Efficacy of an In-Well Sonde to Determine Magnetic Susceptibility of Aquifer Sediment

Todd H. Wiedemeier

T.H. Wiedemeier & Associates, Inc.

Denver, Colorado

todd@thwa.com

(303) 250-4477

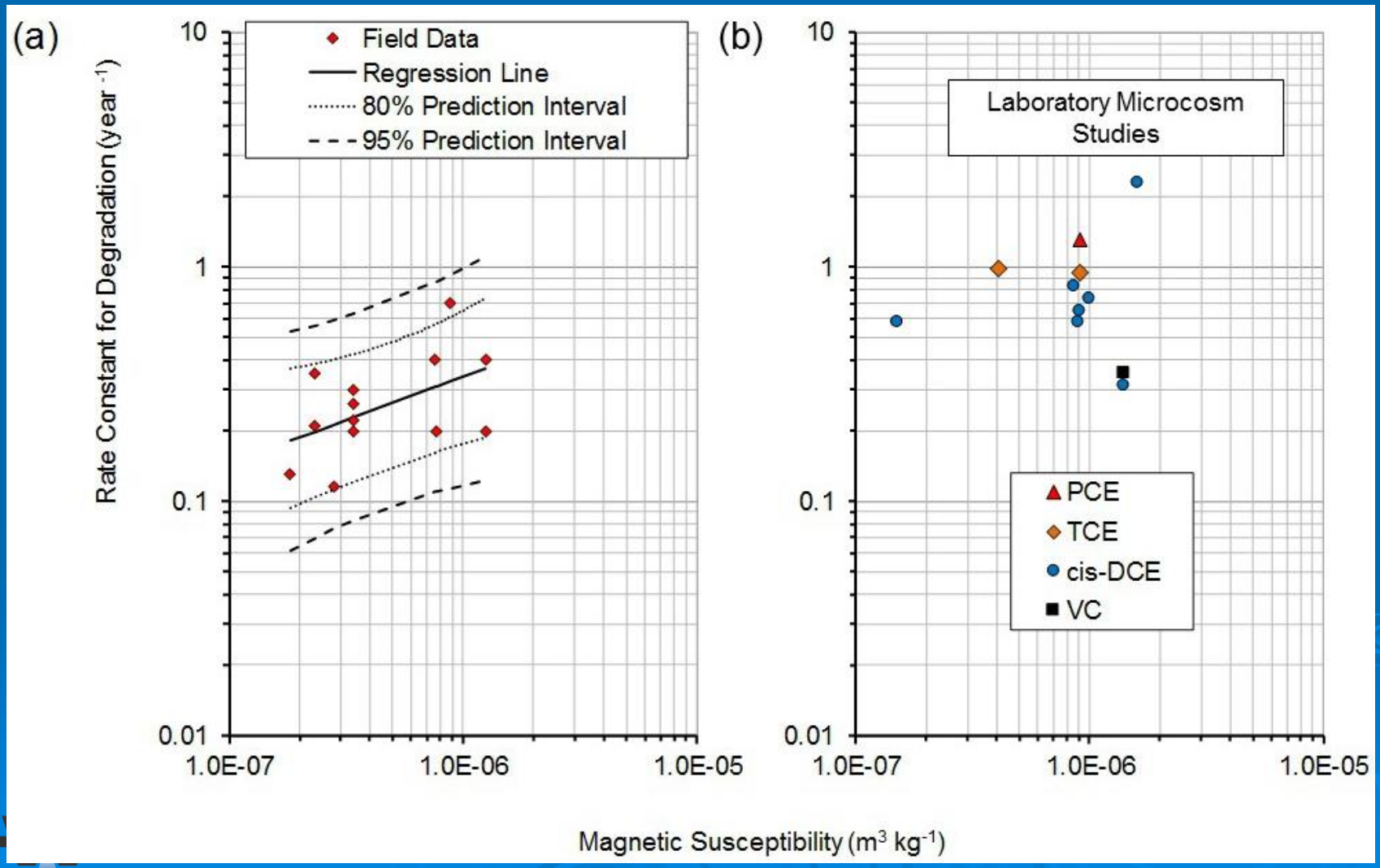
Barbara H. Wilson, John T. Wilson

Scissortail Environmental Solutions, LLC

Mark L. Ferrey

Minnesota Pollution Control Agency

Groundwater Monitoring & Remediation 2017 doi: 10.1111/gwmr.12197



The Material Presented Herein was Developed For ESTCP Project ER-201584

Providing Additional Support for Monitored Natural Attenuation by Including Quantitative Lines of Evidence for Abiotic Degradation and Co-Metabolic Oxidation of Chlorinated Ethylenes

Project Team for ER-201584

Dr. John T. Wilson
Scissortail Environmental Solutions, LLC

Dr. David L. Freedman
Clemson University

Dr. Brady Lee
PNNL

Barbara H. Wilson
Scissortail Environmental Solutions, LLC

Mark Ferrey
Minnesota Pollution Control Agency

Todd Wiedemeier
T.H.Wiedemeier & Associates, Inc

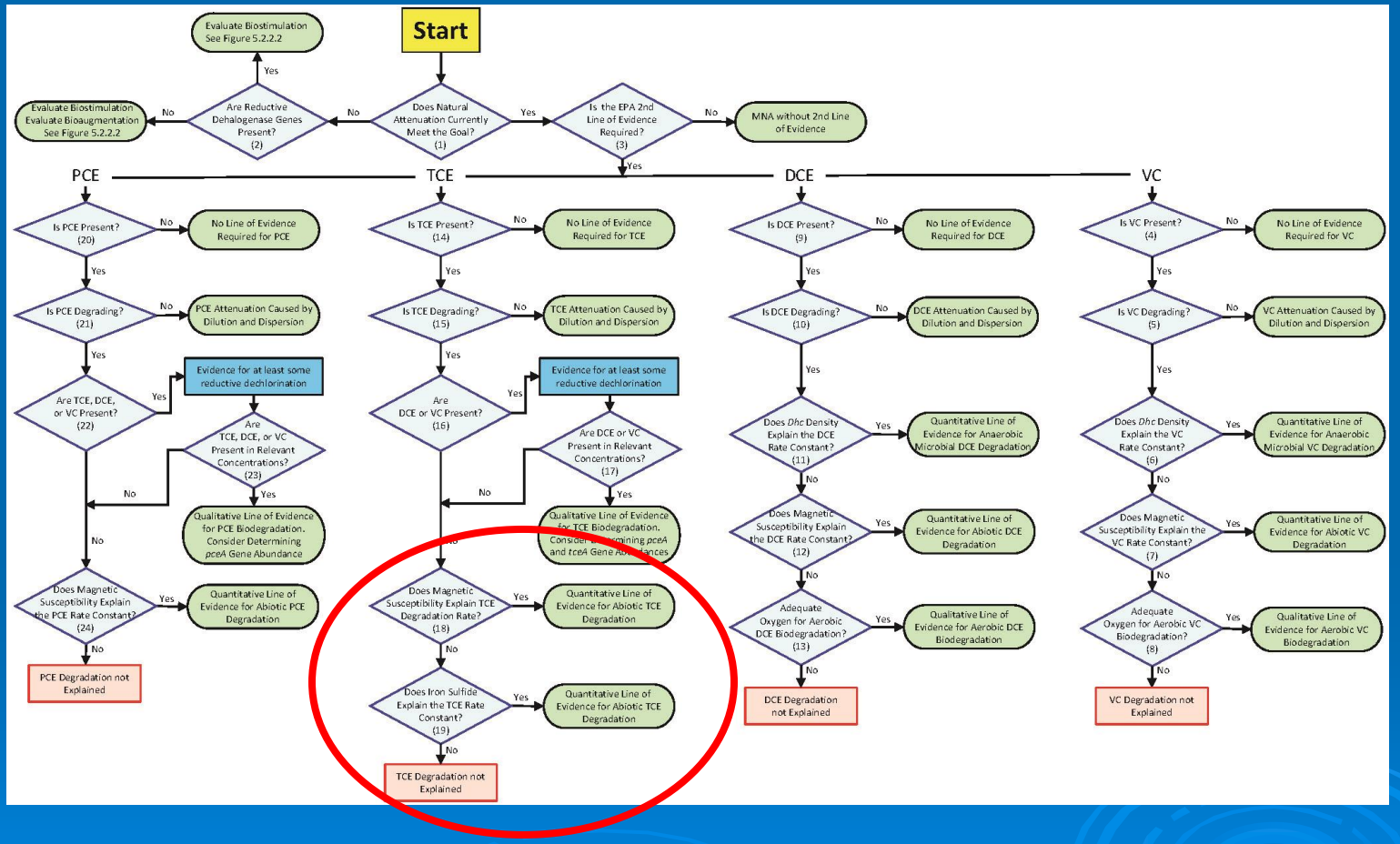
WIEDEMEIER & ASSOCIATES

ER-201584 Background

- ESTCP Project Number ER-201129 developed a quantitative framework to aid in the selection of MNA or bioremediation approaches at sites contaminated with chlorinated ethylenes

ESTCP Project ER-201129

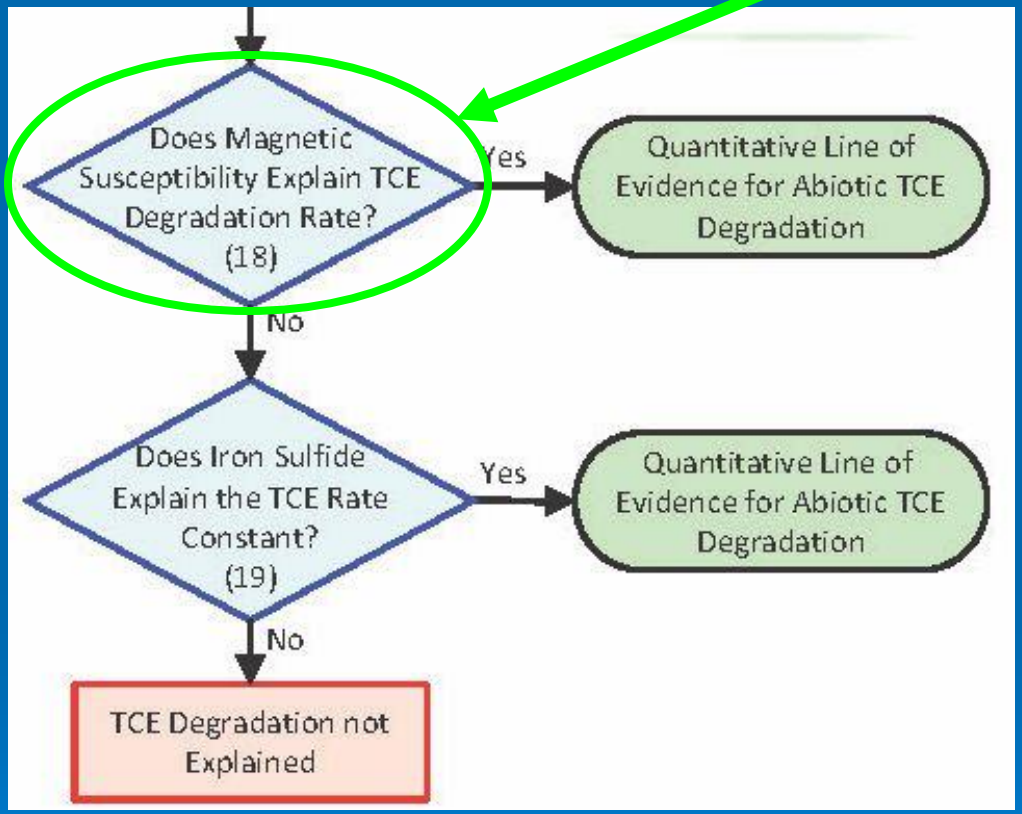
Identified Shortcomings



Led to ESTCP Project ER-201584

WIEDEMEIER & ASSOCIATES

Shortcomings Under ER-201129



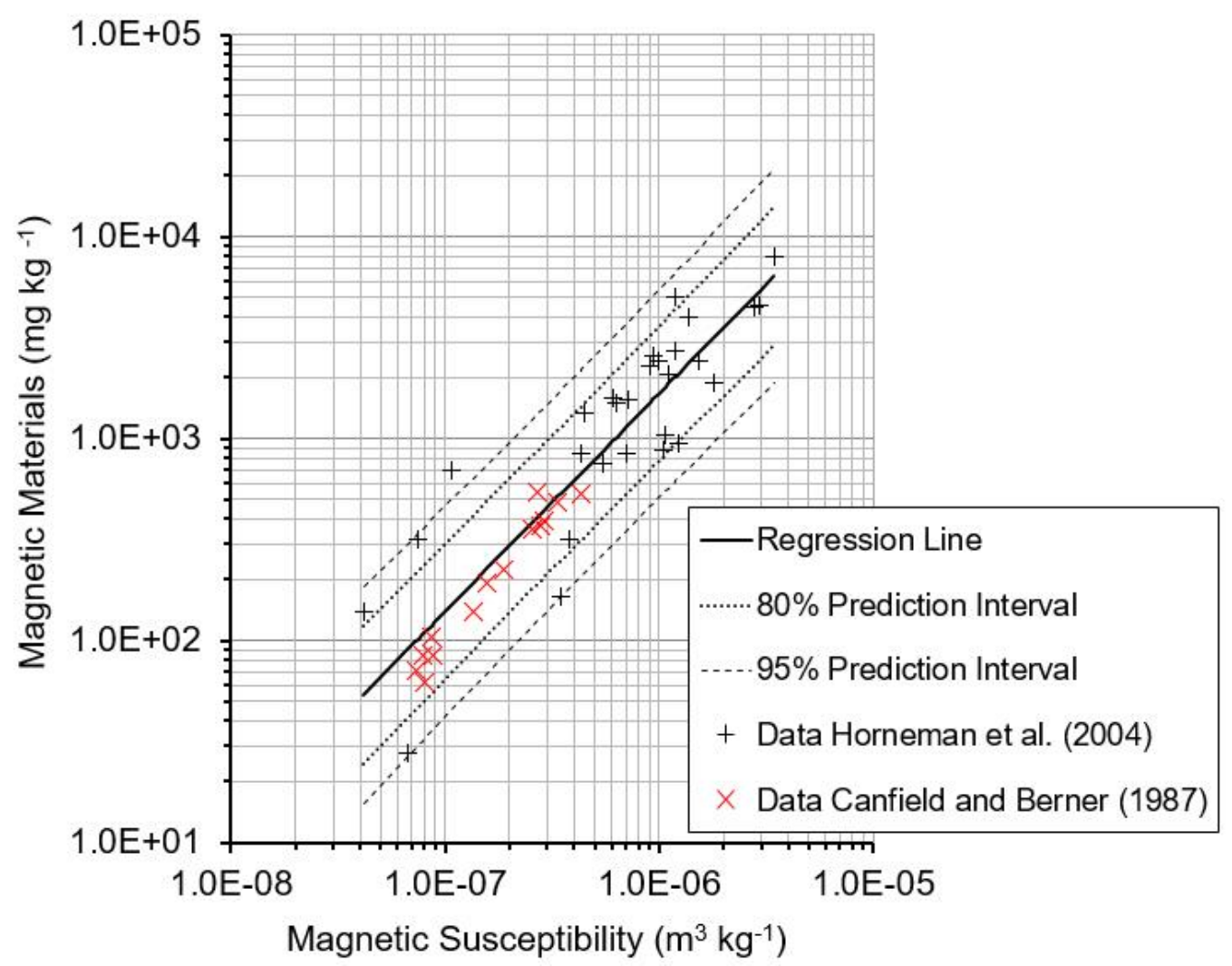
- Magnetic Susceptibility Data only Available from Cores – Needed Inexpensive Method for Existing PVC Wells

WIEDEMEIER & ASSOCIATES

- This presentation presents an affordable technique to measure magnetic susceptibility with a sonde (probe) that can be inserted into an existing non-metallic monitoring well.

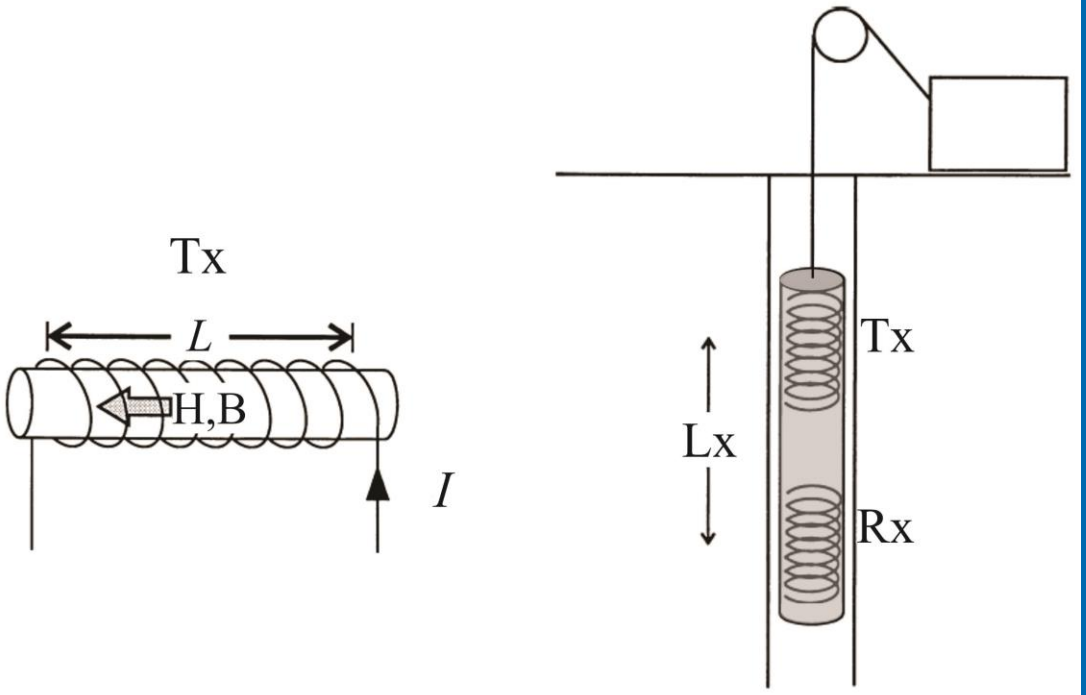
WIEDEMEIER & ASSOCIATES

Mass Magnetic Susceptibility Versus Magnetic Material Content



WIEDEMEIER & ASSOCIATES

Theory for Mass Magnetic Susceptibility Probe/Sonde



Where: Tx Transmitting Coil
H = Magnetic Intensity (amp/m)
L = Length of Solenoid (cm)
I = Current (amp)
B = Flux Density (weber/m)
Rx = Receiving Coil
Lx = Coil Spacing (cm)

WIEDEMEIER & ASSOCIATES

Test Design – Magnetic Susceptibility

- Use Existing Technology, Specifically a Down-Well Sonde, to Obtain Magnetic Susceptibility Data from Existing Non-Metallic Monitoring Wells
- Compare the Real-Time Data Collected Using the Sonde to Existing Laboratory Analytical Data Obtained From Borehole Core Samples to Benchmark/Validate the Sonde
- Determine if it Provides Reasonable Data By Making Plots of Mass Magnetic Susceptibility Data Collected Using the Sonde Versus That Collected from Soil/Sediment Laboratory Analytical Data

WIEDEMEIER & ASSOCIATES

Magnetic Susceptibility Sonde

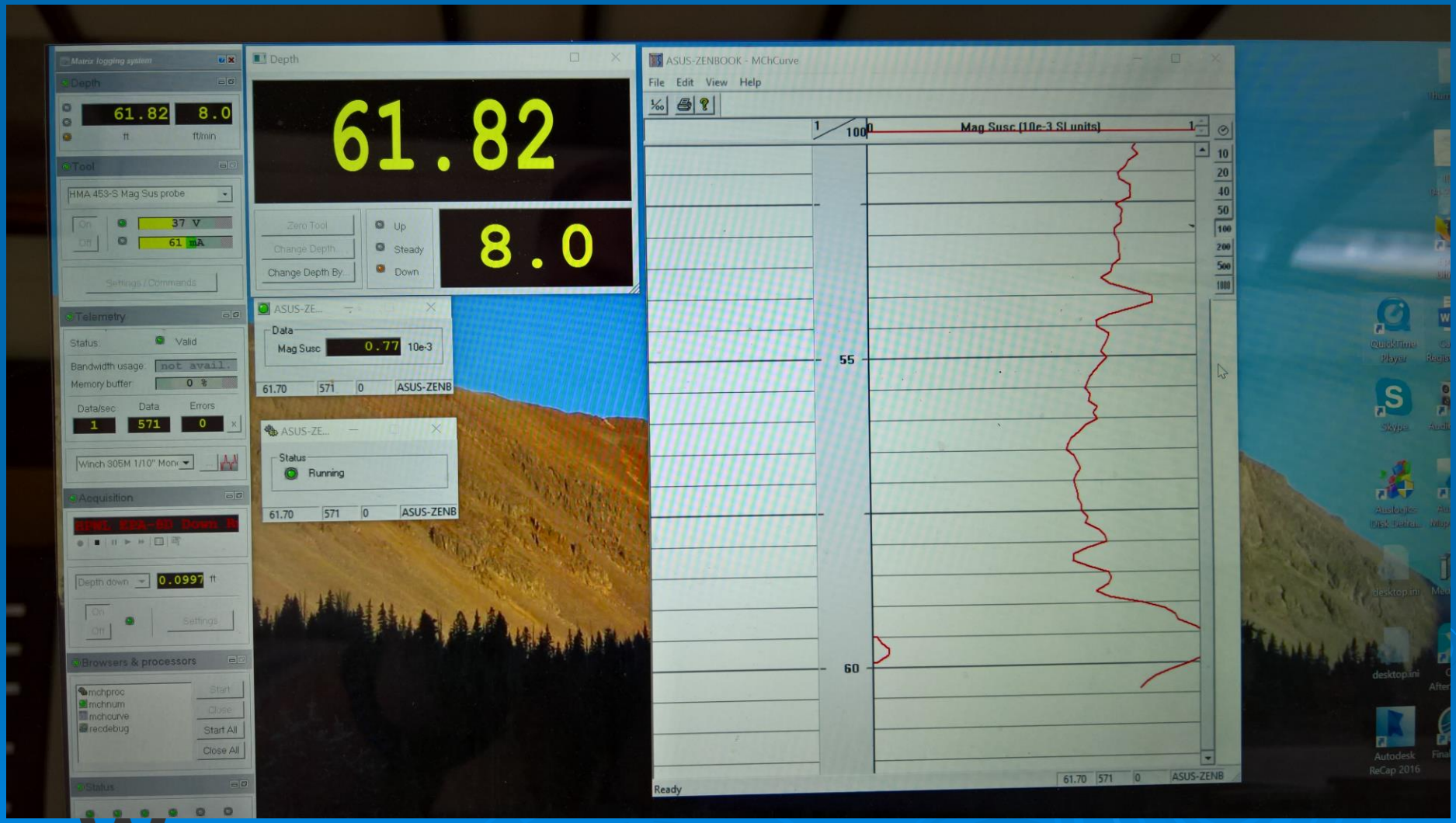
Magnetic Susceptibility Winch

WIEDEMEIER
& ASSOCIATES

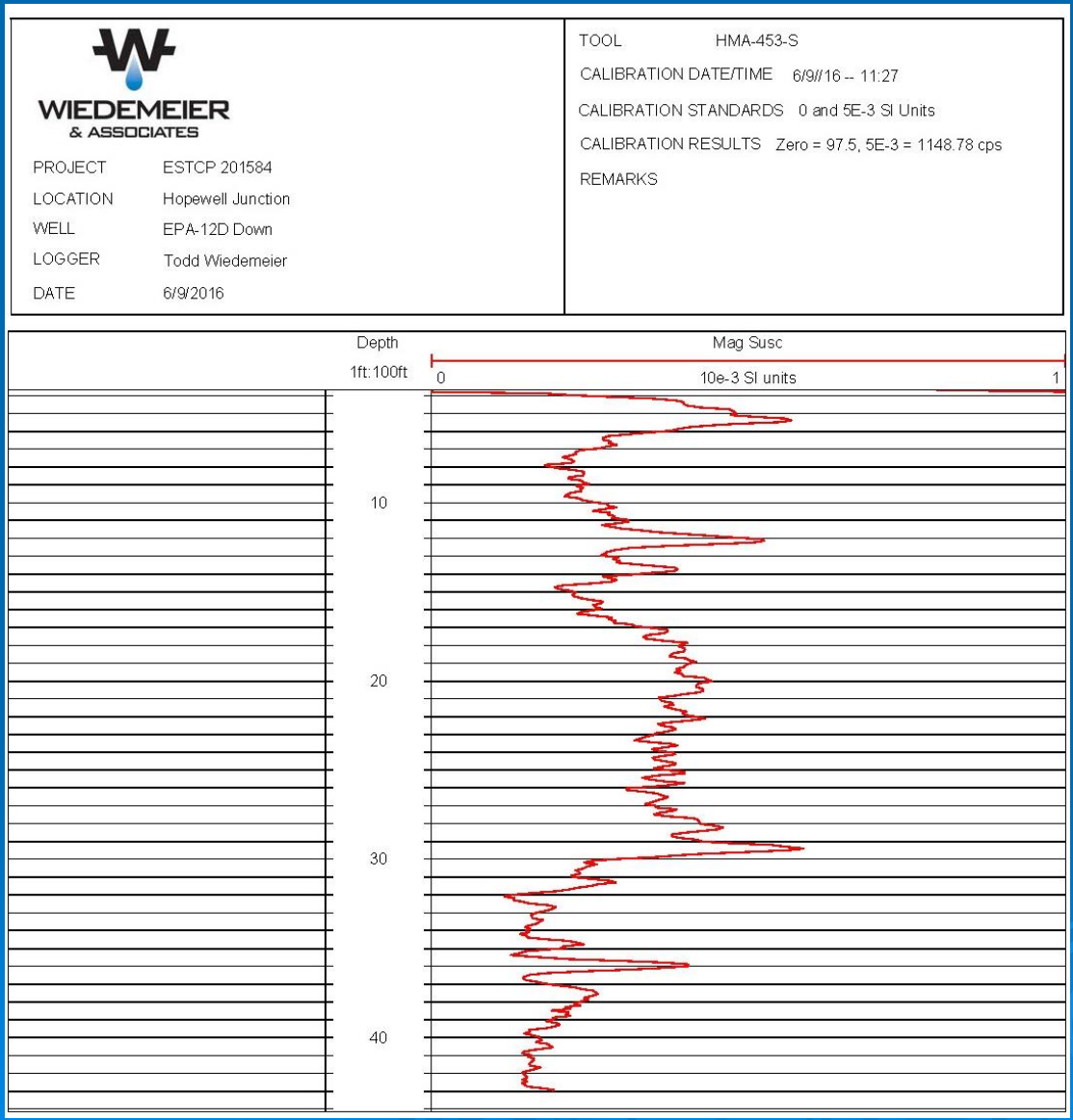
Magnetic Susceptibility Winch and Pulley

WIEDEMEIER
& ASSOCIATES

Magnetic Susceptibility – Real-Time Readout



Raw Data Output from WellCAD



Magnetic Susceptibility of Silica Sand

To Ensure that Sonde Was Not Measuring the Mass Magnetic Susceptibility of the Sand Pack in the Well, Samples Were Collected from Sand Used for Well Construction. Results Below Limit of Quantification, Two to Three Orders Of Magnitude Below Field Results, Basically Non-Detect

Table XX

Magnetic Susceptibility Results for 10-20 Silica Sand

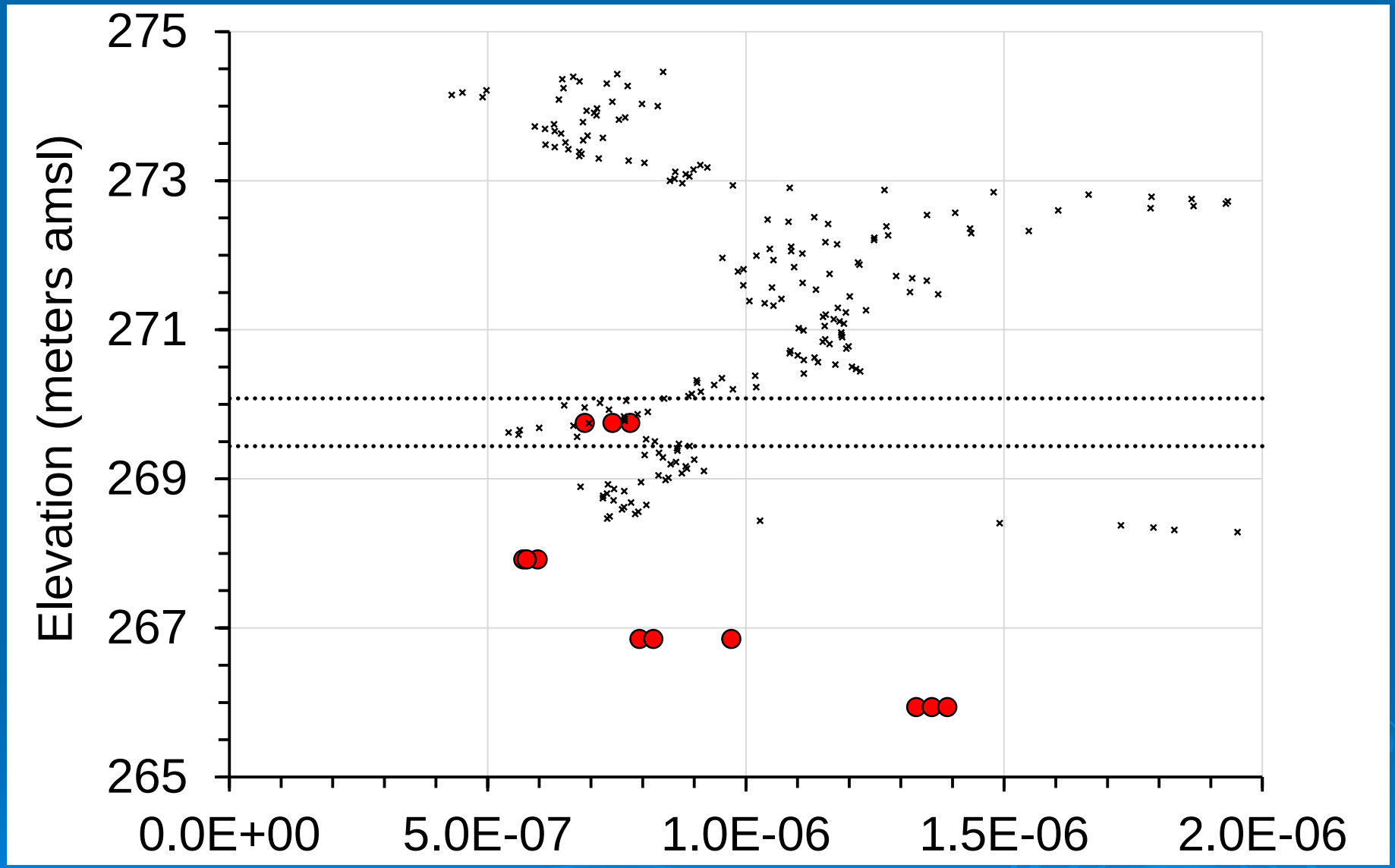
ESTCP Project Number ER-201584

Sample Identification	Date	Mass Magnetic Susceptibility[a/] (m^3/kg)	Flag[b/]	Error Range (m^3/kg)
Premier Silica - Corner 1	6/18/2016	6.47E-09	J	± 2.21E-09
Premier Silica - Corner 2	6/18/2016	6.69E-09	J	± 3.86E-09
Premier Silica - Corner 3	6/18/2016	6.30E-09	J	± 1.03E-09
Premier Silica - Corner 4	6/18/2016	4.45E-09	J	± 2.58E-09
Premier Silica - Bottom Center	6/18/2016	6.50E-09	J	± 3.34E-09

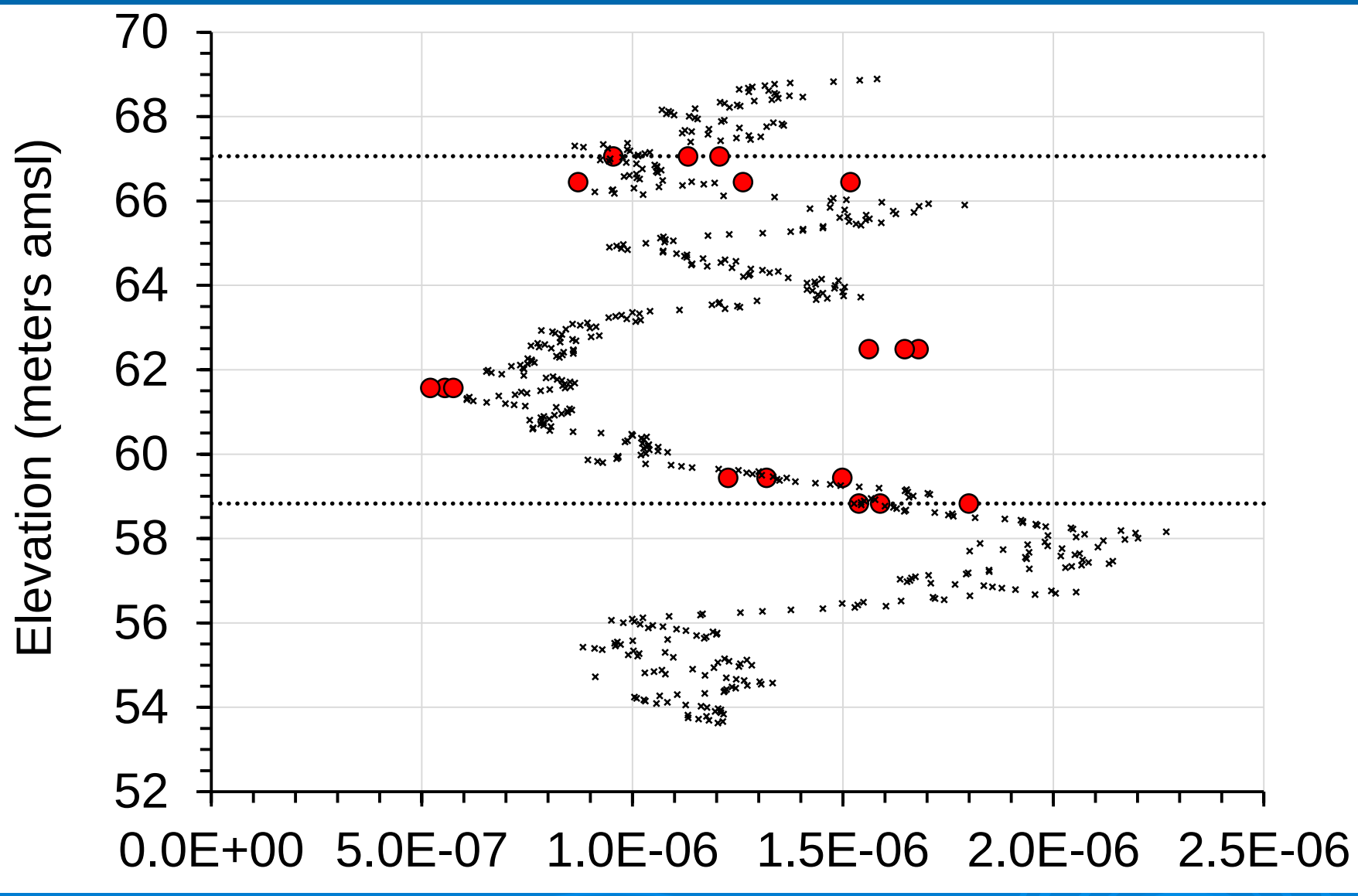
Notes:

a/ Analyses completed by Microbial Insights

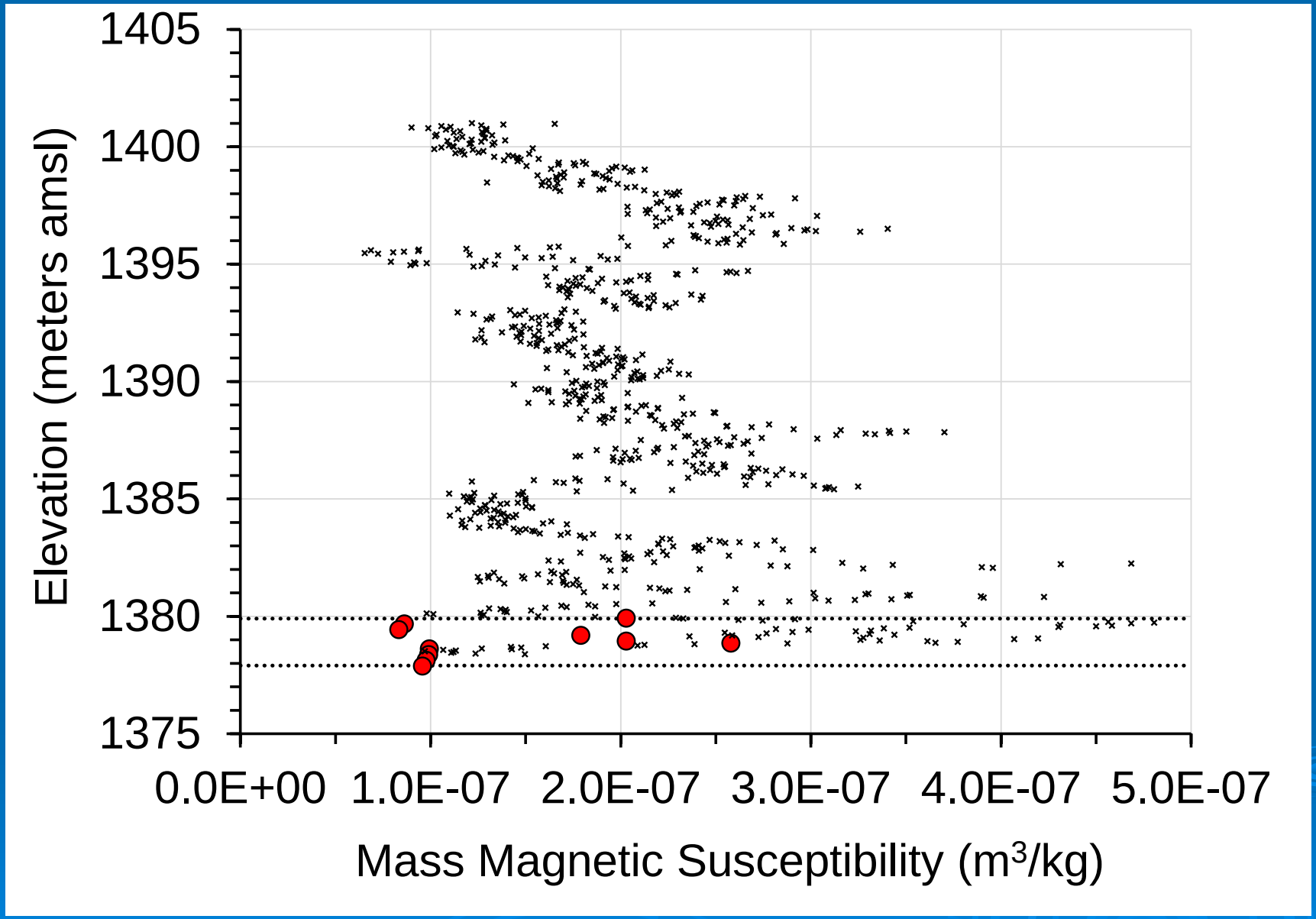
b/ J= estimated concentration between between the quantitation and minimum detection limits.



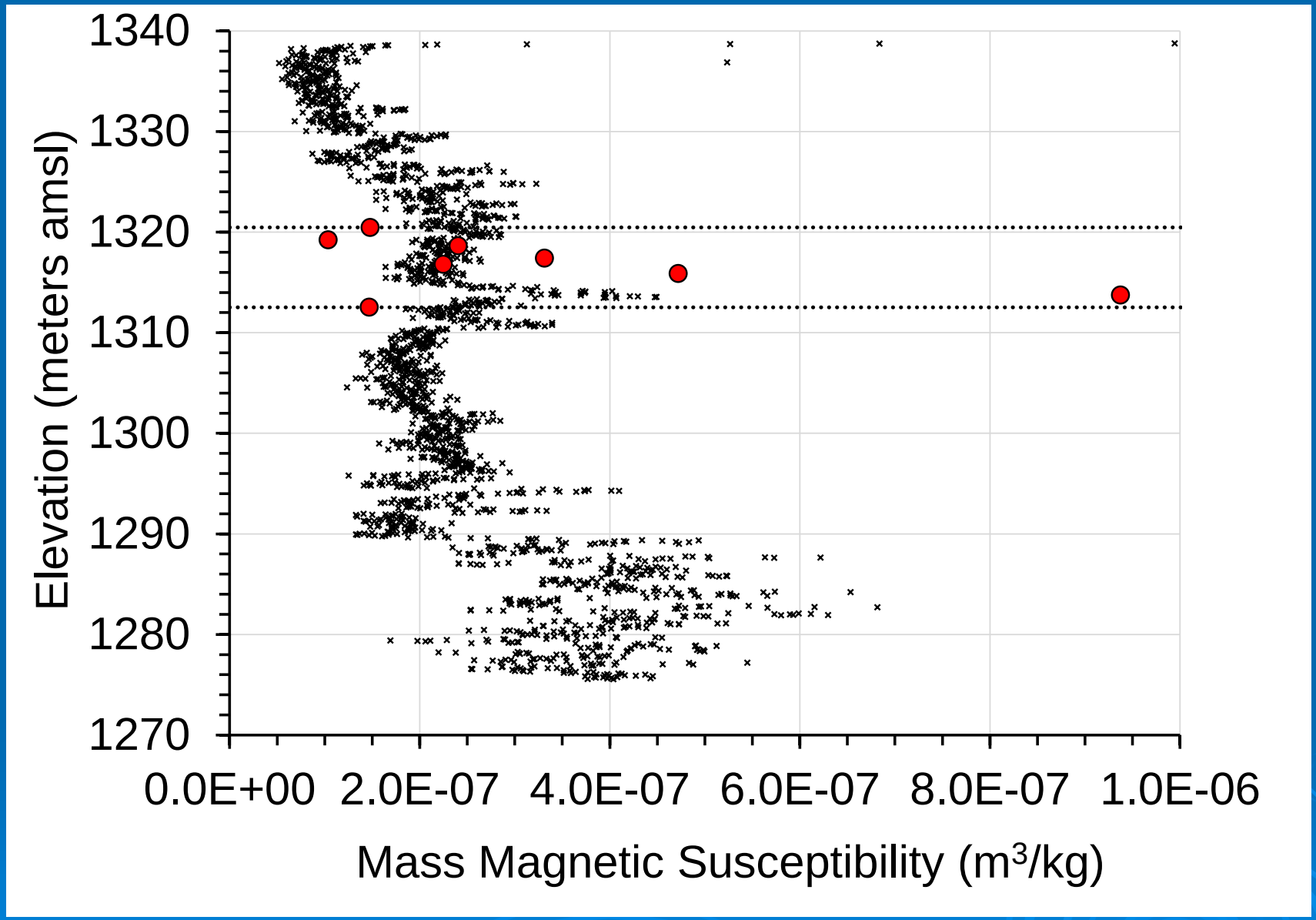
WIEDEMEIER & ASSOCIATES



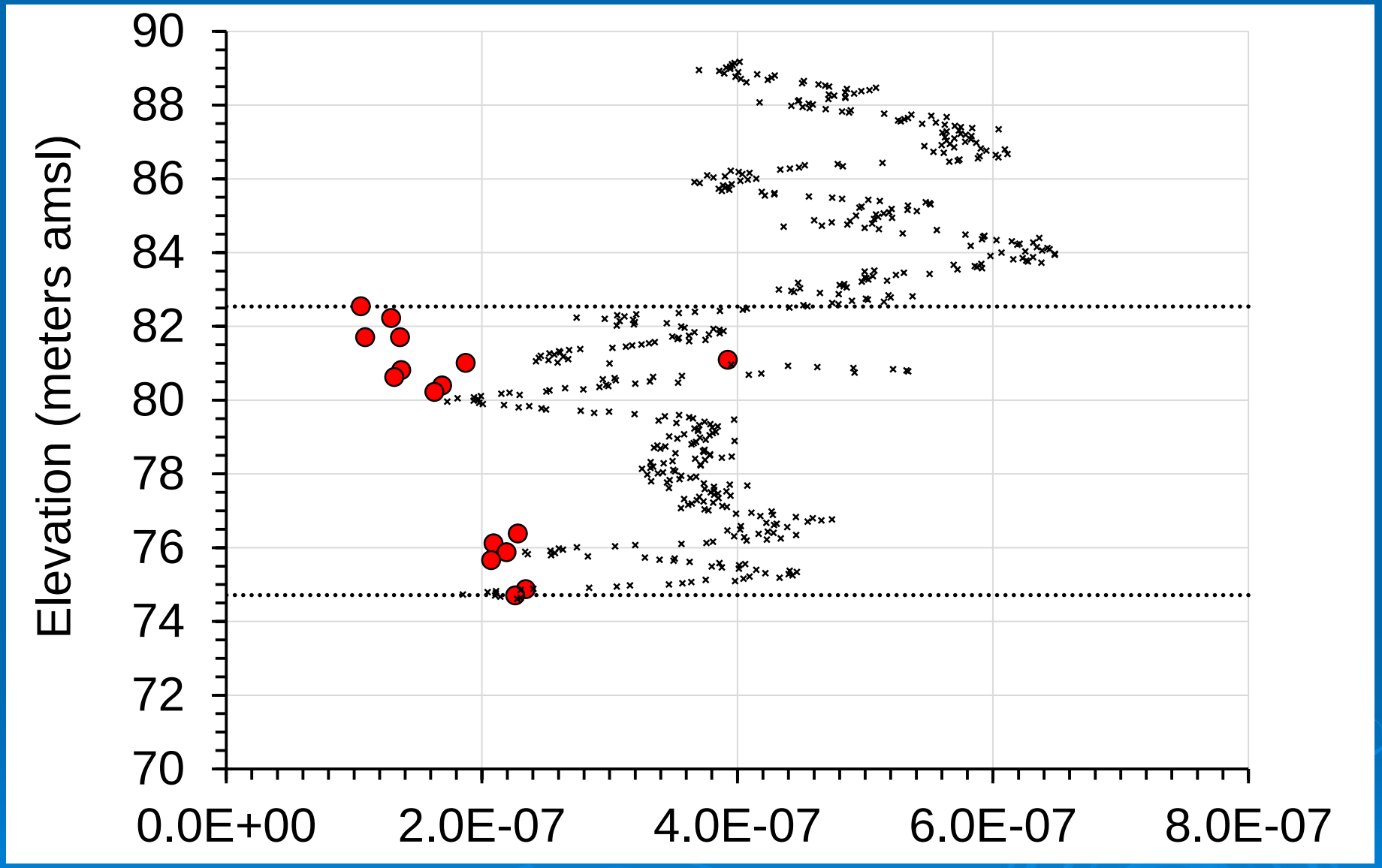
WIEDEMEIER & ASSOCIATES



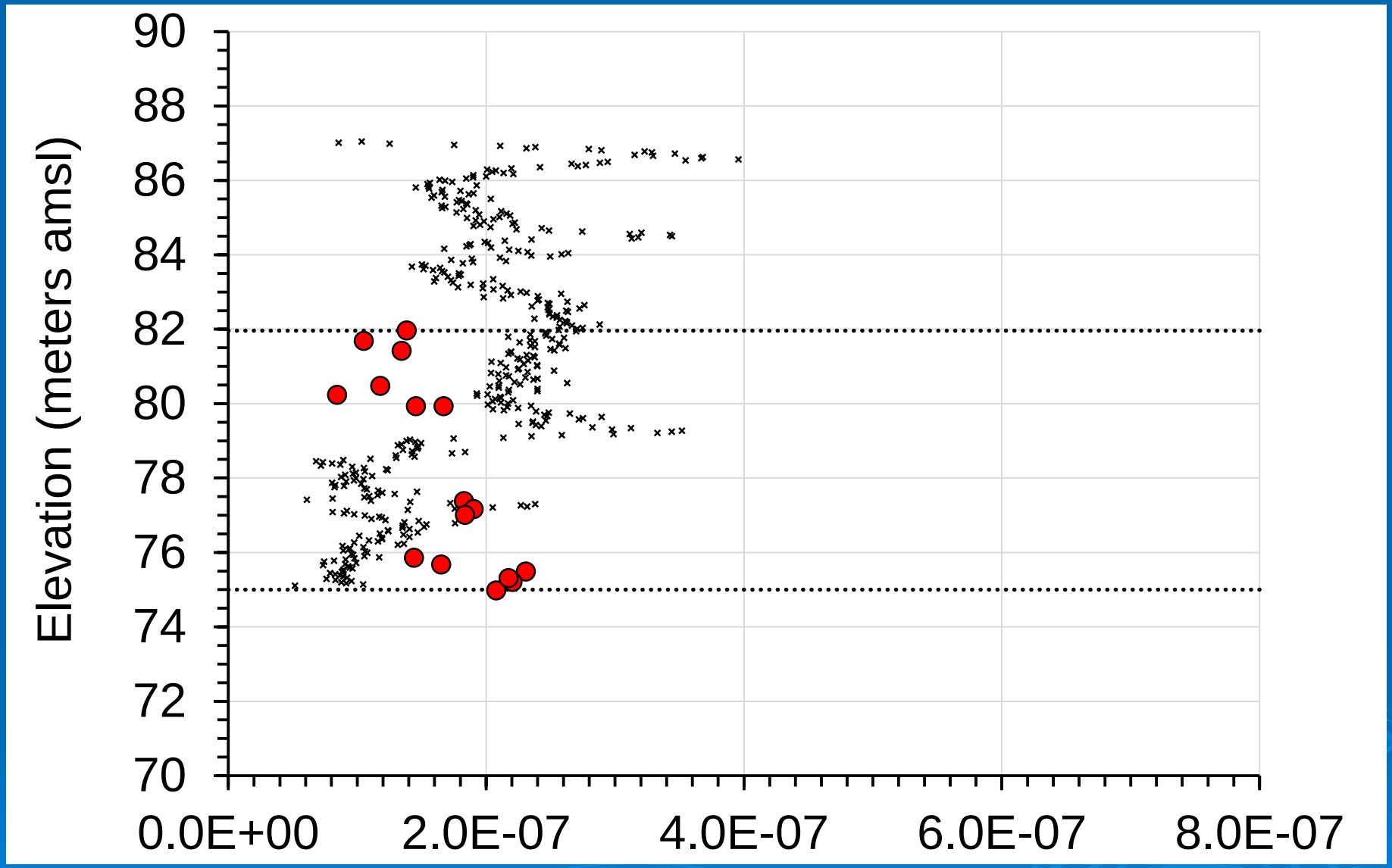
WIEDEMEIER & ASSOCIATES



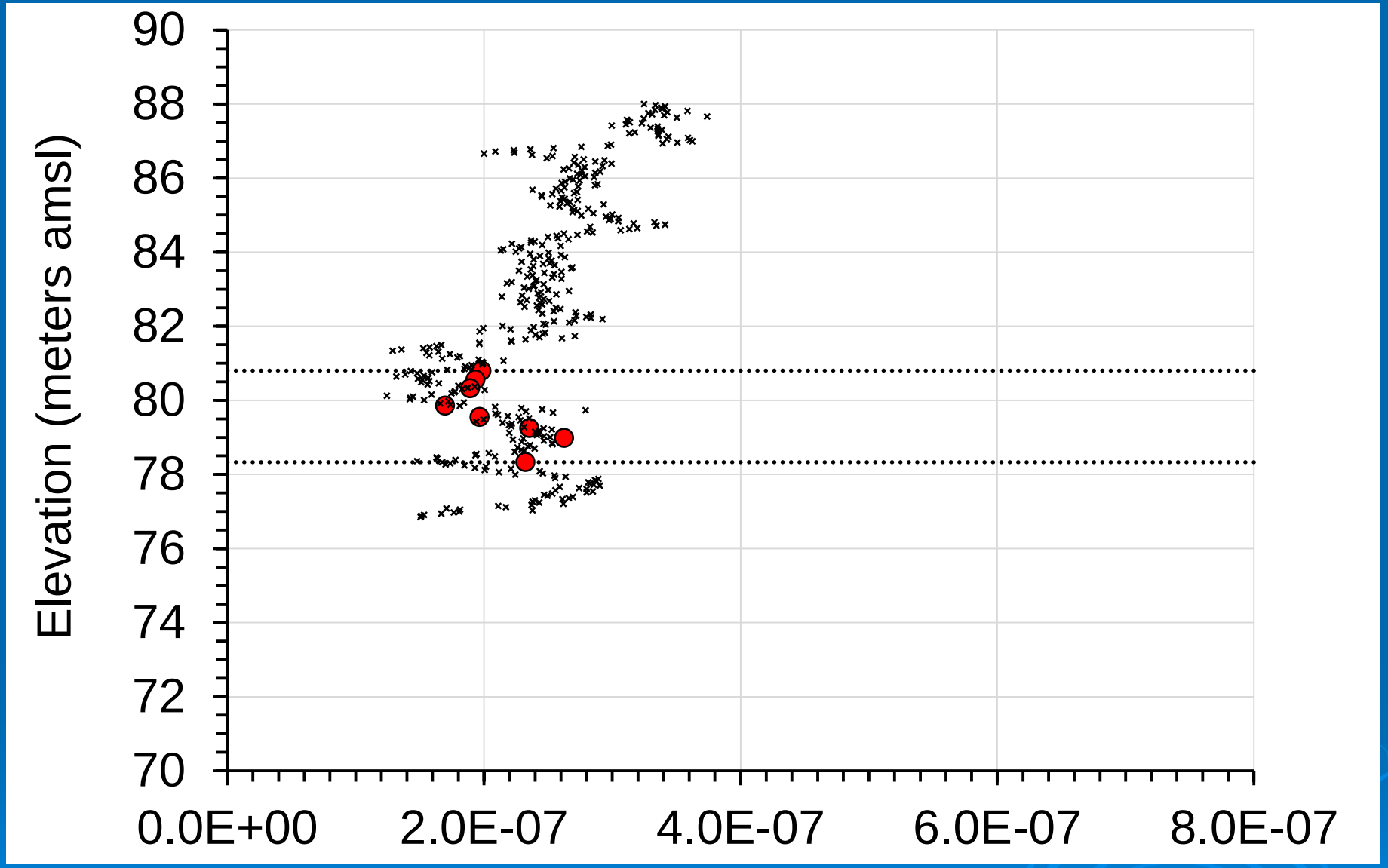
WIEDEMEIER & ASSOCIATES



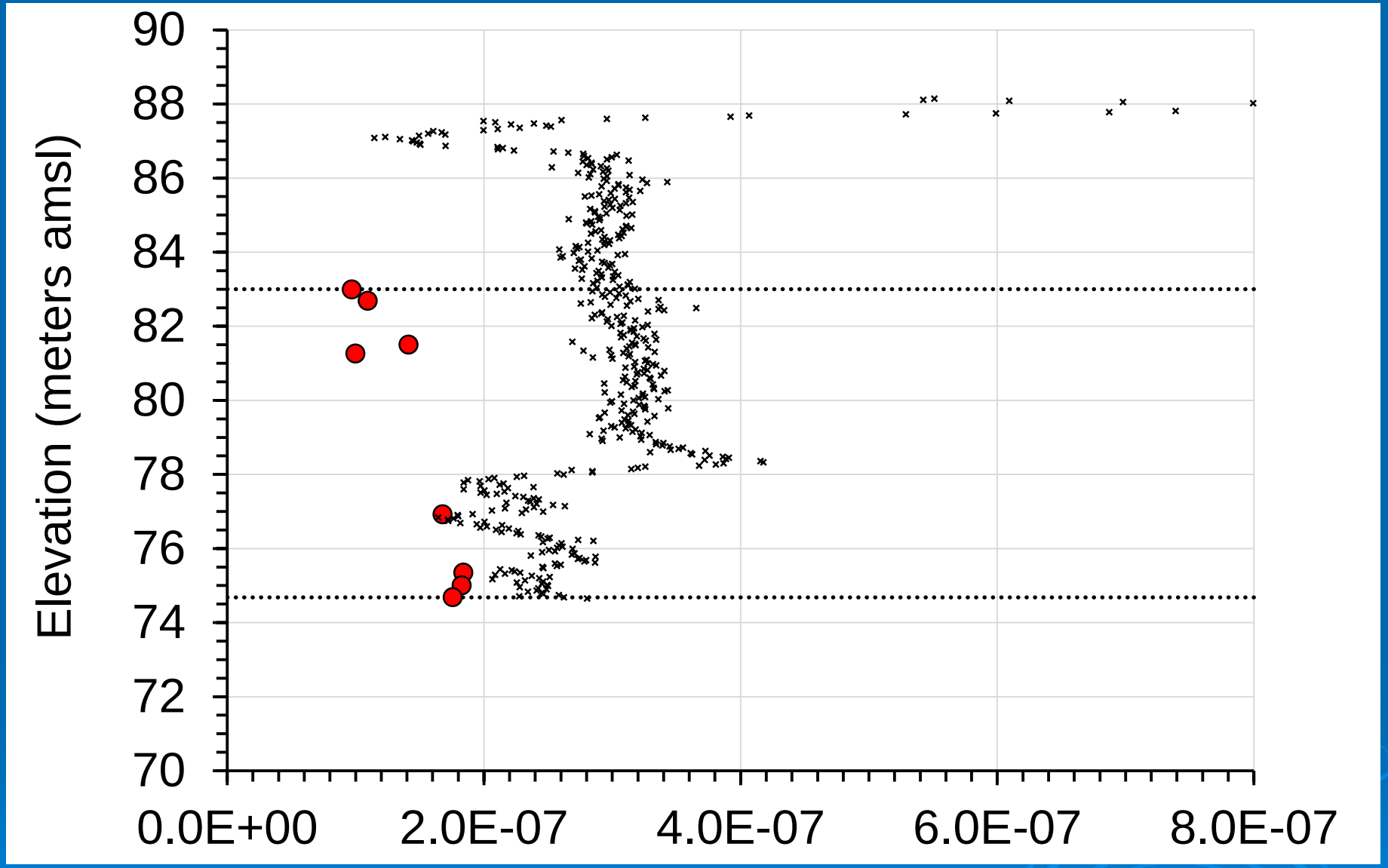
WIEDEMEIER & ASSOCIATES



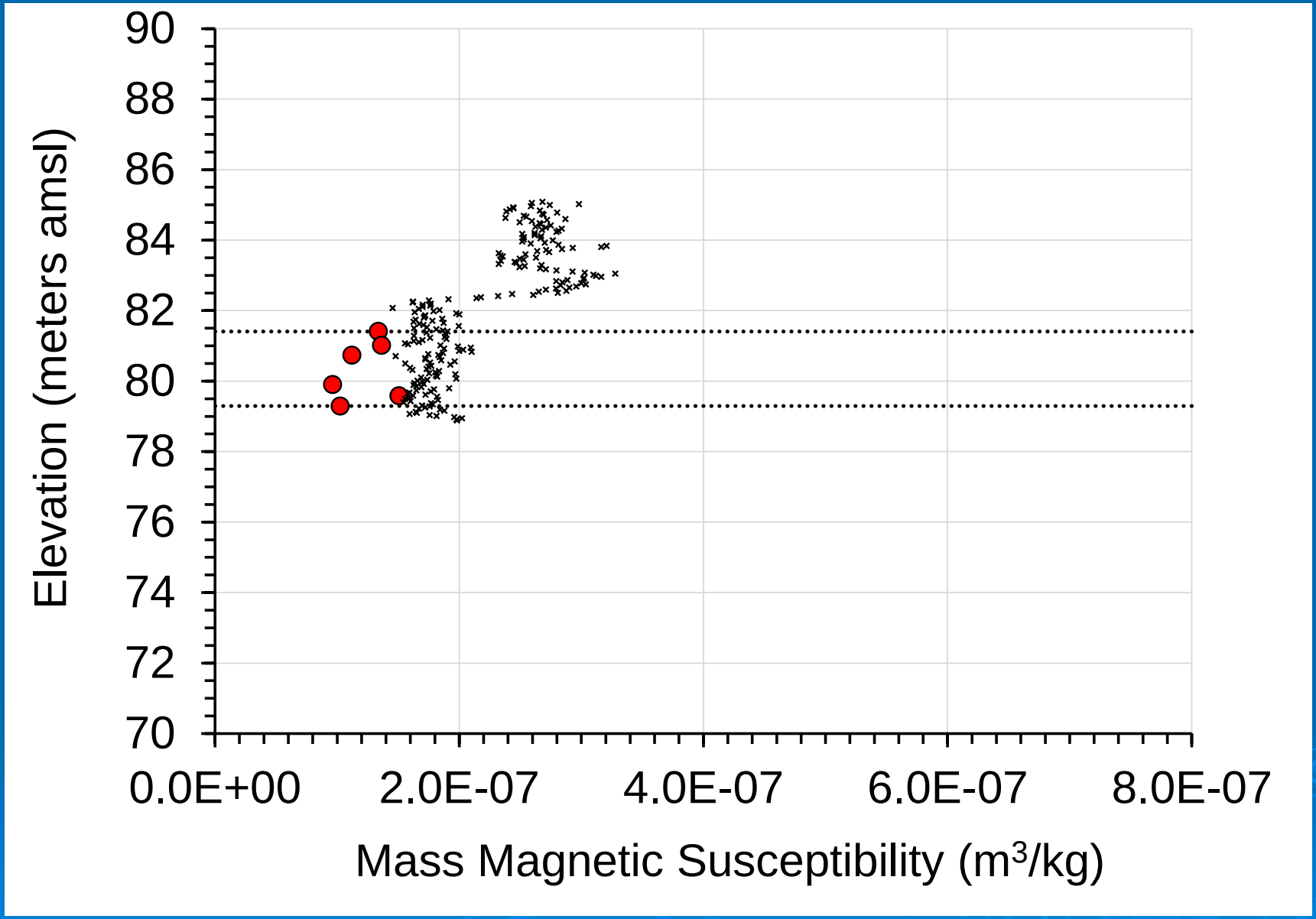
WIEDEMEIER & ASSOCIATES



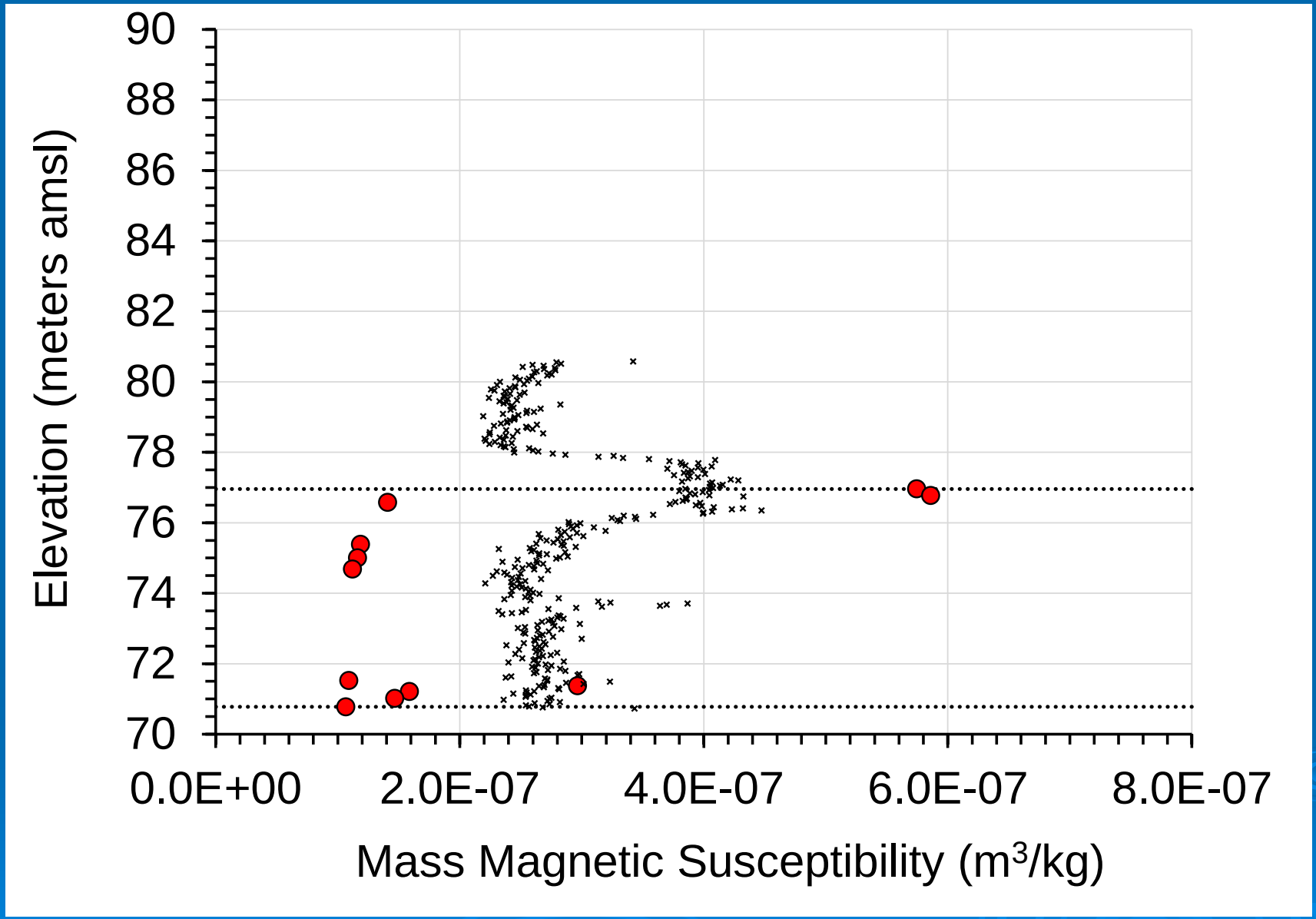
WIEDEMEIER & ASSOCIATES



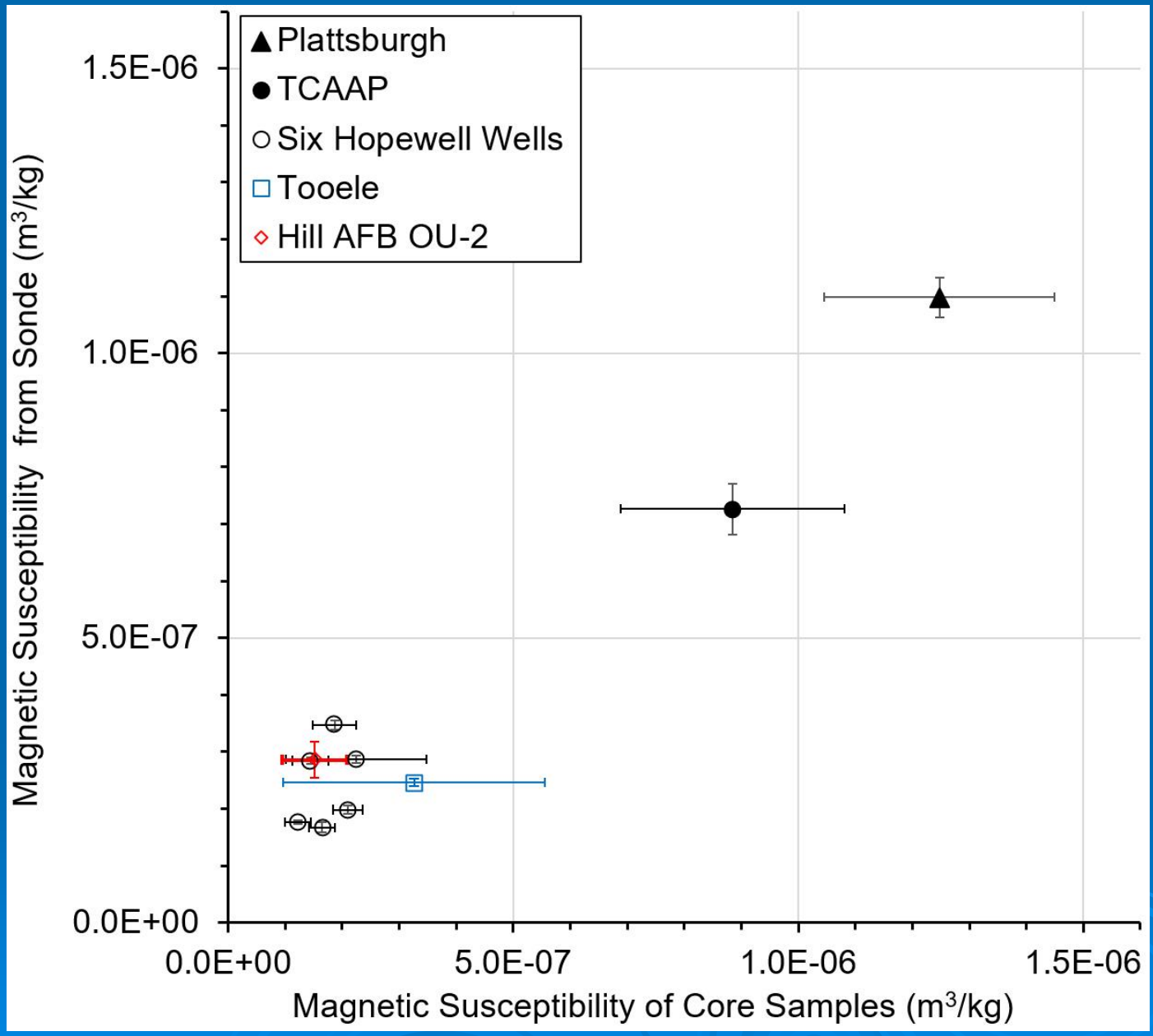
WIEDEMEIER & ASSOCIATES



WIEDEMEIER & ASSOCIATES



WIEDEMEIER & ASSOCIATES



WIEDEMEIER & ASSOCIATES

Conclusions

- If appropriate monitoring wells are available (non-metallic), downhole magnetic susceptibility sondes in groundwater monitoring wells can provide a less expensive alternative to the collection and analysis of borehole core data

- These data that can be used to evaluate field-scale rate constants for abiotic degradation of PCE, TCE, and *c*DCE by magnetite.

WIEDEMEIER & ASSOCIATES

Conclusions

- Wells or segments of wells are appropriate for use with a magnetic susceptibility sonde when (1) they are constructed with PVC screens and risers, (2) they do not contain iron or steel, and (3) they have an internal diameter of 5.1 cm (2 inches) or 10.2 cm (4 inches).

- If a well with a casing diameter of 5.1 cm (2 inches) is not straight, there is a possibility that the sonde will bind against the sides of the casing or screen. In this survey, there was no indication of a problem with wells with a casing diameter of 10.2 cm (4 inches).

WIEDEMEIER & ASSOCIATES

Conclusions

- Because there were many more data points provided from the sonde (hundreds) compared to core samples, the sonde data provided more precision in the estimate of average value for magnetic susceptibility

WIEDEMEIER & ASSOCIATES

Conclusions

- In most cases, the means of the two measurements could not be distinguished at 95% confidence. When the means could be distinguished, they still agreed within a factor of two

WIEDEMEIER & ASSOCIATES

Recommendations

- Use magnetic susceptibility to provide a second line of evidence as defined by USEPA (1999).
- Use magnetic susceptibility to evaluate whether abiotic degradation by magnetite is a plausible explanation for a rate constant that is extracted from the monitoring data and the geological and hydrological properties of the site.
- Do not use magnetic susceptibility to estimate or predict a rate constant for degradation

WIEDEMEIER & ASSOCIATES

Recommendations

- The rate constant is extracted by analyzing monitoring data from several wells that lie along a transect in the direction of groundwater flow.
- If possible, the magnetic susceptibility data should be collected in the same wells that provided the concentration data used to extract the field-scale rate constant.

WIEDEMEIER & ASSOCIATES

Recommendations

- If information is available on vertical distribution of hydraulic conductivity, or on the texture of unconsolidated porous media, use that information to filter the data on magnetic susceptibility, and take the mean of the data points that are associated with the regions that carry the major portion of groundwater flow.

WIEDEMEIER & ASSOCIATES

Recommendations

- Review the data provided by the sonde.
- Exclude from interpretation any data where there is a sharp transition to a very high magnetic susceptibility.
- These data may be associated with steel or iron in centralizers in the well, or with tools that might have been dropped into to borehole.

WIEDEMEIER & ASSOCIATES

Providing Additional Support for Monitored Natural Attenuation by Including Quantitative Lines of Evidence for Abiotic Degradation and Co-Metabolic Oxidation of Chlorinated Ethylenes

ER-201584

Completed May 2017

Search ESTCP, Then 201584