Risk Analysis for Proposed Copper, Lead, and Zinc Benchmarks/Action Levels

Presentation to the ISWGP Work Group

January 15, 2009

HERRERA
ENVIRONMENTAL
CONSULTANTS

Analysis Goal

- Determine risk of exceeding acute water quality standards given proposed benchmarks/action levels for copper, lead, and zinc and different levels of dilution within the receiving water

Presentation Overview

- Primer on risk based analysis using Monte Carlo simulation
- Description of analysis methods
- Presentation of analysis results

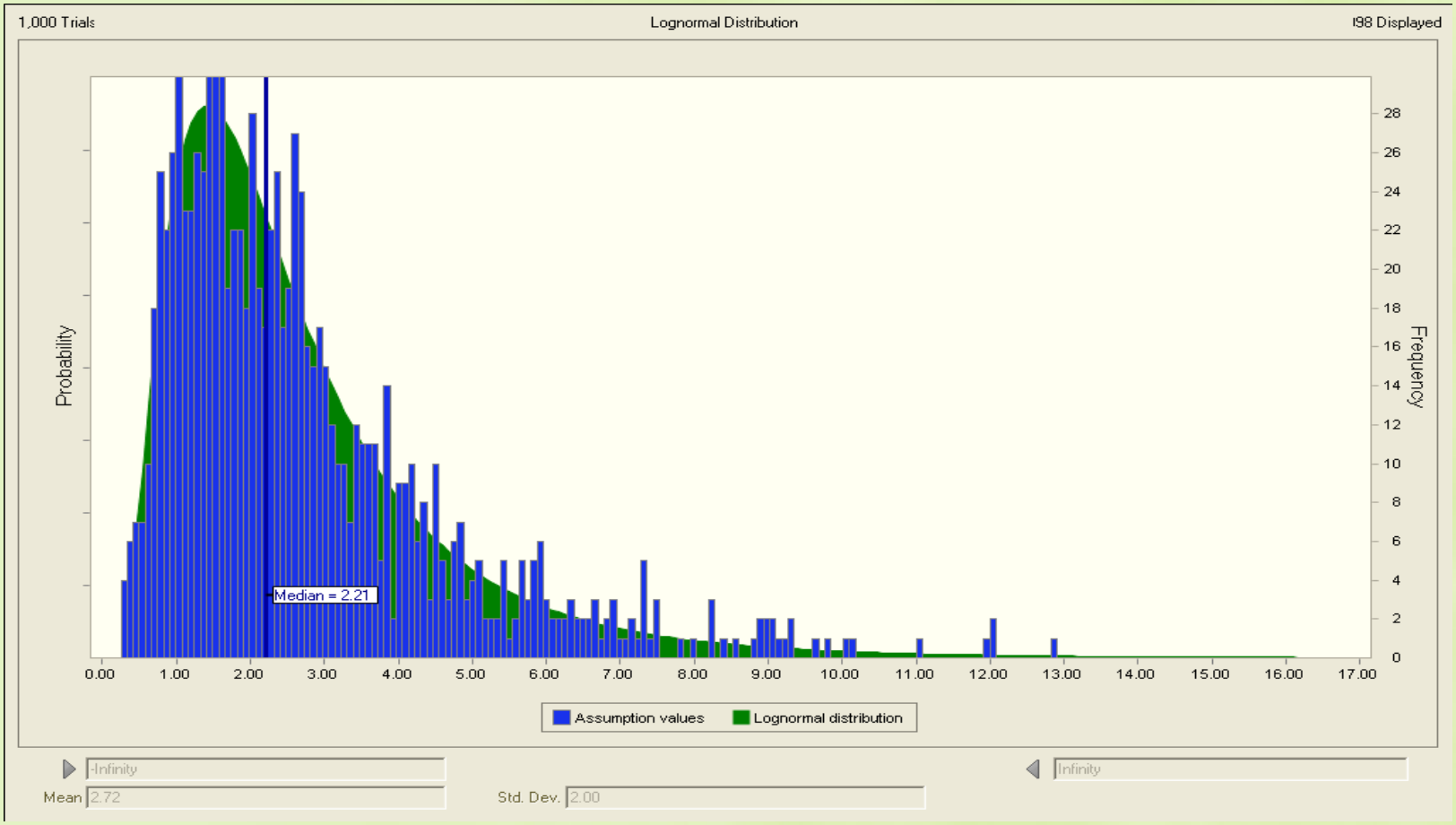
Risk Based Analysis Primer

- “Risk” is generally understood to describe the probability of some undesirable event
- Risk based analysis is based on:
  - Determine likelihood that the undesirable event will occur
  - Compare likelihood of the undesirable effect to a defined risk acceptance criteria

Risk Based Analysis Primer

- Probability distribution
  - Used to quantify risk
  - Describes the uncertainty of the data based on natural spatial and temporal variability and measurement variability

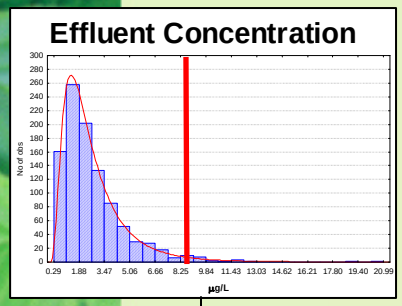
Risk Based Analysis Primer

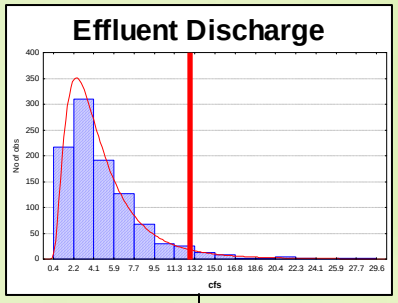


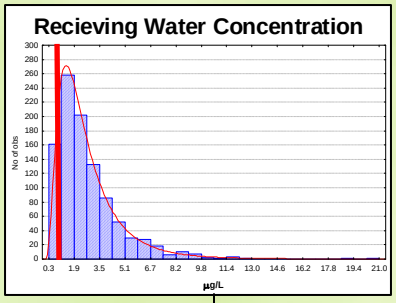
Risk Based Analysis Primer

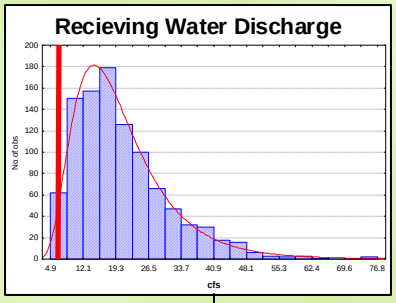
- Monte Carlo Simulation
  - Calculates multiple model output scenarios by repeatedly sampling values for each input variable based on computer generated probability distributions
  - Probability distribution can be derived for the model's output that indicates which predicted values have a higher probability of occurrence
  - The probability of exceeding an effect threshold specific threshold for detrimental effects also can be determined using this procedure

Risk Based Analysis Primer

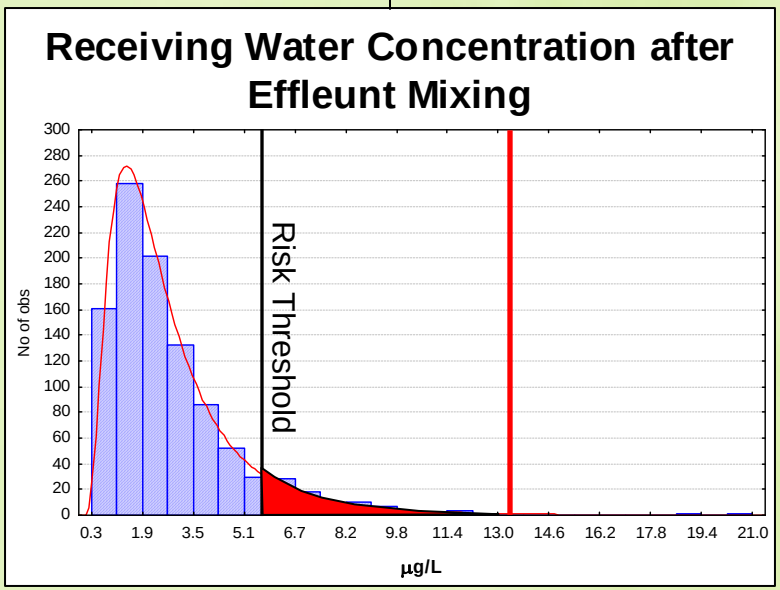








Dilution Model



Is probability of exceeding effect threshold higher than defined risk criteria?

ISWGP Risk Analysis

- Monte Carlo simulations performed using a simple dilution model:

$$C_r = (1/F_d \times C_f) + ([1 - 1/F_d] \times C_b)$$

Where:

C_r = receiving water concentration at facility point of discharge

F_d = dilution factor

C_f = effluent concentration

C_b = receiving water background concentration

ISWGP Risk Analysis

- Separate analyses performed for:
  - Representative receiving water conditions in western and eastern Washington
  - Dilution factors of 1 and 5
- “Translator values” used to estimate dissolved metal concentrations in receiving water for benchmarks/action levels based on total metals
- Receiving water concentrations after effluent mixing compared to acute water quality standards
  - “Risk” assessed based on the proportion of these comparisons that indicated the water quality standard will be exceeded

ISWGP Risk Analysis

- Input variables:
  - Receiving water background concentrations
  - Translator values
  - Hardness dependant water quality standards

Receiving Water Background Concentrations

- Representative background concentration for dissolved copper, lead, and zinc obtained from queries of the Environmental Information Management (EIM) database
  - Separate database queries performed for eastern and western Washington
  - Database queries screened to only include data from ambient monitoring studies in rivers and streams
- Regression on order statistics used to compute summary statistics that account for non-detect values in the data
- Crystal Ball software package used to fit theoretical distribution to the data

Receiving Water Background Concentrations

	West WA Dissolved Copper (μg/L)	East WA Dissolved Copper (μg/L)
n	833	353
Percent detected	71.7%	99.2%
Mean	1.01	0.94
Standard Deviation	1.43	5.27
Coefficient of Variation	1.42	5.59
Lower 95% C.I.	0.91	0.39
Upper 95% C.I.	1.10	1.49
25th percentile	0.35	0.44
Median (50th percentile)	0.65	0.65
75th percentile	1.19	0.96
Inter Quartile Range	0.84	0.53

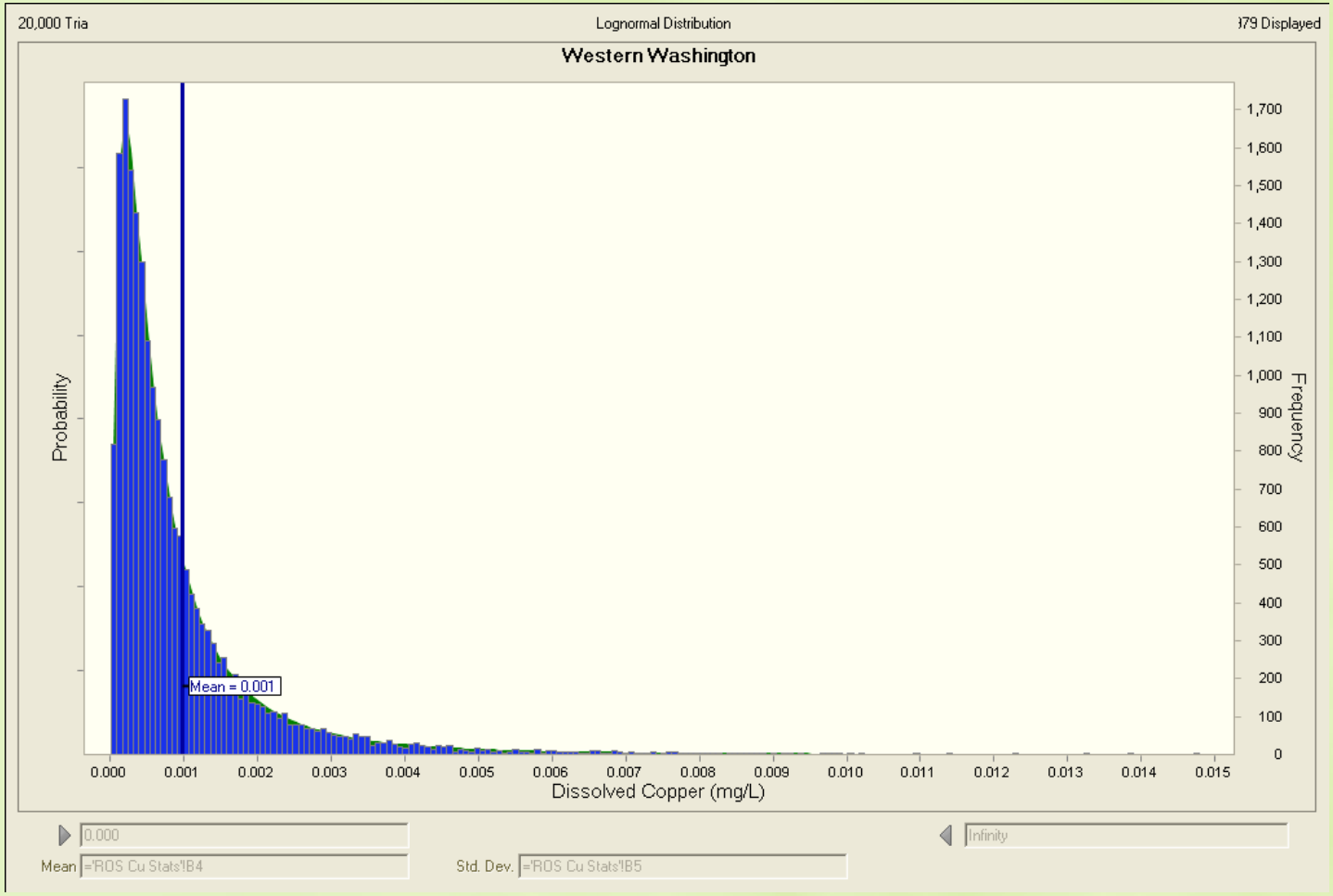
Receiving Water Background Concentrations

	West WA Dissolved Lead (μg/L)	East WA Dissolved Lead (μg/L)
n	681	346
Percent detected	36.6%	61.8%
Mean	0.06	0.19
Standard Deviation	0.18	0.88
Coefficient of Variation	2.72	4.58
Lower 95% C.I.	0.05	0.10
Upper 95% C.I.	0.08	0.29
25th percentile	0.01	0.01
Median (50th percentile)	0.02	0.03
75th percentile	0.06	0.11
Inter Quartile Range	0.05	0.10

Receiving Water Background Concentrations

	West WA Dissolved Zinc (μg/L)	East WA Dissolved Zinc (μg/L)
n	828	353
Percent detected	62.2%	86.4%
Mean	3.36	13.9
Standard Deviation	6.70	25.4
Coefficient of Variation	2.00	1.83
Lower 95% C.I.	2.90	11.25
Upper 95% C.I.	3.81	16.55
25th percentile	0.50	0.95
Median (50th percentile)	1.28	3.02
75th percentile	3.27	9.63
Inter Quartile Range	2.77	8.69

Receiving Water Background Concentrations



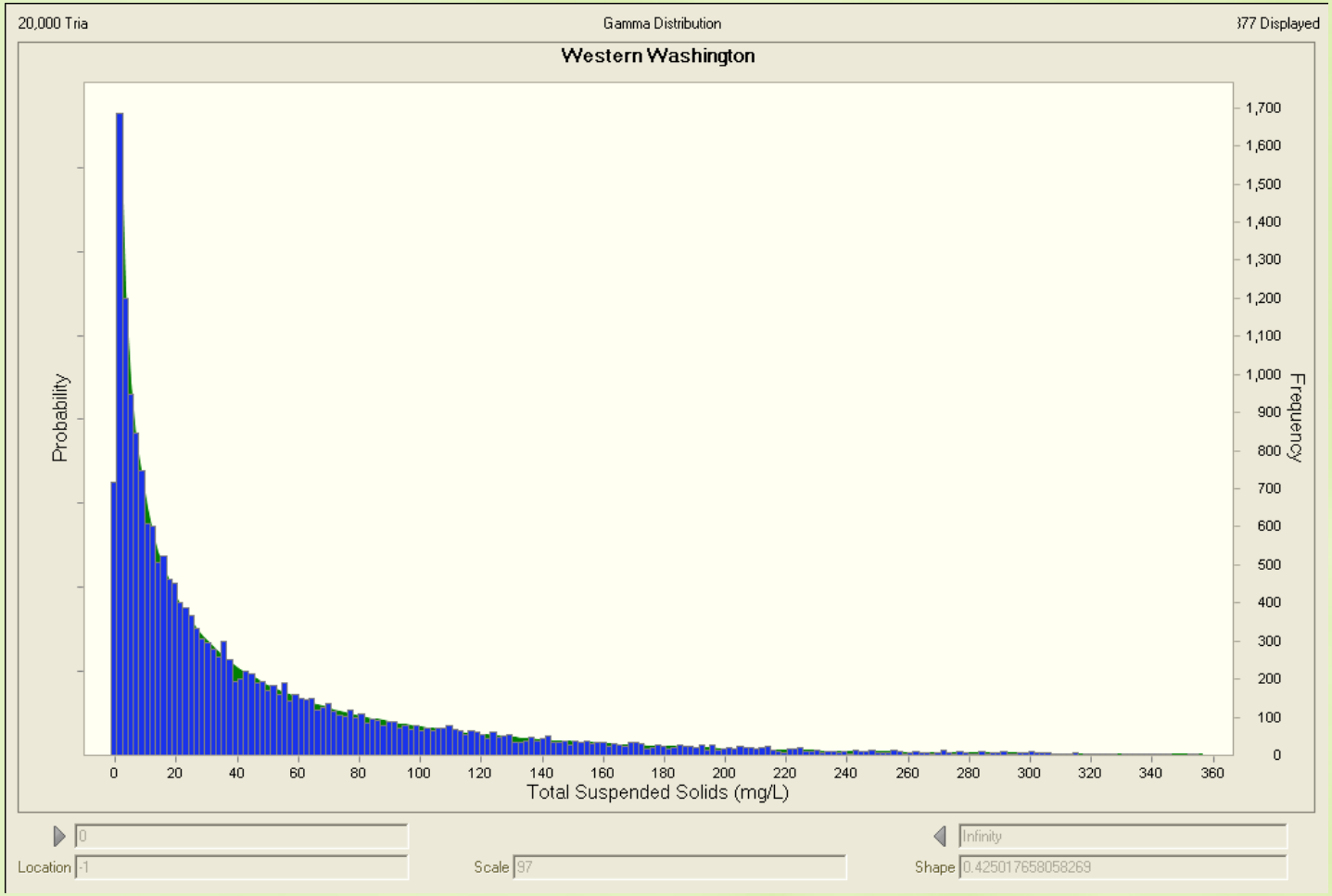
Translator Values

- Translator values developed by Ecology (Pelletier 1996) used estimate the dissolved metal concentration in the receiving water for benchmarks/action levels that are based on total metals
- Ecology translator values vary depending total suspended solids concentrations in the receiving water
  - EIM queried to obtain representative total suspended solids concentrations for eastern and western Washington

Representative TSS Concentrations for Calculating Translator Values

	West WA TSS (mg/L)	**East WA TSS (mg/L)**
n	29,631	31,811
Mean	34.4	49.1
Standard Deviation	295.1	383.2
Coefficient of Variation	8.6	7.8
Lower 95% C.I.	31.0	44.9
Upper 95% C.I.	37.7	53.3
25th percentile	2.0	3.0
Median (50th percentile)	5.0	7.0
75th percentile	13.0	21.0
Inter Quartile Range	11.0	18.0

Representative TSS Concentrations for Calculating Translator Values



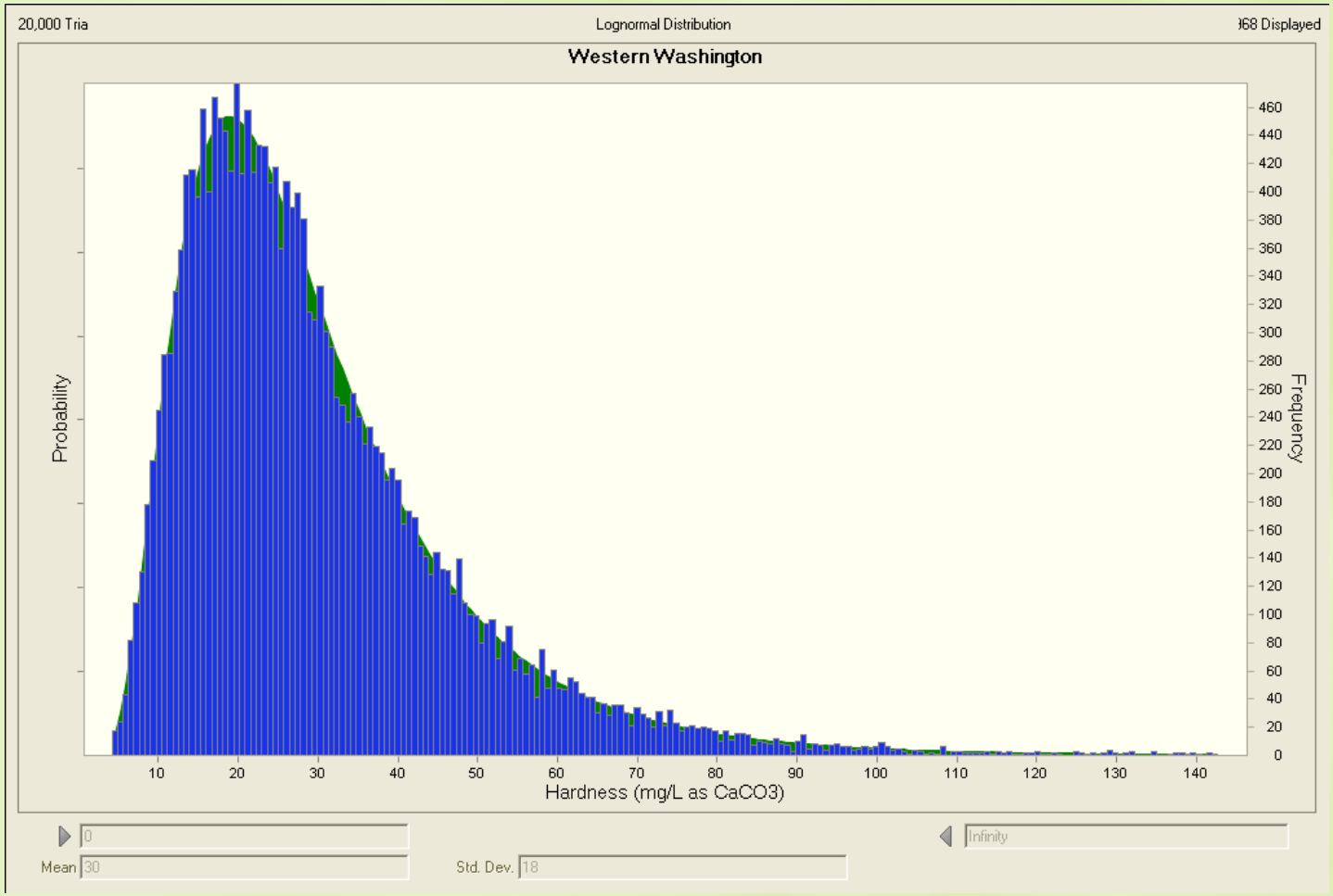
Hardness Dependant Water Quality Standards

- Receiving water concentrations after effluent mixing compared to applicable acute water quality standards to determine if proposed benchmark/action levels are protective
- Water quality standards vary with receiving water hardness
  - EIM queried to obtain representative hardness concentrations for eastern and western Washington

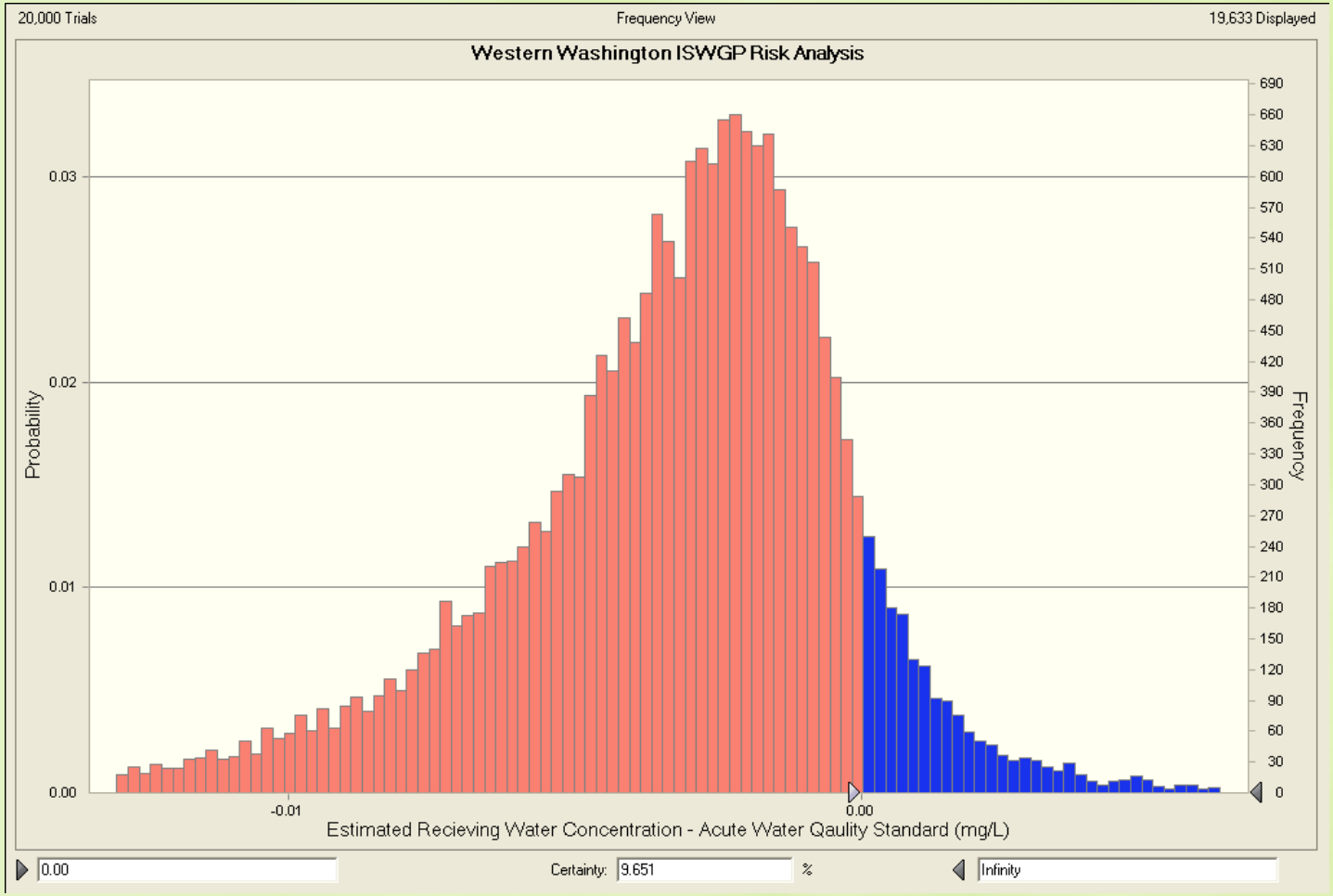
Representative Hardness Concentrations for Calculating Water Quality Standards

	West WA Hardness (mg/L)	**East WA Hardness (mg/L)**
n	8,983	7,670
Mean	32.8	82.8
Standard Deviation	30.8	199.0
Coefficient of Variation	0.9	2.4
Lower 95% C.I.	32.2	78.4
Upper 95% C.I.	33.4	87.3
25th percentile	18.0	35.0
Median (50th percentile)	25.6	68.0
75th percentile	38.0	100.0
Inter Quartile Range	20.0	65.0

Representative Hardness Concentrations for Calculating Water Quality Standards



ISWGP Risk Analysis Results



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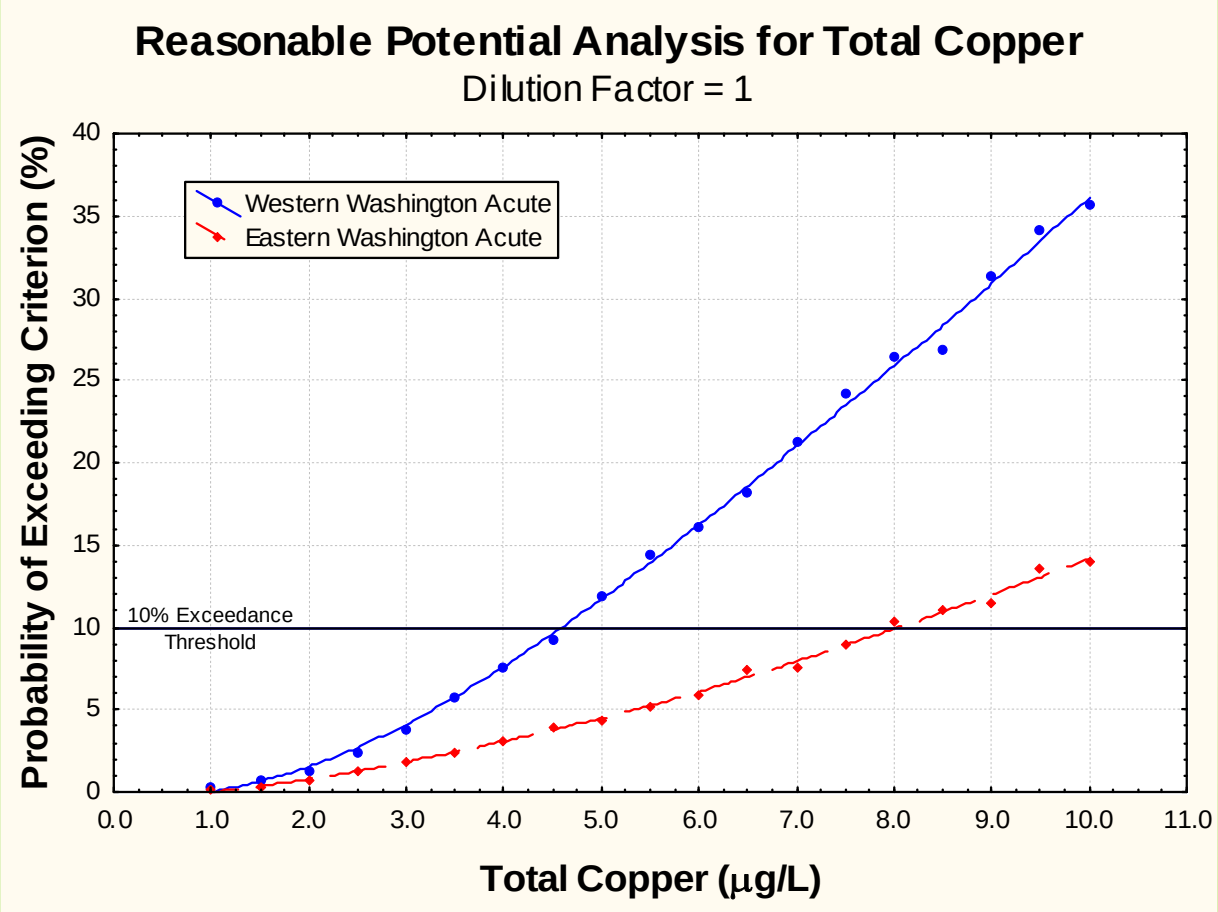

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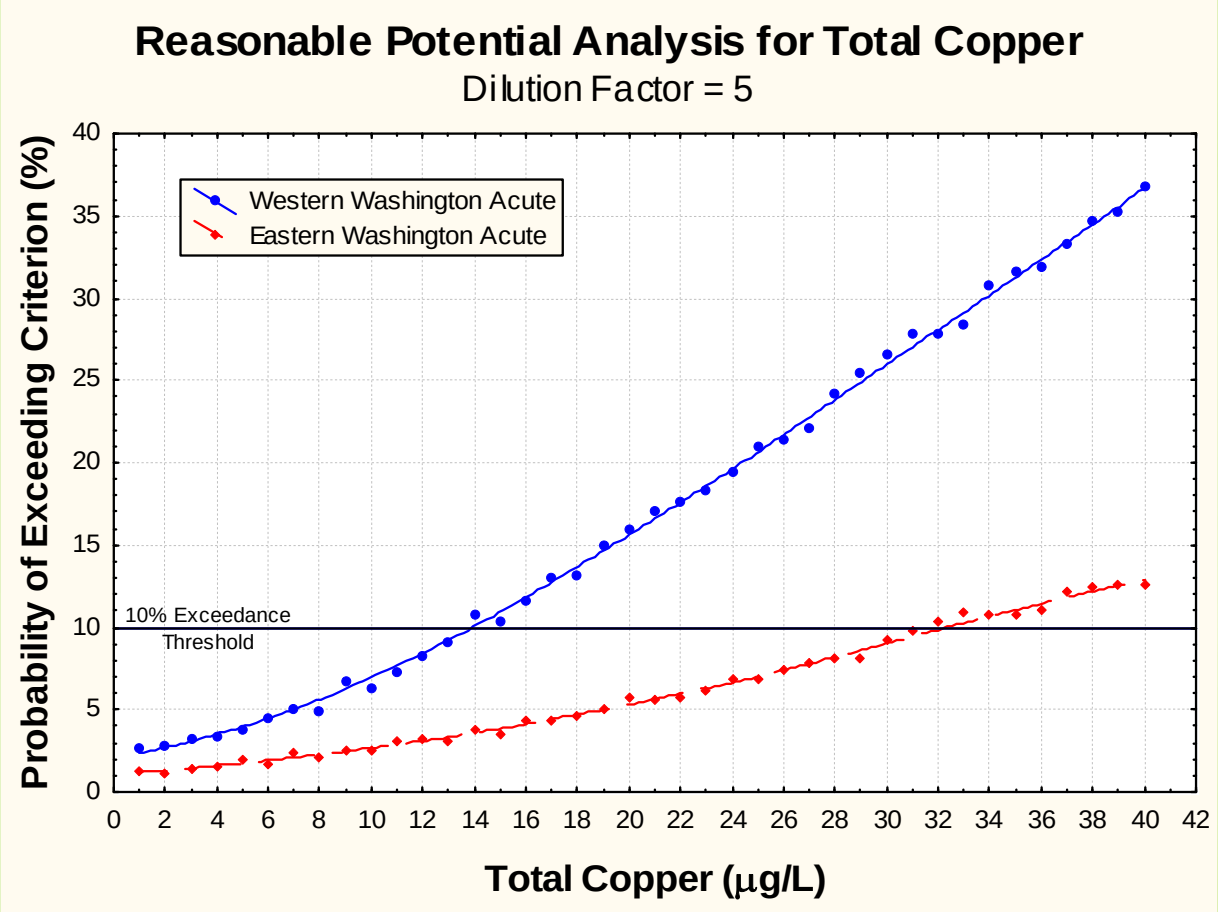
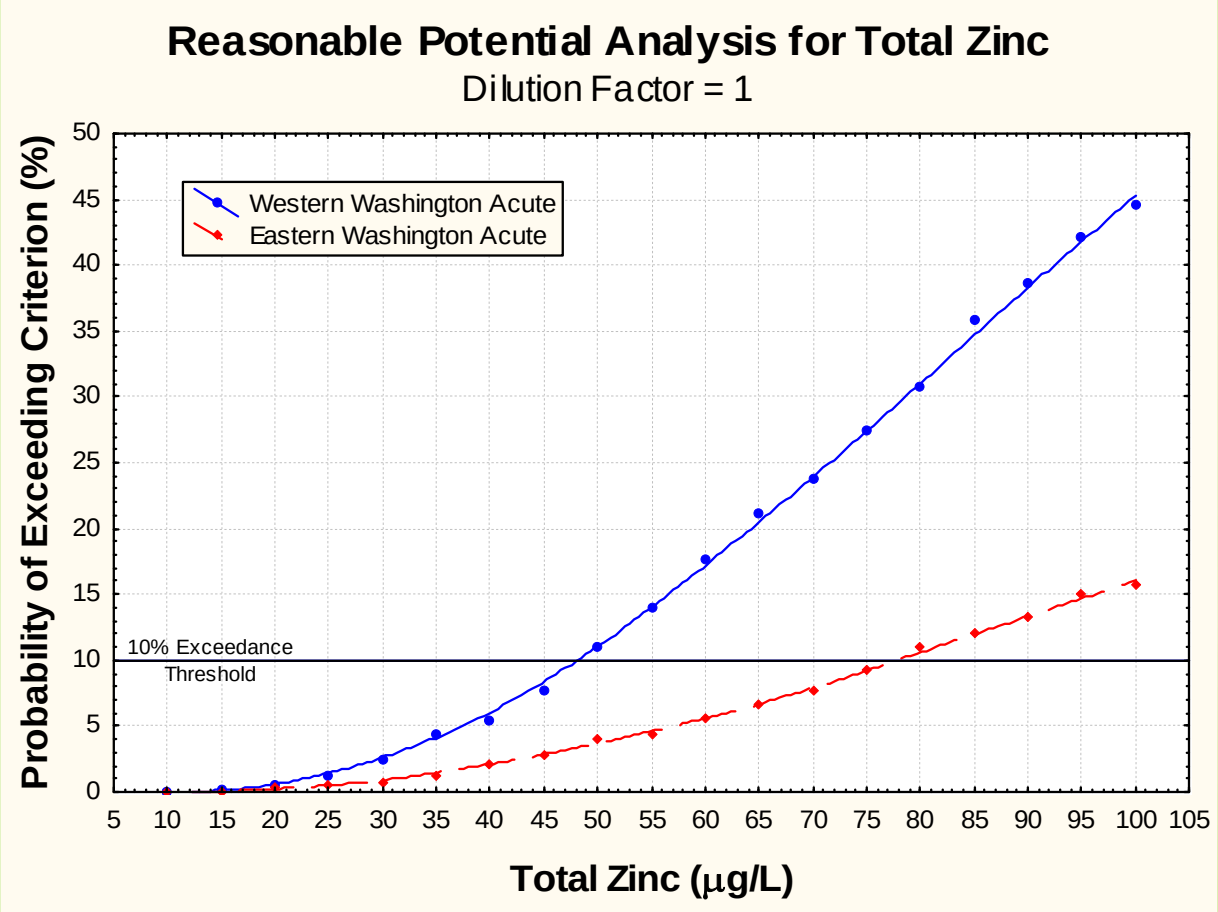


ISWGP Risk Analysis Results

		Probability of Exceeding Acute WQ Criterion (%)	
	Benchmark (µg/L)	DF = 1	DF = 5
Copper, Total	Western WA: 14	52.61	9.86
	Eastern WA: 32	52.50	9.66
Zinc, Total	Western WA: 200	85.68	9.77
	Eastern WA: 255	55.56	10.17
Lead, Total	Western WA: 310	90.07	10.22
	Eastern WA: 640	74.27	10.38

Questions?

ISWGP Risk Analysis Results



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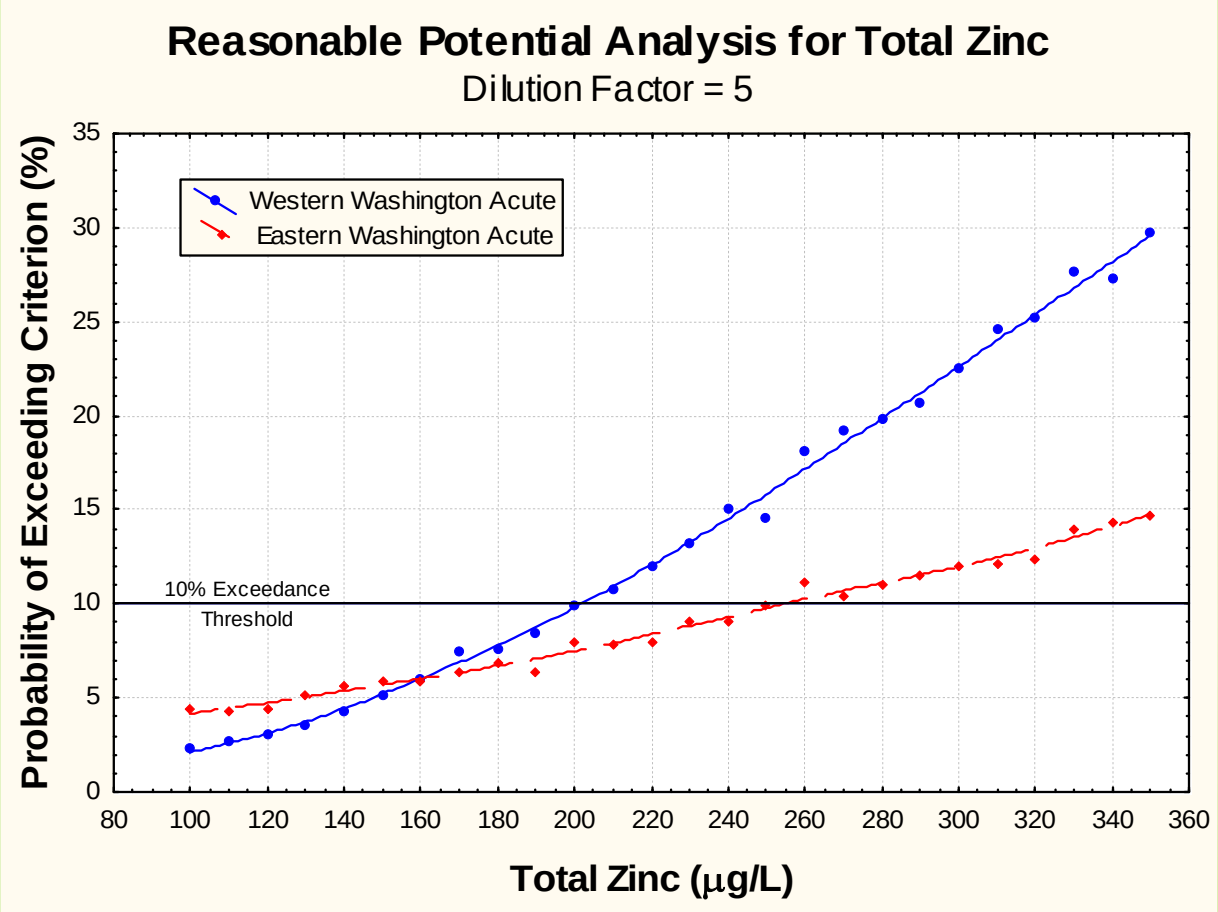

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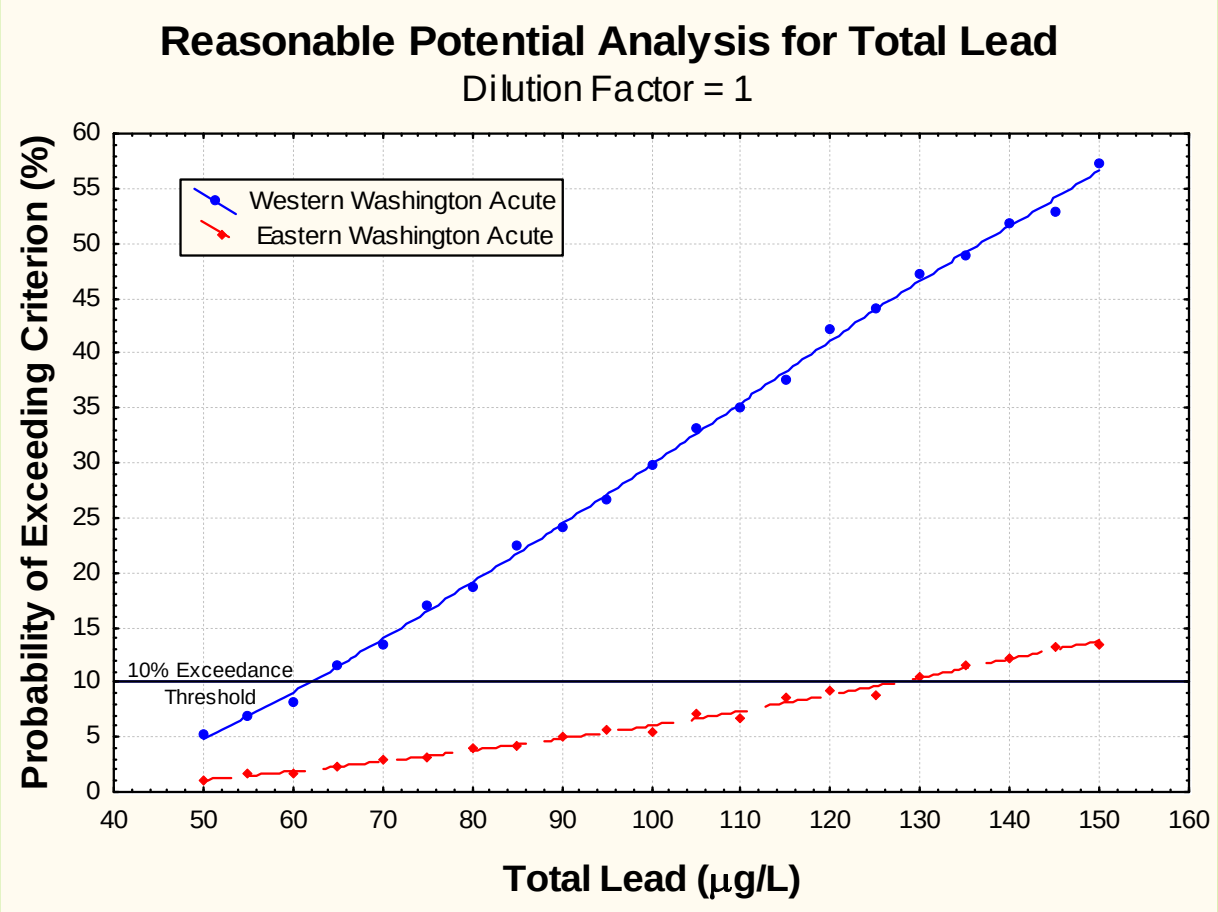
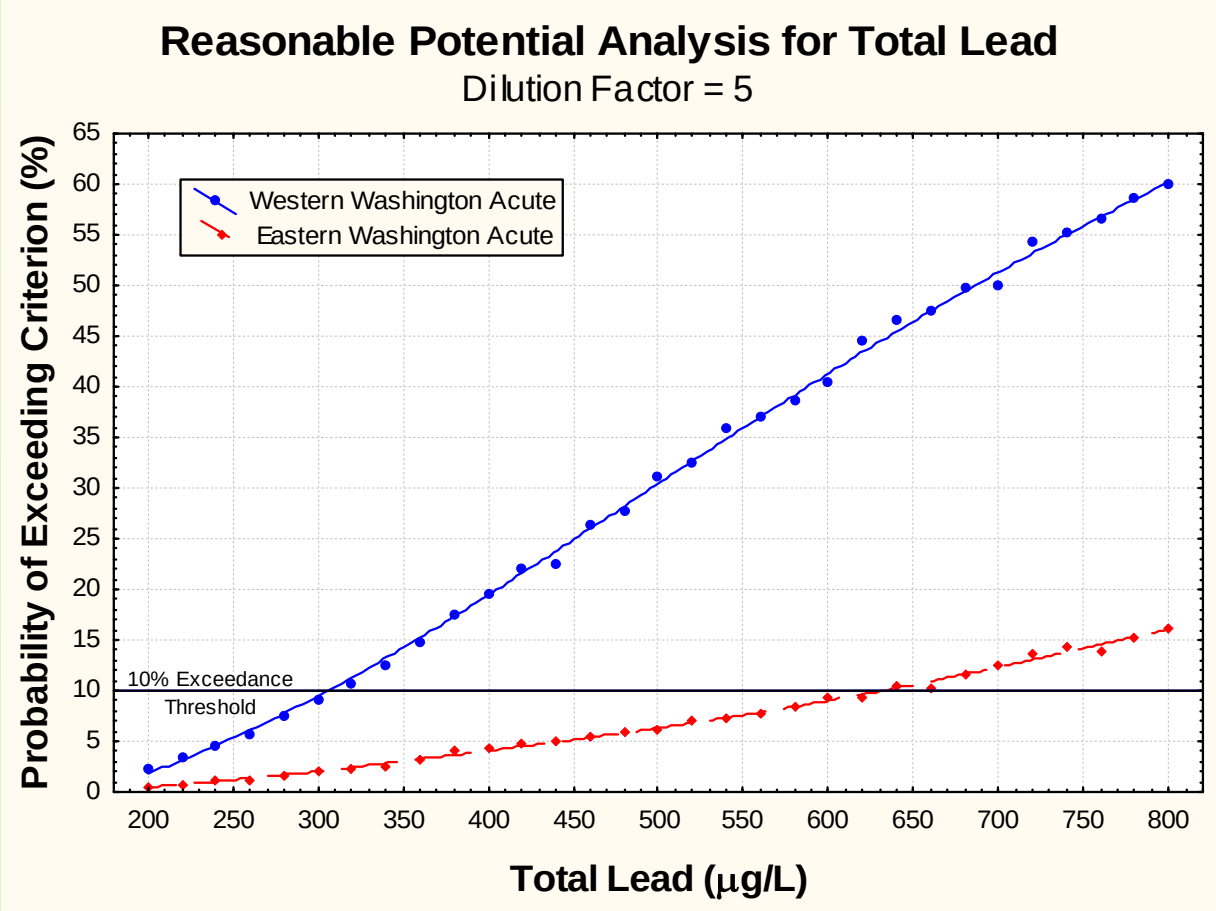
ISWGP Risk Analysis Results