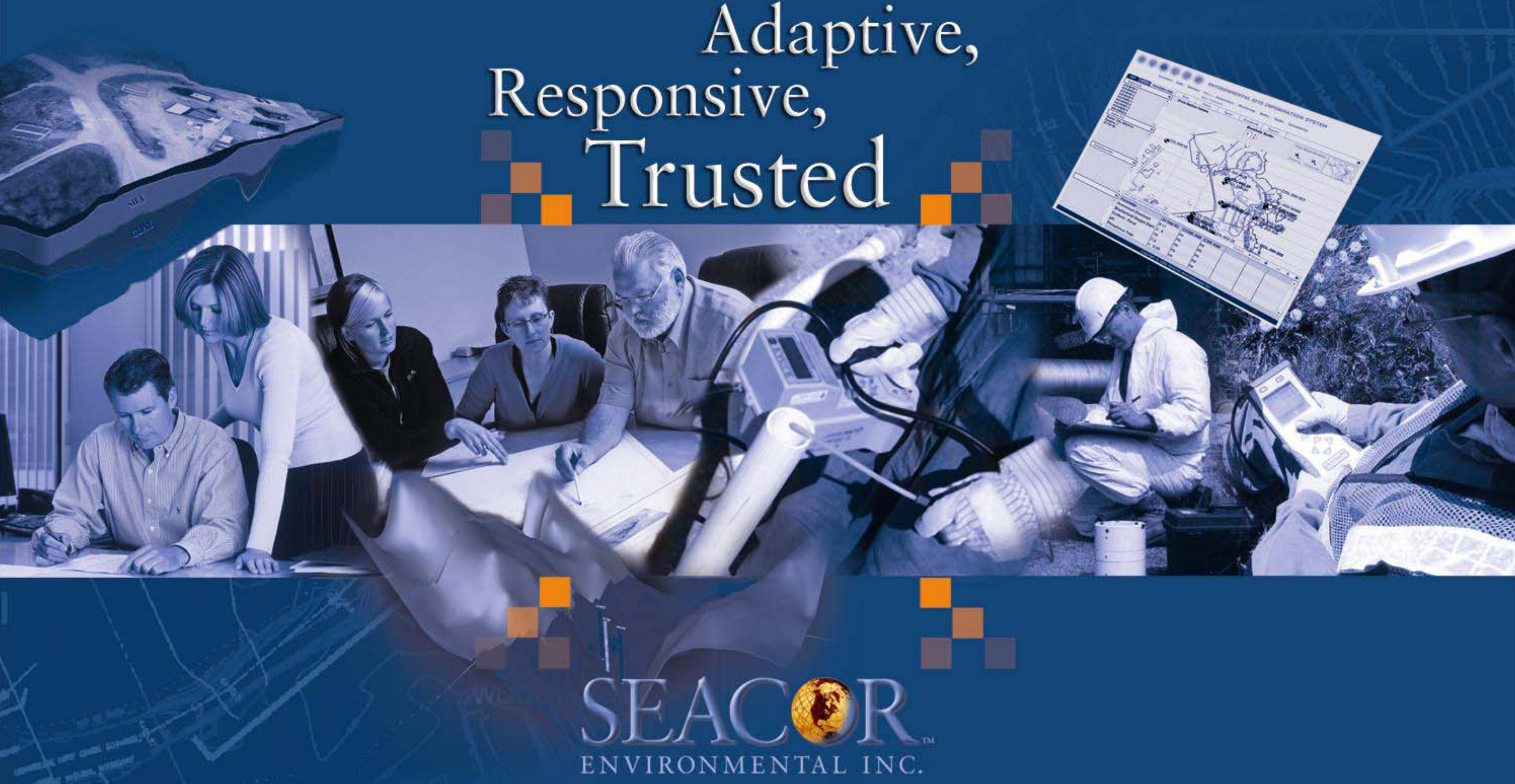
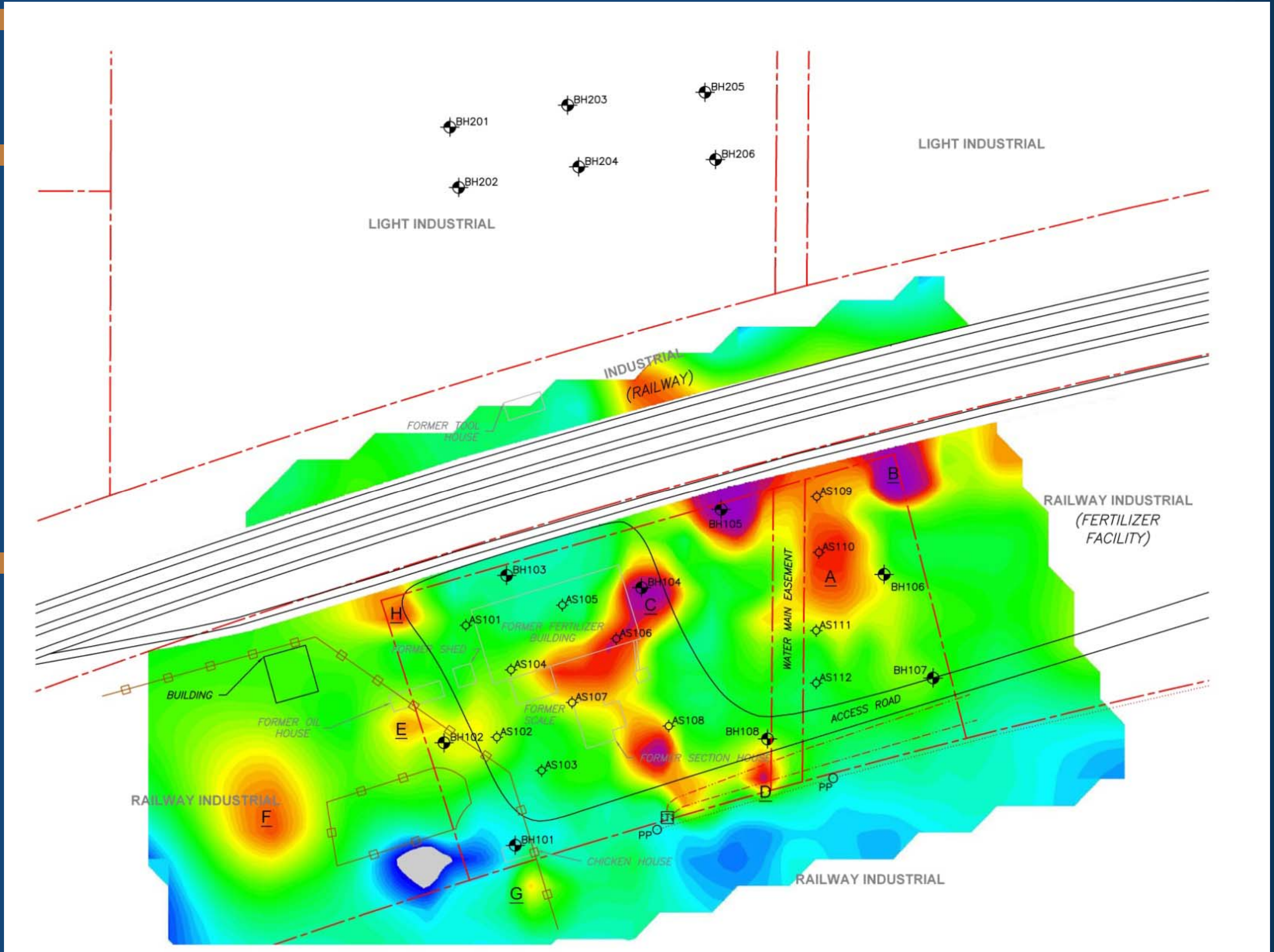
VISUALIZING & ANALYSIS TECHNIQUES FOR DIFFERENTIATING EC ANOMALIES AT A FERTILIZER DISTRIBUTION FACILITY



Site Background



EM31 SURVEY RESULTS

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Site Background: cont'd

- Previous consultant conducted prelim statistical analysis that showed 3 areas that are sig. different for 6 soil and/or groundwater salinity parameters using Student's T distribution with 90% confidence level
  - Statistically different groups were: BH201 to BH206; BH101 to BH104; and BH106 to BH108.
  - The on-site locations also showed some differences when compared to off-site locations.

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What Were the Issues to Address

- AENV 2001 Salt Guidelines have 4 categories for “grading” soil salinity (good, fair, poor, unsuitable)
  - How do you visualize 4 levels of “impact” when conventional is either meet or does not meet criteria
- Within the 3 groups of significantly different soil salinity, is the soil salinity:
  - 1. Background vs Anthropogenic sources
  - 2. Any off-site source (background or anthropogenic)
  - 3. Are the EC sources related

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Analysis Process

- First needed to visualize the horiz and vert extent of the EC anomalies.
- Once extents of anomalies were determined, could then segregate the data for more detailed analysis (chemical comparisions, supplemental sampling etc.)
- It was decided to apply Golden Software, Inc. Surfer 8 to generate EC contour maps:
  - Software available in-house & routinely applied to generate groundwater contours
  - Salinity highly mobile through groundwater phase

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How was Surfer Applied: Depth Segregation

- Surfer did not allow contouring of the existing EC data in true 3-D as it only allows 1 vertical (or Z-axis) data point (typically groundwater elevation)
  - The site data has 2 Z-axis data points: Soil sample depth and EC value
- 11 Field Sample depth intervals (m bgs):
  - 0-0.15, 0-0.6, 0.15-0.6, 0.6-1.2, 1.1-1.5, 1.2-1.8, 1.8-2.4, 2.6-3.1, 3.4-3.8, 4.1-4.6, 4.9-5.3
  - Number of data points not consistent for each sample depth otherwise a contour could have been done for each depth
- 2-D contours required segregating data by a set depth so the 11 different soil sample intervals were categorized into 5 set depths

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How was Surfer Applied: Depth Segregation cont'd

TABLE 1: Set Sample Depths	
Sample Interval (m bgs)	**Set Sample Depth**
0.0 – 0.15	0.15
0.15 - 0.6	0.3
0.6 - 1.2	0.9
1.2 - 1.8	1.5
> 1.8	3.0

- NOTE: The 3.0m set depth included all soil samples below 1.8 m below ground surface (m bgs) because a review of the EC values in this category indicated a generally consistent EC within the same borehole

How was Surfer Applied: Selecting contouring method

- Surfer generates contours by dividing the site into blocks and interpolating the value for the center of each block or each corner of the block based on surrounding data.
- The interpolated value for each corner or center of the block is influenced by the available data therefore the more data points the more “reliable” the contours generated.

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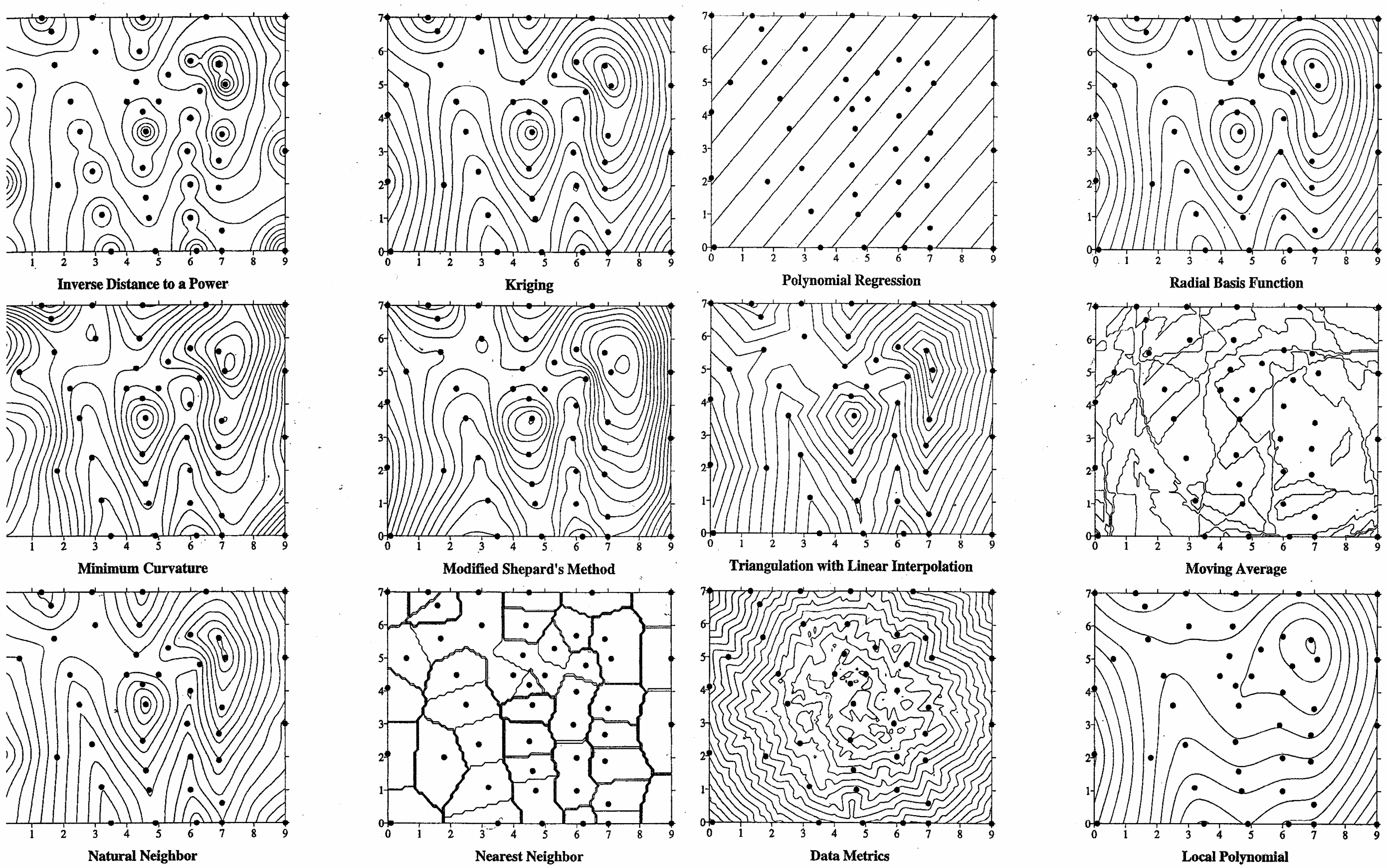
How was Surfer Applied: Selecting contouring method cont'd

- Surfer offers 12 different mathematical algorithms to interpolate the value for each block or corner of each block. The number of data points also influences which method would be best to apply.
- For the EC contour analysis, we needed method that would also show "bulls-eyes" but not too many "bulls-eyes" - role of bulls-eyes explained later.

How was Surfer Applied: Selecting contouring method cont'd



This is a comparison of the different gridding methods. For these examples, the same file, DEMOGRID.DAT, was used. All the defaults for the various methods were accepted. This data set contains 47 data points, irregularly spaced over the extent of the map. The data point locations are indicated with dots on the maps.

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"Surfer 8 – User's Guide", Golden Software, Inc., 2002, pp.153-154.

How was Surfer Applied: Role of "Bulls-Eyes"

- Typically, when Surfer is applied to generate groundwater contours, unusual data points that produce "bulls-eyes" are removed to generate what would be the likely "natural" smooth contour
- However, the difference between anthropogenic and natural EC sources should appear as "bulls-eyes" so all data points were included
- Phase IIs identified less than 0.2 m of topsoil. However, AENV 2001 Salt Guidelines list separate criteria for topsoil and subsoil samples. Only subsoil criteria were applied to avoid excluding valuable data points for generating contours.

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Picture is Worth a Thousand Words: 0.15m Depth

ELECTRICAL CONDUCTIVITY CONTOUR AT 0.15m DEPTH

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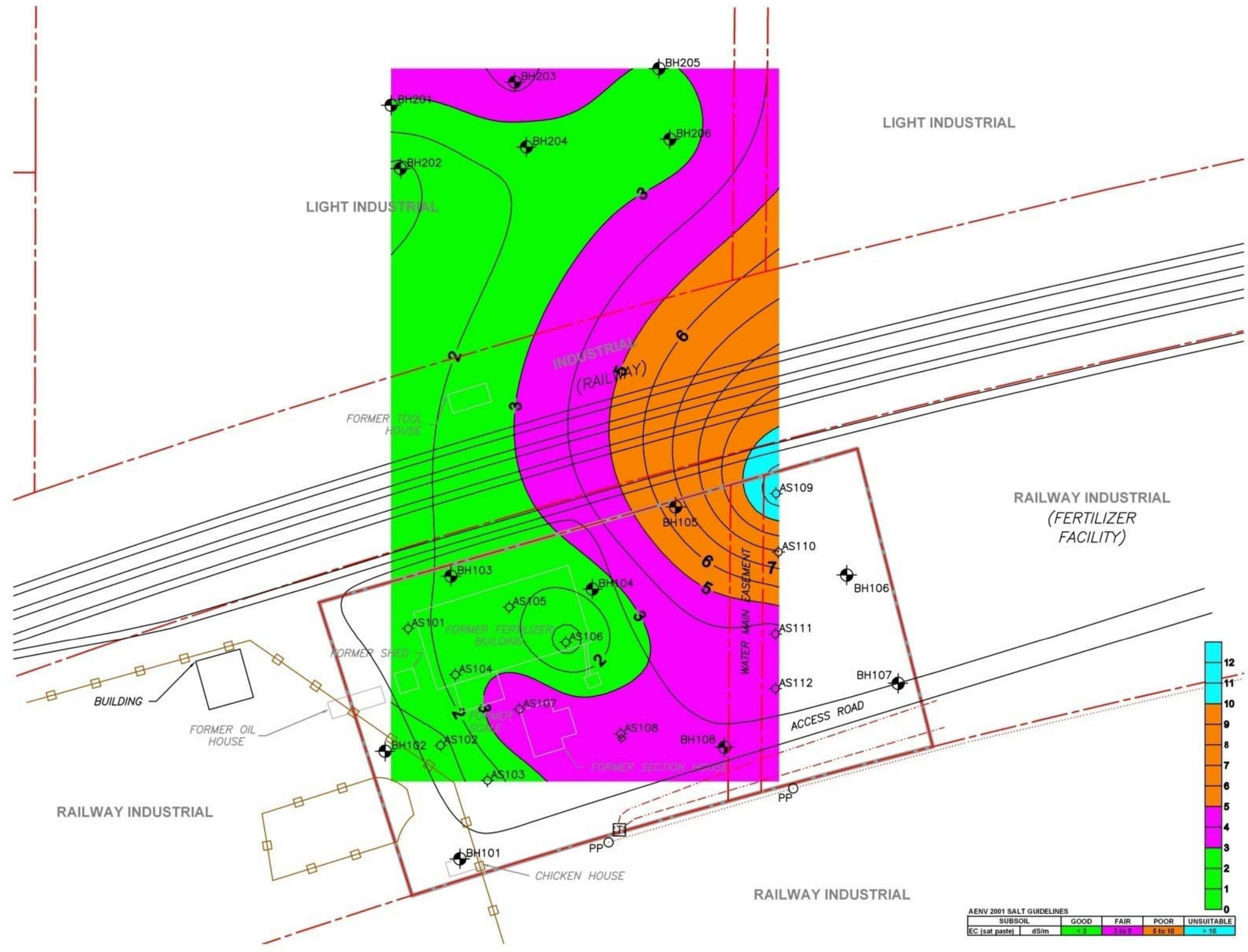
Picture is Worth a Thousand Words: 0.3m Depth



ELECTRICAL CONDUCTIVITY CONTOUR AT 0.3m DEPTH

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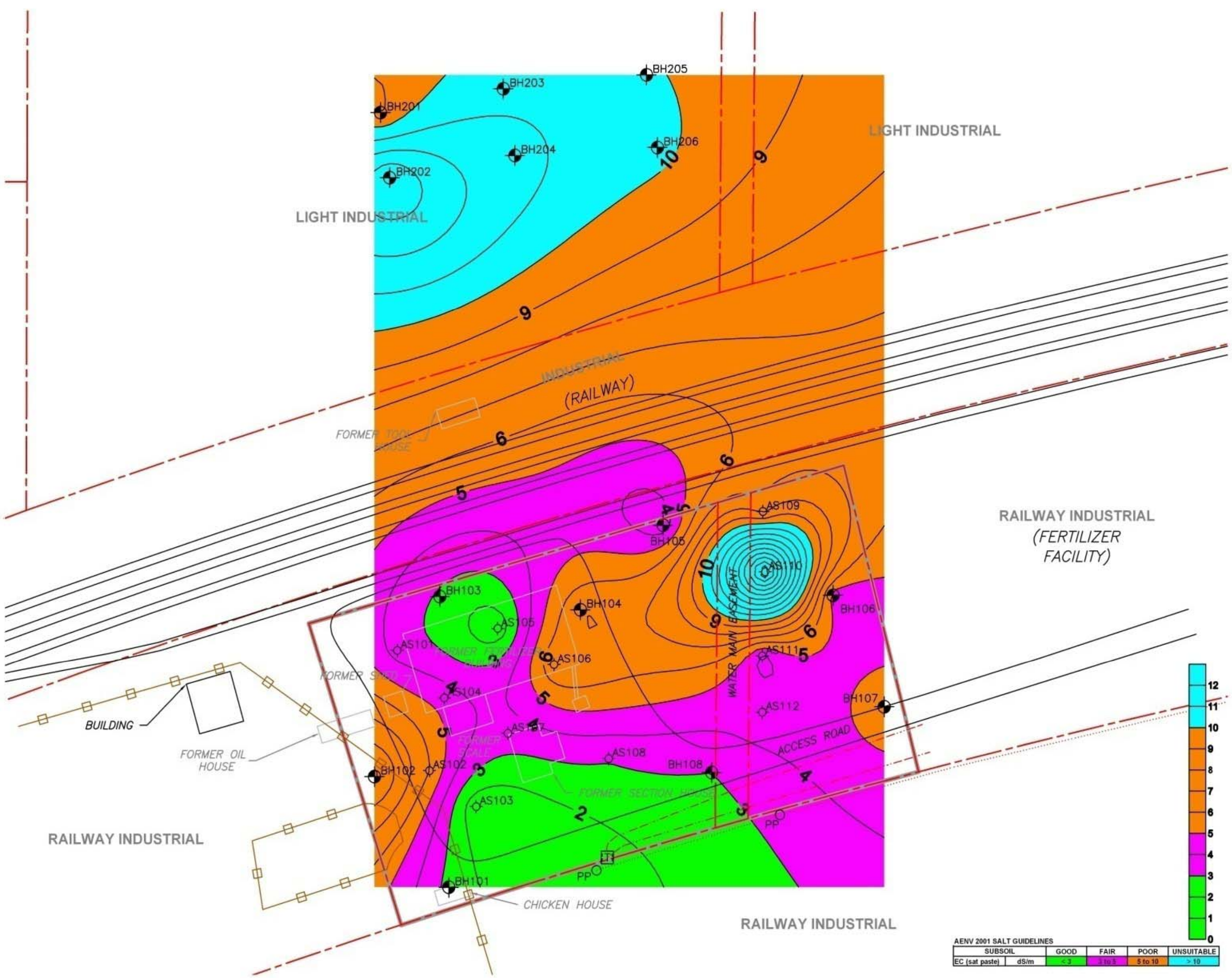
Picture is Worth a Thousand Words: 1.5m Depth



ELECTRICAL CONDUCTIVITY CONTOUR AT 1.5m DEPTH

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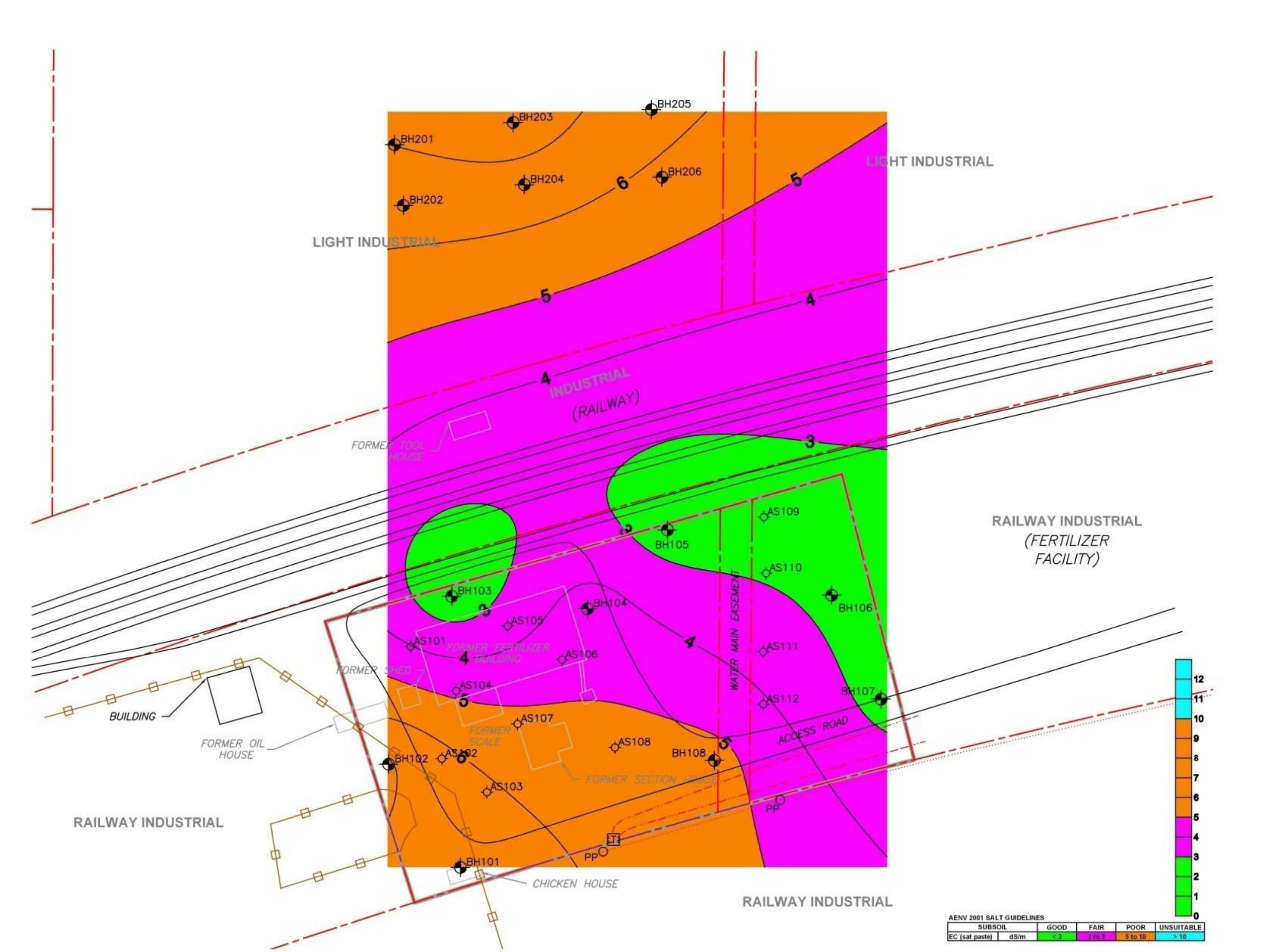
Picture is Worth a Thousand Words: 3.0m Depth



ELECTRICAL CONDUCTIVITY CONTOUR AT 3.0m DEPTH

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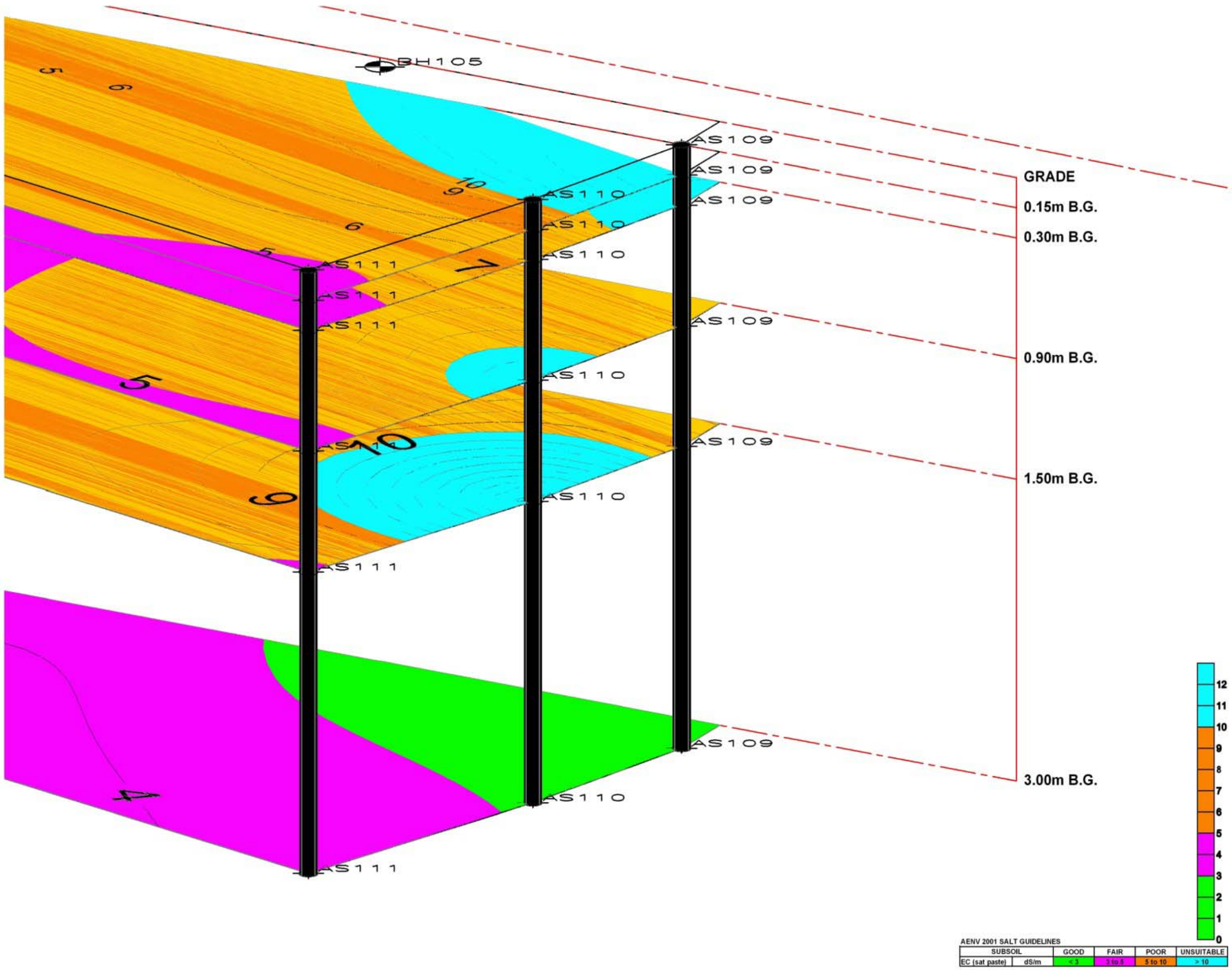
Picture is Worth a Thousand Words: 3-D Profile



3-D MODEL OF AS110 EC ANOMALY

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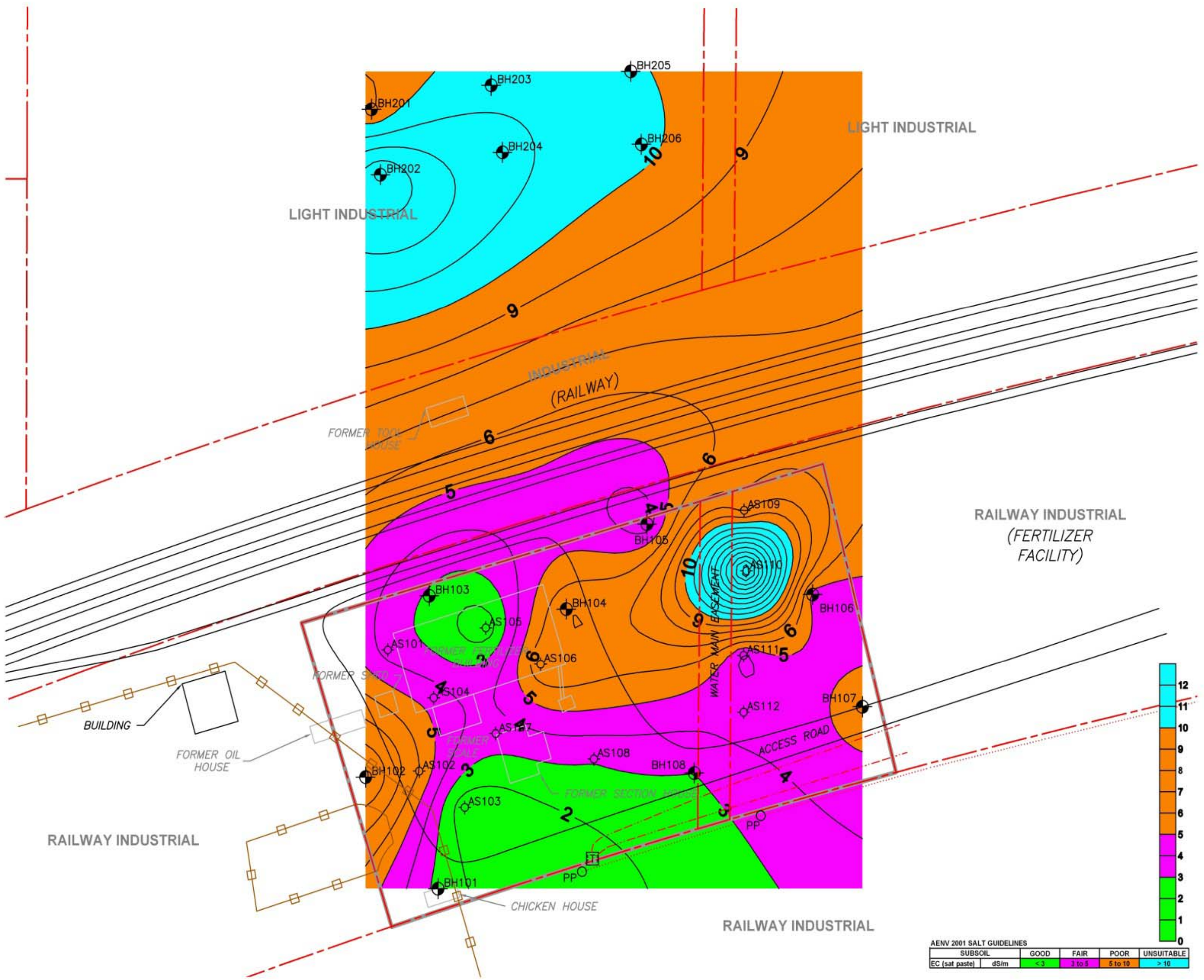
Soil Chemistry Analysis & Results



ELECTRICAL CONDUCTIVITY CONTOUR AT 1.5m DEPTH

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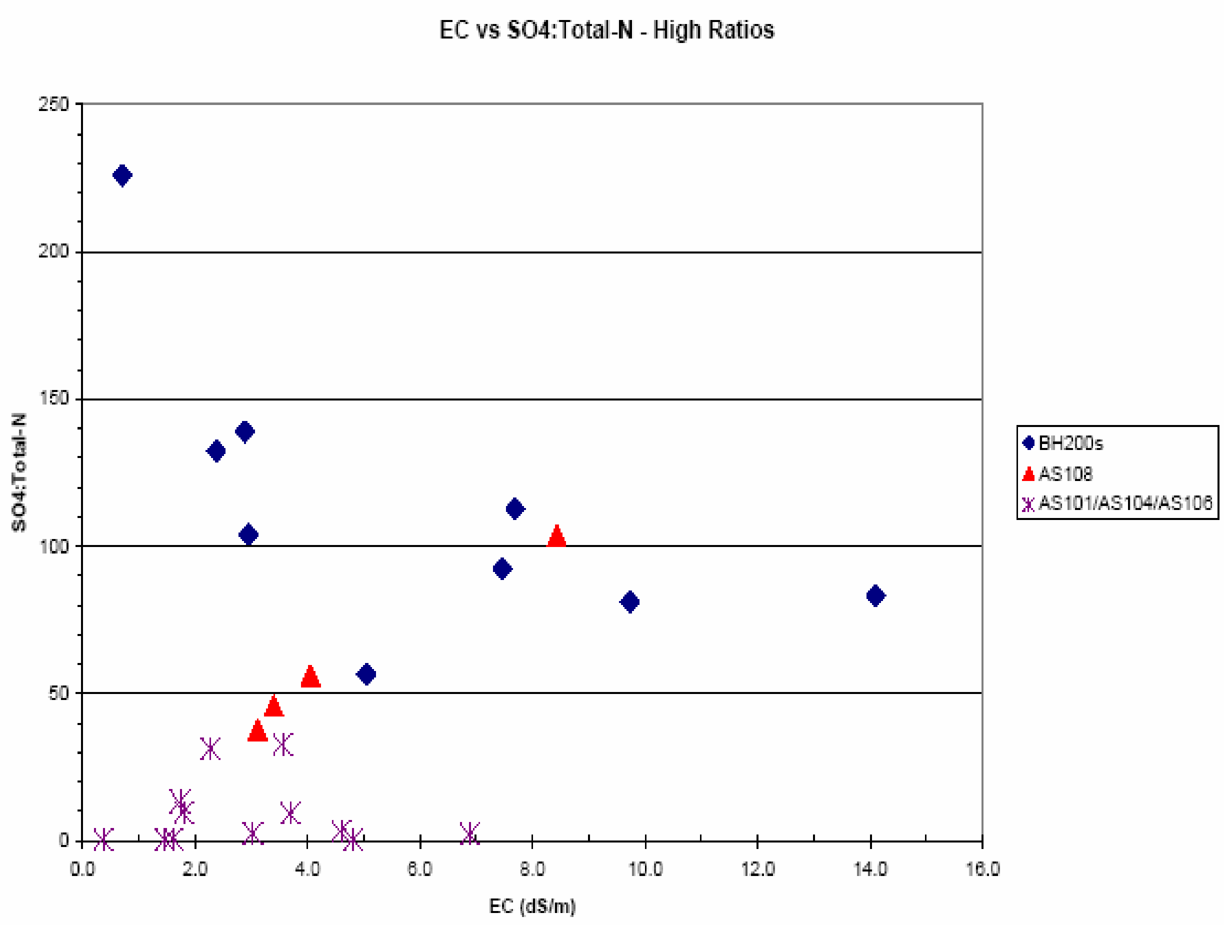
Soil Chemistry Analysis & Results:



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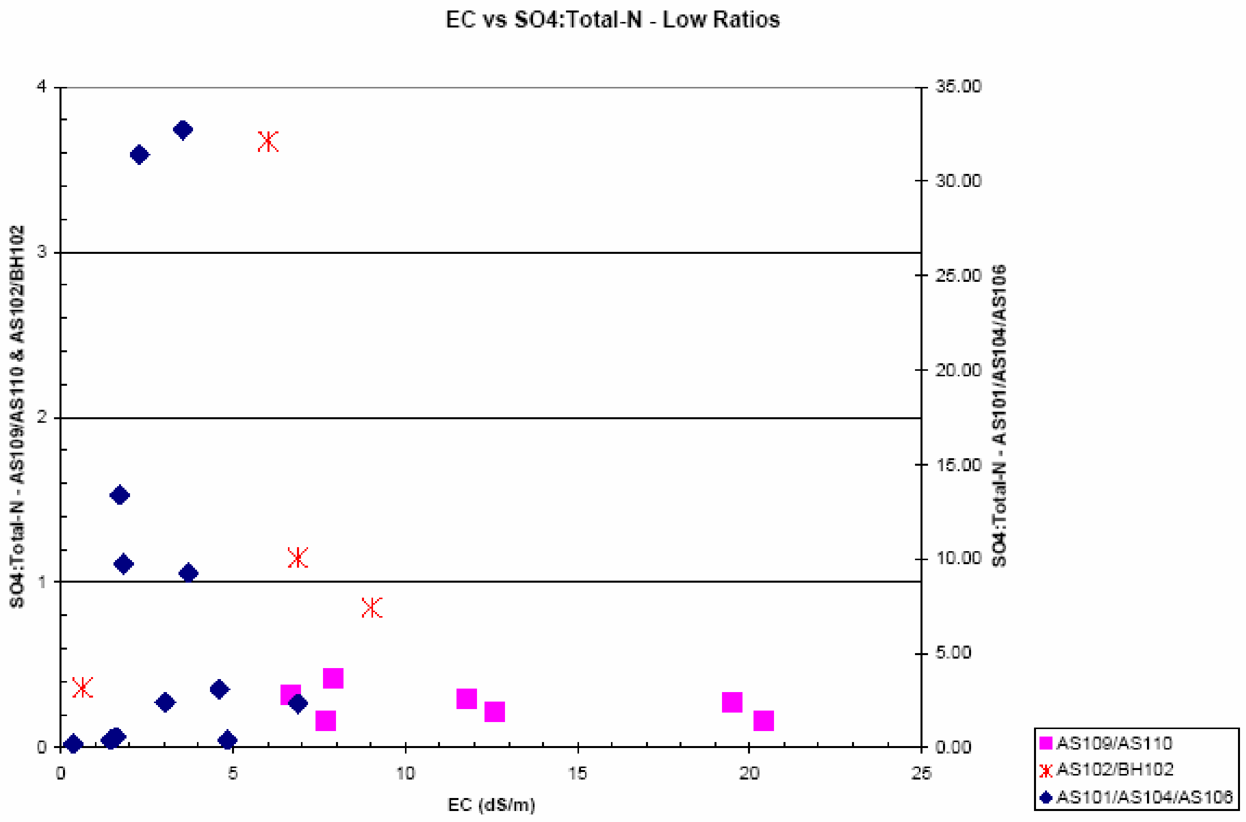
Soil Chemistry Analysis & Results: Chemical Comparisons cont'd



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Follow-Up Assessment

- Supplemental Phase II conducted in August 2007 to collect detailed soil salinity data in the 4 EC hotspots, collect additional background samples, and collect some delineation data for the 4 EC hotspots
- Analysis of August 2007 analytical results are currently being conducted and the full results will be included in the paper

Follow-Up Assessment: cont'd

EC Anomaly	EC (uS/cm)	Ammonia Nitrogen (mg/L)	Nitrate (ug/g)	Soluble Chloride (mg/L)	Soluble Sulphate (mg/L)
AS108	2.40-4.67	<0.5-13	1.2-52	51-205	1010-2970
AS102/BH102	5.01-9.84	<0.9-2.9	*180-410*	112-239	1230-2970
AS101AS104/AS106	.97-3.86	0.9-3.5	2.3-72	*11-63*	*324-1970*
AS109/AS110	3.91-19.20	*13-1700*	*300-580*	*93-1750*	*248-4160*
BH201-BH206	0.75-8.84	0.6-4.4	*0.60-17*	12-177	*135-6460*
BACKGROUND	1.88-7.60	0.5-1.7	30-220	18-772	594-4080

EC Anomaly	Total Nitrogen (mg/L)	Soluble Calcium (mg/L)	Soluble Potassium (mg/L)	Soluble Magnesium (mg/L)	Soluble Sodium (mg/L)
AS108	30-108	175-463	16-40	295-450	*78-303*
AS102/BH102	*368-778*	*373-742*	12-51	*351-748*	*269-737*
AS101AS104/AS106	30-167	149-529	15-37	*37-311*	*30-72*
AS109/AS110	*606-2550*	131-847	*40-2240*	44-698	*46-59*
BH201-BH206	*21-44*	41-411	6-31	*18-744*	*44-1350*
BACKGROUND	*69-383*	128-629	16-53	115-602	*70-1010*

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Summary/Conclusions

- Application of Surfer with traditional visual tools such as the EM31/38 provides a detailed and simple method of understanding and visually presenting salinity data to the client for remediation and/or risk management planning.
- Areas between "bulls-eyes" generally where Surfer is relying more on interpolating to calc the values therefore would only consider "bulls-eyes" for any further data analysis/ graphical comparisons. Alternatively, areas between "bulls-eyes" also represent data gaps where additional investigation would improve "reliability" of the EC contours.
- There is also potential to test more detailed analysis, different contouring formulas/options in Surfer, application of different software, or different depth intervals.

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Questions

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