NORZINC
A PREMIUM MINE DEVELOPER

Parent Company of Canadian Zinc

Memorandum

To: MVLWB **Pages:** 2

Date: April 5, 2022

Re: Upstream Water Quality Outliers and Statistics, MV2021L2-0004

In their comments on CZN's responses to Information Requests (IR's) 1-4 relating to effluent quality criteria (EQC), specifically those relating to IR #4 and upstream water quality outliers, the GNWT commented that "while the outliers removed from the dataset appear acceptable, CZN has not outlined the approach used to identify them". The GNWT recommended that "CZN provide the methodology used to identify outliers in the dataset". Other reviewers also recommended that CZN provide statistical information to support the removal of outliers.

In our approach to reviewing appropriate upstream water quality based on 90th percentile concentrations, we noted that for many parameters, there is an undue influence on the result from a very limited number of samples. We discovered that for total metals, the cause was elevated concentrations due to high sediment load, as indicated by elevated TSS concentrations, which can occur in a mountain stream prone to significant flow variations. We reported total vs dissolved concentrations, noting that dissolved concentrations were considerably lower. Some may argue that all total metals results, regardless of sediment load influence, should be included in upstream water quality assessment, but we submit that such an approach would be flawed because it leads to upstream water quality assignment based on very few samples strongly influenced by episodic high suspended load occurrences. Further, we do not it to be appropriate to assume upstream water quality based on such an approach for the purpose of setting long-term EQC. In our opinion, upstream water quality metals concentrations should be based on dissolved concentrations to avoid influence of suspended load.

We note that water quality guidelines for lead and zinc are now based on dissolved concentrations, these being the more relevant toxicological form, and it seems the guidelines for other metals may also be changed to the dissolved form in future e.g. copper. However, rather than base 90th percentiles on dissolved metals, we removed those samples for which the total metal concentration was clearly an outlier from the majority, and negatively skewed the resulting total metal percentile. There are likely other outlier samples in the database that we did not remove. Similarly, we found outlier nitrite values which appear to correlate with sampling by ECCC at a location 4 km upstream. These concentrations are not reflective of nitrite concentrations immediately upstream of the Mine. As such, we believe the above rationale is sufficient by itself to justify the removal of sample values considered outliers.

To illustrate the conservatism of the assumed 90th percentiles with the outliers removed, Table 1 below compares the 65th percentiles to the assumed 90th percentiles for those parameters that had

identified outliers. It should be noted that the 65th percentiles were the basis for the fixed EQC and upstream water quality defined in MV2008L2-0002, the latter to be used for effluent discharge using the variable load discharge approach. Note that the adjusted 90th percentiles for all metals except mercury in Table 1 have much higher concentrations than the 65th percentiles, and that none of the adjusted 90th percentiles are lower than the 65th percentiles.

Table 1: Upstream Water Quality – 65th percentiles vs 90th percentiles with outliers removed

Parameter	65th Percentile	90th Percentile*
Arsenic	0.213	0.57
Cadmium	0.03	0.05
Copper	0.54	1.05
Iron	84	166
Mercury	10	10
Nitrite	0.005	0.005
Nitrite low water	0.004	0.005

* Outliers removed
All parameters relate to open water high flow season, except where noted
Metals are ug/l, nitrite mg/L

In addition to the above, out of interest, we performed statistics on the parameters for which outliers were removed. The results are attached. The data is provided along with statistical distributions, including means and standard deviations. What we found was that statistical analysis using all sample results highlighted the outlier samples (in red) as being much higher concentrations than the means and the majority of the other sample results. However, we also found that the inclusion of the outliers also skewed the statistical analysis. Repeating the statistics without the outliers showed that most sample results fall within a narrow range, and the outliers occur well outside of that range. This explains why the outliers negatively skewed the 90th percentiles when they were included. The statistics for nitrite, open water high flow season, suggest one outlier might not have been excluded as it appears close to the mean in the chart. However, this is a function of the x-axis scale. A review of the data suggests we should exclude this sample, and likely should have also excluded the result of 0.0157 mg/L in June given that all other results are 0.0016 mg/L or non-detect.

Unbounded DLs removed, remaining DLs = 1/2 DLs

TOTAL METALS

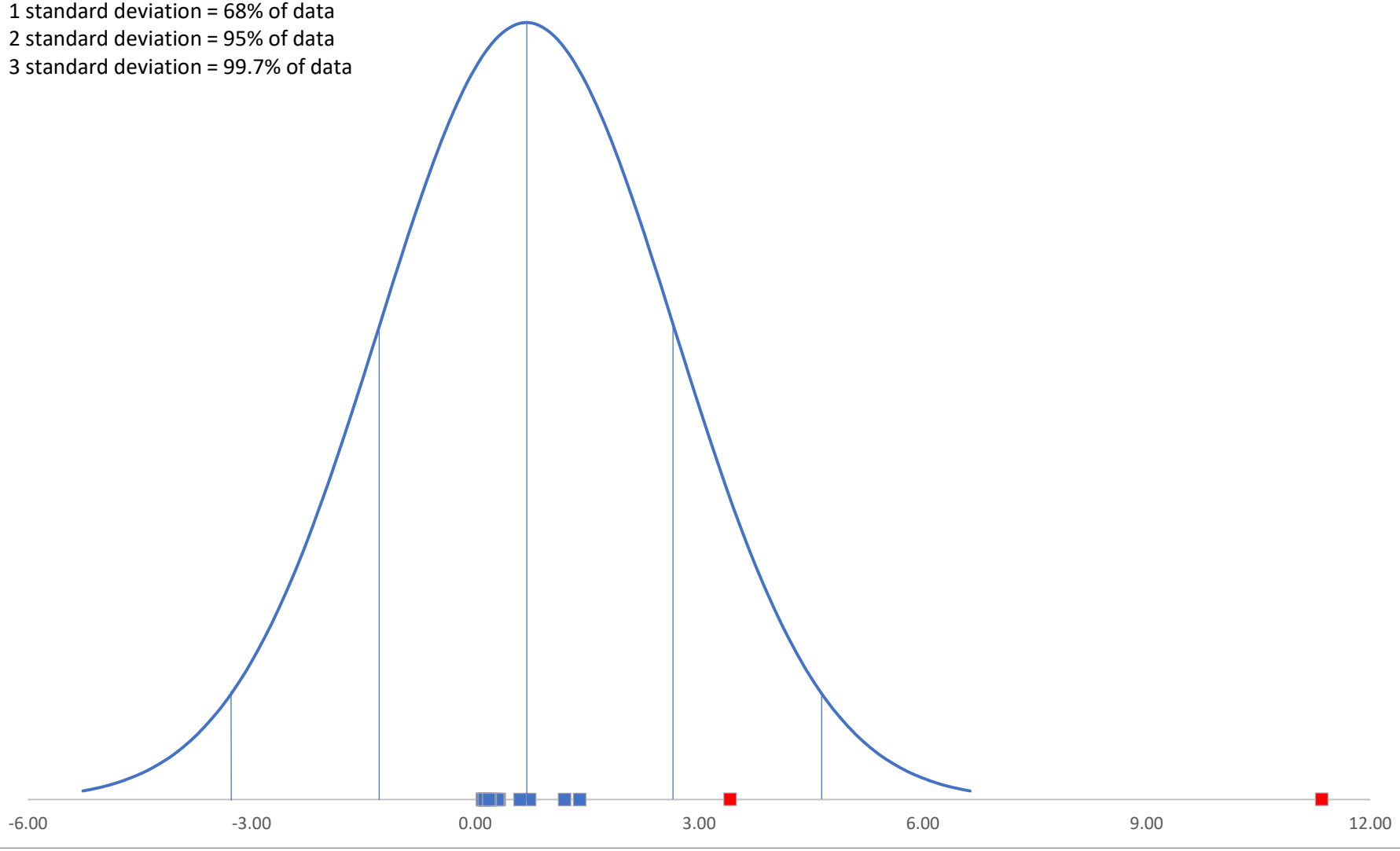
= concs reported as below method DL, reported as 1/2 DL ;empty cells represent unbounded DLs.
= summary statistics calculated but not used.
= removed outliers

Arsenic - Upstream (µg/L)

Under ice					Open water high flow					Open water low flow			Under Ice	Open high	Open low
Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov				
0.109		0.080	0.110	0.480	0.320	0.110	0.130	0.100	0.120	0.110	0.200	P65	0.127	0.213	0.195
		0.120	0.110	0.135	1.200	0.110	0.100	0.140	0.130	0.300	0.800	P75	0.143	0.295	0.254
		0.099	0.100		0.229	0.120	0.200	**11.350**	0.100	0.130	0.115	P90	0.163	1.06	0.350
			0.100		0.159	0.120	0.300	0.600	0.140	0.120		P95	0.277	2.11	0.575
						0.140			0.130	0.272		n	14	34	10
						0.130			0.200			Max	0.48	11.35	0.80
						1.400			0.100						
						0.730									
0.168	0.119	0.145	0.152		0.252	0.281	0.312	0.139	0.122	0.106					
								3.420	0.184	0.168					

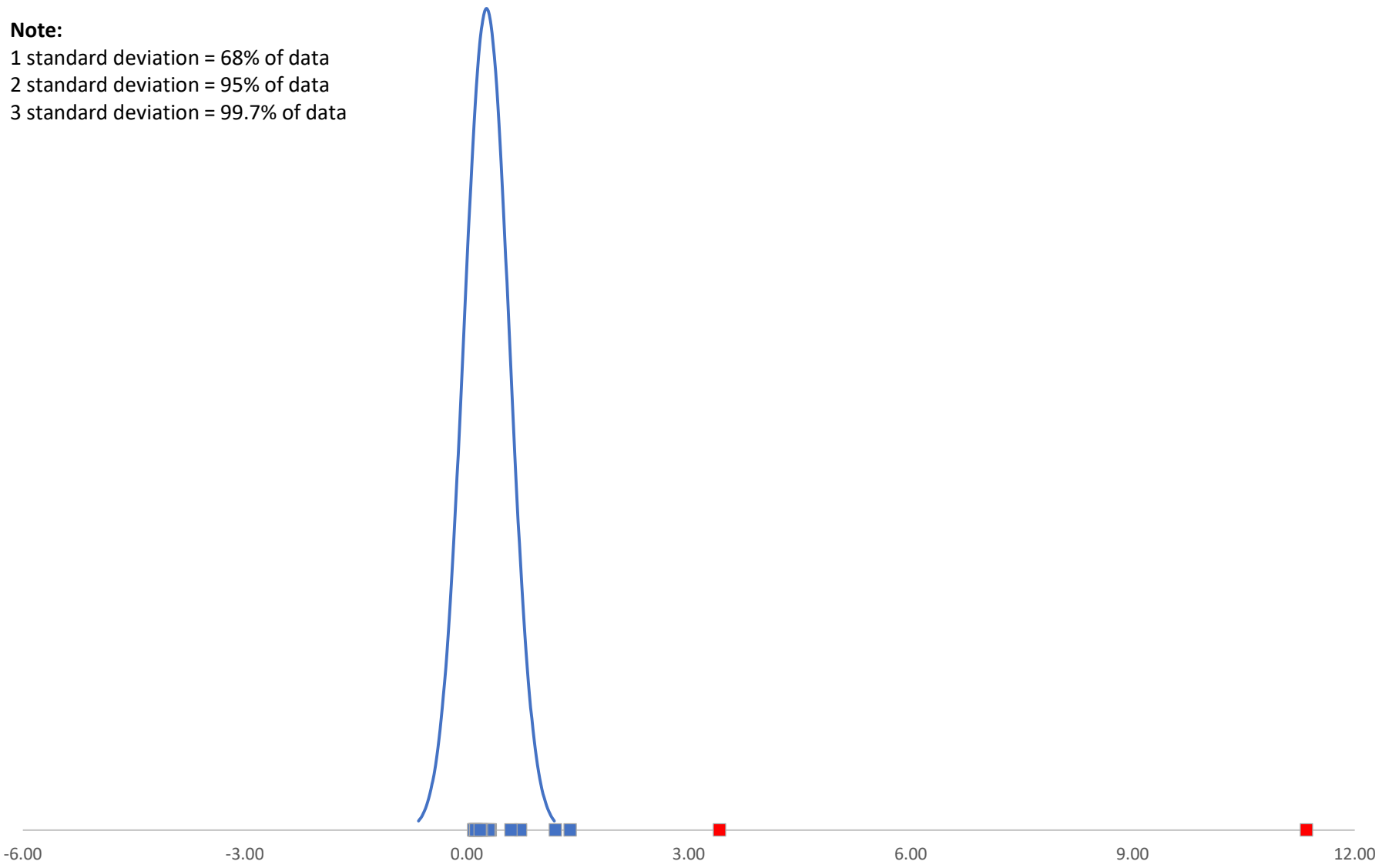
Arsenic - Upstream
Open water high flow - with the red outliers
Mean (µg/L): 0.69
Standard Deviation: 1.98

Note:
1 standard deviation = 68% of data
2 standard deviation = 95% of data
3 standard deviation = 99.7% of data



Arsenic - Upstream
Open water high flow - without the red outliers
Mean (µg/L): 0.27
Standard Deviation: 0.31

Note:
1 standard deviation = 68% of data
2 standard deviation = 95% of data
3 standard deviation = 99.7% of data



Unbounded DLs removed, remaining DLs = 1/2 DLs

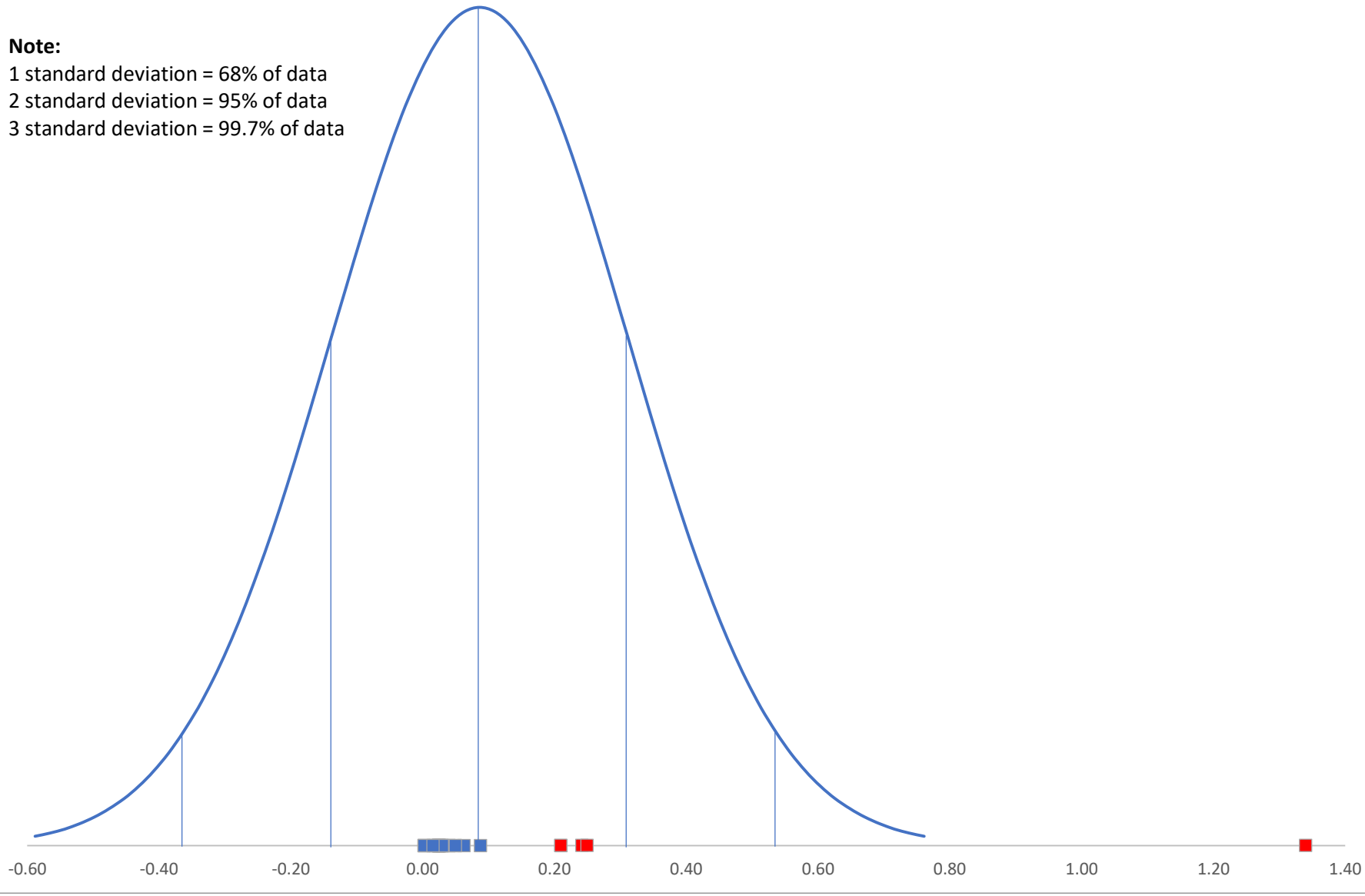
TOTAL METALS

= concs reported as below method DL, reported as 1/2 DL ;empty cells represent unbounded DLs.
= summary statistics calculated but not used.
= removed outliers

Under ice					Open water high flow					Open water low flow			Under Ice	Open high	Open low
Cadmium - Upstream (µg/L)															
Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov				
0.013		0.031	0.051	0.025	0.050	0.019	0.024	0.025	0.003	0.050	0.020	P65	0.028	0.030	0.028
		0.027	0.030	0.013	0.063	0.031	0.030	0.050	0.022	0.030	0.260	P75	0.031	0.043	0.030
		0.014	0.034		**0.210**	0.024	0.040	0.023	0.026	0.010	0.009	P90	0.036	0.210	0.050
			0.037		0.023	0.026	0.040	**1.340**	0.026	0.027		P95	0.042	0.244	0.155
					0.025	0.025		**0.250**	0.029	0.029		n	14	36	11
						0.024			0.030	0.014		Max	0.05	1.34	0.26
						0.088			0.030						
						0.210									
0.003	0.003	0.003	0.005		0.024	0.016	0.003	0.003	0.003	0.003					
								0.242	0.016	0.016					

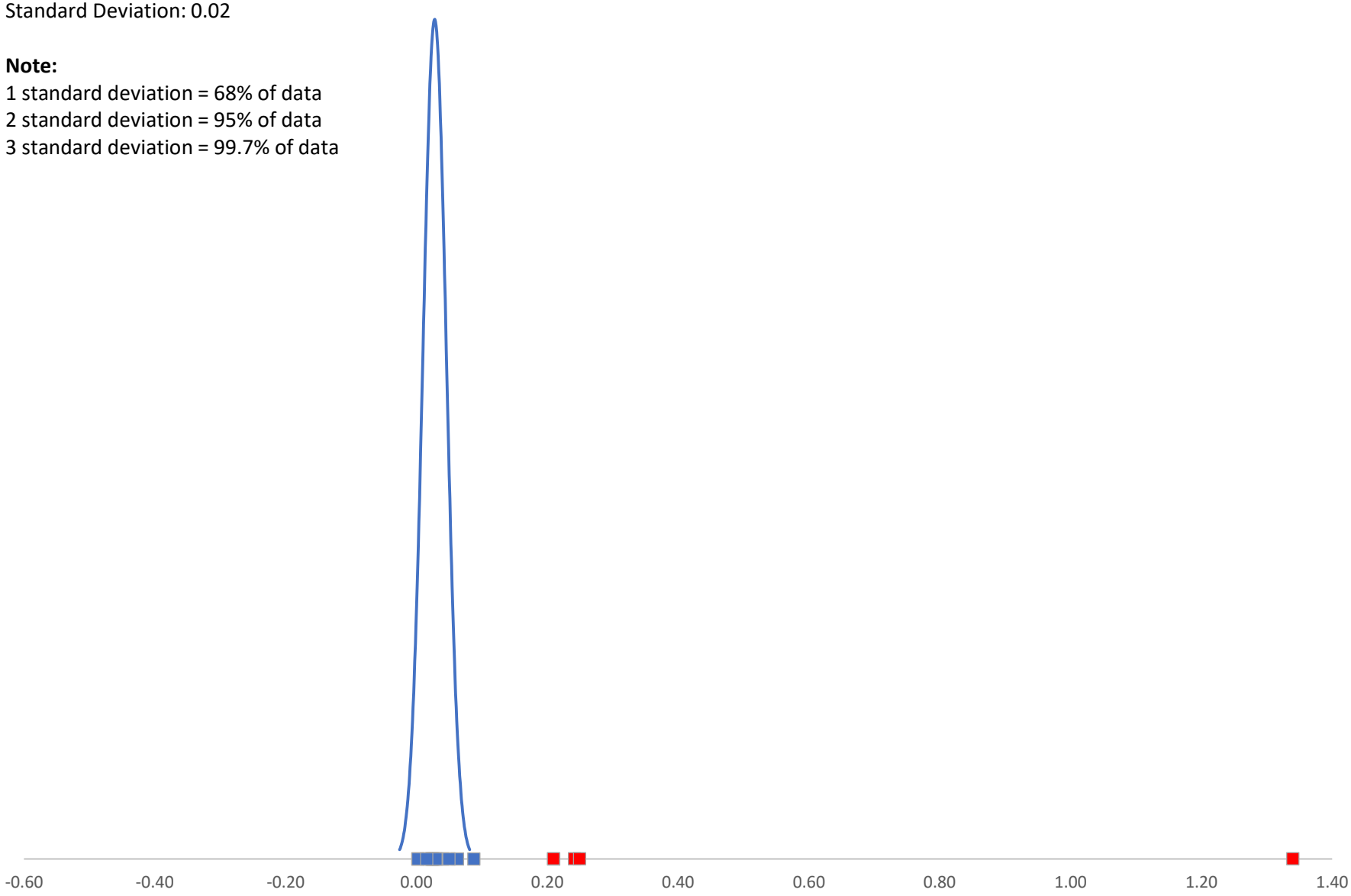
Cadmium - Upstream
Open water high flow - with the red outliers
Mean (µg/L): 0.09
Standard Deviation: 0.22

Note:
1 standard deviation = 68% of data
2 standard deviation = 95% of data
3 standard deviation = 99.7% of data



Cadmium - Upstream
Open water high flow - without the red outliers
Mean (µg/L): 0.03
Standard Deviation: 0.02

Note:
1 standard deviation = 68% of data
2 standard deviation = 95% of data
3 standard deviation = 99.7% of data



Unbounded DLs removed, remaining DLs = 1/2 DLs

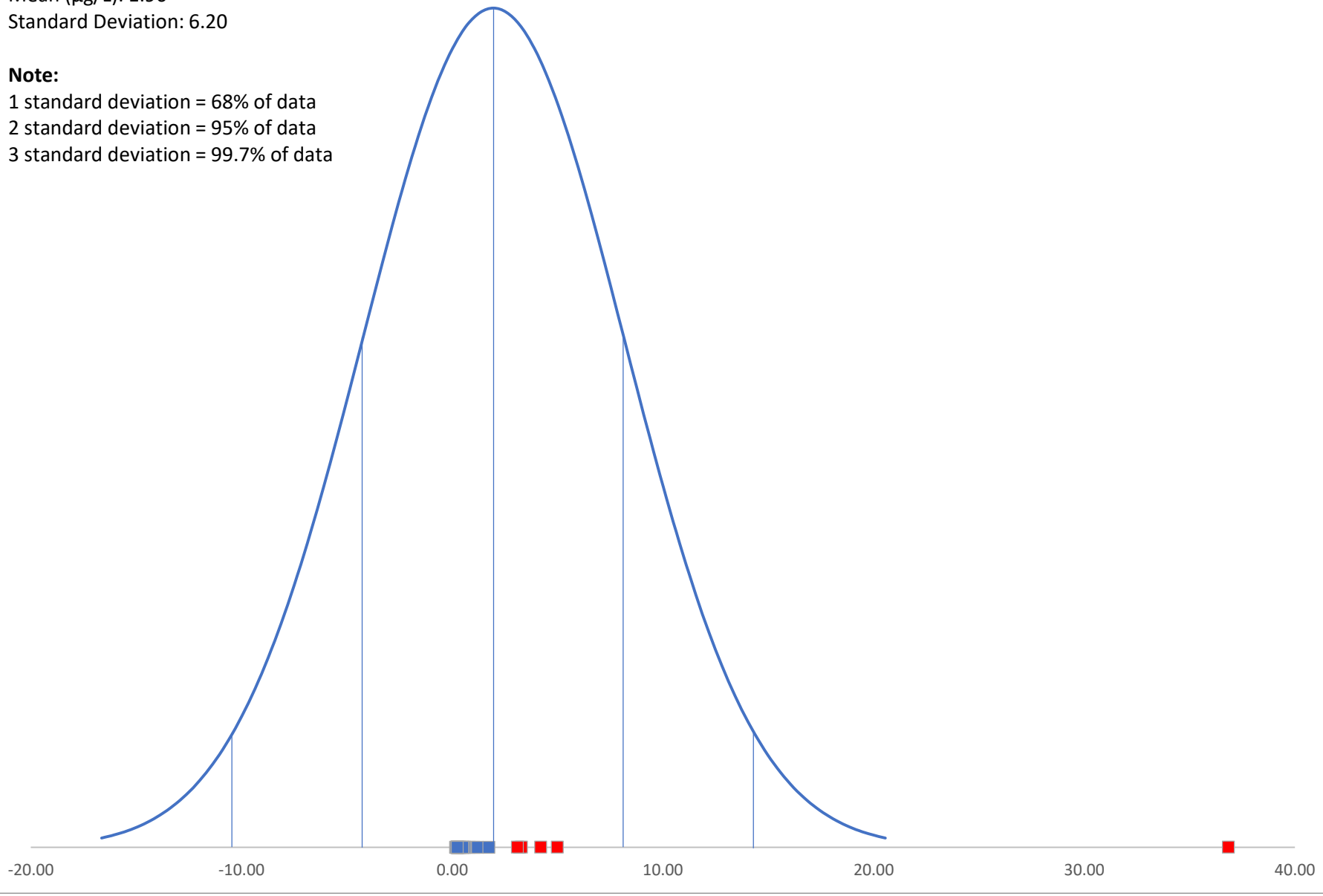
TOTAL METALS

= concs reported as below method DL, reported as 1/2 DL ;empty cells represent unbounded DLs.
= summary statistics calculated but not used.
= removed outliers

Under ice					Open water high flow					Open water low flow			Under Ice	Open high	Open low
Copper - Upstream (µg/L)															
Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov				
0.183		0.040	0.140	0.200	1.030	0.500	0.260	0.533	0.160	0.190	0.300	P65	0.229	0.540	0.250
		0.060	0.820	0.182	**3.300**	0.250	0.600	0.240	0.210	0.300	1.300	P75	0.250	0.927	0.288
		0.211	0.150		0.824	0.250	0.600	**36.850**	0.220	0.220	0.206	P90	0.432	3.260	0.400
			0.160		0.300	0.380	1.200	3.200	0.280	0.160		P95	0.619	4.447	0.850
						0.360			0.190	0.236		n	14	35	10
						0.340			0.400			Max	0.82	36.85	1.30
						0.260			**5.000**						
						1.740									
						3.100									
0.250	0.250	0.510	0.250		0.500	0.250	0.250	0.250	0.250	0.250					
								4.210	0.250	0.250					

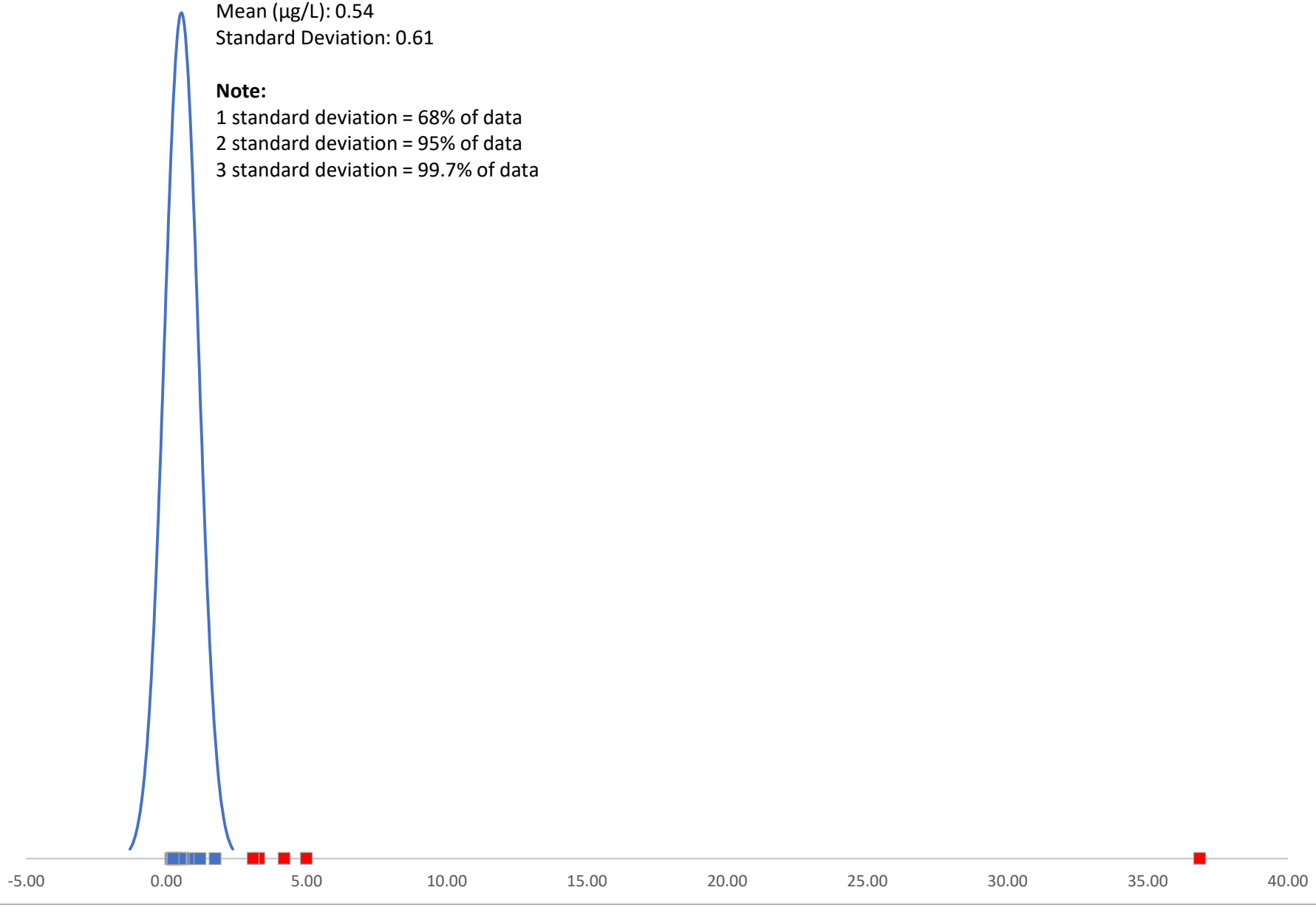
Copper - Upstream
Open water high flow - with the red outliers
Mean (µg/L): 1.96
Standard Deviation: 6.20

Note:
1 standard deviation = 68% of data
2 standard deviation = 95% of data
3 standard deviation = 99.7% of data



Copper - Upstream
Open water high flow - without the red outliers
Mean (µg/L): 0.54
Standard Deviation: 0.61

Note:
1 standard deviation = 68% of data
2 standard deviation = 95% of data
3 standard deviation = 99.7% of data



Unbounded DLs removed, remaining DLs = 1/2 DLs

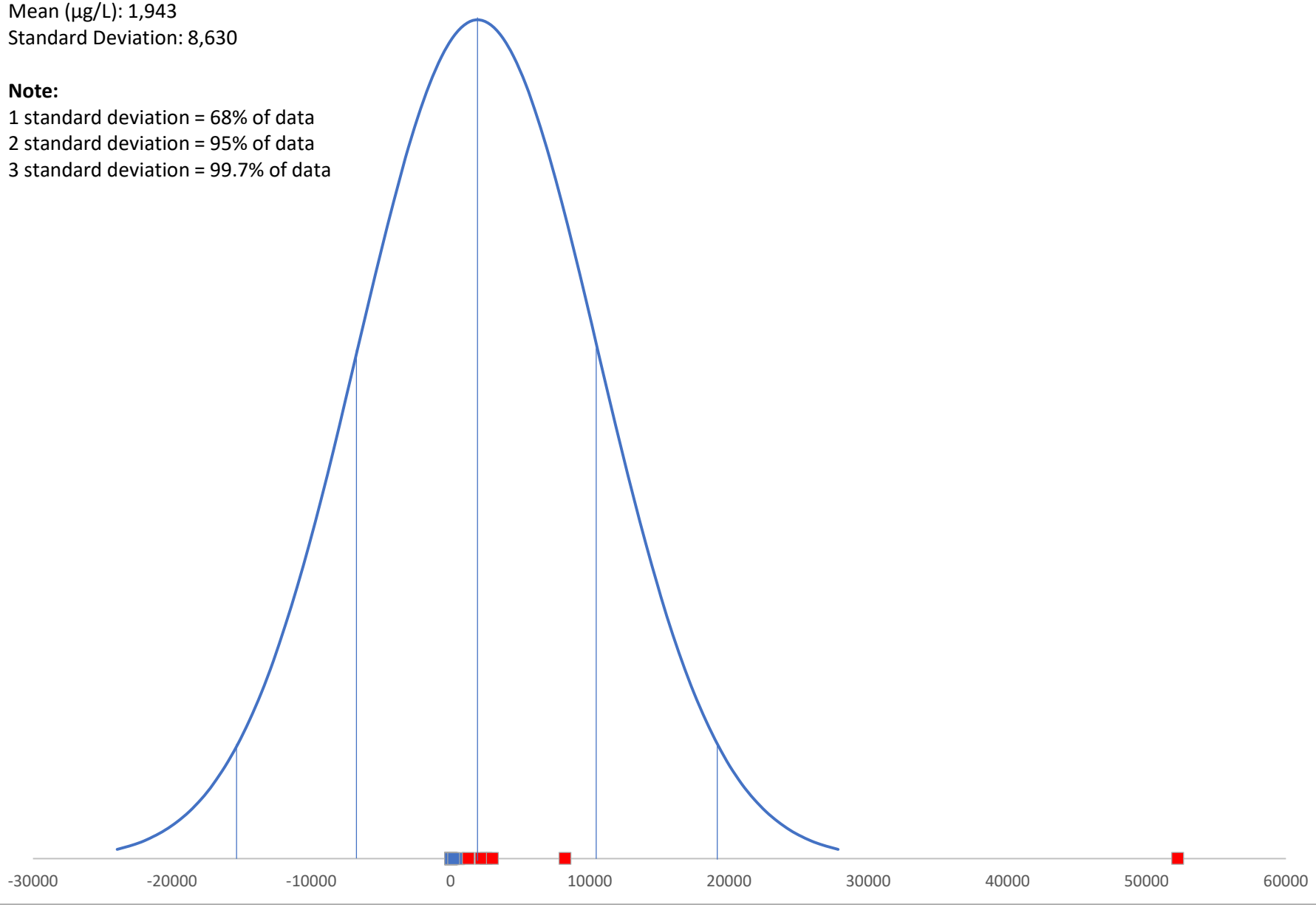
TOTAL METALS

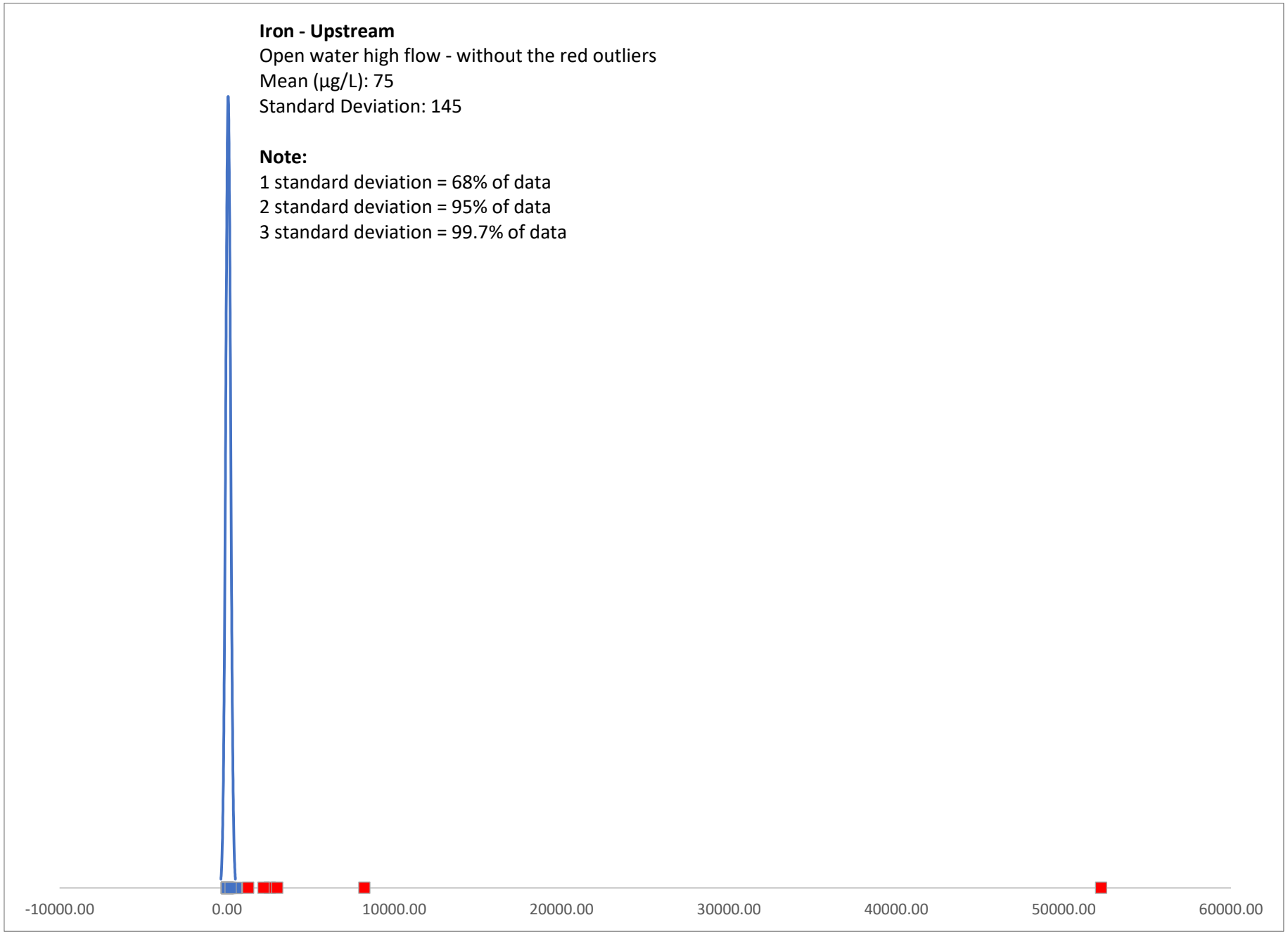
= concs reported as below method DL, reported as 1/2 DL ;empty cells represent unbounded DLs.
= summary statistics calculated but not used.
= removed outliers

Under ice					Open water high flow					Open water low flow			Under Ice	Open high	Open low
Iron - Upstream (µg/L)															
Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov				
0.250		0.250	1	16	99	3	13	87	2	18	322	P65	15	84	15
		4	4	73	609	18	24	3	5	10	26	P75	15	166	17
		0.250	2		**2,570**	9	14	4	3	8		P90	15	2,348	56
			0.500		166	60	555	**52,250**	9	6		P95	36	4,062	189
					54	82		**2,200**	6	6		n	14	37	10
						40			21	0.250		Max	73	52,250	322
						17			19						
						1,290									
						3,020									
15	15	15	15		222	120	15	15	15	15					
								8,230	15	15					

Iron - Upstream
Open water high flow - with the red outliers
Mean (µg/L): 1,943
Standard Deviation: 8,630

Note:
1 standard deviation = 68% of data
2 standard deviation = 95% of data
3 standard deviation = 99.7% of data




Iron - Upstream
Open water high flow - without the red outliers
Mean (µg/L): 75
Standard Deviation: 145
Note:
1 standard deviation = 68% of data
2 standard deviation = 95% of data
3 standard deviation = 99.7% of data
-10000.00
0.00
10000.00
20000.00
30000.00
40000.00
50000.00
60000.00

Unbounded DLs removed, remaining DLs = 1/2 DLs

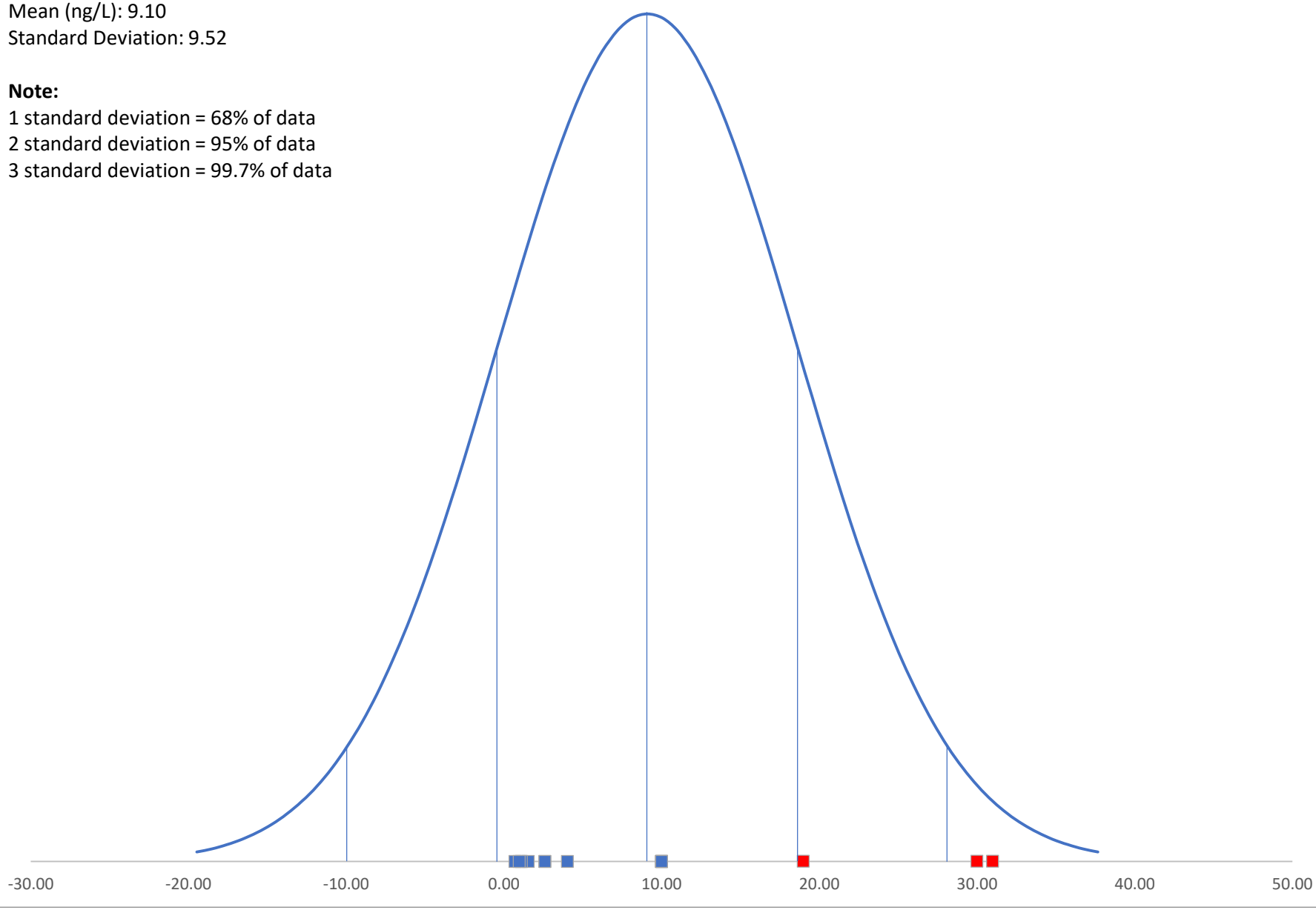
TOTAL METALS

= concs reported as below method DL, reported as 1/2 DL ;empty cells represent unbounded DLs.
= summary statistics calculated but not used.
= removed outliers

Under ice					Open water high flow					Open water low flow			Under Ice	Open high	Open low
Mercury - Upstream (ng/L)															
Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov				
0.600		0.630	0.690		10.0		10.0	10.0	10.0	10.0	10.0	P65	0.6	10.0	9.3
					4.0		10.0	**31.0**	**30.0**	2.5	10.0	P75	0.7	10.0	10.0
					2.6		10.0				1.0	P90	1.4	23.4	10.0
0.540	0.250	0.610	2.5		2.6	1.1	1.6	1.1	0.7	1.0		P95	2.0	30.2	10.0
								19.0	1.0	0.7		n	7	17	7
												Max	2.51	31.0	10.0

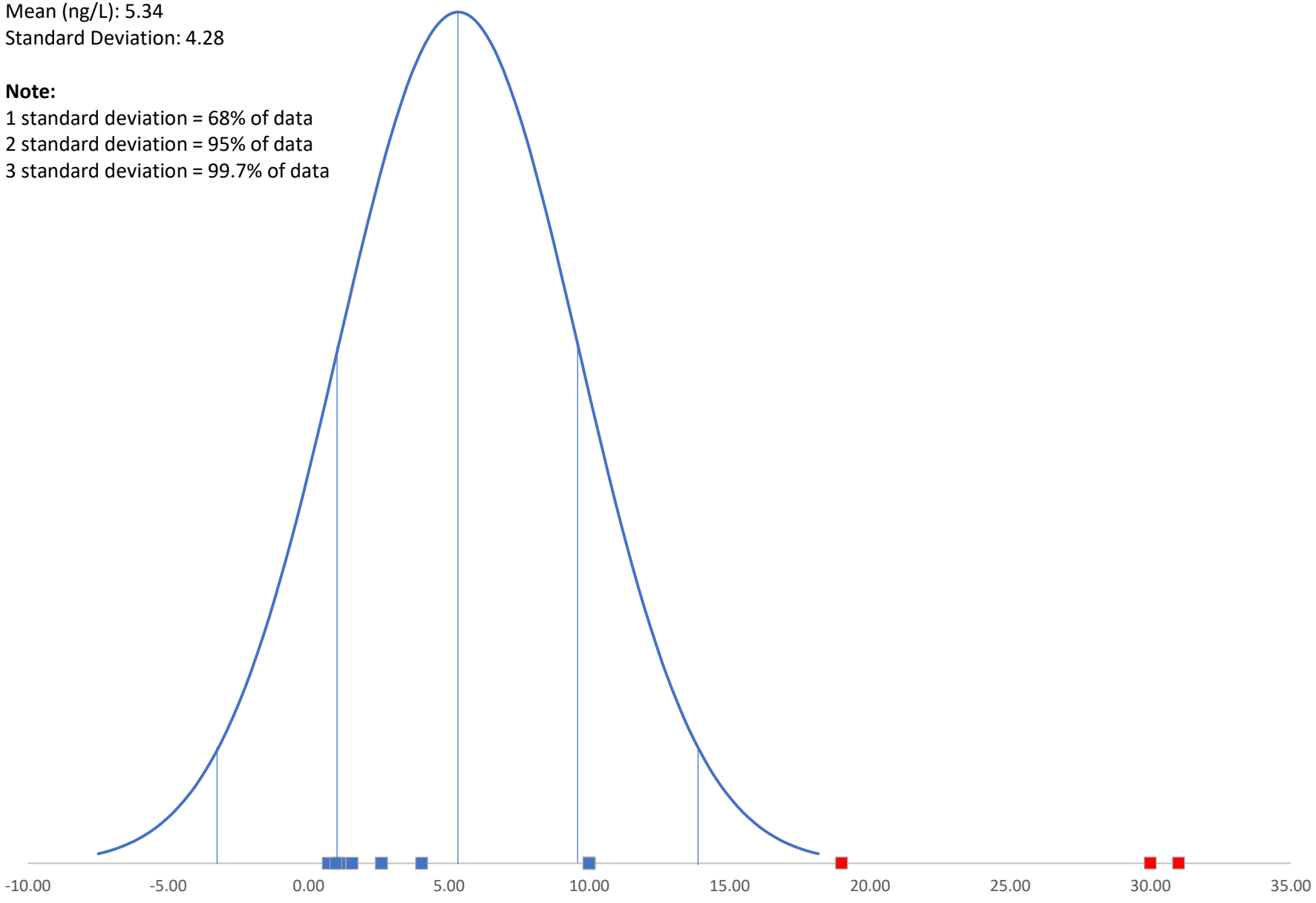
Mercury - Upstream
Open water high flow - with the red outliers
Mean (ng/L): 9.10
Standard Deviation: 9.52

Note:
1 standard deviation = 68% of data
2 standard deviation = 95% of data
3 standard deviation = 99.7% of data



Mercury - Upstream
Open water high flow - without the red outliers
Mean (ng/L): 5.34
Standard Deviation: 4.28

Note:
1 standard deviation = 68% of data
2 standard deviation = 95% of data
3 standard deviation = 99.7% of data



Unbounded DLs removed, remaining DLs = 1/2 DLs

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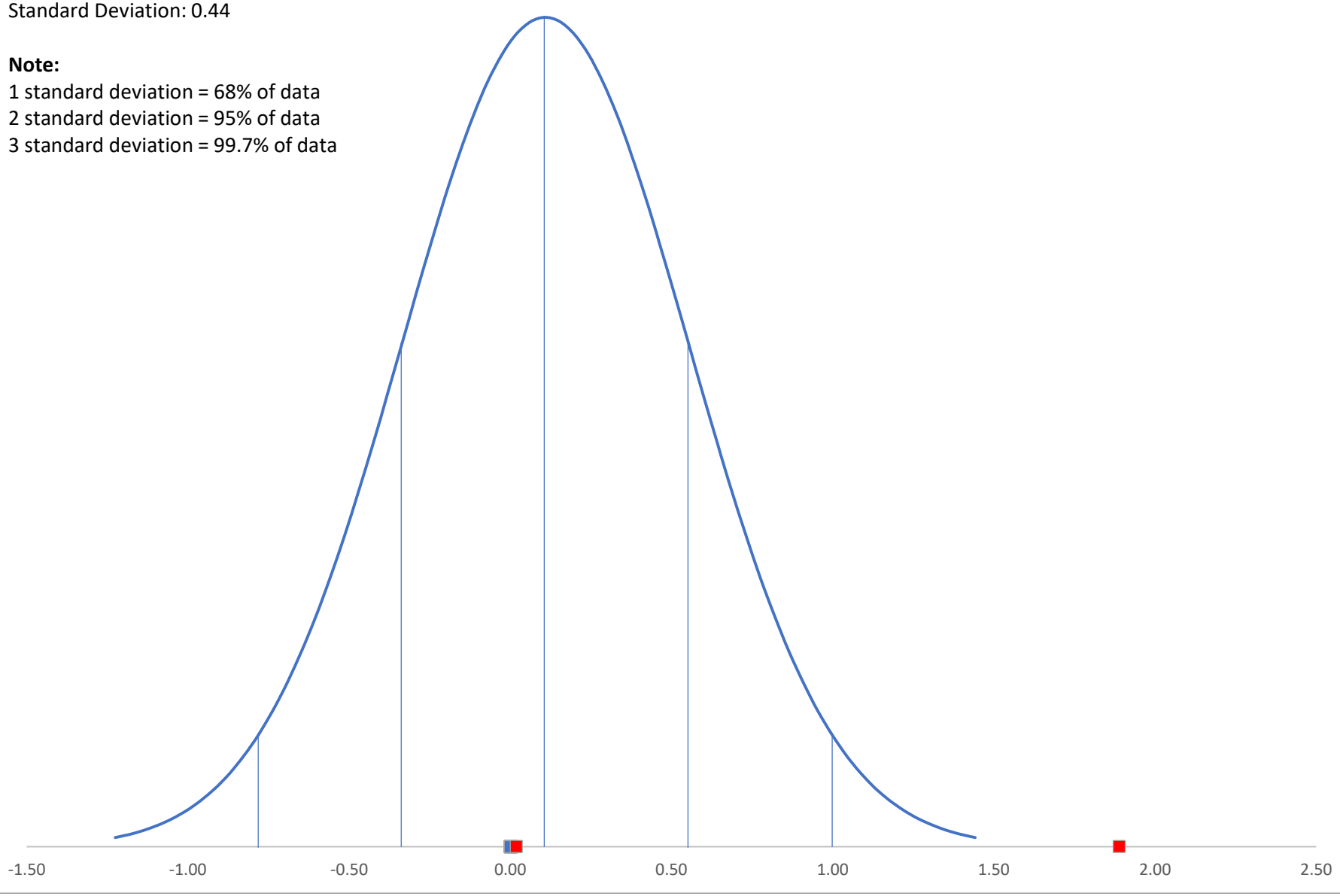
= concs reported as below method DL, reported as 1/2 DL ;empty cells represent unbounded DLs.
= summary statistics calculated but not used.
= removed outliers

Under ice					Open water high flow					Open water low flow	
Nitrite - Upstream (mg/L)											
Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
0.001		0.005	0.005	0.005	0.001	0.005		0.005	0.005	0.003	0.001
		0.001	0.005		0.001	**1.890**		0.005		0.005	
						0.005				0.005	
						0.020				**0.080**	
						0.001				0.001	
						0.0157					
0.0005	0.0005	0.001	0.0005		0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	
								0.0005	0.0016	0.0005	

	Under Ice	Open high	Open low
P65	0.004	0.005	0.004
P75	0.005	0.005	0.005
P90	0.005	0.017	0.028
P95	0.005	0.300	0.054
n	10	18	8
Max	0.005	1.890	0.080

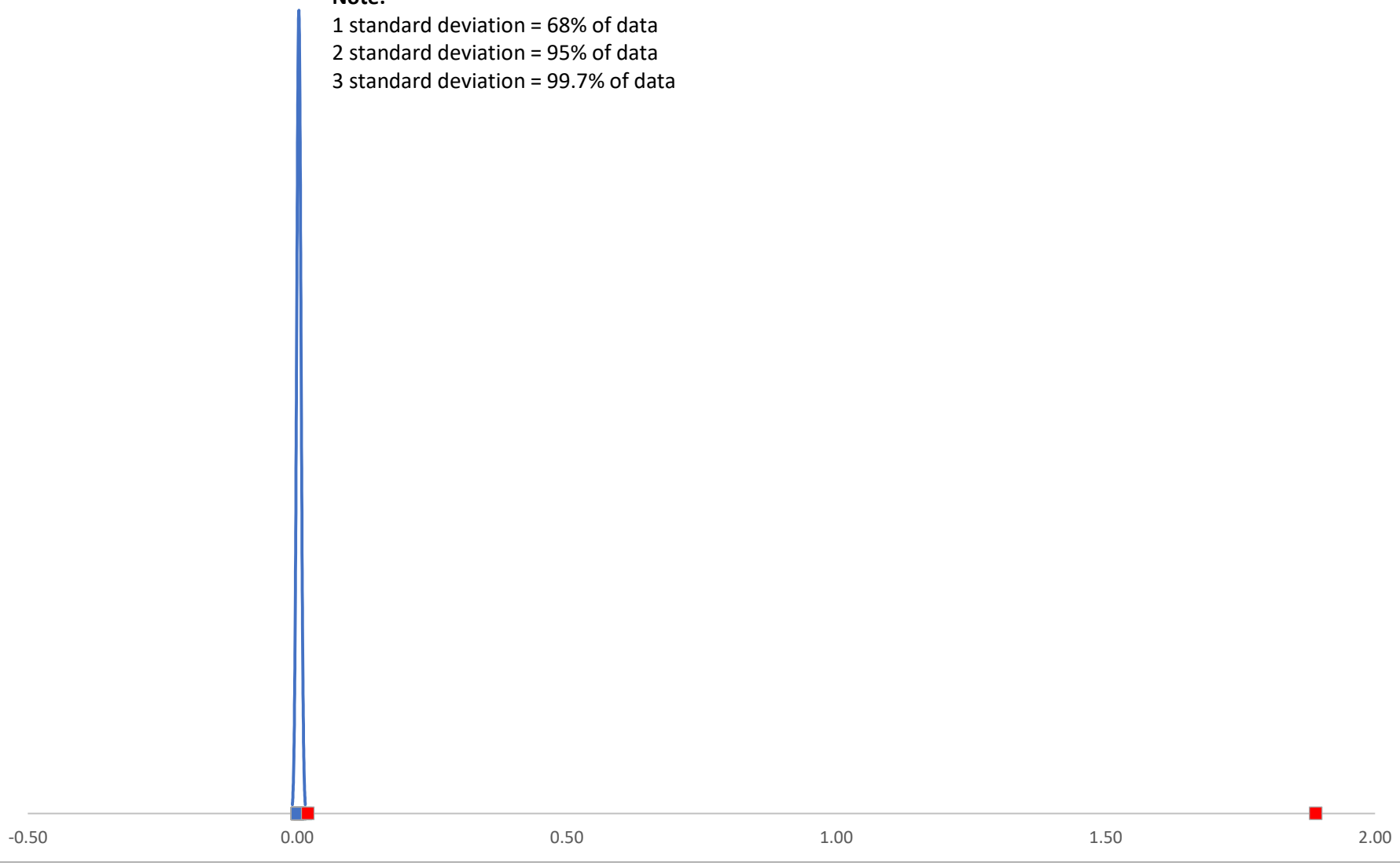
Nitrite - Upstream
Open water high flow - with the red outliers
Mean (mg/L): 0.11
Standard Deviation: 0.44

Note:
1 standard deviation = 68% of data
2 standard deviation = 95% of data
3 standard deviation = 99.7% of data



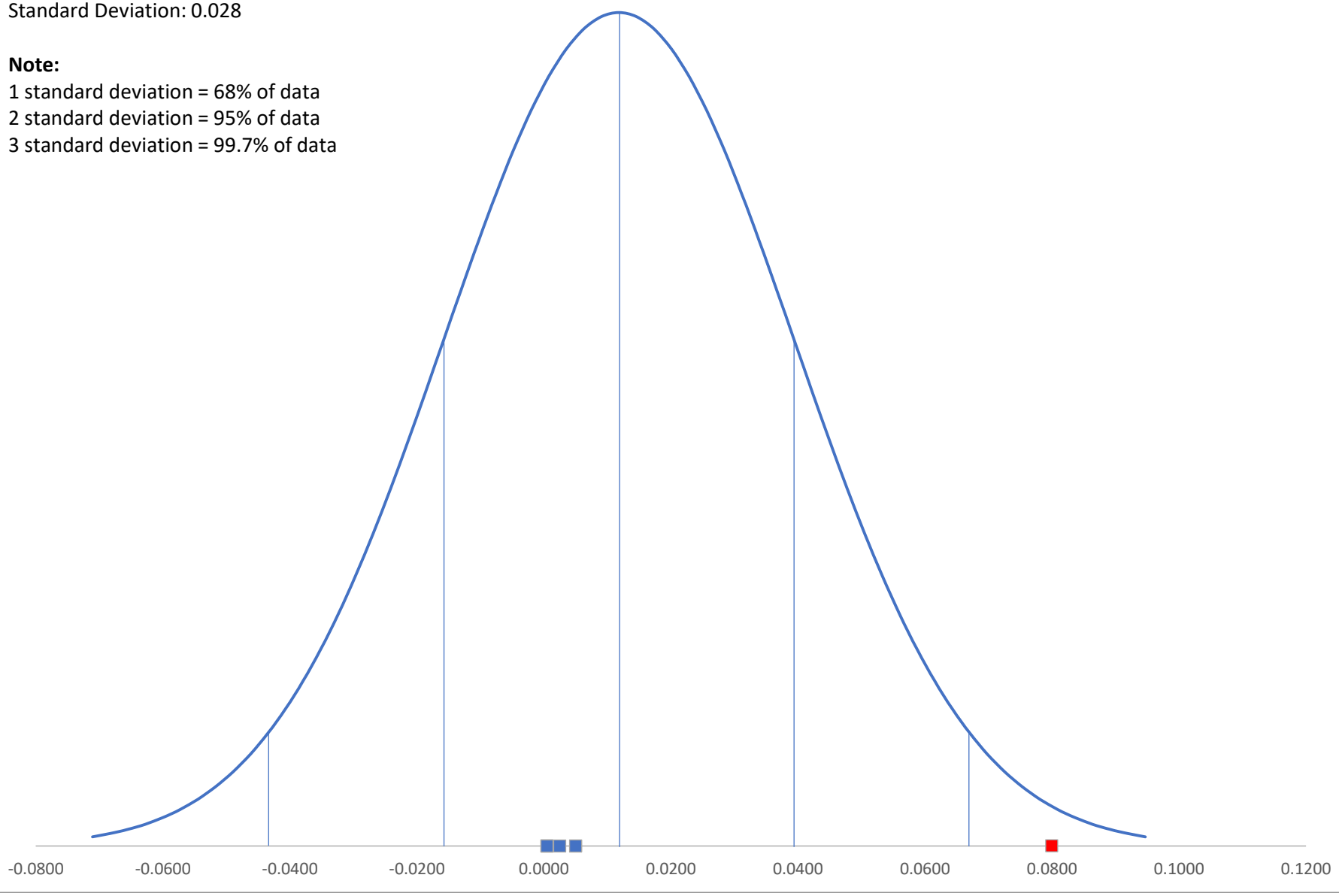
Nitrite - Upstream
Open water high flow - without the red outliers
Mean (mg/L): 0.003
Standard Deviation: 0.004

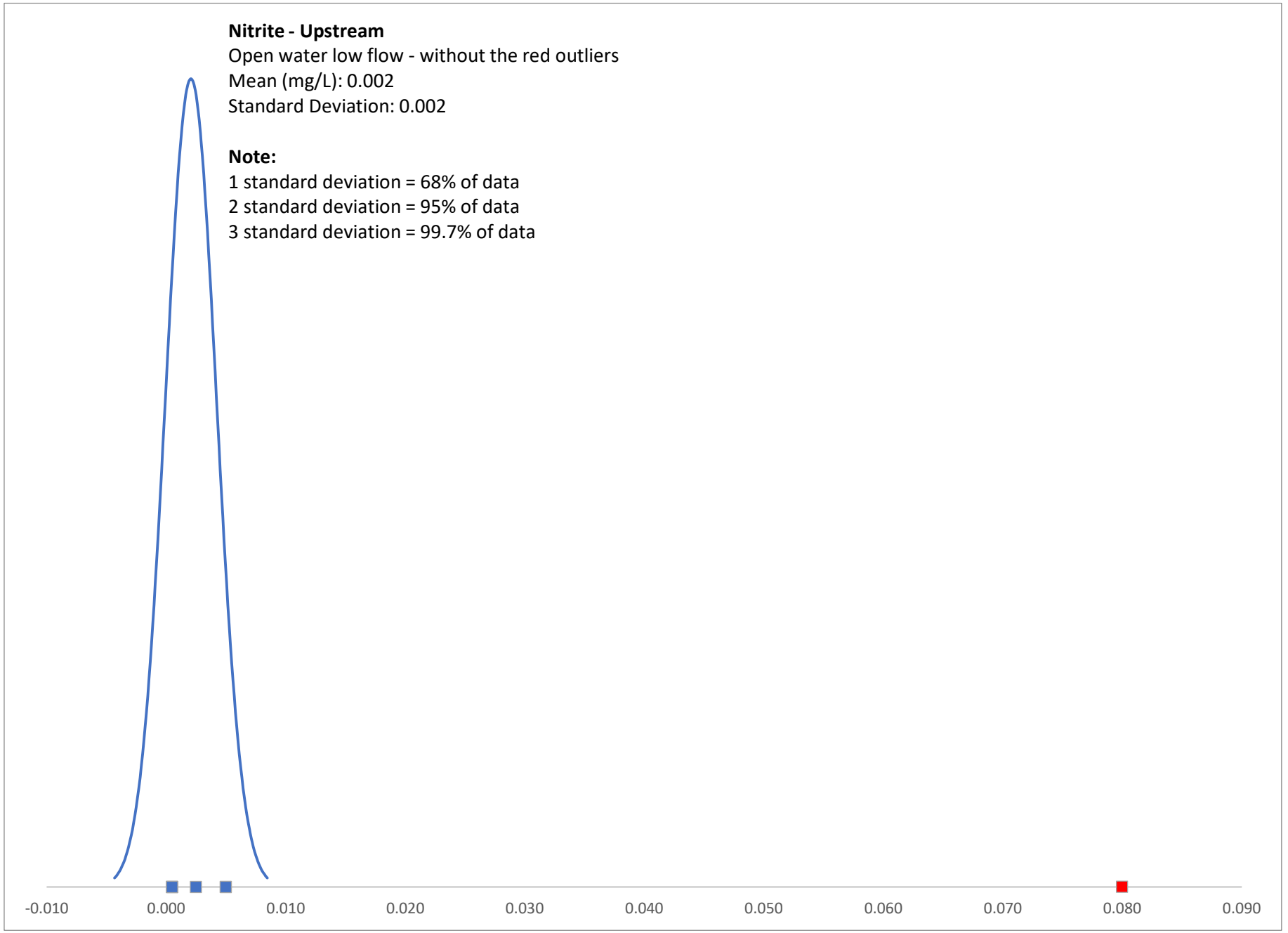
Note:
1 standard deviation = 68% of data
2 standard deviation = 95% of data
3 standard deviation = 99.7% of data



Nitrite - Upstream
Open water low flow - with the red outliers
Mean (mg/L): 0.012
Standard Deviation: 0.028

Note:
1 standard deviation = 68% of data
2 standard deviation = 95% of data
3 standard deviation = 99.7% of data




Nitrite - Upstream
Open water low flow - without the red outliers
Mean (mg/L): 0.002
Standard Deviation: 0.002
Note:
1 standard deviation = 68% of data
2 standard deviation = 95% of data
3 standard deviation = 99.7% of data
-0.010
0.000
0.010
0.020
0.030
0.040
0.050
0.060
0.070
0.080
0.090