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Scientific Notebook # 510

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Walter Illman

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Geostatistical Analysis of Pneumatic, Hydraulic and Thermal Properties of Unsaturated Fractured Rocks at the ALRS (Apache Leap Research Site)

Objectives of this Study:

- To investigate the variation in pneumatic, hydraulic, and thermal properties of unsaturated fractured tuffs at the Apache Leap Research Site, near Superior, AZ.

- To summarize the statistical data & properties on hydrological properties including its model structure, covariance type, mean, variance, and skewness

- To establish which parameters vary the most in a statistical sense so that subsequent numerical modeling can incorporate this information.

Computers used: PC in my CNWRA office (San Antonio, TX)

Code used: ISATIS geostatistical package
Excel 97 SR-2 spreadsheet
Version 3.1.3 RWF 9/30/02

Collaborators: Debra Hughson
Randall Fedors - RWF
Cynthia Dinwiddie

11/19/2001 (TEF) (1)

To do for TEF report — geometric means

Add a section on: Comparison of ALRS & YM data
→ Insitu testing of Processes AMR
→ Gary LeCain's WRI reports
Surface BH data
→ Comparison of matrix values.

→ Fracture densities → I am not so sure how one would apply the correction factor.

orientation bias — orientation of fractures → corrected → yes, corrected

Check if quoted means are arithmetic / geom. mean.

$K_{sat} = 21.31 \times 10^{-9}$ m/s

$K = \frac{k \rho g}{\mu}$ $\quad k = \frac{K\mu}{\rho g} = \frac{(21.31\times10^{-9}\,m/s)(1.00\times10^{-3}\,Ns/m^2)}{(1000\,kg/m^3)(9.8\,m/s^2)}$

$= 2.17\times10^{-15}\,m^2$

3/31/2002 WI

11/19/2001 (TEF) (2)

(1) Calculation of geometric means

		Geo. mean	Arith. mean
Field	k_a	$7.75\times10^{-16}\,m^2$	$2.71\times10^{-14}\,m$
	k_w	$7.89\times10^{-16}\,m^2$	$2.77\times10^{-14}\,m$
Lab.	k_a	$1.77\times10^{-15}\,m^2$	$5.71\times10^{-15}\,m$
	k_w	$5.66\times10^{-16}\,m^2$	$2.18\times10^{-15}\,m$

WI 3/31/02

Look at geometric mean values (Table 4-2 to calculate the) ⇒ Take $10^{\wedge}$ value to get geo mean of variable.

Go to p. 20-22 for spreadsheet used to calculate geometric/arithmetic means

(2) Fracture density values → corrections done
⇒ Type in material from Rasmussen et al (1990) report

(3) Check report

stochastic continuum vs. dual continuum approach

Think about this and properly state the reasons why we can use statistics from ALRS at Yucca Mtn.

WI 3/31/02

Information potentially subject to copyright protection was redacted from this location. The redacted material is from the following reference:

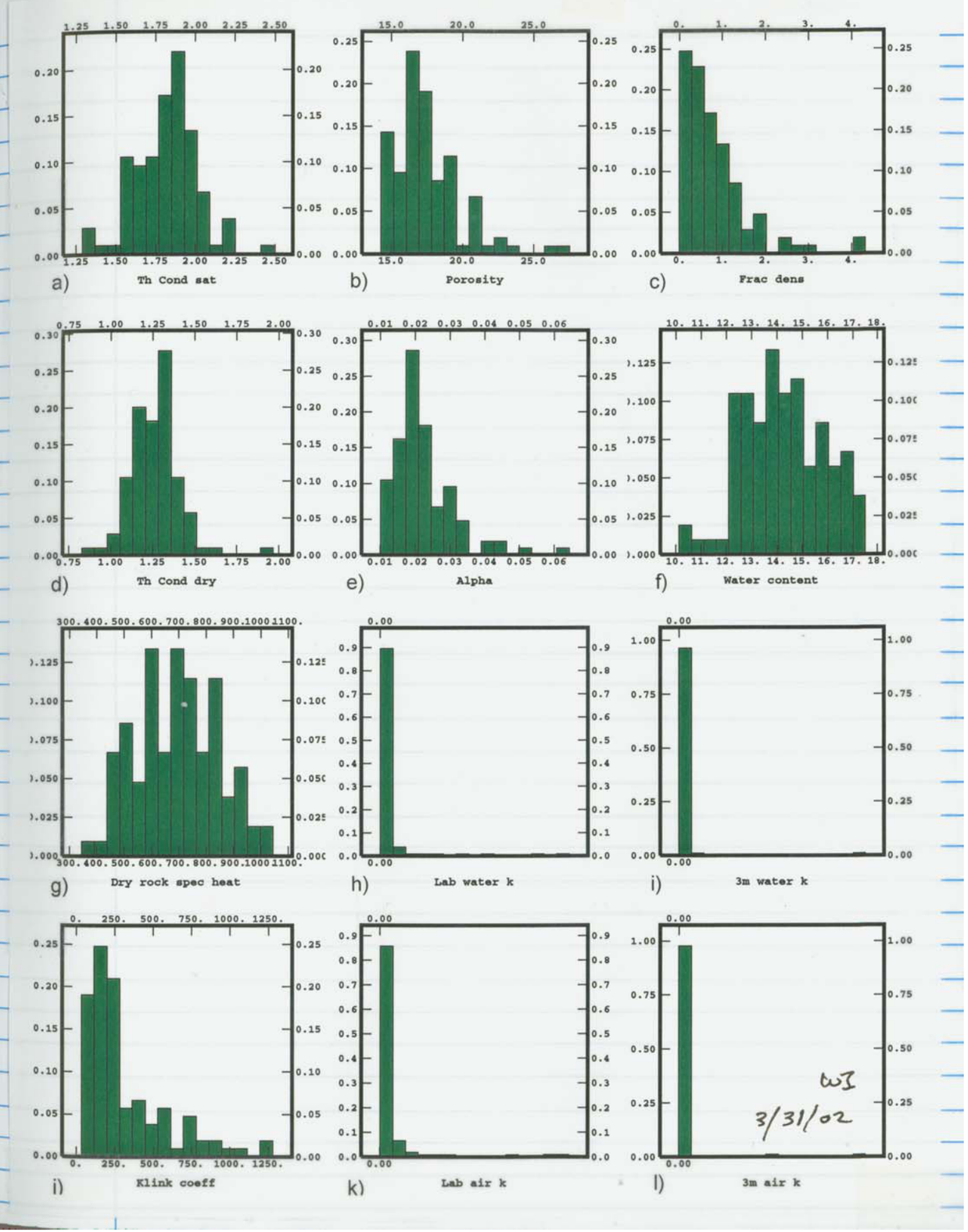
Illman, W.A. and S.P. Neuman. “Type-Curve Interpretation of a Cross-Hole Pneumatic Test in Unsaturated Fractured Tuff.” Figure 1. Water Resources Research. Vol. 37, No. 3. pp. 583-604. 2001.

Data originates from the Apache Leap Research Site (ALRS) located near Superior, AZ.

The site is approximately 100 miles north of Tucson, AZ.

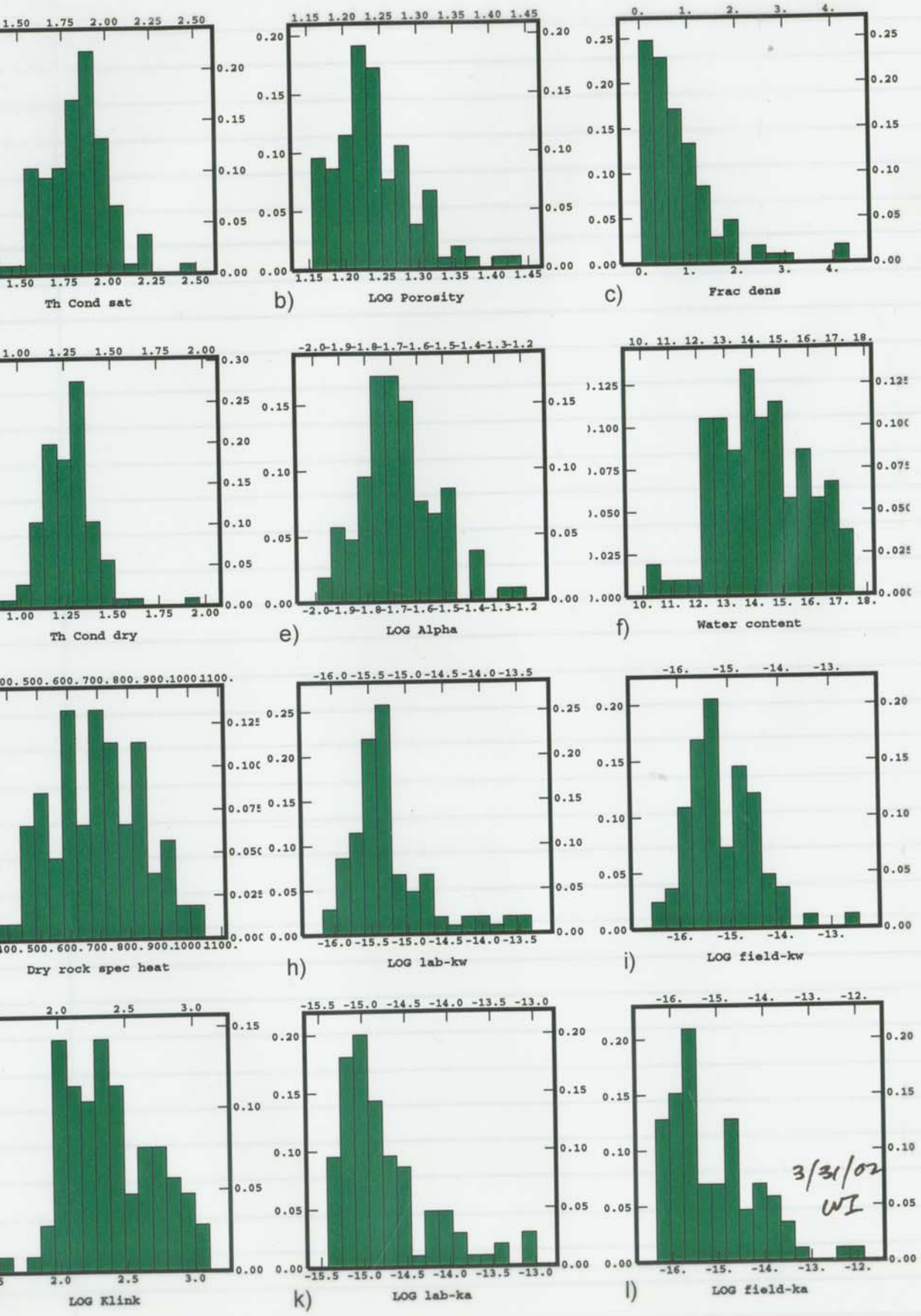
Details to the site can be found in various NUREGs completed for the NRC.

3/31/02 WI



WI
3/31/02

3/31/02 Histograms of logio transformed variables



3/31/02
WI

3/31/02

Information potentially subject to copyright protection was redacted from this location. The redacted material is from the following reference:

Illman, W.A. and S.P. Neuman. "Type-Curve Interpretation of a Cross-Hole Pneumatic Test in Unsaturated Fractured Tuff." Figure 6. Water Resources Research. Vol. 37, No. 3. pp. 583-604. 2001.

This figure suggests that fracture density is not a good measure of air permeability at the site.

3/31/02 WI

Information potentially subject to copyright protection was redacted from page 8. The redacted material is from the following reference:

Vesselinov. Figure 3: A three-dimensional perspective of boreholes.... 2000. Further information on this reference is unknown.

Information potentially subject to copyright protection was redacted from page 9. The redacted material is from the following reference:

Illman, W.A. and S.P. Neuman. “Type-Curve Interpretation of a Cross-Hole Pneumatic Test in Unsaturated Fractured Tuff.” Figure 2. Water Resources Research. Vol. 37, No. 3. pp. 583-604. 2001.

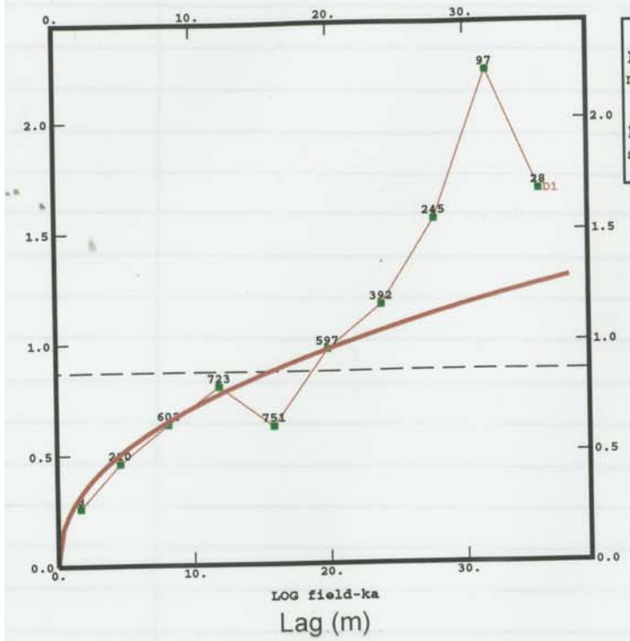
Location of data sets used for the geostatistical analysis conducted in this report

The W-series, G-series, and V-series boreholes were drilled after the completion of X, Y-, Z+ series boreholes

3/31/02 WI

There should be additional boreholes at the site – drilled after the completion of pneumatic tests conducted by Illman (1998) and Illman et al. (1998)

3/31/02 WI



Variogram Fitting

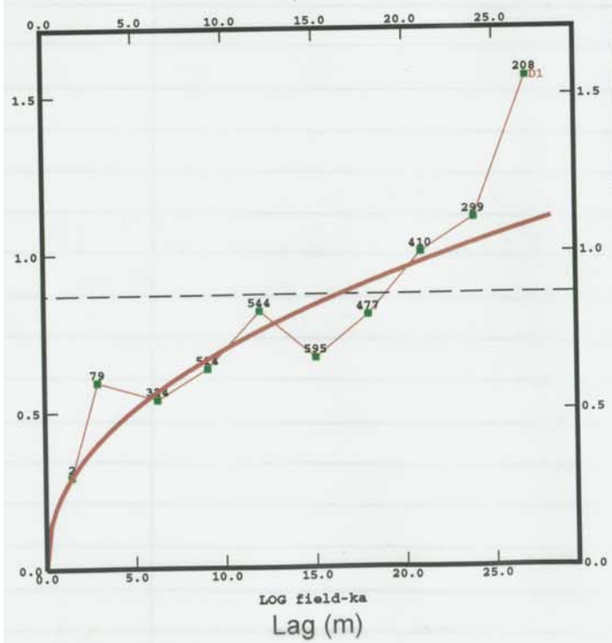
Experimental Variogram(s) : 1 direction(s)

D1 - Az= 0.00, Ay= 0.00, Ax= 0.00
Angular tolerance = 90.00
Lag = 4m, Tolerance = 50.00%, Count = 10

Model : 1 basic structure(s)

S1 - Power - Scale = 0.6047m - Exp. = 0.45
Sill = 0.2012

parameters should be defined in the ISATIS manual.



Variogram Fitting

Experimental Variogram(s) : 1 direction(s)

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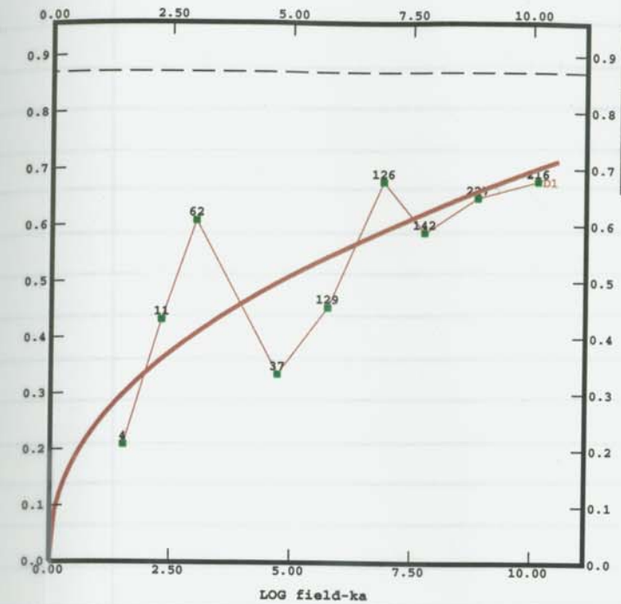
Angular tolerance = 90.00
Lag = 3m, Tolerance = 50.00%, Count = 10

Model : 1 basic structure(s)

S1 - Power - Scale = 0.6047m - Exp. = 0.45
Sill = 0.1968

3/31/02 WI



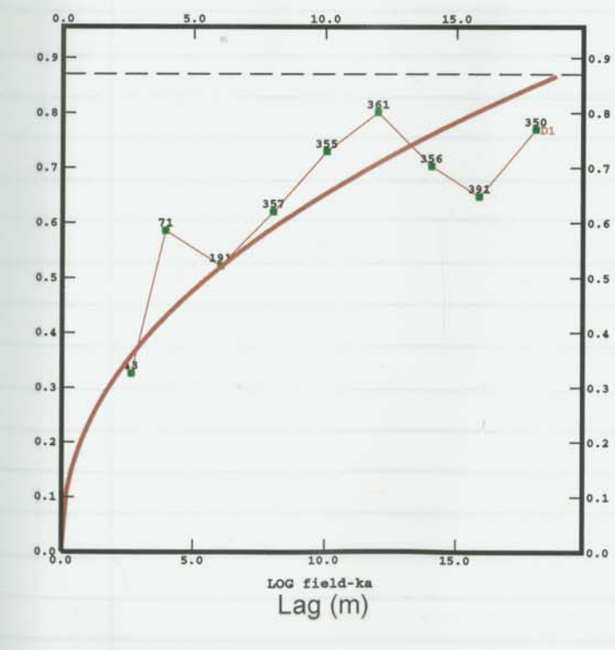
Variogram Fitting

Experimental Variogram(s) : 1 direction(s)

D1 - Az= 0.00, Ay= 0.00, Ax= 0.00
Angular tolerance = 90.00
Lag = 1.12m, Tolerance = 50.00%, Count = 10

Model : 1 basic structure(s)

S1 - Power - Scale = 0.6047m - Exp. = 0.45
Sill = 0.1973



Variogram Fitting

Experimental Variogram(s) : 1 direction(s)

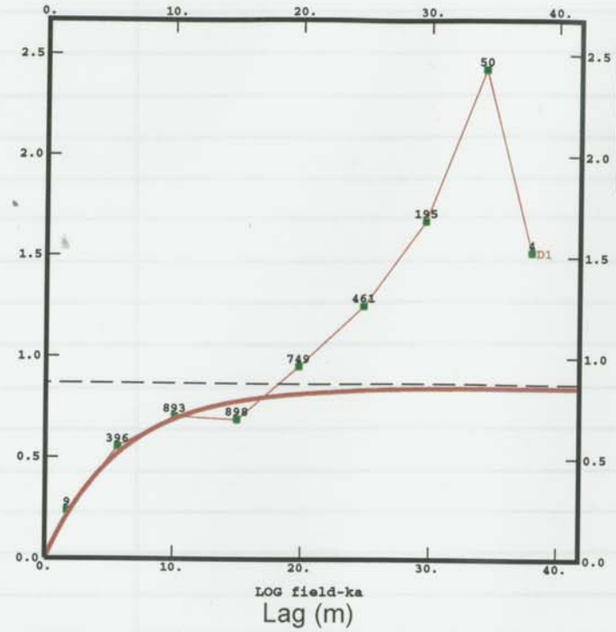
D1 - Az= 0.00, Ay= 0.00, Ax= 0.00
Angular tolerance = 90.00
Lag = 2m, Tolerance = 50.00%, Count = 10

Model : 1 basic structure(s)

S1 - Power - Scale = 0.6047m - Exp. = 0.45
Sill = 0.1845

3/31/02 WI

3/31/02 Fitted Variograms



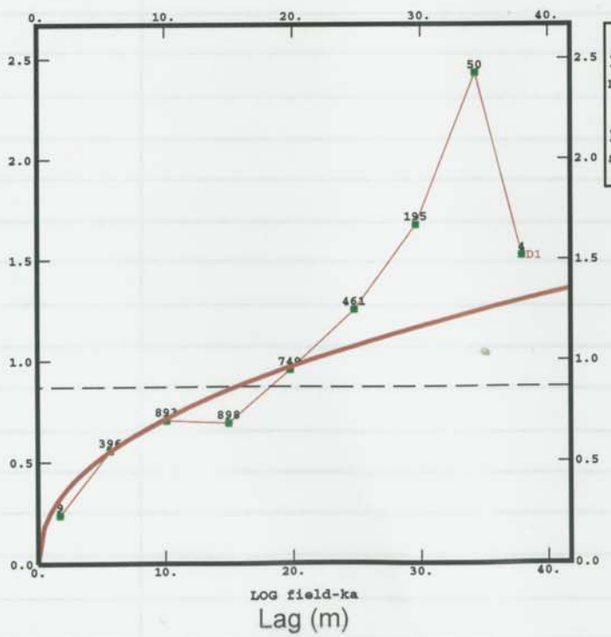
Variogram Fitting

Experimental Variogram(s) : 1 direction(s)

D1 - Az= 0.00, Ay= 0.00, Ax= 0.00
Angular tolerance = 90.00
Lag = 5m, Tolerance = 50.00%, Count = 10

Model : 1 basic structure(s)

S1 - Exponential - Scale = 18m
Sill = 0.8500



Variogram Fitting

Experimental Variogram(s) : 1 direction(s)

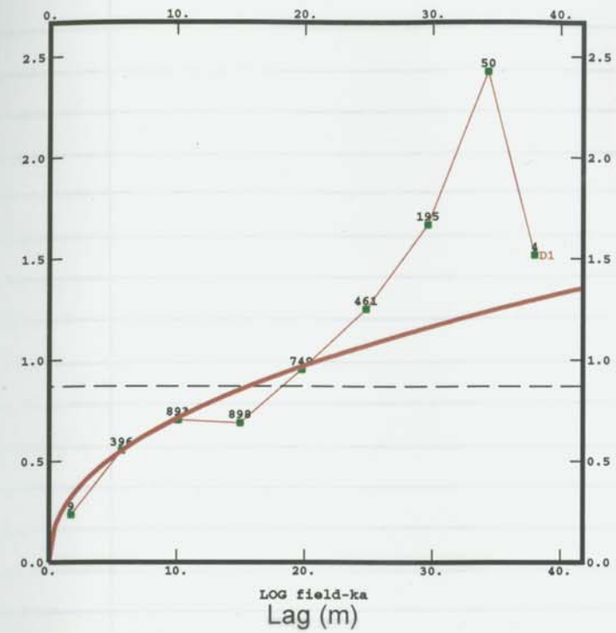
D1 - Az= 0.00, Ay= 0.00, Ax= 0.00
Angular tolerance = 90.00
Lag = 5m, Tolerance = 50.00%, Count = 10

Model : 1 basic structure(s)

S1 - Power - Scale = 0.6047m - Exp. = 0.45
Sill = 0.2016

3/3/02 WI

3/31/02 Fitted Variograms



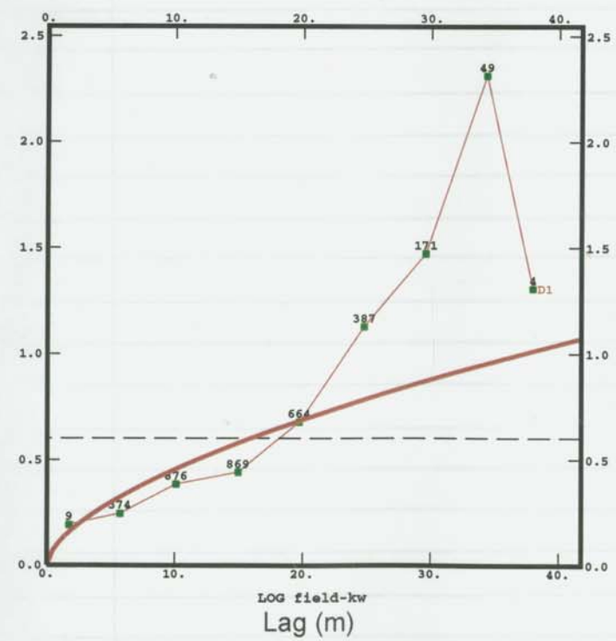
Variogram Fitting

Experimental Variogram(s) : 1 direction(s)

D1 - Az= 0.00, Ay= 0.00, Ax= 0.00
Angular tolerance = 90.00
Lag = 5m, Tolerance = 50.00%, Count = 10

Model : 1 basic structure(s)

S1 - Power - Scale = 0.6047m - Exp. = 0.45
Sill = 0.2016



Variogram Fitting

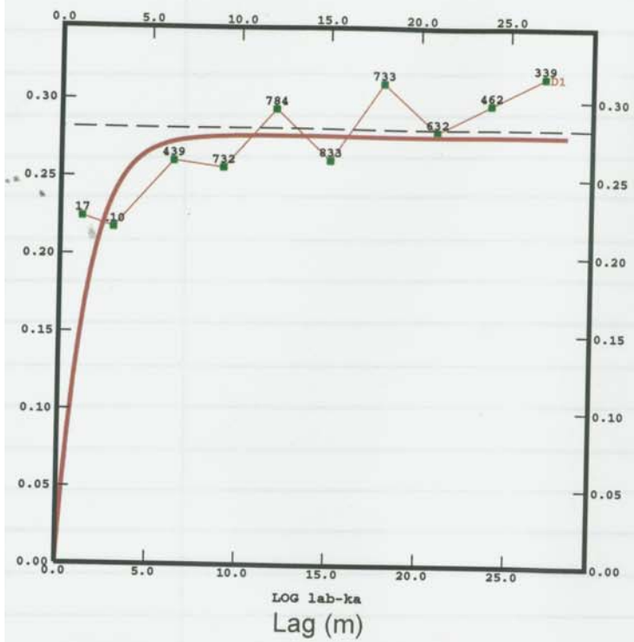
Experimental Variogram(s) : 1 direction(s)

D1 - Az= 0.00, Ay= 0.00, Ax= 0.00
Angular tolerance = 90.00
Lag = 5m, Tolerance = 50.00%, Count = 10

Model : 1 basic structure(s)

S1 - Power - Scale = 6m - Exp. = 0.60
Sill = 0.3349

3/31/02 WI



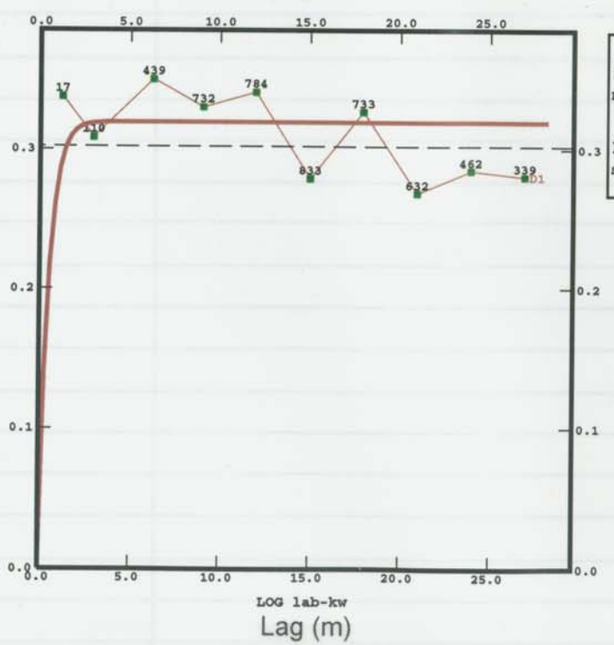
Variogram Fitting

Experimental Variogram(s) : 1 direction(s)

D1 - Az= 0.00, Ay= 0.00, Ax= 0.00
Angular tolerance = 90.00
Lag = 3m, Tolerance = 50.00%, Count = 10

Model : 1 basic structure(s)

S1 - Exponential - Scale = 4.4831724m
Sill = 0.2769



Variogram Fitting

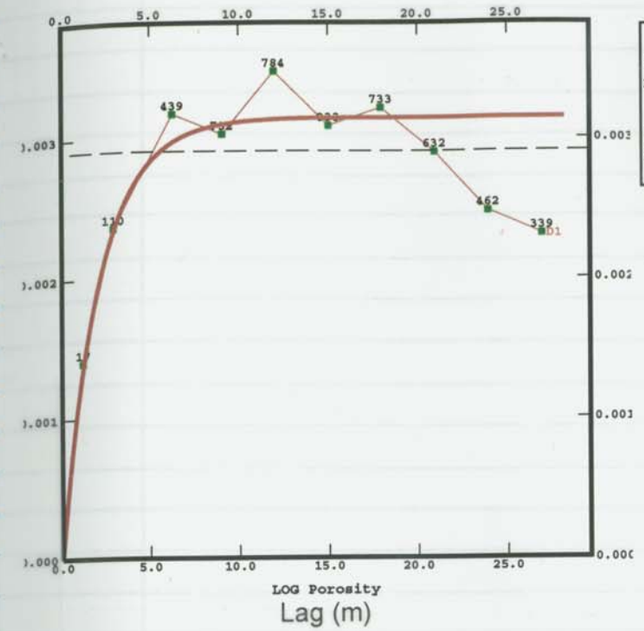
Experimental Variogram(s) : 1 direction(s)

D1 - Az= 0.00, Ay= 0.00, Ax= 0.00
Angular tolerance = 90.00
Lag = 3m, Tolerance = 50.00%, Count = 10

Model : 1 basic structure(s)

S1 - Exponential - Scale = 1.4831724m
Sill = 0.3193

3/31/02 WZ



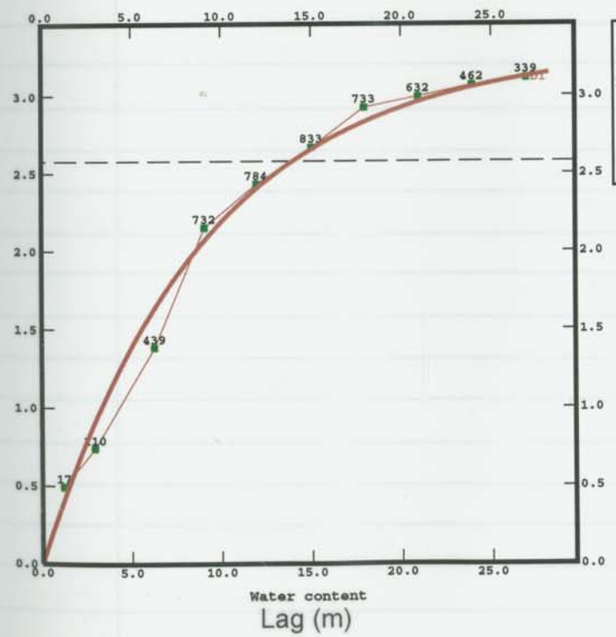
Variogram Fitting

Experimental Variogram(s) : 1 direction(s)

D1 - Az= 0.00, Ay= 0.00, Ax= 0.00
Angular tolerance = 90.00
Lag = 3m, Tolerance = 50.00%, Count = 10

Model : 1 basic structure(s)

S1 - Exponential - Scale = 6.4831724m
Sill = 0.0031



Variogram Fitting

Experimental Variogram(s) : 1 direction(s)

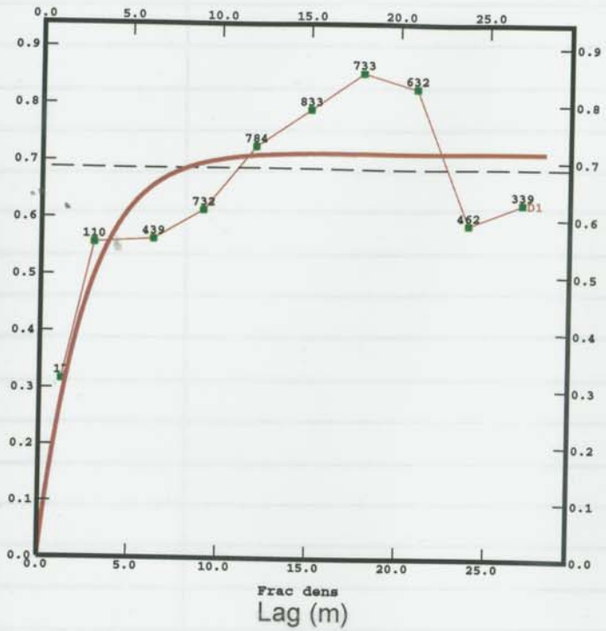
D1 - Az= 0.00, Ay= 0.00, Ax= 0.00
Angular tolerance = 90.00
Lag = 3m, Tolerance = 50.00%, Count = 10

Model : 1 basic structure(s)

S1 - Exponential - Scale = 27.483172m
Sill = 3.2964

3/31/02 WZ

3/31/02 Fitted Variograms



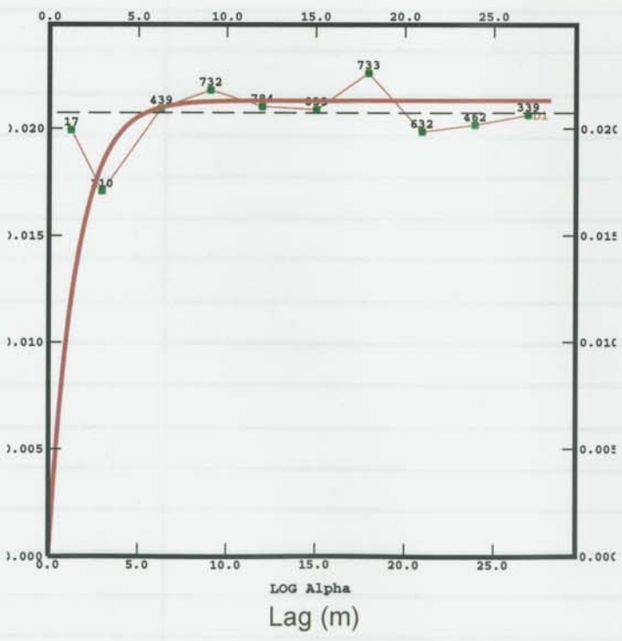
Variogram Fitting

Experimental Variogram(s) : 1 direction(s)

D1 - Az= 0.00, Ay= 0.00, Ax= 0.00
Angular tolerance = 90.00
Lag = 3m, Tolerance = 50.00%, Count = 10

Model : 1 basic structure(s)

S1 - Exponential - Scale = 7.5m
Sill = 0.7158



Variogram Fitting

Experimental Variogram(s) : 1 direction(s)

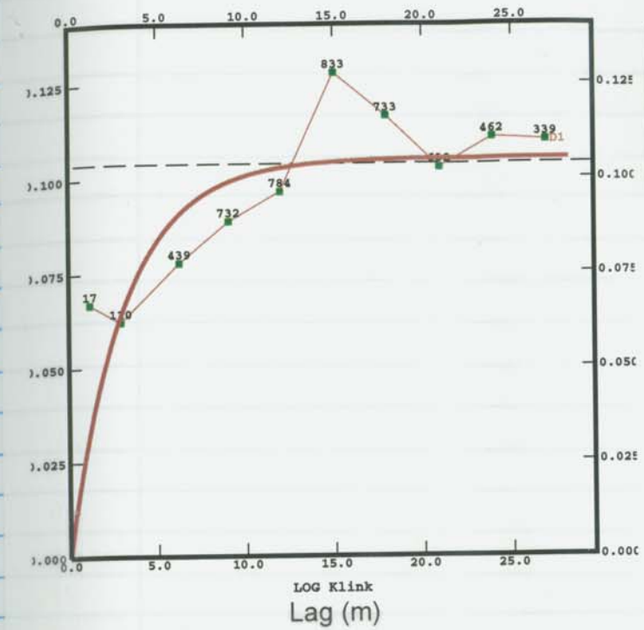
D1 - Az= 0.00, Ay= 0.00, Ax= 0.00
Angular tolerance = 90.00
Lag = 3m, Tolerance = 50.00%, Count = 10

Model : 1 basic structure(s)

S1 - Exponential - Scale = 4.4831724m
Sill = 0.0213

3/31/02 WI

3/31/02 Fitted Variograms



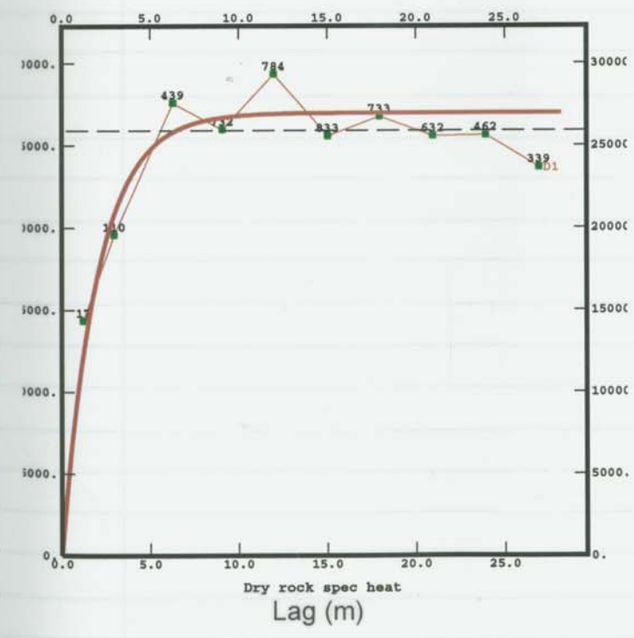
Variogram Fitting

Experimental Variogram(s) : 1 direction(s)

D1 - Az= 0.00, Ay= 0.00, Ax= 0.00
Angular tolerance = 90.00
Lag = 3m, Tolerance = 50.00%, Count = 10

Model : 1 basic structure(s)

S1 - Exponential - Scale = 9.5m
Sill = 0.1053



Variogram Fitting

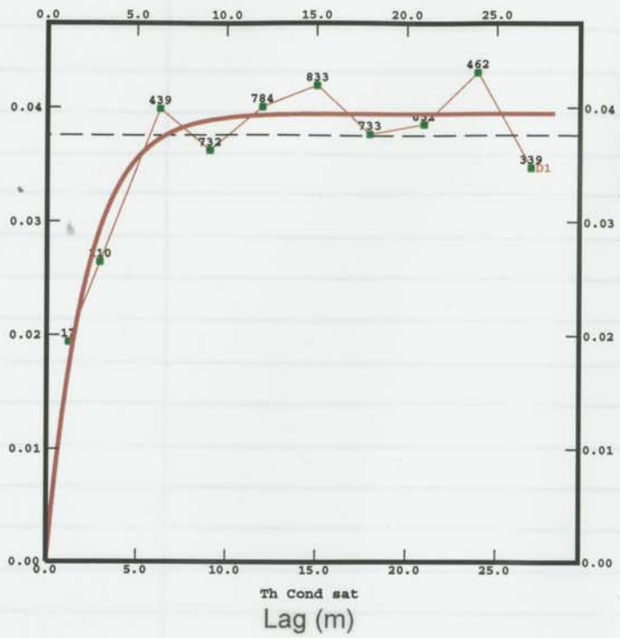
Experimental Variogram(s) : 1 direction(s)

D1 - Az= 0.00, Ay= 0.00, Ax= 0.00
Angular tolerance = 90.00
Lag = 3m, Tolerance = 50.00%, Count = 10

Model : 1 basic structure(s)

S1 - Exponential - Scale = 6m
Sill = 26975.6262

3/31/02 WI



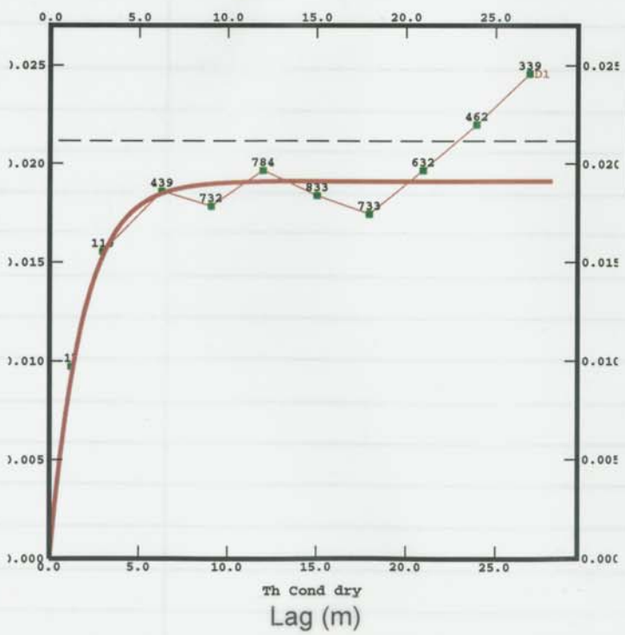
Variogram Fitting

Experimental Variogram(s) : 1 direction(s)

D1 - Az= 0.00, Ay= 0.00, Ax= 0.00
Angular tolerance = 90.00
Lag = 3m, Tolerance = 50.00%, Count = 10

Model : 1 basic structure(s)

S1 - Exponential - Scale = 6.5m
Sill = 0.0395



Variogram Fitting

Experimental Variogram(s) : 1 direction(s)

D1 - Az= 0.00, Ay= 0.00, Ax= 0.00
Angular tolerance = 90.00
Lag = 3m, Tolerance = 50.00%, Count = 10

Model : 1 basic structure(s)

S1 - Exponential - Scale = 5.5m
Sill = 0.0191

3/31/02 WI

Geostatistical Analysis

(1) Results and draft report were submitted to Debra Hughson late November. All tables were completed on time and within budget.

(2) As the submitted deliverable was a draft, figures have not been modified at that time so that it would conform with CNWRA deliverable standards: RWF for WI 10/1/02
→ numbers on axes are too small
→ values are given on all 4 ~~axes~~ sides WI 3/31/02

(3) Much of the effort was expended on writing the draft deliverable and refining the tests. RWF for WI 10/1/02

(4) Recent work included ~~a~~ incorporation of additional material by Randy Fedors and Cynthia Drivoddie of the CNWRA. Those authors have made a significant contribution in associating the ARS data with Yucca Mtn.

3/31/02 WI

3/31/02

Spreadsheet employed to calculate the geom/arith mean of LOG10 ka, kw values from the laboratory and the field

Field ka	LOG10 ka	Field kw	LOG10 kw	Lab ka	LOG10 ka	Lab kw	LOG10 kw
4.73E-16	-1.53E+01	3.00E-16	-1.55E+01	8.43E-15	-1.41E+01	1.46E-15	-1.48E+01
2.13E-16	-1.57E+01	3.68E-17	-1.64E+01	1.51E-15	-1.48E+01	4.80E-16	-1.53E+01
6.63E-15	-1.42E+01	2.97E-16	-1.55E+01	1.36E-15	-1.49E+01	2.24E-16	-1.56E+01
1.00E-16	-1.60E+01	1.06E-16	-1.60E+01	5.35E-16	-1.53E+01	1.23E-16	-1.59E+01
5.44E-17	-1.63E+01	1.16E-16	-1.59E+01	4.40E-16	-1.54E+01	1.02E-16	-1.60E+01
2.54E-15	-1.46E+01	5.92E-15	-1.42E+01	4.17E-16	-1.54E+01	1.41E-16	-1.59E+01
7.92E-17	-1.61E+01	5.74E-16	-1.52E+01	3.98E-16	-1.54E+01	1.50E-16	-1.58E+01
1.59E-15	-1.48E+01	4.42E-16	-1.54E+01	2.55E-14	-1.36E+01	1.49E-14	-1.38E+01
6.61E-14	-1.32E+01	2.62E-15	-1.46E+01	1.71E-15	-1.48E+01	3.43E-16	-1.55E+01
1.37E-15	-1.49E+01	1.94E-15	-1.47E+01	1.35E-15	-1.49E+01	4.57E-16	-1.53E+01
9.83E-16	-1.50E+01	8.75E-16	-1.51E+01	8.19E-16	-1.51E+01	7.05E-17	-1.62E+01
2.06E-15	-1.47E+01	1.27E-15	-1.49E+01	6.03E-16	-1.52E+01	2.51E-16	-1.56E+01
1.59E-16	-1.58E+01	1.96E-16	-1.57E+01	2.50E-15	-1.46E+01	1.61E-15	-1.48E+01
1.98E-16	-1.57E+01	4.87E-16	-1.53E+01	2.04E-15	-1.47E+01	1.14E-15	-1.49E+01
9.87E-17	-1.60E+01	9.81E-17	-1.60E+01	6.63E-15	-1.42E+01	3.84E-15	-1.44E+01
3.97E-15	-1.44E+01	2.07E-15	-1.47E+01	9.94E-16	-1.50E+01	4.94E-16	-1.53E+01
9.18E-15	-1.40E+01	2.54E-15	-1.46E+01	1.35E-15	-1.49E+01	6.75E-16	-1.52E+01
1.44E-15	-1.48E+01	1.32E-15	-1.49E+01	1.52E-15	-1.48E+01	8.31E-16	-1.51E+01
1.79E-16	-1.57E+01	4.10E-16	-1.54E+01	6.51E-16	-1.52E+01	2.79E-16	-1.56E+01
9.90E-17	-1.60E+01	7.05E-17	-1.62E+01	3.07E-15	-1.45E+01	7.04E-16	-1.52E+01
2.21E-16	-1.57E+01	3.46E-16	-1.55E+01	1.27E-15	-1.49E+01	4.70E-16	-1.53E+01
8.30E-17	-1.61E+01	2.09E-16	-1.57E+01	2.76E-15	-1.46E+01	3.75E-16	-1.54E+01
8.32E-17	-1.61E+01	4.98E-16	-1.53E+01	1.63E-15	-1.48E+01	2.81E-16	-1.56E+01
6.75E-17	-1.62E+01	1.14E-16	-1.59E+01	2.17E-15	-1.47E+01	2.74E-16	-1.56E+01
1.33E-15	-1.49E+01	2.92E-16	-1.55E+01	1.48E-15	-1.48E+01	3.17E-16	-1.55E+01
2.87E-16	-1.55E+01	1.98E-16	-1.57E+01	9.92E-16	-1.50E+01	4.75E-16	-1.53E+01
1.66E-15	-1.48E+01	2.76E-17	-1.66E+01	9.51E-16	-1.50E+01	5.71E-16	-1.52E+01
1.60E-16	-1.58E+01	4.40E-16	-1.54E+01	6.30E-16	-1.52E+01	2.98E-16	-1.55E+01
5.18E-17	-1.63E+01	1.51E-16	-1.58E+01	6.00E-16	-1.52E+01	3.32E-16	-1.55E+01
3.40E-16	-1.55E+01	1.37E-16	-1.59E+01	5.27E-16	-1.53E+01	2.56E-16	-1.56E+01
3.43E-16	-1.55E+01	1.29E-16	-1.59E+01	6.01E-16	-1.52E+01	2.09E-16	-1.57E+01
2.09E-16	-1.57E+01	1.08E-16	-1.60E+01	9.04E-16	-1.50E+01	5.16E-16	-1.53E+01
1.92E-16	-1.57E+01	5.25E-15	-1.43E+01	7.20E-16	-1.51E+01	3.82E-16	-1.54E+01
9.69E-17	-1.60E+01	5.96E-16	-1.52E+01	8.50E-16	-1.51E+01	4.43E-16	-1.54E+01
5.10E-15	-1.43E+01	5.11E-16	-1.53E+01	5.20E-16	-1.53E+01	2.17E-16	-1.57E+01
4.21E-16	-1.54E+01	1.28E-15	-1.49E+01	6.59E-16	-1.52E+01	1.77E-16	-1.58E+01
1.10E-15	-1.50E+01	4.27E-15	-1.44E+01	3.52E-15	-1.45E+01	4.71E-16	-1.53E+01
1.65E-15	-1.48E+01	1.48E-15	-1.48E+01	1.78E-15	-1.47E+01	3.66E-16	-1.54E+01
1.68E-14	-1.38E+01	9.15E-16	-1.50E+01	6.02E-16	-1.52E+01	1.13E-16	-1.59E+01
1.57E-15	-1.48E+01	3.63E-16	-1.54E+01	6.56E-16	-1.52E+01	1.04E-16	-1.60E+01
3.45E-16	-1.55E+01	2.20E-16	-1.57E+01	4.99E-16	-1.53E+01	1.47E-16	-1.58E+01
4.46E-16	-1.54E+01	2.20E-16	-1.57E+01	6.18E-16	-1.52E+01	2.45E-16	-1.56E+01
6.55E-17	-1.62E+01	3.48E-15	-1.45E+01	6.01E-15	-1.42E+01	1.65E-15	-1.48E+01
9.70E-17	-1.60E+01	1.34E-15	-1.49E+01	1.42E-14	-1.38E+01	1.83E-15	-1.47E+01
7.82E-15	-1.41E+01	2.98E-15	-1.45E+01	1.56E-15	-1.48E+01	2.27E-16	-1.56E+01
1.54E-15	-1.48E+01	3.12E-15	-1.45E+01	2.51E-15	-1.46E+01	2.94E-16	-1.55E+01
1.91E-15	-1.47E+01	2.23E-15	-1.47E+01	5.88E-16	-1.52E+01	2.04E-16	-1.57E+01
1.86E-15	-1.47E+01	3.98E-16	-1.54E+01	2.10E-15	-1.47E+01	1.12E-15	-1.50E+01
5.41E-16	-1.53E+01	3.33E-16	-1.55E+01	9.74E-16	-1.50E+01	3.71E-16	-1.54E+01
1.09E-16	-1.60E+01	4.93E-16	-1.53E+01	1.25E-14	-1.39E+01	8.44E-15	-1.41E+01

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	1.85E-16	-1.57E+01	3.26E-16	-1.55E+01	8.39E-16	-1.51E+01	4.29E-16	-1.54E+01
	2.71E-16	-1.56E+01	5.80E-16	-1.52E+01	7.81E-16	-1.51E+01	4.34E-16	-1.54E+01
	1.35E-16	-1.59E+01	1.91E-16	-1.57E+01	7.26E-16	-1.51E+01	3.62E-16	-1.54E+01
	3.01E-16	-1.55E+01	1.68E-16	-1.58E+01	9.85E-16	-1.50E+01	4.76E-16	-1.53E+01
	1.45E-16	-1.58E+01	9.60E-17	-1.60E+01	2.72E-15	-1.46E+01	5.88E-16	-1.52E+01
	1.04E-16	-1.60E+01	5.41E-17	-1.63E+01	8.84E-15	-1.41E+01	1.08E-15	-1.50E+01
	7.09E-17	-1.61E+01	9.80E-15	-1.40E+01	1.74E-14	-1.38E+01	3.19E-15	-1.45E+01
	4.58E-17	-1.63E+01	2.63E-15	-1.46E+01	7.40E-14	-1.31E+01	2.45E-14	-1.36E+01
	1.65E-14	-1.38E+01	4.43E-14	-1.34E+01	1.05E-15	-1.50E+01	1.43E-16	-1.58E+01
	1.79E-14	-1.37E+01	4.24E-15	-1.44E+01	1.01E-13	-1.30E+01	4.48E-14	-1.33E+01
	6.62E-13	-1.22E+01	1.95E-12	-1.17E+01	4.20E-15	-1.44E+01	1.36E-15	-1.49E+01
	1.20E-14	-1.39E+01	2.82E-16	-1.55E+01	6.91E-16	-1.52E+01	3.77E-16	-1.54E+01
	4.73E-17	-1.63E+01	2.00E-16	-1.57E+01	5.25E-16	-1.53E+01	4.33E-16	-1.54E+01
	8.29E-17	-1.61E+01	2.74E-15	-1.46E+01	6.30E-16	-1.52E+01	2.69E-16	-1.56E+01
	8.71E-15	-1.41E+01	1.00E-14	-1.40E+01	7.92E-16	-1.51E+01	4.31E-16	-1.54E+01
	2.45E-14	-1.36E+01	3.12E-15	-1.45E+01	8.49E-16	-1.51E+01	3.72E-16	-1.54E+01
	1.94E-15	-1.47E+01	8.68E-15	-1.41E+01	5.49E-16	-1.53E+01	2.10E-16	-1.57E+01
	3.77E-14	-1.34E+01	5.26E-15	-1.43E+01	9.95E-16	-1.50E+01	4.02E-16	-1.54E+01
	2.37E-14	-1.36E+01	1.75E-15	-1.48E+01	8.21E-16	-1.51E+01	4.10E-16	-1.54E+01
	2.34E-16	-1.56E+01	6.72E-16	-1.52E+01	3.81E-16	-1.54E+01	1.47E-16	-1.58E+01
	6.17E-15	-1.42E+01	4.28E-16	-1.54E+01	2.86E-15	-1.45E+01	5.61E-16	-1.53E+01
	4.95E-15	-1.43E+01	6.89E-16	-1.52E+01	1.95E-15	-1.47E+01	3.56E-16	-1.54E+01
	2.03E-16	-1.57E+01	5.76E-16	-1.52E+01	3.55E-14	-1.34E+01	1.06E-14	-1.40E+01
	2.95E-16	-1.55E+01	1.08E-15	-1.50E+01	5.31E-15	-1.43E+01	4.60E-16	-1.53E+01
	3.89E-16	-1.54E+01	1.26E-15	-1.49E+01	1.01E-15	-1.50E+01	2.44E-16	-1.56E+01
	4.40E-16	-1.54E+01	2.09E-15	-1.47E+01	1.20E-14	-1.39E+01	2.63E-15	-1.46E+01
	5.95E-15	-1.42E+01	7.26E-16	-1.51E+01	2.60E-15	-1.46E+01	2.67E-16	-1.56E+01
	3.48E-16	-1.55E+01	3.28E-16	-1.55E+01	8.56E-16	-1.51E+01	1.47E-16	-1.58E+01
	1.34E-16	-1.59E+01	1.40E-15	-1.49E+01	1.19E-15	-1.49E+01	3.05E-16	-1.55E+01
	3.42E-15	-1.45E+01	3.62E-15	-1.44E+01	5.16E-15	-1.43E+01	1.68E-15	-1.48E+01
	1.23E-14	-1.39E+01	5.79E-16	-1.52E+01	1.03E-15	-1.50E+01	4.88E-16	-1.53E+01
	1.40E-15	-1.49E+01	3.51E-13	-1.25E+01	1.02E-14	-1.40E+01	5.57E-15	-1.43E+01
	7.90E-16	-1.51E+01	4.56E-16	-1.53E+01	9.16E-14	-1.30E+01	3.84E-14	-1.34E+01
	1.92E-16	-1.57E+01	**2.97E-14**	**-1.51E+01**	8.97E-15	-1.40E+01	9.88E-16	-1.50E+01
	1.34E-12	-1.19E+01		**7.89E-16**	1.29E-15	-1.49E+01	4.36E-16	-1.54E+01
	9.60E-17	-1.60E+01			1.18E-15	-1.49E+01	3.58E-16	-1.54E+01
Arith mean	**2.71E-14**	**-1.51E+01**			6.14E-16	-1.52E+01	2.13E-16	-1.57E+01
Geo mean		**7.75E-16**			1.23E-15	-1.49E+01	4.57E-16	-1.53E+01
					2.41E-15	-1.46E+01	8.31E-16	-1.51E+01
					1.02E-15	-1.50E+01	1.37E-16	-1.59E+01
					2.09E-15	-1.47E+01	6.69E-16	-1.52E+01
					3.38E-14	-1.35E+01	1.94E-14	-1.37E+01
					9.23E-15	-1.40E+01	5.31E-15	-1.43E+01
					7.92E-16	-1.51E+01	2.41E-16	-1.56E+01
					2.82E-15	-1.45E+01	1.60E-15	-1.48E+01
					5.50E-15	-1.43E+01	2.03E-15	-1.47E+01
					1.08E-15	-1.50E+01	4.16E-16	-1.54E+01
					7.66E-16	-1.51E+01	3.38E-16	-1.55E+01
					8.24E-16	-1.51E+01	4.93E-16	-1.53E+01
					1.02E-15	-1.50E+01	4.92E-16	-1.53E+01
					9.14E-16	-1.50E+01	3.80E-16	-1.54E+01
					2.37E-15	-1.46E+01	6.35E-16	-1.52E+01

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1.35E-15	-1.49E+01	5.81E-16	-1.52E+01
1.83E-15	-1.47E+01	6.27E-16	-1.52E+01
1.21E-15	-1.49E+01	4.40E-16	-1.54E+01
5.71E-15	**-1.48E+01**	**2.18E-15**	**-1.52E+01**
	1.77E-15		**5.66E-16**

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LAST ENTRY
RWF 9/30/02

I have reviewed this scientific notebook and find it in agreement with QAP-001. There is sufficient information regarding methods used for conducting tests, acquiring and analyzing data so that another qualified individual could repeat the activity.

R. C. Pen
10/1/02