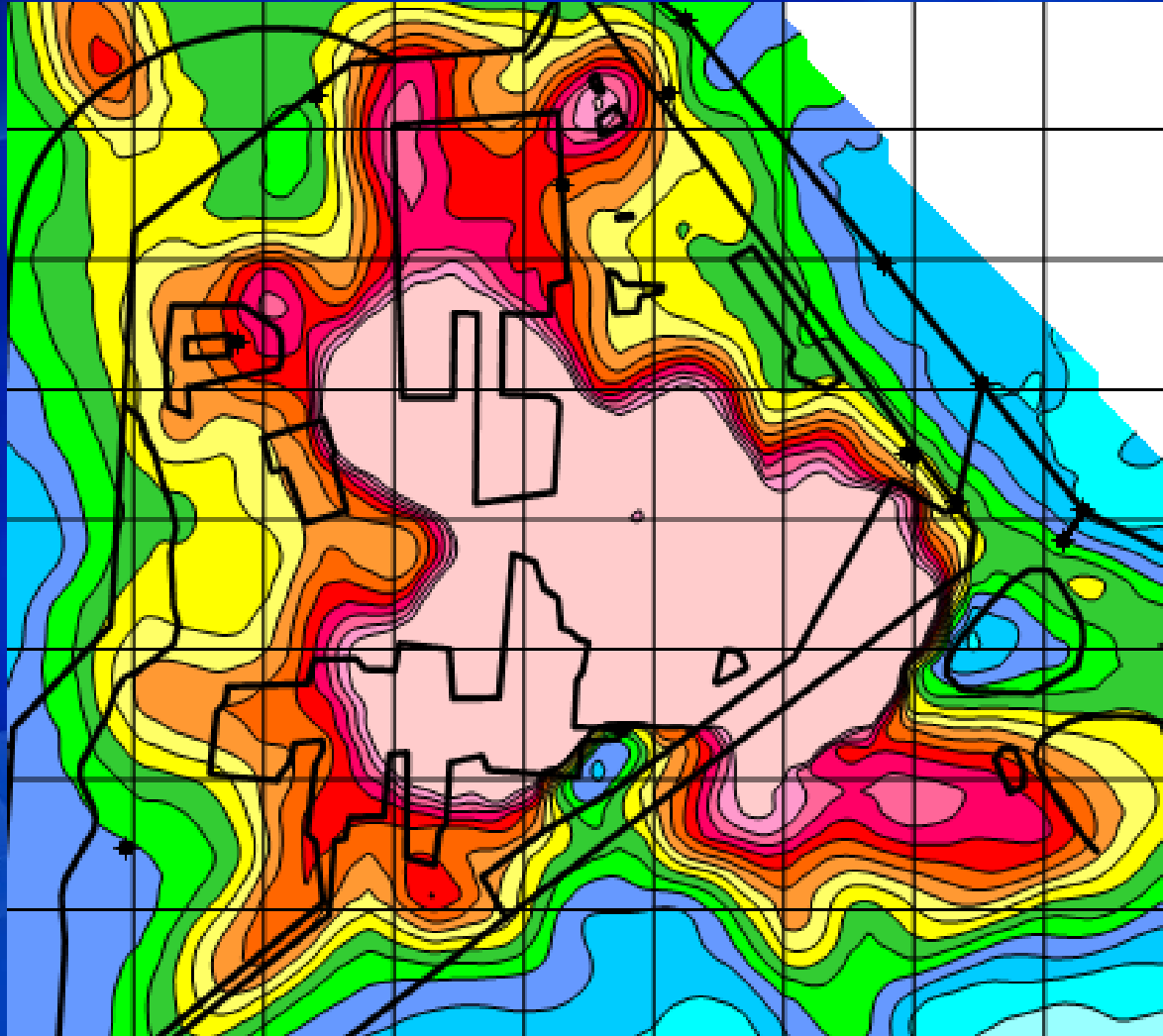
Depth	Num Samp	1st Quart	Median	3rd Quart	IQR Max	% Excluded	MaxValue
D1 - 0.5 m	0	12	20	27	57	0.00%	52
D2 - 1 m	0	10	19	26	58	0.00%	52
D3 - 3 m	58	0	9	16	44	1.22%	51
D4 - 5 m	4761	0	0	0	0	100.00%	51
D5 - 7 m	4761	0	0	0	0	100.00%	56

Depth	Mean	Mean+2SD	Mean+2.5SD	Mean+3SD	Maximum
D1 - 0.5 m	20.31813	41.83051	47.20861	52.5867	52
D2 - 1 m	19.2526	41.24182	46.73912	52.23642	52
D3 - 3 m	10.40372	31.40641	36.65708	41.90775	51
D4 - 5 m	1.867274	13.83278	16.82415	19.81553	51
D5 - 7 m	0.5815877	9.849784	12.16683	14.48388	56

Examples

- Metallic Interference at a Gas Plant
- Electrical and Cathodic Interference

Metallic Interferences



Deletion of Data

- Data Removed by Proximity to Structures
 - Very time consuming iterative process



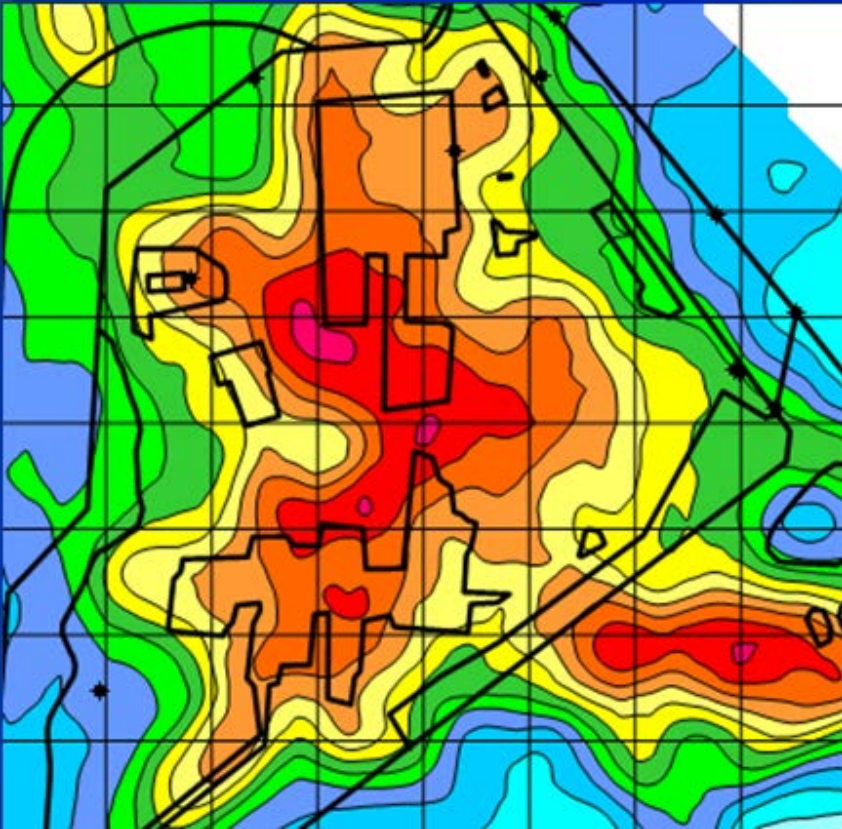
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Transform Data

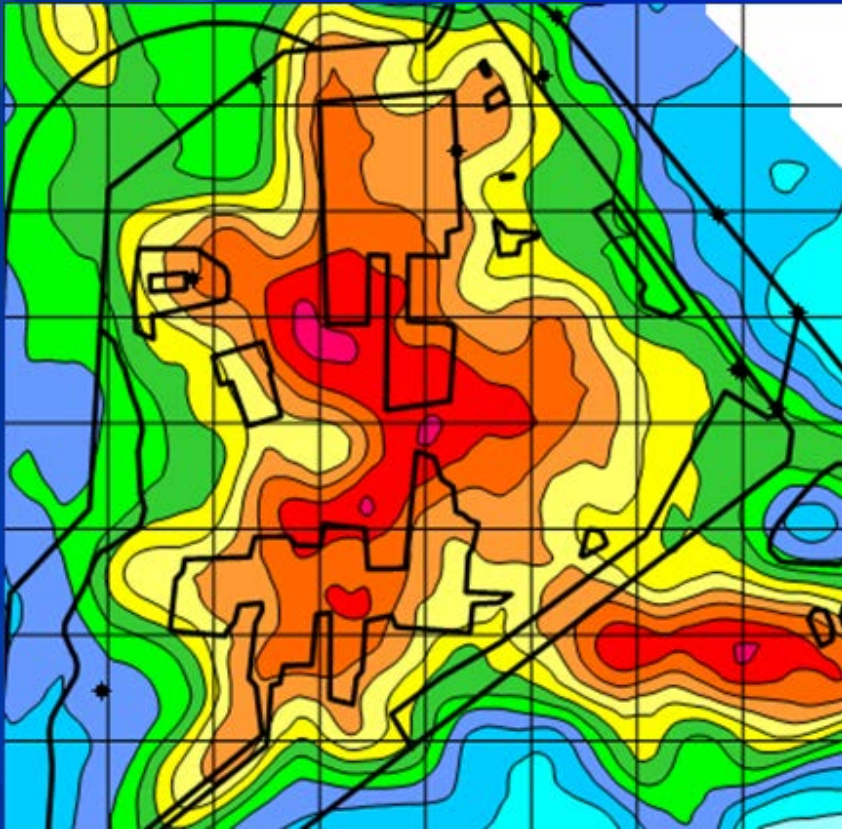
Data Deleted



6 Hours

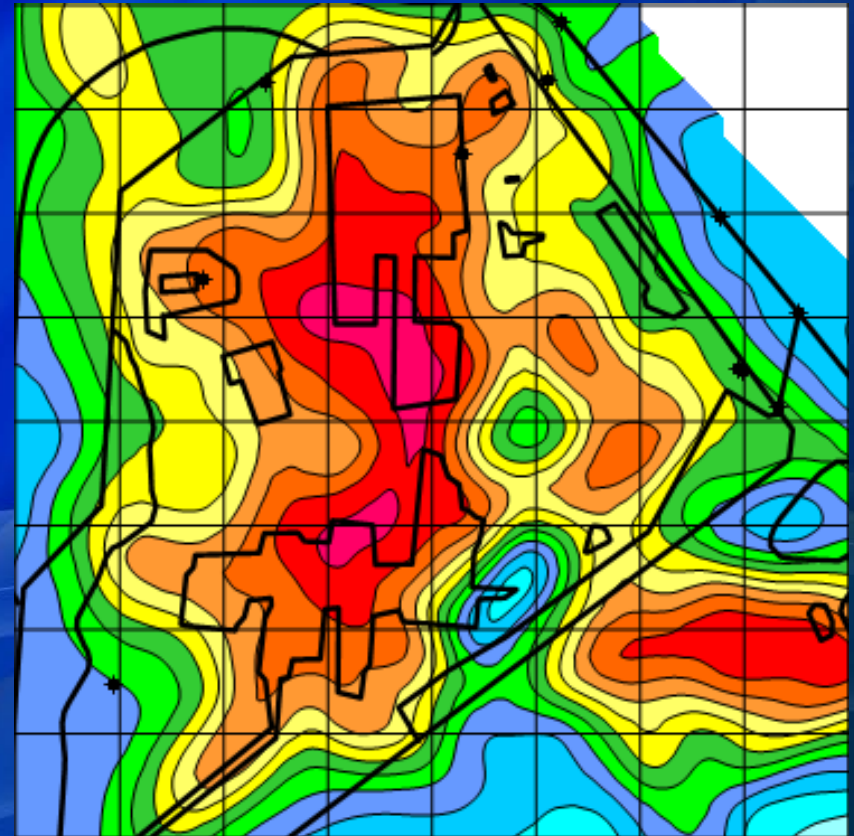
Transform Data

Data Deleted



6 Hours

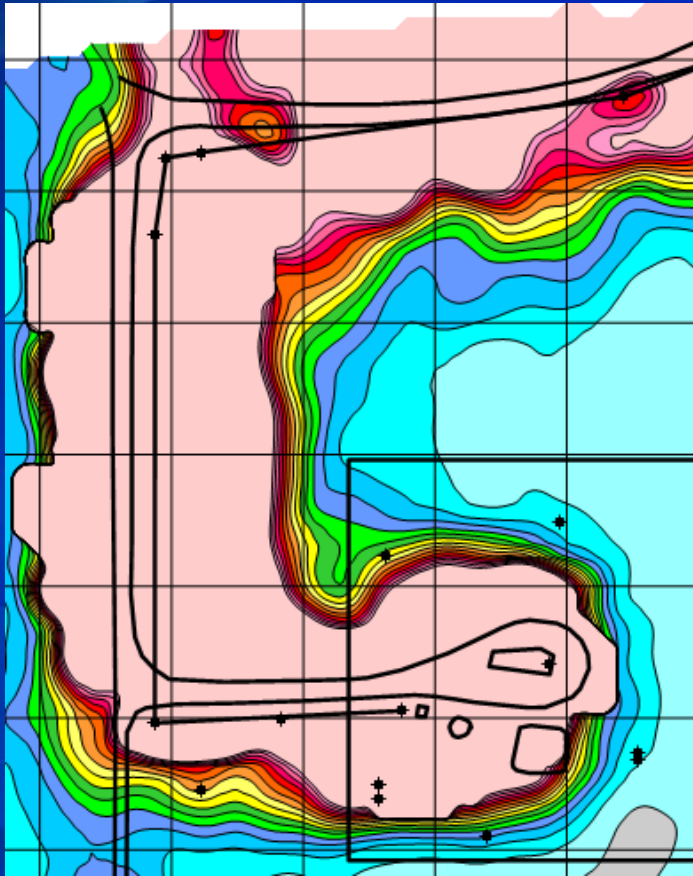
Data Transformed



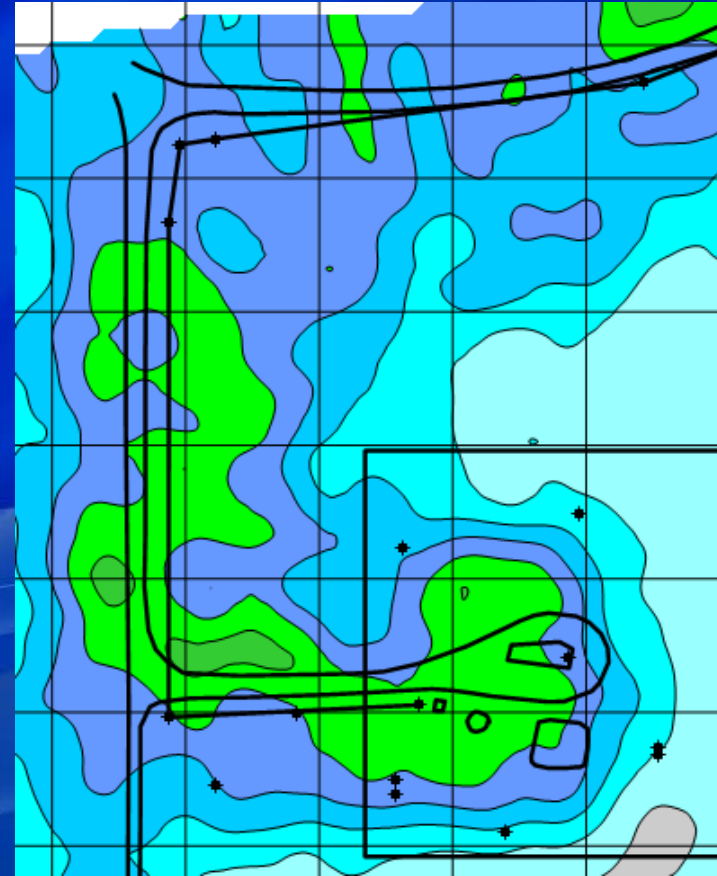
6 Seconds

Electrical and Cathodic Interference

Raw Data



Multiplier of 0.25



Conclusions

- 3 Approaches to Interference
- Do nothing
- Delete data
- Transform data
 - Quartile Statistical Basis
 - Variable multiplier factor