APPENDIX C. METHODOLOGY AND EQUATIONS FOR CHARACTERIZING EFFLUENT AND BACKGROUND CONCENTRATIONS IN DETERMINATION OF REASONABLE POTENTIAL TO EXCEED NUMERICAL CRITERIA [REVOKED]

(1) **Effluent.**

(A) **Measures of central tendency.** $C_{E(mean)}$ represents the mean of an effluent distribution. $C_{E(mean)}$ is a geometric mean, unless the geometric mean is not determinable, in which case an arithmetic mean is used. Where one or the other form of the mean must be used in an equation, that form is explicitly stated.

(i) **$C_{E(avg)}$.** $C_{E(avg)}$ is calculated according to Equation C-1.

$$C_{E(avg)} = \frac{\left(\sum_{i=1}^{N} x_i\right)}{N} \qquad [C\text{-}1]$$

(ii) **$C_{E(geomean)}$.** $C_{E(geomean)}$ is calculated according to either of the two forms of Equation C-2, which are equivalent.

$$C_{E(geomean)} = EXP\left(\frac{\left(\sum_{i=1}^{N} \ln(x_i)\right)}{N}\right) = \sqrt[N]{\prod_{i=1}^{N} x_i} \qquad [C\text{-}2]$$

(B) **Effluent variability.** An effluent data set's standard deviation is the primary measure of its variability. Generally, as the mean of an effluent distribution increases, its standard deviation also tends to increase. The coefficient of variation is a measure of a data set's variability relative to its arithmetic mean.

(i) **Standard deviation of untransformed effluent data set (s_x).** The standard deviation of an untransformed effluent data set is calculated according to Equation C-3..

$$s_X = \sqrt{\frac{N\sum_{i=1}^{N}\left(x_i{}^2\right) - \left(\sum_{i=1}^{N} x_i\right)^2}{N\left(N-1\right)}}\ , \qquad [C\text{-}3]$$

where N is the number of data points in the effluent data set.

(ii) **Standard deviation of log-transformed effluent data set ($s_{ln(x)}$).** The standard deviation of a log-transformed effluent data set is calculated according to Equation C-4.

$$s_{\ln(x)} = \sqrt{\frac{N\sum_{i=1}^{N}\left(\ln(x_i)^2\right) - \left(\sum_{i=1}^{N}\ln(x_i)\right)^2}{N(N-1)}}\ , \qquad [C-4]$$

where N is the number of data points in the effluent data set.

The standard deviation of a log-transformed data set applies only to the transformed data set and cannot be translated back into an equivalent untransformed data set standard deviation, i.e.,

$$EXP\left(s_{\ln(x)}\right) \neq s_x$$

(iii) **CV.** The CV of an untransformed data set is calculated according to Equation C-5. At least 10 data points are required. If less than 10 data points are available, a value of 0.6 is assumed.

$$CV = \frac{s_x}{C_{E(avg)}}\ , \qquad [C-5]$$

where $C_{E(avg)}$ and s_x are determined according to Equations C-1 and C-3, respectively.

(C) **C_{95} and $C_{95(M)}$.** The use of both C_{95} and $C_{95(M)}$ assumes a log-normal effluent distribution. For the purpose of determining whether **effluent limitations** are required, C_{95} represents the 95^{th} percentile effluent concentration. For the purpose of determining whether further **effluent monitoring** is required if C_{95} does not exhibit reasonable potential, $C_{95(M)}$ is used.

(i) **C_{95}.** The method by which C_{95} is determined is dependent on whether there are 10or more data points available.

(1) **Less than 10 data points available.** The mean effluent concentration ($C_{E(mean)}$) is multiplied by a reasonable potential factor (RPF_{95}), which represents the 95^{th} percentile maximum likelihood estimator for a log-normal distribution, according to Equation C-6. If only one data point is available, it is assumed to represent the effluent mean. RPF_{95} is calculated according to Equation C-7, assuming a CV of 0.6.

$$C_{95} = C_{E(mean)} \times RPF_{95} \qquad [C-6]$$

$$RPF_{95} = EXP\left(1.645\sqrt{\ln\left(1+CV^2\right)} - 0.5\ln\left(1+CV^2\right)\right) \qquad [C-7]$$

Since a CV of 0.6 is assumed, RPF_{95} = 2.135 and Equation C-6 reduces to $C_{95} = C_{E(mean)} \times 2.135$. Where determinable, the geometric mean, $C_{E(geomean)}$, shall be used as $C_{E(mean)}$ in Equation C-6. The arithmetic mean, $C_{E(avg)}$, may be used if the geometric mean is unknown or undeterminable.

(2) **Ten or more data points available.** C_{95} is obtained directly from the data set as the inverse of the cumulative log-normal distribution function at a 95% probability using Equation C-8.

$$C_{95} = \mathrm{EXP}\left(\ln(x)_{avg} + 1.645 \times s_{\ln(x)}\right) \qquad \text{[C-8]}$$

where $\ln(x)_{avg}$ is the arithmetic mean of the log-transformed effluent data set and $s_{\ln(x)}$ is the standard deviation of the log-transformed effluent data set.

(ii) **$C_{95(M)}$.** The smaller the size of an effluent data set, the greater the uncertainty of its distribution. The extreme case occurs where only one data point is available. Where less than 10 data points are available to determine C_{95}, further effluent monitoring may be warranted for the purpose of future reevaluation of reasonable potential. The method used, referred to as the TSD method, is described in Section 3.3.2 of Technical Support Document for Water Quality-Based Toxics Control, EPA Publication No. EPA/505/2-90-001, March 1991. A log-normal distribution and a CV of 0.6 are assumed. $C_{95(M)}$ is calculated according to Equation C-9.

$$C_{95(M)} = C_{E(max)} \times RPF_{95(M)} \qquad \text{[C-9]}$$

$C_{E(max)}$ is the highest concentration of a toxicant in its effluent data set. If only one data point is available, it is considered to be $C_{E(max)}$. $RPF_{95(M)}$ is determined at a 95% confidence level and a 95% probability basis, according to Equation C-10.

$$RPF_{95(M)} = \frac{\mathrm{EXP}\left(1.645\sqrt{\ln\left(1+CV^2\right)} - 0.5\ln\left(1+CV^2\right)\right)}{\mathrm{EXP}\left(z_N\sqrt{\ln\left(1+CV^2\right)} - 0.5\ln\left(1+CV^2\right)\right)} \qquad \text{[C-10]}$$

where z_N is the upper k^{th} percentile of the normal distribution,
$k = (1\text{-confidence level})^{1/N} = (0.05)^{1/N}$ for the 95% confidence level, and
CV=0.6.

Table C-1 lists $RPF_{95(M)}$ values for vales of N from 1 to 9, where CV is assumed to be 0.6.

Table C-1. $RPF_{95(M)}$ and z_N Values for N<10

N	z_N	$RPF_{95(M)}$
1	-1.645	6.199
2	-0.760	3.795
3	-0.336	3.000
4	-0.068	2.585
5	0.124	2.324
6	0.272	2.141
7	0.390	2.006
8	0.489	1.898
9	0.574	1.811

(2) **Background (C_B).**

(A) **Numerical criteria for toxic substances:** As described in OAC 252:690-3-11 and 14, C_B is the background concentration representative of low stream flow (7Q2) conditions.

(B) **Human health and raw water criteria.** As described in OAC 252:690-3-11 and 15, C_B is the long term background concentration representative of average stream flow conditions, and is expressed as a geometric mean.

(C) **Agriculture criteria.** As described in OAC 252:690-3-11 and 16, if site-specific mineral constituent background data is used (as opposed to the historical YMS and SS criteria in Appendix F of OAC 785:45), C_B is calculated as the arithmetic average of the site-specific background data distribution. If historical YMS and SS data from Appendix F of OAC 785:45 are used, C_B is calculated according to Equation C-11.

$$C_B = 2 \times C_{B(YMS)} - C_{B(SS)} \qquad [C\text{-}11]$$

APPENDIX C. METHODOLOGY AND EQUATIONS FOR CHARACTERIZING EFFLUENT AND BACKGROUND CONCENTRATIONS IN DETERMINATION OF REASONABLE POTENTIAL TO EXCEED NUMERICAL CRITERIA [NEW]

I. EFFLUENT

A. Measures of central tendency. $C_{E(mean)}$ represents the mean of an effluent distribution. $C_{E(mean)}$ is a geometric mean, unless the geometric mean is not determinable in which case an arithmetic mean is used. Where one or the other form of the mean must be used in an equation, that form is explicitly stated [WHAT? WHERE? …in the equation?].

(1) **$C_{E(avg)}$.** $C_{E(avg)}$ is calculated as follows:

$$C_{E(avg)} = \frac{\left(\sum_{i=1}^{N} x_i\right)}{N} \qquad [C\text{-}1]$$

(2) **$C_{E(geomean)}$.** $C_{E(geomean)}$ is calculated according to either of the following two forms, which are equivalent.

$$C_{E(geomean)} = EXP\left(\frac{\left(\sum_{i=1}^{N} \ln(x_i)\right)}{N}\right) = \sqrt[N]{\prod_{i=1}^{N} x_i} \qquad [C\text{-}2]$$

B. Effluent variability. An effluent data set's standard deviation is the primary measure of its variability. Generally, as the mean of an effluent distribution increases, its standard deviation also tends to increase. The coefficient of variation is a measure of a data set's variability relative to its arithmetic mean.

(1) **Standard deviation of untransformed effluent data set (s_x).** The standard deviation of an untransformed effluent data set is calculated as follows:

$$s_x = \sqrt{\frac{N\sum_{i=1}^{N}\left(x_i^{\,2}\right) - \left(\sum_{i=1}^{N} x_i\right)^2}{N(N-1)}}\ , \qquad [C\text{-}3]$$

where N is the number of data points in the effluent data set.

(2) **Standard deviation of log-transformed effluent data set ($s_{ln(x)}$).** The standard deviation of a log-transformed effluent data set is calculated as follows:

$$s_{\ln(x)} = \sqrt{\frac{N\sum_{i=1}^{N}\left(\ln(x_i)^2\right) - \left(\sum_{i=1}^{N}\ln(x_i)\right)^2}{N(N-1)}}\ , \qquad [C-4]$$

where N is the number of data points in the effluent data set.

The standard deviation of a log-transformed data set applies only to the transformed data set and cannot be translated back into an equivalent untransformed data set standard deviation, for example:

$$EXP\left(s_{\ln(x)}\right) \neq s_x$$

(3) **CV.** The CV of an untransformed data set is calculated as follows, when using at least ten (10) data points (if less than ten (10) data points are available, a value of 0.6 is assumed):

$$CV = \frac{s_x}{C_{E(avg)}}\ , \qquad [C-5]$$

where $C_{E(avg)}$ and s_x are determined according to Equations C-1 and C-3, respectively.

C. **C_{95} and $C_{95(M)}$.** The use of both C_{95} and $C_{95(M)}$ assumes a log-normal effluent distribution. For the purpose of determining whether **effluent limitations** are required, C_{95} represents the 95th percentile effluent concentration. For the purpose of determining whether further **effluent monitoring** is required, if C_{95} does not exhibit reasonable potential then $C_{95(M)}$ is used.

(1) **C_{95}.** The method by which C_{95} is determined is dependent on whether there are 10or more data points available.

(a) **Less than 10 data points available.** The mean effluent concentration ($C_{E(mean)}$) is multiplied by a reasonable potential factor (RPF_{95}), which represents the 95th percentile maximum likelihood estimator for a log-normal distribution, according to Equation C-6. If only one data point is available, it is assumed to represent the effluent mean. RPF_{95} is calculated according to Equation C-7, assuming a CV of 0.6.

$$C_{95} = C_{E(mean)} \times RPF_{95} \qquad [C-6]$$

$$RPF_{95} = EXP\left(1.645\sqrt{\ln\left(1+CV^2\right)} - 0.5\ln\left(1+CV^2\right)\right) \qquad [C-7]$$

Since a CV of 0.6 is assumed, RPF_{95} = 2.135 and Equation C-6 reduces to $C_{95} = C_{E(mean)} \times 2.135$. Where determinable, the geometric mean, $C_{E(geomean)}$, shall be used as $C_{E(mean)}$ in Equation C-6. The arithmetic mean, $C_{E(avg)}$, may be used if the geometric mean is unknown or undeterminable.

(b) **Ten or more data points available.** C_{95} is obtained directly from the data set as the inverse of the cumulative log-normal distribution function at a 95% probability using Equation C-8.

$$C_{95} = \text{EXP}\left(\ln(x)_{avg} + 1.645 \times s_{\ln(x)}\right) \qquad \text{[C-8]}$$

where $\ln(x)_{avg}$ is the arithmetic mean of the log-transformed effluent data set and $s_{\ln(x)}$ is the standard deviation of the log-transformed effluent data set.

(2) **$C_{95(M)}$.** The smaller the size of an effluent data set, the greater the uncertainty of its distribution. The extreme case occurs where only one data point is available. Where less than 10 data points are available to determine C_{95}, further effluent monitoring may be warranted for the purpose of future reevaluation of reasonable potential. The method used, referred to as the TSD method, is described in Section 3.3.2 of Technical Support Document for Water Quality-Based Toxics Control, EPA Publication No. EPA/505/2-90-001, March 1991. A log-normal distribution and a CV of 0.6 are assumed. $C_{95(M)}$ is calculated according to Equation C-9.

$$C_{95(M)} = C_{E(max)} \times RPF_{95(M)} \qquad \text{[C-9]}$$

$C_{E(max)}$ is the highest concentration of a toxicant in its effluent data set. If only one data point is available, it is considered to be $C_{E(max)}$. $RPF_{95(M)}$ is determined at a 95% confidence level and a 95% probability basis, according to Equation C-10.

$$RPF_{95(M)} = \frac{\text{EXP}\left(1.645\sqrt{\ln\left(1+CV^2\right)} - 0.5\ln\left(1+CV^2\right)\right)}{\text{EXP}\left(z_N\sqrt{\ln\left(1+CV^2\right)} - 0.5\ln\left(1+CV^2\right)\right)} \qquad \text{[C-10]}$$

where z_N is the upper k^{th} percentile of the normal distribution,
$k = (1\text{-confidence level})^{1/N} = (0.05)^{1/N}$ for the 95% confidence level, and
CV=0.6.

Table C-1 lists $RPF_{95(M)}$ values for vales of N from 1 to 9, where CV is assumed to be 0.6.

Table C-1. $RPF_{95(M)}$ and z_N Values for N<10

N	z_N	$RPF_{95(M)}$
1	-1.645	6.199
2	-0.760	3.795
3	-0.336	3.000
4	-0.068	2.585
5	0.124	2.324
6	0.272	2.141
7	0.390	2.006
8	0.489	1.898
9	0.574	1.811

(II) **BACKGROUND (C_B).**

(A) Numerical criteria for toxic substances: As described in OAC 252:690-3-11 and 14, C_B is the background concentration representative of low stream flow (7Q2) conditions.

(B) Human health and raw water criteria. As described in OAC 252:690-3-11 and 15, C_B is the long term background concentration representative of average stream flow conditions, and is expressed as a geometric mean.

(C) Agriculture criteria. As described in OAC 252:690-3-11 and 16, if site-specific mineral constituent background data is used (as opposed to the historical YMS and SS criteria in Appendix F of OAC 785:45), C_B is calculated as the arithmetic average of the site-specific background data distribution. If historical YMS and SS data from Appendix F of OAC 785:45 are used, C_B is calculated according to Equation C-11.

$$C_B = 2 \times C_{B(YMS)} - C_{B(SS)} \quad \text{[C-11]}$$

APPENDIX I. PERFORMANCE-BASED EFFLUENT MONITORING FREQUENCY REDUCTIONS [REVOKED]

Where one or more permit violations of any kind for a limited parameter (not resulting in SNC) have been exhibited during the previous permit cycle, Table I-1 is used to determine performance-based monitoring frequency reductions. Where there has been no permit violation of any kind for a limited parameter during the previous permit cycle, Table I-2 is used to determine performance-based monitoring frequency reductions. If Wa permit contains a monthly average mass loading limit, but not a monthly average concentration limit, the equivalent monthly average concentration limit may be derived from the monthly average mass loading limit and the flow basis (the high 30-day average flow during the previous permit cycle for industrial facilities and the design flow for municipal facilities). Performance-based monitoring frequency reductions shall not be based on a weekly average, a daily minimum or a daily maximum concentration limit. If a facility has demonstrated SNC during the previous permit cycle, then an increase in monitoring frequency pursuant to Table I-3 is used. Any process control tests performed, as required by OAC 252:606, Appendix A, must be reported on any submitted DMRs, as required by 40 CFR § 122.41 (L)(4)(ii), provided the control test sample meets all the sample protocol requirements as contained in the OPDES permit.. Any monitoring frequency reduction granted in a permit does not affect the requirement to conduct or report any control tests performed.

Table I-1. Performance Based Monitoring Frequency Reductions (One or More Permit Violations During the Previous Permit Cycle Not Resulting in SNC)

Baseline Monitoring Frequency (previous permit cycle)	Ratio (Percent) of Long-term Average Effluent Concentration for The Previous Permit Cycle to Monthly Average Concentration Limit [a]				
	< 25%	≥25% and <50%	≥50% and <65%	≥65% and <75%	≥75%
7/week (daily)	3/week	4/week	5/week	6/week	NR
6/week	3/week	4/week	4/week	5/week	NR
5/week	3/week	3/week	4/week	NR	NR
4/week	2/week	3/week	NR	NR	NR
3/week	2/week	2/week	NR	NR	NR
2/week	1/week	NR	NR	NR	NR
1/week	2/month	NR	NR	NR	NR
2/month	NR	NR	NR	NR	NR
1/month	NR	NR	NR	NR	NR

[a] NR means “no reduction.”

Table I-2. Performance Based Monitoring Frequency Reductions
(No Permit Violations During The Previous Permit Cycle)*

Baseline Monitoring Frequency (previous permit cycle)	Ratio (Percent) of Long-term Average Effluent Concentration for The Previous Permit Cycle to Monthly Average Concentration Limit [a]				
	< 25%	≥25% and <50%	≥50% and <65%	≥65% and <75%	≥75%
7/week (daily)	2/week	3/week	4/week	5/week	6/week
6/week	2/week	3/week	3/week	4/week	5/week
5/week	1/week	2/week	3/week	4/week	4/week
4/week	1/week	2/week	2/week	3/week	NR
3/week	1/week	2/week	2/week	NR	NR
2/week	2/month	1/week	1/week	NR	NR
1/week	1/month	2/month	NR	NR	NR
2/month	1/month	NR	NR	NR	NR
1/month	NR	NR	NR	NR	NR
1/2 months	NR	NR	NR	NR	NR

[a] NR means "no reduction."

* The frequency reductions stated in Table I-2 do not affect the need to conduct control tests and do not affect the number of control tests to be conducted, see, OAC 252:690-3-91.

Table I-3. Monitoring Frequency Increases

Baseline Monitoring Frequency (previous permit cycle)	Increased Monitoring Frequency for parameters demonstrating a violation during the previous permit cycle [a]
7/week (daily)	NI
6/week	7/week
5/week	7/week
4/week	6/week
3/week	5/week
2/week	4/week
1/week	3/week
2/month	2/week
1/month	1/week
1/2 months (every other month)	2/month
1/3 months (once per quarter)	1/month
1/6 months (semi-annually)	1/month
1/year	1/month

[a] NI means "no increase"

APPENDIX I. PERFORMANCE-BASED EFFLUENT MONITORING FREQUENCY REDUCTIONS AND INCREASES [NEW]

If a permit contains a monthly average mass loading limit, but not a monthly average concentration limit, the equivalent monthly average concentration limit may be derived from the monthly average mass loading limit and the flow basis (the high 30-day average flow during the previous permit cycle for industrial facilities and the design flow for municipal facilities).

Table I-1. Performance Based Monitoring Frequency Reductions (No Permit Violations During The Previous Permit Cycle)*

Baseline Monitoring Frequency (previous permit cycle)	Ratio (Percent) of Long-term Average Effluent Concentration for The Previous Permit Cycle to Monthly Average Concentration Limit [a]				
	< 25%	≥25% and <50%	≥50% and <65%	≥65% and <75%	≥75%
7/week (daily)	2/week	3/week	4/week	5/week	6/week
6/week	2/week	3/week	3/week	4/week	5/week
5/week	1/week	2/week	3/week	4/week	4/week
4/week	1/week	2/week	2/week	3/week	NR
3/week	1/week	2/week	2/week	NR	NR
2/week	2/month	1/week	1/week	NR	NR
1/week	1/month	2/month	NR	NR	NR
2/month	1/month	NR	NR	NR	NR
1/month	NR	NR	NR	NR	NR
1/2 months	NR	NR	NR	NR	NR

[a] NR means “no reduction.”

* The frequency reductions stated in Table I-2 do not affect the need to conduct control tests and do not affect the number of control tests to be conducted. *See*, 252:690-3-91.

Table I-2. Monitoring Frequency Increases

Baseline Monitoring Frequency (previous permit cycle)	Increased Monitoring Frequency for parameters demonstrating a violation during the previous permit cycle [a]
7/week (daily)	NI
6/week	7/week
5/week	7/week
4/week	6/week
3/week	5/week
2/week	4/week
1/week	3/week
2/month	2/week
1/month	1/week
1/2 months (every other month)	2/month
1/3 months (once per quarter)	1/month
1/6 months (semi-annually)	1/month
1/year	1/month

[a] NI means "no increase"

APPENDIX J. BACKGROUND MONITORING [REVOKED]

Background monitoring is unnecessary if a BT/C ratio is > 1.0. The maximum BT/C ratio for which background monitoring is required, which decreases as the value of the associated criterion increases, is expressed by Equations J-1, J-2 and J-3.

$$(BT/C)_{max} = 1.0 \text{, where the criterion} \leq 1.0\ \mu g/l. \qquad [J\text{-}1]$$

$$(BT/C)_{max} = \frac{1}{2^{\log(\text{criterion})}} \text{, where the criterion} > 1.0\ \mu g/l \text{ and} \leq 1000\ \mu g/l. \qquad [J\text{-}2]$$

$$(BT/C)_{max} = 0.125 \text{, where the criterion} > 1000\ \mu g/l. \qquad [J\text{-}3]$$

If the BT/C ratio ≤ $(BT/C)_{max}$, then background monitoring is required.

The relationship between criterion magnitude and $(BT/C)_{max}$, and under what conditions that background monitoring is required, is illustrated in Figure J-1.

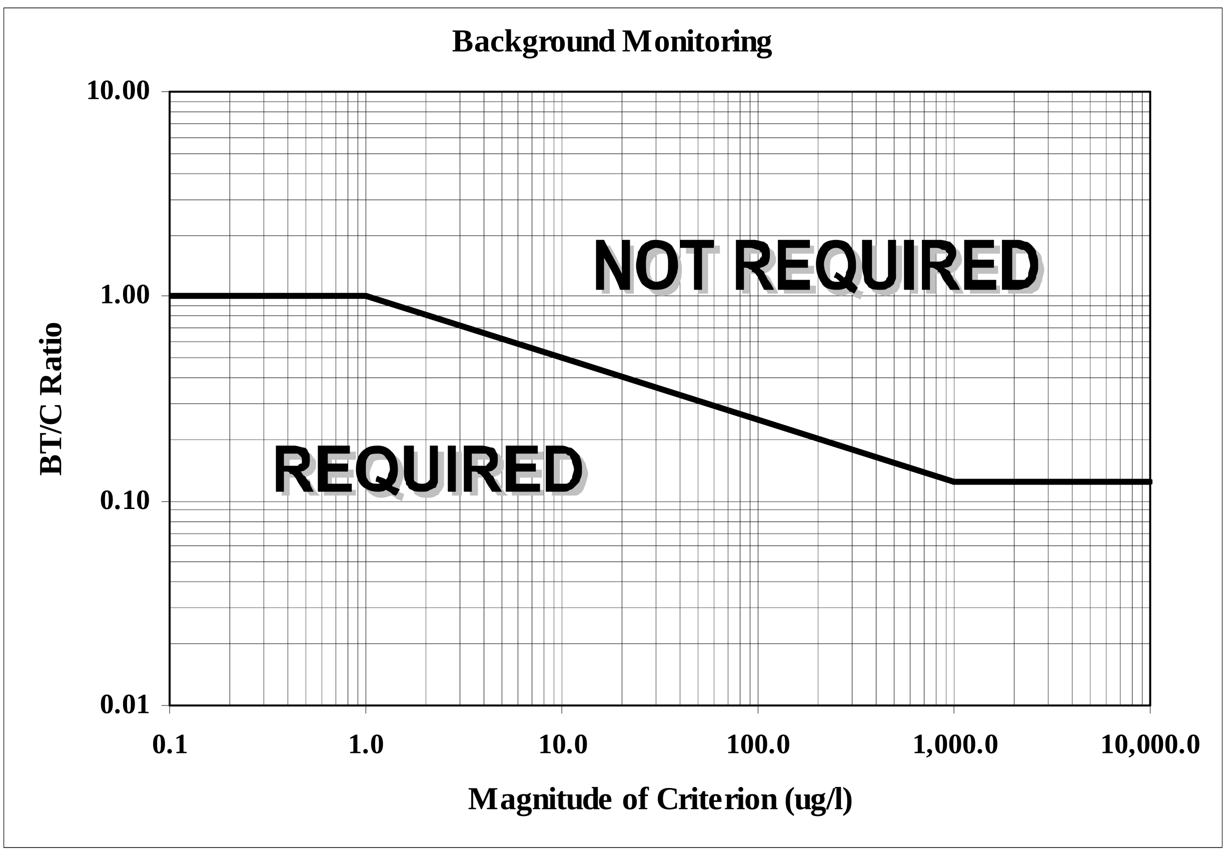

Figure J-1. $(BT/C)_{max}$ Threshold for Background Monitoring

APPENDIX J. BACKGROUND MONITORING [NEW]

Background monitoring is unnecessary if a BT/C ratio is > 1.0. The maximum BT/C ratio for which background monitoring is required, which decreases as the value of the associated criterion increases, is expressed by Equations J-1, J-2 and J-3.

$$(BT/C)_{max} = 1.0 \text{, where the criterion} \leq 1.0\ \mu g/l. \qquad [J\text{-}1]$$

$$(BT/C)_{max} = \frac{1}{2^{\log(\text{criterion})}} \text{, where the criterion} > 1.0\ \mu g/l \text{ and} \leq 1000\ \mu g/l. \qquad [J\text{-}2]$$

$$(BT/C)_{max} = 0.125 \text{, where the criterion} > 1000\ \mu g/l. \qquad [J\text{-}3]$$

If the BT/C ratio ≤ $(BT/C)_{max}$, then background monitoring is required.

The relationship between criterion magnitude and $(BT/C)_{max}$, and under what conditions that background monitoring is required is illustrated in Figure J-1.

Figure J-1. $(BT/C)_{max}$ Threshold for Background Monitoring