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National Measurement Institute

Proficiency Test Report AQA 20-07 Trace Elements in Potable Water

September 2020

ACKNOWLEDGMENTS

This study was conducted by the National Measurement Institute (NMI). Support funding was provided by the Australian Government Department of Industry, Science, Energy and Resources.

I would like to thank the management and staff of the participating laboratories for supporting the study. It is only through widespread participation that we can provide an effective service to laboratories.

The assistance of the following NMI staff members in the planning, conducting and reporting of the study is acknowledged.

Luminita Antin

Andrew Evans

Hamish Lenton

Ping Di

I would also like to thank Simon Mills from Envirolab for reviewing this report.

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Accredited for compliance with ISO/IEC 17043

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1 SUMMARY

This report presents the results of the proficiency test AQA 20-07, Trace Elements in Potable Water. The study focused on the measurement of total: Al, As, Ba, Be, Bi, Cd, Co, Cr, Cs, Cu, Fe, Hg, La, Li, Mn, Mo, Ni, Pb, Sb, Se, Sn, Sr, Th, Tl, U, V and Zn.

The sample set consisted of two water samples.

Seventeen laboratories registered to participate and sixteen submitted results.

The assigned values were the robust average of participants' results. The associated uncertainties were estimated from the robust standard deviation of the participants' results.

The outcomes of the study were assessed against the aims as follows, to:

i. compare the performance of participant laboratories and assess their accuracy;

Laboratory performance was assessed using both z-scores and E_n-scores.

Of 430 z-scores, 410 (95%) returned a satisfactory score of $|z| \leq 2.0$.
Of 430 E_n-scores, 376 (87%) returned a satisfactory score of $|E_n| \leq 1.0$.

ii. evaluate the laboratories' methods used in determination of total elements in potable water;

Rounding of results and reporting results with an insufficient number of significant figures was one of the main causes for participants' poor performance.

iii. evaluate within laboratory precision-repeatability;

In some cases, the reported results and the expanded measurement uncertainty in the two study samples are significantly different.

iv. compare the performance of participant laboratories with their past performance;

On average, participants' performance in potable water has remained consistent over time.

v. develop the practical application of traceability and measurement uncertainty and provide participants with information that will be useful in assessing their uncertainty estimates;

Of 430 numerical results, 408 (95%) were reported with an expanded measurement uncertainty. An example of estimating measurement uncertainty using only the proficiency testing data is given in Appendix 3.

vi. produce materials that can be used in method validation and as control samples.

The study samples were checked for homogeneity and are well characterised, both by in-house testing and from the results of the proficiency round. Surplus test samples are available for sale.

2 INTRODUCTION

2.1 NMI Proficiency Testing Program

The National Measurement Institute (NMI) is responsible for Australia's national measurement infrastructure providing a wide range of services, including a chemical proficiency testing program.

Proficiency testing (PT) "is evaluation of participant performance against pre-established criteria by means of inter-laboratory comparison."[1] NMI PT studies target chemical testing in areas of high public significance such as trade, environment and food safety. NMI offers studies in:

- inorganic analytes in soil, water, food and pharmaceuticals;
- pesticide residues in fruit and vegetables, soil and water;
- petroleum hydrocarbons in soil and water;
- PFAS in water, soil, biota and food;
- allergens in food;
- controlled drug assay; and
- folic acid in flour.

AQA 20-07 is the 26th NMI proficiency study of inorganic analytes in water.

2.2 Study Aims

The aims of the study were to:

- compare the performance of participant laboratories and assess their accuracy;
- evaluate the laboratories' methods used in determination of total elements in potable water;
- evaluate within laboratory precision repeatability;
- compare the performance of participant laboratories with their past performance;
- develop the practical application of traceability and measurement uncertainty; and
- produce materials that can be used in method validation and as control samples.

2.3 Study Conduct

The conduct of NMI proficiency tests is described in the NMI Chemical Proficiency Testing Study Protocol.[2] The statistical methods used are described in the NMI Chemical Proficiency Statistical Manual.[3] These documents have been prepared with reference to ISO Standard 17043[1] and The International Harmonized Protocol for Proficiency Testing of (Chemical) Analytical Laboratories.[4]

NMI is accredited by National Association of Testing Authorities, Australia (NATA) to ISO/IEC 17043 as a provider of proficiency testing schemes. This proficiency test is within the scope of NMI's accreditation.

The choice of the test method was left to the participating laboratories.

3 STUDY INFORMATION

3.1 Selection of Matrices and Inorganic Analytes

The thirty-two tests were selected from those for which an investigation level is published in the Australian Drinking Water Guidelines[5] and are commonly measured by water testing laboratories.

3.2 Participation

Seventeen laboratories participated and sixteen submitted results.

The timetable of the study was:

Invitation issued:	4 May 2020
Samples dispatched:	25 May 2020
Results due:	23 June 2020
Interim report issued:	24 June 2020

3.3 Test Material Specification

Two samples were provided for analysis:

Samples S1 and S2 were the same unfiltered potable water spiked for 27 elements and preserved by adding 2% (v/w) HNO_3 and 0.01% (v/w) HCl.

3.4 Laboratory Code

All participant laboratories were assigned a confidential code number.

3.5 Sample Preparation, Analysis and Homogeneity Testing

The same preparation procedure was followed as in previous studies. A partial homogeneity test was conducted for all elements in Samples S1 and S2.[1] The test samples from previous studies were demonstrated to be sufficiently homogeneous for the evaluation of participants' performance. Results from partial homogeneity testing are reported in this study as homogeneity values.

The preparation, analysis and homogeneity testing of the study samples are described in Appendix 1. In the present study, the test samples were demonstrated to be sufficiently homogeneous for all of the analytes assessed.

3.6 Stability of Analytes

No stability study was carried out for samples S1 and S2. Stability studies conducted for previous proficiency studies of metals in water found no significant changes in any of the analytes' concentration.

3.7 Sample Storage, Dispatch and Receipt

Samples S1 and S2 were refrigerated before dispatch.

The samples were dispatched by courier on 25 May 2020.

A description of the test samples, instructions for participants, and a form for participants to confirm the receipt of the test samples were sent with the samples.

An Excel spreadsheet for the electronic reporting of results was e-mailed to participants.

3.8 Instructions to Participants

Participants were instructed as follows:

- Quantitatively analyse the samples using your normal test method.
- Participants are asked to report results in units of mg/L for:

SAMPLE S1 unfiltered, acidified potable water		SAMPLE S2 unfiltered, acidified potable water	
Test Total	**Maximum Level mg/L**	**Test Total**	**Maximum Level mg/L**
As	<0.02	Al	<0.25
Be	<0.02	As	<0.010
Cd	<0.01	Ba	<0.25
Cr	<0.02	Bi	<0.02
Cu	<1	Co	<0.01
Hg	<0.005	Cs	<0.02
Mn	<0.5	Fe	<0.5
Mo	<0.02	Hg	<0.0025
Ni	<0.02	La	<0.05
Pb	<0.02	Li	<0.05
Sb	<0.010	Mn	<0.75
Se	<0.010	Se	<0.010
Sn	<0.010	Sr	<0.5
Tl	<0.010	Th	<0.020
V	<0.020	Tl	<0.010
Zn	<2.5	U	<0.020

- Report results using the electronic results sheet emailed to you.
- Report results as you would report to a client. For each analyte in each sample, report the expanded measurement uncertainty associated with your analytical result (e.g. 5.23 ± 0.51 mg/L).
- Please send us the requested details regarding the test method and the basis of your uncertainty estimate.

3.9 Interim Report

An interim report was emailed to participants on 24 June 2020.

4 PARTICIPANT LABORATORY INFORMATION

4.1 Test Method Summaries

Summaries of test methods for total elements are transcribed in Table 1. The instruments and settings reported by participants are presented in Appendix 5.

Table 1 Methodology for Total Elements

Lab. Code	Method Reference	Sample Volume (mL)	Temp. (°C)	Time (min)	Vol. HNO_3 (mL)	Vol. HCl (mL)
1*	APHA Method 3030 E; US EPA Method 245.7 (Hg)	10	100	60	0.5	
2	In house W32 referencing APHA 3125					
4	200.7-8					
5	USEPA 3005	10	95	120	0.5	
6	US-EPA 6010B, US-EPA 6020	30	95	90	3	1
8		40	100	480	2	
9	USEPA Method 3005A	10	95	120	0.2	0.5
10		30	95-100	90	2	
11	USEPA SW846 and in house	10	95	120	0.5	
12*	ASNZS 40:20 Appendix H Metals					
13	USEPA 200.8					
15	USEPA Method 3050B	50	85	120	1	1
16	6020					
17	APHA 3125; USEPA SW846 - 6020	1				
18	USEPA6020	10	95	90	0.2	0.3

*Additional Information in Table 2

4.2 Additional Information

Participants had the option to report additional information for each sample analysed. These are transcribed in Table 2.

Table 2 Additional Information

Lab Code	Additional Information
1	Methodology for Total Elements: Digestion for Hg only: Sample Volume 2 mL, Regent 8 mL H2O, 1.5 mL of 33% HCl and 0.2 mL 0.1 N Potassium Bromide/potassium bromate solution
12	Methodology for Total Elements: This method does not require digestion S1 and S2: These PT samples are being used as part of our validation/method development that is currently being finalised. Instrumental Techniques: Reaction Cell + Reaction gas, where UC are NA Standard mode was used with Ar.
13	Instrumental Techniques: Where either H2 or O2 is selected for the Gas a mix of H2 and N2O was used.

4.3 Basis of Participants' Measurement Uncertainty Estimates

Participants were requested to provide information about the basis of their uncertainty estimates (Table 3).

Table 3 Basis of Uncertainty Estimate

Lab. Code	Approach to Estimating MU	Information Sources for MU Estimation[a]		Guide Document for Estimating MU
		Precision	Method Bias	
1	Standard deviation of replicate analyses multiplied by 2 or 3	Control Samples – SS Duplicate Analysis Instrument Calibration	Instrument Calibration Laboratory Bias from PT Studies Recoveries of SS	Eurachem/CITAC Guide
2	Top Down – precision and estimates of the method and laboratory bias	Control Samples – CRM Duplicate Analysis	CRM Instrument Calibration Standard Purity	Nordtest Report TR537
3	Top Down – precision and estimates of the method and laboratory bias	Control Samples – CRM Duplicate Analysis	CRM	NMI Uncertainty Course
4	Top Down – precision and estimates of the method and laboratory bias	Control Samples – CRM Duplicate Analysis	CRM Recoveries of SS	Top Down Approach
5	Bottom Up (ISO/GUM, fish bone/ cause and effect diagram)	Control Samples Duplicate Analysis Instrument Calibration	CRM Instrument Calibration Laboratory Bias from PT Studies Standard Purity Recoveries of SS	ISO/GUM
6	Bottom Up (ISO/GUM, fish bone/ cause and effect diagram)	Control Samples – CRM Duplicate Analysis	CRM Instrument Calibration Recoveries of SS	ISO/GUM
8	Standard deviation of replicate analyses multiplied by 2 or 3	Control Samples – CRM Duplicate Analysis	CRM	ISO/GUM
9	Top Down – precision and estimates of the method and laboratory bias	Control Samples – CRM Duplicate Analysis	CRM	Eurachem/CITAC Guide
10	Top Down – precision and estimates of the method and laboratory bias	Control Samples – SS Duplicate Analysis	Instrument Calibration Recoveries of SS	Nordtest Report TR537
11	Top Down – precision and estimates of the method and laboratory bias	Control Samples – SS Duplicate Analysis	CRM Instrument Calibration	Eurachem/CITAC Guide
12		Control Samples – RM Instrument Calibration		
13	Top Down – precision and estimates of the method and laboratory bias	Control Samples – CRM	CRM Recoveries of SS	NATA Technical Note 33
15	Standard deviation of replicate analyses multiplied by 2 or 3	Control Samples – SS Duplicate Analysis	Recoveries of SS	NATA Technical Note 33
16	Standard deviation of replicate analyses multiplied by 2 or 3	Control Samples – CRM Duplicate Analysis	CRM	Eurachem/CITAC Guide
17	Top Down – precision and estimates of the method and laboratory bias	Control Samples – RM Duplicate Analysis Instrument Calibration		NATA Technical Note 33
18	Bottom Up (ISO/GUM, fish bone/ cause and effect diagram)	Control Samples – RM Duplicate Analysis Instrument Calibration	Instrument Calibration Recoveries of SS	Eurachem/CITAC Guide

[a]RM = Reference Material, CRM = Certified Reference Material, SS =Spiked samples.

4.4 Participant Comments on this PT Study or Suggestions for Future Studies

The study co-ordinator welcomes comments or suggestions from participants about this study or possible future studies. Such feedback may be useful in improving future studies.

There were no comments from participants on this study.

5 PRESENTATION OF RESULTS AND STATISTICAL ANALYSIS

5.1 Results Summary

Participant results are listed in Tables 4 to 35 with resultant summary statistics: robust average, median, maximum, minimum, robust standard deviation (SD_{rob}) and robust coefficient of variation (CV_{rob}). Bar charts of results and performance scores are presented in Figures 2 to 33. An example chart with interpretation guide is shown in Figure 1.

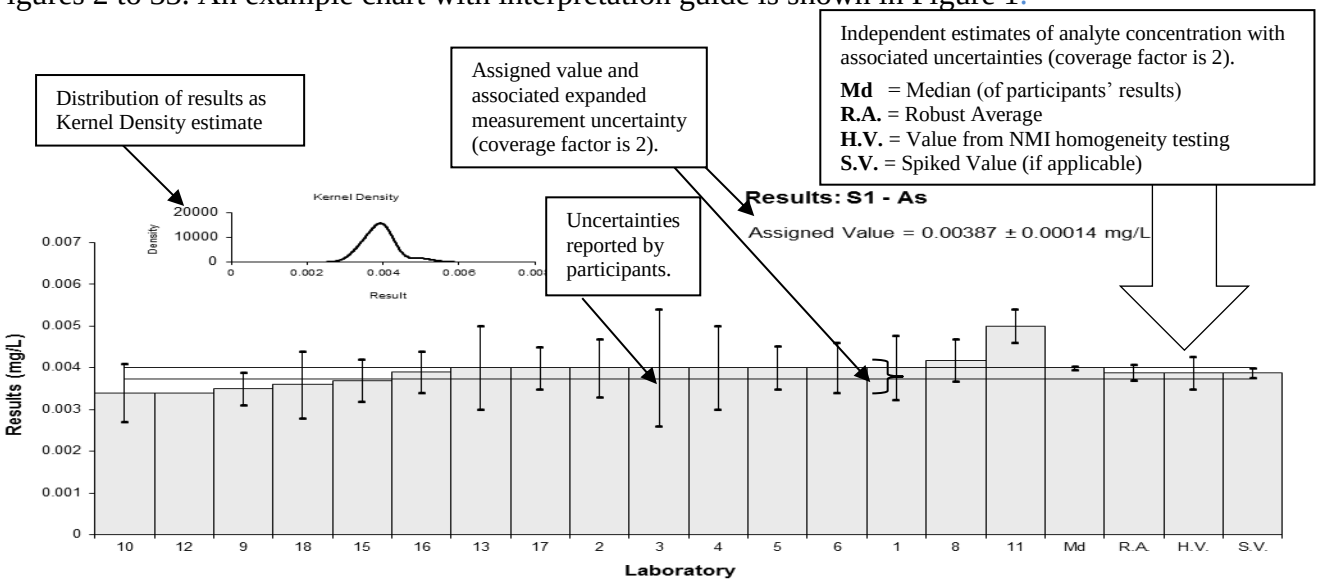


Figure 1 Guide to Presentation of Results

5.2 Assigned Value

An example of the assigned value calculation using data from the present study is given in Appendix 2. The assigned value is defined as: 'the value attributed to a particular property of a proficiency test item'.[1] In this study the property is the mass concentration of analyte. Assigned values were the robust average of participants' results; the expanded uncertainties were estimated from the associated robust standard deviations.

5.3 Robust Average

The robust averages and associated expanded measurement uncertainties were calculated using the procedure described in 'Statistical methods for use in proficiency testing by inter-laboratory comparisons, ISO13528:2015(E)'.[6]

5.4 Robust Between-Laboratory Coefficient of Variation

The robust between-laboratory coefficient of variation (robust CV) is a measure of the variability of participants' results and was calculated using the procedure described in ISO13528:2015(E).[6]

5.5 Performance Coefficient of Variation (PCV)

The performance coefficient of variation (PCV) is a measure of the between laboratory variation that in the judgement of the study coordinator would be expected from participants. It is important to note that is not the coefficient of variation of participant results. The fixed value set for PCV is based on the existing regulation, the acceptance criteria indicated by the methods, the matrix, the concentration level of analyte and on experience from previous studies. It is backed up by mathematical models such as Thompson Horwitz equation.[7] By setting a fixed and realistic value for the PCV, the participant's performance does not depend on other participants' performance and can be compared from study to study and against achievable performance.

5.6 Target Standard Deviation

The target standard deviation (σ) is the product of the assigned value (*X)* and the performance coefficient of variation (PCV) as presented in Equation 1.

$$\sigma = (X) * PCV \qquad \text{Equation 1}$$

This value is used for calculation of participant z-scores and provides scaling for laboratory deviation from the assigned value.

5.7 z-Score

An example of z-score calculation using data from the present study is given in Appendix 2.

For each participant's result, a z-score is calculated according to Equation 2 below:

$$z = \frac{(\chi - X)}{\sigma} \qquad \text{Equation 2}$$

where:

z is z-score
χ is participants' result
X is the study assigned value
σ is the target standard deviation

A z-score with absolute value (|z|):

- $|z| \leq 2.0$ is satisfactory;
- $2.0 < |z| < 3.0$ is questionable;
- $|z| \geq 3.0$ is unsatisfactory.

5.8 E_n-Score

An example of E_n-score calculation using data from the present study is given in Appendix 2.

The E_n-score is complementary to the z-score in assessment of laboratory performance. E_n-score includes measurement uncertainty and is calculated according to Equation 3 below:

$$E_n = \frac{(\chi - X)}{\sqrt{U_{\chi}^2 + U_X^2}} \qquad \text{Equation 3}$$

where:

E_n is E_n-score
χ is participants' result
X is the study assigned value
U_{χ} is the expanded uncertainty of the participants' result
U_X is the expanded uncertainty of the assigned value

An E_n-score with absolute value ($|E_n|$):

- $|E_n| \leq 1.0$ is satisfactory;
- $|E_n| > 1.0$ is unsatisfactory.

5.9 Traceability and Measurement Uncertainty

Laboratories accredited to ISO/IEC Standard 17025:2018[8] must establish and demonstrate the traceability and measurement uncertainty associated with their test results. Guidelines for quantifying uncertainty in analytical measurement are described in the Eurachem/CITAC Guide.[9]

6 TABLES AND FIGURES

Table 4

Sample Details

Sample No.	S1
Matrix.	Potable Water
Analyte.	As
Units	mg/L

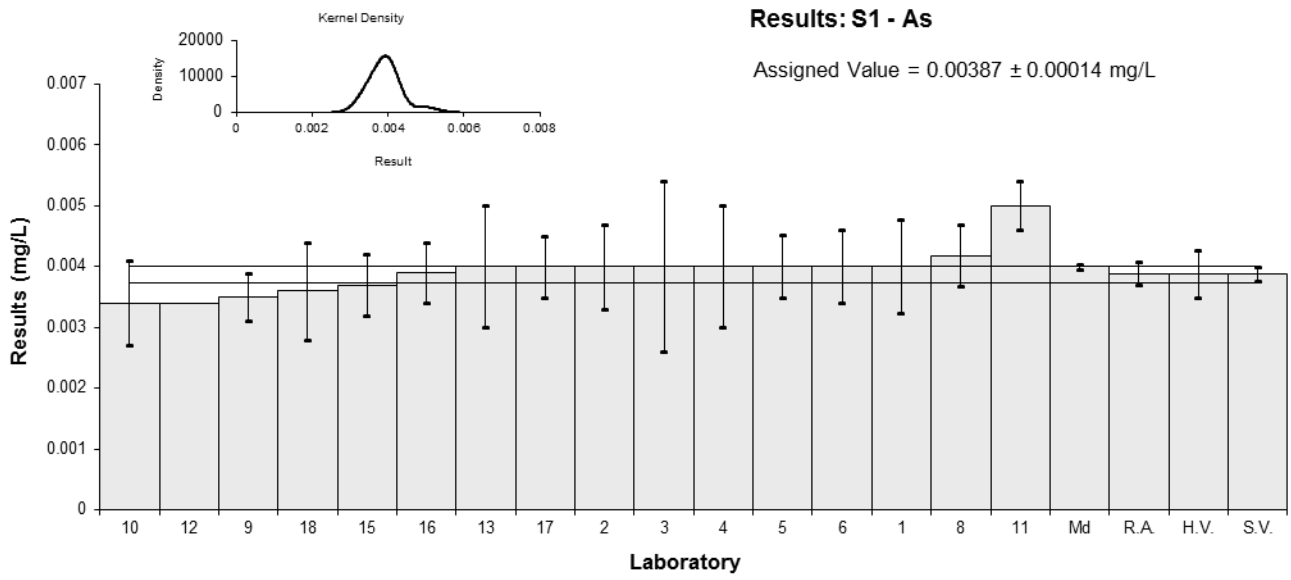
Participant Results

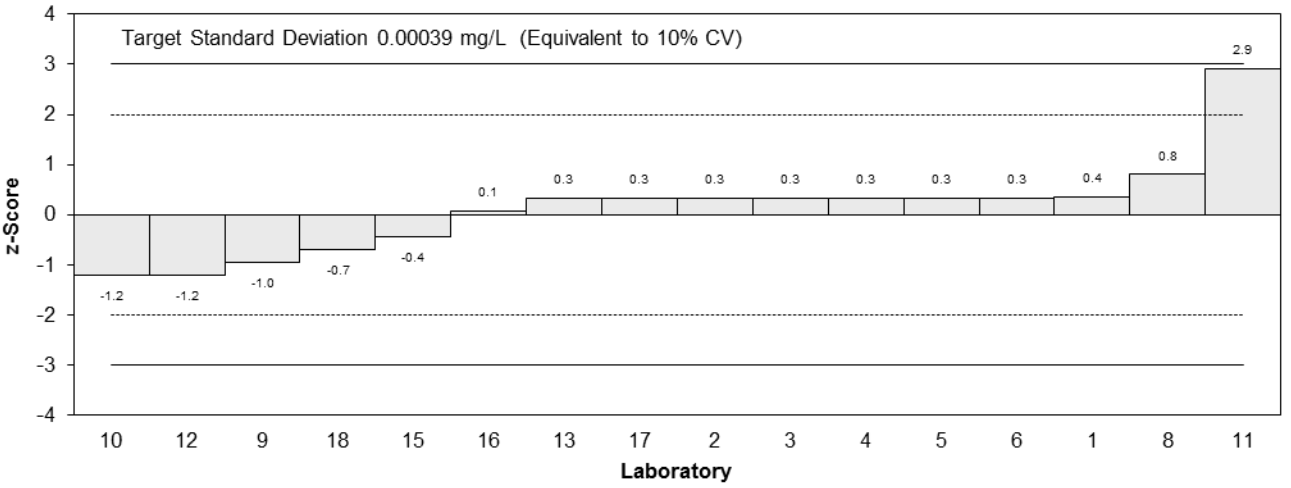
Lab Code	Result	Uncertainty	z-Score	E_n-Score
1	0.00401	0.00077	0.36	0.18
2	0.004	0.0007	0.34	0.18
3	0.004	0.0014	0.34	0.09
4	0.004	0.001	0.34	0.13
5	0.004	0.00052	0.34	0.24
6	0.0040	0.0006	0.34	0.21
8	0.00418	0.0005	0.80	0.60
9	0.0035	0.00039	-0.96	-0.89
10	0.0034	0.0007	-1.21	-0.66
11	0.005	0.0004	2.92	2.67
12	0.0034	NR	-1.21	-3.36
13	0.004	0.001	0.34	0.13
15	0.0037	0.0005	-0.44	-0.33
16	0.0039	0.0005	0.08	0.06
17	0.004	0.0005	0.34	0.25
18	0.0036	0.0008	-0.70	-0.33

Statistics

Assigned Value*	0.00387	0.00014
Spike	0.00388	0.00011
Homogeneity Value	0.00388	0.00039
Robust Average	0.00388	0.00019
Median	0.00400	0.00004
Mean	0.00392	
N	16	
Max.	0.005	
Min.	0.0034	
Robust SD	0.0003	
Robust CV	7.7%	

*The Assigned Value was calculated as the Robust Average of the combined results of Samples S1 and S2


Kernel Density
Density
20000
10000
0
0
0.002
0.004
0.006
0.008
Result
Results: S1 - As
Assigned Value = 0.00387 ± 0.00014 mg/L
Results (mg/L)
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0
10 12 9 18 15 16 13 17 2 3 4 5 6 1 8 11 Md R.A. H.V. S.V.
Laboratory


z-Scores: S1 - As
Target Standard Deviation 0.00039 mg/L (Equivalent to 10% CV)
z-Score
4
3
2
1
0
-1
-2
-3
-4
-1.2 -1.2 -1.0 -0.7 -0.4 0.1 0.3 0.3 0.3 0.3 0.3 0.3 0.3 0.4 0.8 2.9
10 12 9 18 15 16 13 17 2 3 4 5 6 1 8 11
Laboratory

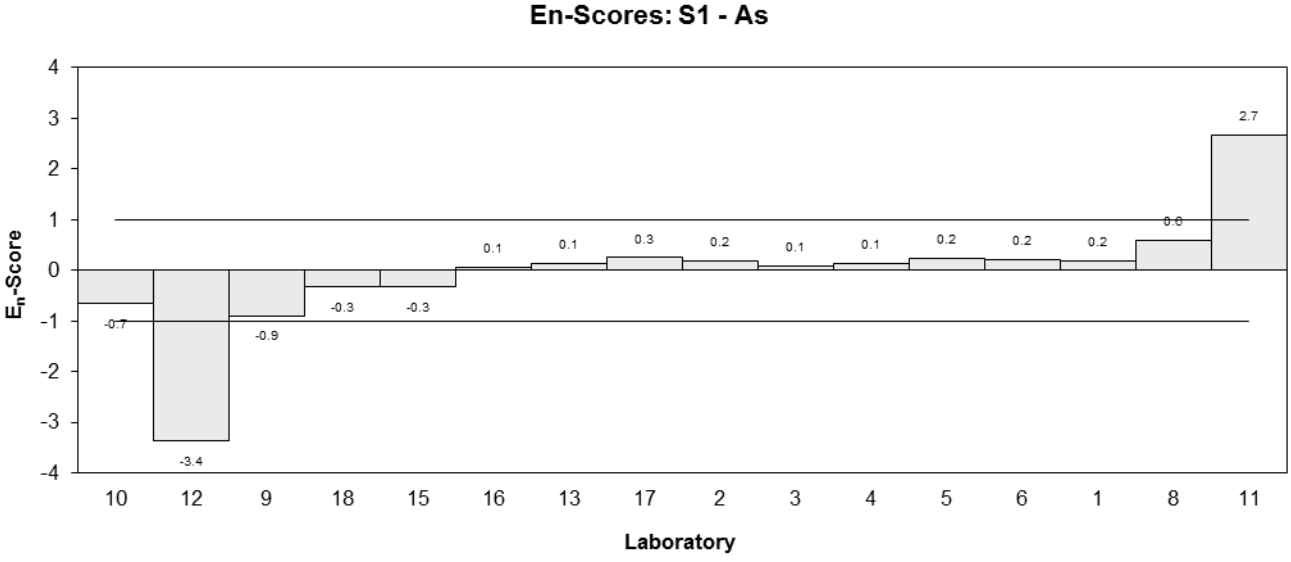

En-Scores: S1 - As
En-Score
4
3
2
1
0
-1
-2
-3
-4
-0.7 -3.4 -0.9 -0.3 -0.3 0.1 0.1 0.3 0.2 0.1 0.1 0.2 0.2 0.2 0.6 2.7
10 12 9 18 15 16 13 17 2 3 4 5 6 1 8 11
Laboratory

Figure 2

Table 5

Sample Details

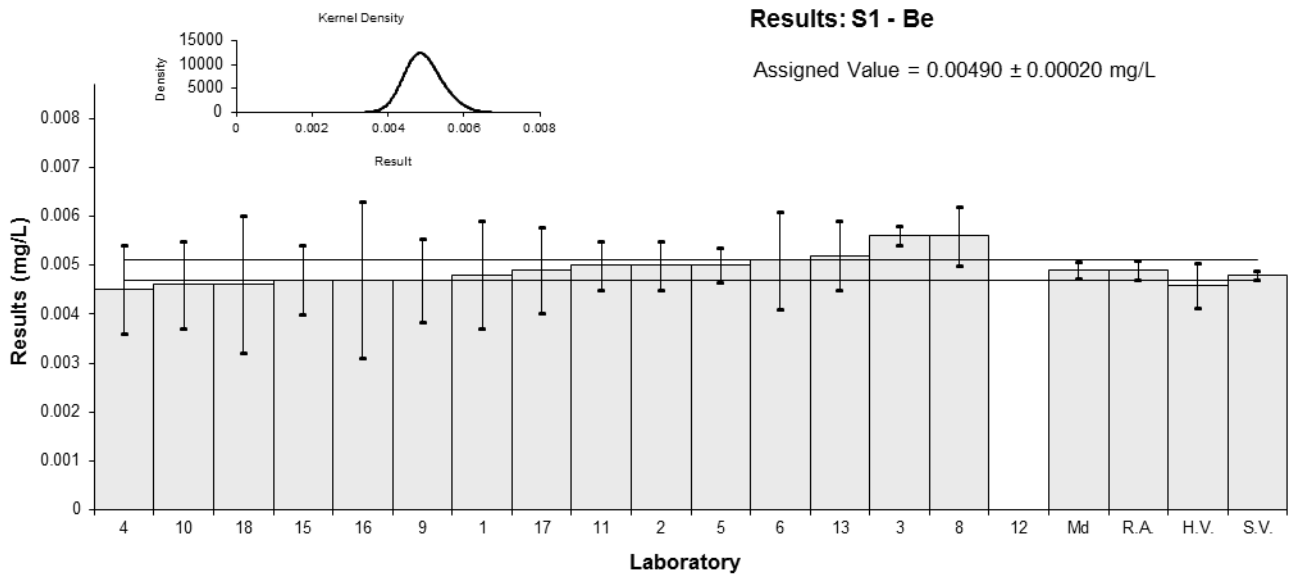
Sample No.	S1
Matrix.	Potable Water
Analyte.	Be
Units	mg/L

Participant Results

Lab Code	Result	Uncertainty	z-Score	E_n-Score
1	0.0048	0.0011	-0.20	-0.09
2	0.005	0.0005	0.20	0.19
3	0.0056	0.0002	1.43	2.47
4	0.0045	0.0009	-0.82	-0.43
5	0.005	0.00035	0.20	0.25
6	0.0051	0.0010	0.41	0.20
8	0.0056	0.0006	1.43	1.11
9	0.0047	0.00085	-0.41	-0.23
10	0.0046	0.0009	-0.61	-0.33
11	0.005	0.0005	0.20	0.19
12	NT	NT		
13	0.0052	0.0007	0.61	0.41
15	0.0047	0.0007	-0.41	-0.27
16	0.0047	0.0016	-0.41	-0.12
17	0.0049	0.00087	0.00	0.00
18	0.0046	0.0014	-0.61	-0.21

Statistics

Assigned Value	0.00490	0.00020
Spike	0.00480	0.00010
Homogeneity Value	0.00458	0.00046
Robust Average	0.00490	0.00020
Median	0.00490	0.00016
Mean	0.00493	
N	15	
Max.	0.0056	
Min.	0.0045	
Robust SD	0.00031	
Robust CV	6.3%	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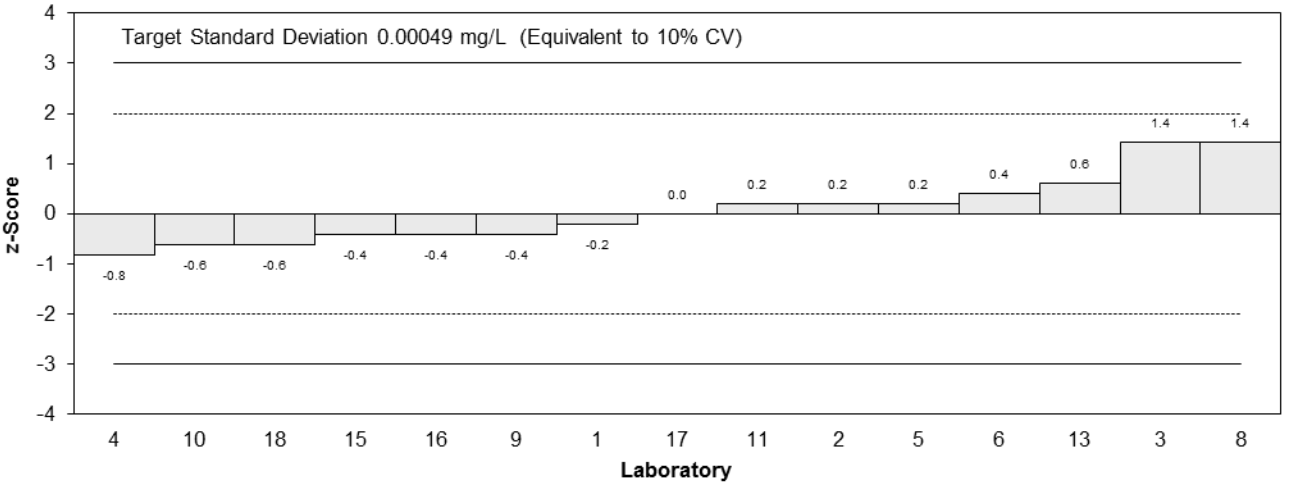
10000
5000
0
0
0.002
0.004
0.006
0.008
Result
Results: S1 - Be
Assigned Value = 0.00490 ± 0.00020 mg/L
Results (mg/L)
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0
4 10 18 15 16 9 1 17 11 2 5 6 13 3 8 12 Md R.A. H.V. S.V.
Laboratory


z-Scores: S1 - Be
Target Standard Deviation 0.00049 mg/L (Equivalent to 10% CV)
z-Score
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3
2
1
0
-1
-2
-3
-4
-0.8 -0.6 -0.6 -0.4 -0.4 -0.4 -0.2 0.0 0.2 0.2 0.2 0.4 0.6 1.4 1.4
4 10 18 15 16 9 1 17 11 2 5 6 13 3 8
Laboratory

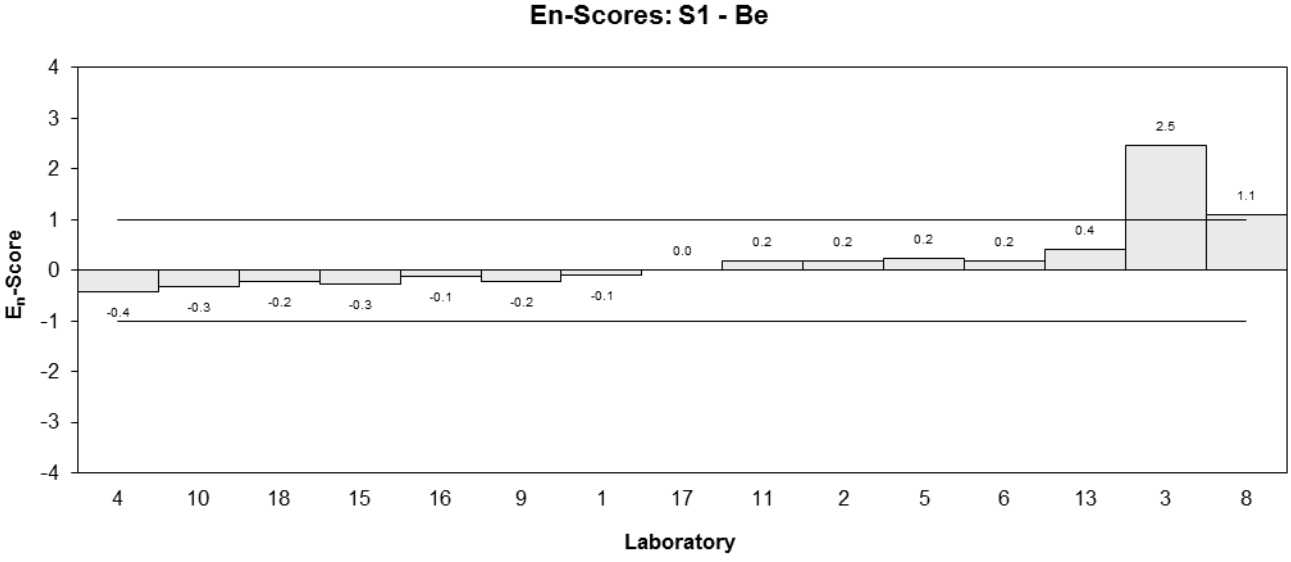

En-Scores: S1 - Be
En-Score
4
3
2
1
0
-1
-2
-3
-4
-0.4 -0.3 -0.2 -0.3 -0.1 -0.2 -0.1 0.0 0.2 0.2 0.2 0.2 0.4 2.5 1.1
4 10 18 15 16 9 1 17 11 2 5 6 13 3 8
Laboratory

Figure 3

Table 6

Sample Details

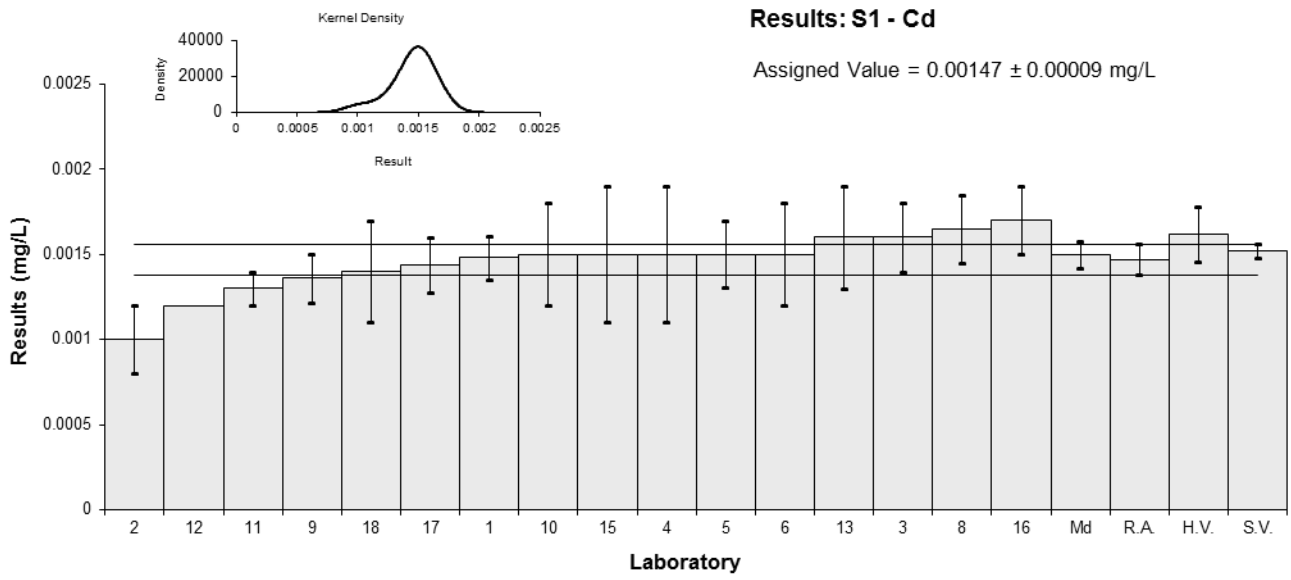
Sample No.	S1
Matrix.	Potable Water
Analyte.	Cd
Units	mg/L

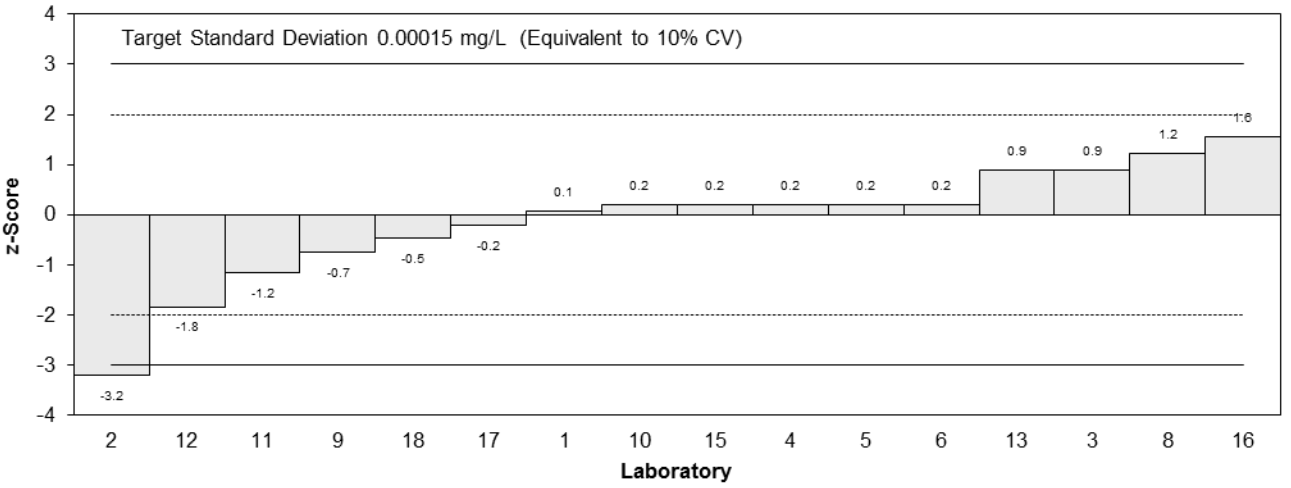
Participant Results

Lab Code	Result	Uncertainty	z-Score	E_n-Score
1	0.00148	0.00013	0.07	0.06
2	0.001	0.0002	-3.20	-2.14
3	0.0016	0.0002	0.88	0.59
4	0.0015	0.0004	0.20	0.07
5	0.0015	0.000195	0.20	0.14
6	0.0015	0.0003	0.20	0.10
8	0.00165	0.0002	1.22	0.82
9	0.00136	0.000140	-0.75	-0.66
10	0.0015	0.0003	0.20	0.10
11	0.0013	0.0001	-1.16	-1.26
12	0.0012	NR	-1.84	-3.00
13	0.0016	0.0003	0.88	0.42
15	0.0015	0.0004	0.20	0.07
16	0.0017	0.0002	1.56	1.05
17	0.00144	0.00016	-0.20	-0.16
18	0.0014	0.0003	-0.48	-0.22

Statistics

Assigned Value	0.00147	0.00009
Spike	0.00152	0.00004
Homogeneity Value	0.00162	0.00016
Robust Average	0.00147	0.00009
Median	0.00150	0.00008
Mean	0.00145	
N	16	
Max.	0.0017	
Min.	0.001	
Robust SD	0.00014	
Robust CV	9.5%	


Kernel Density
Density
40000
20000
0
0
0.0005
0.001
0.0015
0.002
0.0025
Result
Results: S1 - Cd
Assigned Value = 0.00147 ± 0.00009 mg/L
Results (mg/L)
0.0025
0.002
0.0015
0.001
0.0005
0
2 12 11 9 18 17 1 10 15 4 5 6 13 3 8 16 Md R.A. H.V. S.V.
Laboratory


z-Scores: S1 - Cd
Target Standard Deviation 0.00015 mg/L (Equivalent to 10% CV)
z-Score
4
3
2
1
0
-1
-2
-3
-4
-3.2
-1.8
-1.2
-0.7
-0.5
-0.2
0.1
0.2
0.2
0.2
0.2
0.2
0.9
0.9
1.2
1.6
2 12 11 9 18 17 1 10 15 4 5 6 13 3 8 16
Laboratory

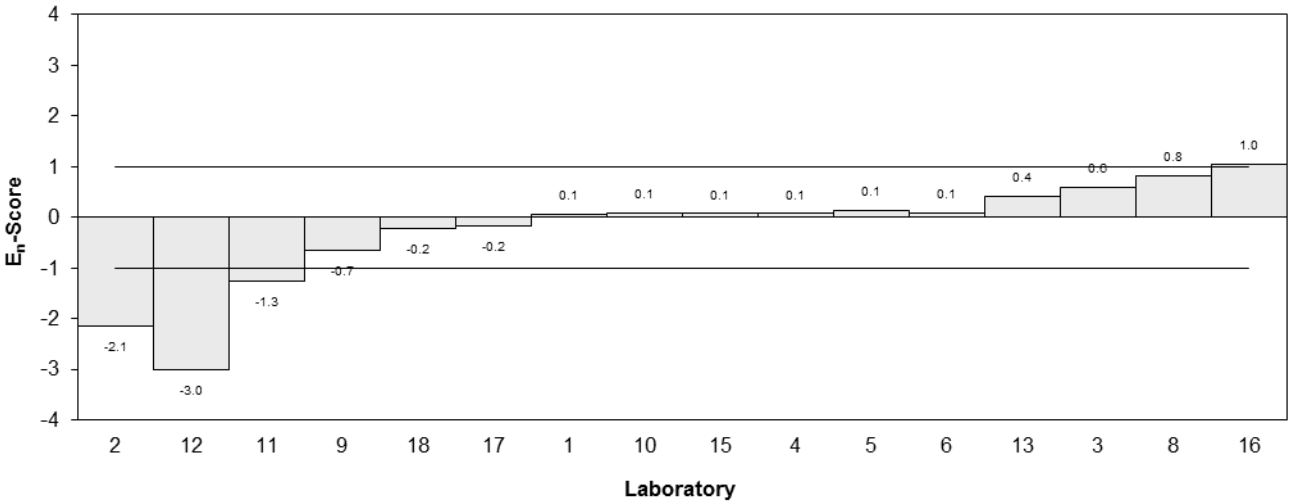

En-Scores: S1 - Cd
En-Score
4
3
2
1
0
-1
-2
-3
-4
-2.1
-3.0
-1.3
-0.7
-0.2
-0.2
0.1
0.1
0.1
0.1
0.1
0.1
0.4
0.6
0.8
1.0
2 12 11 9 18 17 1 10 15 4 5 6 13 3 8 16
Laboratory

Figure 4

Table 7

Sample Details

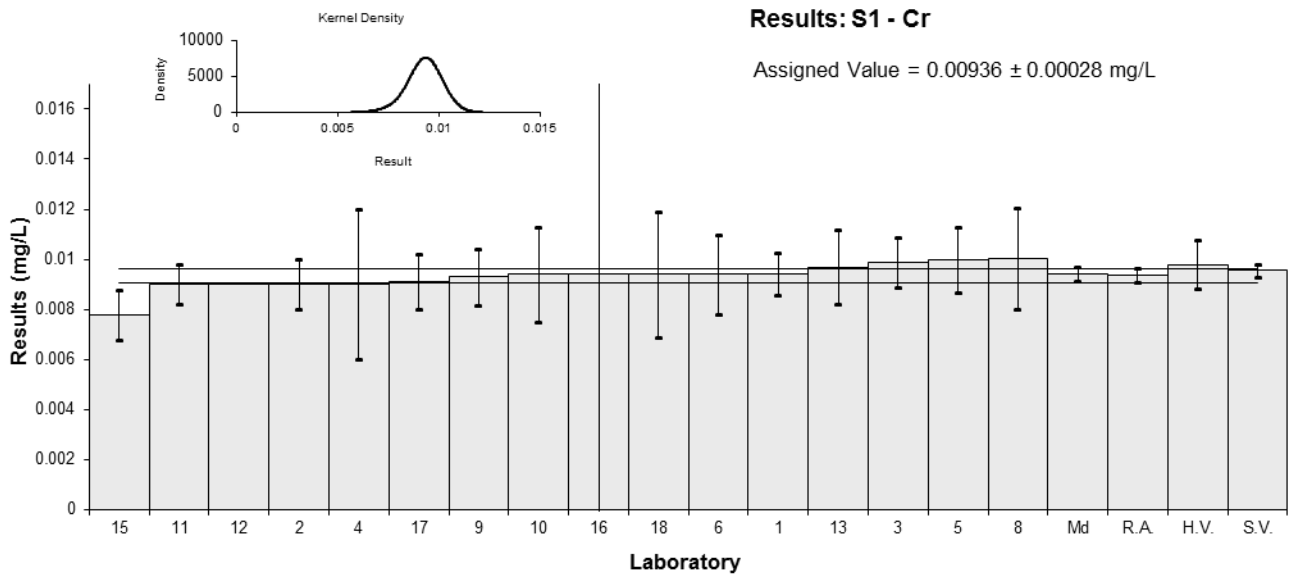
Sample No.	S1
Matrix.	Potable Water
Analyte.	Cr
Units	mg/L

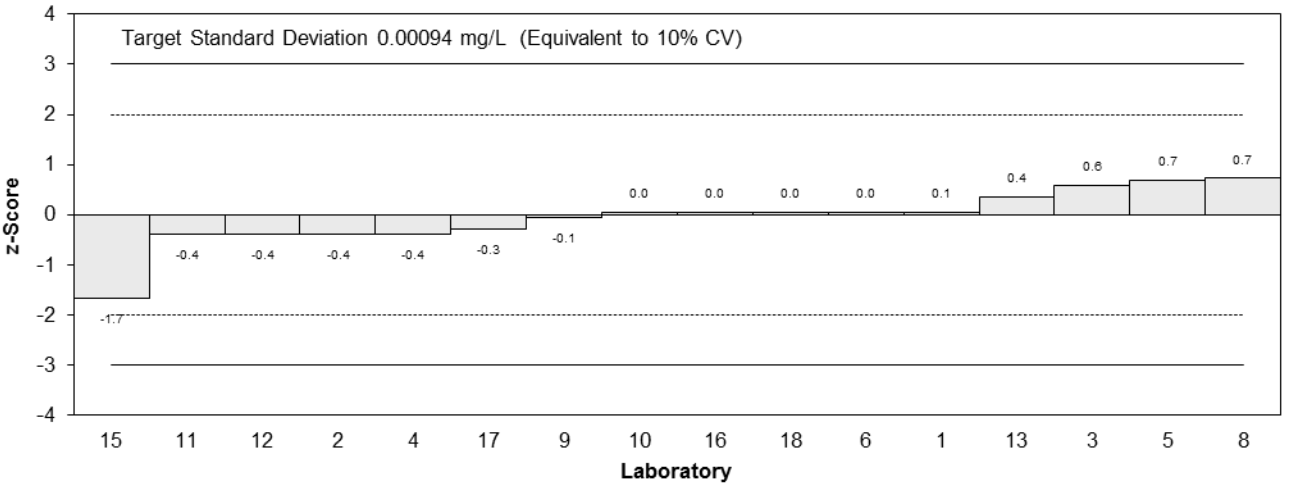
Participant Results

Lab Code	Result	Uncertainty	z-Score	E_n-Score
1	0.00941	0.00084	0.05	0.06
2	0.009	0.001	-0.38	-0.35
3	0.0099	0.001	0.58	0.52
4	0.009	0.003	-0.38	-0.12
5	0.010	0.0013	0.68	0.48
6	0.0094	0.0016	0.04	0.02
8	0.01004	0.002	0.73	0.34
9	0.0093	0.00114	-0.06	-0.05
10	0.0094	0.0019	0.04	0.02
11	0.009	0.0008	-0.38	-0.42
12	0.009	NR	-0.38	-1.29
13	0.0097	0.0015	0.36	0.22
15	0.0078	0.001	-1.67	-1.50
16	0.0094	0.0281	0.04	0.00
17	0.0091	0.0011	-0.28	-0.23
18	0.0094	0.0025	0.04	0.02

Statistics

Assigned Value	0.00936	0.00028
Spike	0.00955	0.00027
Homogeneity Value	0.00980	0.00098
Robust Average	0.00936	0.00028
Median	0.00940	0.00028
Mean	0.00930	
N	16	
Max.	0.01004	
Min.	0.0078	
Robust SD	0.00045	
Robust CV	4.8%	


Kernel Density
Density
10000
5000
0
0
0.005
0.01
0.015
Result
Results: S1 - Cr
Assigned Value = 0.00936 ± 0.00028 mg/L
Results (mg/L)
0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
15 11 12 2 4 17 9 10 16 18 6 1 13 3 5 8 Md R.A. H.V. S.V.
Laboratory


z-Scores: S1 - Cr
Target Standard Deviation 0.00094 mg/L (Equivalent to 10% CV)
z-Score
4
3
2
1
0
-1
-2
-3
-4
-1.7
-0.4 -0.4 -0.4 -0.4 -0.3 -0.1 0.0 0.0 0.0 0.0 0.1 0.4 0.6 0.7 0.7
15 11 12 2 4 17 9 10 16 18 6 1 13 3 5 8
Laboratory

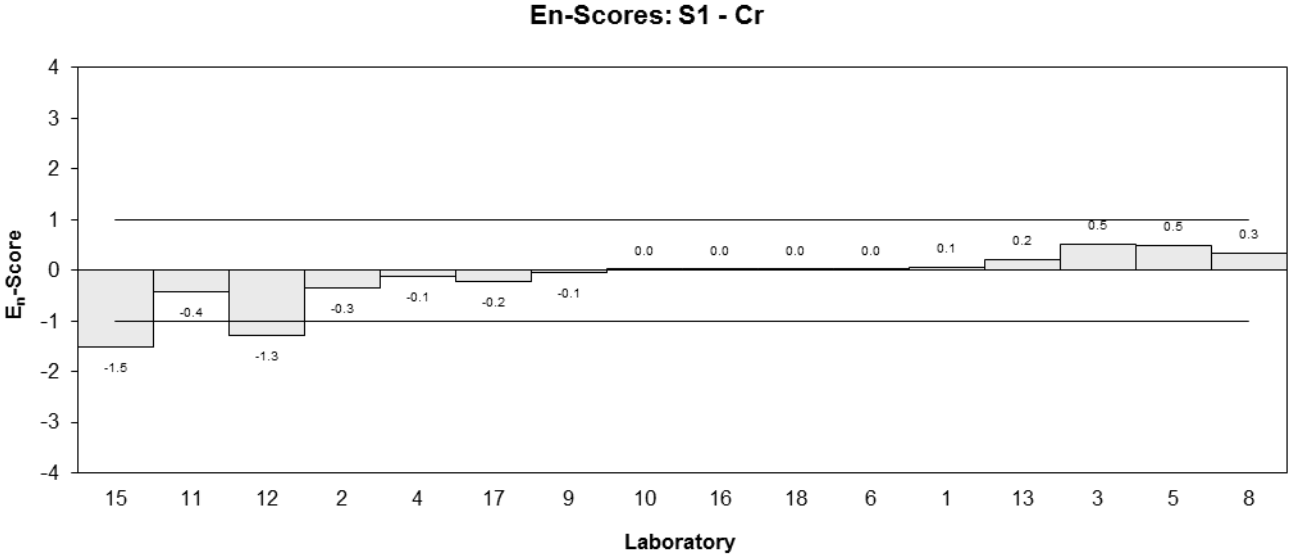

En-Scores: S1 - Cr
En-Score
4
3
2
1
0
-1
-2
-3
-4
-1.5 -0.4 -1.3 -0.3 -0.1 -0.2 -0.1 0.0 0.0 0.0 0.0 0.1 0.2 0.5 0.5 0.3
15 11 12 2 4 17 9 10 16 18 6 1 13 3 5 8
Laboratory

Figure 5

Table 8

Sample Details

Sample No.	S1
Matrix.	Potable Water
Analyte.	Cu
Units	mg/L

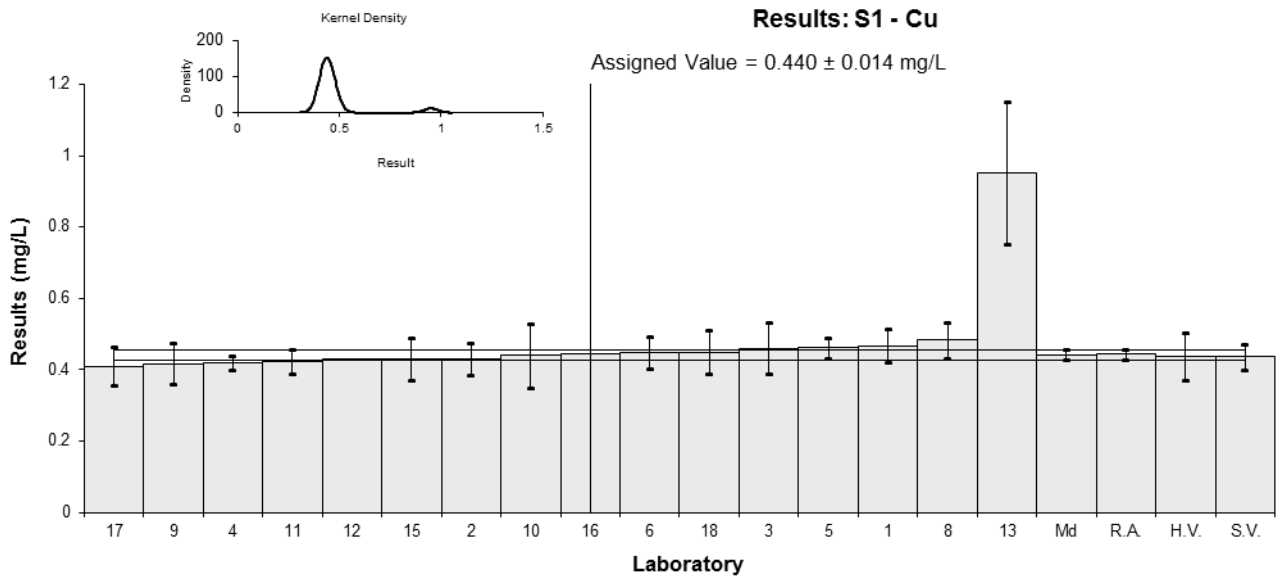
Participant Results

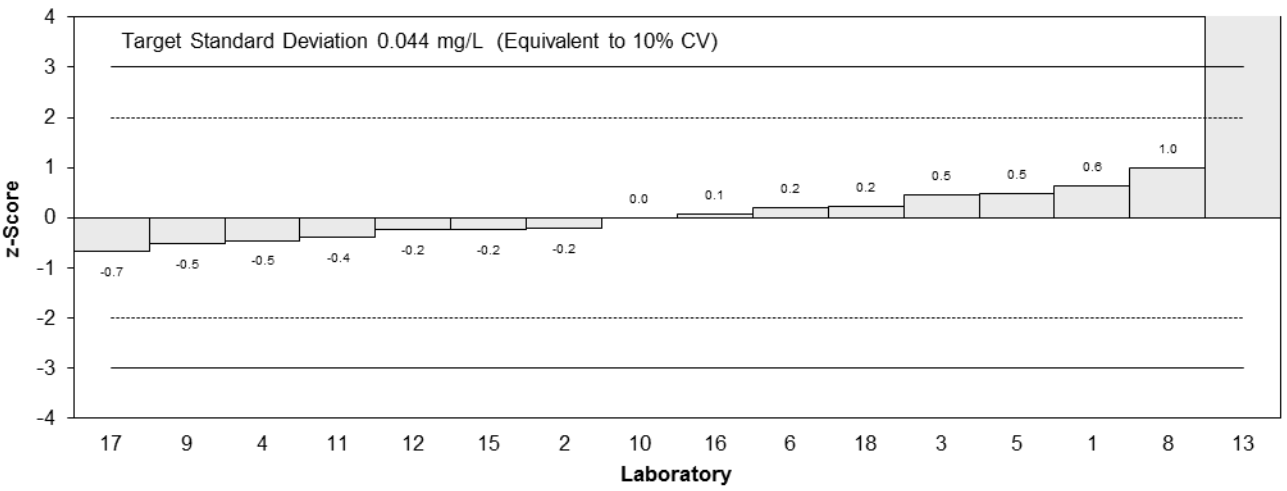
Lab Code	Result	Uncertainty	z-Score	E_n-Score
1	0.468	0.047	0.64	0.57
2	0.431	0.045	-0.20	-0.19
3	0.46	0.071	0.45	0.28
4	0.42	0.02	-0.45	-0.82
5	0.461	0.03	0.48	0.63
6	0.449	0.045	0.20	0.19
8	0.48381	0.05	1.00	0.84
9	0.417	0.0570	-0.52	-0.39
10	0.44	0.09	0.00	0.00
11	0.423	0.0351	-0.39	-0.45
12	0.43	NR	-0.23	-0.71
13	0.9519	0.1999	11.63	2.55
15	0.43	0.06	-0.23	-0.16
16	0.4434	1.3302	0.08	0.00
17	0.41	0.0529	-0.68	-0.55
18	0.45	0.06	0.23	0.16

Statistics

Assigned Value*	0.440	0.014
Spike	0.437	0.036
Homogeneity Value	0.437	0.066
Robust Average	0.443	0.016
Median	0.442	0.015
Mean	0.473	
N	16	
Max.	0.9519	
Min.	0.41	
Robust SD	0.025	
Robust CV	5.6%	

*Robust Average excluding Laboratory 13


Results: S1 - Cu
Assigned Value = 0.440 ± 0.014 mg/L
Kernel Density
Density
Result
Results (mg/L)
Laboratory
17 9 4 11 12 15 2 10 16 6 18 3 5 1 8 13 Md R.A. H.V. S.V.


z-Scores: S1 - Cu
Target Standard Deviation 0.044 mg/L (Equivalent to 10% CV)
z-Score
Laboratory
17 9 4 11 12 15 2 10 16 6 18 3 5 1 8 13
-0.7 -0.5 -0.5 -0.4 -0.2 -0.2 -0.2 0.0 0.1 0.2 0.2 0.5 0.5 0.6 1.0

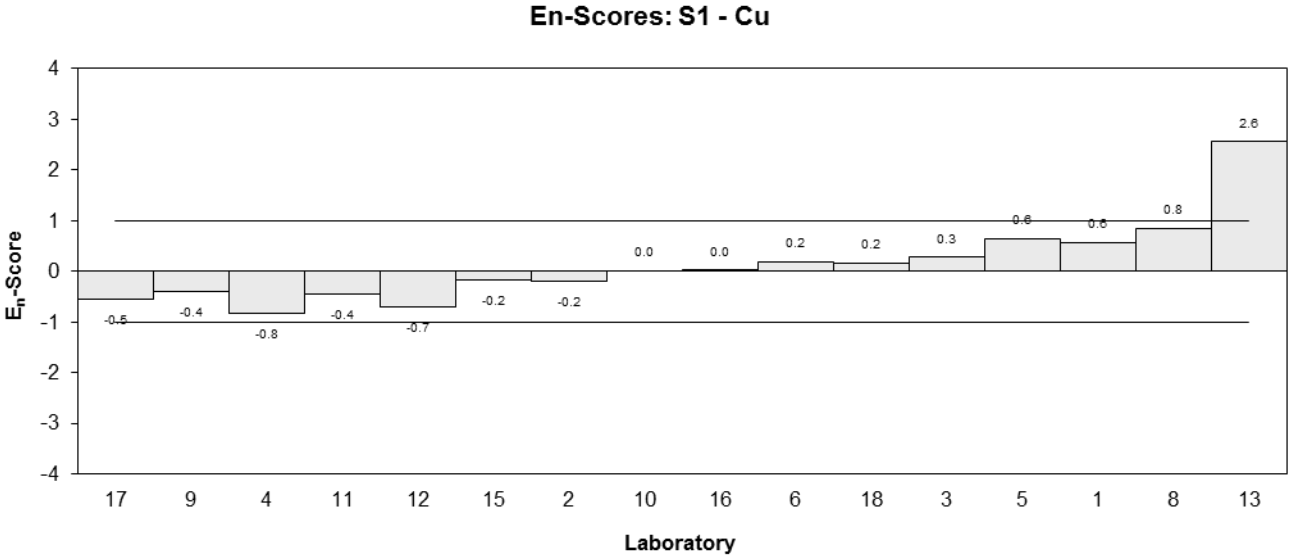

En-Scores: S1 - Cu
En-Score
Laboratory
17 9 4 11 12 15 2 10 16 6 18 3 5 1 8 13
-0.5 -0.4 -0.8 -0.4 -0.7 -0.2 -0.2 0.0 0.0 0.2 0.2 0.3 0.6 0.6 0.8 2.6

Figure 6

Table 9

Sample Details

Sample No.	S1
Matrix.	Potable Water
Analyte.	Hg
Units	mg/L

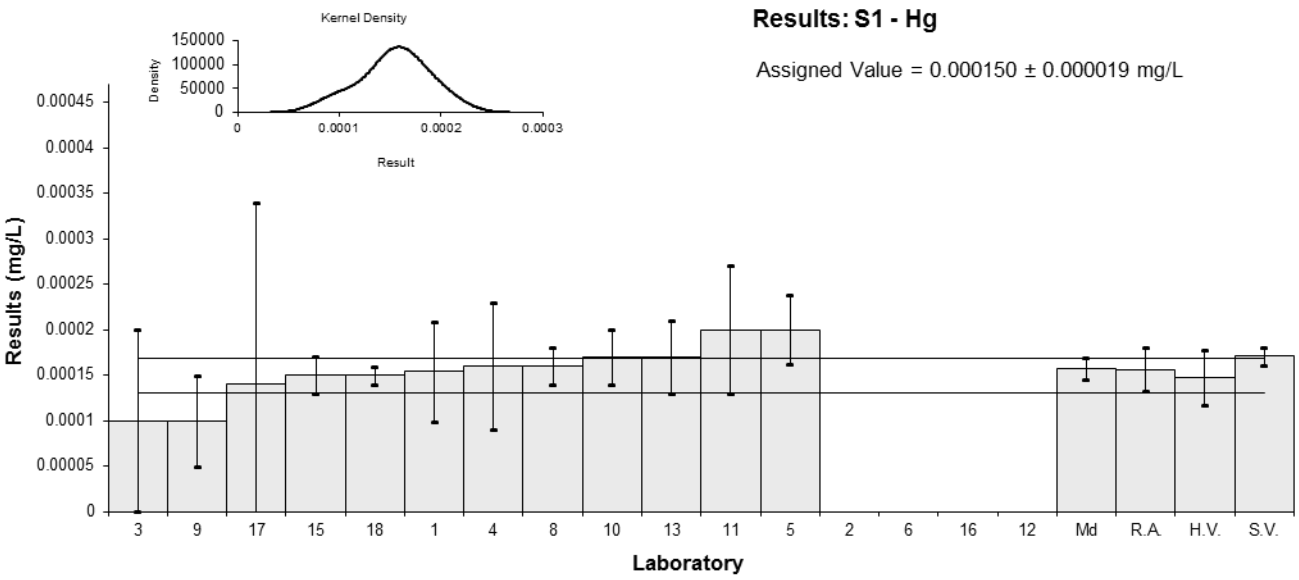
Participant Results

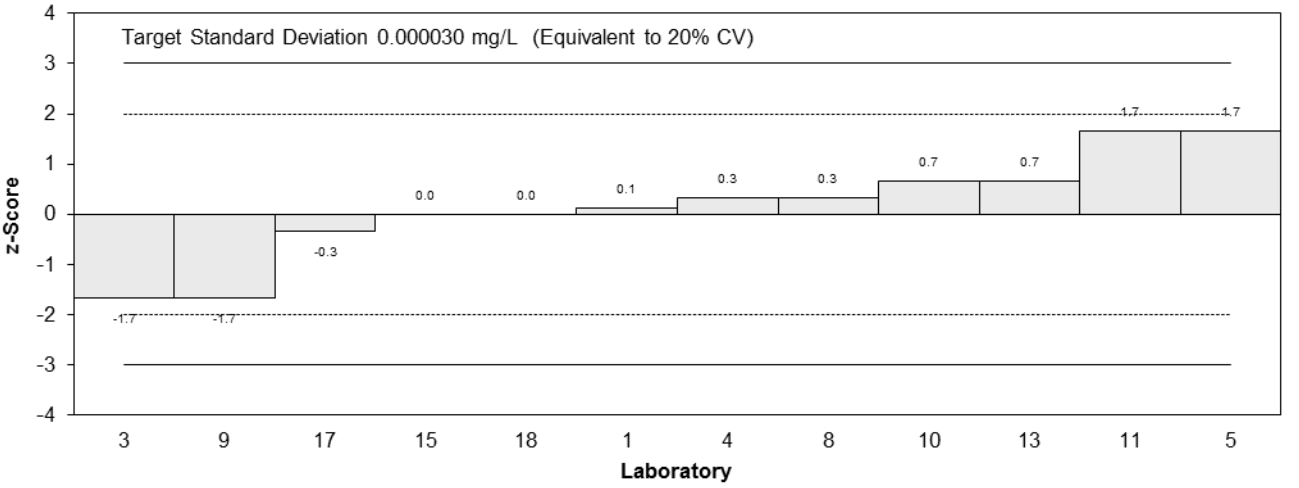
Lab Code	Result	Uncertainty	z-Score	E_n-Score
1	0.000154	0.000055	0.13	0.07
2	<0.0005	NR		
3	0.0001	0.0001	-1.67	-0.49
4	0.00016	0.00007	0.33	0.14
5	0.0002	0.000038	1.67	1.18
6	<0.0005	NR		
8	0.00016	0.00002	0.33	0.36
9	0.0001	0.00005	-1.67	-0.93
10	0.00017	0.00003	0.67	0.56
11	0.0002	0.00007	1.67	0.69
12	NT	NT		
13	0.00017	0.00004	0.67	0.45
15	0.00015	0.00002	0.00	0.00
16	<0.001	0.0005		
17	0.00014	0.0002	-0.33	-0.05
18	0.00015	0.00001	0.00	0.00

Statistics

Assigned Value*	0.000150	0.000019
Spike	0.000171	0.000010
Homogeneity Value	0.000147	0.000030
Robust Average	0.000156	0.000024
Median	0.000157	0.000012
Mean	0.000155	
N	12	
Max.	0.0002	
Min.	0.0001	
Robust SD	0.000033	
Robust CV	21%	

*The Assigned Value was calculated as the Robust Average of the combined results of Samples S1 and S2


Kernel Density
Density
Result
Results: S1 - Hg
Assigned Value = 0.000150 ± 0.000019 mg/L
Results (mg/L)
Laboratory
3 9 17 15 18 1 4 8 10 13 11 5 2 6 16 12 Md R.A. H.V. S.V.


z-Scores: S1 - Hg
Target Standard Deviation 0.000030 mg/L (Equivalent to 20% CV)
z-Score
Laboratory
3 9 17 15 18 1 4 8 10 13 11 5

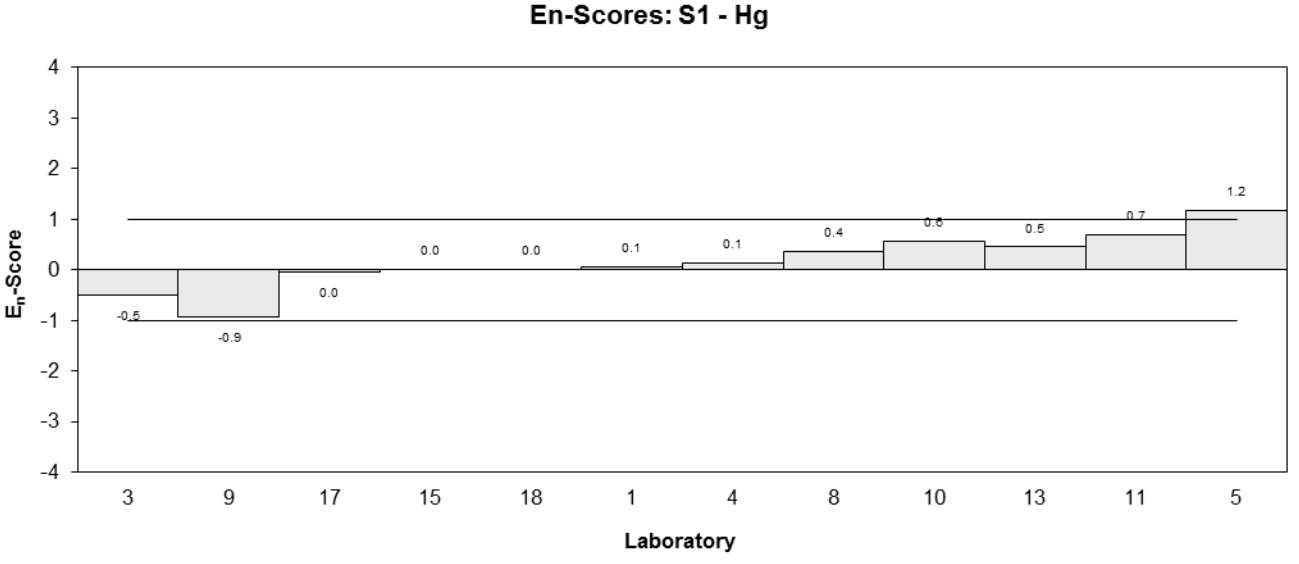

En-Scores: S1 - Hg
En-Score
Laboratory
3 9 17 15 18 1 4 8 10 13 11 5

Figure 7

Table 10

Sample Details

Sample No.	S1
Matrix.	Potable Water
Analyte.	Mn
Units	mg/L

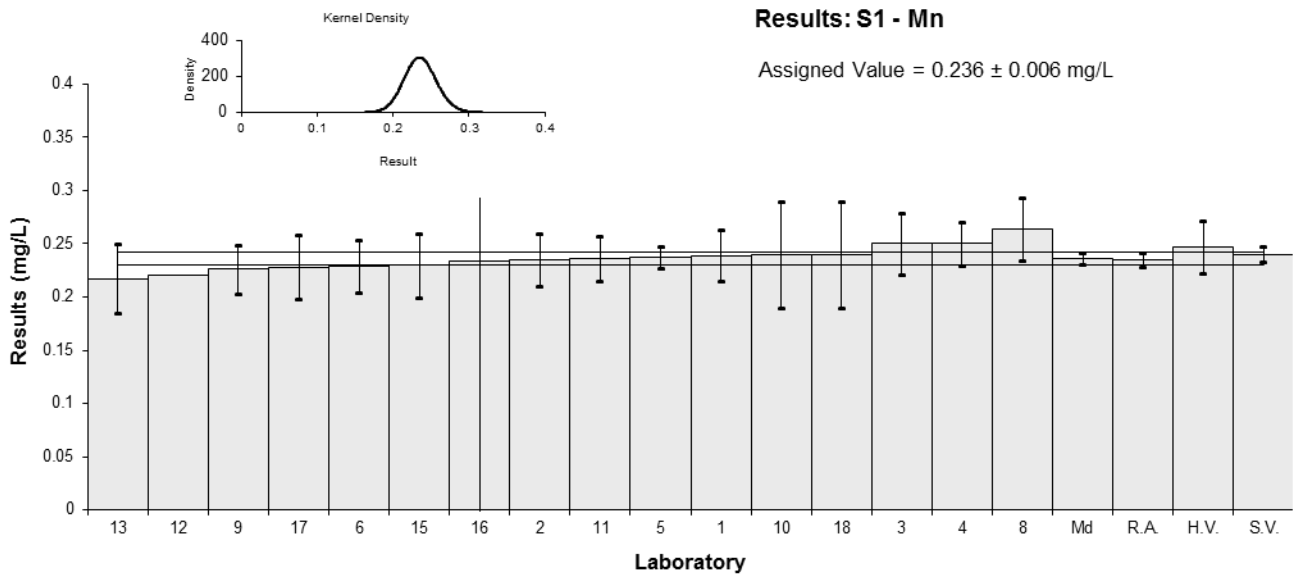
Participant Results

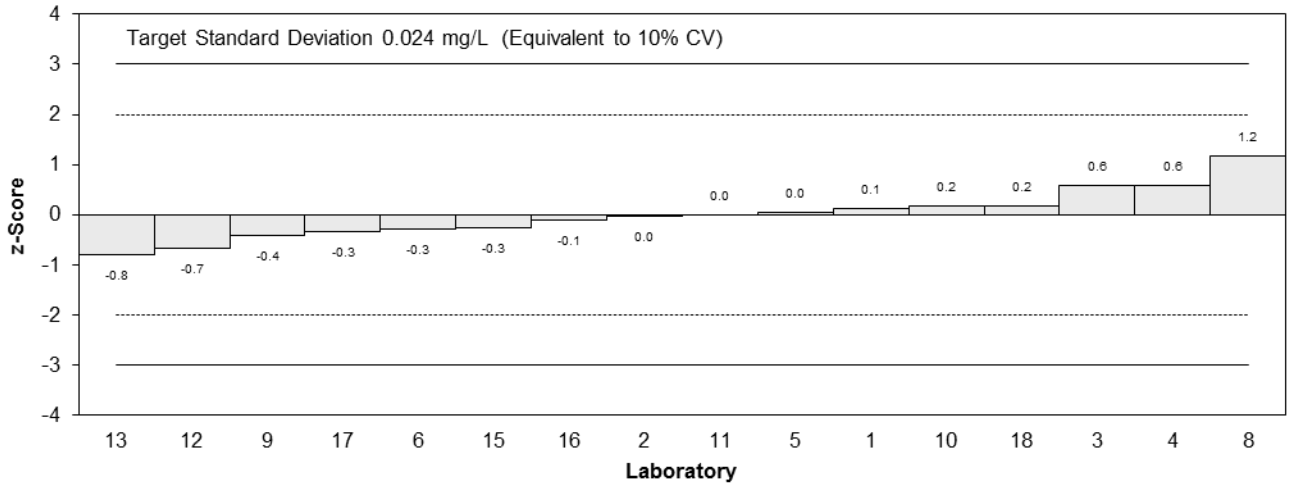
Lab Code	Result	Uncertainty	z-Score	E_n-Score
1	0.239	0.024	0.13	0.12
2	0.235	0.025	-0.04	-0.04
3	0.25	0.029	0.59	0.47
4	0.25	0.02	0.59	0.67
5	0.237	0.01	0.04	0.09
6	0.229	0.025	-0.30	-0.27
8	0.26378	0.03	1.18	0.91
9	0.226	0.0226	-0.42	-0.43
10	0.24	0.05	0.17	0.08
11	0.236	0.0212	0.00	0.00
12	0.22	NR	-0.68	-2.67
13	0.2173	0.0326	-0.79	-0.56
15	0.23	0.03	-0.25	-0.20
16	0.2335	0.7006	-0.11	0.00
17	0.228	0.030	-0.34	-0.26
18	0.24	0.05	0.17	0.08

Statistics

Assigned Value*	0.236	0.006
Spike	0.240	0.007
Homogeneity Value	0.247	0.025
Robust Average	0.235	0.007
Median	0.236	0.005
Mean	0.236	
N	16	
Max.	0.26378	
Min.	0.2173	
Robust SD	0.011	
Robust CV	4.7%	

*The Assigned Value was calculated as the Robust Average of the combined results of Samples S1 and S2


Kernel Density
Density
Result
Results: S1 - Mn
Assigned Value = 0.236 ± 0.006 mg/L
Results (mg/L)
Laboratory
13 12 9 17 6 15 16 2 11 5 1 10 18 3 4 8 Md R.A. H.V. S.V.


z-Scores: S1 - Mn
Target Standard Deviation 0.024 mg/L (Equivalent to 10% CV)
z-Score
Laboratory
13 12 9 17 6 15 16 2 11 5 1 10 18 3 4 8
-0.8 -0.7 -0.4 -0.3 -0.3 -0.3 -0.1 0.0 0.0 0.0 0.1 0.2 0.2 0.6 0.6 1.2

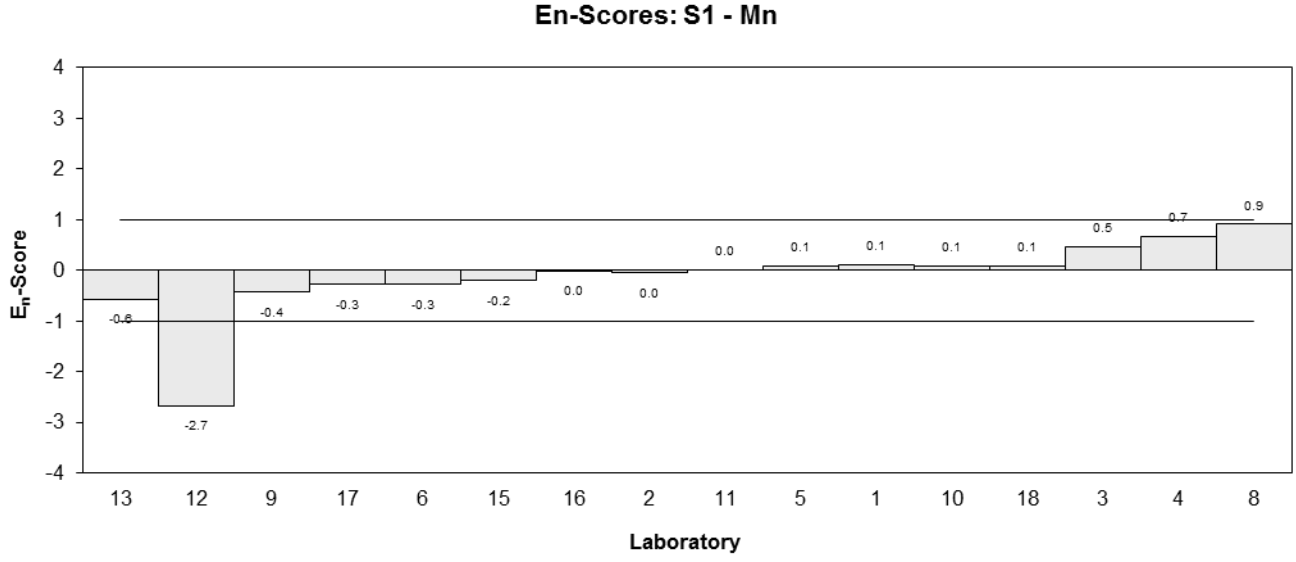

En-Scores: S1 - Mn
En-Score
Laboratory
13 12 9 17 6 15 16 2 11 5 1 10 18 3 4 8
-0.6 -2.7 -0.4 -0.3 -0.3 -0.2 0.0 0.0 0.0 0.1 0.1 0.1 0.1 0.5 0.7 0.9

Figure 8

Table 11

Sample Details

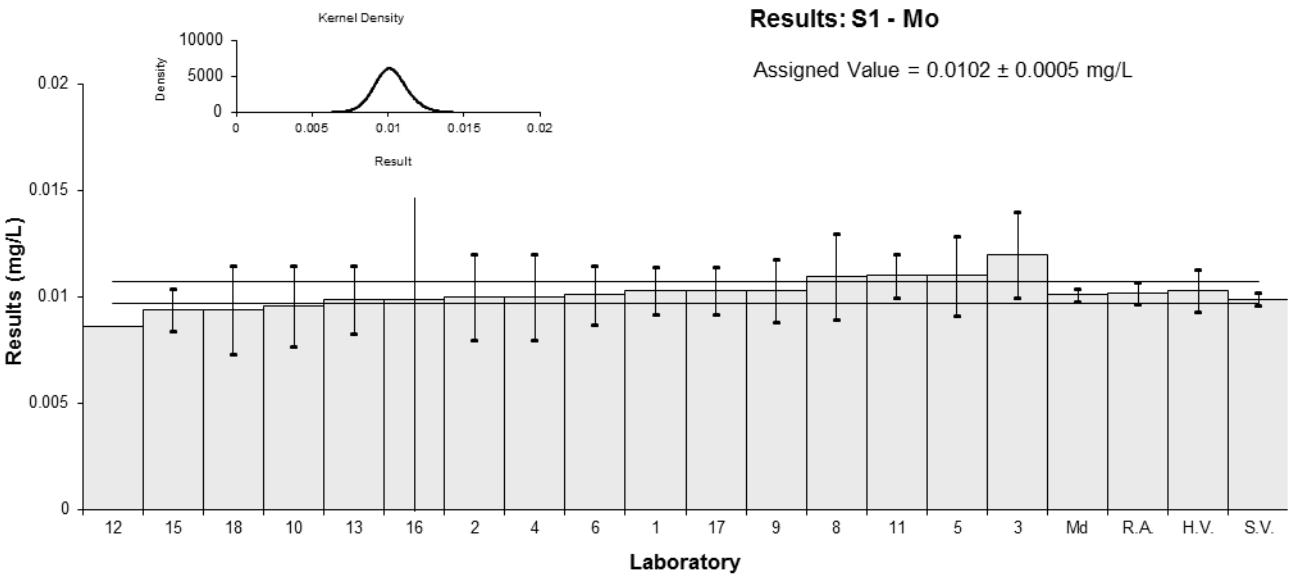
Sample No.	S1
Matrix.	Potable Water
Analyte.	Mo
Units	mg/L

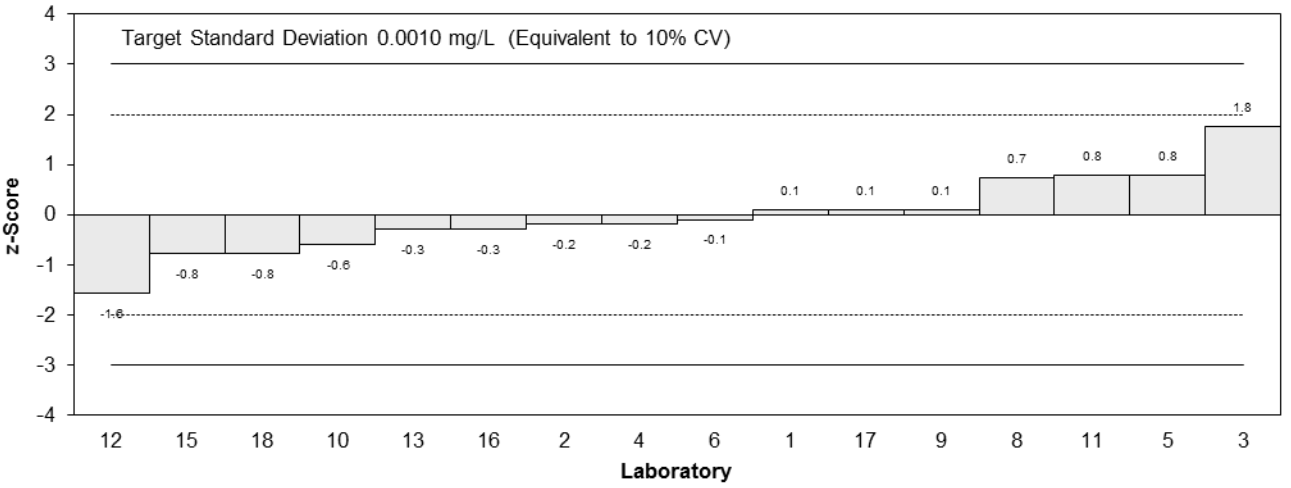
Participant Results

Lab Code	Result	Uncertainty	z-Score	E_n-Score
1	0.0103	0.0011	0.10	0.08
2	0.010	0.002	-0.20	-0.10
3	0.012	0.002	1.76	0.87
4	0.010	0.002	-0.20	-0.10
5	0.011	0.00187	0.78	0.41
6	0.0101	0.0014	-0.10	-0.07
8	0.01095	0.002	0.74	0.36
9	0.0103	0.00145	0.10	0.07
10	0.0096	0.0019	-0.59	-0.31
11	0.011	0.001	0.78	0.72
12	0.0086	NR	-1.57	-3.20
13	0.0099	0.0016	-0.29	-0.18
15	0.0094	0.001	-0.78	-0.72
16	0.0099	0.0296	-0.29	-0.01
17	0.0103	0.0011	0.10	0.08
18	0.0094	0.0021	-0.78	-0.37

Statistics

Assigned Value	0.0102	0.0005
Spike	0.0099	0.0003
Homogeneity Value	0.0103	0.0010
Robust Average	0.0102	0.0005
Median	0.0101	0.0003
Mean	0.0102	
N	16	
Max.	0.012	
Min.	0.0086	
Robust SD	0.0007	
Robust CV	6.9%	


Kernel Density
Density
10000
5000
0
0
0.005
0.01
0.015
0.02
Result
Results: S1 - Mo
Assigned Value = 0.0102 ± 0.0005 mg/L
Results (mg/L)
0.02
0.015
0.01
0.005
0
12 15 18 10 13 16 2 4 6 1 17 9 8 11 5 3 Md R.A. H.V. S.V.
Laboratory


z-Scores: S1 - Mo
Target Standard Deviation 0.0010 mg/L (Equivalent to 10% CV)
z-Score
4
3
2
1
0
-1
-2
-3
-4
-1.6
-0.8
-0.8
-0.6
-0.3
-0.3
-0.2
-0.2
-0.1
0.1
0.1
0.1
0.7
0.8
0.8
1.8
12 15 18 10 13 16 2 4 6 1 17 9 8 11 5 3
Laboratory

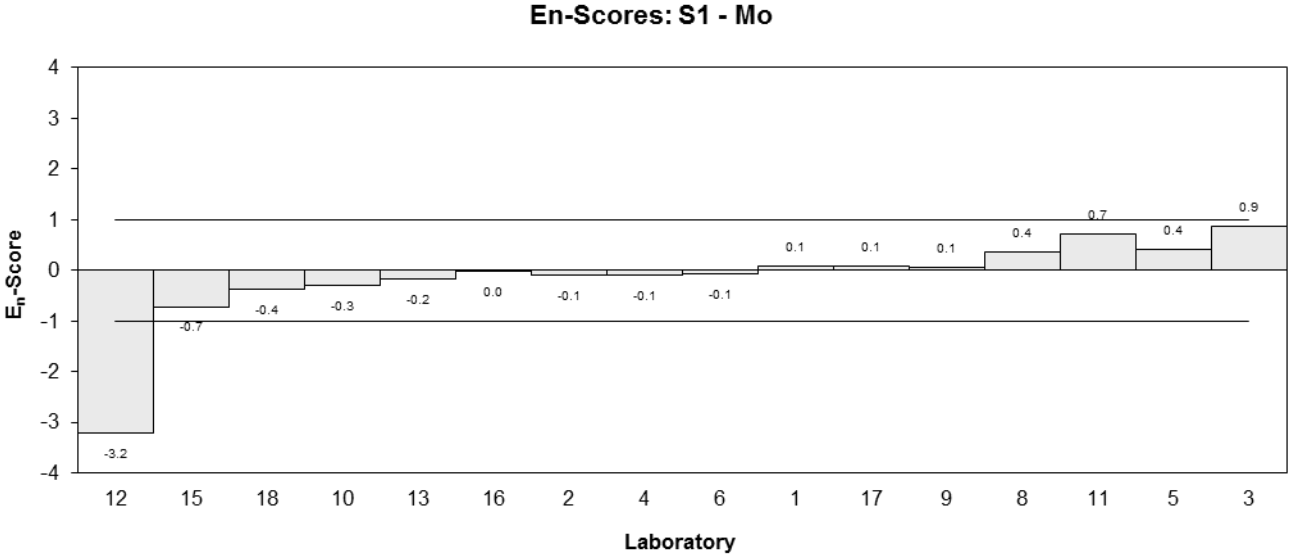

En-Scores: S1 - Mo
En-Score
4
3
2
1
0
-1
-2
-3
-4
-3.2
-0.7
-0.4
-0.3
-0.2
0.0
-0.1
-0.1
-0.1
0.1
0.1
0.1
0.4
0.7
0.4
0.9
12 15 18 10 13 16 2 4 6 1 17 9 8 11 5 3
Laboratory

Figure 9

Table 12

Sample Details

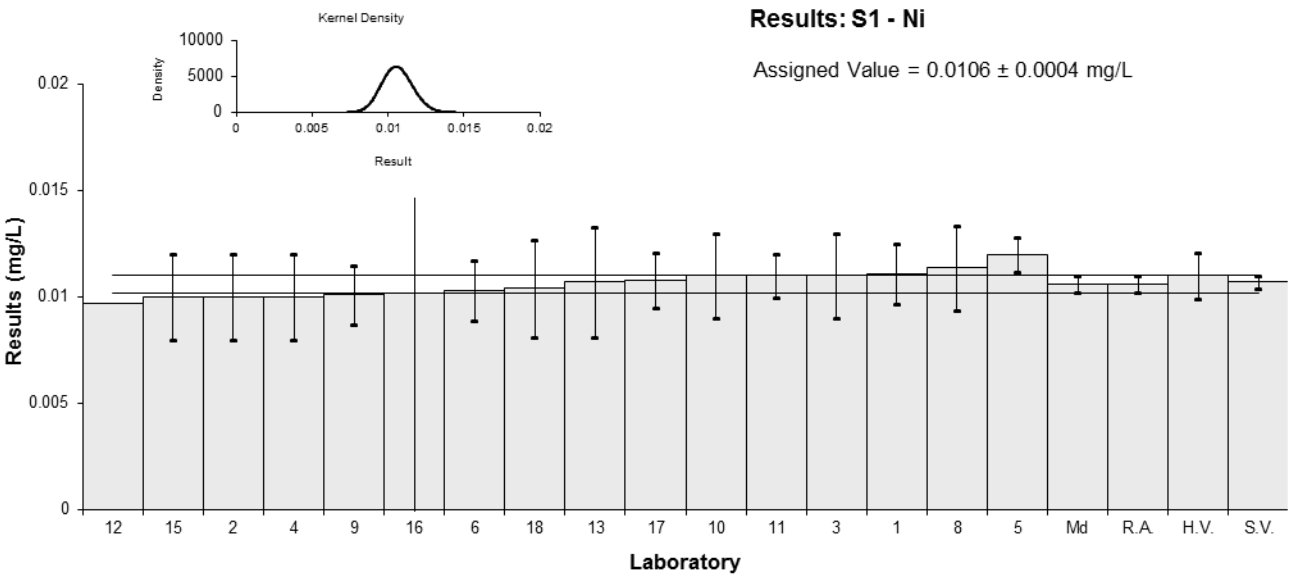
Sample No.	S1
Matrix.	Potable Water
Analyte.	Ni
Units	mg/L

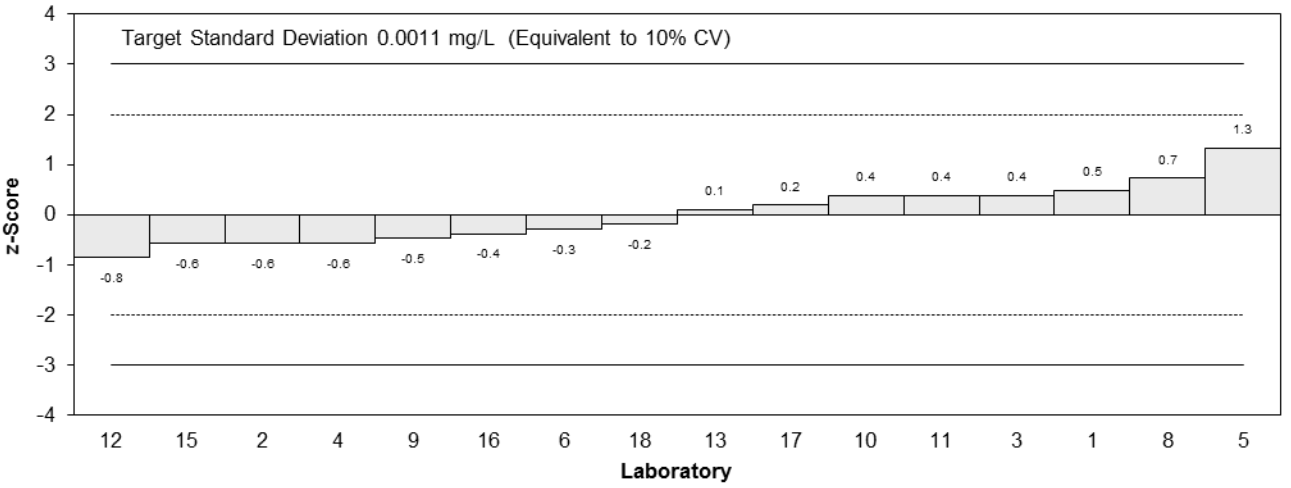
Participant Results

Lab Code	Result	Uncertainty	z-Score	E_n-Score
1	0.0111	0.0014	0.47	0.34
2	0.010	0.002	-0.57	-0.29
3	0.011	0.002	0.38	0.20
4	0.010	0.002	-0.57	-0.29
5	0.012	0.0008	1.32	1.57
6	0.0103	0.0014	-0.28	-0.21
8	0.01137	0.002	0.73	0.38
9	0.0101	0.00139	-0.47	-0.35
10	0.011	0.002	0.38	0.20
11	0.011	0.001	0.38	0.37
12	0.0097	NR	-0.85	-2.25
13	0.0107	0.0026	0.09	0.04
15	0.010	0.002	-0.57	-0.29
16	0.0102	0.0306	-0.38	-0.01
17	0.0108	0.0013	0.19	0.15
18	0.0104	0.0023	-0.19	-0.09

Statistics

Assigned Value	0.0106	0.0004
Spike	0.0107	0.0003
Homogeneity Value	0.0110	0.0011
Robust Average	0.0106	0.0004
Median	0.0106	0.0004
Mean	0.0106	
N	16	
Max.	0.012	
Min.	0.0097	
Robust SD	0.0006	
Robust CV	5.7%	


Kernel Density
Density
10000
5000
0
0
0.005
0.01
0.015
0.02
Result
Results: S1 - Ni
Assigned Value = 0.0106 ± 0.0004 mg/L
Results (mg/L)
0.02
0.015
0.01
0.005
0
12 15 2 4 9 16 6 18 13 17 10 11 3 1 8 5 Md R.A. H.V. S.V.
Laboratory


z-Scores: S1 - Ni
Target Standard Deviation 0.0011 mg/L (Equivalent to 10% CV)
z-Score
4
3
2
1
0
-1
-2
-3
-4
-0.8 -0.6 -0.6 -0.6 -0.5 -0.4 -0.3 -0.2 0.1 0.2 0.4 0.4 0.4 0.5 0.7 1.3
12 15 2 4 9 16 6 18 13 17 10 11 3 1 8 5
Laboratory

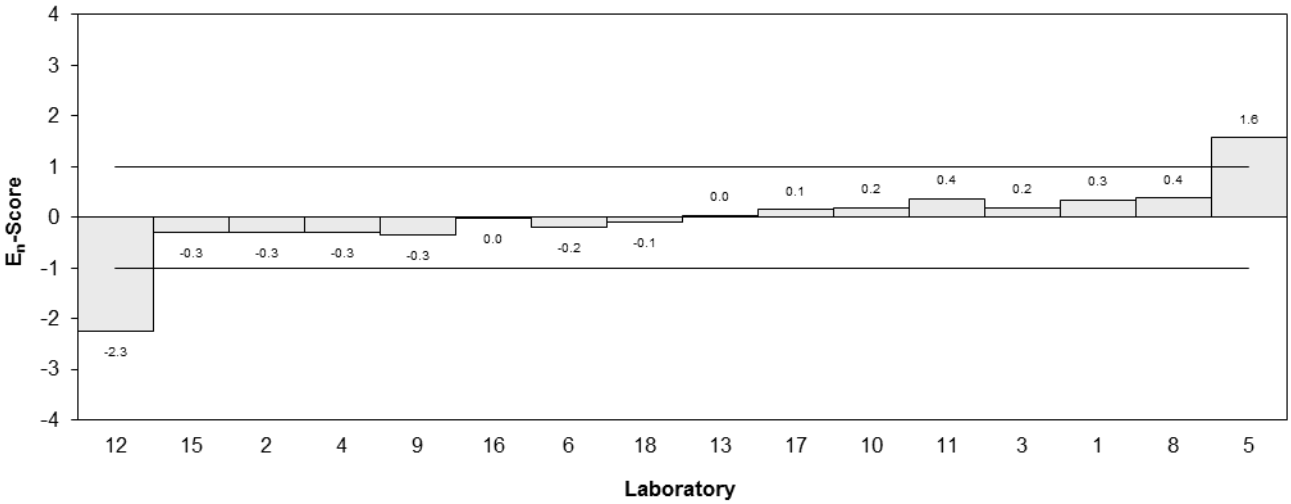

En-Scores: S1 - Ni
En-Score
4
3
2
1
0
-1
-2
-3
-4
-2.3 -0.3 -0.3 -0.3 -0.3 0.0 -0.2 -0.1 0.0 0.1 0.2 0.4 0.2 0.3 0.4 1.6
12 15 2 4 9 16 6 18 13 17 10 11 3 1 8 5
Laboratory

Figure 10

Table 13

Sample Details

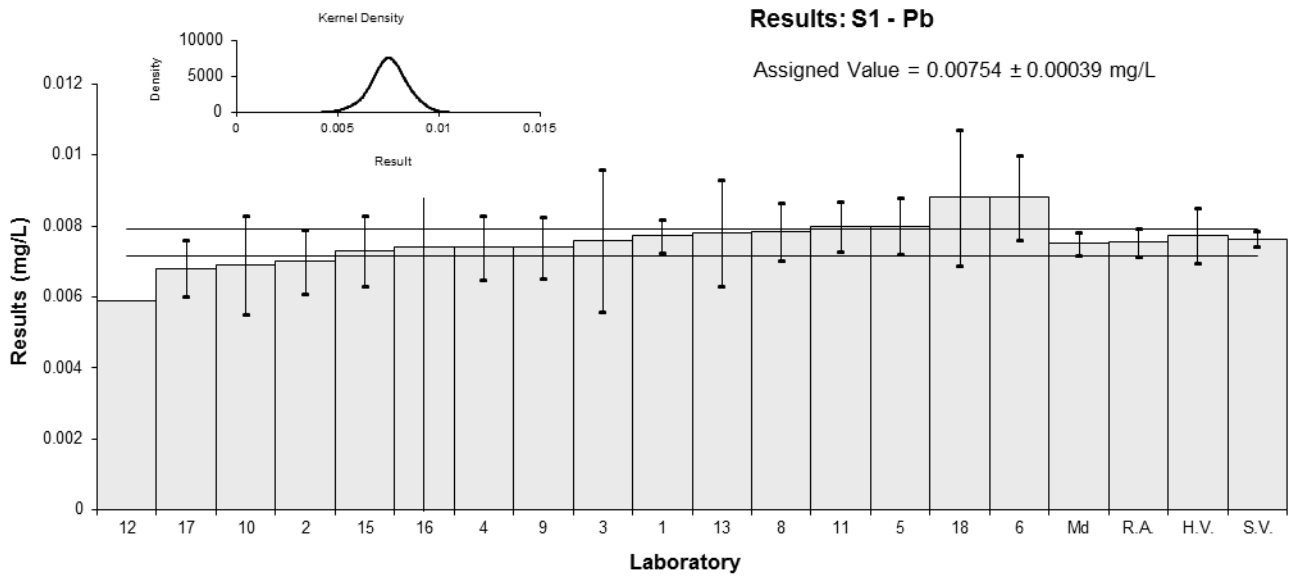
Sample No.	S1
Matrix.	Potable Water
Analyte.	Pb
Units	mg/L

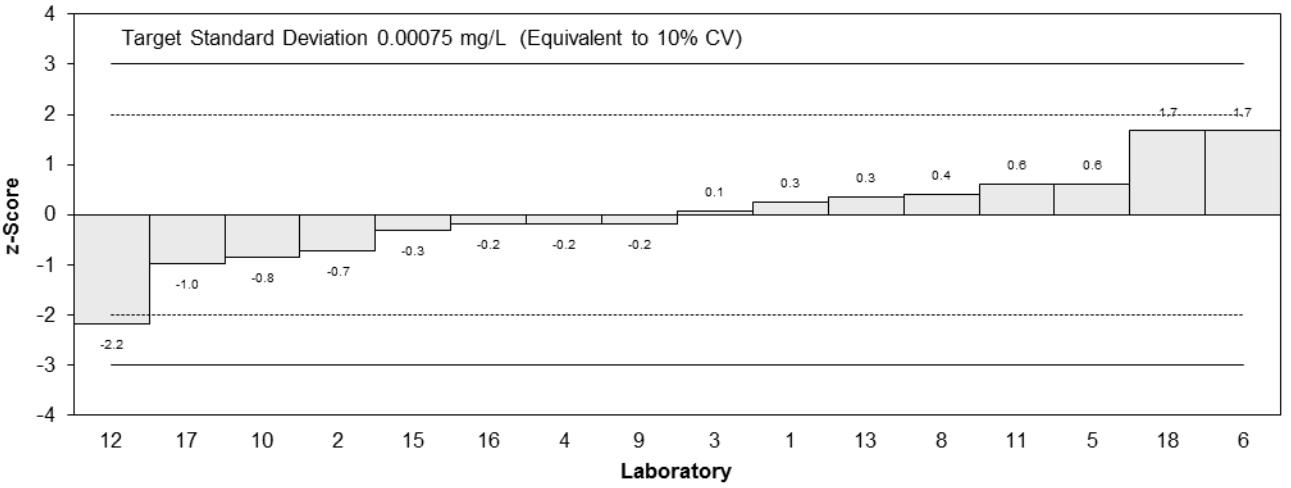
Participant Results

Lab Code	Result	Uncertainty	z-Score	E_n-Score
1	0.00773	0.00047	0.25	0.31
2	0.007	0.0009	-0.72	-0.55
3	0.0076	0.002	0.08	0.03
4	0.0074	0.0009	-0.19	-0.14
5	0.008	0.0008	0.61	0.52
6	0.0088	0.0012	1.67	1.00
8	0.00784	0.0008	0.40	0.34
9	0.0074	0.00086	-0.19	-0.15
10	0.0069	0.0014	-0.85	-0.44
11	0.008	0.0007	0.61	0.57
12	0.0059	NR	-2.18	-4.21
13	0.0078	0.0015	0.34	0.17
15	0.0073	0.001	-0.32	-0.22
16	0.0074	0.0222	-0.19	-0.01
17	0.0068	0.000798	-0.98	-0.83
18	0.0088	0.0019	1.67	0.65

Statistics

Assigned Value	0.00754	0.00039
Spike	0.00764	0.00022
Homogeneity Value	0.00773	0.00077
Robust Average	0.00754	0.00039
Median	0.00750	0.00033
Mean	0.00754	
N	16	
Max.	0.0088	
Min.	0.0059	
Robust SD	0.00062	
Robust CV	8.2%	


Kernel Density
Density
10000
5000
0
0
0.005
0.01
0.015
Result
Results: S1 - Pb
Assigned Value = 0.00754 ± 0.00039 mg/L
Results (mg/L)
0.012
0.01
0.008
0.006
0.004
0.002
0
12 17 10 2 15 16 4 9 3 1 13 8 11 5 18 6 Md R.A. H.V. S.V.
Laboratory


z-Scores: S1 - Pb
Target Standard Deviation 0.00075 mg/L (Equivalent to 10% CV)
z-Score
4
3
2
1
0
-1
-2
-3
-4
-2.2
-1.0
-0.8
-0.7
-0.3
-0.2
-0.2
-0.2
0.1
0.3
0.3
0.4
0.6
0.6
1.7
1.7
12 17 10 2 15 16 4 9 3 1 13 8 11 5 18 6
Laboratory

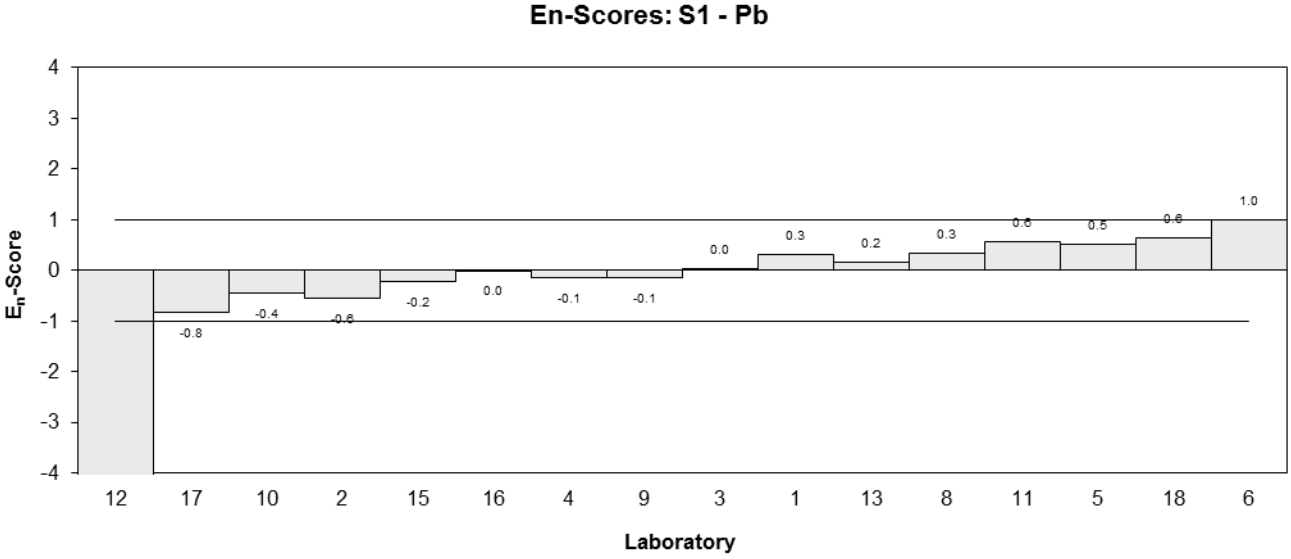

En-Scores: S1 - Pb
En-Score
4
3
2
1
0
-1
-2
-3
-4
-0.8
-0.4
-0.6
-0.2
0.0
-0.1
-0.1
0.0
0.3
0.2
0.3
0.6
0.5
0.6
1.0
12 17 10 2 15 16 4 9 3 1 13 8 11 5 18 6
Laboratory

Figure 11

Table 14

Sample Details

Sample No.	S1
Matrix.	Potable Water
Analyte.	Sb
Units	mg/L

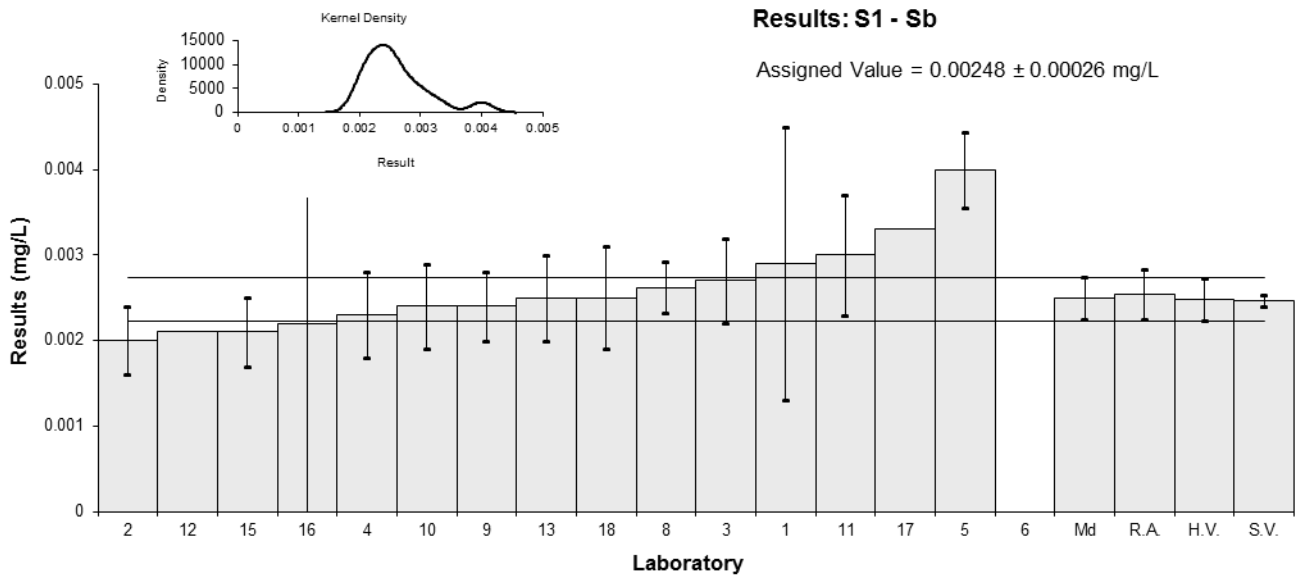
Participant Results

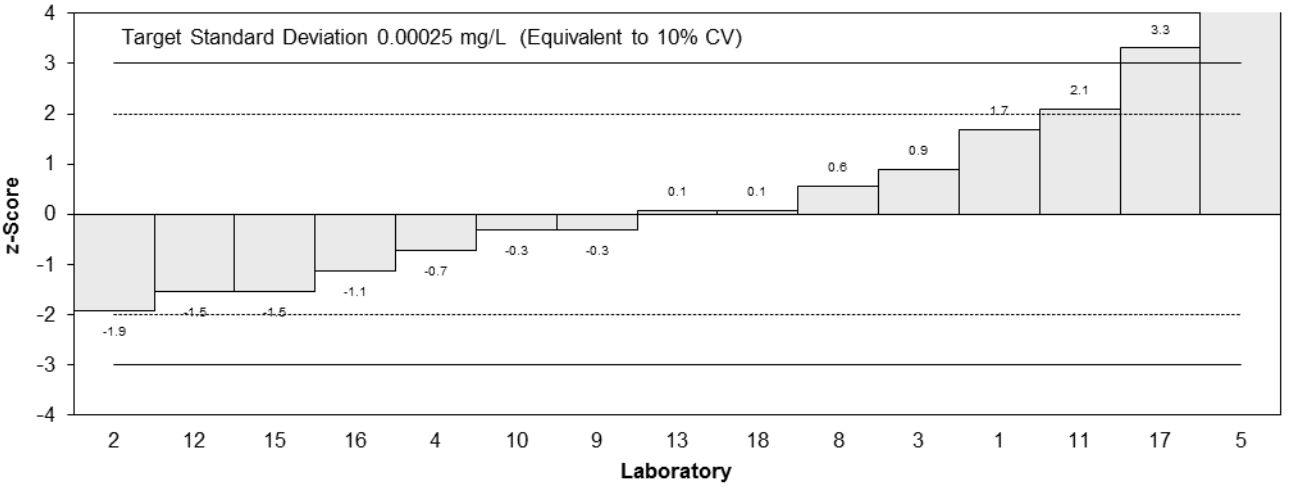
Lab Code	Result	Uncertainty	z-Score	E_n-Score
1	0.0029	0.0016	1.69	0.26
2	0.002	0.0004	-1.94	-1.01
3	0.0027	0.0005	0.89	0.39
4	0.0023	0.0005	-0.73	-0.32
5	0.004	0.00044	6.13	2.97
6	<0.005	NR		
8	0.00262	0.0003	0.56	0.35
9	0.0024	0.00040	-0.32	-0.17
10	0.0024	0.0005	-0.32	-0.14
11	0.003	0.0007	2.10	0.70
12	0.0021	NR	-1.53	-1.46
13	0.0025	0.0005	0.08	0.04
15	0.0021	0.0004	-1.53	-0.80
16	0.0022	0.0065	-1.13	-0.04
17	0.0033	NR	3.31	3.15
18	0.0025	0.0006	0.08	0.03

Statistics

Assigned Value*	0.00248	0.00026
Spike	0.00247	0.00007
Homogeneity Value	0.00248	0.00025
Robust Average	0.00254	0.00029
Median	0.00250	0.00025
Mean	0.00260	
N	15	
Max.	0.004	
Min.	0.002	
Robust SD	0.00044	
Robust CV	17%	

*Robust Average excluding Laboratory 5


Kernel Density
Density
15000
10000
5000
0
0
0.001
0.002
0.003
0.004
0.005
Result
Results: S1 - Sb
Assigned Value = 0.00248 ± 0.00026 mg/L
Results (mg/L)
0.005
0.004
0.003
0.002
0.001
0
2
12
15
16
4
10
9
13
18
8
3
1
11
17
5
6
Md
R.A.
H.V.
S.V.
Laboratory


z-Scores: S1 - Sb
Target Standard Deviation 0.00025 mg/L (Equivalent to 10% CV)
z-Score
4
3
2
1
0
-1
-2
-3
-4
-1.9
-1.5
-1.5
-1.1
-0.7
-0.3
-0.3
0.1
0.1
0.6
0.9
1.7
2.1
3.3
2
12
15
16
4
10
9
13
18
8
3
1
11
17
5
Laboratory

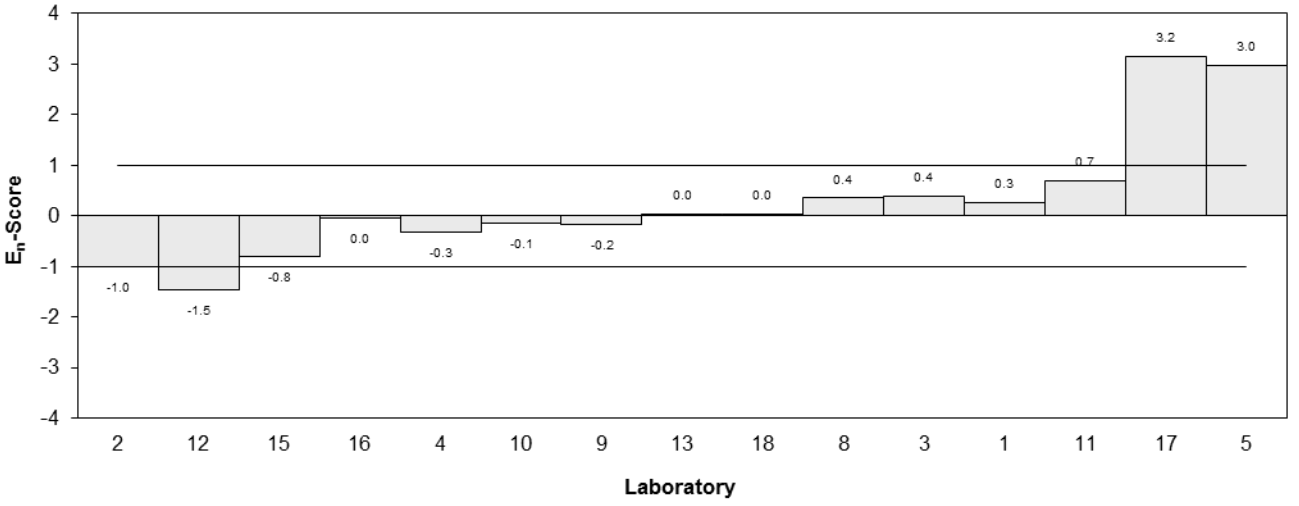

En-Scores: S1 - Sb
En-Score
4
3
2
1
0
-1
-2
-3
-4
-1.0
-1.5
-0.8
0.0
-0.3
-0.1
-0.2
0.0
0.0
0.4
0.4
0.3
0.7
3.2
3.0
2
12
15
16
4
10
9
13
18
8
3
1
11
17
5
Laboratory

Figure 12

Table 15

Sample Details

Sample No.	S1
Matrix.	Potable Water
Analyte.	Se
Units	mg/L

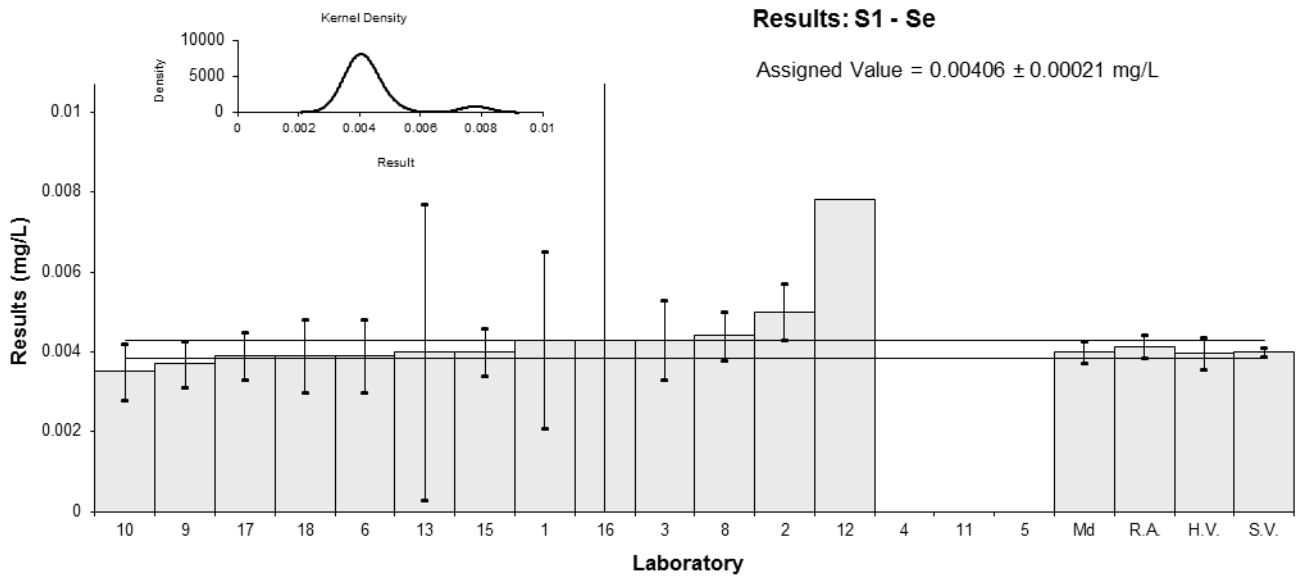
Participant Results

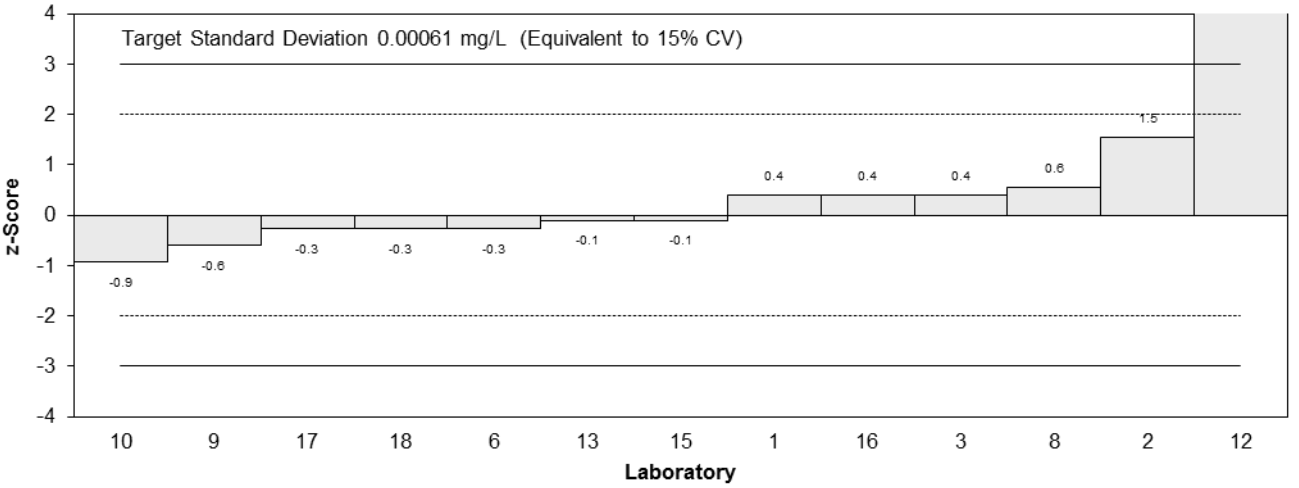
Lab Code	Result	Uncertainty	z-Score	E_n-Score
1	0.0043	0.0022	0.39	0.11
2	0.005	0.0007	1.54	1.29
3	0.0043	0.001	0.39	0.24
4	<0.005	NR		
5	<0.01	0.001		
6	0.0039	0.0009	-0.26	-0.17
8	0.0044	0.0006	0.56	0.54
9	0.0037	0.00057	-0.59	-0.59
10	0.0035	0.0007	-0.92	-0.77
11	<0.01	NR		
12	0.0078	NR	6.14	17.81
13	0.0040	0.0037	-0.10	-0.02
15	0.0040	0.0006	-0.10	-0.09
16	0.0043	0.0130	0.39	0.02
17	0.0039	0.000596	-0.26	-0.25
18	0.0039	0.0009	-0.26	-0.17

Statistics

Assigned Value*	0.00406	0.00021
Spike	0.00401	0.00011
Homogeneity Value	0.00397	0.00040
Robust Average	0.00414	0.00030
Median	0.00400	0.00027
Mean	0.00438	
N	13	
Max.	0.0078	
Min.	0.0035	
Robust SD	0.00044	
Robust CV	11%	

*The Assigned Value was calculated as the Robust Average of the combined results of Samples S1 and S2, excluding Laboratory 12


Results: S1 - Se
Assigned Value = 0.00406 ± 0.00021 mg/L
Kernel Density
Density
Result
Results (mg/L)
Laboratory
10 9 17 18 6 13 15 1 16 3 8 2 12 4 11 5 Md R.A. H.V. S.V.


z-Scores: S1 - Se
Target Standard Deviation 0.00061 mg/L (Equivalent to 15% CV)
z-Score
Laboratory
10 9 17 18 6 13 15 1 16 3 8 2 12
-0.9 -0.6 -0.3 -0.3 -0.3 -0.1 -0.1 0.4 0.4 0.4 0.6 1.5

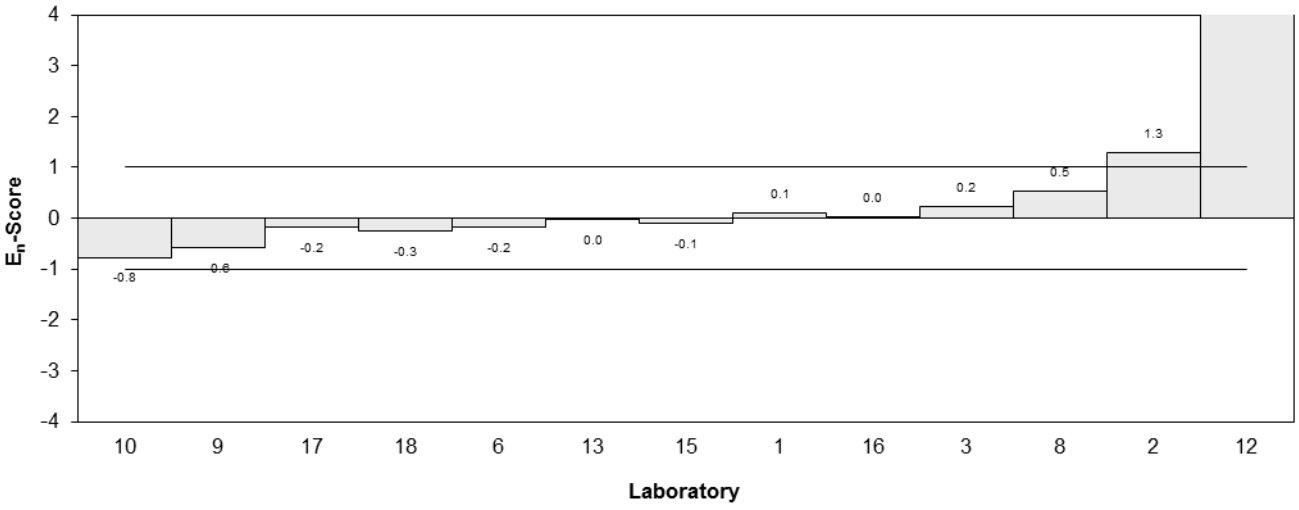

En-Scores: S1 - Se
En-Score
Laboratory
10 9 17 18 6 13 15 1 16 3 8 2 12
-0.8 -0.6 -0.2 -0.3 -0.2 0.0 -0.1 0.1 0.0 0.2 0.5 1.3

Figure 13

Table 16

Sample Details

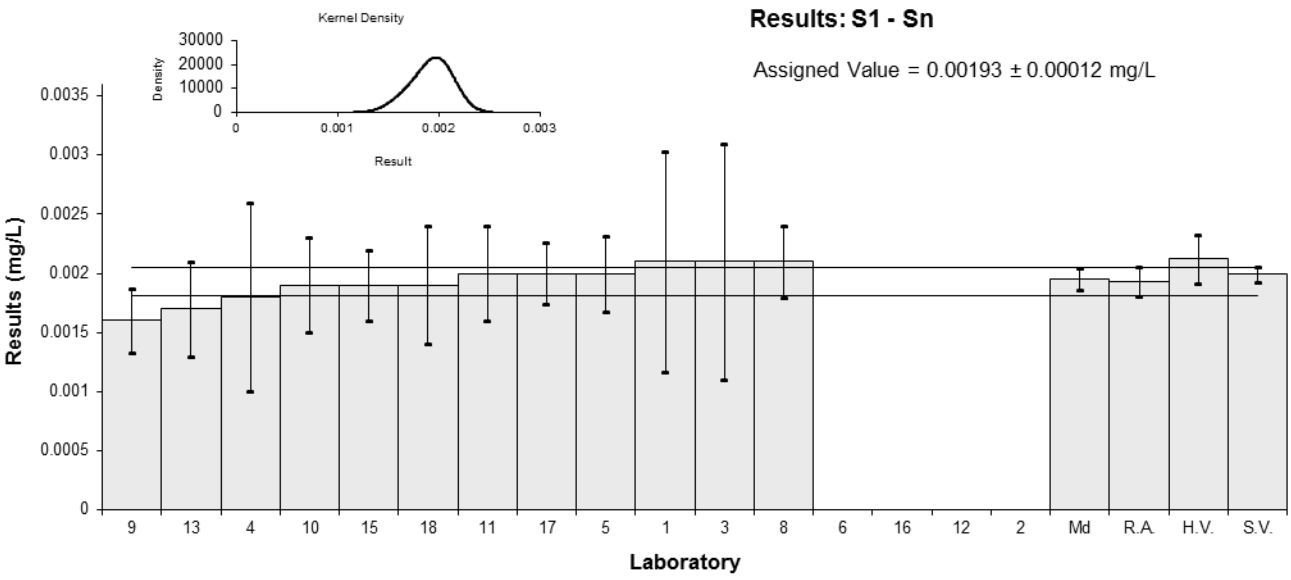
Sample No.	S1
Matrix.	Potable Water
Analyte.	Sn
Units	mg/L

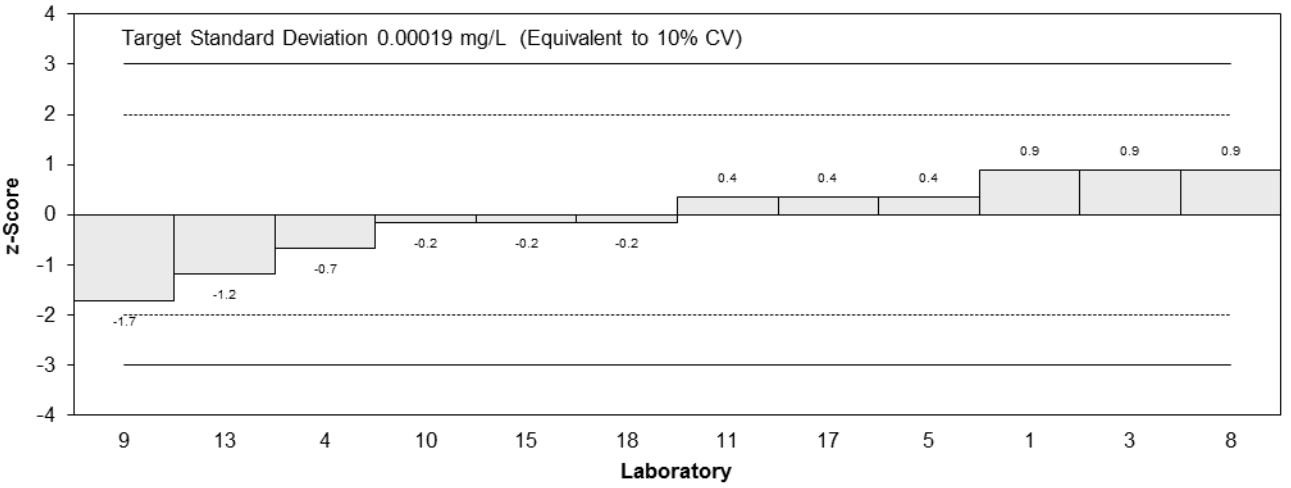
Participant Results

Lab Code	Result	Uncertainty	z-Score	E_n-Score
1	0.00210	0.00093	0.88	0.18
2	NT	NT		
3	0.0021	0.001	0.88	0.17
4	0.0018	0.0008	-0.67	-0.16
5	0.002	0.00032	0.36	0.20
6	<0.005	NR		
8	0.0021	0.0003	0.88	0.53
9	0.0016	0.00027	-1.71	-1.12
10	0.0019	0.0004	-0.16	-0.07
11	0.002	0.0004	0.36	0.17
12	NT	NT		
13	0.0017	0.0004	-1.19	-0.55
15	0.0019	0.0003	-0.16	-0.09
16	NR	NR		
17	0.002	0.00026	0.36	0.24
18	0.0019	0.0005	-0.16	-0.06

Statistics

Assigned Value	0.00193	0.00012
Spike	0.00199	0.00006
Homogeneity Value	0.00212	0.00021
Robust Average	0.00193	0.00012
Median	0.00195	0.00009
Mean	0.00193	
N	12	
Max.	0.0021	
Min.	0.0016	
Robust SD	0.00016	
Robust CV	8.3%	


Kernel Density
Density
30000
20000
10000
0
0
0.001
0.002
0.003
Result
Results: S1 - Sn
Assigned Value = 0.00193 ± 0.00012 mg/L
Results (mg/L)
0.0035
0.003
0.0025
0.002
0.0015
0.001
0.0005
0
9 13 4 10 15 18 11 17 5 1 3 8 6 16 12 2 Md R.A. H.V. S.V.
Laboratory


z-Scores: S1 - Sn
Target Standard Deviation 0.00019 mg/L (Equivalent to 10% CV)
z-Score
4
3
2
1
0
-1
-2
-3
-4
-1.7
-1.2
-0.7
-0.2
-0.2
-0.2
0.4
0.4
0.4
0.9
0.9
0.9
9 13 4 10 15 18 11 17 5 1 3 8
Laboratory

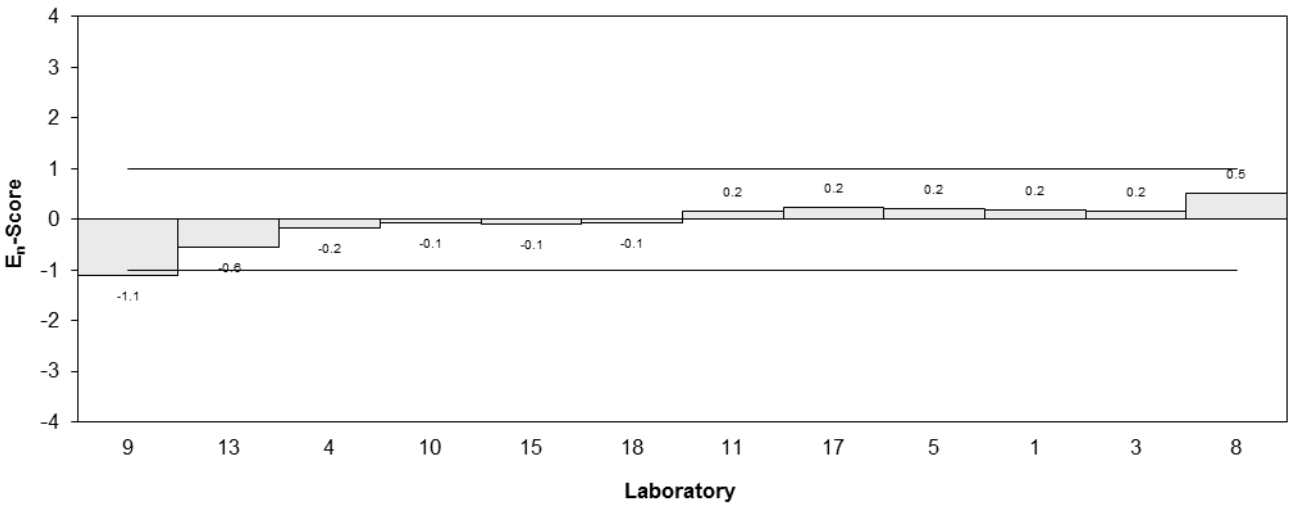

En-Scores: S1 - Sn
En-Score
4
3
2
1
0
-1
-2
-3
-4
-1.1
-0.6
-0.2
-0.1
-0.1
-0.1
0.2
0.2
0.2
0.2
0.2
0.5
9 13 4 10 15 18 11 17 5 1 3 8
Laboratory

Figure 14

Table 17

Sample Details

Sample No.	S1
Matrix.	Potable Water
Analyte.	Tl
Units	mg/L

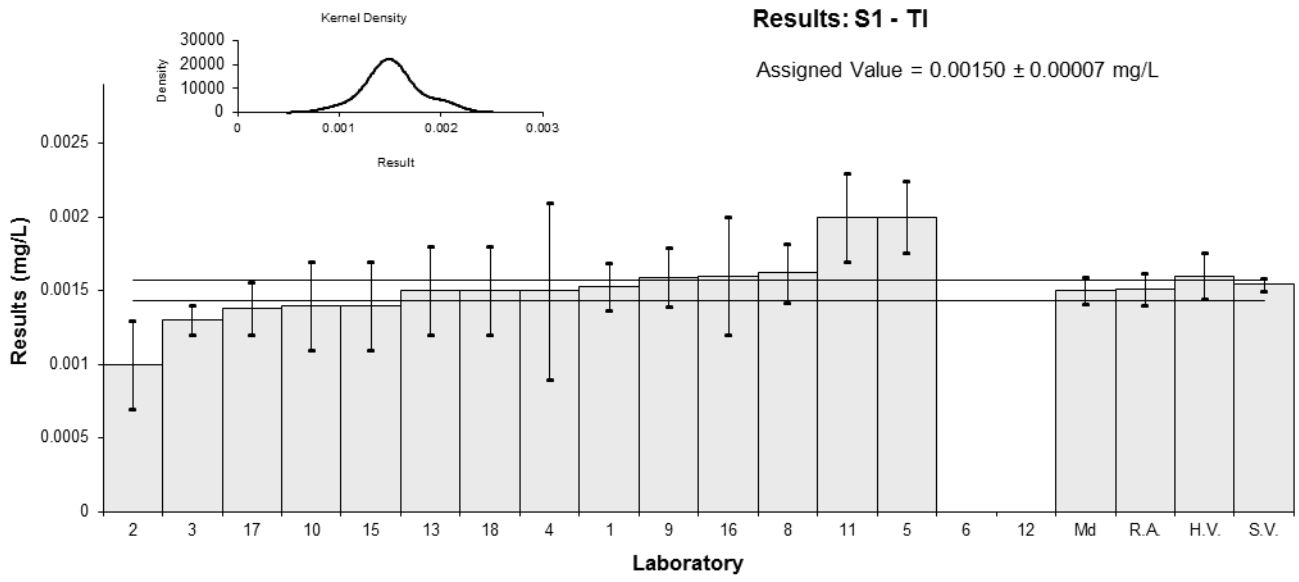
Participant Results

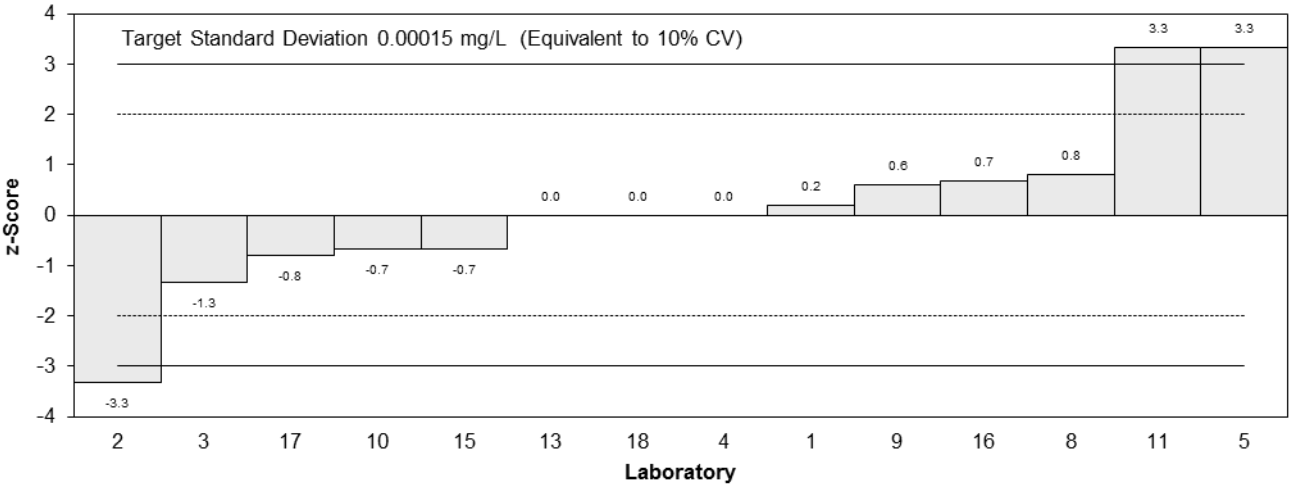
Lab Code	Result	Uncertainty	z-Score	E_n-Score
1	0.00153	0.00016	0.20	0.17
2	0.001	0.0003	-3.33	-1.62
3	0.0013	0.0001	-1.33	-1.64
4	0.0015	0.0006	0.00	0.00
5	0.002	0.00024	3.33	2.00
6	<0.005	NR		
8	0.00162	0.0002	0.80	0.57
9	0.00159	0.00020	0.60	0.43
10	0.0014	0.0003	-0.67	-0.33
11	0.002	0.0003	3.33	1.62
12	NT	NT		
13	0.0015	0.0003	0.00	0.00
15	0.0014	0.0003	-0.67	-0.33
16	0.0016	0.0004	0.67	0.25
17	0.00138	0.00018	-0.80	-0.62
18	0.0015	0.0003	0.00	0.00

Statistics

Assigned Value*	0.00150	0.00007
Spike	0.00154	0.00004
Homogeneity Value	0.00160	0.00016
Robust Average	0.00151	0.00011
Median	0.00150	0.00009
Mean	0.00152	
N	14	
Max.	0.002	
Min.	0.001	
Robust SD	0.00017	
Robust CV	11%	

*The Assigned Value was calculated as the Robust Average of the combined results of Samples S1 and S2


Kernel Density
Density
30000
20000
10000
0
0
0.001
0.002
0.003
Result
Results: S1 - Tl
Assigned Value = 0.00150 ± 0.00007 mg/L
Results (mg/L)
0.0025
0.002
0.0015
0.001
0.0005
0
2 3 17 10 15 13 18 4 1 9 16 8 11 5 6 12 Md R.A. H.V. S.V.
Laboratory


z-Scores: S1 - Tl
Target Standard Deviation 0.00015 mg/L (Equivalent to 10% CV)
z-Score
4
3
2
1
0
-1
-2
-3
-4
-3.3
-1.3
-0.8
-0.7
-0.7
0.0
0.0
0.0
0.2
0.6
0.7
0.8
3.3
3.3
2 3 17 10 15 13 18 4 1 9 16 8 11 5
Laboratory

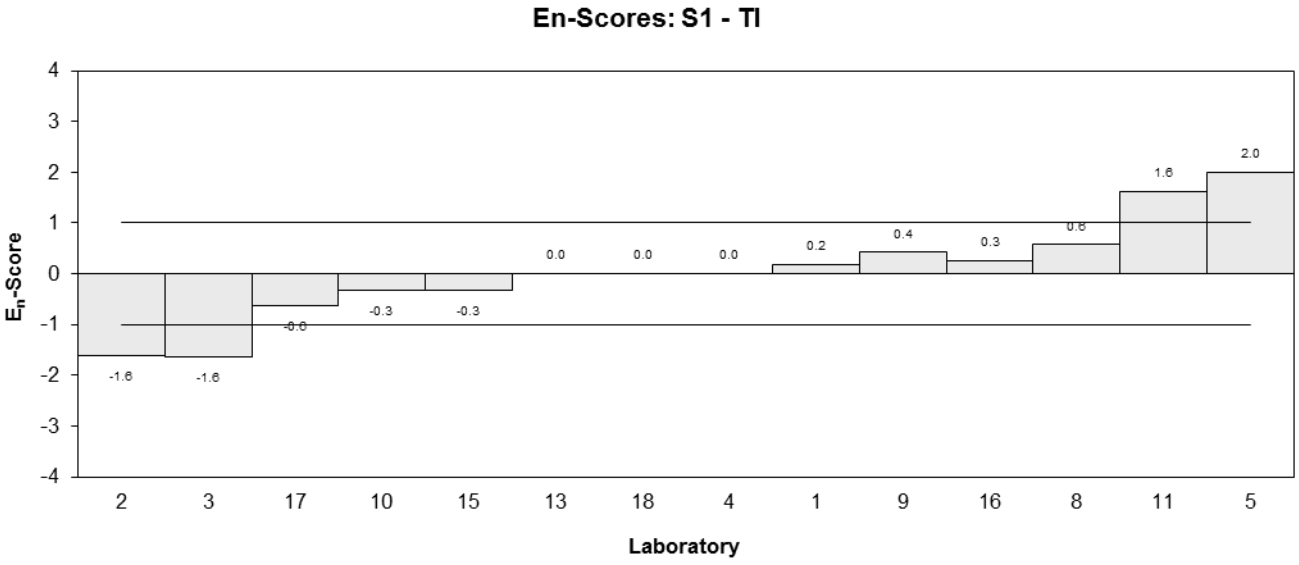

En-Scores: S1 - Tl
En-Score
4
3
2
1
0
-1
-2
-3
-4
-1.6
-1.6
-0.6
-0.3
-0.3
0.0
0.0
0.0
0.2
0.4
0.3
0.6
1.6
2.0
2 3 17 10 15 13 18 4 1 9 16 8 11 5
Laboratory

Figure 15

Table 18

Sample Details

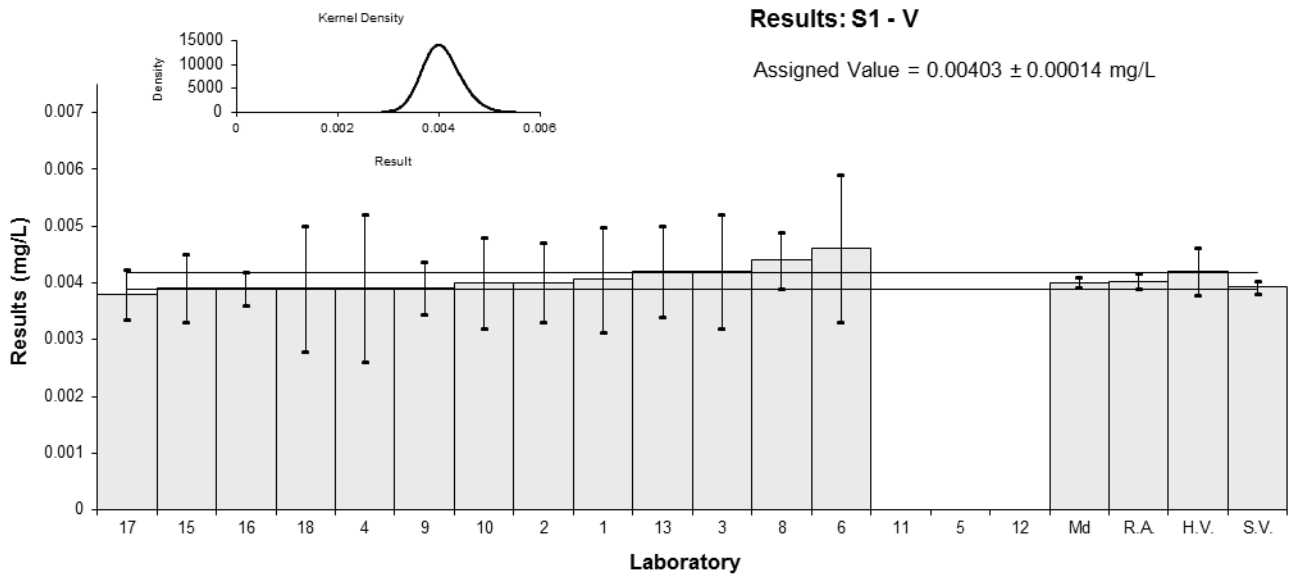
Sample No.	S1
Matrix.	Potable Water
Analyte.	V
Units	mg/L

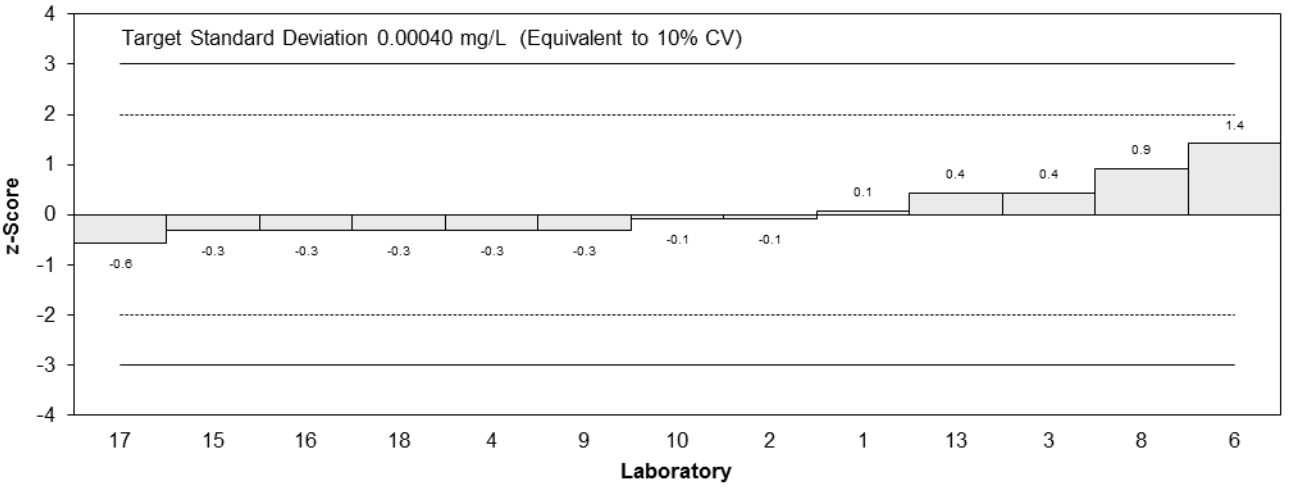
Participant Results

Lab Code	Result	Uncertainty	z-Score	E_n-Score
1	0.00406	0.00092	0.07	0.03
2	0.004	0.0007	-0.07	-0.04
3	0.0042	0.001	0.42	0.17
4	0.0039	0.0013	-0.32	-0.10
5	<0.01	0.0006		
6	0.0046	0.0013	1.41	0.44
8	0.0044	0.0005	0.92	0.71
9	0.0039	0.00046	-0.32	-0.27
10	0.0040	0.0008	-0.07	-0.04
11	<0.01	NR		
12	NT	NT		
13	0.0042	0.0008	0.42	0.21
15	0.0039	0.0006	-0.32	-0.21
16	0.0039	0.0003	-0.32	-0.39
17	0.0038	0.000437	-0.57	-0.50
18	0.0039	0.0011	-0.32	-0.12

Statistics

Assigned Value	0.00403	0.00014
Spike	0.00392	0.00011
Homogeneity Value	0.00420	0.00042
Robust Average	0.00403	0.00014
Median	0.00400	0.00009
Mean	0.00406	
N	13	
Max.	0.0046	
Min.	0.0038	
Robust SD	0.0002	
Robust CV	5%	


Kernel Density
Density
15000
10000
5000
0
0
0.002
0.004
0.006
Result
Results: S1 - V
Assigned Value = 0.00403 ± 0.00014 mg/L
Results (mg/L)
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0
17 15 16 18 4 9 10 2 1 13 3 8 6 11 5 12 Md R.A. H.V. S.V.
Laboratory


z-Scores: S1 - V
Target Standard Deviation 0.00040 mg/L (Equivalent to 10% CV)
z-Score
4
3
2
1
0
-1
-2
-3
-4
-0.6
-0.3
-0.3
-0.3
-0.3
-0.3
-0.1
-0.1
0.1
0.4
0.4
0.9
1.4
17 15 16 18 4 9 10 2 1 13 3 8 6
Laboratory

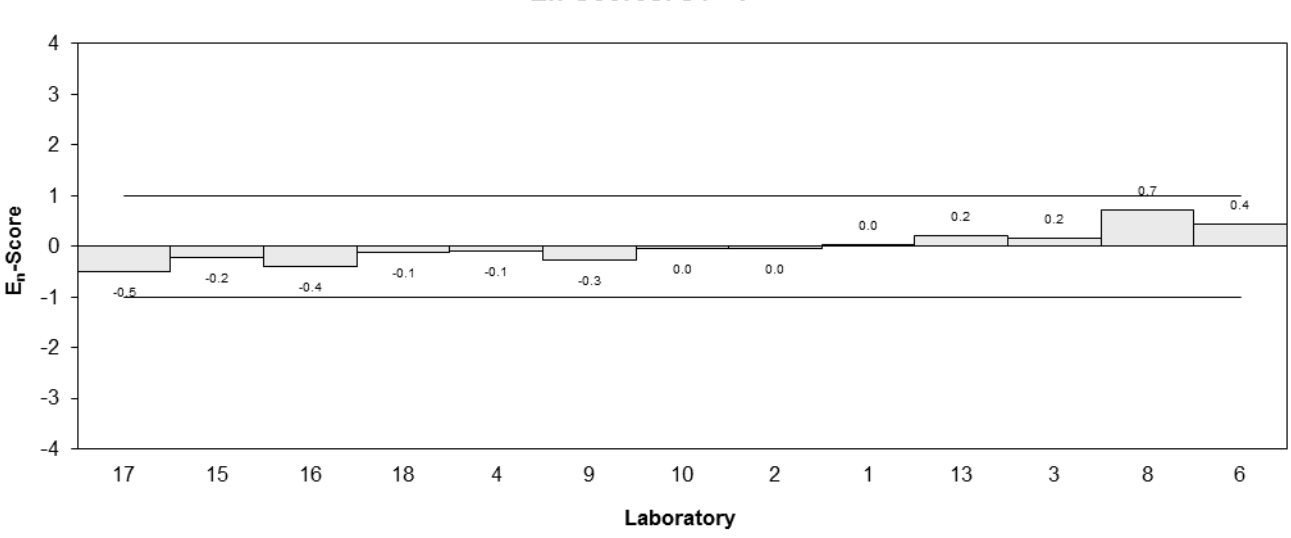

En-Scores: S1 - V
En-Score
4
3
2
1
0
-1
-2
-3
-4
-0.5
-0.2
-0.4
-0.1
-0.1
-0.3
0.0
0.0
0.0
0.2
0.2
0.7
0.4
17 15 16 18 4 9 10 2 1 13 3 8 6
Laboratory

Figure 16

Table 19

Sample Details

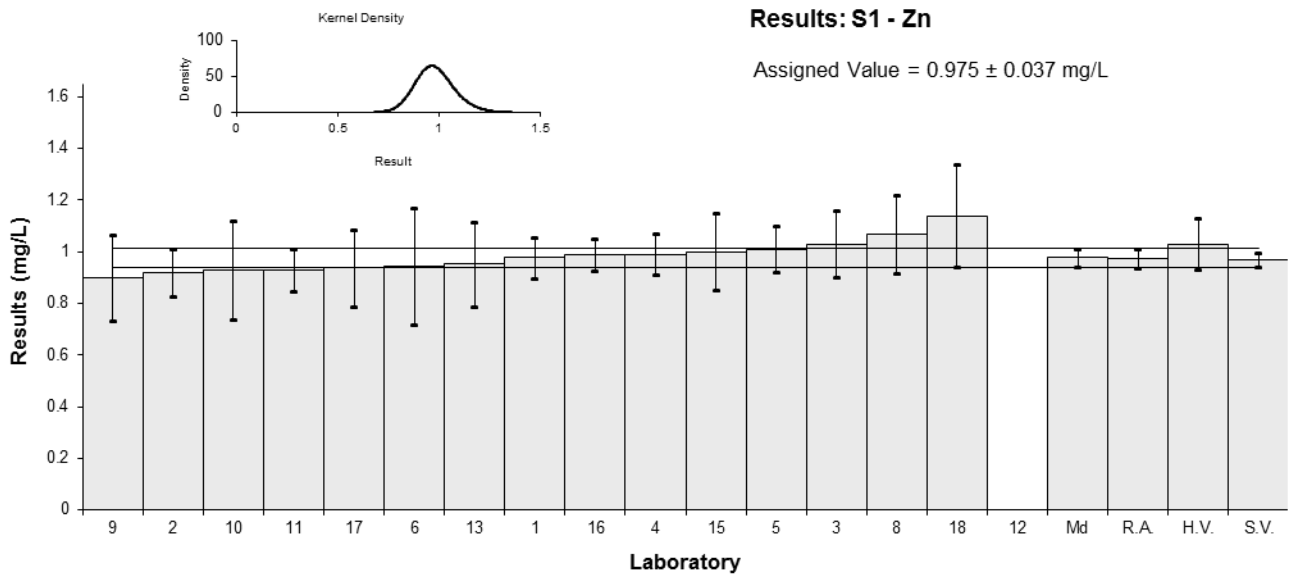
Sample No.	S1
Matrix.	Potable Water
Analyte.	Zn
Units	mg/L

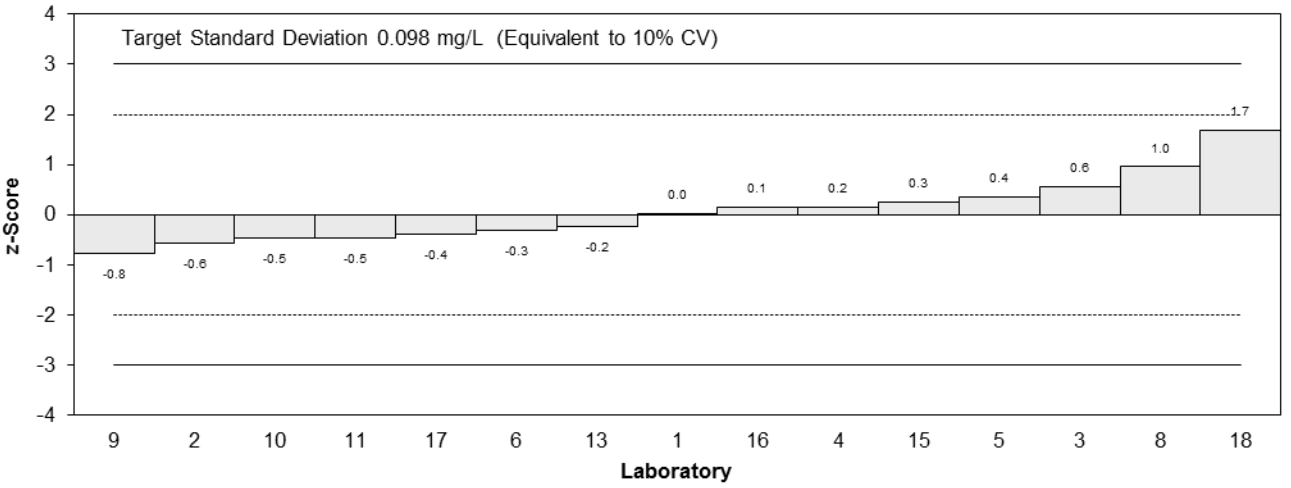
Participant Results

Lab Code	Result	Uncertainty	z-Score	E_n-Score
1	0.977	0.079	0.02	0.02
2	0.919	0.09	-0.57	-0.58
3	1.03	0.13	0.56	0.41
4	0.99	0.08	0.15	0.17
5	1.01	0.09	0.36	0.36
6	0.944	0.227	-0.32	-0.13
8	1.068	0.15	0.95	0.60
9	0.900	0.1660	-0.77	-0.44
10	0.93	0.19	-0.46	-0.23
11	0.930	0.0818	-0.46	-0.50
12	NT	NT		
13	0.9519	0.1618	-0.24	-0.14
15	1.0	0.15	0.26	0.16
16	0.9890	0.0621	0.14	0.19
17	0.937	0.150	-0.39	-0.25
18	1.14	0.20	1.69	0.81

Statistics

Assigned Value	0.975	0.037
Spike	0.968	0.027
Homogeneity Value	1.03	0.10
Robust Average	0.975	0.037
Median	0.977	0.033
Mean	0.981	
N	15	
Max.	1.14	
Min.	0.9	
Robust SD	0.058	
Robust CV	5.9%	


Kernel Density
Density
Result
Results: S1 - Zn
Assigned Value = 0.975 ± 0.037 mg/L
Results (mg/L)
Laboratory
9 2 10 11 17 6 13 1 16 4 15 5 3 8 18 12 Md R.A. H.V. S.V.


z-Scores: S1 - Zn
Target Standard Deviation 0.098 mg/L (Equivalent to 10% CV)
z-Score
Laboratory
9 2 10 11 17 6 13 1 16 4 15 5 3 8 18
-0.8 -0.6 -0.5 -0.5 -0.4 -0.3 -0.2 0.0 0.1 0.2 0.3 0.4 0.6 1.0 1.7

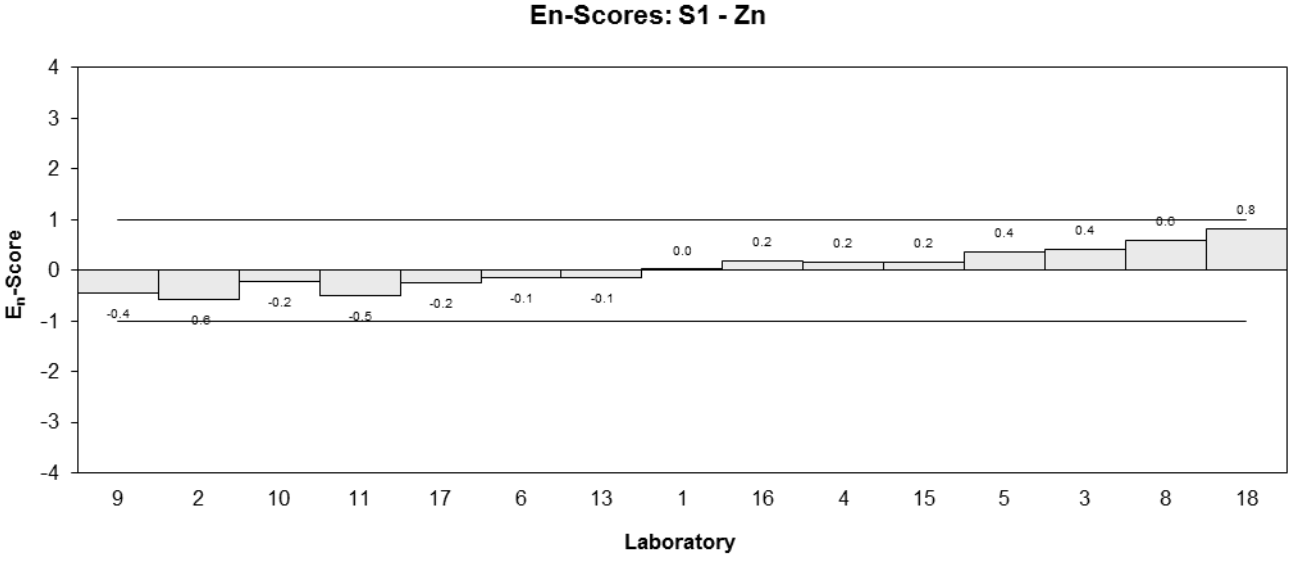

En-Scores: S1 - Zn
En-Score
Laboratory
9 2 10 11 17 6 13 1 16 4 15 5 3 8 18
-0.4 -0.6 -0.2 -0.5 -0.2 -0.1 -0.1 0.0 0.2 0.2 0.2 0.4 0.4 0.6 0.8

Figure 17

Table 20

Sample Details

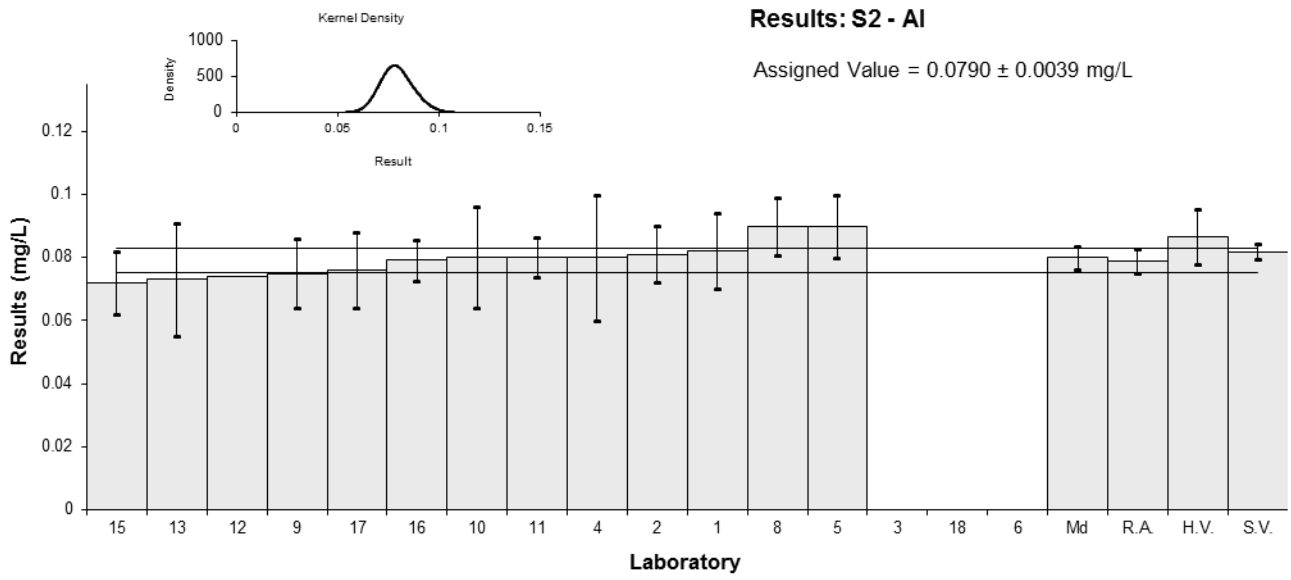
Sample No.	S2
Matrix.	Potable Water
Analyte.	Al
Units	mg/L

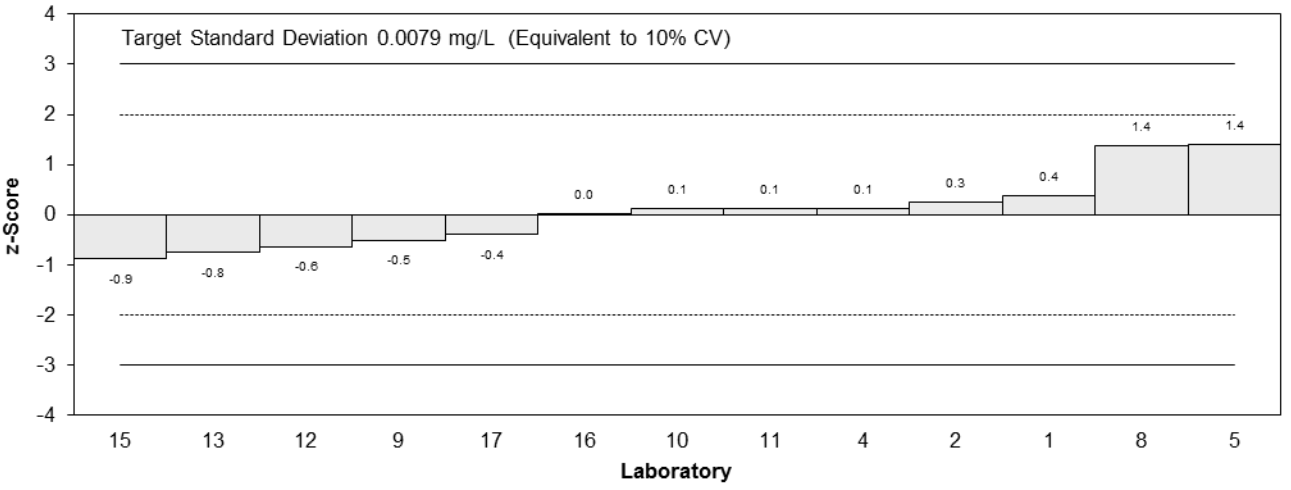
Participant Results

Lab Code	Result	Uncertainty	z-Score	E_n-Score
1	0.082	0.012	0.38	0.24
2	0.081	0.009	0.25	0.20
3	<0.01	0.01		
4	0.08	0.02	0.13	0.05
5	0.09	0.01	1.39	1.02
6	NT	NT		
8	0.0899	0.009	1.38	1.11
9	0.075	0.0108	-0.51	-0.35
10	0.080	0.016	0.13	0.06
11	0.08	0.0062	0.13	0.14
12	0.074	NR	-0.63	-1.28
13	0.073	0.018	-0.76	-0.33
15	0.072	0.01	-0.89	-0.65
16	0.0791	0.00632	0.01	0.01
17	0.076	0.0119	-0.38	-0.24
18	NT	NT		

Statistics

Assigned Value	0.0790	0.0039
Spike	0.0819	0.0025
Homogeneity Value	0.0867	0.0087
Robust Average	0.0790	0.0039
Median	0.0800	0.0036
Mean	0.0794	
N	13	
Max.	0.09	
Min.	0.072	
Robust SD	0.0056	
Robust CV	7.1%	


Kernel Density
Density
1000
500
0
0
0.05
0.1
0.15
Result
Results: S2 - Al
Assigned Value = 0.0790 ± 0.0039 mg/L
Results (mg/L)
0.12
0.1
0.08
0.06
0.04
0.02
0
15 13 12 9 17 16 10 11 4 2 1 8 5 3 18 6 Md R.A. H.V. S.V.
Laboratory


z-Scores: S2 - Al
Target Standard Deviation 0.0079 mg/L (Equivalent to 10% CV)
z-Score
4
3
2
1
0
-1
-2
-3
-4
-0.9
-0.8
-0.6
-0.5
-0.4
0.0
0.1
0.1
0.1
0.3
0.4
1.4
1.4
15 13 12 9 17 16 10 11 4 2 1 8 5
Laboratory

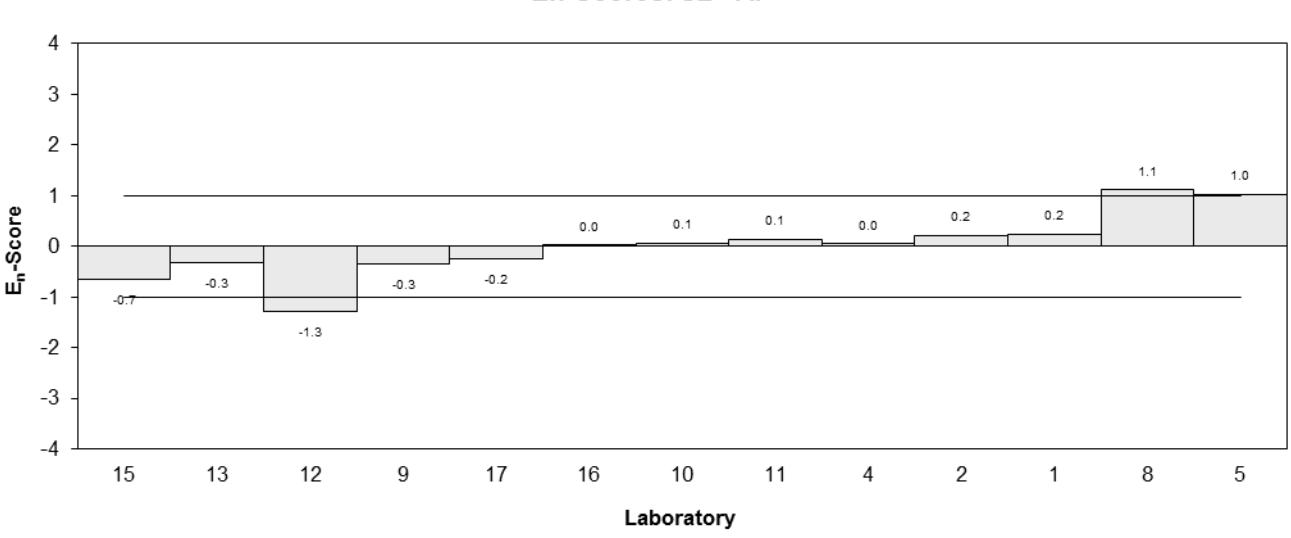

En-Scores: S2 - Al
En-Score
4
3
2
1
0
-1
-2
-3
-4
-0.7
-0.3
-1.3
-0.3
-0.2
0.0
0.1
0.1
0.0
0.2
0.2
1.1
1.0
15 13 12 9 17 16 10 11 4 2 1 8 5
Laboratory

Figure 18

Table 21

Sample Details

Sample No.	S2
Matrix.	Potable Water
Analyte.	As
Units	mg/L

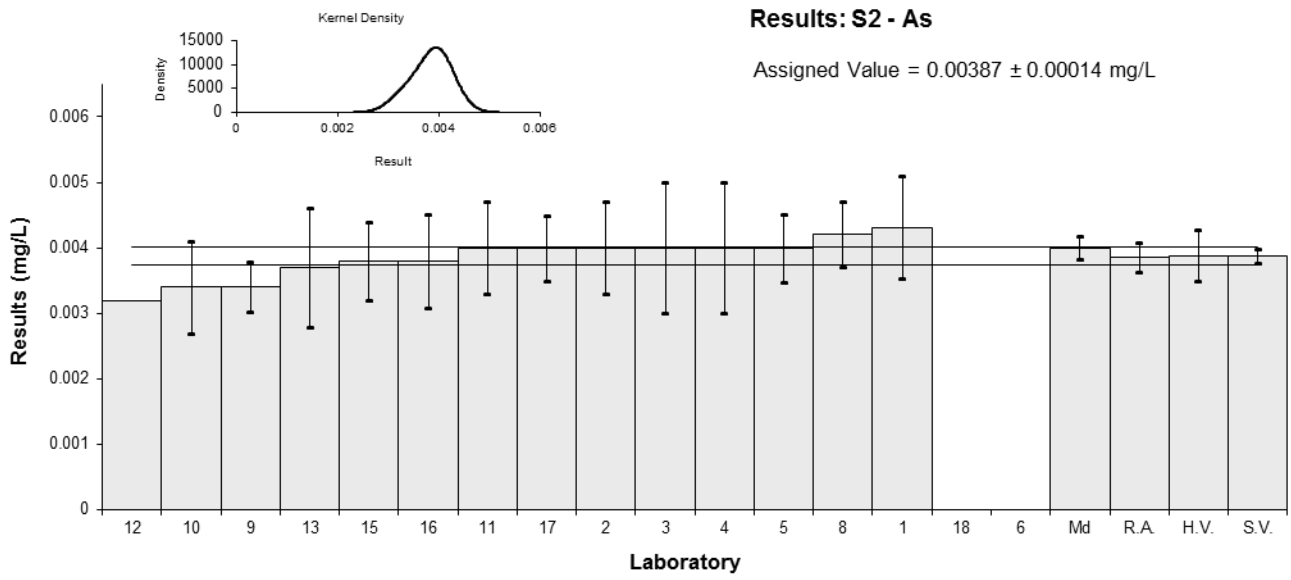
Participant Results

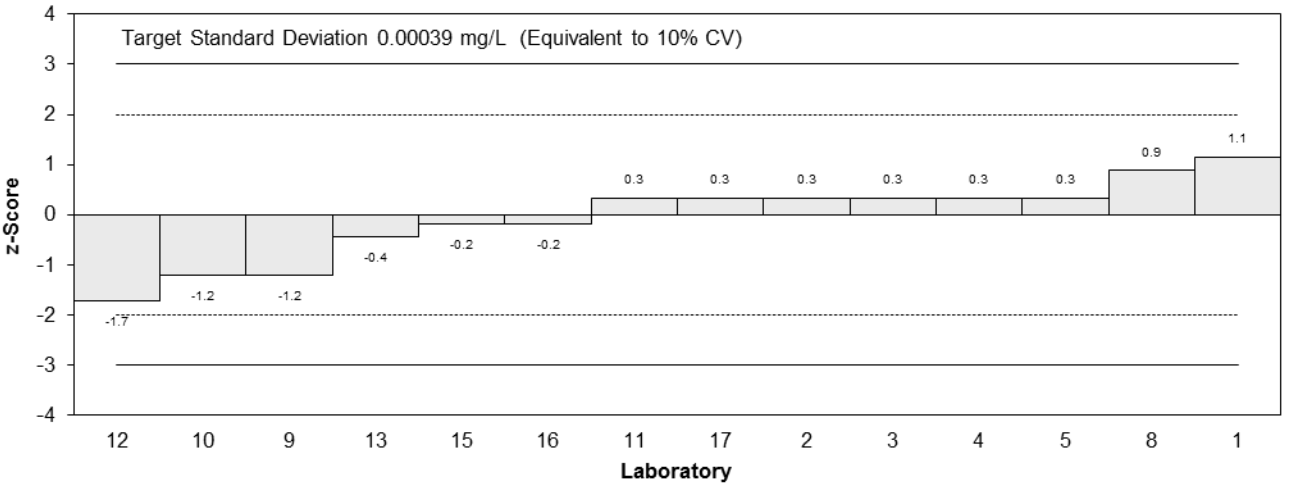
Lab Code	Result	Uncertainty	z-Score	E_n-Score
1	0.00431	0.00078	1.14	0.56
2	0.004	0.0007	0.34	0.18
3	0.004	0.001	0.34	0.13
4	0.004	0.001	0.34	0.13
5	0.004	0.00052	0.34	0.24
6	NT	NT		
8	0.00421	0.0005	0.88	0.65
9	0.0034	0.00038	-1.21	-1.16
10	0.0034	0.0007	-1.21	-0.66
11	0.004	0.0007	0.34	0.18
12	0.0032	NR	-1.73	-4.79
13	0.0037	0.0009	-0.44	-0.19
15	0.0038	0.0006	-0.18	-0.11
16	0.0038	0.00072	-0.18	-0.10
17	0.004	0.0005	0.34	0.25
18	NT	NT		

Statistics

Assigned Value*	0.00387	0.00014
Spike	0.00388	0.00011
Homogeneity Value	0.00388	0.00039
Robust Average	0.00386	0.00023
Median	0.00400	0.00017
Mean	0.00384	
N	14	
Max.	0.00431	
Min.	0.0032	
Robust SD	0.00034	
Robust CV	8.8%	

*The Assigned Value was calculated as the Robust Average of the combined results of Samples S1 and S2


Kernel Density
Density
15000
10000
5000
0
0
0.002
0.004
0.006
Result
Results: S2 - As
Assigned Value = 0.00387 ± 0.00014 mg/L
Results (mg/L)
0.006
0.005
0.004
0.003
0.002
0.001
0
12 10 9 13 15 16 11 17 2 3 4 5 8 1 18 6 Md R.A. H.V. S.V.
Laboratory


z-Scores: S2 - As
Target Standard Deviation 0.00039 mg/L (Equivalent to 10% CV)
z-Score
4
3
2
1
0
-1
-2
-3
-4
-1.7
-1.2
-1.2
-0.4
-0.2
-0.2
0.3
0.3
0.3
0.3
0.3
0.3
0.9
1.1
12 10 9 13 15 16 11 17 2 3 4 5 8 1
Laboratory

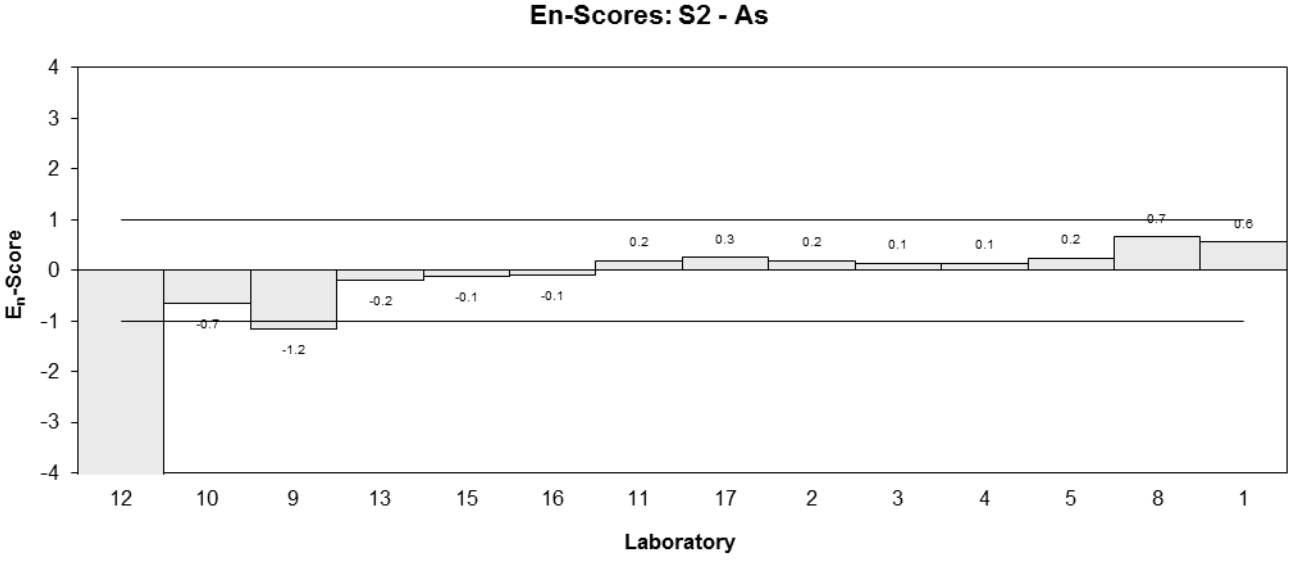

En-Scores: S2 - As
En-Score
4
3
2
1
0
-1
-2
-3
-4
-0.7
-1.2
-0.2
-0.1
-0.1
0.2
0.3
0.2
0.1
0.1
0.2
0.7
0.6
12 10 9 13 15 16 11 17 2 3 4 5 8 1
Laboratory

Figure 19

Table 22

Sample Details

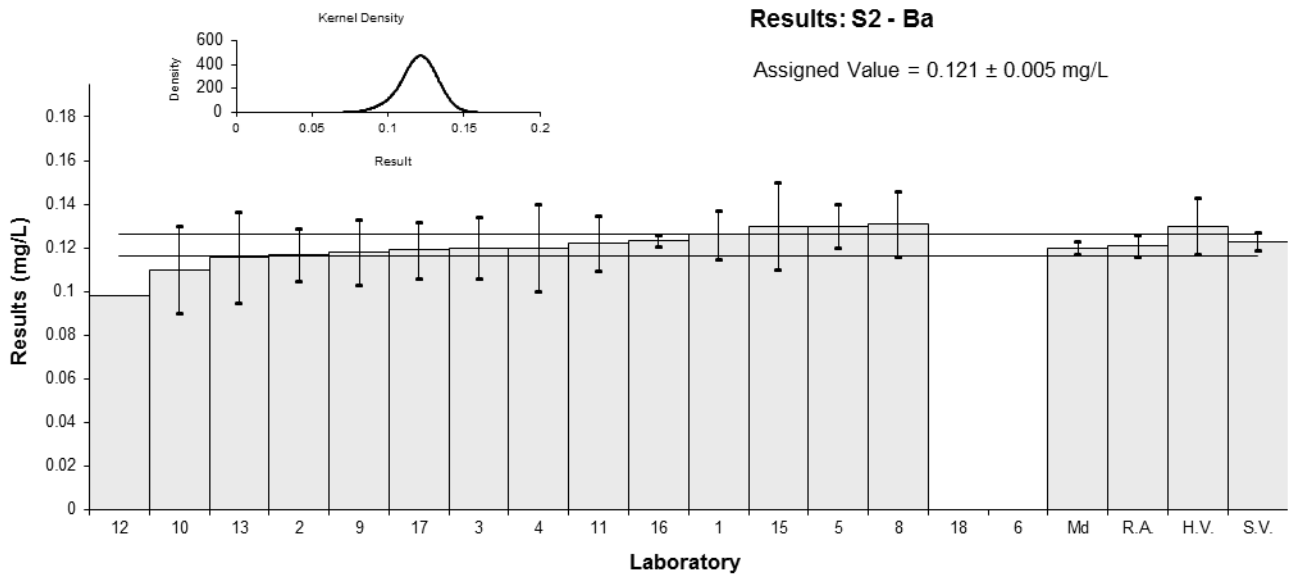
Sample No.	S2
Matrix.	Potable Water
Analyte.	Ba
Units	mg/L

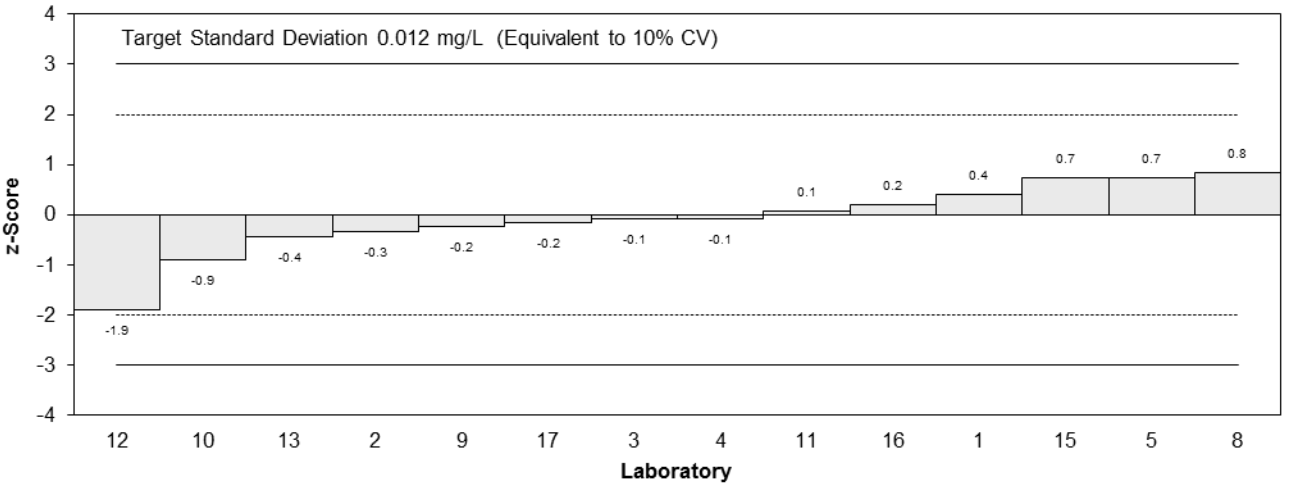
Participant Results

Lab Code	Result	Uncertainty	z-Score	E_n-Score
1	0.126	0.011	0.41	0.41
2	0.117	0.012	-0.33	-0.31
3	0.12	0.014	-0.08	-0.07
4	0.12	0.02	-0.08	-0.05
5	0.130	0.01	0.74	0.80
6	NT	NT		
8	0.13116	0.015	0.84	0.64
9	0.118	0.0148	-0.25	-0.19
10	0.11	0.02	-0.91	-0.53
11	0.122	0.0125	0.08	0.07
12	0.098	NR	-1.90	-4.60
13	0.1157	0.0208	-0.44	-0.25
15	0.13	0.02	0.74	0.44
16	0.1235	0.00264	0.21	0.44
17	0.119	0.0128	-0.17	-0.15
18	NT	NT		

Statistics

Assigned Value	0.121	0.005
Spike	0.123	0.004
Homogeneity Value	0.130	0.013
Robust Average	0.121	0.005
Median	0.120	0.003
Mean	0.120	
N	14	
Max.	0.13116	
Min.	0.098	
Robust SD	0.008	
Robust CV	6.6%	


Kernel Density
Density
600
400
200
0
0
0.05
0.1
0.15
0.2
Result
Results: S2 - Ba
Assigned Value = 0.121 ± 0.005 mg/L
Results (mg/L)
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
12 10 13 2 9 17 3 4 11 16 1 15 5 8 18 6 Md R.A. H.V. S.V.
Laboratory


z-Scores: S2 - Ba
Target Standard Deviation 0.012 mg/L (Equivalent to 10% CV)
z-Score
4
3
2
1
0
-1
-2
-3
-4
-1.9
-0.9
-0.4
-0.3
-0.2
-0.2
-0.1
-0.1
0.1
0.2
0.4
0.7
0.7
0.8
12 10 13 2 9 17 3 4 11 16 1 15 5 8
Laboratory

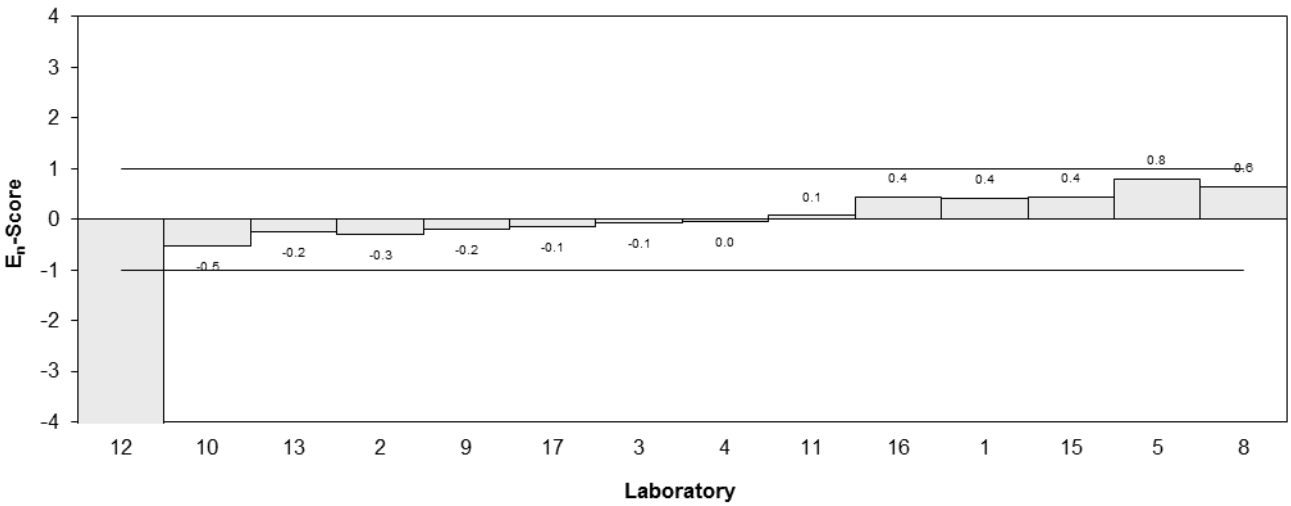

En-Scores: S2 - Ba
En-Score
4
3
2
1
0
-1
-2
-3
-4
-0.5
-0.2
-0.3
-0.2
-0.1
-0.1
0.0
0.1
0.4
0.4
0.4
0.8
0.6
12 10 13 2 9 17 3 4 11 16 1 15 5 8
Laboratory

Figure 20

Table 23

Sample Details

Sample No.	S2
Matrix.	Potable Water
Analyte.	Bi
Units	mg/L

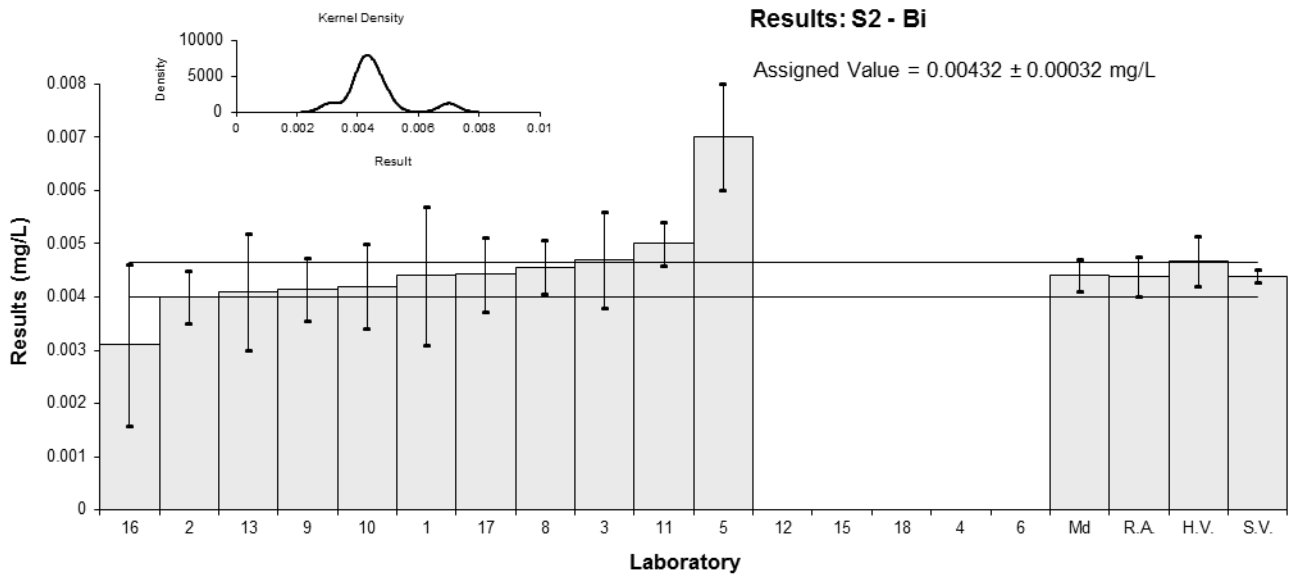
Participant Results

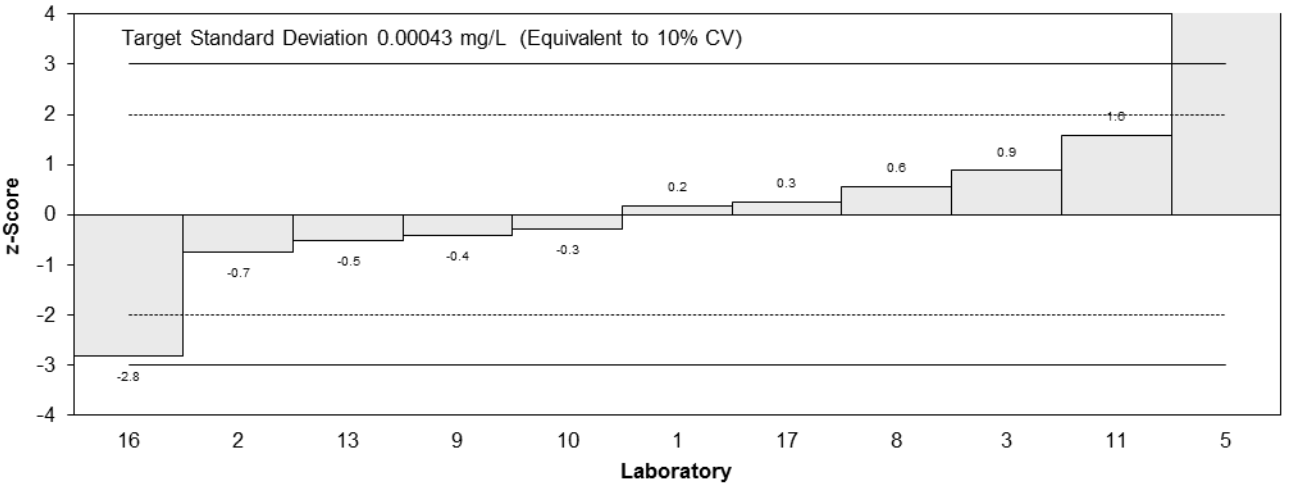
Lab Code	Result	Uncertainty	z-Score	E_n-Score
1	0.0044	0.0013	0.19	0.06
2	0.004	0.0005	-0.74	-0.54
3	0.0047	0.0009	0.88	0.40
4	NT	NT		
5	0.007	0.001	6.20	2.55
6	NT	NT		
8	0.00456	0.0005	0.56	0.40
9	0.00414	0.000590	-0.42	-0.27
10	0.0042	0.0008	-0.28	-0.14
11	0.005	0.0004	1.57	1.33
12	NT	NT		
13	0.0041	0.0011	-0.51	-0.19
15	NT	NT		
16	0.0031	0.00151	-2.82	-0.79
17	0.00443	0.00070	0.25	0.14
18	NT	NT		

Statistics

Assigned Value*	0.00432	0.00032
Spike	0.00439	0.00012
Homogeneity Value	0.00467	0.00047
Robust Average	0.00439	0.00038
Median	0.00440	0.00030
Mean	0.00451	
N	11	
Max.	0.007	
Min.	0.0031	
Robust SD	0.0005	
Robust CV	11%	

*Robust Average excluding Laboratory 5


Kernel Density
Density
Result
Results: S2 - Bi
Assigned Value = 0.00432 ± 0.00032 mg/L
Results (mg/L)
Laboratory
16 2 13 9 10 1 17 8 3 11 5 12 15 18 4 6 Md R.A. H.V. S.V.


z-Scores: S2 - Bi
Target Standard Deviation 0.00043 mg/L (Equivalent to 10% CV)
z-Score
Laboratory
16 2 13 9 10 1 17 8 3 11 5
-2.8 -0.7 -0.5 -0.4 -0.3 0.2 0.3 0.6 0.9 1.6

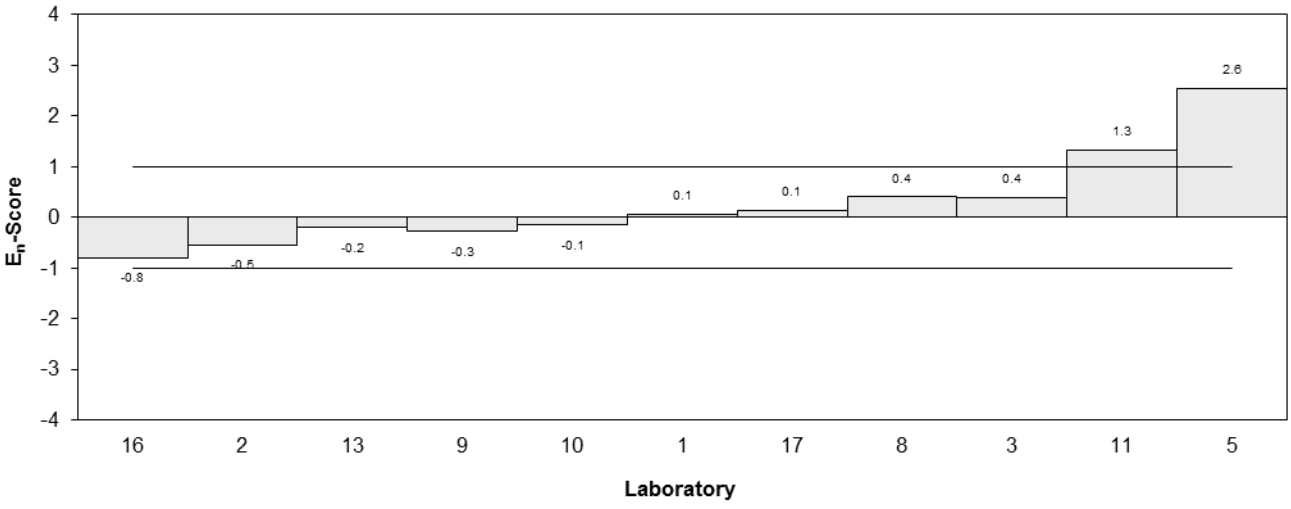

En-Scores: S2 - Bi
En-Score
Laboratory
16 2 13 9 10 1 17 8 3 11 5
-0.8 -0.5 -0.2 -0.3 -0.1 0.1 0.1 0.4 0.4 1.3 2.6

Figure 21

Table 24

Sample Details

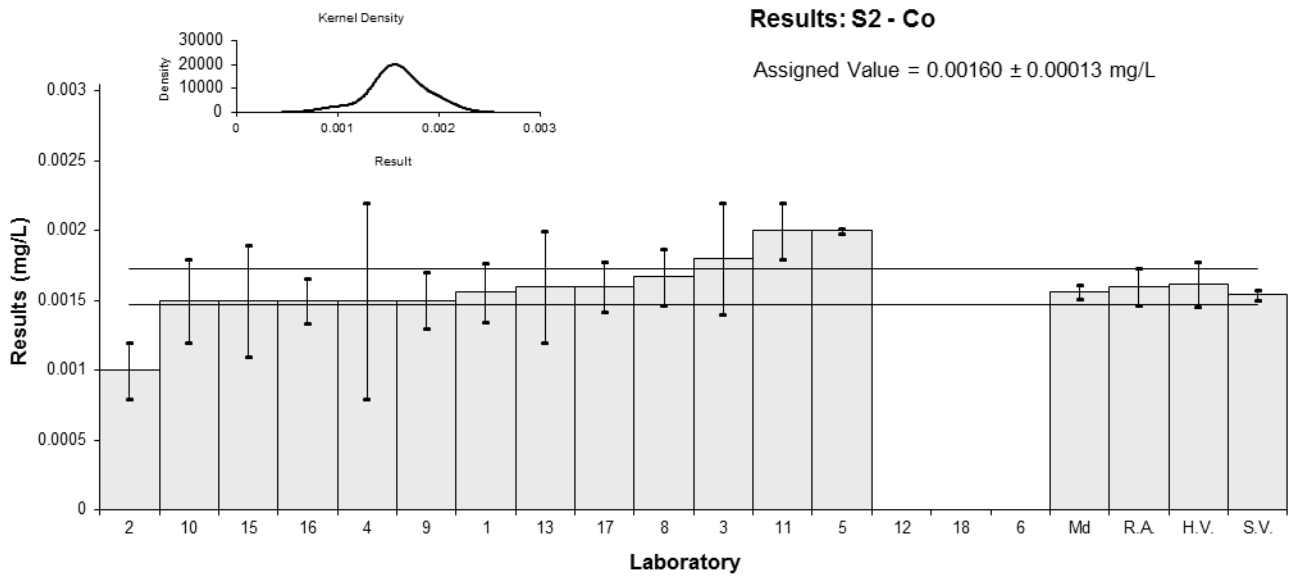
Sample No.	S2
Matrix.	Potable Water
Analyte.	Co
Units	mg/L

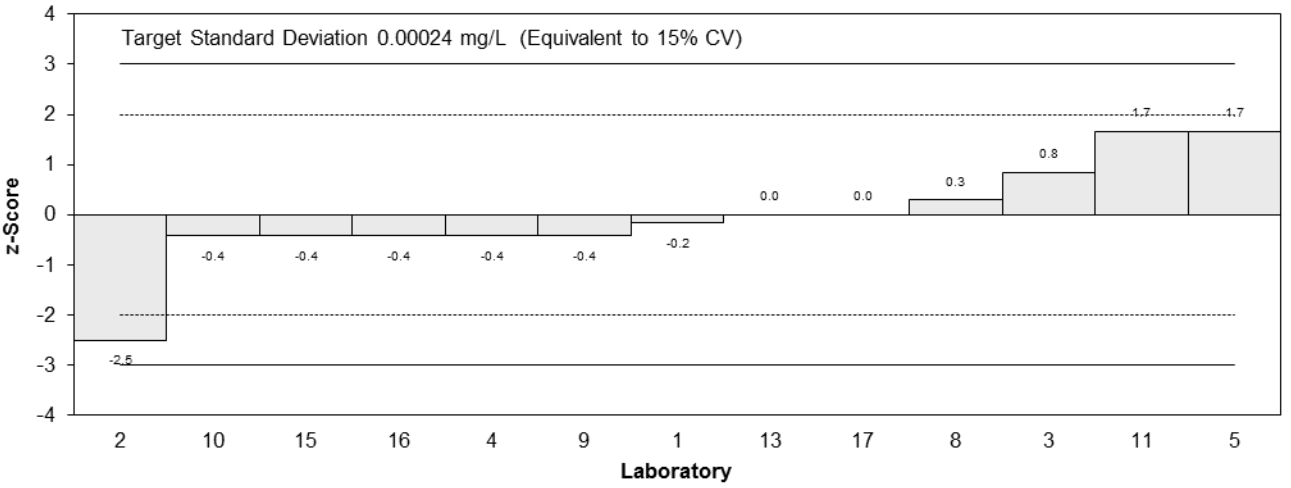
Participant Results

Lab Code	Result	Uncertainty	z-Score	E_n-Score
1	0.00156	0.00021	-0.17	-0.16
2	0.001	0.0002	-2.50	-2.52
3	0.0018	0.0004	0.83	0.48
4	0.0015	0.0007	-0.42	-0.14
5	0.002	0.00002	1.67	3.04
6	NT	NT		
8	0.00167	0.0002	0.29	0.29
9	0.0015	0.00020	-0.42	-0.42
10	0.0015	0.0003	-0.42	-0.31
11	0.002	0.0002	1.67	1.68
12	NT	NT		
13	0.0016	0.0004	0.00	0.00
15	0.0015	0.0004	-0.42	-0.24
16	0.0015	0.00016	-0.42	-0.49
17	0.0016	0.00018	0.00	0.00
18	NT	NT		

Statistics

Assigned Value	0.00160	0.00013
Spike	0.00154	0.00004
Homogeneity Value	0.00162	0.00016
Robust Average	0.00160	0.00013
Median	0.00156	0.00005
Mean	0.00159	
N	13	
Max.	0.002	
Min.	0.001	
Robust SD	0.00018	
Robust CV	11%	


Kernel Density
Density
Result
Results: S2 - Co
Assigned Value = 0.00160 ± 0.00013 mg/L
Results (mg/L)
Laboratory
2 10 15 16 4 9 1 13 17 8 3 11 5 12 18 6 Md R.A. H.V. S.V.


z-Scores: S2 - Co
Target Standard Deviation 0.00024 mg/L (Equivalent to 15% CV)
z-Score
Laboratory
2 10 15 16 4 9 1 13 17 8 3 11 5

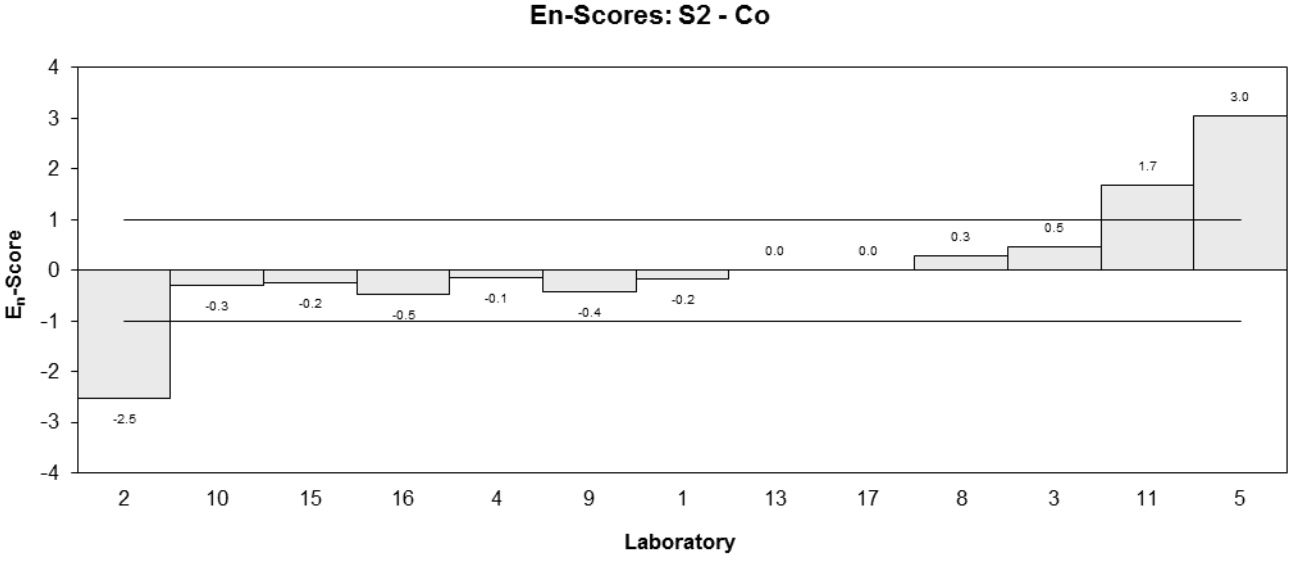

En-Scores: S2 - Co
En-Score
Laboratory
2 10 15 16 4 9 1 13 17 8 3 11 5

Figure 22

Table 25

Sample Details

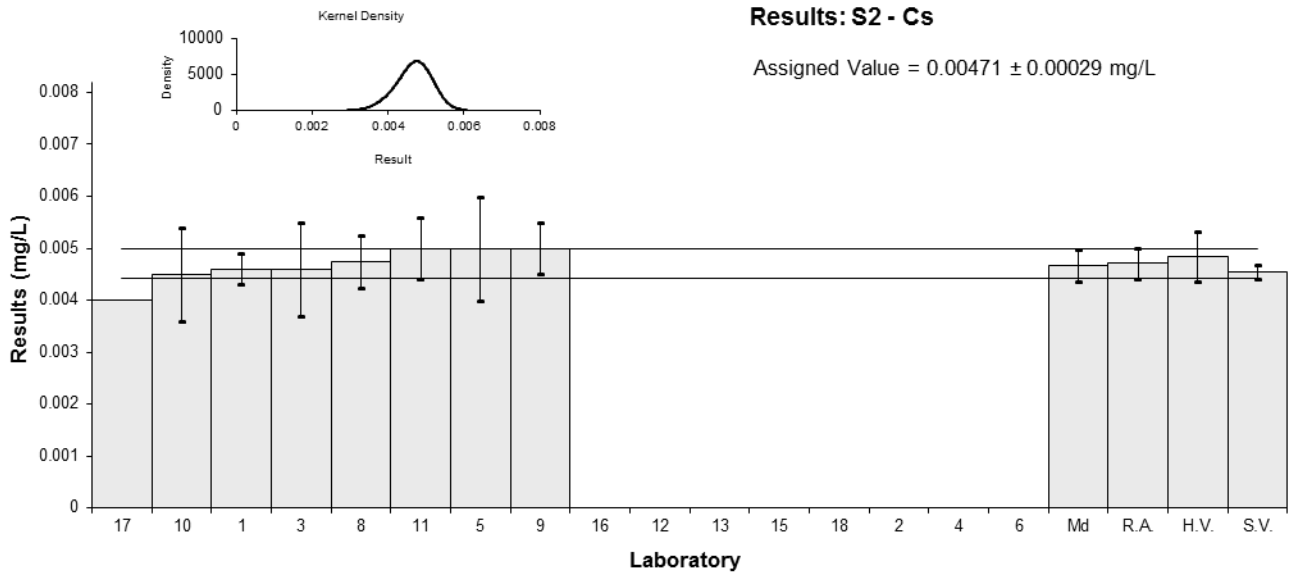
Sample No.	S2
Matrix.	Potable Water
Analyte.	Cs
Units	mg/L

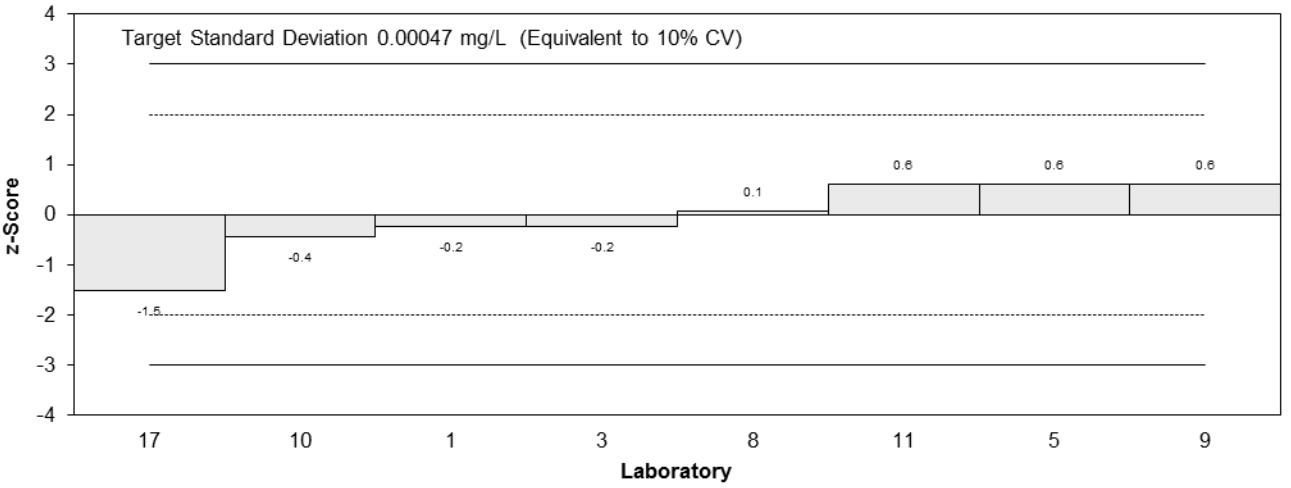
Participant Results

Lab Code	Result	Uncertainty	z-Score	E_n-Score
1	0.00460	0.00029	-0.23	-0.27
2	NT	NT		
3	0.0046	0.0009	-0.23	-0.12
4	NT	NT		
5	0.005	0.001	0.62	0.28
6	NT	NT		
8	0.00474	0.0005	0.06	0.05
9	0.005	0.0005	0.62	0.50
10	0.0045	0.0009	-0.45	-0.22
11	0.005	0.0006	0.62	0.44
12	NT	NT		
13	NT	NT		
15	NT	NT		
16	NR	NR		
17	0.004	NR	-1.51	-2.45
18	NT	NT		

Statistics

Assigned Value	0.00471	0.00029
Spike	0.00455	0.00013
Homogeneity Value	0.00483	0.00048
Robust Average	0.00471	0.00029
Median	0.00467	0.00031
Mean	0.00468	
N	8	
Max.	0.005	
Min.	0.004	
Robust SD	0.00032	
Robust CV	6.8%	


Kernel Density
Density
10000
5000
0
0
0.002
0.004
0.006
0.008
Result
Results: S2 - Cs
Assigned Value = 0.00471 ± 0.00029 mg/L
Results (mg/L)
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0
17
10
1
3
8
11
5
9
16
12
13
15
18
2
4
6
Md
R.A.
H.V.
S.V.
Laboratory


z-Scores: S2 - Cs
Target Standard Deviation 0.00047 mg/L (Equivalent to 10% CV)
z-Score
4
3
2
1
0
-1
-2
-3
-4
-1.5
-0.4
-0.2
-0.2
0.1
0.6
0.6
0.6
17
10
1
3
8
11
5
9
Laboratory

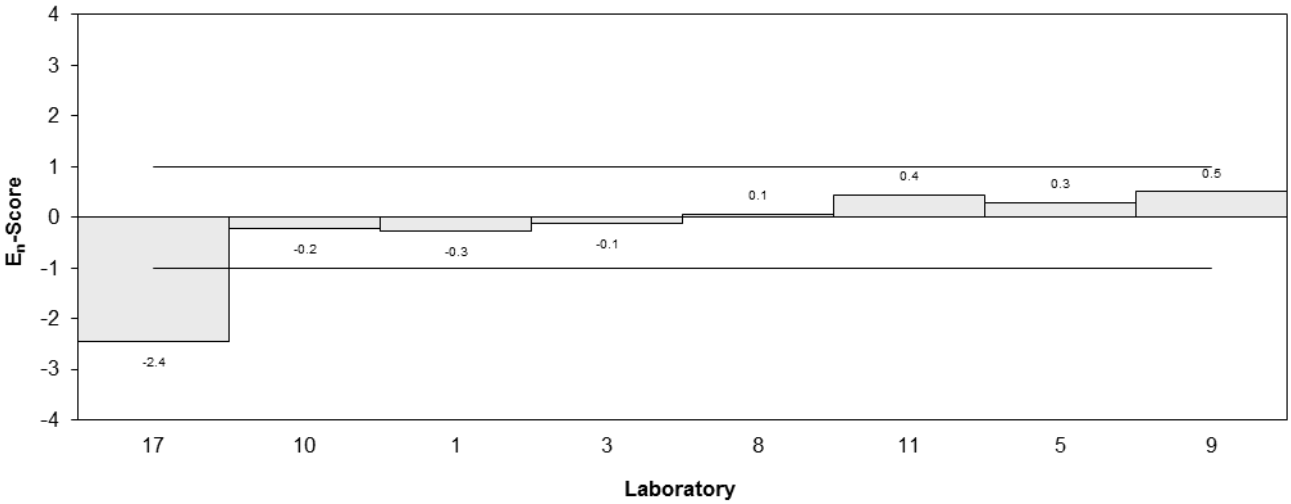

En-Scores: S2 - Cs
En-Score
4
3
2
1
0
-1
-2
-3
-4
-2.4
-0.2
-0.3
-0.1
0.1
0.4
0.3
0.5
17
10
1
3
8
11
5
9
Laboratory

Figure 23

Table 26

Sample Details

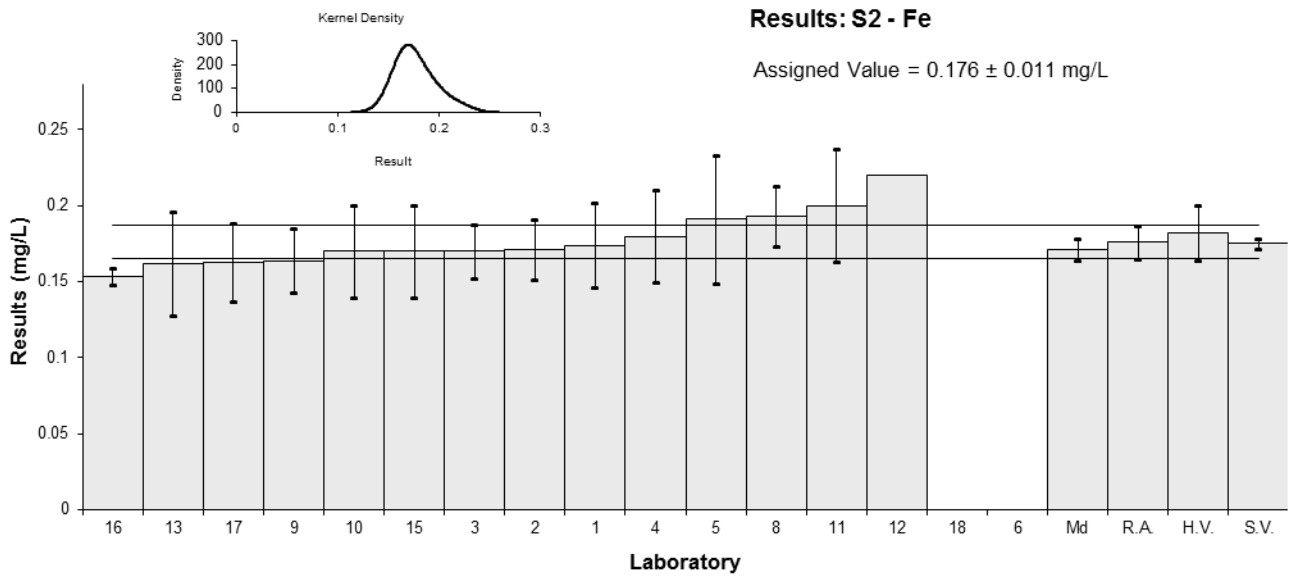
Sample No.	S2
Matrix.	Potable Water
Analyte.	Fe
Units	mg/L

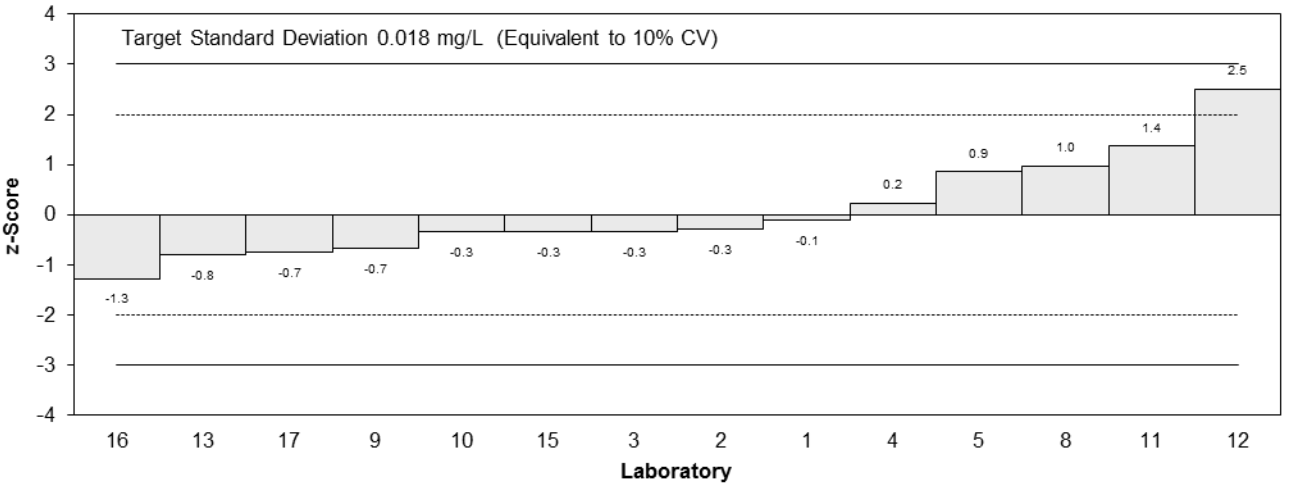
Participant Results

Lab Code	Result	Uncertainty	z-Score	E_n-Score
1	0.174	0.028	-0.11	-0.07
2	0.171	0.020	-0.28	-0.22
3	0.17	0.018	-0.34	-0.28
4	0.18	0.03	0.23	0.13
5	0.191	0.042	0.85	0.35
6	NT	NT		
8	0.193	0.02	0.97	0.74
9	0.164	0.0207	-0.68	-0.51
10	0.17	0.03	-0.34	-0.19
11	0.20	0.0372	1.36	0.62
12	0.22	NR	2.50	4.00
13	0.1619	0.0340	-0.80	-0.39
15	0.17	0.03	-0.34	-0.19
16	0.1536	0.00567	-1.27	-1.81
17	0.163	0.0257	-0.74	-0.47
18	NT	NT		

Statistics

Assigned Value	0.176	0.011
Spike	0.175	0.003
Homogeneity Value	0.182	0.018
Robust Average	0.176	0.011
Median	0.171	0.007
Mean	0.177	
N	14	
Max.	0.22	
Min.	0.1536	
Robust SD	0.017	
Robust CV	9.7%	


Kernel Density
Density
300
200
100
0
0
0.1
0.2
0.3
Result
Results: S2 - Fe
Assigned Value = 0.176 ± 0.011 mg/L
Results (mg/L)
0.25
0.2
0.15
0.1
0.05
0
16 13 17 9 10 15 3 2 1 4 5 8 11 12 18 6 Md R.A. H.V. S.V.
Laboratory


z-Scores: S2 - Fe
Target Standard Deviation 0.018 mg/L (Equivalent to 10% CV)
z-Score
4
3
2
1
0
-1
-2
-3
-4
-1.3
-0.8
-0.7
-0.7
-0.3
-0.3
-0.3
-0.3
-0.1
0.2
0.9
1.0
1.4
2.5
16 13 17 9 10 15 3 2 1 4 5 8 11 12
Laboratory

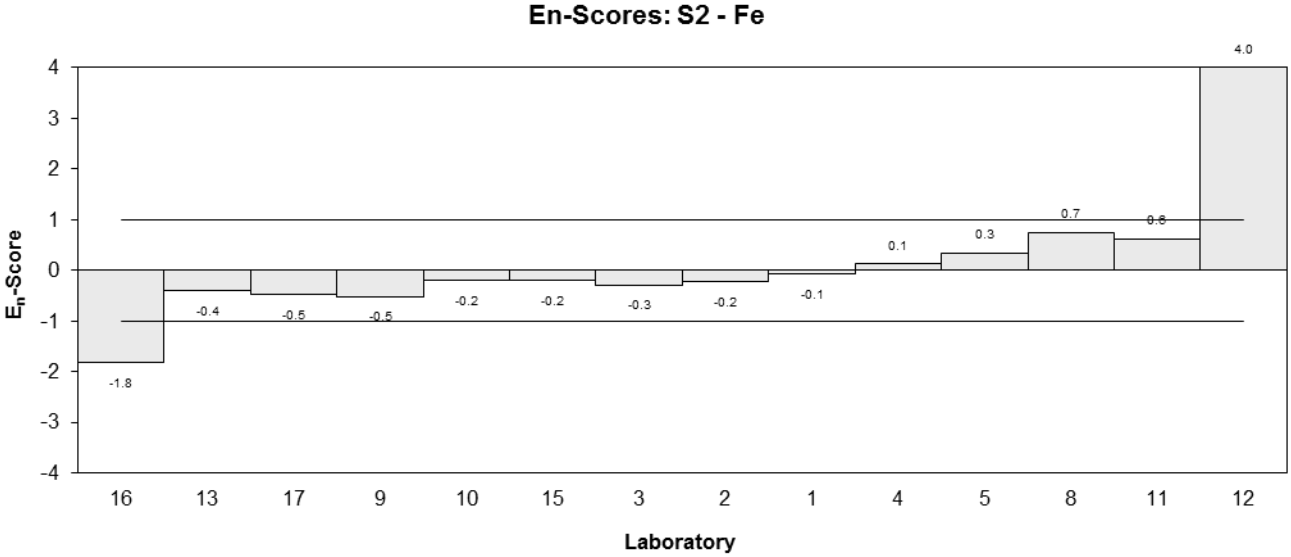

En-Scores: S2 - Fe
En-Score
4
3
2
1
0
-1
-2
-3
-4
-1.8
-0.4
-0.5
-0.5
-0.2
-0.2
-0.3
-0.2
-0.1
0.1
0.3
0.7
0.6
4.0
16 13 17 9 10 15 3 2 1 4 5 8 11 12
Laboratory

Figure 24

Table 27

Sample Details

Sample No.	S2
Matrix.	Potable Water
Analyte.	Hg
Units	mg/L

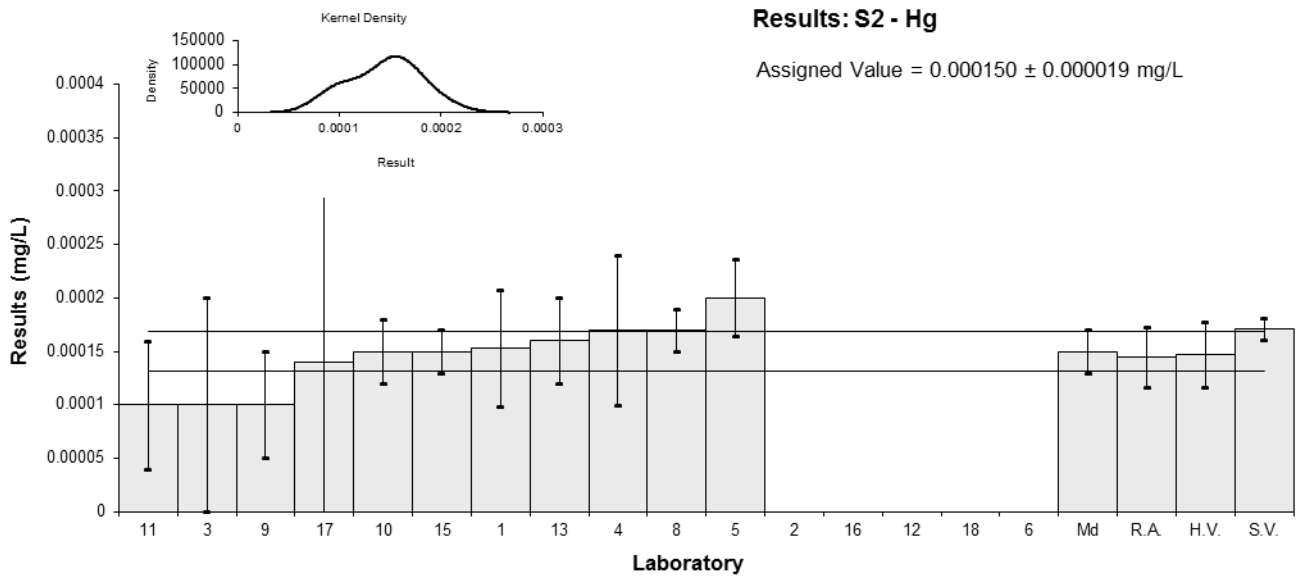
Participant Results

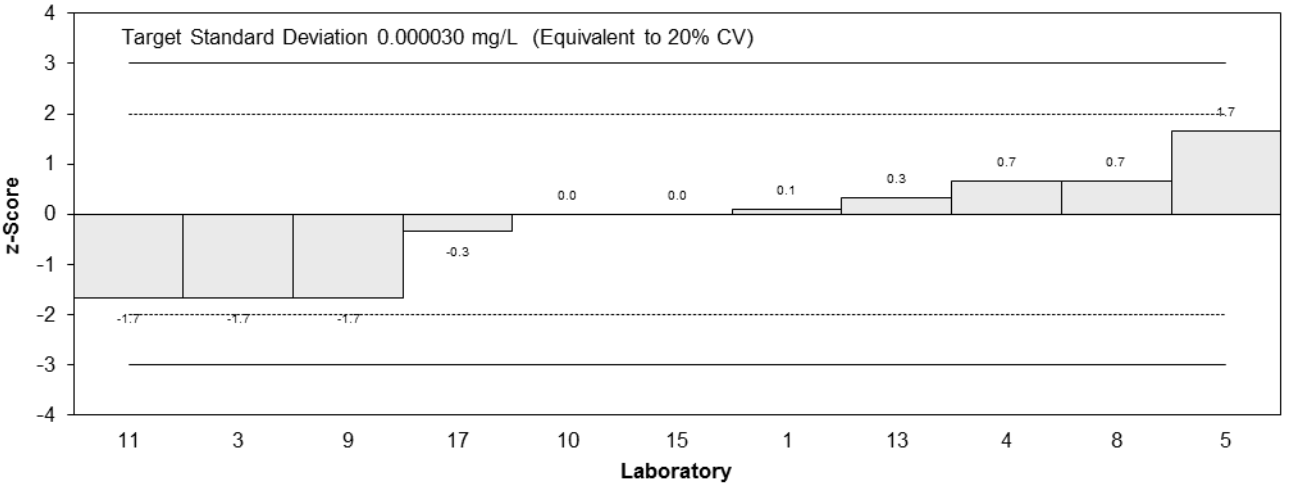
Lab Code	Result	Uncertainty	z-Score	E_n-Score
1	0.000153	0.000055	0.10	0.05
2	<0.0005	NR		
3	0.0001	0.0001	-1.67	-0.49
4	0.00017	0.00007	0.67	0.28
5	0.0002	0.000036	1.67	1.23
6	NT	NT		
8	0.00017	0.00002	0.67	0.72
9	0.0001	0.00005	-1.67	-0.93
10	0.00015	0.00003	0.00	0.00
11	0.0001	0.00006	-1.67	-0.79
12	NT	NT		
13	0.00016	0.00004	0.33	0.23
15	0.00015	0.00002	0.00	0.00
16	<0.001	0.00013		
17	0.00014	0.0002	-0.33	-0.05
18	NT	NT		

Statistics

Assigned Value*	0.000150	0.000019
Spike	0.000171	0.000010
Homogeneity Value	0.000147	0.000030
Robust Average	0.000145	0.000028
Median	0.000150	0.000020
Mean	0.000145	
N	11	
Max.	0.0002	
Min.	0.0001	
Robust SD	0.000037	
Robust CV	26%	

*The Assigned Value was calculated as the Robust Average of the combined results of Samples S1 and S2


Results: S2 - Hg
Assigned Value = 0.000150 ± 0.000019 mg/L
Kernel Density
Density
Result
Results (mg/L)
Laboratory
11 3 9 17 10 15 1 13 4 8 5 2 16 12 18 6 Md R.A. H.V. S.V.


z-Scores: S2 - Hg
Target Standard Deviation 0.000030 mg/L (Equivalent to 20% CV)
z-Score
Laboratory
11 3 9 17 10 15 1 13 4 8 5

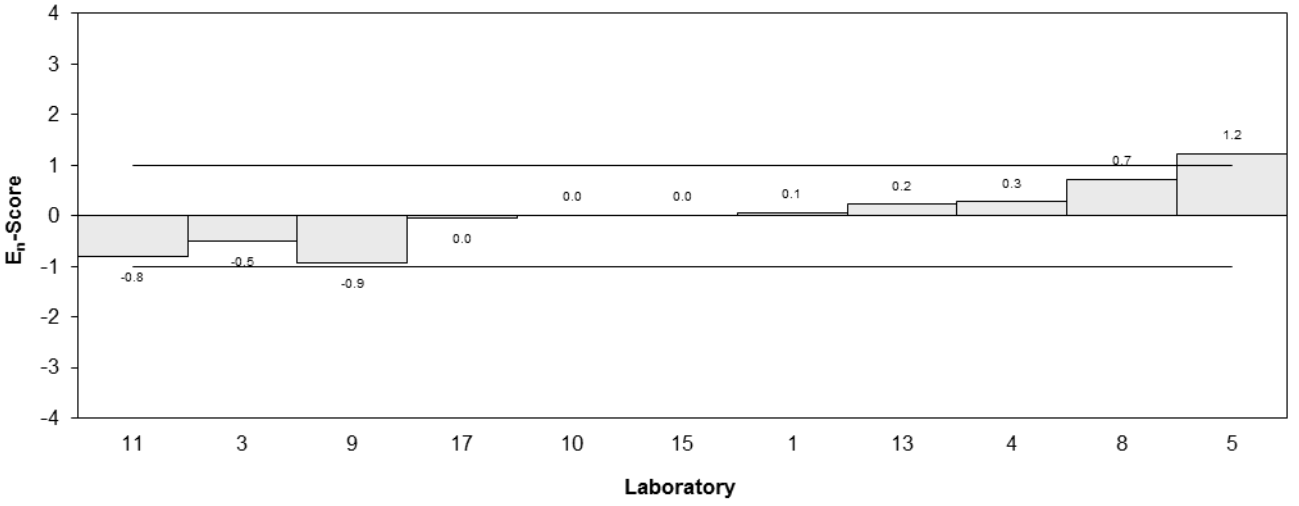

En-Scores: S2 - Hg
En-Score
Laboratory
11 3 9 17 10 15 1 13 4 8 5

Figure 25

Table 28

Sample Details

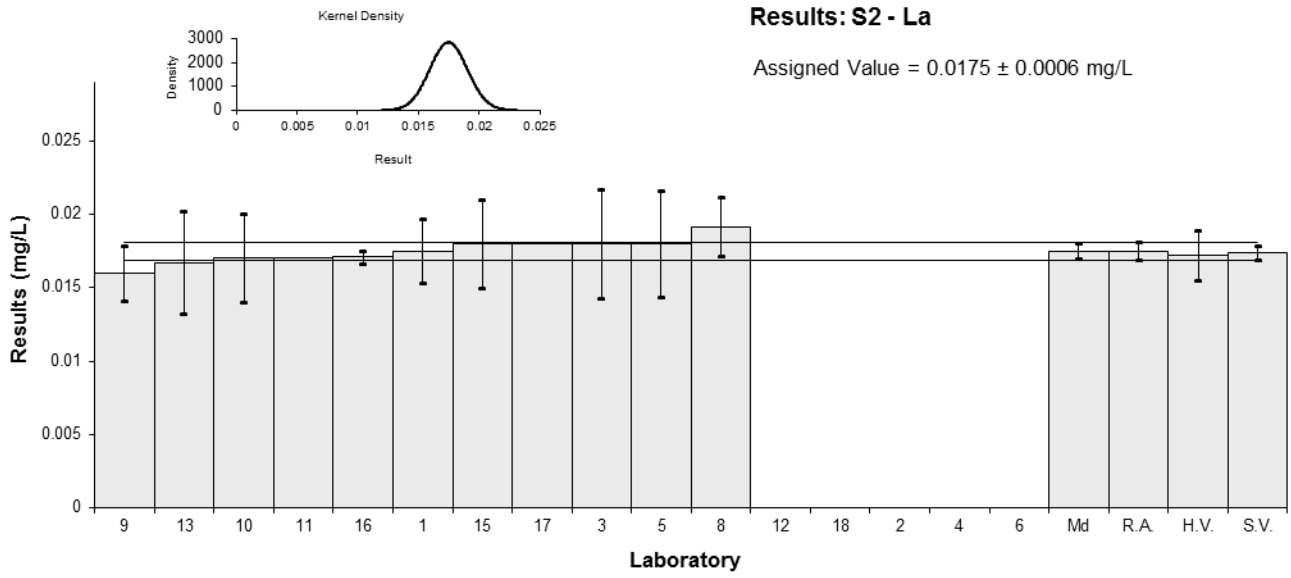
Sample No.	S2
Matrix.	Potable Water
Analyte.	La
Units	mg/L

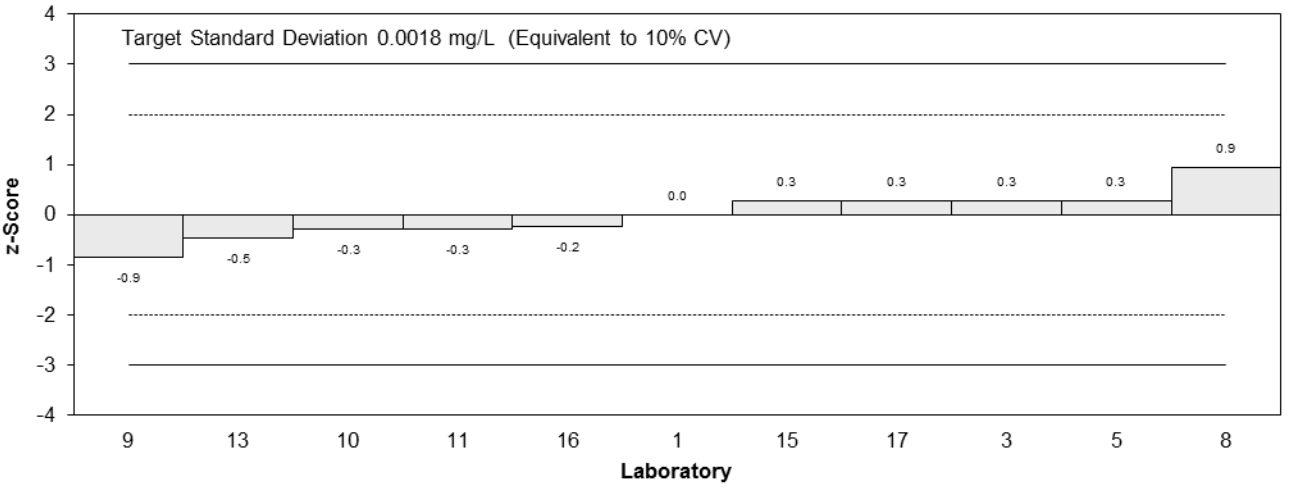
Participant Results

Lab Code	Result	Uncertainty	z-Score	E_n-Score
1	0.0175	0.0022	0.00	0.00
2	NT	NT		
3	0.018	0.0037	0.29	0.13
4	NT	NT		
5	0.018	0.0036	0.29	0.14
6	NT	NT		
8	0.01916	0.002	0.95	0.79
9	0.016	0.0019	-0.86	-0.75
10	0.017	0.003	-0.29	-0.16
11	0.017	NR	-0.29	-0.83
12	NT	NT		
13	0.0167	0.0035	-0.46	-0.23
15	0.018	0.003	0.29	0.16
16	0.0171	0.00042	-0.23	-0.55
17	0.018	NR	0.29	0.83
18	NT	NT		

Statistics

Assigned Value	0.0175	0.0006
Spike	0.0174	0.0005
Homogeneity Value	0.0172	0.0017
Robust Average	0.0175	0.0006
Median	0.0175	0.0005
Mean	0.0175	
N	11	
Max.	0.01916	
Min.	0.016	
Robust SD	0.0008	
Robust CV	4.6%	


Kernel Density
Density
3000
2000
1000
0
0
0.005
0.01
0.015
0.02
0.025
Result
Results: S2 - La
Assigned Value = 0.0175 ± 0.0006 mg/L
Results (mg/L)
0.025
0.02
0.015
0.01
0.005
0
9
13
10
11
16
1
15
17
3
5
8
12
18
2
4
6
Md
R.A.
H.V.
S.V.
Laboratory


z-Scores: S2 - La
Target Standard Deviation 0.0018 mg/L (Equivalent to 10% CV)
z-Score
4
3
2
1
0
-1
-2
-3
-4
-0.9
-0.5
-0.3
-0.3
-0.2
0.0
0.3
0.3
0.3
0.3
0.9
9
13
10
11
16
1
15
17
3
5
8
Laboratory

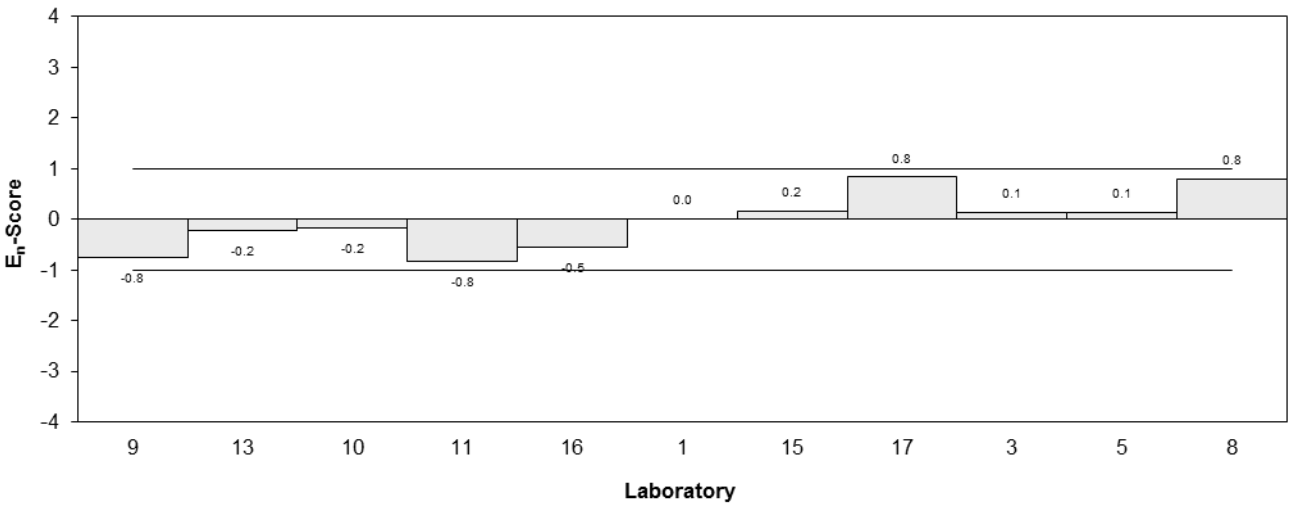

En-Scores: S2 - La
En-Score
4
3
2
1
0
-1
-2
-3
-4
-0.8
-0.2
-0.2
-0.8
-0.5
0.0
0.2
0.8
0.1
0.1
0.8
9
13
10
11
16
1
15
17
3
5
8
Laboratory

Figure 26

Table 29

Sample Details

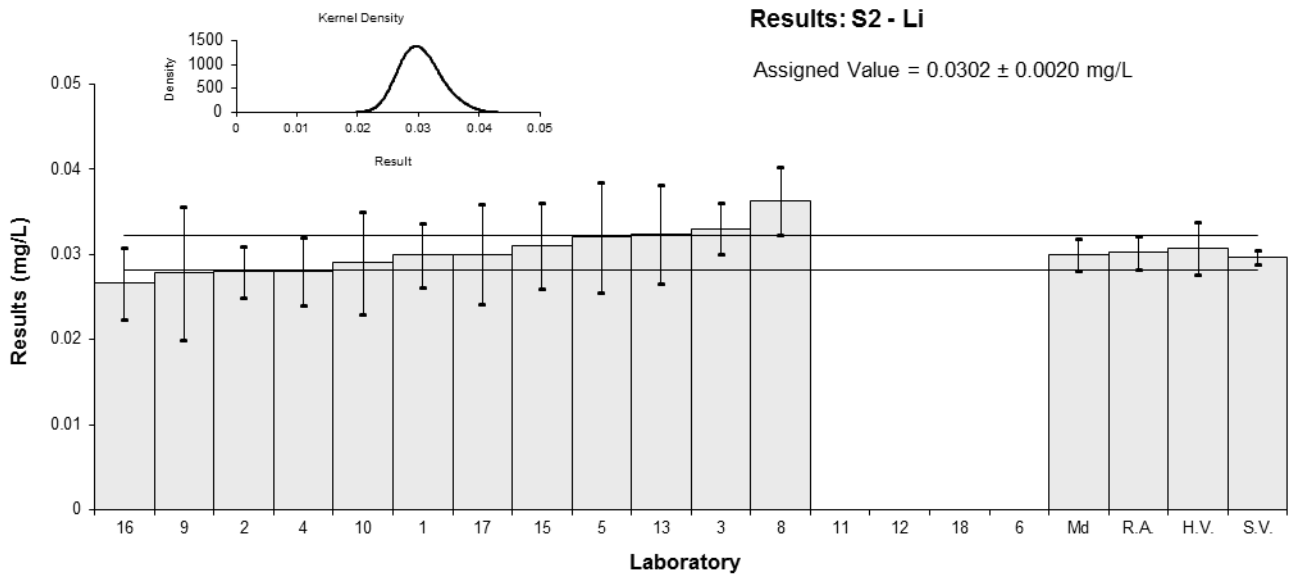
Sample No.	S2
Matrix.	Potable Water
Analyte.	Li
Units	mg/L

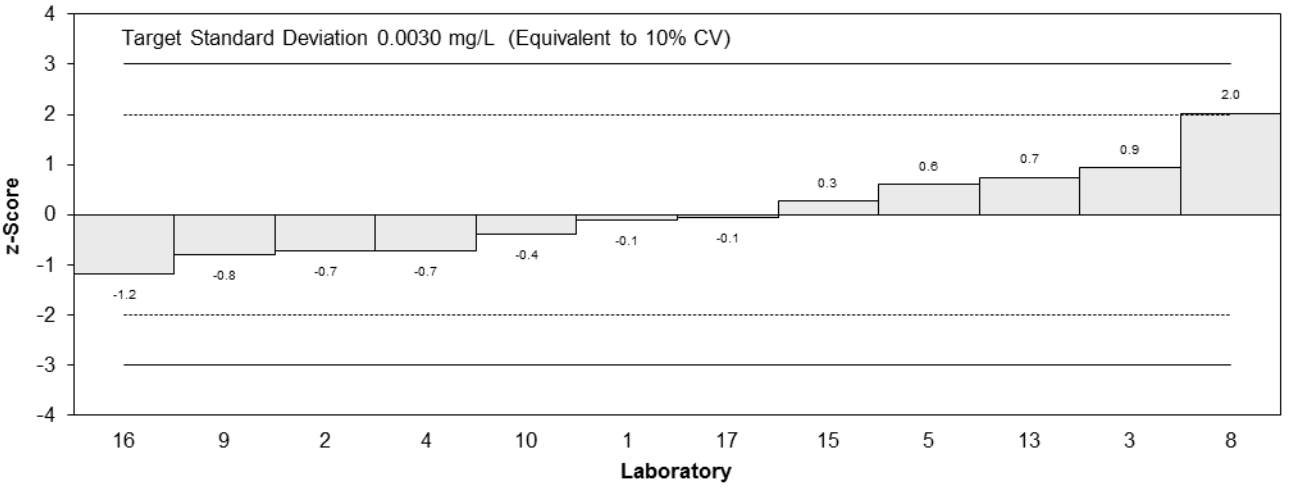
Participant Results

Lab Code	Result	Uncertainty	z-Score	E_n-Score
1	0.0299	0.0037	-0.10	-0.07
2	0.028	0.003	-0.73	-0.61
3	0.033	0.003	0.93	0.78
4	0.028	0.004	-0.73	-0.49
5	0.032	0.0064	0.60	0.27
6	NT	NT		
8	0.03629	0.004	2.02	1.36
9	0.0278	0.00784	-0.79	-0.30
10	0.029	0.006	-0.40	-0.19
11	NT	NT		
12	NT	NT		
13	0.0324	0.0058	0.73	0.36
15	0.031	0.005	0.26	0.15
16	0.0266	0.00420	-1.19	-0.77
17	0.03	0.0059	-0.07	-0.03
18	NT	NT		

Statistics

Assigned Value	0.0302	0.0020
Spike	0.0297	0.0008
Homogeneity Value	0.0307	0.0031
Robust Average	0.0302	0.0020
Median	0.0300	0.0019
Mean	0.0303	
N	12	
Max.	0.03629	
Min.	0.0266	
Robust SD	0.0027	
Robust CV	8.9%	


Results: S2 - Li
Assigned Value = 0.0302 ± 0.0020 mg/L
Kernel Density
Density
Result
Results (mg/L)
Laboratory
16 9 2 4 10 1 17 15 5 13 3 8 11 12 18 6 Md R.A. H.V. S.V.


z-Scores: S2 - Li
Target Standard Deviation 0.0030 mg/L (Equivalent to 10% CV)
z-Score
Laboratory
16 9 2 4 10 1 17 15 5 13 3 8
-1.2 -0.8 -0.7 -0.7 -0.4 -0.1 -0.1 0.3 0.6 0.7 0.9 2.0

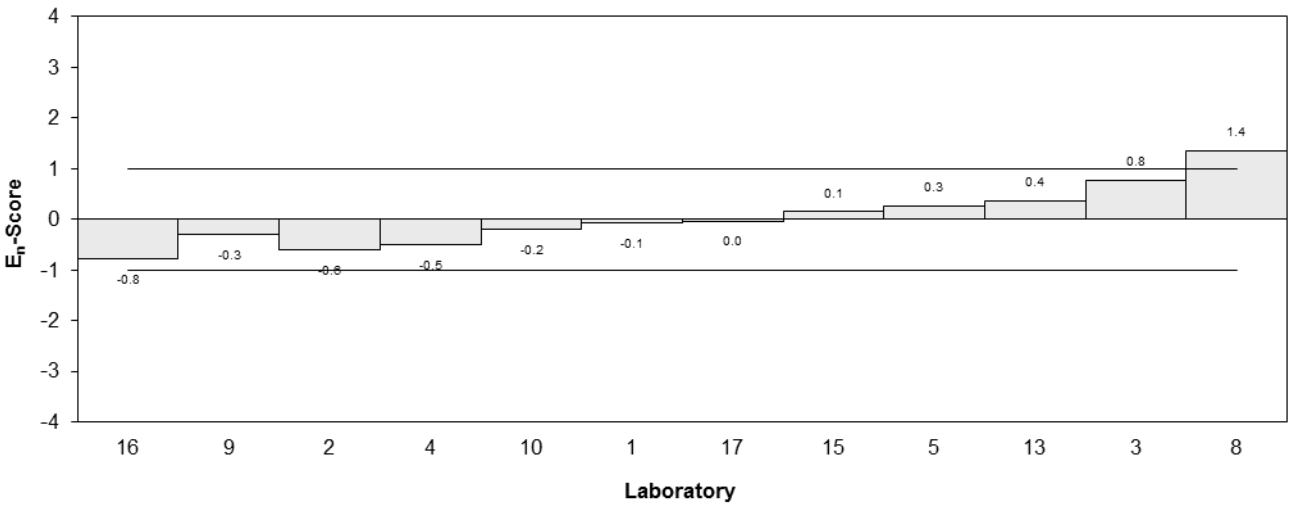

En-Scores: S2 - Li
En-Score
Laboratory
16 9 2 4 10 1 17 15 5 13 3 8
-0.8 -0.3 -0.6 -0.5 -0.2 -0.1 0.0 0.1 0.3 0.4 0.8 1.4

Figure 27

Table 30

Sample Details

Sample No.	S2
Matrix.	Potable Water
Analyte.	Mn
Units	mg/L

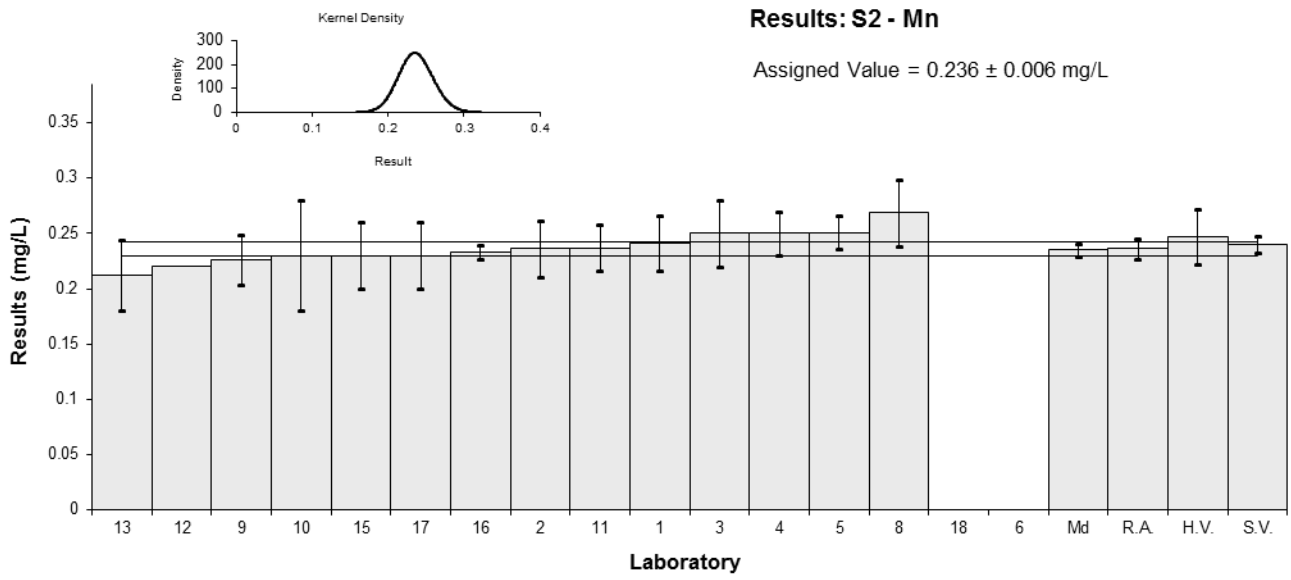
Participant Results

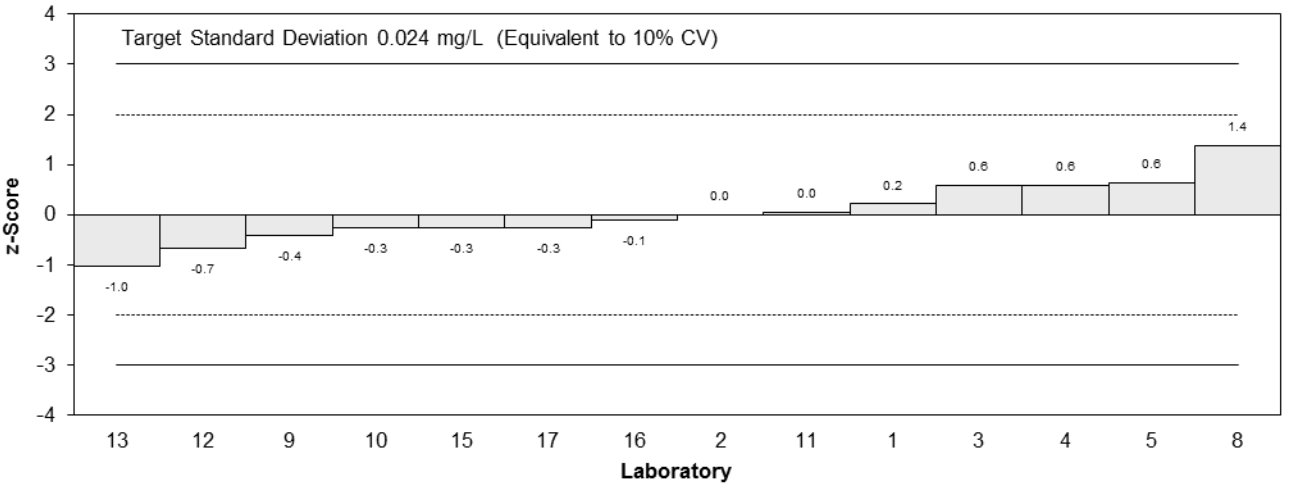
Lab Code	Result	Uncertainty	z-Score	E_n-Score
1	0.241	0.025	0.21	0.19
2	0.236	0.025	0.00	0.00
3	0.25	0.03	0.59	0.46
4	0.25	0.02	0.59	0.67
5	0.251	0.015	0.64	0.93
6	NT	NT		
8	0.26843	0.03	1.37	1.06
9	0.226	0.0226	-0.42	-0.43
10	0.23	0.05	-0.25	-0.12
11	0.237	0.0213	0.04	0.05
12	0.22	NR	-0.68	-2.67
13	0.2117	0.0318	-1.03	-0.75
15	0.23	0.03	-0.25	-0.20
16	0.2332	0.00651	-0.12	-0.32
17	0.23	0.0303	-0.25	-0.19
18	NT	NT		

Statistics

Assigned Value*	0.236	0.006
Spike	0.240	0.007
Homogeneity Value	0.247	0.025
Robust Average	0.236	0.009
Median	0.235	0.006
Mean	0.237	
N	14	
Max.	0.26843	
Min.	0.2117	
Robust SD	0.014	
Robust CV	5.9%	

*The Assigned Value was calculated as the Robust Average of the combined results of Samples S1 and S2


Kernel Density
Density
Result
Results: S2 - Mn
Assigned Value = 0.236 ± 0.006 mg/L
Results (mg/L)
Laboratory
13 12 9 10 15 17 16 2 11 1 3 4 5 8 18 6 Md R.A. H.V. S.V.


z-Scores: S2 - Mn
Target Standard Deviation 0.024 mg/L (Equivalent to 10% CV)
z-Score
Laboratory
13 12 9 10 15 17 16 2 11 1 3 4 5 8
-1.0 -0.7 -0.4 -0.3 -0.3 -0.3 -0.1 0.0 0.0 0.2 0.6 0.6 0.6 1.4

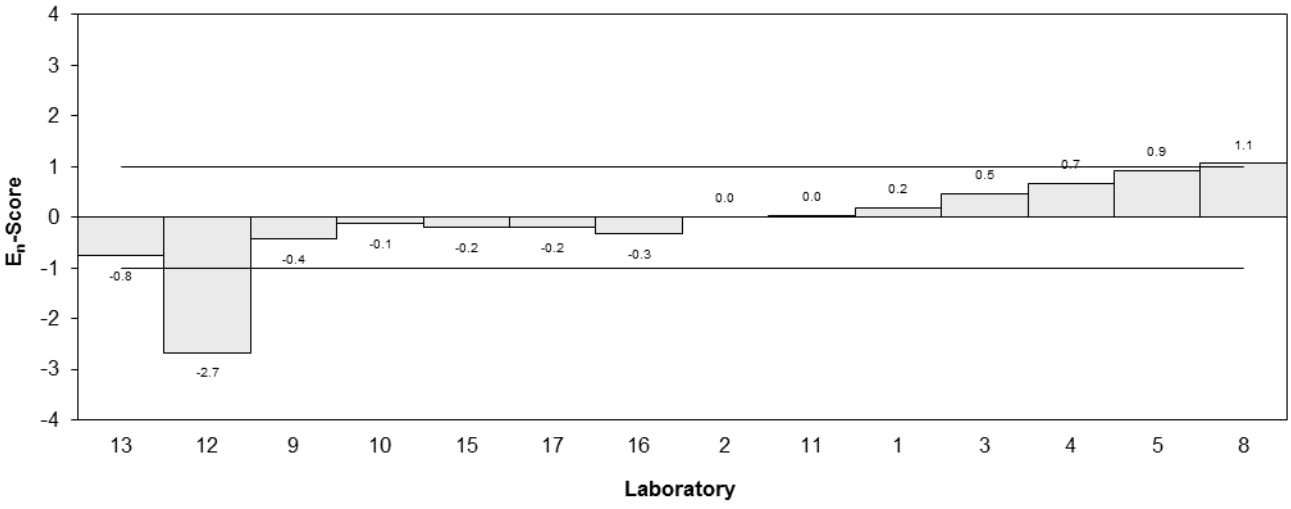

En-Scores: S2 - Mn
En-Score
Laboratory
13 12 9 10 15 17 16 2 11 1 3 4 5 8
-0.8 -2.7 -0.4 -0.1 -0.2 -0.2 -0.3 0.0 0.0 0.2 0.5 0.7 0.9 1.1

Figure 28

Table 31

Sample Details

Sample No.	S2
Matrix.	Potable Water
Analyte.	Se
Units	mg/L

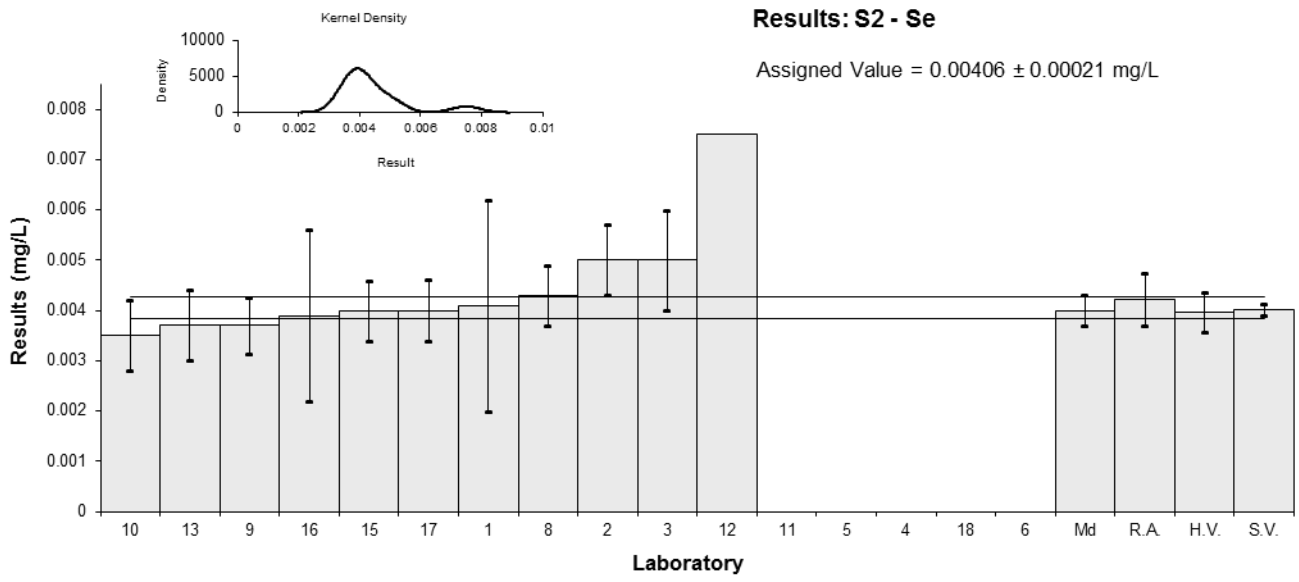
Participant Results

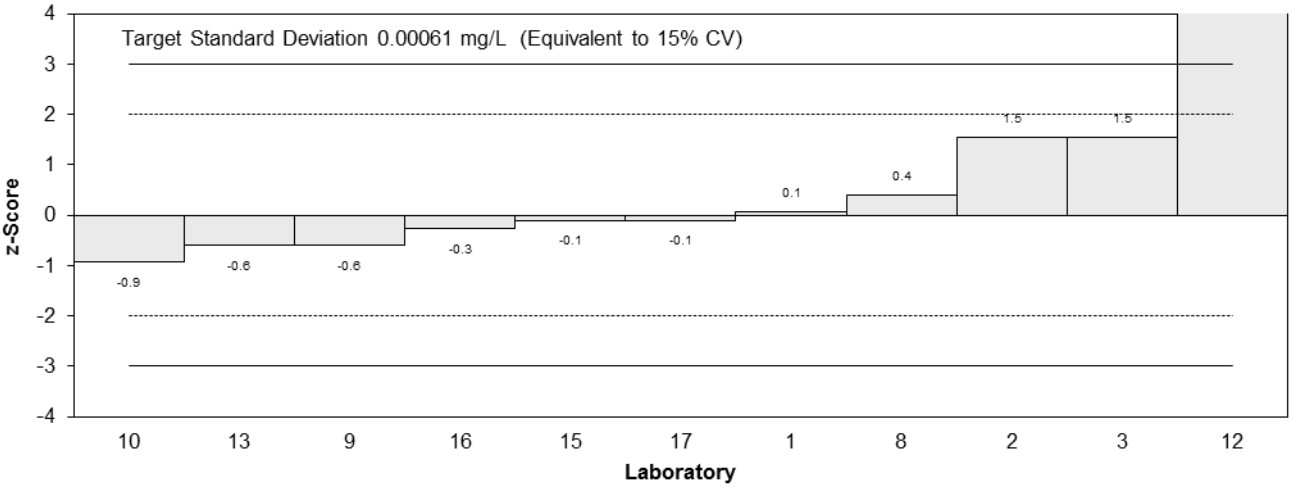
Lab Code	Result	Uncertainty	z-Score	E_n-Score
1	0.0041	0.0021	0.07	0.02
2	0.005	0.0007	1.54	1.29
3	0.005	0.001	1.54	0.92
4	<5	NR		
5	<0.01	0.001		
6	NT	NT		
8	0.0043	0.0006	0.39	0.38
9	0.0037	0.00057	-0.59	-0.59
10	0.0035	0.0007	-0.92	-0.77
11	<0.01	NR		
12	0.0075	NR	5.65	16.38
13	0.0037	0.0007	-0.59	-0.49
15	0.0040	0.0006	-0.10	-0.09
16	0.0039	0.00170	-0.26	-0.09
17	0.004	0.000611	-0.10	-0.09
18	NT	NT		

Statistics

Assigned Value*	0.00406	0.00021
Spike	0.00401	0.00011
Homogeneity Value	0.00397	0.00040
Robust Average	0.00422	0.00051
Median	0.00400	0.00030
Mean	0.00443	
N	11	
Max.	0.0075	
Min.	0.0035	
Robust SD	0.00067	
Robust CV	16%	

*The Assigned Value was calculated as the Robust Average of the combined results of Samples S1 and S2 excluding Laboratory 12


Results: S2 - Se
Assigned Value = 0.00406 ± 0.00021 mg/L
Kernel Density
Density
Result
Results (mg/L)
Laboratory
10 13 9 16 15 17 1 8 2 3 12 11 5 4 18 6 Md R.A. H.V. S.V.


z-Scores: S2 - Se
Target Standard Deviation 0.00061 mg/L (Equivalent to 15% CV)
z-Score
Laboratory
10 13 9 16 15 17 1 8 2 3 12

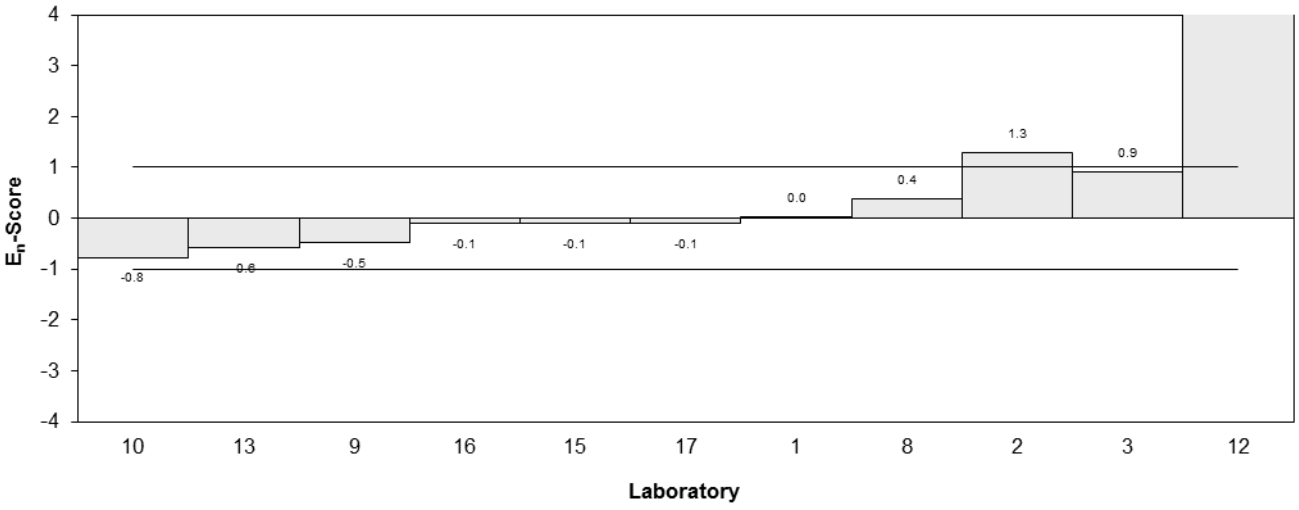

En-Scores: S2 - Se
En-Score
Laboratory
10 13 9 16 15 17 1 8 2 3 12

Figure 29

Table 32

Sample Details

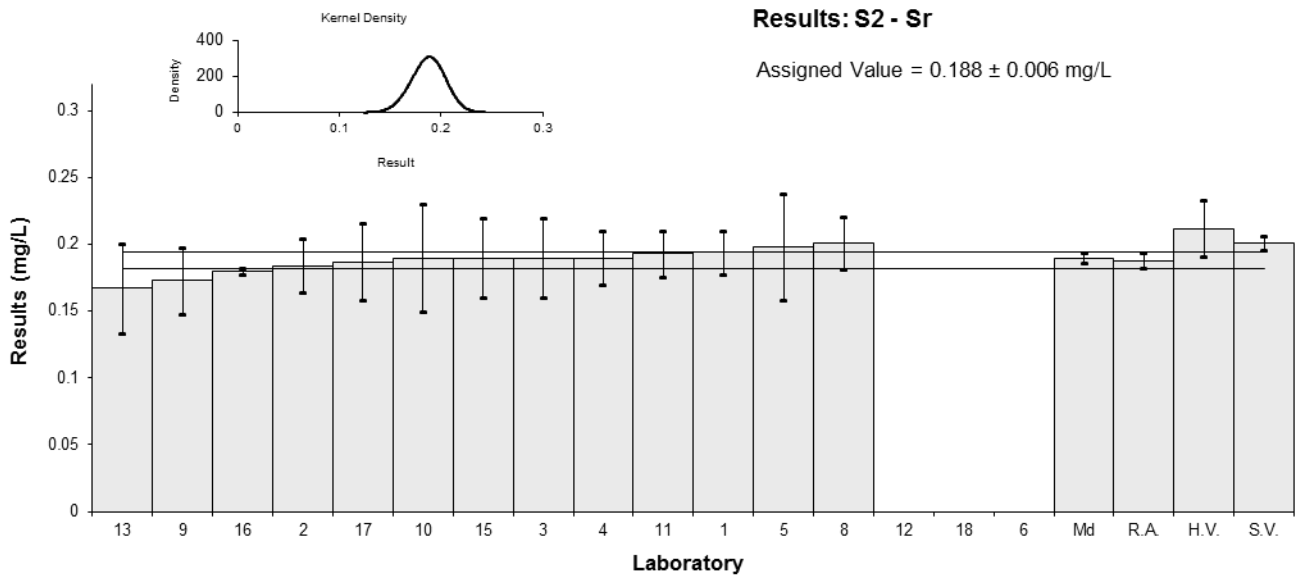
Sample No.	S2
Matrix.	Potable Water
Analyte.	Sr
Units	mg/L

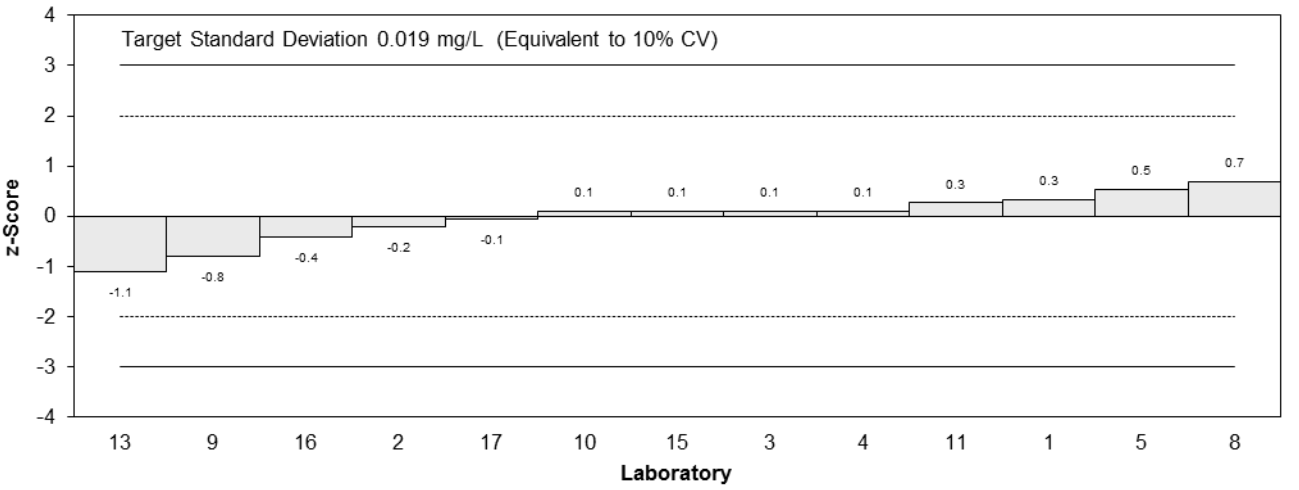
Participant Results

Lab Code	Result	Uncertainty	z-Score	E_n-Score
1	0.194	0.016	0.32	0.35
2	0.184	0.020	-0.21	-0.19
3	0.19	0.03	0.11	0.07
4	0.19	0.02	0.11	0.10
5	0.198	0.04	0.53	0.25
6	NT	NT		
8	0.20105	0.02	0.69	0.62
9	0.173	0.0251	-0.80	-0.58
10	0.19	0.04	0.11	0.05
11	0.193	0.017	0.27	0.28
12	NT	NT		
13	0.1673	0.0335	-1.10	-0.61
15	0.19	0.03	0.11	0.07
16	0.1800	0.00281	-0.43	-1.21
17	0.187	0.0288	-0.05	-0.03
18	NT	NT		

Statistics

Assigned Value	0.188	0.006
Spike	0.201	0.005
Homogeneity Value	0.212	0.021
Robust Average	0.188	0.006
Median	0.190	0.004
Mean	0.187	
N	13	
Max.	0.20105	
Min.	0.1673	
Robust SD	0.009	
Robust CV	4.8%	


Kernel Density
Density
Result
Results: S2 - Sr
Assigned Value = 0.188 ± 0.006 mg/L
Results (mg/L)
Laboratory
13 9 16 2 17 10 15 3 4 11 1 5 8 12 18 6 Md R.A. H.V. S.V.


z-Scores: S2 - Sr
Target Standard Deviation 0.019 mg/L (Equivalent to 10% CV)
z-Score
Laboratory
13 9 16 2 17 10 15 3 4 11 1 5 8
-1.1 -0.8 -0.4 -0.2 -0.1 0.1 0.1 0.1 0.1 0.3 0.3 0.5 0.7

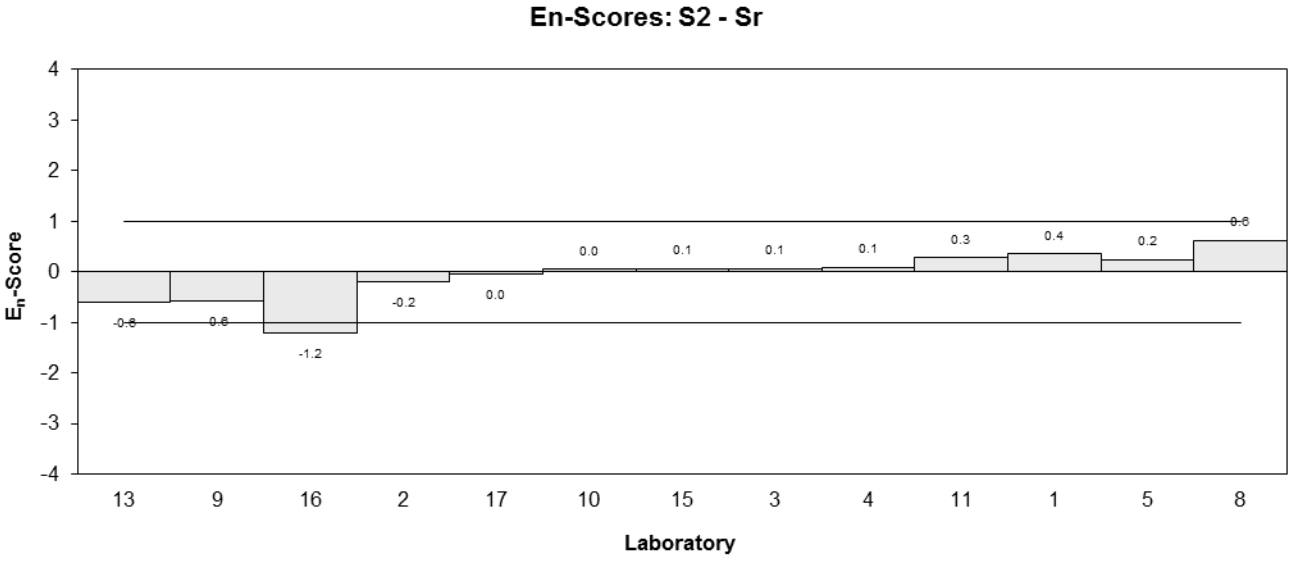

En-Scores: S2 - Sr
En-Score
Laboratory
13 9 16 2 17 10 15 3 4 11 1 5 8
-0.6 -0.6 -1.2 -0.2 0.0 0.0 0.1 0.1 0.1 0.3 0.4 0.2 0.6

Figure 30

Table 33

Sample Details

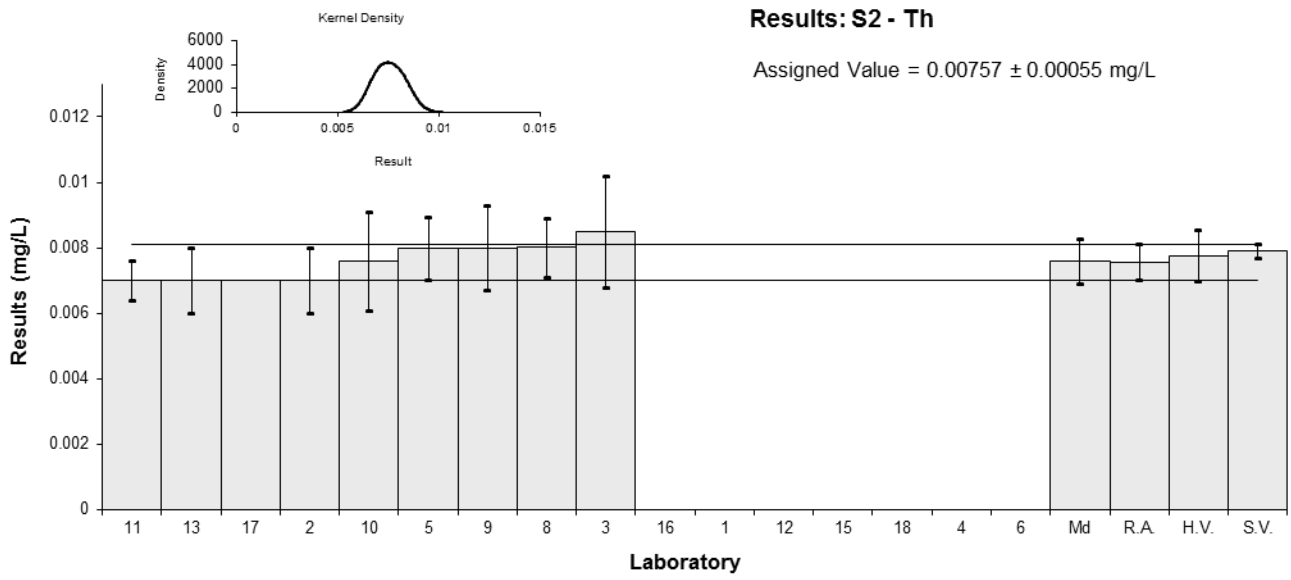
Sample No.	S2
Matrix.	Potable Water
Analyte.	Th
Units	mg/L

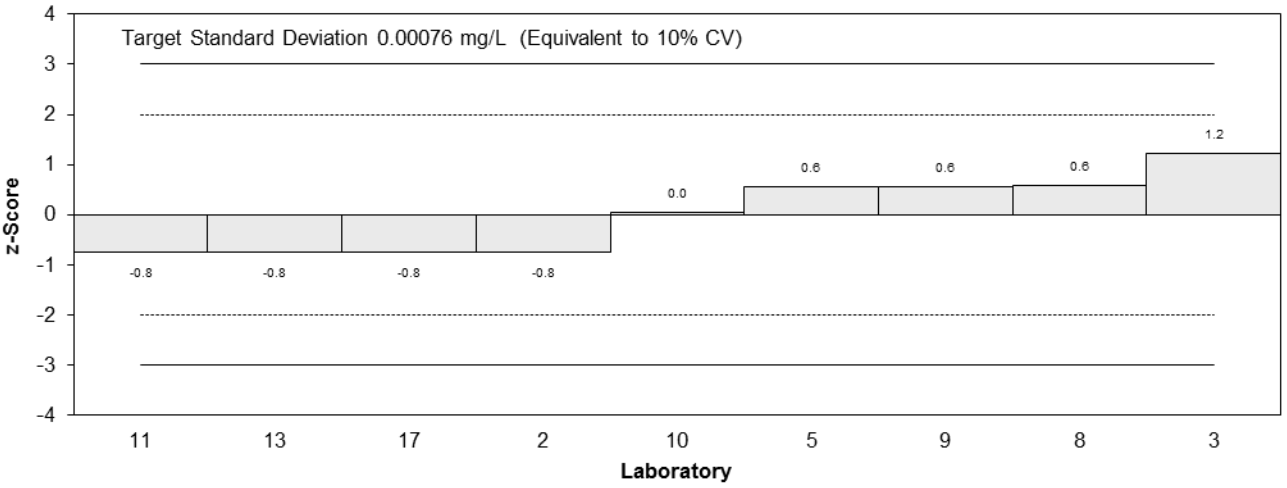
Participant Results

Lab Code	Result	Uncertainty	z-Score	E_n-Score
1	NT	NT		
2	0.007	0.001	-0.75	-0.50
3	0.0085	0.0017	1.23	0.52
4	NT	NT		
5	0.008	0.00096	0.57	0.39
6	NT	NT		
8	0.00802	0.0009	0.59	0.43
9	0.008	0.0013	0.57	0.30
10	0.0076	0.0015	0.04	0.02
11	0.007	0.0006	-0.75	-0.70
12	NT	NT		
13	0.0070	0.0010	-0.75	-0.50
15	NT	NT		
16	NR	NR		
17	0.007	NR	-0.75	-1.04
18	NT	NT		

Statistics

Assigned Value	0.00757	0.00055
Spike	0.00790	0.00022
Homogeneity Value	0.00777	0.00078
Robust Average	0.00757	0.00055
Median	0.00760	0.00068
Mean	0.00757	
N	9	
Max.	0.0085	
Min.	0.007	
Robust SD	0.00066	
Robust CV	8.7%	


Kernel Density
Density
6000
4000
2000
0
0
0.005
0.01
0.015
Result
Results: S2 - Th
Assigned Value = 0.00757 ± 0.00055 mg/L
Results (mg/L)
0.012
0.01
0.008
0.006
0.004
0.002
0
11
13
17
2
10
5
9
8
3
16
1
12
15
18
4
6
Md
R.A.
H.V.
S.V.
Laboratory


z-Scores: S2 - Th
Target Standard Deviation 0.00076 mg/L (Equivalent to 10% CV)
z-Score
4
3
2
1
0
-1
-2
-3
-4
-0.8
-0.8
-0.8
-0.8
0.0
0.6
0.6
0.6
1.2
11
13
17
2
10
5
9
8
3
Laboratory

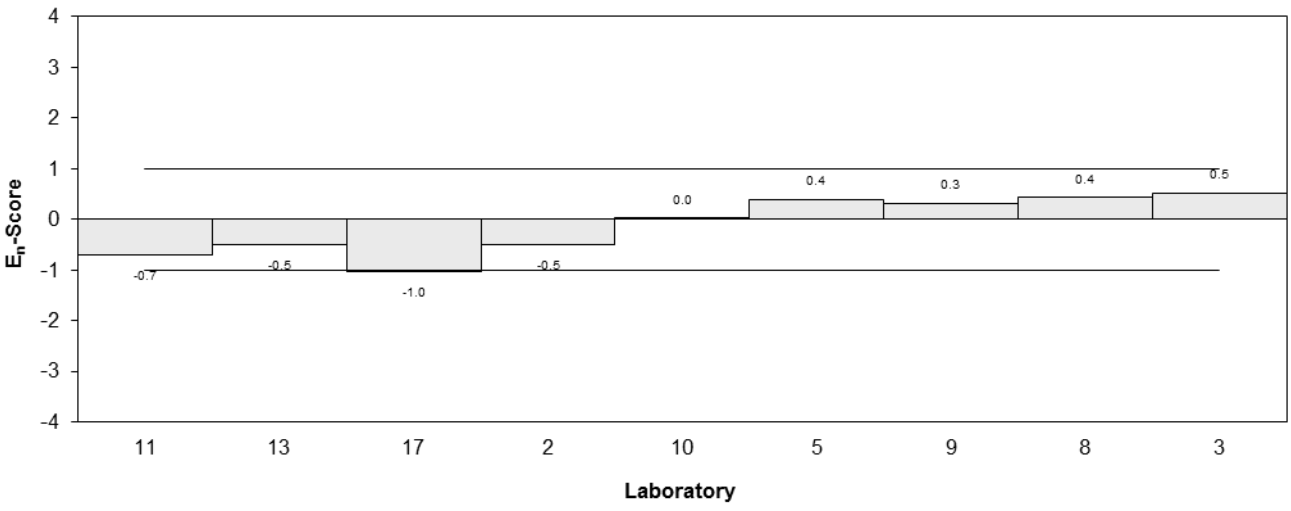

En-Scores: S2 - Th
En-Score
4
3
2
1
0
-1
-2
-3
-4
-0.7
-0.5
-1.0
-0.5
0.0
0.4
0.3
0.4
0.5
11
13
17
2
10
5
9
8
3
Laboratory

Figure 31

Table 34

Sample Details

Sample No.	S2
Matrix.	Potable Water
Analyte.	Tl
Units	mg/L

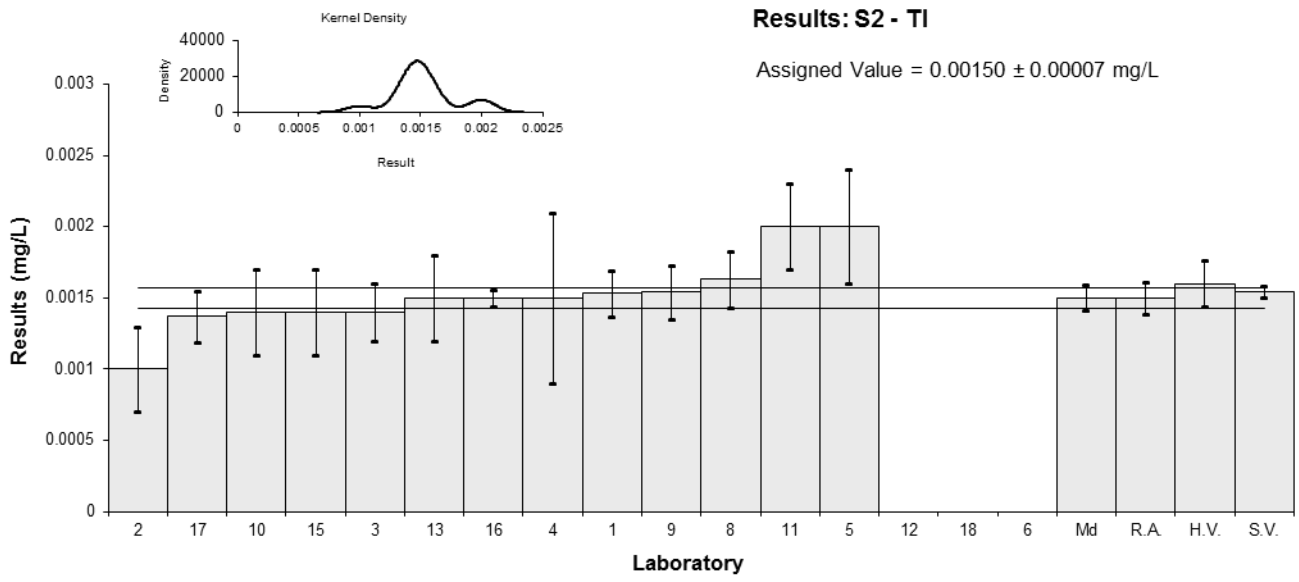
Participant Results

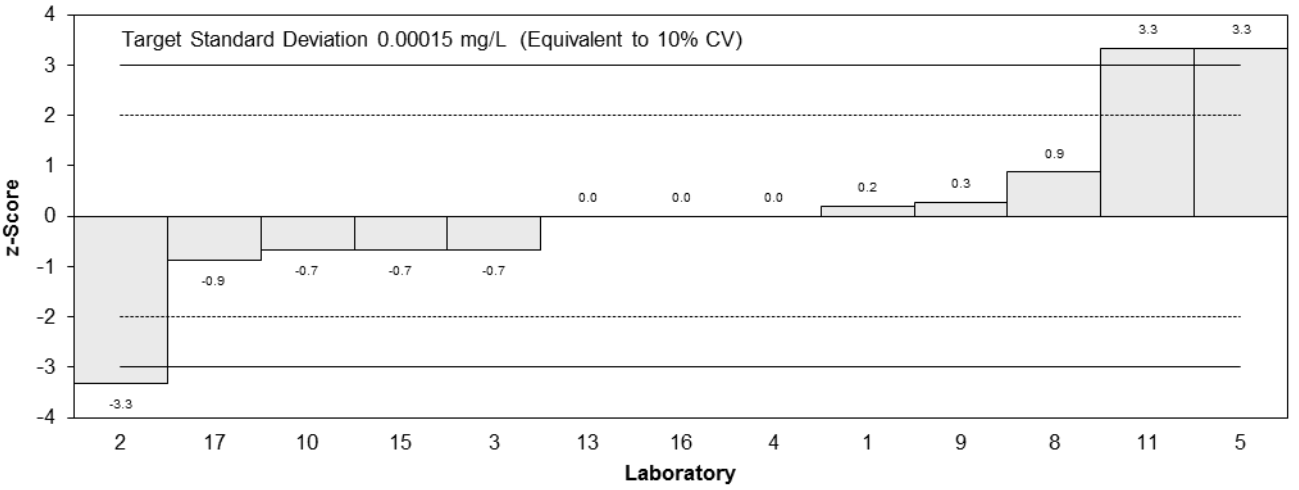
Lab Code	Result	Uncertainty	z-Score	E_n-Score
1	0.00153	0.00016	0.20	0.17
2	0.001	0.0003	-3.33	-1.62
3	0.0014	0.0002	-0.67	-0.47
4	0.0015	0.0006	0.00	0.00
5	0.002	0.0004	3.33	1.23
6	NT	NT		
8	0.00163	0.0002	0.87	0.61
9	0.00154	0.00019	0.27	0.20
10	0.0014	0.0003	-0.67	-0.33
11	0.002	0.0003	3.33	1.62
12	NT	NT		
13	0.0015	0.0003	0.00	0.00
15	0.0014	0.0003	-0.67	-0.33
16	0.0015	0.00006	0.00	0.00
17	0.00137	0.00018	-0.87	-0.67
18	NT	NT		

Statistics

Assigned Value*	0.00150	0.00007
Spike	0.00154	0.00004
Homogeneity Value	0.00160	0.00016
Robust Average	0.00150	0.00011
Median	0.00150	0.00009
Mean	0.00152	
N	13	
Max.	0.002	
Min.	0.001	
Robust SD	0.00015	
Robust CV	10%	

*The Assigned Value was calculated as the Robust Average of the combined results of Samples S1 and S2


Results: S2 - Tl
Assigned Value = 0.00150 ± 0.00007 mg/L
Kernel Density
Density
Result
Results (mg/L)
Laboratory
2 17 10 15 3 13 16 4 1 9 8 11 5 12 18 6 Md R.A. H.V. S.V.


z-Scores: S2 - Tl
Target Standard Deviation 0.00015 mg/L (Equivalent to 10% CV)
z-Score
Laboratory
2 17 10 15 3 13 16 4 1 9 8 11 5
-3.3 -0.9 -0.7 -0.7 -0.7 0.0 0.0 0.0 0.2 0.3 0.9 3.3 3.3

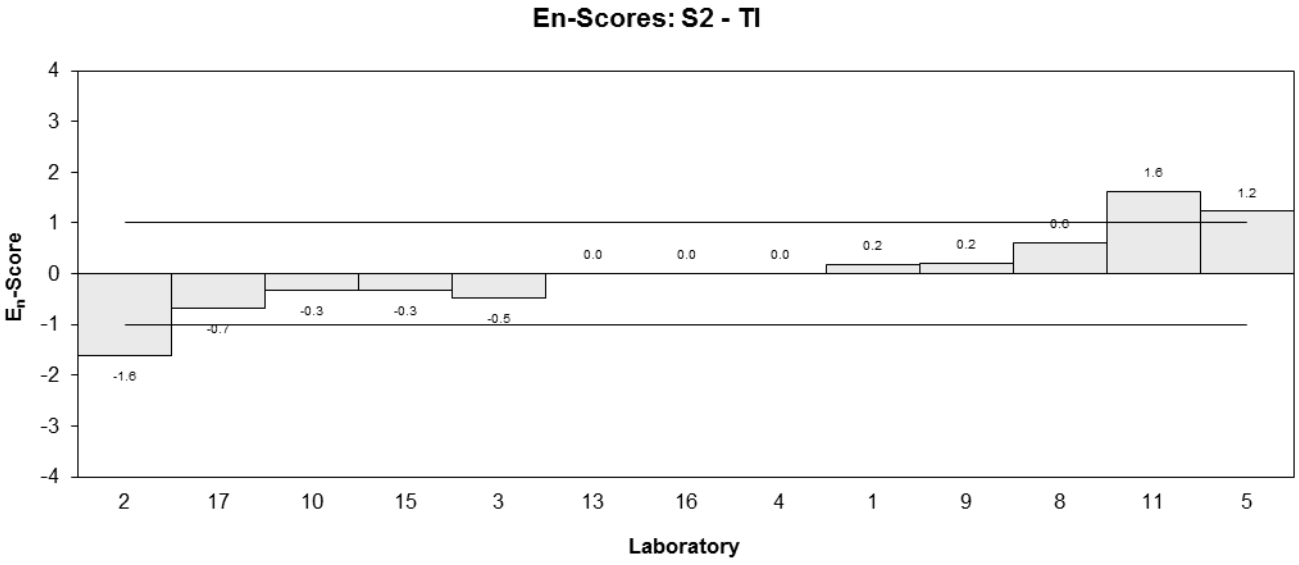

En-Scores: S2 - Tl
En-Score
Laboratory
2 17 10 15 3 13 16 4 1 9 8 11 5
-1.6 -0.7 -0.3 -0.3 -0.5 0.0 0.0 0.0 0.2 0.2 0.6 1.6 1.2

Figure 32

Table 35

Sample Details

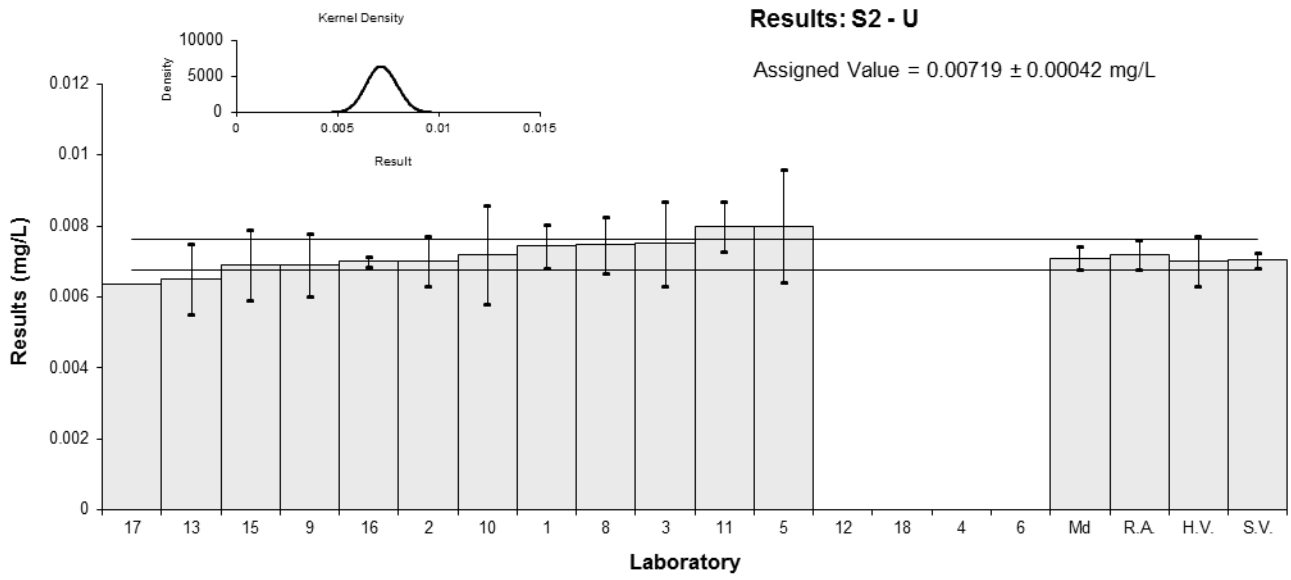
Sample No.	S2
Matrix.	Potable Water
Analyte.	U
Units	mg/L

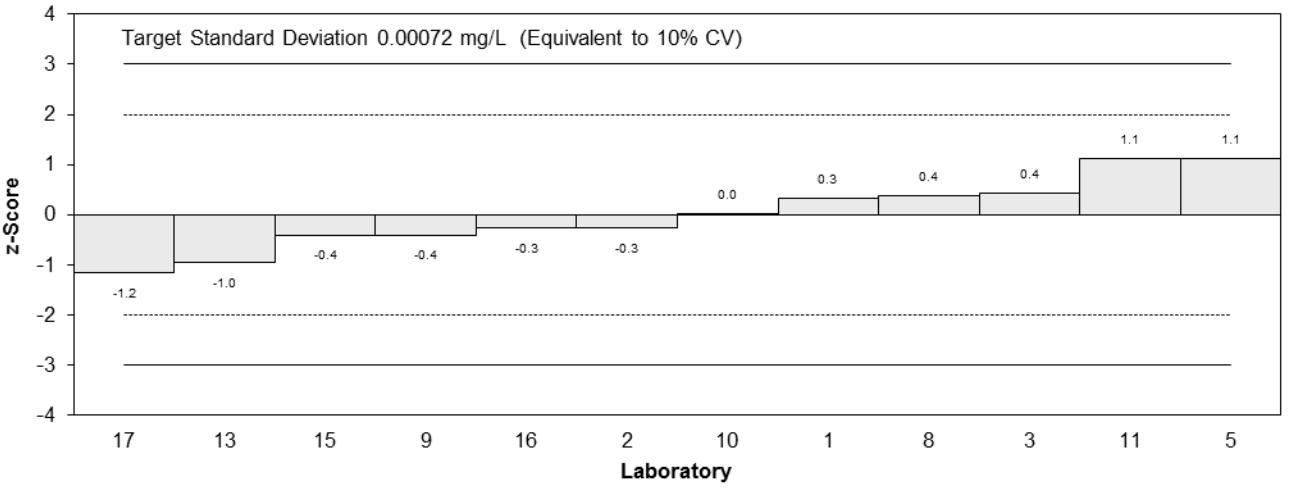
Participant Results

Lab Code	Result	Uncertainty	z-Score	E_n-Score
1	0.00743	0.00060	0.33	0.33
2	0.007	0.0007	-0.26	-0.23
3	0.0075	0.0012	0.43	0.24
4	NT	NT		
5	0.008	0.0016	1.13	0.49
6	NT	NT		
8	0.007469	0.0008	0.39	0.31
9	0.00690	0.000870	-0.40	-0.30
10	0.0072	0.0014	0.01	0.01
11	0.008	0.0007	1.13	0.99
12	NT	NT		
13	0.0065	0.0010	-0.96	-0.64
15	0.0069	0.001	-0.40	-0.27
16	0.0070	0.00014	-0.26	-0.43
17	0.00636	NR	-1.15	-1.98
18	NT	NT		

Statistics

Assigned Value	0.00719	0.00042
Spike	0.00703	0.00020
Homogeneity Value	0.00702	0.00070
Robust Average	0.00719	0.00042
Median	0.00710	0.00033
Mean	0.00719	
N	12	
Max.	0.008	
Min.	0.00636	
Robust SD	0.00059	
Robust CV	8.2%	


Kernel Density
Density
10000
5000
0
0
0.005
0.01
0.015
Result
Results: S2 - U
Assigned Value = 0.00719 ± 0.00042 mg/L
Results (mg/L)
0.012
0.01
0.008
0.006
0.004
0.002
0
17 13 15 9 16 2 10 1 8 3 11 5 12 18 4 6 Md R.A. H.V. S.V.
Laboratory


z-Scores: S2 - U
Target Standard Deviation 0.00072 mg/L (Equivalent to 10% CV)
z-Score
4
3
2
1
0
-1
-2
-3
-4
-1.2
-1.0
-0.4
-0.4
-0.3
-0.3
0.0
0.3
0.4
0.4
1.1
1.1
17 13 15 9 16 2 10 1 8 3 11 5
Laboratory

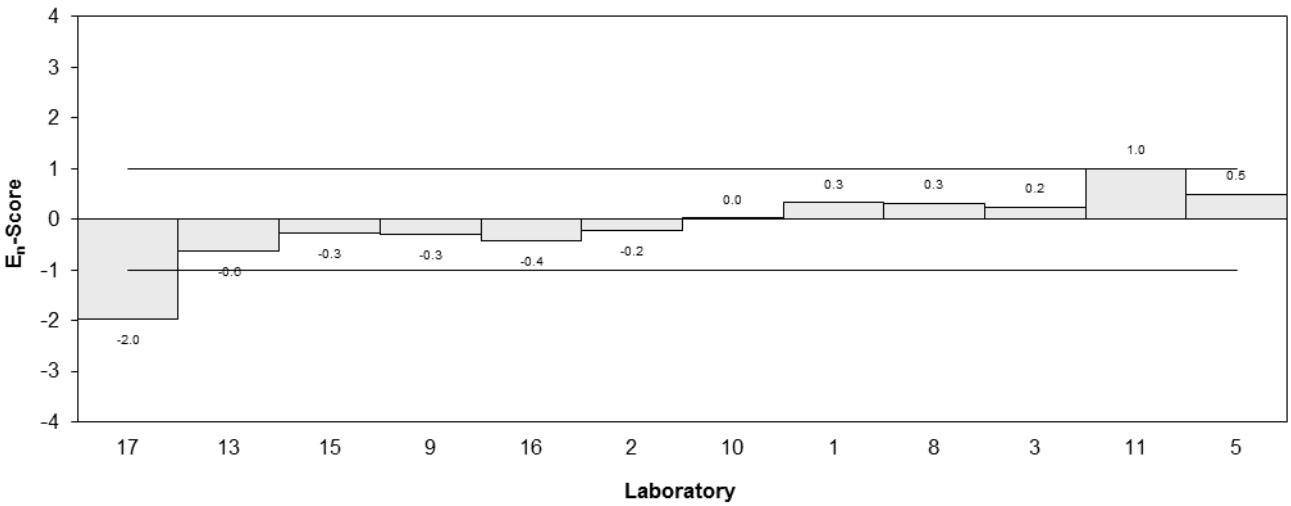

En-Scores: S2 - U
En-Score
4
3
2
1
0
-1
-2
-3
-4
-2.0
-0.6
-0.3
-0.3
-0.4
-0.2
0.0
0.3
0.3
0.2
1.0
0.5
17 13 15 9 16 2 10 1 8 3 11 5
Laboratory

Figure 33

7 DISCUSSION OF RESULTS

7.1 Assigned Value

Samples S1 and S2 – were duplicate portions of the same unfiltered and acidified potable water to which known amounts of single element standard solutions were added. The analytes' concentrations in the two tests samples were the same.

Participants were asked to report for Sample S1 results for total: As, Be, Cd, Cr, Cu, Hg, Mn, Mo, Ni, Pb, Sb, Se, Sn, Tl, V and Zn, and for S2 to report results for total: Al, As, Ba, Bi, Co, Cs, Fe, Hg, La, Li, Mn, Se, Sr, Th, Tl and U. The sample was chilled before dispatch.

Assigned Values for the 32 tests were the robust average of participants' results. The robust averages used as assigned values and their associated expanded uncertainties were calculated using the procedure described in 'ISO13528:2015(E), Statistical methods for use in proficiency testing by interlaboratory comparisons'. Results less than 50% and more than 150% of the robust average were removed before calculation of each assigned value.[6] Appendix 2 sets out the calculation of the robust average and assigned value for Be in Sample S1 and its associated uncertainty.

Assigned values for As, Hg, Mn, Se and Tl in S1 and S2 were calculated as the robust average of the combined results of both samples

Spiked Values for each test of interest includes both the incurred value and the fortified value.

Assigned values, spiked values and homogeneity values were in agreement with each other within their estimates of uncertainty for all elements of interest.

Traceability The assigned values are not traceable to any external reference; they are traceable to the consensus of participants' results derived from a variety of measurement methods and (presumably) a variety of calibrators. So although expressed in SI units, the metrological traceability of the assigned values has not been established.

7.2 Measurement Uncertainty Reported by Participants

Participants were asked to report an estimate of the expanded measurement uncertainty associated with their results. Of 430 numerical results, 408 (95%) were reported with an expanded measurement uncertainty, indicating that the majority of laboratories have addressed this requirement of ISO 17025.[8] The magnitude of these expanded uncertainties was within the range 1% to 300% of the reported value. The participants used a wide variety of procedures to estimate the expanded measurement uncertainty. These are presented in Table 3.

Approaches to estimating measurement uncertainty include: standard deviation of replicate analysis, Horwitz formula, professional judgement, bottom up approach, top down approach using precision and estimates of method and laboratory bias and top down approach using only the reproducibility from inter-laboratory comparison studies.[9 – 15]

Proficiency tests allow a check of the reasonableness of uncertainty estimates. Results and the expanded MU are presented in the bar charts for each analyte (Figure 2 to 33). In this study in some cases, the reported expanded measurement uncertainty has been over (e.g. Laboratories 4 and 16 for Cr in S1) or under-estimated (e.g. Lab 5 for Co in S2). As a simple rule of thumb, when the uncertainty estimate is smaller than the assigned uncertainty value or larger than the uncertainty of the assigned value plus twice the target standard deviation then this should be viewed as suspect.

Double counting the precision uncertainty components and overestimation of the laboratory or method bias are the most common errors seen in the laboratories' estimated uncertainty budgets. According to General Accreditation Guidance, Estimating and reporting

measurement uncertainty of chemical test results [12] and to NORDTEST TR 537 [10] the most common experimental data used for estimating the precision component for the measurement uncertainty calculation in the top down approach are from:

- Stable control samples that cover the whole analytical process (including extraction) and **have a matrix similar** to the samples; **or**
- Stable control samples **and** duplicate analyses if control samples do not cover whole analytical process (e.g. the control sample is a synthetic sample - we have to take into consideration uncertainties arising from different matrices); **or**
- When control samples are not stable, from analysis of natural duplicates (gives within-day variation for sampling and measurement) and long-term uncertainty component from the variation in the instrument calibration; **or**
- Replicate analyses performed on the same sample at different times to obtain estimates of intermediate precision; within-batch replication provides estimates of repeatability only.

The most common sources for estimating the method bias component for the measurement uncertainty calculation are from:

- Certified reference material recoveries; **or**
- Participation in PT studies (laboratory bias from at least 6 successful PT studies) ; **or**
- From sample spike recoveries.

When a laboratory has successfully participated in at least 6 proficiency testing studies, the standard deviation from proficiency testing studies only, can also be used to estimate the uncertainty of their measurement results.[10, 12] An example of estimating measurement uncertainty using proficiency testing data only is given in Appendix 3.

Some laboratories estimated uncertainties for measurement results larger than the reported results themselves. Measurement uncertainty is the range estimated by laboratories that contain the true value. The reported result should be within the estimated range.

Three laboratories attached estimates of the expanded measurement uncertainty to results reported as less than their limit of detection. An estimate of uncertainty expressed as a numerical value cannot be attached to a result expressed as a range.[9]

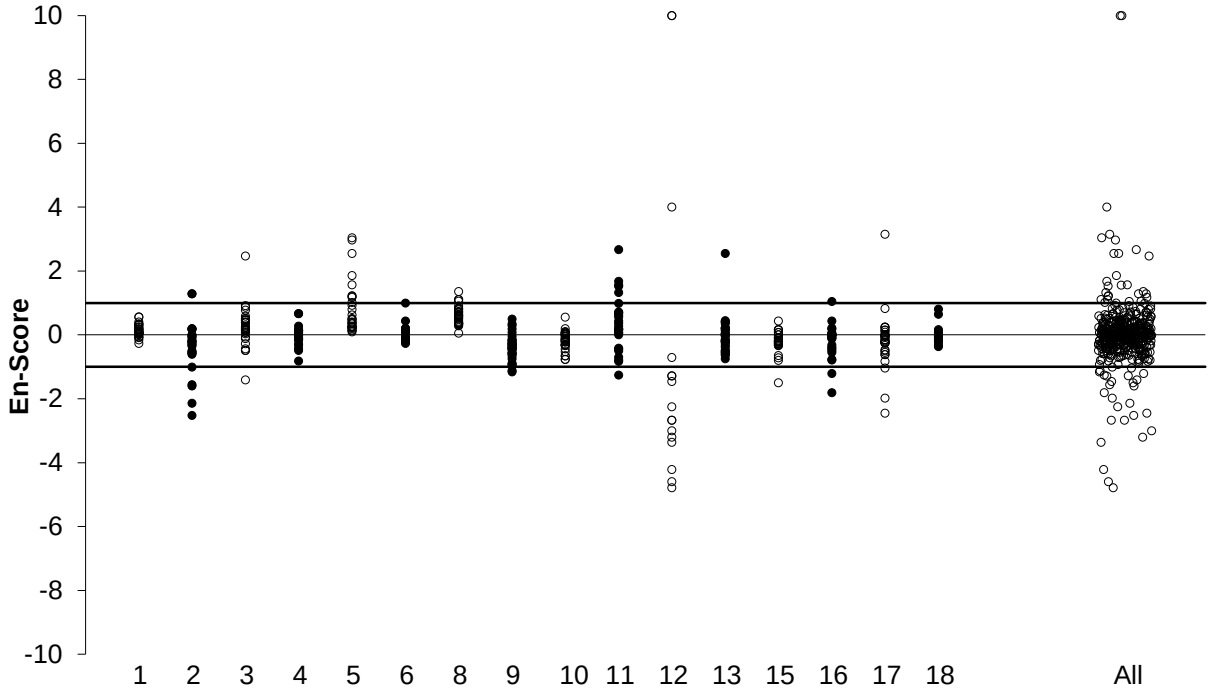
In some cases the results were reported with an inappropriate number of significant figures. The recommended format is to write uncertainty to no more than two significant figures and then to write the result with the corresponding number of decimal places. For example, instead of 18.44 ± 3.4 mg/L, it is better to report 18.4 ± 3.4 mg/L or instead of 0.0023 ± 0.00048 mg/L, it is better to report 0.0023 ± 0.0005 mg/L.[9]

7.3 E_n-score

E_n-score should be interpreted only in conjunction with z-scores. The E_n-score indicates how closely a result agrees with the assigned value taking into account the respective uncertainties. An unsatisfactory E_n score for an analyte can either be caused by an inappropriate measurement, an inappropriate estimation of measurement uncertainty, or both.

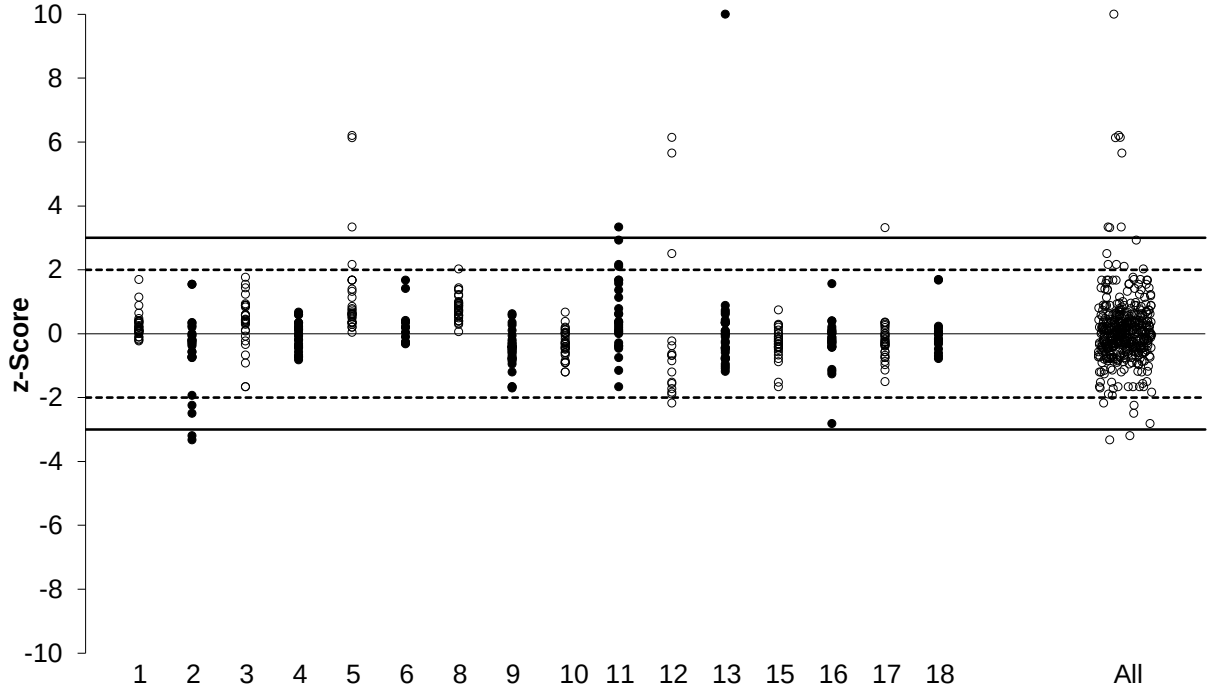
The dispersal of participants' E_n-scores is graphically presented in Figure 34. Where a laboratory did not report an expanded uncertainty with a result, an expanded uncertainty of zero (0) was used to calculate the E_n-score.

Of 430 results for which E_n-scores were calculated, 376 (87%) returned a satisfactory score of $|E_n| \leq 1.0$ indicating agreement of the participants' results with the assigned values within their respective expanded measurement uncertainties.



Scores of >10 or < -10 have been plotted as 10 or -10.

Figure 34 E_n-Score Dispersal by Laboratory



Scores of >10 or <-10 have been plotted as 10 or -10.

Figure 35 z-Score Dispersal by Laboratory

7.4 z-Score

The z-score compares the participant's deviation from the assigned value with the target standard deviation set for proficiency assessment.

The target standard deviation defines satisfactory performance in a proficiency test. Target standard deviations equivalent to 10%, 15% and 20% CV were used to calculate z-scores. Unlike the standard deviation based on between laboratories CV, setting the target standard deviation as a realistic, set value enables z-scores to be used as fixed reference value points for assessment of laboratory performance, independent of group performance.

The between laboratories coefficient of variation predicted by the Thompson equation[7] and the between laboratories coefficient of variation resulted in this study are presented for comparison in Table 36.

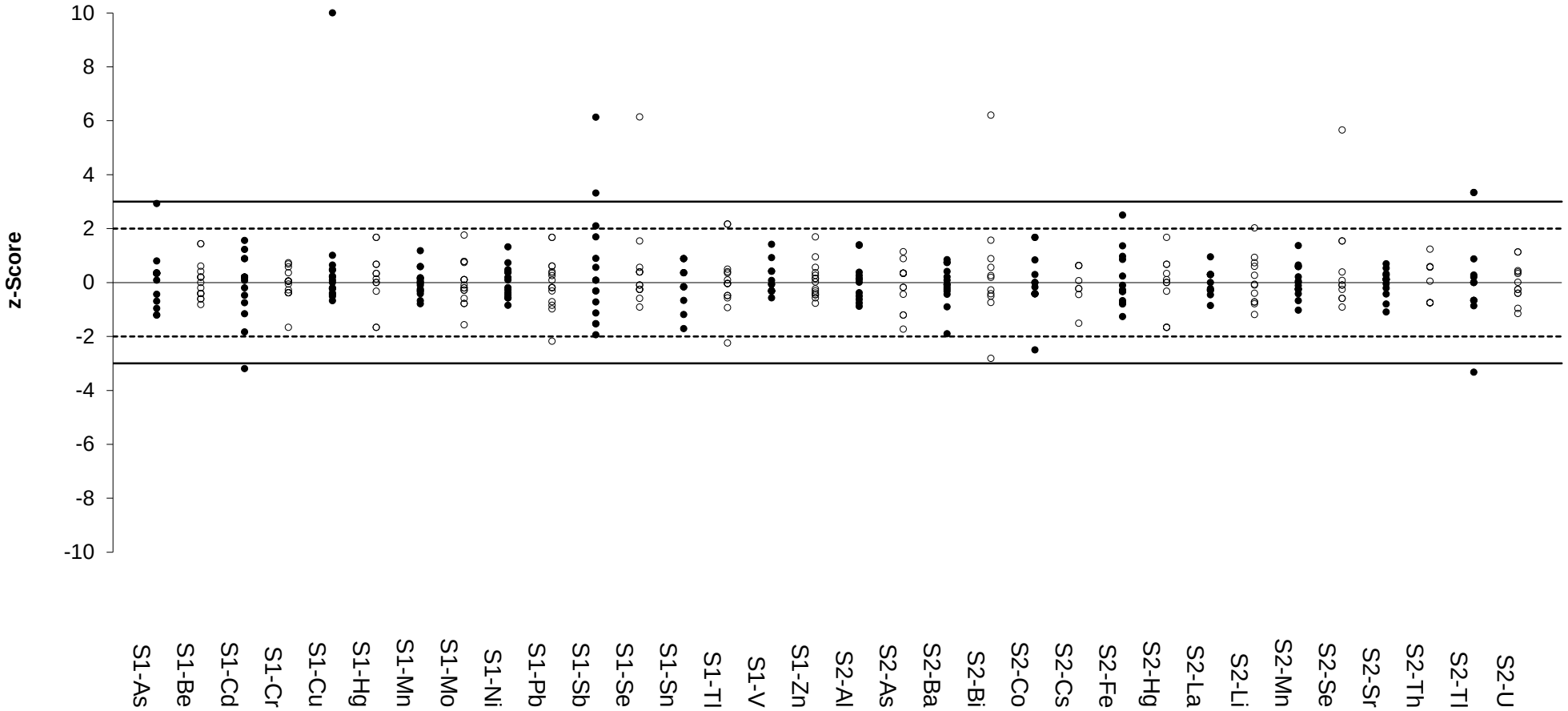
The dispersal of participants' z-scores is presented in Figure 35 (by laboratory code) and in Figure 36 (by test). Of 430 results for which z-scores were calculated, 410 (95%) returned a satisfactory score of $|z| \leq 2.0$ and 10 (2%) were questionable with a score of $2.0 < |z| < 3.0$. Participants with multiple z-scores larger than 2.0 or smaller than -2.0 should check for laboratory bias.

Laboratories **1, 3, 4, 6, 9, 10, 15** and **18** returned satisfactory z-scores for all inorganic analytes reported.

Table 36 Between Laboratories CV of this study, Thompson CV and Set Target CV

Sample	Test	Assigned value (mg/L)	Between Laboratories CV*	Thompson/ Horwitz CV	Target SD (as CV)
S1	As	0.00387	7.7%	22%	10%
S1	Be	0.00490	6.3%	22%	10%
S1	Cd	0.00147	9.5%	22%	10%
S1	Cr	0.00936	4.8%	22%	10%
S1	Cu	0.440	5%	18%	10%
S1	Hg	0.000150	21%	22%	20%
S1	Mn	0.236	4.7%	20%	10%
S1	Mo	0.0102	6.9%	22%	10%
S1	Ni	0.0106	5.7%	22%	10%
S1	Pb	0.00754	8.2%	22%	10%
S1	Sb	0.00248	15%	22%	10%
S1	Se	0.00406	8.7%	22%	15%
S1	Sn	0.00193	8.3%	22%	10%
S1	Tl	0.00151	11%	22%	15%
S1	V	0.00403	5%	22%	10%
S1	Zn	0.975	5.9%	16%	10%
S2	Al	0.0790	7.1%	22%	10%
S2	As	0.00387	8.8%	22%	10%
S2	Ba	0.121	6.6%	22%	10%
S2	Bi	0.00432	9.3%	22%	10%
S2	Co	0.00160	11%	22%	15%
S2	Cs	0.00471	6.8%	22%	10%
S2	Fe	0.176	9.7%	21%	10%
S2	Hg	0.000150	26%	22%	20%
S2	La	0.0175	4.6%	22%	10%
S2	Li	0.0302	8.9%	22%	10%
S2	Mn	0.236	5.9%	20%	10%
S2	Se	0.00406	11%	22%	15%
S2	Sr	0.188	4.8%	21%	10%
S2	Th	0.00757	8.7%	22%	10%
S2	Tl	0.00150	10%	22%	10%
S2	U	0.00719	8.2%	22%	10%

*Robust between -laboratory CV outliers removed



Scores of >10 and <-10 have been plotted as 10 or -10.

Figure 36 z-Score Dispersal by Test

Table 37 Summary of Participants' Results and Performance for S1.

Lab Code	As (mg/L)	Be (mg/L)	Cd (mg/L)	Cr (mg/L)	Cu (mg/L)	Hg (mg/L)	Mn (mg/L)	Mo (mg/L)	Ni (mg/L)	Pb (mg/L)	Sb (mg/L)	Se (mg/L)	Sn (mg/L)	Tl (mg/L)	V (mg/L)	Zn (mg/L)
A.V.	0.00387	0.00490	0.00147	0.00936	0.440	0.000150	0.236	0.0102	0.0106	0.00754	0.00248	0.00406	0.00193	0.00150	0.00403	0.975
H.V.	0.00388	0.00458	0.00162	0.00980	0.547	0.000147	0.247	0.0103	0.0110	0.00773	0.00248	0.00397	0.00212	0.00160	0.00420	1.03
S.V.	0.00388	0.00480	0.00152	0.00955	0.497	0.000171	0.240	0.0099	0.0107	0.00764	0.00247	0.00401	0.00199	0.00154	0.00392	0.968
1	0.00401	0.0048	0.00148	0.00941	0.468	0.000154	0.239	0.0103	0.0111	0.00773	0.0029	0.0043	0.00210	0.00153	0.00406	0.977
2	0.004	0.005	0.001	0.009	0.431	<0.0005	0.235	0.010	0.010	0.007	0.002	0.005	NT	0.001	0.004	0.919
3	0.004	0.0056	0.0016	0.0099	0.46	0.0001	0.25	0.012	0.011	0.0076	0.0027	0.0043	0.0021	0.0013	0.0042	1.03
4	0.004	0.0045	0.0015	0.009	0.42	0.00016	0.25	0.010	0.010	0.0074	0.0023	<0.005	0.0018	0.0015	0.0039	0.99
5	0.004	0.005	0.0015	0.010	0.461	0.0002	0.237	0.011	0.012	0.008	0.004	<0.01	0.002	0.002	<0.01	1.01
6	0.0040	0.0051	0.0015	0.0094	0.449	<0.0005	0.229	0.0101	0.0103	0.0088	<0.005	0.0039	<0.005	<0.005	0.0046	0.944
8	0.00418	0.0056	0.00165	0.01004	0.48381	0.00016	0.26378	0.01095	0.01137	0.00784	0.00262	0.0044	0.0021	0.00162	0.0044	1.068
9	0.0035	0.0047	0.00136	0.0093	0.417	0.0001	0.226	0.0103	0.0101	0.0074	0.0024	0.0037	0.0016	0.00159	0.0039	0.900
10	0.0034	0.0046	0.0015	0.0094	0.44	0.00017	0.24	0.0096	0.011	0.0069	0.0024	0.0035	0.0019	0.0014	0.0040	0.93
11	0.005	0.005	0.0013	0.009	0.423	0.0002	0.236	0.011	0.011	0.008	0.003	<0.01	0.002	0.002	<0.01	0.930
12	0.0034	NT	0.0012	0.009	0.43	NT	0.22	0.0086	0.0097	0.0059	0.0021	0.0078	NT	NT	NT	NT
13	0.004	0.0052	0.0016	0.0097	0.9519	0.00017	0.2173	0.0099	0.0107	0.0078	0.0025	0.0040	0.0017	0.0015	0.0042	0.9519
15	0.0037	0.0047	0.0015	0.0078	0.43	0.00015	0.23	0.0094	0.010	0.0073	0.0021	0.0040	0.0019	0.0014	0.0039	1.0
16	0.0039	0.0047	0.0017	0.0094	0.4434	<0.001	0.2335	0.0099	0.0102	0.0074	0.0022	0.0043	NR	0.0016	0.0039	0.9890
17	0.004	0.0049	0.00144	0.0091	0.41	0.00014	0.228	0.0103	0.0108	0.0068	0.0033	0.0039	0.002	0.00138	0.0038	0.937
18	0.0036	0.0046	0.0014	0.0094	0.45	0.00015	0.24	0.0094	0.0104	0.0088	0.0025	0.0039	0.0019	0.0015	0.0039	1.14

Shaded cells are results which returned a questionable or unsatisfactory z-score. A.V. = Assigned Value, H.V. = Homogeneity Value, S.V. = Spike Value

Table 38 Summary of Participants' Results and Performance for S2

Lab Code	Al (mg/L)	As (mg/L)	Ba (mg/L)	Bi (mg/L)	Co (mg/L)	Cs (mg/L)	Fe (mg/L)	Hg (mg/L)	La (mg/L)	Li (mg/L)	Mn (mg/L)	Se (mg/L)	Sr (mg/L)	Th (mg/L)	Tl (mg/L)	U (mg/L)
A.V.	0.0790	0.00387	0.121	0.00432	0.00160	0.00471	0.176	0.000150	0.0175	0.0302	0.236	0.00406	0.188	0.00757	0.00150	0.00719
H.V.	0.0867	0.00388	0.130	0.00467	0.00162	0.00483	0.182	0.000147	0.0172	0.0307	0.247	0.00397	0.240	0.00777	0.00160	0.00702
S.V.	0.0819	0.00388	0.123	0.00439	0.00154	0.00455	0.175	0.000171	0.0174	0.0297	0.240	0.00401	0.201	0.00790	0.00154	0.00430
1	0.082	0.00431	0.126	0.0044	0.00156	0.00460	0.174	0.000153	0.0175	0.0299	0.241	0.0041	0.194	NT	0.00153	0.00743
2	0.081	0.004	0.117	0.004	0.001	NT	0.171	<0.0005	NT	0.028	0.236	0.005	0.184	0.007	0.001	0.007
3	<0.01	0.004	0.12	0.0047	0.0018	0.0046	0.17	0.0001	0.018	0.033	0.25	0.005	0.19	0.0085	0.0014	0.0075
4	0.08	0.004	0.12	NT	0.0015	NT	0.18	0.00017	NT	0.028	0.25	<5	0.19	NT	0.0015	NT
5	0.09	0.004	0.130	0.007	0.002	0.005	0.191	0.0002	0.018	0.032	0.251	<0.01	0.198	0.008	0.002	0.008
6	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
8	0.0899	0.00421	0.13116	0.00456	0.00167	0.00474	0.193	0.00017	0.01916	0.03629	0.26843	0.0043	0.20105	0.00802	0.00163	0.007469
9	0.075	0.0034	0.118	0.00414	0.0015	0.005	0.164	0.0001	0.016	0.0278	0.226	0.0037	0.173	0.008	0.00154	0.00690
10	0.080	0.0034	0.11	0.0042	0.0015	0.0045	0.17	0.00015	0.017	0.029	0.23	0.0035	0.19	0.0076	0.0014	0.0072
11	0.08	0.004	0.122	0.005	0.002	0.005	0.20	0.0001	0.017	NT	0.237	<0.01	0.193	0.007	0.002	0.008
12	0.074	0.0032	0.098	NT	NT	NT	0.22	NT	NT	NT	0.22	0.0075	NT	NT	NT	NT
13	0.073	0.0037	0.1157	0.0041	0.0016	NT	0.1619	0.00016	0.0167	0.0324	0.2117	0.0037	0.1673	0.0070	0.0015	0.0065
15	0.072	0.0038	0.13	NT	0.0015	NT	0.17	0.00015	0.018	0.031	0.23	0.0040	0.19	NT	0.0014	0.0069
16	0.0791	0.0038	0.1235	0.0031	0.0015	NR	0.1536	<0.001	0.0171	0.0266	0.2332	0.0039	0.1800	NR	0.0015	0.0070
17	0.076	0.004	0.119	0.00443	0.0016	0.004	0.163	0.00014	0.018	0.03	0.23	0.004	0.187	0.007	0.00137	0.00636
18	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT

Shaded cells are results which returned a questionable or unsatisfactory z-score. A.V. = Assigned Value, H.V. = Homogeneity Value, S.V. = Spike Value

7.5 Participants' Results and Analytical Methods for Total Elements

The Australian Drinking Water Guidelines for parameters in water are expressed in units of mg/L.[5] In the present study participants were requested to analyse samples using their normal test method and to report a single result in units of mg/L. A summary of participants' results and performance is presented in Tables 37 and 38 and in Figures 35 and 36.

Rounding of results and reporting results with an insufficient number of significant figures was one of the main causes for unsatisfactory results.
Analytical test results are rounded to prevent misleading impression of precision. However, most of the instrumental techniques used by participants in the present study should be capable of producing results with up to two significant figures to a reasonable degree of certainty at ppb level for most tests. Potable water is a less challenging matrix than sea water; while participants reported test results with 2 - 3 significant figures in the previous PT study in seawater, the same participants reported some results with only one significant figure in the present study. The level of analytes in the two studies were comparable. This suggests that change of unit is a source of confusion and/or that results could have been transferred from calculation spreadsheets that automatically apply the rounding rule. Laboratories should consider revising their calculation/reporting procedure.
Caution should be exercised when a rounding protocol is designed by a laboratory in order to avoid inadvertently losses of important information. According to Eurachem/CITAC Guide, "The reported result has to provide enough information in case a decision has to be made (e.g. when the result is close to the accepted guideline)."

Thallium in S1 and S2 was the analyte with the largest number of unsatisfactory results. Most of these results were reported with only one significant figure.

Participants were requested to analyse the drinking water samples for total elements. The method descriptions provided by participants are presented in Tables 1 and 2 and instrumental conditions are presented in Appendix 5.

No significant difference was observed between the performances of participants who performed digestion and the ones who did not conduct a digestion procedure on the test samples. Instrumental measurement was one of the main factors that influenced the results. However, participants' performance does not reflect only the instrument performance, but also the performance of the analyst and of the analytical method used by the testing laboratory. Thus, these results should not be construed as an evaluation of a particular instrument.

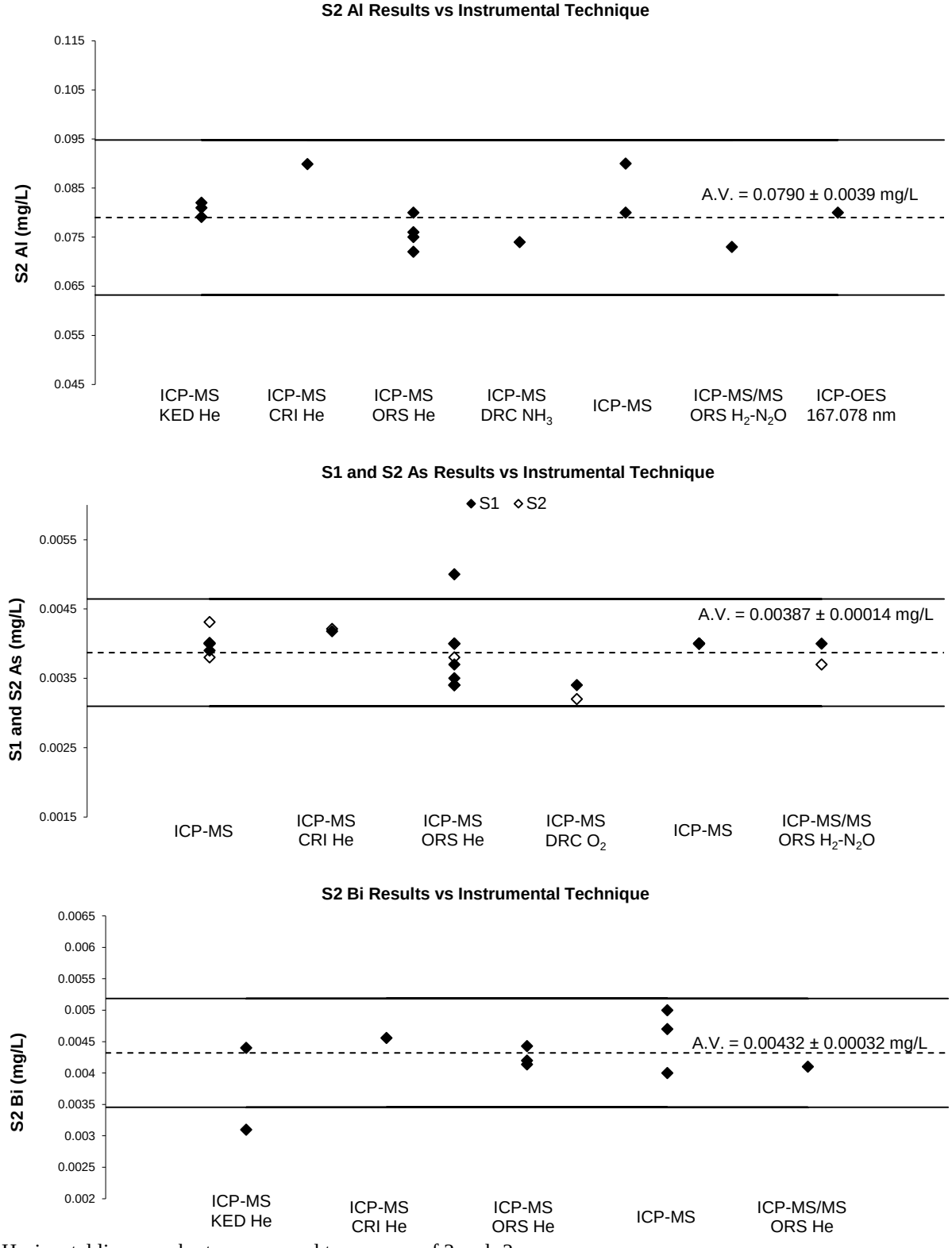
Participants used a wide variety of instrumental techniques, collision/reaction cells and cell gases. Most laboratories reported using ICP-MS with a collision/reaction cell, some used ICP-OES, and some only ICP-MS. One participant reported using ICP-MS in MS/MS mode. Plots of participants' results versus instrumental technique used are presented in Figure 37.

Individual Element Commentary

Aluminium measurements at low level have not posed significant problems for laboratories. The between-laboratory CV for Al in S2 was 7.1%. With the exception of one, all participants used ICP-MS in collision mode or in reaction mode with NH_3 as a reaction gas or a mixture of H_2 and N_2O. One laboratory reported using ICP-OES with wavelength 167.078 nm for Al measurement. All instrumental techniques produced satisfactory results.

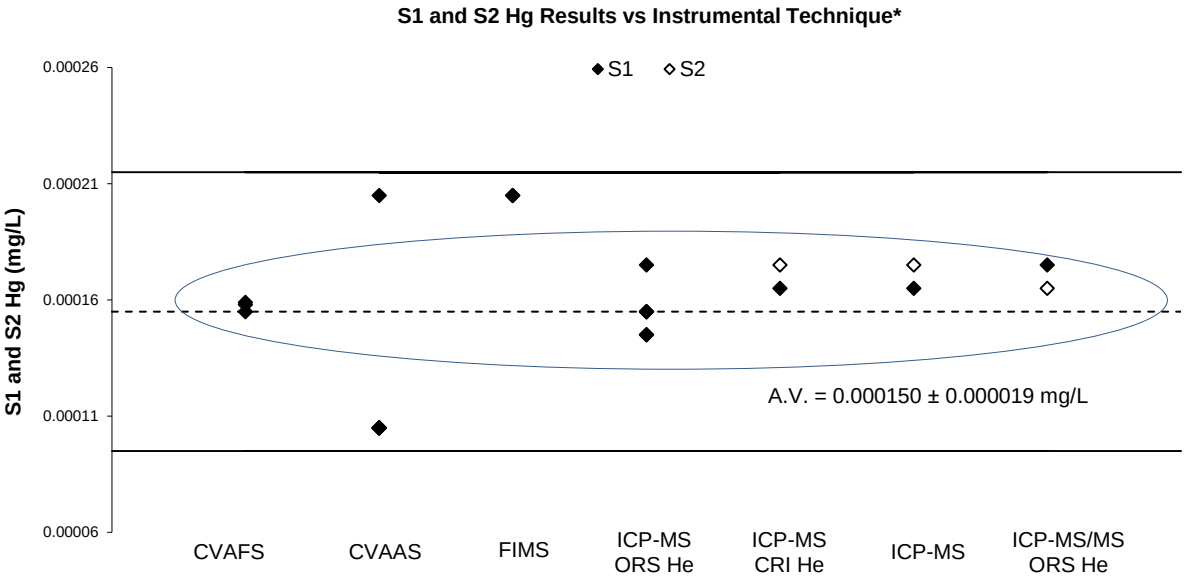
Arsenic level in the two potable water samples was 0.00387 mg/L and was 1.94 µg/L in the seawater sample S1 from PT Study AQA 19-16. Of 7 laboratories who participated in the

present study and reported results with only one significant figure, 3 also participated in AQA 19-16 but reported results with 2 - 3 significant figures. All used the same instrumental technique for As measurements in the 2 studies capable of producing As results with up to three significant figures, with a reasonable degree of certainty not only in seawater but in potable water too. The instrumental technique used by participants is presented in Figure 37.

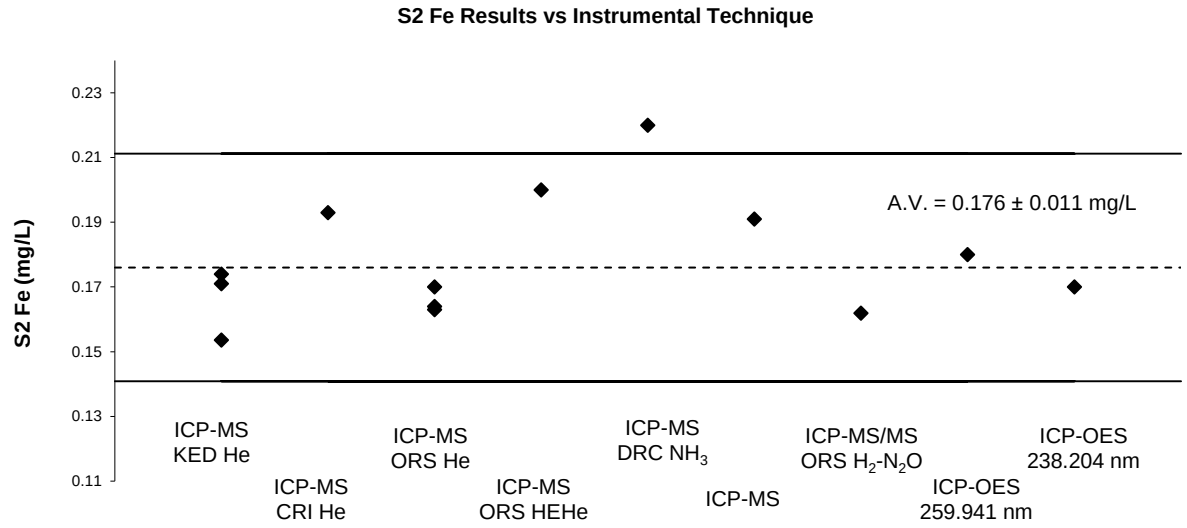


Horizontal lines on charts correspond to z-scores of 2 and -2.

Figure 37 Participants' Results vs Instrumental Technique



*There is an excellent agreement between the circled Hg results; the results not circled represent the rounded up results or the results reported with an insufficient nr of significant figures



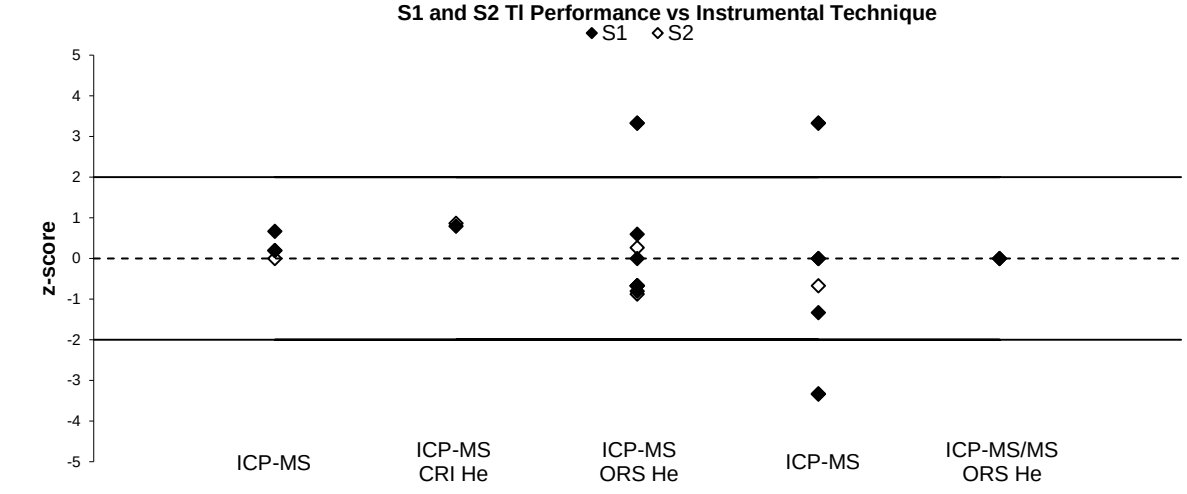
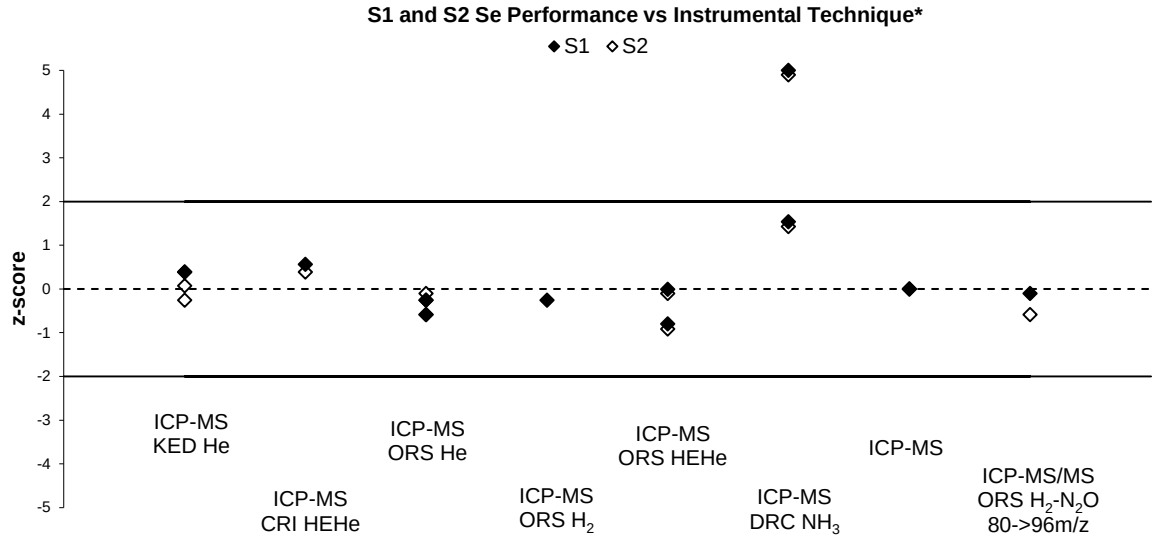


Figure 37 Participants' Results and Performance vs Instrumental Technique (continued)



*Laboratory 12 z-scores for Se in S1 and S2 have been plotted as 5 and 4.9 respectively.

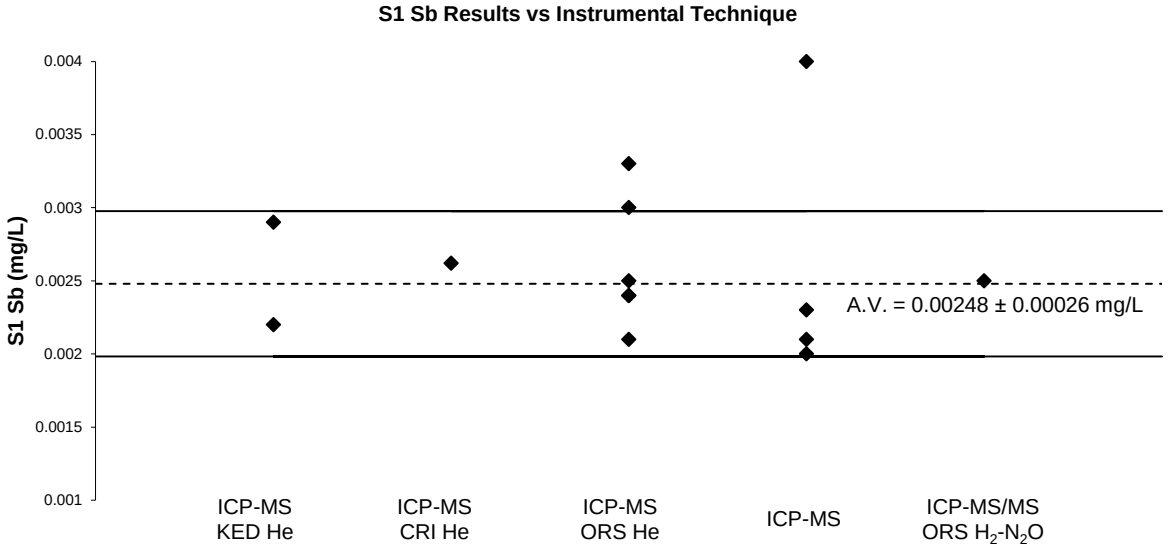


Figure 37 Participants' Results and Performance vs Instrumental Technique (continued)

Mercury Although Hg level in S1 and S2 was low (0.000150 mg/L) the between- laboratory CV (21%) was smaller than that predicted by Thomson and Horwitz (22%). There was excellent agreement between the reported results for Hg, regardless of instrumental technique used (Figure 37) with the exception of results which have been rounded up and/or reported with an inappropriate number of significant figures.

Thallium in S1 and S2 was the analyte with the largest number of unsatisfactory z-scores. All results reported for Tl with only one significant figure were unsatisfactory. There was no evident relationship between participants' performance and instrumental technique used (Figure 37).

Selenium All participants reported satisfactory results for Se in the two study sample, with the exception of one. The latter has specified*: "These PT samples are being used as part of our validation/method development that is currently being finalised."* Participants used 8 different instrumental techniques: ICP-MS in collision, reaction or MS/MS mode and with various collision/reaction gases: He, NH_3, H_2, and a mixture of H_2 and N_2O (see Figure 37).

7.6 Participants' Within – Laboratory Repeatability

Samples S1 and S2 were duplicate portions of the same fortified potable sample. The analytes' concentrations in the two test samples were identical. Of 32 tests As, Hg, Mn, Se and Tl were requested in both study samples.

Scatter plots of z-scores in Samples S1 and S2 are presented in Figures 38 to 42.

Points close to the diagonal axis represent excellent repeatability, and points close to zero represent excellent repeatability and accuracy.

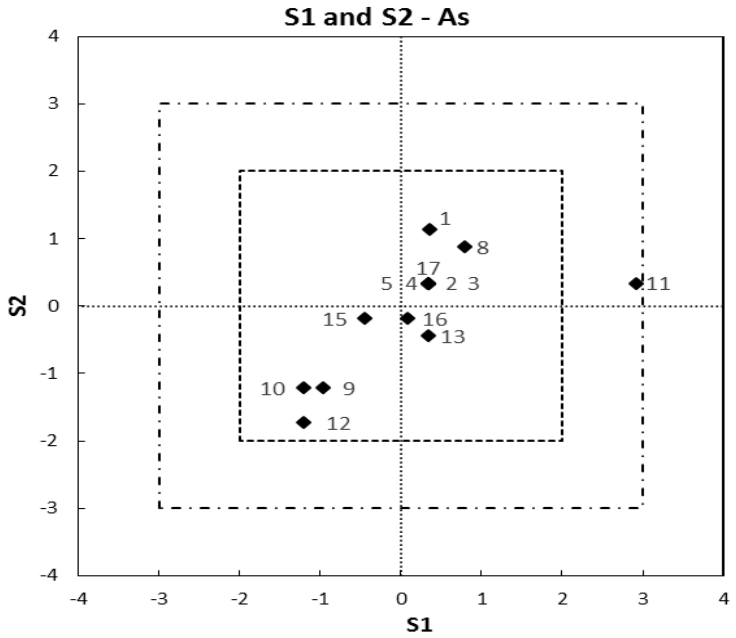


Figure 38 Scatter Plots of z-Scores for As in S1 and S2

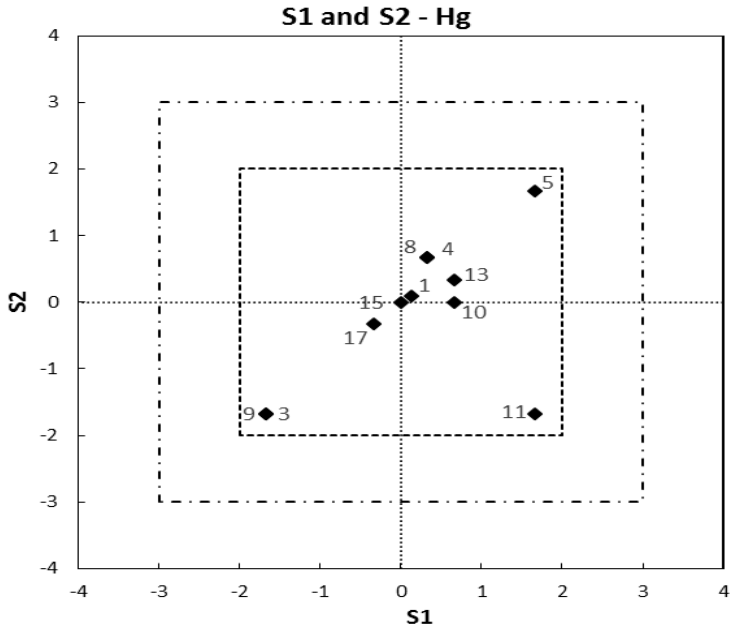


Figure 39 Scatter Plots of z-Scores for Hg in S1 and S2

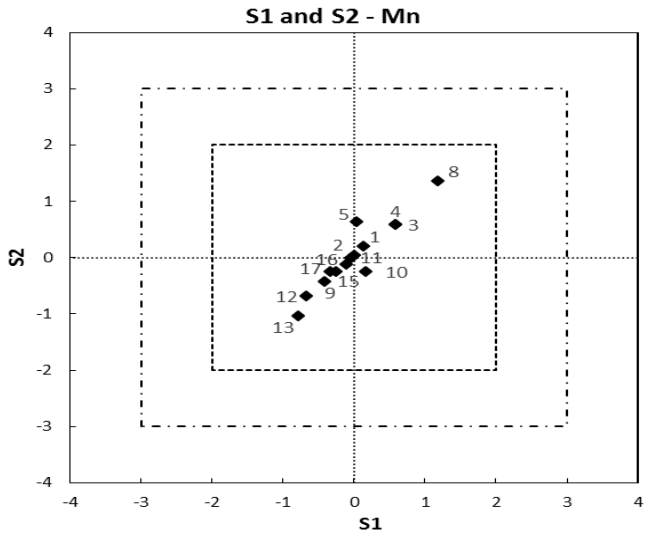
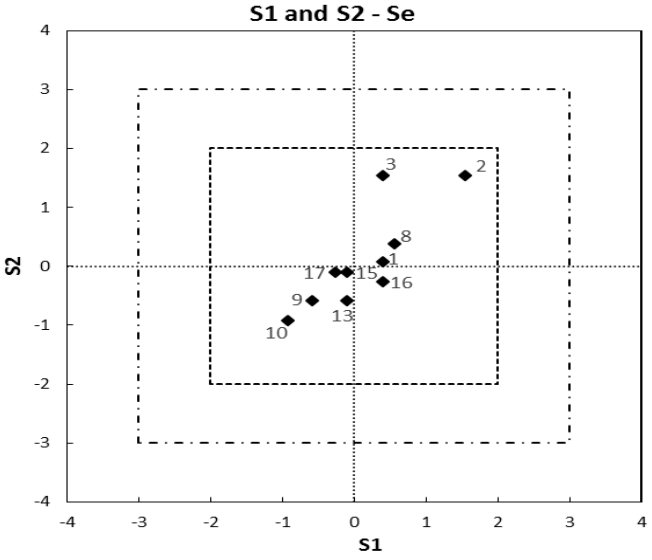


Figure 40 Scatter Plots of z-Scores for Mn in S1 and S2



Laboratory 12 is off scale

Figure 41 Scatter Plots of z-Scores for Se in S1 and S2

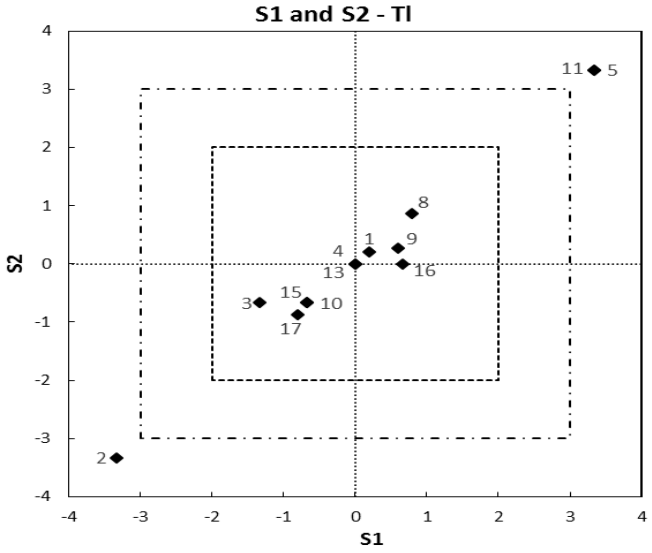


Figure 42 Scatter Plots of z-Scores for Tl in S1 and S2

Results reported for the above elements and the expanded MU are presented in the bar charts for each of these analyte in both study samples (Figure 43 to 47). In some cases, the reported results and the expanded measurement uncertainty in the two identical study samples are significantly different (e.g. Lab 13 results reported for Se and Lab 16 results reported for Tl).

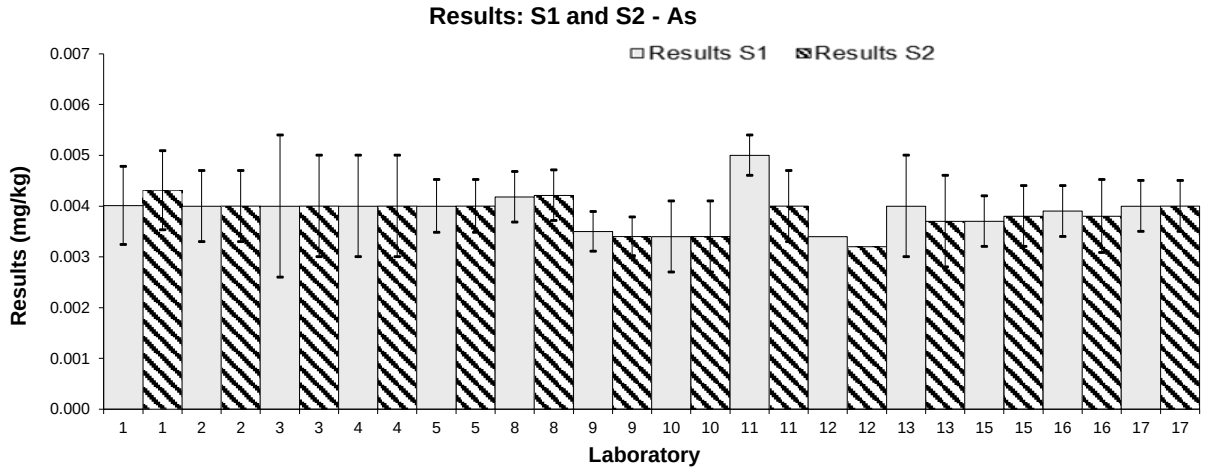


Figure 43 Bar Charts of Results for S1 and S2 – As

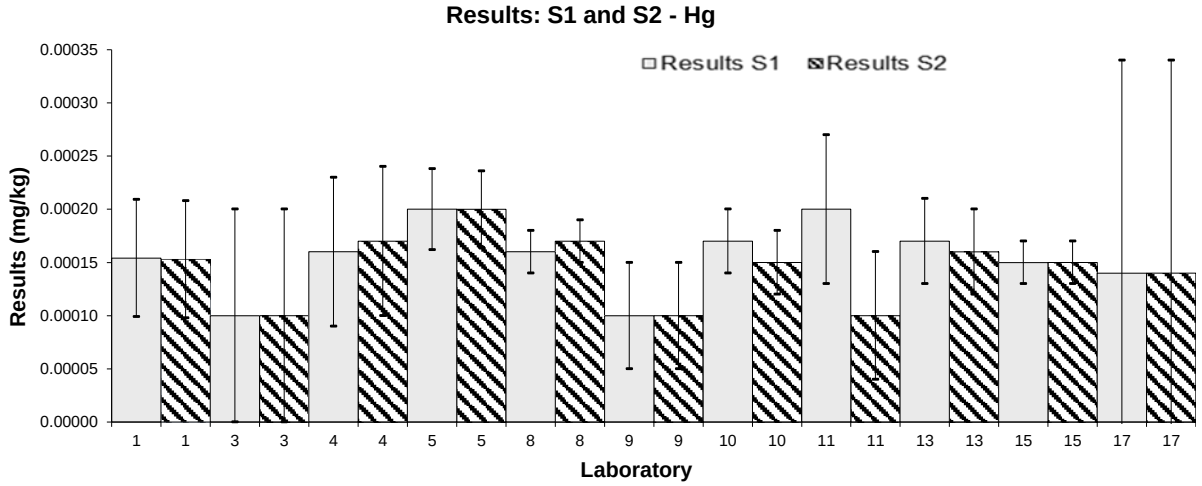


Figure 44 Bar Charts of Results for S1 and S2 – Hg

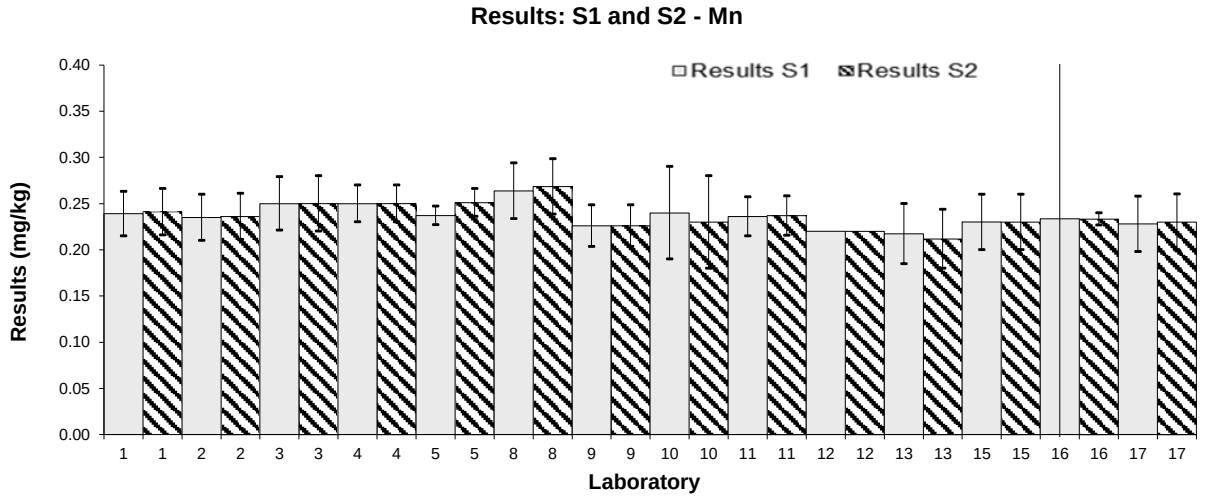


Figure 45 Bar Charts of Results for S1 and S2 – Mn

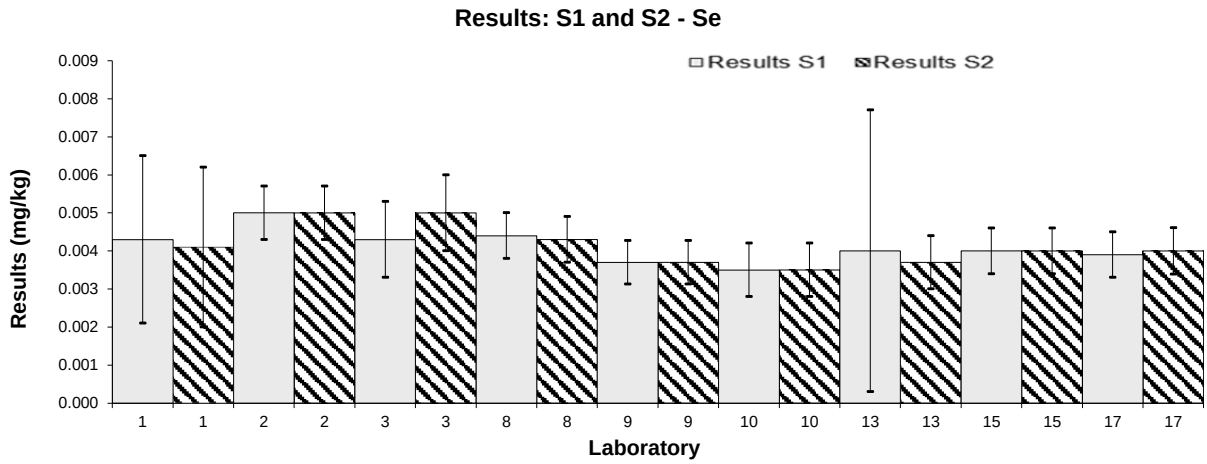


Figure 46 Bar Charts of Results for S1 and S2 – Se

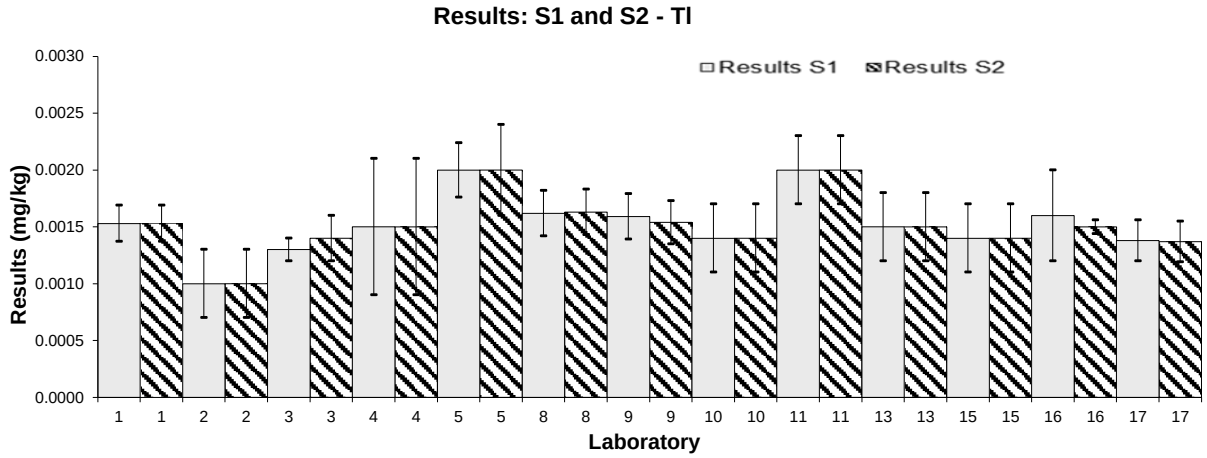


Figure 47 Bar Charts of Results for S1 and S2 – Tl

7.7 Comparison with Previous NMI Proficiency Tests of Metals in Water

AQA 20-07 is the fifth NMI proficiency test of metals in potable water. For most analytes, the same fixed target standard deviation was used in the present study as in previous studies of metals in water. This allowed for a comparison of participants' performance (z-score) over time and provided a benchmark for progressive improvement.

Despite different analytes concentrations, on average participants' performance has remained consistent with a percentage of satisfactory z-scores ranging from 88% to 95% and satisfactory E_n -scores from 80% to 87% (Figure 48).

Previously, few participants reported results for antimony in potable water. However, this study has shown a significant increase in reported results, with 88% of participants reporting numerical values, compared to 64% in 2018 and 56% in 2014.

Individual performance history reports are emailed to each participant at the end of the study; the consideration of z-scores for an analyte over time provides much more useful information than a single z-score.

Over time, laboratories should expect at least 95% of their scores to lie within the range $|z| \leq 2.0$. Scores in the range $2.0 < |z| < 3.0$ can occasionally can occur, however these should be interpreted in conjunction with the other scores obtained by that laboratory. For example, a trend of z-scores on one side of the zero line is an indication of method or laboratory bias.

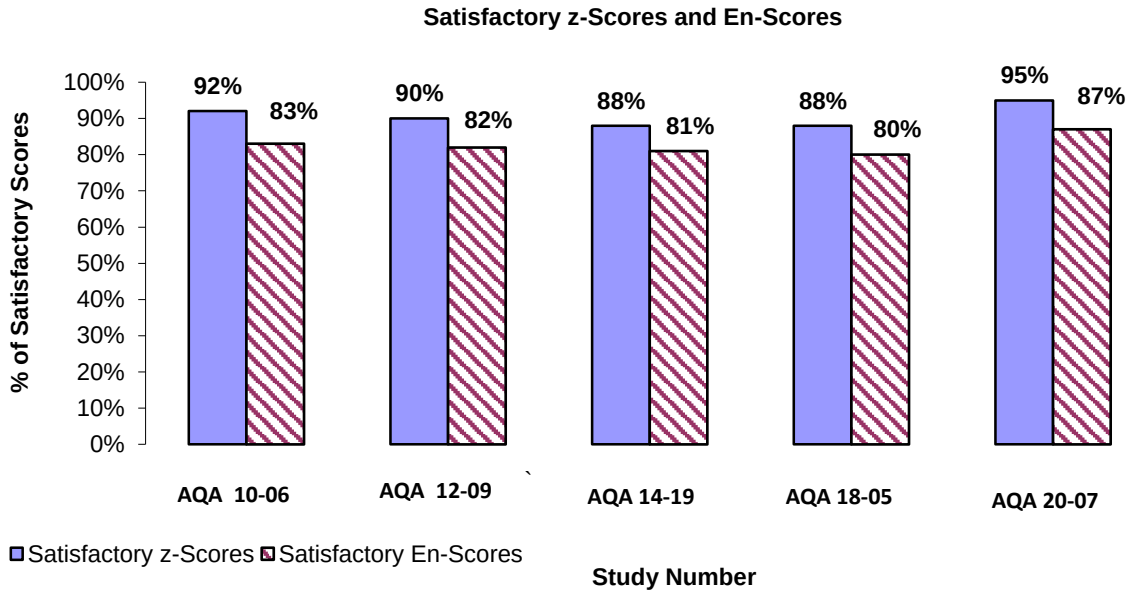


Figure 48 Participants' Performance in Metals in Potable Water over Time

7.8 Reference Materials and Certified Reference Materials

Participants reported whether control samples (spiked samples, certified reference materials-CRMs or matrix specific reference materials-RMs) had been used (Table 39).

Table 39 Control Samples Used by Participants

Lab. Code	Description of Control Samples
1	Spiked Sample
2	CRM - CWW-TM-A, B and C
3	CRM - NMIA MX014
4	CRM - CWWTMA, CWWTMC
6	CRM - Agal 3, Agal 4, Agal 6, Agal 7, pharmtab
8	CRM - Hi Purity ICP-MS-68A, B & C
9	CRM - Choice Analytical High Purity Multi Standards
10	Spiked Sample
11	Spiked Sample
12	RM
13	CRM - TM-25.5, TM-26.3, TMDA-52.4, TMDA-52.3, CASS-6
15	Spiked Sample
16	CRM - NIST SRM 1640 Trace elements in natural water
17	RM
18	RM

Some laboratories reported using certified reference materials. These materials may not meet the internationally recognised definition of a Certified Reference Material:

> *'a reference material, accompanied by documentation issued by an authoritative body and providing one or more specified property values with associated uncertainties and traceabilities, using valid procedures'*[16]

8 REFERENCES

[1] ISO17043:2010, Conformity assessment – *General requirements for proficiency testing*.

[2] NMI 2019, *NMI Chemical Proficiency Testing Study Protocol*, viewed 17 July 2020, <https://www.industry.gov.au>.

[3] NMI 2019, *NMI Chemical Proficiency Testing Statistical Manual*, viewed 17 July 2020, <https://www.industry.gov.au>.

[4] Thompson, M, Ellison, S.L.R & Wood, R 2006, 'The International Harmonized Protocol for the Proficiency Testing of Analytical Chemistry Laboratories', *Pure Appl. Chem*, vol 78, pp 145-196.

[5] National Health and Medical Research Council – *Australian Drinking Water Guidelines*, viewed 10 March 2020, <https://www.nhmrc.gov.au/about-us/publications/australian-drinking-water-guidelines>.

[6] ISO13528:2015(E), *Statistical methods for use in proficiency testing by interlaboratory comparisons.*

[7] Thompson, M, 2000, 'Recent trends in inter-laboratory precision at ppb and sub-ppb concentrations in relation to fitness for purpose criteria in proficiency testing', *Analyst*, vol 125, pp 385-386.

[8] ISO/IEC 17025:2018, *General requirements for the competence of testing and calibration laboratories*.

[9] Eurachem/CITAC, 2012, *Quantifying uncertainty in Analytical Measurement*, 3rd edition, viewed 17 July 2020, <https://www.eurachem.org>.

[10] Bertil, M, Näykki, T, Hovind, H & Krysell, M 2012, *Nordtest Report Handbook for Calculation of Measurement Uncertainty in Environmental Laboratories TR 537*, 3rd Edition, Nordest Tekniikantie, Finland, Esopo.

[11] Hibbert, B 2007, *Quality Assurance for the Analytical Chemistry Laboratory*, Oxford University Press.

[12] NATA 2018, *General Accreditation, Guidance, Estimating and Reporting Measurement Uncertainty of Chemical Test Results*.

[13] ISO (2008), *Guide to the Expression of Uncertainty in Measurement (GUM)*, Geneva, Switzerland.

[14] Eurolab 2002, Technical Report No 1/2002 - *Measurement Uncertainty in Testing.*

[15] NMI, *Estimating Measurement Uncertainty for Chemists* – viewed 17 July 2020, <https://www.industry.gov.au/client-services/training-and-assessment>.

[16] JCGM 200:2008, *International vocabulary of metrology – Basic and general concepts and associated terms* (VIM), 3rd edition.

APPENDIX 1 - SAMPLE PREPARATION, ANALYSIS AND HOMOGENEITY TESTING

Sample Preparation

Samples S1 and S2– were prepared from potable water. Approximately 10 L of tap water were stabilised by adding 2% (v/w) nitric acid and 0.01% (v/w) HCl and were then further fortified for 27 elements.

Sample Analysis and Homogeneity Testing

A partial homogeneity test was conducted for all analytes of interest. Three bottles were analysed in duplicate and the average of the results was reported as the homogeneity value.

Methodology for Total Elements

For analysis of total elements in both samples, a test portion of 30 mL was transferred to a 50 mL graduated polypropylene centrifuge tube. The samples were digested using 2 mL of nitric on a hot block at 90±100ºC for 90 min.

Testing involved measurements using ICP-MS. The measurement instrument was calibrated using external standards for targeted analytes. A set of quality control samples consisting of blanks, blank matrix spike, duplicates and sample matrix spikes was carried out through the same set of procedures and analysed at the same time as the samples. A summary of the ion/s used for each analyte is given in Table 40.

Table 40 Instrumental Technique used for Total Elements

Analyte	Instrument	Internal Standard	Reaction/ Collision Cell (if applicable)	Cell Mode/Gas (if applicable)	S1 Final Dilution Factor	S2 Final Dilution Factor	Ion (m/z)
Al	ICP-MS	Rh	NA	NA	NA	1	27
As	ICP-MS	Rh	ORS	He	1	1	75
Ba	ICP-MS	Rh	ORS	He	NA	1	138
Be	ICP-MS	Rh	NA	NA	1	NA	9
Bi	ICP-MS	Ir	ORS	He	NA	1	209
Cd	ICP-MS	Rh	NA	NA	1	NA	111
Co	ICP-MS	Rh	ORS	He	NA	1	59
Cr	ICP-MS	Rh	ORS	He	1	NA	52
Cs	ICP-MS	Rh	ORS	He	NA	1	133
Cu	ICP-MS	Rh	ORS	He	1	NA	63
Fe	ICP-MS	Rh	NA	NA	NA	1	56
Hg	ICP-MS	Rh	NA	NA	1	1	202
La	ICP-MS	Rh	ORS	He	NA	1	139
Li	ICP-MS	Rh	ORS	He	NA	1	7
Mn	ICP-MS	Rh	ORS	He	1	1	55
Mo	ICP-MS	Rh	ORS	He	1	NA	95
Ni	ICP-MS	Rh	ORS	He	1	NA	60
Pb	ICP-MS	Ir	NA	NA	1	NA	Average of 206, 207, 208
Sb	ICP-MS	Ir	ORS	He	1	NA	121
Se	ICP-MS	Rh	ORS	HEHe	1	1	78
Sn	ICP-MS	Rh	NA	NA	1	NA	118
Sr	ICP-MS	Rh	ORS	He	NA	1	88
Th	ICP-MS	Ir	NA	NA	NA	1	232
Tl	ICP-MS	Rh	ORS	He	1	1	205
U	ICP-MS	Ir	NA	NA	NA	1	238
V	ICP-MS	Rh	ORS	He	1	NA	51
Zn	ICP-MS	Rh	ORS	He	1	NA	64

APPENDIX 2 - ASSIGNED VALUE, Z-SCORE AND E_N SCORE CALCULATION

The assigned value was calculated as the robust average using the procedure described in 'ISO13528:2015(E), Statistical methods for use in proficiency testing by inter-laboratory comparisons – Annex C'.[6] The uncertainty was estimated as:

$$u_{rob\ av} = 1.25 * S_{rob\ av} / \sqrt{p} \qquad \text{Equation 4}$$

where:

$u_{rob\ av}$ robust average standard uncertainty
$S_{rob\ av}$ robust average standard deviation
p number of results

The expanded uncertainty ($U_{rob\ av}$) is the standard uncertainty multiplied by a coverage factor of 2 at approximately 95% confidence level.

A worked example is set out below in Table 41.

Table 41 Uncertainty of Assigned Value for Be in Sample S1

No. results (p)	15
Robust Average	0.0049 mg/L
$S_{rob\ av}$	0.0003 mg/L
$u_{rob\ av}$	0.0001 mg/L
k	2
$U_{rob\ av}$	0.0002 mg/L

The assigned value for Be in Sample S1 is **0.0049 ± 0.0002 mg/L.**

z-Score and E_n-score

For each participant's result a z-score and E_n-score are calculated according to Equation 2 and Equation 3 respectively (see page 9).

A worked example is set out below in Table 42.

Table 42 z-Score and E_n-score for Be result reported by Laboratory 15 in S1

As Result mg/L	Assigned Value mg/L	Set Target Standard Deviation	z-Score	E_n-Score
0.0047±0.0007	0.0049±0.0002	10% as CV or 0.10x0.0049= =0.00049 mg/L	$z = \frac{(0.0047 - 0.0049)}{0.00049}$ z = -0.41	$En = \frac{(0.0047 - 0.0049)}{\sqrt{0.0007^2 + 0.0002^2}}$ E_n=-0.27

APPENDIX 3 - USING PT DATA FOR UNCERTAINTY ESTIMATION

When a laboratory has successfully participated in at least 6 proficiency testing studies, the standard deviation from proficiency testing studies can be used to estimate the uncertainty of their measurement results.[10, 12] Between 2007 and 2020, NMI carried out 26 proficiency tests of metals in water. These studies involved analyses of dissolved or total elements at low and high levels in potable, fresh (river), saline water, ground water and waste water. Laboratory X participated and submitted satisfactory results in 18 of these PTs. This data can be separated into two ranges of results: 0.001 to 0.01 mg/L and 0.01 to 0.10 mg/L. Results are presented in Tables 43 and 44.

Table 43 Laboratory X Reported Results for Ni at 0.001 to 0.01 mg/L Level.

Study No.	Sample	Laboratory result* mg/L	Assigned value mg/L	Robust CV of all results (%)	Number of Results
AQA 11-07	Fresh	0.0015 ± 0.0003	0.001 ± 0.00001	24	15
	Fresh	0.0039 ± 0.00078	0.00306 ± 0.00016	18	19
	Fresh	0.0039 ± 0.00078	0.00306 ± 0.00016	9.6	19
AQA 12-20	Saline	0.0039 ± 0.0008	0.0037 ± 0.00028	13	19
AQA 13-09	Fresh	0.0044 ± 0.0009	0.00409 ± 0.00017	7.9	15
AQA 13-22	Saline	0.0017 ± 0.00034	0.00165 ± 0.00014	13	14
	Saline	0.00384 ± 0.00077	0.00378 ± 0.00012	13	14
AQA 15-06	Sea	0.0018 ±0.0004	0.00177 ± 0.00021	28	12
	Sea	0.00172 ± 0.0004	0.00177 ± 0.00021	28	11
AQA 15-18	Surface	0.002 ± 0.0003	0.00196 ± 0.00013	7.8	10
AQA 16-03	Waste	0.0041 ± 0.0008	0.00398 ± 0.00031	8.6	9
AQA 16-15	Sea	0.007 ± 0.001	0.00652 ± 0.00038	9.4	16
AQA 17-16	Sea	0.0015 ± 0.0003	0.00143 ± 0.00029	22	10
AQA 18-16	Sea	0.0022 ± 0.0005	0.00206 ± 0.00015	11	14
AQA 19-07	Fresh	0.0018 ± 0.0004	0.00187 ± 0.00009	5.3	10
AQA 19-16	Sea	0.0021 ± 0.0004	0.00168 ± 0.00037	25	8
Average				15**	

* Expanded uncertainty at 95% confidence level. ** The mean value of Robust CV was used.

Table 44 Laboratory X Reported Results for Ni at 0.01 to 0.10 mg/L Level.

Study No.	Sample	Laboratory result* mg/L	Assigned value mg/L	Robust CV of all results (%)	Number of Results
AQA 11-17	Waste	0.1 ± 0.009	0.099 ± 0.001	2	15
	Waste	0.1 ± 0.009	0.098 ± 0.001	2	15
AQA 12-09	Potable	0.047 ± 0.007	0.045 ± 0.002	6.7	19
	Potable	0.055 ± 0.008	0.053 ± 0.002	7.4	19
AQA 12-20	Saline	0.0415 ± 0.0083	0.0384 ± 0.0021	11	22
AQA 13-09	Fresh	0.0393 ± 0.004	0.0361 ± 0.001	4.8	16
	Fresh	0.0258 ± 0.003	0.0272 ± 0.0025	15	15
AQA 14-08	Ground	0.019 ± 0.004	0.0191 ± 0.0007	7.9	13
AQA 14-19	Potable	0.019 ± 0.004	0.0183 ± 0.0013	11	14
AQA 15-18	Surface	0.036 ± 0.0035	0.0336 ± 0.0013	5.1	13
AQA 16-03	Waste	0.042 ± 0.0045	0.0352 ± 0.005	19	11
AQA 16-15	Sea	0.0456 ± 0.006	0.0409 ± 0.0029	12	17
AQA 17-16	Sea	0.0116 ± 0.0012	0.0101 ± 0.0023	27	9
AQA 18-05	Potable	0.017 ± 0.002	0.0172 ± 0.001	8.7	16
AQA 18-16	Sea	0.015 ± 0.003	0.0138 ± 0.0014	15	15
AQA 19-07	Fresh	0.029 ± 0.0035	0.0283 ± 0.0009	4.3	11
AQA 20-07	Potable	0.01 ± 0.002	0.0106 ± 0.0004	6	16
Average				9.7**	

* Expanded uncertainty at 95% confidence level. ** The mean value of Robust CV was used.

Taking the average of the robust CVs over these PT samples for each concentration range gives estimates of the relative standard uncertainty of 15% and 9.7% respectively. Using a coverage factor of two gives relative expanded uncertainties of 30% and 20% respectively, at a level of confidence of 95% level.

Table 45 sets out the expanded uncertainty for results of the measurement of Ni in fresh, saline, waste or potable water over the ranges 0.001 – 0.01 mg/L and 0.01 – 0.10 mg/L.

Table 45 Uncertainty of Ni results estimated using PT data.

Results mg/L	Uncertainty mg/L
0.00050	0.00015
0.00100	0.00030
0.0100	0.0020
0.100	0.020
0.150	0.030

The estimates of 30% and 20% relative passes the test of being reasonable, and the analysis of the thirty-three different PT samples over ten years can be assumed to include all the relevant uncertainty components (different matrices, operators, reagents, calibrators etc.), and so complies with ISO 17025.[8]

APPENDIX 4 - ACRONYMS AND ABBREVIATIONS

APHA	American Public Health Association
ASNZS	Standards Australia and Standards New Zealand
CITAC	Cooperation on International Traceability in Analytical Chemistry
CRI	Collision Reaction Interface
CRM	Certified Reference Material
CV	Coefficient of Variation
CVAAS	Cold Vapour-Atomic Absorption Spectrometry
CVAFS	Cold Vapour-Atomic Fluorescence Spectroscopy
DRC	Dynamic Reaction Cell
GUM	Guide to the Expression of Uncertainty in Measurement
HEHe	High Energy He Mode
ICP-MS	Inductively Coupled Plasma - Mass Spectrometry
ICP-MS/MS	Inductively Coupled Plasma - Tandem Mass Spectrometry
ICP-OES-AV	Inductively Coupled Plasma - Optical Emission Spectrometry- axial view
ICP-OES-AV-buffer	Inductively Coupled Plasma - Optical Emission Spectrometry- axial view with buffer
ISO	International Organisation for Standardisation
Max	Maximum Value in a Set of Results
Md	Median
Min	Minimum Value in a Set of Results
MU	Measurement Uncertainty
NATA	National Association of Testing Authorities
NIST	National Institute of Standards and Technology
NMI	National Measurement Institute (of Australia)
NR	Not Reported
NT	Not Tested
ORC	Octopole Reaction Cell
ORS	Octopole Reaction System
PCV	Performance Coefficient of Variation
PT	Proficiency Test
RM	Reference Material
Robust CV	Robust Coefficient of Variation
Robust SD	Robust Standard Deviation
S.V.	Spiked or Formulated Concentration of a PT Sample
SI	The International System of Units
s^2_{sam}	Sampling Variance
s_a/σ	Analytical Standard Deviation Divided by the Target Standard Deviation
SRM	Standard Reference Material (Trademark of NIST)
Target SD	Target Standard Deviation
σ	Target Standard Deviation
UC	Universal Cell
USEPA	United States Environmental Protection Agency

APPENDIX 5 - INSTRUMENT DETAILS FOR TOTAL ELEMENTS

Table 46 Instrument Conditions Al

Laboratory Code	Instrument	Internal standard	Reaction Cell	Reaction Gas	S1 Final Dilution Factor	S2 Final Dilution Factor	Wavelength (nm)/ Ion(m/z)/ Absorbance(nm)
1	ICP-MS	Sc	KED	He	NA	1	27
2	ICP-MS	Sc	KED	He	NA	1	27
3					NA		
4	ICP-OES-AV-buffer	Y	NA		NA	1	167.078
5	ICP-MS	Yes			NA		
6	NA	NA	NA	NA	NA	NA	NA
8	ICP-MS		CRI	He	NA		27
9	ORC ICPMS	Ir, Rh & Sc	ORS	He	NA	1	27 (m/z)
10	ICP-MS	Sc	ORS	NA	NA	1.25	27
11	ICP-MS	Rh, Sc, Ir	ORS	He	NA	NA	27
12	ICP-MS	Sc	DRC	NH3	NA	10	26.9815
13	ICP-MS/MS	Sc	ORS	H2-N2O	NA	1	27
15	ICP-MS		ORS	He	NA	1	
16	ICP-MS	Sc	KED	He	NA		
17	ICP-OES-AV		ORS	He	NA		27
18	NA	NA	NA	NA	NA	NA	NA

Table 47 Instrument Conditions As

Laboratory Code	Instrument	Internal standard	Reaction Cell	Reaction Gas	S1 Final Dilution Factor	S2 Final Dilution Factor	Wavelength (nm)/ Ion(m/z)/ Absorbance(nm)
1	ICP-MS	Te	KED	He	1	1	75
2	ICP-MS	Ge	KED	He	1	1	75
3							
4	ICP-MS	Ge	KED		1	1	75
5	ICP-MS	Yes					
6	ICP-MS	Germanium	ORS	He	13.3	NA	75
8	ICP-MS		CRI	He			75
9	ORC ICPMS	Ir, Rh & Sc	ORS	He	1	1	75 (m/z)
10	ICP-MS	Rh	ORS	He	1.25	1.25	75
11	ICP-MS	Rh, Sc, Ir	ORS	He	NA	NA	75
12	ICP-MS	Ga	DRC	O2	10	10	90.9165
13	ICP-MS/MS	Ge	ORS	H2-N2O	1	1	75 -> 91
15	ICP-MS		ORS	He	1	1	
16	ICP-MS	Rh	KED	He			
17	ICP-OES-AV		ORS	He			
18	ICP-MS	Ge	ORS	He	1.05	NA	75

Table 48 Instrument Conditions Ba

Laboratory Code	Instrument	Internal standard	Reaction Cell	Reaction Gas	S1 Final Dilution Factor	S2 Final Dilution Factor	Wavelength (nm)/ Ion(m/z)/ Absorbance(nm)
1	ICP-MS	Tb	KED	He	NA	1	137
2	ICP-MS	Rh	NA	NA	NA	1	138
3					NA		
4	ICP-OES-AV-buffer	Y	NA		NA	1	233.527
5	ICP-MS	Yes			NA		
6	NA	NA	NA	NA	NA	NA	NA
8	ICP-MS		CRI	He	NA		137
9	ORC ICPMS	Ir, Rh & Sc	ORS	He	NA	1	137 (m/z)
10	ICP-MS	Rh	ORS	He	NA	1.25	134
11	ICP-MS	Rh, Sc, Ir	ORS	He	NA	NA	137
12	ICP-MS	In	UC	NA	NA	10	136.905
13	ICP-MS/MS	Tb	ORS	He	NA	1	137
15	ICP-MS		ORS	He	NA	10	
16	ICP-MS	Ir	KED	He	NA		
17	ICP-OES-AV		ORS	He	NA		
18	NA	NA	NA	NA	NA	NA	NA

Table 49 Instrument Conditions Be

Laboratory Code	Instrument	Internal standard	Reaction Cell	Reaction Gas	S1 Final Dilution Factor	S2 Final Dilution Factor	Wavelength (nm)/ Ion(m/z)/ Absorbance(nm)
1	ICP-MS	Sc	KED	He	1	NA	9
2	ICP-MS	Sc	NA	NA	1	NA	9
3						NA	
4	ICP-MS	Sc			1	NA	9
5	ICP-MS	Yes				NA	
6	ICP-MS	Rhodium			1.33	NA	9
8	ICP-MS		CRI	He		NA	9
9	ORC ICPMS	Ir, Rh & Sc	ORS	He	1	NA	9 (m/z)
10	ICP-MS	Sc	ORS	NA	1.25	NA	9
11	ICP-MS	Rh, Sc, Ir	ORS		NA	NA	9
12						NA	
13	ICP-MS/MS	Sc	ORS	NA	1	NA	9
15	ICP-MS		ORS	NA	1	NA	
16	ICP-MS	Sc	KED	He		NA	
17	ICP-OES-AV		ORS	He		NA	
18	ICP-MS	Li6	NA	NA	1.05	NA	9

Table 50 Instrument Conditions Bi

Laboratory Code	Instrument	Internal standard	Reaction Cell	Reaction Gas	S1 Final Dilution Factor	S2 Final Dilution Factor	Wavelength (nm)/ Ion(m/z)/ Absorbance(nm)
1	ICP-MS	Tb	KED	He	NA	1	209
2	ICP-MS	Ir	NA	NA	NA	1	209
3					NA		
4					NA		Not tested
5	ICP-MS	Yes			NA		
6	NA	NA	NA	NA	NA	NA	NA
8	ICP-MS		CRI	He	NA		209
9	ORC ICPMS	Ir, Rh & Sc	ORS	He	NA	1	209 (m/z)
10	ICP-MS	Ir	ORS	He	NA	1.25	209
11	ICP-MS	Rh, Sc, Ir	ORS		NA	NA	209
12					NA		
13	ICP-MS/MS	Ir	ORS	He	NA	1	209
15					NA		
16	ICP-MS	Sc	KED	He	NA		
17	ICP-OES-AV		ORS	He	NA		
18	NA	NA	NA	NA	NA	NA	NA

Table 51 Instrument Conditions Cd

Laboratory Code	Instrument	Internal standard	Reaction Cell	Reaction Gas	S1 Final Dilution Factor	S2 Final Dilution Factor	Wavelength (nm)/ Ion(m/z)/ Absorbance(nm)
1	ICP-MS	Rh	KED	He	1	NA	111
2	ICP-MS	Rh	NA	NA	1	NA	111
3						NA	
4	ICP-MS	In			1	NA	111
5	ICP-MS	Yes				NA	
6	ICP-MS	Rhodium			1.33	NA	111,114
8	ICP-MS		CRI	He		NA	111
9	ORC ICPMS	Ir, Rh & Sc	ORS	He	1	NA	111 (m/z)
10	ICP-MS	Rh	ORS	He	1.25	NA	111
11	ICP-MS	Rh, Sc, Ir	ORS	He	NA	NA	111
12	ICP-MS	Rh	UC	NA	10	NA	110.904
13	ICP-MS/MS	Te	ORS	He	1	NA	111
15	ICP-MS		ORS	He	1	NA	
16	ICP-MS	In	KED	He		NA	
17	ICP-OES-AV		ORS	He		NA	
18	ICP-MS	Ir	ORS	He	1.05	NA	111

Table 52 Instrument Conditions Co

Laboratory Code	Instrument	Internal standard	Reaction Cell	Reaction Gas	S1 Final Dilution Factor	S2 Final Dilution Factor	Wavelength (nm)/ Ion(m/z)/ Absorbance(nm)
1	ICP-MS	Ga	KED	He	NA	1	59
2	ICP-MS	Ge	KED	He	NA	1	59
3					NA		
4	ICP-MS	Ga	KED		NA	1	59
5	ICP-MS	Yes			NA		
6	NA	NA	NA	NA	NA	NA	NA
8	ICP-MS		CRI	He	NA		59
9	ORC ICPMS	Ir, Rh & Sc	ORS	He	NA	1	59 (m/z)
10	ICP-MS	Rh	ORS	He	NA	1.25	59
11	ICP-MS	Rh, Sc, Ir	ORS	He	NA	NA	59
12					NA		
13	ICP-MS/MS	Ge	ORS	He	NA	1	59
15	ICP-MS		ORS	He	NA	1	
16	ICP-MS	Rh	KED	He	NA		
17	ICP-OES-AV		ORS	He	NA		
18	NA	NA	NA	NA	NA	NA	NA

Table 53 Instrument Conditions Cr

Laboratory Code	Instrument	Internal standard	Reaction Cell	Reaction Gas	S1 Final Dilution Factor	S2 Final Dilution Factor	Wavelength (nm)/ Ion(m/z)/ Absorbance(nm)
1	ICP-MS	Sc	KED	He	1	NA	52
2	ICP-MS	Sc	KED	He	1	NA	52
3						NA	
4	ICP-MS	Ga	DRC	NH3	1	NA	52
5	ICP-MS	Yes				NA	
6	ICP-MS	Germanium	ORS	He	1.33	NA	
8	ICP-MS		CRI	He		NA	52
9	ORC ICPMS	Ir, Rh & Sc	ORS	He	1	NA	52 (m/z)
10	ICP-MS	Rh	ORS	He	1.25	NA	52
11	ICP-MS	Rh, Sc, Ir	ORS	He	NA	NA	52
12	ICP-MS	Ga	DRC	NH3	10	NA	51.9405
13	ICP-MS/MS	Ge	ORS	H2-N2O	1	NA	52
15	ICP-MS		ORS	He	1	NA	
16	ICP-MS	Rh	KED	He		NA	
17	ICP-OES-AV		ORS	He		NA	
18	ICP-MS	Ge	ORS	He	1.05	NA	52

Table 54 Instrument Conditions Cs

Laboratory Code	Instrument	Internal standard	Reaction Cell	Reaction Gas	S1 Final Dilution Factor	S2 Final Dilution Factor	Wavelength (nm)/ Ion(m/z)/ Absorbance(nm)
1	ICP-MS	Tb	KED	He	NA	1	133
2					NA		
3					NA		
4					NA		Not tested
5	ICP-MS	Yes			NA		
6	NA	NA	NA	NA	NA	NA	NA
8	ICP-MS		CRI	He	NA		133
9	ICP-MS	Ir, Rh & Sc	NA	He	NA	1	44 (m/z)
10	ICP-MS	Rh	ORS	He	NA	1.25	133
11	ICP-MS	Rh, Sc, Ir	ORS	He	NA	NA	133
12					NA		
13					NA		
15					NA		
16					NA		
17	ICP-MS	Ir	ORS	He	NA		133
18	NA	NA	NA	NA	NA	NA	NA

Table 55 Instrument Conditions Cu

Laboratory Code	Instrument	Internal standard	Reaction Cell	Reaction Gas	S1 Final Dilution Factor	S2 Final Dilution Factor	Wavelength (nm)/ Ion(m/z)/ Absorbance(nm)
1	ICP-MS	Ga	KED	He	1	NA	63
2	ICP-MS	Ge	KED	He	1	NA	63
3						NA	
4	ICP-OES-AV-buffer	Y	NA		1	NA	324.754
5	ICP-MS	Yes				NA	
6	ICP-MS	Germanium	ORS	He	13.3	NA	63,65
8	ICP-MS		CRI	He		NA	63
9	ORC ICPMS	Ir, Rh & Sc	ORS	He	1	NA	63 (m/z)
10	ICP-OES-AV	Y			2	NA	327.395
11	ICP-MS	Rh, Sc, Ir	ORS	He	NA	NA	63
12	ICP-MS	Ga	DRC	NH3	10	NA	62.9298
13	ICP-MS/MS	Ge	ORS	He	1	NA	63
15	ICP-MS		ORS	He	10	NA	
16	ICP-MS	Rh	KED	He		NA	
17	ICP-OES-AV		ORS	He		NA	
18	ICP-OES-AV	Lu	NA	NA	1.05	NA	324.754

Table 56 Instrument Conditions Fe

Laboratory Code	Instrument	Internal standard	Reaction Cell	Reaction Gas	S1 Final Dilution Factor	S2 Final Dilution Factor	Wavelength (nm)/ Ion(m/z)/ Absorbance(nm)
1	ICP-MS	Sc	KED	He	NA	1	56
2	ICP-MS	Sc	KED	He	NA	1	56
3					NA		
4	ICP-OES-AV-buffer	Y	NA		NA	1	259.941
5	ICP-MS	Yes			NA		
6	NA	NA	NA	NA	NA	NA	NA
8	ICP-MS		CRI	He	NA		56
9	ORC ICPMS	Ir, Rh & Sc	ORS	He	NA	1	56 (m/z)
10	ICP-OES-AV	Y			NA	2	238.204
11	ICP-MS	Rh, Sc, Ir	ORS	HEHe	NA	NA	56
12	ICP-MS	Ga	DRC	NH3	NA	10	55.9349
13	ICP-MS/MS	Ge	ORS	H2-N2O	NA	1	56
15	ICP-MS		ORS	He	NA	10	
16	ICP-MS	Rh	KED	He	NA		
17	ICP-OES-AV		ORS	He	NA		
18	NA	NA	NA	NA	NA	NA	NA

Table 57 Instrument Conditions Hg

Laboratory Code	Instrument	Internal standard	Reaction Cell	Reaction Gas	S1 Final Dilution Factor	S2 Final Dilution Factor	Wavelength (nm)/ Ion(m/z)/ Absorbance(nm)
1	Atomic Fluorescence	NA	NA	NA	5	5	254
2	ICP-MS	Ir	NA	NA	1	1	201
3							
4	ICP-MS	Ir			1	1	201
5	FIMS	Yes					
6	ICP-MS	Rhodium			1.33	NA	200,202
8	ICP-MS		CRI	He			202
9	CVAAS	NA	NA	NA	1	1	253nm
10	ICP-MS	Ir	ORS	He	1.25	1.25	202
11	CVAAS				NA	NA	253.7
12							
13	ICP-MS/MS	Ir	ORS	He	1	1	202
15	ICP-MS		ORS	He	1		
16	ICP-MS	Ir	KED	He			
17	ICP-OES-AV		ORS	He			
18	CVAFS	NA	NA	NA	1.05	NA	253.7

Table 58 Instrument Conditions La

Laboratory Code	Instrument	Internal standard	Reaction Cell	Reaction Gas	S1 Final Dilution Factor	S2 Final Dilution Factor	Wavelength (nm)/ Ion(m/z)/ Absorbance(nm)
1	ICP-MS	Tb	KED	He	NA	1	139
2					NA		
3					NA		
4					NA		Not tested
5	ICP-MS	Yes			NA		
6	NA	NA	NA	NA	NA	NA	NA
8	ICP-MS		CRI	He	NA		139
9	ICP-MS	Ir, Rh & Sc	NA	He	NA	1	139 (m/z)
10	ICP-MS	Rh	ORS	He	NA	1.25	139
11	ICP-MS	Rh, Sc, Ir	ORS	He	NA	NA	139
12					NA		
13	ICP-MS/MS	Tb	ORS	He	NA	1	139
15	ICP-MS		ORS	He	NA	1	
16	ICP-MS	Ir	KED	He	NA		
17	ICP-MS		ORS	He	NA		
18	NA	NA	NA	NA	NA	NA	NA

Table 59 Instrument Conditions Li

Laboratory Code	Instrument	Internal standard	Reaction Cell	Reaction Gas	S1 Final Dilution Factor	S2 Final Dilution Factor	Wavelength (nm)/ Ion(m/z)/ Absorbance(nm)
1	ICP-MS	Sc	KED	He	NA	1	7
2	ICP-MS	Sc	NA	NA	NA	1	7
3					NA		
4	ICP-MS	Sc			NA	1	3
5	ICP-MS	Yes			NA		
6	NA	NA	NA	NA	NA	NA	NA
8	ICP-MS		CRI		NA		7
9	ORC ICPMS	Ir, Rh & Sc	ORS	He	NA	1	7 (m/z)
10	ICP-MS	Sc	ORS	NA	NA	1.25	7
11	ICP-MS	Rh, Sc, Ir	ORS	NA	NA	NA	7
12					NA		
13	ICP-MS/MS	Sc	ORS	NA	NA	1	7
15	ICP-MS		ORS	He	NA	1	
16	ICP-MS	Sc	KED	He	NA		
17	ICP-OES-AV		ORS	He	NA		
18	NA	NA	NA	NA	NA	NA	NA

Table 60 Instrument Conditions Mn

Laboratory Code	Instrument	Internal standard	Reaction Cell	Reaction Gas	S1 Final Dilution Factor	S2 Final Dilution Factor	Wavelength (nm)/ Ion(m/z)/ Absorbance(nm)
1	ICP-MS	Sc	KED	He	1	1	55
2	ICP-MS	Sc	KED	He	1	1	55
3							
4	ICP-OES-AV-buffer	Y	NA		1	1	257.611
5	ICP-MS	Yes					
6	ICP-MS	Rhodium			13.3	NA	55
8	ICP-MS		CRI	He			55
9	ORC ICPMS	Ir, Rh & Sc	ORS	He	1	1	55 (m/z)
10	ICP-OES-AV	Y				2	257.61
11	ICP-MS	Rh, Sc, Ir	ORS	He	NA	NA	55
12	ICP-MS	Ga	UC	NA	10	10	54.9381
13	ICP-MS/MS	Sc	ORS	H2-N2O	1	1	55
15	ICP-MS		ORS	He	10	10	
16	ICP-MS	Rh	KED	He			
17	ICP-OES-AV		ORS	He			
18	ICP-MS	Ge	ORS	He	1.05	NA	55

Table 61 Instrument Conditions Mo

Laboratory Code	Instrument	Internal standard	Reaction Cell	Reaction Gas	S1 Final Dilution Factor	S2 Final Dilution Factor	Wavelength (nm)/ Ion(m/z)/ Absorbance(nm)
1	ICP-MS	Rh	KED	He	1	NA	98
2	ICP-MS	Rh	NA	NA	1	NA	95
3						NA	
4	ICP-MS	In			1	NA	95
5	ICP-MS	Yes				NA	
6	ICP-MS	Rhodium			1.33	NA	98
8	ICP-MS		CRI	He		NA	95
9	ORC ICPMS	Ir, Rh & Sc	ORS	He	1	NA	95 (m/z)
10	ICP-MS	Rh	ORS	He	1.25	NA	95
11	ICP-MS	Rh, Sc, Ir	ORS	He	NA	NA	95
12	ICP-MS	Rh	UC	NA	10	NA	94.9058
13	ICP-MS/MS	In	ORS	H2-N2O	1	NA	98 -> 130
15	ICP-MS		ORS	He	1	NA	
16	ICP-MS	Rh	KED	He		NA	
17	ICP-OES-AV		ORS	He		NA	
18	ICP-MS	Rh	ORS	He	1.05	NA	95

Table 62 Instrument Conditions Ni

Laboratory Code	Instrument	Internal standard	Reaction Cell	Reaction Gas	S1 Final Dilution Factor	S2 Final Dilution Factor	Wavelength (nm)/ Ion(m/z)/ Absorbance(nm)
1	ICP-MS	Ga	KED	He	1	NA	60
2	ICP-MS	Ge	KED	He	1	NA	60
3						NA	
4	ICP-MS	Ga	KED		1	NA	60
5	ICP-MS	Yes				NA	
6	ICP-MS	Germanium	ORS	He	1.33	NA	58,60
8	ICP-MS		CRI	He		NA	60
9	ORC ICPMS	Ir, Rh & Sc	ORS	He	1	NA	60 (m/z)
10	ICP-MS	Rh	ORS	He	1.25	NA	60
11	ICP-MS	Rh, Sc, Ir	ORS	He	NA	NA	60
12	ICP-MS	Ga	KED	He	10	NA	59.9332
13	ICP-MS/MS	Ge	ORS	He	1	NA	60
15	ICP-MS		ORS	He	1	NA	
16	ICP-MS	Rh	KED	He		NA	
17	ICP-OES-AV		ORS	He		NA	
18	ICP-MS	Ge	ORS	He	1.05	NA	60

Table 63 Instrument Conditions Pb

Laboratory Code	Instrument	Internal standard	Reaction Cell	Reaction Gas	S1 Final Dilution Factor	S2 Final Dilution Factor	Wavelength (nm)/ Ion(m/z)/ Absorbance(nm)
1	ICP-MS	Tb	KED	He	1	NA	206+207+208
2	ICP-MS	Ir	NA	NA	1	NA	206+207+208
3						NA	
4	ICP-MS	Ir			1	NA	208
5	ICP-MS	Yes				NA	
6	ICP-MS	Rhodium			1.33	NA	206,207,208
8	ICP-MS		CRI	He		NA	sum of isotopes
9	ORC ICPMS	Ir, Rh & Sc	ORS	He	1	NA	208 (m/z)
10	ICP-MS	Ir	ORS	He	1.25	NA	208
11	ICP-MS	Rh, Sc, Ir	ORS	He	NA	NA	208
12	ICP-MS	Lu	UC	NA	10	NA	208
13	ICP-MS/MS	Ir	ORS	He	1	NA	208
15	ICP-MS		ORS	He	1	NA	
16	ICP-MS	Ir	KED	He		NA	
17	ICP-OES-AV		ORS	He		NA	
18	ICP-MS	Ir	ORS	He	1.05	NA	208

Table 64 Instrument Conditions Sb

Laboratory Code	Instrument	Internal standard	Reaction Cell	Reaction Gas	S1 Final Dilution Factor	S2 Final Dilution Factor	Wavelength (nm)/ Ion(m/z)/ Absorbance(nm)
1	ICP-MS	Rh	KED	He	1	NA	121
2	ICP-MS	Rh	NA	NA	1	NA	121
3						NA	
4	ICP-MS	In			1	NA	121
5	ICP-MS	Yes				NA	
6	ICP-MS	Rhodium			1.33	NA	121,123
8	ICP-MS		CRI	He		NA	121
9	ORC ICPMS	Ir, Rh & Sc	ORS	He	1	NA	121 (m/z)
10	ICP-MS	Rh	ORS	He	1.25	NA	121
11	ICP-MS	Rh, Sc, Ir	ORS	He	NA	NA	121
12	ICP-MS	Rh	UC	NA	10	NA	120.904
13	ICP-MS/MS	Te	ORS	H2-N2O	1	NA	121
15	ICP-MS		ORS	He	1	NA	
16	ICP-MS	Ir	KED	He		NA	
17	ICP-OES-AV		ORS	He		NA	
18	ICP-MS	In	ORS	He	1.05	NA	121

Table 65 Instrument Conditions Se

Laboratory Code	Instrument	Internal standard	Reaction Cell	Reaction Gas	S1 Final Dilution Factor	S2 Final Dilution Factor	Wavelength (nm)/ Ion(m/z)/ Absorbance(nm)
1	ICP-MS	Te	KED	He	1	1	82
2	ICP-MS	Rh	DRC	NH3	1	1	82
3							
4	ICP-MS	Ge	KED		1	1	78
5	ICP-MS	Yes					
6	ICP-MS	Germanium	ORS	He	13.3	NA	78
8	ICP-MS		CRI	HEHe			78
9	ORC ICPMS	Ir, Rh & Sc	ORS	He	1	1	78 (m/z)
10	ICP-MS	Rh	ORS	HEHe	1.25	1.25	78
11	ICP-MS	Rh, Sc, Ir	ORS	HEHe	NA	NA	78
12	ICP-MS	Ga	DRC	NH3	10	10	81.9167
13	ICP-MS/MS	Ge	ORS	H2-N2O	1	1	80 -> 96
15	ICP-MS		ORS	HEHe	1	1	
16	ICP-MS	Rh	KED	He			
17	ICP-OES-AV		ORS	He			
18	ICP-MS	Ge	ORS	H2	1.05	NA	78

Table 66 Instrument Conditions Sn

Laboratory Code	Instrument	Internal standard	Reaction Cell	Reaction Gas	S1 Final Dilution Factor	S2 Final Dilution Factor	Wavelength (nm)/ Ion(m/z)/ Absorbance(nm)
1	ICP-MS	Rh	KED	He	1	NA	120
2						NA	
3						NA	
4	ICP-MS	In			1	NA	118
5	ICP-MS	Yes				NA	
6	ICP-MS	Rhodium			1.33	NA	118
8	ICP-MS		CRI	He		NA	118
9	ORC ICPMS	Ir, Rh & Sc	ORS	He	1	NA	188 (m/z)
10	ICP-MS	Rh	ORS	He	1.25	NA	118
11	ICP-MS	Rh, Sc, Ir	ORS	He	NA	NA	189
12						NA	
13	ICP-MS/MS	In	ORS	H2-N2O	1	NA	118
15	ICP-MS		ORS	He	1	NA	
16						NA	
17	ICP-OES-AV		ORS	He		NA	
18	ICP-MS	In	ORS	He	1.05	NA	118

Table 67 Instrument Conditions Sr

Laboratory Code	Instrument	Internal standard	Reaction Cell	Reaction Gas	S1 Final Dilution Factor	S2 Final Dilution Factor	Wavelength (nm)/ Ion(m/z)/ Absorbance(nm)
1	ICP-MS	Rh	KED	He	NA	1	88
2	ICP-MS	Rh	NA	NA	NA	1	88
3					NA		
4	ICP-OES-AV-buffer	Y	NA		NA	1	407.771
5	ICP-MS	Yes			NA		
6	NA	NA	NA	NA	NA	NA	NA
8	ICP-MS		CRI	He	NA		88
9	ORC ICPMS	Ir, Rh & Sc	ORS	He	NA	1	88 (m/z)
10	ICP-MS	Rh	ORS	He	NA	1.25	88
11	ICP-MS	Rh, Sc, Ir	ORS	He	NA	NA	925
12					NA		
13	ICP-MS/MS	In	ORS	H2-N2O	NA	1	88
15	ICP-MS		ORS	He	NA	1	
16	ICP-MS	Ir	KED	He	NA		
17	ICP-OES-AV		ORS	He	NA		
18	NA	NA	NA	NA	NA	NA	NA

Table 68 Instrument Conditions Th

Laboratory Code	Instrument	Internal standard	Reaction Cell	Reaction Gas	S1 Final Dilution Factor	S2 Final Dilution Factor	Wavelength (nm)/ Ion(m/z)/ Absorbance(nm)
1	NA	NA	NA	NA	NA	NA	NA
2	ICP-MS	Ir	NA	NA	NA	1	232
3					NA		
4					NA		Not tested
5	ICP-MS	Yes			NA		
6	NA	NA	NA	NA	NA	NA	NA
8	ICP-MS		CRI	He	NA		232
9	ORC ICPMS	Ir, Rh & Sc	ORS	He	NA	1	232 (m/z)
10	ICP-MS	Ir	ORS	He	NA	1.25	232
11	ICP-MS	Rh, Sc, Ir	ORS	He	NA	NA	232
12					NA		
13	ICP-MS/MS	Ir	ORS	He	NA	1	232
15	ICP-MS		ORS	He	NA	1	
16					NA		
17	ICP-OES-AV		ORS	He	NA		
18	NA	NA	NA	NA	NA	NA	NA

Table 69 Instrument Conditions Tl

Laboratory Code	Instrument	Internal standard	Reaction Cell	Reaction Gas	S1 Final Dilution Factor	S2 Final Dilution Factor	Wavelength (nm)/ Ion(m/z)/ Absorbance(nm)
1	ICP-MS	Tb	KED	He	1	1	205
2	ICP-MS	Ir	NA	NA	1	1	205
3							
4	ICP-MS	Ir			1	1	203
5	ICP-MS	Yes					
6	ICP-MS	Rhodium			1.33	NA	203,205
8	ICP-MS		CRI	He			205
9	ORC ICPMS	Ir, Rh & Sc	ORS	He	1	1	205 (m/z)
10	ICP-MS	Ir	ORS	He	1.25	1.25	205
11	ICP-MS	Rh, Sc, Ir	ORS	He	NA	NA	205
12							
13	ICP-MS/MS	Ir	ORS	He	1	1	205
15	ICP-MS		ORS	He	1	1	
16	ICP-MS	Ir	KED	He			
17	ICP-OES-AV		ORS	He			
18	ICP-MS	Ir	ORS	He	1.05	NA	205

Table 70 Instrument Conditions U

Laboratory Code	Instrument	Internal standard	Reaction Cell	Reaction Gas	S1 Final Dilution Factor	S2 Final Dilution Factor	Wavelength (nm)/ Ion(m/z)/ Absorbance(nm)
1	ICP-MS	Tb	KED	He	NA	1	238
2	ICP-MS	Ir	NA	NA	NA	1	238
3					NA		
4					NA		Not tested
5	ICP-MS	Yes			NA		
6	NA	NA	NA	NA	NA	NA	NA
8	ICP-MS		CRI	He	NA		238
9	ORC ICPMS	Ir, Rh & Sc	ORS	He	NA	1	238 (m/z)
10	ICP-MS	Ir	ORS	He	NA	1.25	238
11	ICP-MS	Rh, Sc, Ir	ORS	He	NA	NA	238
12					NA		
13	ICP-MS/MS	Tb	ORS	He	NA	1	238
15	ICP-MS		ORS	He	NA	1	
16	ICP-MS	Ir	KED	He	NA		
17	ICP-OES-AV		ORS	He	NA		
18	NA	NA	NA	NA	NA	NA	NA

Table 71 Instrument Conditions V

Laboratory Code	Instrument	Internal standard	Reaction Cell	Reaction Gas	S1 Final Dilution Factor	S2 Final Dilution Factor	Wavelength (nm)/ Ion(m/z)/ Absorbance(nm)
1	ICP-MS	Sc	KED	He	1	NA	51
2	ICP-MS	Sc	KED	He	1	NA	51
3						NA	
4	ICP-MS	Ga	KED		1	NA	51
5	ICP-MS	Yes				NA	
6	ICP-MS	Germanium	ORS	He	1.33	NA	51
8	ICP-MS		CRI	He		NA	51
9	ORC ICPMS	Ir, Rh & Sc	ORS	He	1	NA	51 (m/z)
10	ICP-MS	Rh	ORS	He	1.25	NA	51
11	ICP-MS	Rh, Sc, Ir	ORS	He	NA	NA	51
12						NA	
13	ICP-MS/MS	Sc	ORS	H2-N2O	1	NA	51 -> 67
15	ICP-MS		ORS	He	1	NA	
16	ICP-MS	Rh	KED	He		NA	
17	ICP-OES-AV		ORS	He		NA	
18	ICP-MS	Ge	ORS	He	1.05	NA	51

Table 72 Instrument Conditions Zn

Laboratory Code	Instrument	Internal standard	Reaction Cell	Reaction Gas	S1 Final Dilution Factor	S2 Final Dilution Factor	Wavelength (nm)/ Ion(m/z)/ Absorbance(nm)
1	ICP-MS	Te	KED	He	1	NA	66
2	ICP-MS	Ge	KED	He	1	NA	66
3						NA	
4	ICP-OES-AV-buffer	Y	NA		1	NA	213.856
5	ICP-MS	Yes				NA	
6	ICP-MS	Germanium	ORS	He	13.3	NA	66
8	ICP-MS		CRI	He		NA	66
9	ORC ICPMS	Ir, Rh & Sc	ORS	He	1	NA	64 (m/z)
10	ICP-OES-AV	Y			2	NA	213.857
11	ICP-MS	Rh, Sc, Ir	ORS	He	NA	NA	68
12						NA	
13	ICP-MS/MS	Te	ORS	H2-N2O	1	NA	66
15	ICP-MS		ORS	He	10	NA	
16	ICP-MS	Rh	KED	He		NA	
17	ICP-OES-AV		ORS	He		NA	
18	ICP-OES-AV	Lu	NA	NA	1.05	NA	206.2

END OF REPORT