The use of calculated upper confidence intervals in Risk Based Corrective Action

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Background

USEPA “Risk Assessment Guidance for Superfund (RAGS), Volume 1 – Human Health Evaluation Manual” (1989):

Defines the Exposure Point Concentration (EPC) as an estimate of the average chemical concentration in an environmental medium, determined for each exposure unit.

Background

USEPA “Supplemental Guidance to RAGS: Calculating the Concentration Term” (1992):

States that “because of the uncertainly associated with estimating the true average concentration at a site, the 95 percent upper confidence limit (UCL) of the arithmetic mean should be used”.

Background

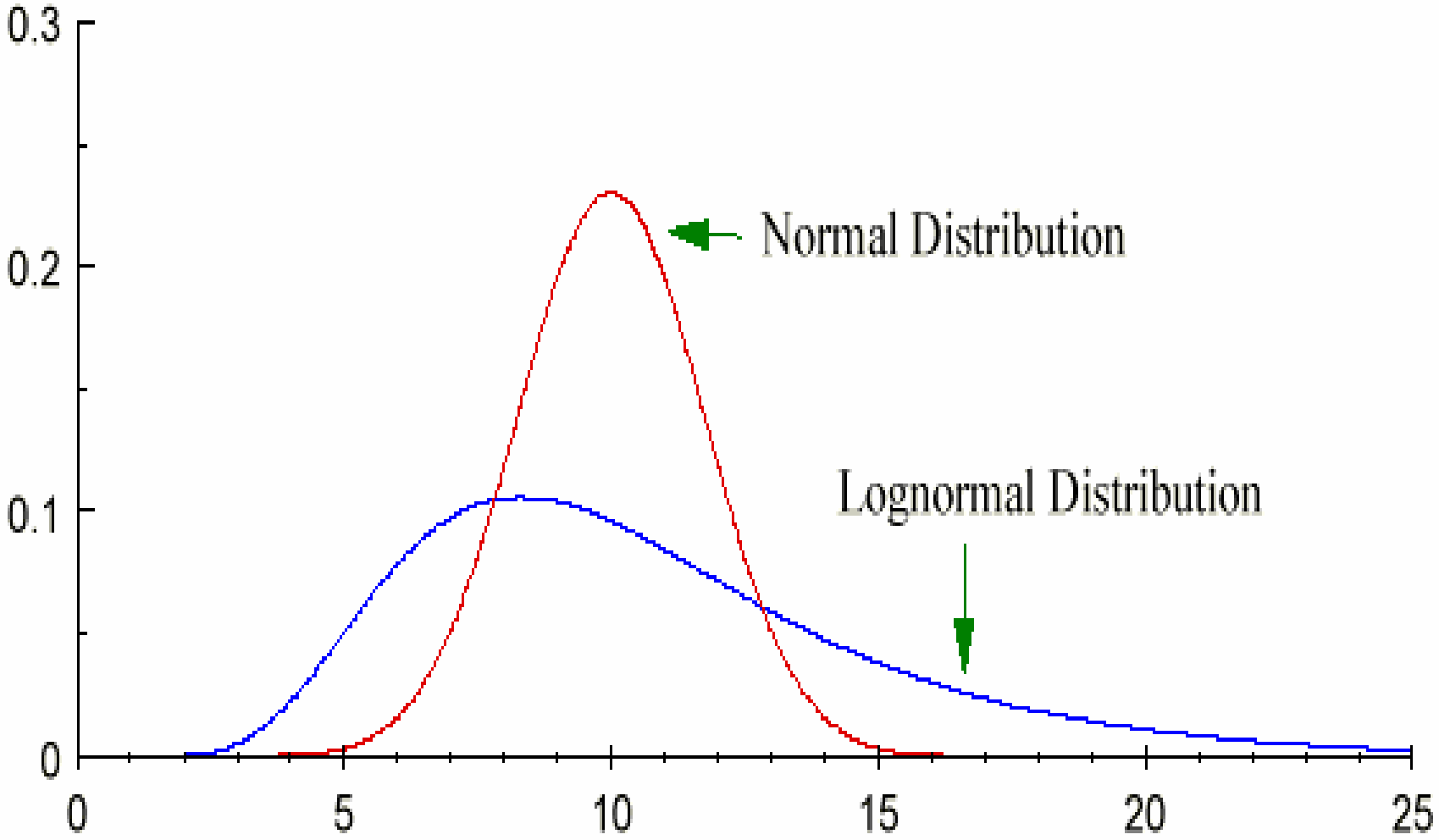
ASTM “Standard Guide for Risk Based Corrective Action Applied at Petroleum Release Sites”:

“Exposure Pathway” = The course a COC takes from the source area to an exposed organism.

“Source Area” = … the location of highest soil and ground water concentrations of the COC.

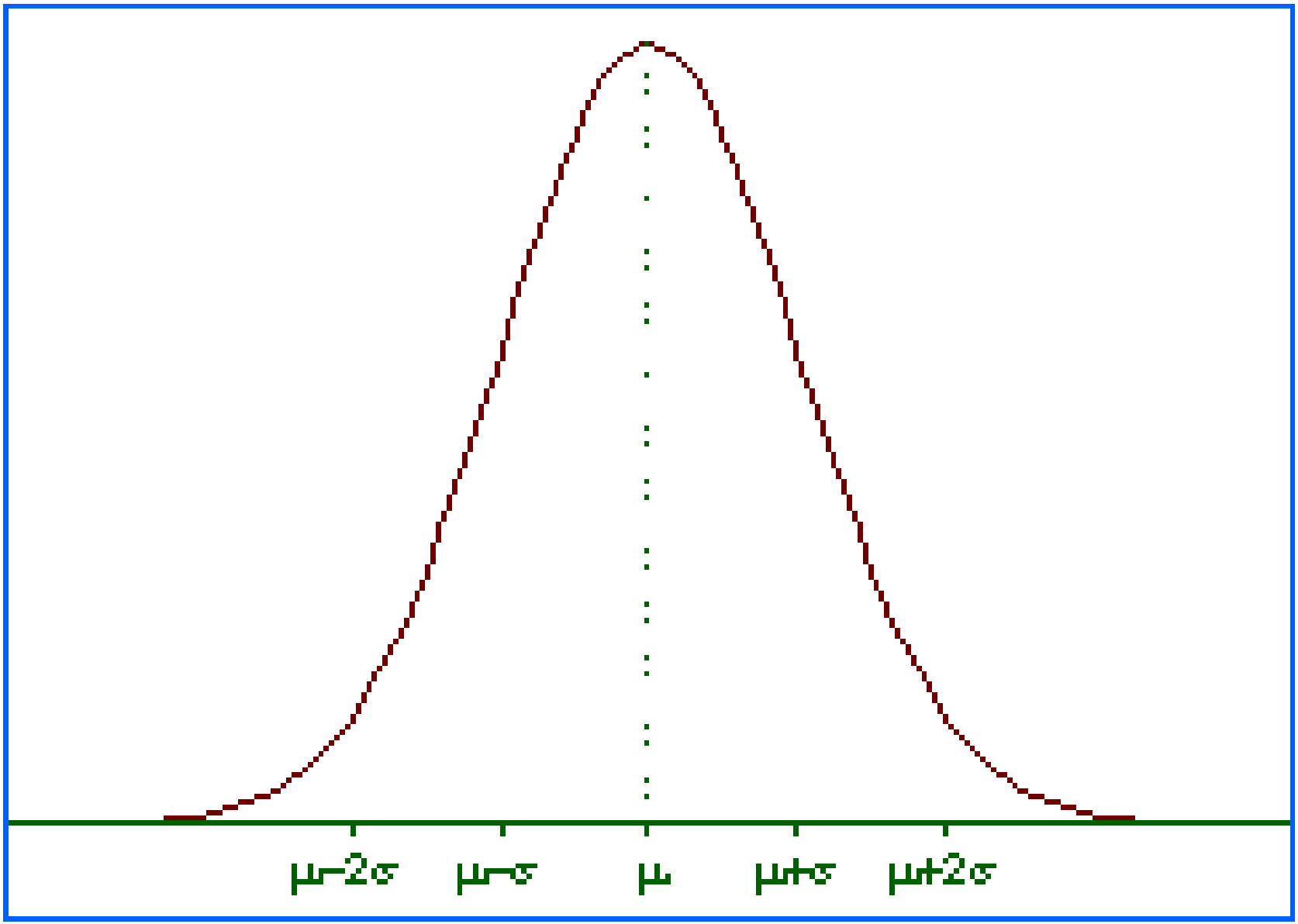
What is an Upper Confidence Limit?

- Environmental samples are subject to variability.
- This variability may show a pattern, called a “distribution”.
- Common distributions for environmental data are the “normal” and the “lognormal” distributions.


0.3
0.2
0.1
0
0
5
10
15
20
25
Normal Distribution
Lognormal Distribution

Calculating the UCL

- The normal and lognormal distributions are defined by two parameters – the center (mean) and the spread of the curve, or how wide or narrow it is (the variance; or standard deviation).
- We can collect data, and use the data to guess what the center and the spread of the distribution are.


μ−2σ
μ−σ
μ
μ+σ
μ+2σ

Calculating the UCL

- An Upper Confidence Limit is generated by taking the sample mean, and adding some number of sample standard deviations to it (depending on your desired confidence level).
- The 95% UCL is a probability statement. It means “I am 95% confident that the true distribution of the sampling data has a population mean less than or equal to my calculated UCL”.
- Mathematical formulas are available to generate these UCL values.

Assumptions made to calculate a UCL

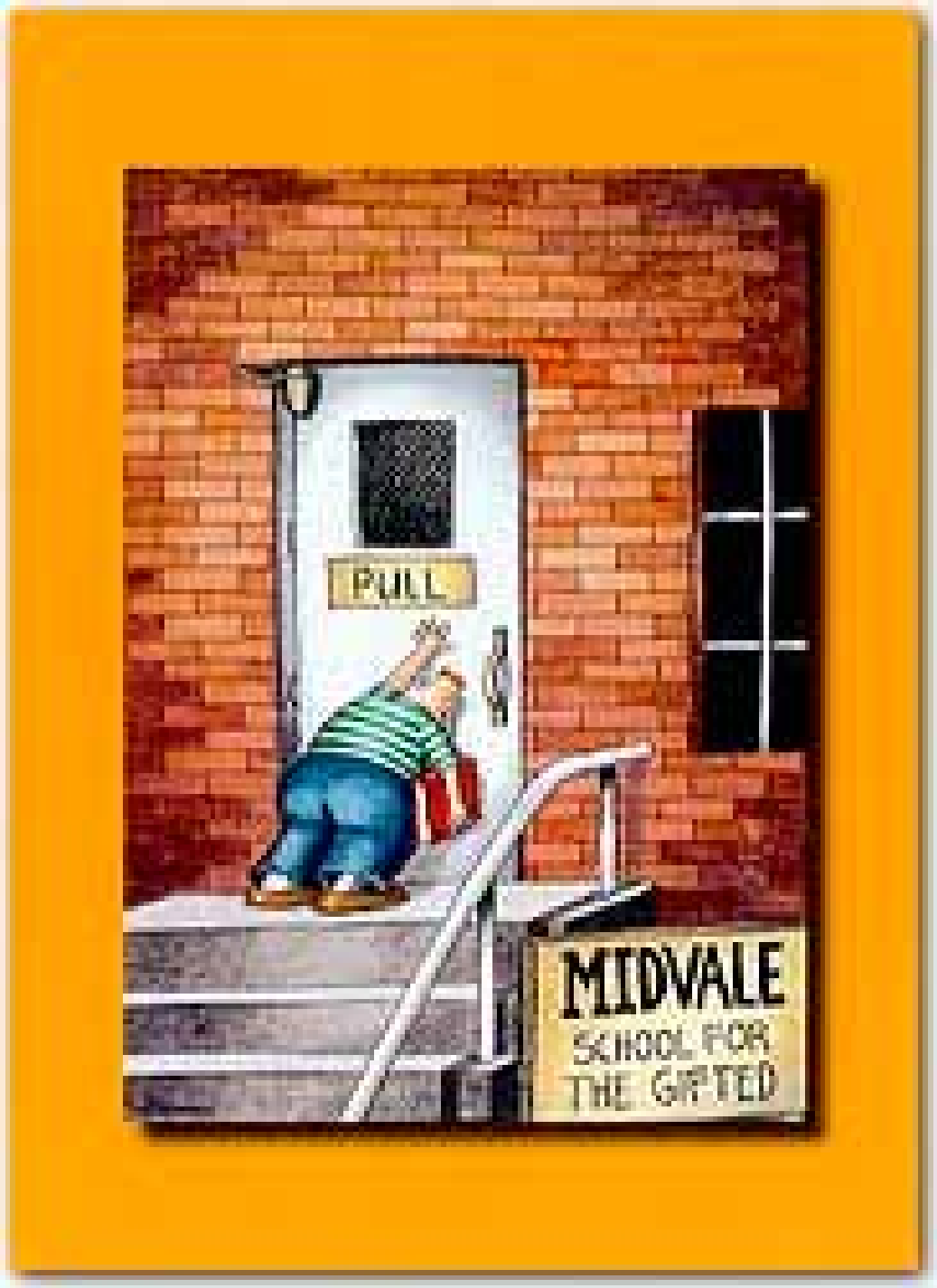
1. Samples are all taken from the same population.
2. The samples are statistically independent (i.e. the value of sample #2 does not depend on the value of sample #1).
3. The distribution of the sample population is known.
4. (Implied for RBCA) – the population of interest is the Source Area.

Common mistakes / errors in applying the UCL

Look for violations of assumptions

1. Sampling from the same population.
2. Independent samples.
3. Known distribution.

The rest is just math…


PULL
MIDVALE
SCHOOL FOR
THE GIFTED

Common Errors - Sampling from the same population

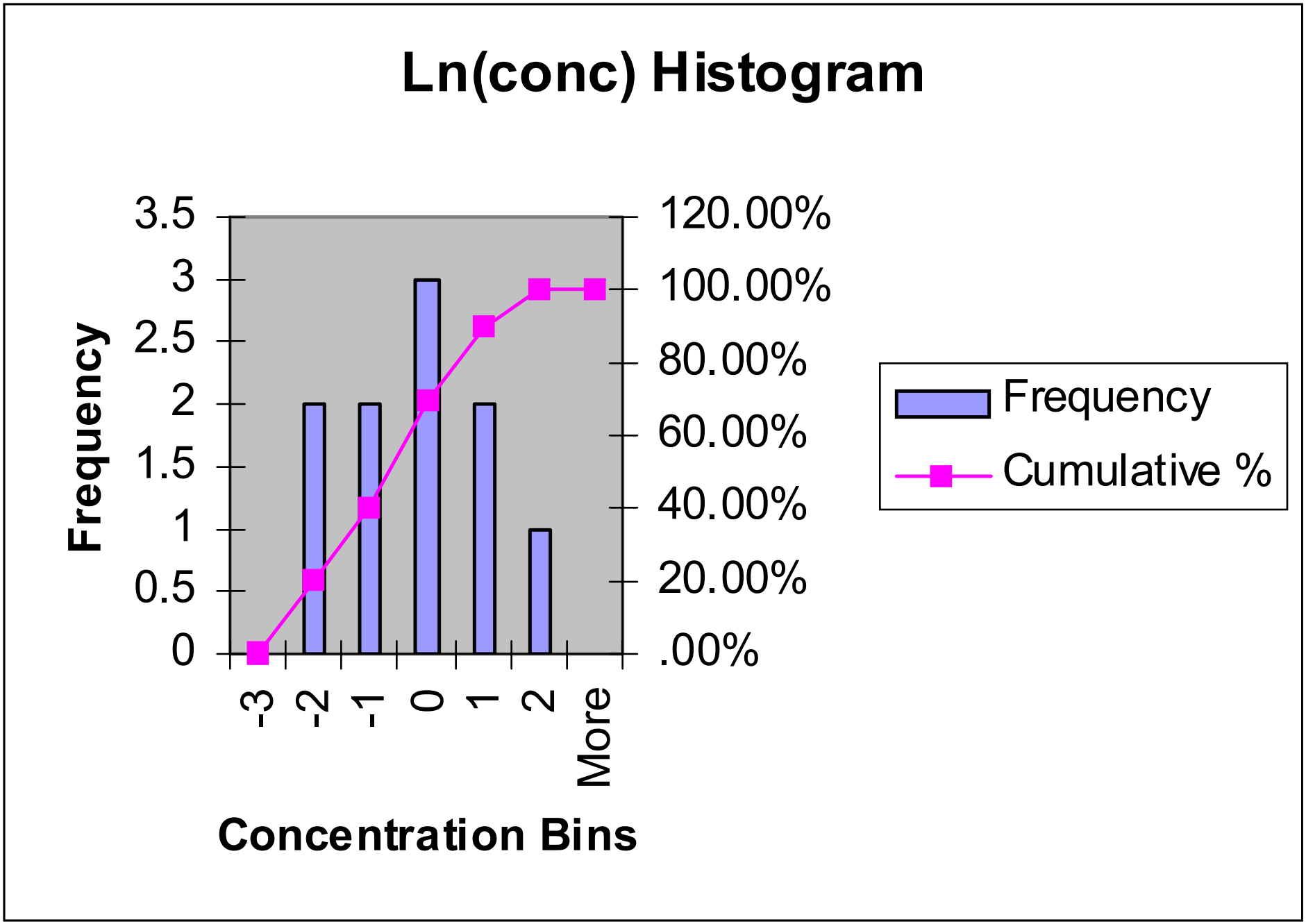
- Samples may be included from outside the source area.
- Samples taken at different time periods and/or samples where different analytical methods were used may be combined.
- General – EPA recommends a minimum of 8 samples for impacted soil volumes less than 125 yd^3 and 12 samples per 3,000 yd^3 for larger impacted volumes

Common Errors – Samples not independent

- Samples may come from a sampling plan designed to identify the boundaries of the source area, not the average concentration.
- General – sampling should be done with a sampling plan designed to ensure independent samples from the source area (Data Quality Objectives)

Common Errors – Distribution is Known

- You need to establish what kind of distribution you have to know what formula to plug the numbers into.
- General – EPA recommends no more than 15% non-detect samples.
- Nonparametric methods exist where estimates can be made without the distribution being known.


Ln(conc) Histogram
Frequency
3.5
3
2.5
2
1.5
1
0.5
0
120.00%
100.00%
80.00%
60.00%
40.00%
20.00%
.00%
-3
-2
-1
0
1
2
More
Concentration Bins
Frequency
Cumulative %

Conclusions

- 95% UCL may be used to estimate source area concentrations at LUST sites.
- This is best done in a Tier 3 level assessment, where a sampling plan is devised and approved prior to data collection.
- For the average LUST site, the UCL may not be time or cost effective.

References

- USEPA, 1989. *Risk Assessment Guidance for Superfund (RAGS), Volume 1 – Human Health Evaluation Manual.* (EPA/540/I-89/002).
- USEPA, 1992. *Statistical Methods for Evaluating the Attainment of Cleanup Standards.* (EPA/230/R-94/004).
- USEPA, 1998. *Guidance for Data Quality Assessment, Practical Methods for Data Analysis.* (EPA/600/R-96/084).
- ASTM, 1995. *Standard Guide for Risk Based Corrective Action Applied at Petroleum Release Sites.* (ASTM: E 1739-95).