

APPENDIX K
COMPLETED FISH AND WILDLIFE RESOURCES IPMACT
ANALYSIS DECISION KEY

Appendix 3C Fish and Wildlife Resources Impact Analysis Decision Key		If YES Go to:	If NO Go to:
1.	Is the site or area of concern a discharge or spill event?	13	2
2.	Is the site or area of concern a point source of contamination to the groundwater which will be prevented from discharging to surface water? Soil contamination is not widespread, or if widespread, is confined under buildings and paved areas.	13	3
3.	Is the site and all adjacent property a developed area with buildings, paved surfaces and little or no vegetation?	4	9
4.	Does the site contain habitat of an endangered, threatened or special concern species?	Section 3.10.1	5
5.	Has the contamination gone off-site?	6	14
6.	Is there any discharge or erosion of contamination to surface water or the potential for discharge or erosion of contamination?	7	14
7.	Are the site contaminants PCBs, pesticides or other persistent, bioaccumulable substances?	Section 3.10.1	8
8.	Does contamination exist at concentrations that could exceed ecological impact SCGs or be toxic to aquatic life if discharged to surface water?	Section 3.10.1	14
9.	Does the site or any adjacent or downgradient property contain any of the following resources? i. Any endangered, threatened or special concern species or rare plants or their habitat ii. Any DEC designated significant habitats or rare NYS Ecological Communities iii. Tidal or freshwater wetlands iv. Stream, creek or river v. Pond, lake, lagoon vi. Drainage ditch or channel vii. Other surface water feature viii. Other marine or freshwater habitat ix. Forest x. Grassland or grassy field xi. Parkland or woodland xii. Shrubby area xiii. Urban wildlife habitat xiv. Other terrestrial habitat	11	10
10.	Is the lack of resources due to the contamination?	3.10.1	14
11.	Is the contamination a localized source which has not migrated and will not migrate from the source to impact any on-site or off-site resources?	14	12
12.	Does the site have widespread surface soil contamination that is not confined under and around buildings or paved areas?	Section 3.10.1	12
13.	Does the contamination at the site or area of concern have the potential to migrate to, erode into or otherwise impact any on-site or off-site habitat of endangered, threatened or special concern species or other fish and wildlife resource? (See #9 for list of potential resources. Contact DEC for information regarding endangered species.)	Section 3.10.1	14
14.	No Fish and Wildlife Resources Impact Analysis needed.		

APPENDIX L
ELEMENTAL MERCURY EXPOSURE ASSESSMENT

ELEMENTAL MERCURY EXPOSURE ASSESSMENT

Off-Site Potential Exposure Pathways – Current Conditions

Elemental mercury (Hg^0) is a volatile contaminant that is present at the site; therefore, exposure to vapor through inhalation of ambient air is evaluated under current conditions. This evaluation uses Hg^0 data collected during the RI via soil and soil vapor sampling. Although the presence of impervious cover is expected to significantly reduce the potential for mercury vapor emissions, Hg^0 exposure is assessed in the absence of cover. Once in the atmosphere, mercury vapors emitted from contaminated soil or soil gas will disperse into a large volume of outdoor air. Estimates of elemental mercury concentrations in ambient air and the associated health risks are discussed in this section.

Soil Gas Emission

Diffusion through vadose zone soil is the dominant transport mechanism from soil gas to outdoor air. Regardless of the vapor source, soil gas contaminant concentrations will decrease (attenuate) as vapor moves through the vadose zone and into the atmosphere. Emissions to ambient air were estimated using the Johnson and Ettinger algorithms, which employ the Millington and Quirk model for estimating effective diffusion (U.S. Environmental Protection Agency [EPA], 2004). Computing the effective diffusion coefficient for unsaturated soil requires the chemical-specific diffusivity in water and the Henry's Law Constant (HLC) for Hg^0 .

The EPA has categorized soil using the U. S. Department of Agriculture's Soil Conservation Service (SCS) soil types (EPA, 2004). Soil parameters, including total porosity, water-filled porosity, and air-filled porosity were selected from the class average value for sand following review of the site boring logs from this RI. The highest mercury soil gas concentration was detected off-site, along Pearl Street, at SV38 ($0.271 \mu\text{g}/\text{m}^3$). The site soil proximal to Pearl Street (SB12, SB19, SB29, SB38, and SB39) is composed of a layer of fill material, with sand being the predominant soil type to the depth of soil gas (15 ft. bgs). Sand is highly permeable and is the most conservative SCS soil type for estimating diffusion when sand and gravel are present (EPA, 2004).

Diffusion through vadose zone soil was modeled using the following equation:

$$D^{eff} = D_{ia} \left(\frac{\theta_a^{3.33}}{n^2} \right) + \left(\frac{D_{iw}}{H'} \right) \times \left(\frac{\theta_w^{3.33}}{n^2} \right)$$

where:

PARAMETER	DESCRIPTION	VALUE	SOURCE
D^{EFF}	Effective diffusion coefficient across soil unsaturated vadose zone, cm ² /s		Calculated (0.00496)
D_{IA}	Diffusivity in air, cm ² /s	0.0307	Hg ⁰ (EPA, 2001)
θ_A	Soil air-filled porosity, cm ³ /cm ³	0.321	Calculated (n-θ _w)
N	Total soil porosity, cm ³ /cm ³	0.375	Sand (EPA, 2004)
D_{IW}	Diffusivity in water, cm ² /s	0.0000063	Hg ⁰ (EPA, 2001)
θ_w	Soil water-filled porosity, cm ³ /cm ³	0.054	Sand (EPA, 2004)
H'	Dimensionless HLC	0.35	Hg ⁰ (EPA, 2020)

Emission flux to the surface can then be calculated by multiplying the concentration of mercury in site soil gas at SV38 by the effective diffusion coefficient and dividing by the distance travelled (15 feet bgs). Emission flux for elemental mercury was derived as shown in the following equation:

$$Q_{calc} = \frac{C_v \times D^{eff}}{d} \times CF$$

where:

PARAMETER	DESCRIPTION	VALUE	SOURCE
Q_{CALC}	Emission flux calculated, mg/m ² -s		Calculated (2.94E-11)
C_v	Concentration in soil vapor sample (mg/m ³)	0.000271	SV38 (maximum)
D	Depth of soil gas sample from ground surface (m)	4.572	15 ft.
CF	Conversion Factor, 1E-04 m ² /cm ²	1E-04	--

Dispersion

Dispersion modeling is used to characterize the atmospheric processes that disperse a contaminant once it has been emitted by a source. Based on the calculated emission flux and meteorological inputs, Hg⁰ air concentrations can be estimated. Receptors that are at off-site locations will have lower exposure to contaminants in air than that which is represented by an on-site or near-site receptor at SV38 (off-site soil vapor location) along Pearl Street. Therefore, evaluation of the northern off-site area is a conservative approach for evaluating more distant resident hazards. Dispersion was evaluated using two approaches: a Q/C model and a box model.

(1) *Q/C Model*

Air dispersion factors (Q/C) are derived from the EPA's Industrial Source Complex model (ISC3) to simulate the dispersion of volatile contaminants in the atmosphere. The Q/C parameter is defined as the inverse ratio of the geometric mean air concentration to the emission flux at the center of the source. The dispersion factor calculation, presented below, represents the best-fit curve developed by EPA in ISC3. The A, B, and C constants are the 90th percentile values for specific climate zones modeled by EPA for the 1996 Soil Screening Guidance (SSG) (EPA, 1996).

$$Q/C = A \times \exp \left[\frac{(\ln A_{site} - B)^2}{C} \right]$$

where:

Parameter	Description	Value	SOURCE
Q/C	Air dispersion factor, g/m ² -s per kg/m ³	Calculated (72.08)	
A	Constant	14.0396	EPA, 1996
A_{SITE}	Areal extent of the site (acres)	1.1	Site-specific
B	Constant	18.9590	EPA, 1996
C	Constant	217.5151	EPA, 1996

Consistent with the approach NYSDEC applied to derive a generic Q/C term in the development of SCOs, the three constants (A, B, and C) represent the average values for Zone VIII which includes Harrisburg, Hartford, and Philadelphia (NYSDEC Technical Support Document [TSD], 2006). The constants for Cleveland were not included in the averaging because the site is located in eastern New York.

The concentration in outdoor air is subsequently calculated using the following equation.

$$C_{OA} = \frac{Q_{calc} \times CF_{g-kg}}{Q/C}$$

where:

Parameter	Description	Value	SOURCE
C_{OA}	Concentration in outdoor air, µg/m ³	Calculated (4.08E-7)	
Q_{CALC}	Emission flux calculated, mg/m ² -s	2.94E-11	Derived Above
CF_{G-KG}	Conversion Factor, 1,000 g/kg	1,000	–
Q/C	Air dispersion factor, g/m ² -s per kg/m ³	72.08	Derived Above

Based on emission and dispersion modeling, the ambient air concentration of Hg⁰ as a result of the highest detected soil gas contamination in SV38 is estimated to be 4E-07 µg/m³, as shown

above. The modeled concentration is 7 orders of magnitude below the acute Hg⁰ action level applied during site investigation activities (1 µg/m³) and is 5 orders of magnitude below the chronic reference concentration (RfC) adopted by NYSDEC to calculate the SCO (0.09 µg/m³) (NYSDEC, 2006). The predicted ambient air concentration is also confirmed by empirical field data which indicate that Hg⁰ was not detected above instrument detection levels during background and onsite investigations. Consequently, acute or chronic non-cancer health effects associated with elemental mercury exposure in ambient air are not expected to occur.

(2) Box Model

A sensitivity analysis was performed to assess potential site-related ambient mercury concentrations by using a “box model” approach (EPA, 1986). The box model estimates a concentration in the breathing zone directly overlying contaminated soil, assuming the box is ventilated by the wind and the contaminant is fully mixed. The height of the box was assumed to be the height of an adult person (2 meters) (EPA, 1986). Assuming that the affected area of the site (A) is configured as a square, the length of the site is equal to the square root of A, or 67 meters. The EPA default value of 4.69 m/s was selected for mean annual wind speed, consistent with the NYSDEC TSD (EPA, 1996; NYSDEC, 2006). The concentration in outdoor air is calculated using the following equation.

$$C_{OA} = \frac{Q_{calc} \times A}{(LS \times V \times MH)}$$

where:

Parameter	Description	Value	SOURCE
C_{OA}	Concentration in outdoor air, µg/m ³		Calculated (2.09E-7)
Q_{CALC}	Emission flux calculated, mg/m ² -s	2.9417E-11	Derived Above
A	Area, m ²	4,464	–
L	Length, m	67	Calculated
V	Average wind velocity, m/s	4.69	NYSDEC, 2006
MH	Mixing Height, 2 m (default)	2	EPA, 1986

Based on emission and dispersion box modeling, the ambient air concentration of Hg⁰ resulting from the highest detected soil gas contamination in SV38 is estimated to be 2E-07 µg/m³, as shown above. The ambient air concentration derived from the box model corroborates the Q/C modeled concentration (4E-07 µg/m³). Based on the maximum Hg⁰ concentration detected in soil gas, soil gas to outdoor air is not a transport mechanism of concern.

Soil Gas to Outdoor Air Attenuation Factor

Soil gas to outdoor air attenuation factors (AF) were calculated using the results of each dispersion model to determine the soil gas concentration that could represent an exposure concern. Vapor attenuation refers to the reduction of volatile contaminant concentrations that occurs during vapor migration in the subsurface, coupled with the dilution that occurs when vapors enter the atmosphere. Measurements of outdoor air concentrations are the most direct way to evaluate potential exposure point concentrations; however, given that on-site monitoring has not indicated that mercury vapor is present at detectable levels, AFs were derived using the equation shown below.

$$\alpha = \frac{C_{OA}}{C_V}$$

where:

Parameter	Description	Value	SOURCE
C_{OA} Q/C MODEL	Concentration in outdoor air, mg/m ³	Calculated (4.0811E-10)	
C_{OA} BOX MODEL	Concentration in outdoor air, mg/m ³	Calculated (2.0954E-10)	
C_V	Concentration in soil gas, mg/m ³	0.000271	SG-38 (max)
α Q/C MODEL	Attenuation Factor, unitless	1.51E-06	Calculated
α BOX MODEL	Attenuation Factor, unitless	7.73E-07	Calculated

The soil gas-to-outdoor air AFs calculated using the Q/C model and the box model are similar at 1.51E-06 and 7.73E-07, respectively. These site-specific AFs indicate that mercury vapor is expected to decrease by approximately 6 orders of magnitude as it moves through the subsurface and into ambient air. Using the more conservative AF obtained from the Q/C model, the soil gas concentration would need to be 66,000 µg/m³ at 15 feet bgs in order to exceed the project action level (1 µg/m³).

Soil Emission

The NYSDEC Residential Use SCO for mercury (0.81 mg/kg) is based on the vapor-phase inhalation pathway and incorporates the assumption that mercury is present entirely as Hg⁰ (Table 5.3.6-1(b), NYSDEC, 2006). To calculate a health-protective soil concentration for inhalation of ambient air, the relationship between the concentration of contaminants in soil and the flux of the volatilized contaminant to the air (i.e., the volatilization factor [VF]) must be established. The NYSDEC applies a “mass-limit” approach to estimate the VF. The mass-limit VF is intended to derive SCOs that do not violate mass-balance considerations, which can occur with infinite source models that assume the vapor source is never depleted. The NYSDEC acknowledges,

however, that the mass-limit approach lacks chemical specificity and has the potential to overestimate inhalation exposures for some volatile chemicals (NYSDEC, 2006).

The generic mass-limit VF (2.67E+04 m³/kg), based on Equation (13) of EPA's Soil Screening Guidance (EPA, 1996), incorporates default values for dispersion, source depth, dry bulk soil density, and the exposure interval (NYSDEC, 2006). The default dispersion term (Q/C), 83.53 g/m²-s per kg/m³, is used to estimate ground-level vapor concentrations from ground-level area sources. NYSDEC evaluated the differences between ground-level concentrations in air and air concentrations in the breathing zone and concluded that breathing zone air may be approximately half of the predicted ground-level concentrations (NYSDEC, 2006). The default dispersion term derived by NYSDEC further assumes that the site is 0.5 acres in size.

The VF was initially recalculated using the previously derived Q/C for the site that is 1.1 acres in size, excludes dispersion constants for Cleveland, and incorporates a 2X breathing zone adjustment using the mass-limit equation shown below.

$$VF = Q/C \times \left[\frac{(T \times 3.15E + 07 \text{ s/yr})}{(\rho_b \times d_s \times 1E + 06 \text{ g/mg})} \right]$$

where:

Parameter	Description	VALUE	SOURCE
VF	Mass-limit volatilization factor, m ³ /kg		Calculated (4.61E+04)
Q/C	Air dispersion factor, g/m ² -s per kg/m ³	144.16	Derived Above
T	Average duration of volatilization, years	70	NYSDEC, 2006
ρ_B	Dry bulk soil density, mg/m ³	1.5	NYSDEC, 2006
D_S	Depth of contamination, meters	4.6	NYSDEC, 2006

The resulting mass-limit VF is greater than the NYSDEC generic value at 4.61E+04 m³/kg.

To assess the validity of the mass-limit VF, the VF was also calculated using the EPA's infinite source model with chemical-specific information for mercury and the soil property information for sand. In this model, the air-filled soil porosity is the most sensitive soil parameter affecting the final steady-state flux of volatile contaminants from soil. The higher the air-filled soil porosity, the greater the emission flux of volatiles (EPA, 1996). Sand and silt have the highest air-filled soil porosity values (0.32 cm³/cm³) among the SCS soil types.

The infinite source VF was calculated using the previously derived Q/C for the site using the equation below (EPA, 1996):

$$VF = \frac{Q/C \times (3.14 \times D_A \times T)^{0.5} \times 1E - 04 \text{ m}^2/\text{cm}^2}{(2 \times \rho_b \times D_A)}$$

where:

Parameter	Description	VALUE	SOURCE
VF	Infinite source volatilization factor, m ³ /kg	Calculated (4.24E+04)	
Q/C	Air dispersion factor, g/m ² -s per kg/m ³	72.08	Derived Above
T	Average duration of volatilization, seconds	2.208E+09	NYSDEC, 2006
ρ_B	Dry bulk soil density, mg/m ³	1.5	NYSDEC, 2006
D_A	Apparent diffusivity, cm ² /s	2.21E-05	Calculated Below

The mass transfer term, apparent diffusivity (D_A), is calculated using the HLC for elemental mercury and the default soil properties for sand, below (EPA, 1996):

$$D_A = \frac{(\theta_a^{3.33} \times D_{ia} \times H' + \theta_w^{3.33} \times D_{iw})/n^2}{(\rho_b \times K_d + \theta_w + \theta_a \times H')}$$

where:

Parameter	Description	VALUE	SOURCE
D_A	Apparent diffusivity, cm ² /s	Calculated (2.21E-05)	
K_d	Soil-water partition coefficient, cm ³ /g	52	EPA, 2002
D_{IA}	Diffusivity in air, cm ² /s	0.0307	Hg ⁰ (EPA, 2001)
θ_A	Soil air-filled porosity, cm ³ /cm ³	0.321	Calculated (n-θ _w)
N	Total soil porosity, cm ³ /cm ³	0.375	Sand (EPA, 2004)
D_{IW}	Diffusivity in water, cm ² /s	0.0000063	Hg ⁰ (EPA, 2001)
θ_w	Soil water-filled porosity, cm ³ /cm ³	0.054	Sand (EPA, 2004)
H'	Dimensionless HLC	0.35	Hg ⁰ (EPA, 2020)
ρ_B	Dry bulk soil density, mg/m ³	1.5	NYSDEC, 2006

The resulting infinite source VF is (4.24E+04 m³/kg) is consistent with the mass-limit VF (4.61E+04 m³/kg). The VF is used to calculate a Residential Use SCO for mercury using the NYSDEC methodology further described below.

NYSDEC adjusts the non-cancer RfC to account for relative source contribution. Relative source contribution (RSC) is the proportion of the total exposure that is allocated to an exposure media (accounting for multi-route exposures) in calculating acceptable concentrations for the media. NYSDEC has adopted a default RSC of 0.2 for all soil contaminants in ambient air, which directly results in a five-fold reduction of the SCO. Elemental mercury does not have an oral reference dose (RfD) and is very poorly absorbed by ingestion or dermal contact; therefore, inhalation exposure is the only germane exposure route. The Agency for Toxic Substances and Disease Registry (ATSDR) indicates that between 0.01 and 0.02 μg/m³ of mercury has been measured in

urban air (ATSDR, 1999). Current levels of mercury in the workplace are low (ATSDR, 1999). Other potential sources of Hg⁰ exposure are limited to cultural/folk uses of mercury, exposure through dental amalgams, and from indoor spills resulting from breakage of thermometers or other mercury-containing instruments (NJDEP, 2002). Therefore, the default RSC (and adjusted RfC, [RfC_{adj}]) is likely to significantly overestimate potential inhalation exposure to Hg⁰ from non-site sources.

For residential use, the Department assumes an exposure frequency of 217 days per year. The target hazard quotient (HQ) represents the ratio of exposure to toxicity for non-carcinogens, and it is set to the threshold level of unity. For volatile contaminants, the NYSDEC SCO is calculated as shown in equations 4 and 5 of the NYSDEC TSD and presented below:

$$SCO_{inhalation} = \frac{1 \times 365 \text{ days}}{\left(217 \frac{\text{days}}{\text{year}} \times 1 \text{ year} \times \left[\frac{1}{RfC_{adj}} \times \frac{1}{VF}\right]\right)}$$

The Residential Use SCO was recalculated using the mass-limit VF, prior to RSC adjustment. The resulting Residential Use Site-Specific Modeled Concentration (SSMC) is 6.97 mg/kg. When adjusted by the RSC, the adjusted Residential Use SSMC is 1.39 mg/kg. For comparison purposes, the NYSDEC default Residential Use SCO is 0.81 mg/kg.

The exposure point concentration (EPC) is the concentration of a constituent in a medium (e.g., soil) that is expected to be contacted by an individual and is assumed to be universally present throughout an exposure area. For this exposure assessment, the 95th percent upper confidence limit (UCL95) of the mean mercury soil concentration within the applicable depth for the VF (4.6 meters) was calculated to develop a conservative estimate of exposure and risk. The UCL95 is typically used as an appropriate reasonable maximum exposure (RME) estimate of concentrations likely to be contacted over time and is the recommended exposure point concentration in human health risk assessments, except in cases where the UCL95 is higher than the maximum concentration (EPA, 1989). Calculation of the UCL95 is dependent on the underlying distribution of sample data. Recommended UCL95 values for soil were derived using EPA's ProUCL Version 5.1 software (EPA, 2015).

Eight RI soil samples underwent selective sequential extraction as previously described. The maximum proportion of Hg⁰ in site soil was 10.87% of the total mercury soil concentration. Applying this maximum to all site soil, it can be assumed that approximately 89% of mercury in soil is present as mercury salts and organic mercury compounds. The SCO for inorganic mercury salts is based on the soil ingestion pathway. Under current conditions, resident exposure to onsite soil through ingestion is an incomplete exposure pathway. Therefore, to account for the results of the speciated soil data, the total soil data within the 0- 4.6-meter soil interval was

adjusted by the worst-case, maximum percent of Hg⁰ value (11%) prior to comparison to the Residential Use SCOs.

As shown in the table below, the site-wide EPC for elemental mercury exceeds both the NYSDEC Residential Use SCO and the Residential Use SSMC only when the risk-based value is adjusted by the RSC.

Source	Criteria (mg/kg)	Hg ⁰ UCL95 (mg/kg)	Exceedance
NYSDEC SCO	0.81	3.941	Yes
NYSDEC SCO (without RSC)	4.05		No
Residential Use SSMC	1.39		Yes
Residential Use SSMC (without RSC)	6.97		No

The relative source contribution is typically applied to contaminants in drinking water when there is documented evidence of widespread presence in other exposure media such as food, soil, air, or consumer products. The basis of the default RSC (0.2) is the EPA's drinking water program, which assumes that a major portion (80%) of total exposure to a contaminant comes from other sources such as diet. Given that the site is currently covered primarily with asphalt paving that will prevent the upward migration of mercury vapor, and that the site-wide Hg⁰ EPC is greater than health-based cleanup goals only when significant non-site exposure is occurring, soil impacts are not expected to represent an exposure concern.

REFERENCES

1. EPA, 2004. User's Guide for Evaluating Subsurface Vapor Intrusion Into Buildings. Office of Emergency and Remedial Response. Washington D.C. February 2004.
2. EPA, 2001. Water9 Software, Version 2. Office of Air Quality Planning and Standards. Research Triangle Park, NC.
3. EPA, 2020. November 2020 Regional Screening Levels. Updated Biannually.
4. EPA, 1996. Soil Screening Guidance: User's Guide. Publication 9355.4-23. Office of Solid Waste and Emergency Response. Washington, DC. July 1996.
5. NYSDEC/NYSDOH, 2006. New York State Brownfield Cleanup Program Development of Soil Cleanup Objectives Technical Support Document. September 2006.
6. EPA, 1986. Development of Advisory Levels for Polychlorinated Biphenyls (PCBs) Cleanup. EPA/600/6-86/002. Office of Research and Development. Washington, D.C. May 1986.
7. EPA, 2002. Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites Appendix A-C "Chemical Properties and Regulatory/Human Health Benchmarks for SSL Calculations". Table C-1: Chemical-Specific Properties used in SSL Calculations and Table C-4: Metal Kd Values (L/kg) as a Function of pH. OSWER 9355.4-24. Washington, DC. December 2002.
8. ATSDR, 1999. Toxicological Profile for Mercury. Agency for Toxic Substances and Disease Registry. March 1999.
9. NJDEP, 2002. New Jersey Mercury Task Force Volume II: Impacts of Mercury in New Jersey. January 2002.
10. EPA, 1989. Risk Assessment Guidance for Superfund. Volume I, Human Health Evaluation Manual (Part A). Interim Final. EPA/540/1-89/002. Office of Emergency and Remedial Response. Washington, DC.
11. EPA, 2015. ProUCL Version 5.1 User Guide. EPA/600/R-07/041. Office of Research and Development. October 2015.

A	B	C	D	E	F	G	H	I	J	K	L
1	UCL Statistics for Data Sets with Non-Detects										
2											
3	User Selected Options										
4	Date/Time of Computation		ProUCL 5.11/15/2021 12:49:38 PM								
5	From File		WorkSheet.xls								
6	Full Precision		OFF								
7	Confidence Coefficient		95%								
8	Number of Bootstrap Operations		2000								
9											
10											
11	Elemental Mercury										
12											
13	General Statistics										
14	Total Number of Observations			210		Number of Distinct Observations			128		
15	Number of Detects			177		Number of Non-Detects			33		
16	Number of Distinct Detects			117		Number of Distinct Non-Detects			15		
17	Minimum Detect			0.00319		Minimum Non-Detect			0.00605		
18	Maximum Detect			80.3		Maximum Non-Detect			1.32		
19	Variance Detects			62.87		Percent Non-Detects			15.71%		
20	Mean Detects			2.062		SD Detects			7.929		
21	Median Detects			0.0968		CV Detects			3.845		
22	Skewness Detects			7.314		Kurtosis Detects			62.74		
23	Mean of Logged Detects			-1.922		SD of Logged Detects			2.263		
24											
25	Normal GOF Test on Detects Only										
26	Shapiro Wilk Test Statistic			0.296		Normal GOF Test on Detected Observations Only					
27	5% Shapiro Wilk P Value			0		Detected Data Not Normal at 5% Significance Level					
28	Lilliefors Test Statistic			0.398		Lilliefors GOF Test					
29	5% Lilliefors Critical Value			0.067		Detected Data Not Normal at 5% Significance Level					
30	Detected Data Not Normal at 5% Significance Level										
31											
32	Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs										
33	KM Mean			1.739		KM Standard Error of Mean			0.505		
34	KM SD			7.297		95% KM (BCA) UCL			2.735		
35	95% KM (t) UCL			2.574		95% KM (Percentile Bootstrap) UCL			2.609		
36	95% KM (z) UCL			2.57		95% KM Bootstrap t UCL			3.392		
37	90% KM Chebyshev UCL			3.254		95% KM Chebyshev UCL			3.941		
38	97.5% KM Chebyshev UCL			4.893		99% KM Chebyshev UCL			6.764		
39											
40	Gamma GOF Tests on Detected Observations Only										
41	A-D Test Statistic			13.52		Anderson-Darling GOF Test					
42	5% A-D Critical Value			0.886		Detected Data Not Gamma Distributed at 5% Significance Level					
43	K-S Test Statistic			0.212		Kolmogorov-Smirnov GOF					
44	5% K-S Critical Value			0.0762		Detected Data Not Gamma Distributed at 5% Significance Level					
45	Detected Data Not Gamma Distributed at 5% Significance Level										
46											
47	Gamma Statistics on Detected Data Only										
48	k hat (MLE)			0.266		k star (bias corrected MLE)			0.265		
49	Theta hat (MLE)			7.757		Theta star (bias corrected MLE)			7.779		
50	nu hat (MLE)			94.1		nu star (bias corrected)			93.84		
51	Mean (detects)			2.062							
52											

A	B	C	D	E	F	G	H	I	J	K	L
53	Gamma ROS Statistics using Imputed Non-Detects										
54	GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs										
55	GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20)										
56	For such situations, GROS method may yield incorrect values of UCLs and BTVs										
57	This is especially true when the sample size is small.										
58	For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates										
59	Minimum	0.00319	Mean	1.74							
60	Maximum	80.3	Median	0.0677							
61	SD	7.315	CV	4.205							
62	k hat (MLE)	0.246	k star (bias corrected MLE)	0.245							
63	Theta hat (MLE)	7.076	Theta star (bias corrected MLE)	7.086							
64	nu hat (MLE)	103.2	nu star (bias corrected)	103.1							
65	Adjusted Level of Significance (β)	0.0489									
66	Approximate Chi Square Value (103.10, α)	80.67	Adjusted Chi Square Value (103.10, β)	80.54							
67	95% Gamma Approximate UCL (use when $n \geq 50$)	2.223	95% Gamma Adjusted UCL (use when $n < 50$)	2.227							
68											
69	Estimates of Gamma Parameters using KM Estimates										
70	Mean (KM)	1.739	SD (KM)	7.297							
71	Variance (KM)	53.25	SE of Mean (KM)	0.505							
72	k hat (KM)	0.0568	k star (KM)	0.0592							
73	nu hat (KM)	23.86	nu star (KM)	24.86							
74	theta hat (KM)	30.61	theta star (KM)	29.39							
75	80% gamma percentile (KM)	0.404	90% gamma percentile (KM)	3.227							
76	95% gamma percentile (KM)	9.719	99% gamma percentile (KM)	35.3							
77											
78	Gamma Kaplan-Meier (KM) Statistics										
79	Approximate Chi Square Value (24.86, α)	14.5	Adjusted Chi Square Value (24.86, β)	14.45							
80	95% Gamma Approximate KM-UCL (use when $n \geq 50$)	2.981	95% Gamma Adjusted KM-UCL (use when $n < 50$)	2.993							
81											
82	Lognormal GOF Test on Detected Observations Only										
83	Shapiro Wilk Approximate Test Statistic	0.951	Shapiro Wilk GOF Test								
84	5% Shapiro Wilk P Value	1.6461E-5	Detected Data Not Lognormal at 5% Significance Level								
85	Lilliefors Test Statistic	0.0752	Lilliefors GOF Test								
86	5% Lilliefors Critical Value	0.067	Detected Data Not Lognormal at 5% Significance Level								
87	Detected Data Not Lognormal at 5% Significance Level										
88											
89	Lognormal ROS Statistics Using Imputed Non-Detects										
90	Mean in Original Scale	1.739	Mean in Log Scale	-2.534							
91	SD in Original Scale	7.315	SD in Log Scale	2.536							
92	95% t UCL (assumes normality of ROS data)	2.573	95% Percentile Bootstrap UCL	2.597							
93	95% BCA Bootstrap UCL	3.004	95% Bootstrap t UCL	3.337							
94	95% H-UCL (Log ROS)	3.833									
95											
96	Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution										
97	KM Mean (logged)	-2.45	KM Geo Mean	0.0863							
98	KM SD (logged)	2.414	95% Critical H Value (KM-Log)	3.634							
99	KM Standard Error of Mean (logged)	0.167	95% H-UCL (KM -Log)	2.917							
100	KM SD (logged)	2.414	95% Critical H Value (KM-Log)	3.634							
101	KM Standard Error of Mean (logged)	0.167									
102											
103	DL/2 Statistics										
104	DL/2 Normal					DL/2 Log-Transformed					

	A	B	C	D	E	F	G	H	I	J	K	L
105	Mean in Original Scale					1.742	Mean in Log Scale					-2.489
106	SD in Original Scale					7.314	SD in Log Scale					2.484
107	95% t UCL (Assumes normality)					2.576	95% H-Stat UCL					3.443
108	DL/2 is not a recommended method, provided for comparisons and historical reasons											
109												
110	Nonparametric Distribution Free UCL Statistics											
111	Data do not follow a Discernible Distribution at 5% Significance Level											
112												
113	Suggested UCL to Use											
114	95% KM (Chebyshev) UCL					3.941						
115												
116	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
117	Recommendations are based upon data size, data distribution, and skewness.											
118	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
119	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
120												