APPENDIX C
MVS MODEL REPORT

MVS MODEL REPORT

(2013 SEDIMENT SAMPLING PROGRAM)

PALOS VERDES SHELF (OU 5 OF THE MONTROSE CHEMICAL CORPORATION SUPERFUND SITE)
LOS ANGELES COUNTY, CALIFORNIA

EPA Contract No. EP-S9-08-03
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LIST OF ACRONYMS AND ABBREVIATIONS

C Tech	C Tech Development Corporation
cm	centimeters
COC	chemical of concern
EA	effluent-affected
EPA	United States Environmental Protection Agency
g/cm^3	grams per cubic centimeter
Geo-EAS	Geostatistical Environmental Assessment Software
kg	kilogram(s)
m	meter(s)
m^3	cubic meters
ug/kg	micrograms per kilogram
MIV	mass inventory volume
MVS	Mining Visualization System
OA	outfall area
OC	organic carbon
PCBs	polychlorinated biphenyls
pph	parts per hundred
PV Shelf	Palos Verdes Shelf
RD	remedial design
Sanitation Districts	Sanitation Districts of Los Angeles County
RL	reporting limit
SSRC	Superfund Sediment Resource Center
SWAC	surface (area) weighted average concentration
TOC	total organic carbon
USGS	United States Geological Survey
UTM	Universal Transverse Mercator
2D	two-dimensional
3D	three-dimensional
%	percent

1.0 INTRODUCTION

A three-dimensional (3D) geostatistical model was developed for sediment at Palos Verdes Shelf (PV Shelf) using analytical and geotechnical data sets generated from tests of sediment samples derived from cores collected in 2013. The geostatistical software package chosen as the basis for the model was the Mining Visualization System (MVS) Version 9.94, by C Tech Development Corporation (C Tech), Bellingham, Washington.

The 3D model of the 2013 sediment data was developed using the same modeling tools and methods utilized to develop the 3D model of the 2009 sediment data. The 2009 model settings were replicated for use in the development of the 2013 model. The 2009 model is documented in Final Data Report for the 2009 Sediment Sampling Program (ITSI Gilbane and CDM Smith 2013).

The 3D model as developed is capable of estimating volumes of contaminated sediment and mass of contaminants, based on both depth and area. The model also provides an assessment of how well-characterized the site is with the sampled data and can also serve as a decision support tool for remedial analyses.

This report outlines the steps taken to develop the model including how the data sets were developed, and presents the model inputs and results.

2.0 METHODS

This section provides descriptions of the methods used in developing the MVS model.

2.1 MODELING SOFTWARE

As previously mentioned, C Tech's MVS Version 9.94 was the software package used to develop the geostatistical model for sediment at PV Shelf. Kriging was chosen as the method of interpolation for the MVS model because it provides both an ability to interpolate sparse measured data in three dimensions and a statistical measurement of the adequacy of the interpolation in the form of confidence. The result is an understandable, repeatable, and geostatistically defensible product.

MVS performs the following functions: (1) analyzes the input data; (2) determines a best fit variogram for the data set being analyzed; and (3) performs ordinary kriging in the domain to be considered in the visualization using the variogram model parameters. The user is given the option to specify values for the parameters that control the variogram-kriging procedure, and the subsequent display and analysis of the data.

For modeling the PV Shelf, fundamental objectives used in developing the MVS variogram and kriging algorithms included: (1) producing kriged distributions that honored the measured point values as closely as possible; and (2) providing the user with a valid mechanism for comparing the modeled and measured domains and a method for documenting the variogram model. An examination of the variogram for the modeled data was completed to arrive at the best fit.

2.2 DATA SELECTION AND EVALUATION

2.2.1 Stratigraphic Data

The bottom depth of each sediment core was used to define the thickness of the modeled area for the stratigraphic model. Shortcomings in the core collection method used in 2009 and again in 2013, i.e., gravity coring, include: (1) potential material loss at the top of the effluent-affected (EA) bed; (2) possible exceedances of the vertical limit of the EA bed (core penetration into the native sediment); and (3) the possibility of the coring device not reaching the bottom of the EA bed, due to refusal. However, these shortcomings are balanced due to the fact that all cores were collected using the same methodology. The core collection approach was consistent with methods developed by the Sanitation Districts of Los Angeles County (Sanitation Districts, 2006) and replicated in the 2009 event. Section 4.3 of the main report discusses EA bed depth relative to core length.

Vertical relief of the sea floor within the baseline modeled area exceeds 110 meters (m); the estimated bed thickness based on core length is less than 1 m. The deposition of sediment in layers over time is a greater relational factor than the absolute measured elevation of samples. Therefore, all geologic data were referenced to depth in the sea floor bed rather than to sea level, to allow the kriging algorithms to fit the chemical data and depositional process most effectively.

2.2.2 Analytical Data (Chemical and Physical)

The geostatistical modeling effort centered on a subset of the sediment data generated from geotechnical and chemical testing of sediment samples derived from the 2013 coring event and subsequent core slicing events. Modeled parameters included bulk density; total organic carbon (TOC); and eight individual forms of DDT.

The following chemical groupings were also modeled: Total DDTs, consisting of six forms of DDT where toxicity data have been established (o,p’-DDD, p,p’-DDD, o,p’-DDE, p,p’DDE, o,p’-DDT, and p,p’-DDT); Total DDT Compounds (Total DDTs plus p,p’-DDMU and p,p’-DDNU); and Total Polychlorinated Biphenyls (Total PCBs). For PCBs, the 2009 short list of congeners and the 2013 expanded list were both analyzed.

The DDT and PCB analytical data were provided by the testing laboratory without carbon normalization relative to organic carbon (OC). Analytical data were normalized to OC for each sample using the specific TOC value reported for that sample, following accepted methodology for sediment (Michelsen, 1992).

Calculations were performed in Microsoft Excel on a sample-by-sample basis. The following equation was used:

$$ug/kg\ OC \quad = \quad ug/kg\ dry\ weight/(kg\ TOC/kg\ dry\ weight)$$

Where:

ug/kg OC = micrograms of the chemical per kilogram of OC
ug/kg dry weight = micrograms of the chemical per kilogram of dry weight sample
kg TOC/kg dry weight = percent (%) TOC in dry weight sample (expressed as a decimal; for example, 44% TOC = 0.44)

For calculating chemical mass, the laboratory-reported bulk density was converted to dry density using the following equation:

$$\mathit{dry\ density} = \mathit{bulk\ density}/(1+W)$$

Where:

W = fractional water content = moisture content/(1-moisture content)

Calculations were performed on a sample-by-sample basis.

Early investigators at PV Shelf converted the density and concentration information for each core sample interval into a value expressed as an “inventory”, using units of mass per area (Eganhouse, 2008). Beginning with the analysis of EPA’s 2009 sediment data, the conversions were done by the model at every grid node after density and concentration were interpolated, rather than just at the individual core location. This method was replicated with the 2013 sediment data set. This approach allowed the model to consider spatial trends for density and concentration separately, rather than assuming that the ratio of one to the other at a given sample interval would remain uniform in interpolated areas between core locations. The approach also provided calculations of the total mass of each analyte or analyte grouping for the entire modeled area(s).

Analytical data were reported in micrograms per kilogram (ug/kg), and the model input files maintained that unit ratio. TOC data were reported in parts per hundred (pph) and were used as such in the normalization process. Bulk density data were reported in grams per cubic centimeter (g/cm^3), and the conversion to dry density maintained the same units.

Results for analytical and geotechnical samples (for both primary and replicate sediment cores) were loaded into the geostatistical input files. Chemistry results for the individual DDT isomers plus the summations of Total DDTs, Total DDT Compounds, and Total PCBs were input to the model. For samples with replicate results, the primary and replicate results were averaged.

Where an individual DDT isomer was reported as less than the reporting limit (RL), the result was input into the MVS model as < RL (e.g., < 3 ug/kg when the RL was 3 ug/kg). Where summations (i.e., Total DDTs, Total DDT Compounds, and Total PCBs) were reported as non-detected, the model assumed a value of < 5 ug/kg. When the MVS model was provided a "< RL" value, the model used ½ of the RL value (e.g., if the value in the MVS input file was "< 5 ug/kg", the software used a value of 2.5 ug/kg).

2.3 MODEL SETUP

Parameters that formed the model input are described below.

2.3.1 Model Domain

The XY model domain for the 2013 sediment model matched the model domain used for the 2009 3D model. The 3D model domain was based on an area that extended roughly 10% beyond the sediment sampling locations. This area was then bounded on the shoreline side at the 30-m isobath, and bounded on the continental-shelf side at the 150-m isobath. Replicating the 2009 model method, the vertical extent of the 3D model was the interpolated surface of the bottom of the retrieved cores from the 2013 dataset.

2.3.2 Grid Cell Resolution

The grid resolution of the 3D model replicated the settings from the 2009 model. A rectilinear grid with a resolution of 371 (X) x 142 (Y) x 44 (Z) was created for the model. This yielded approximately 2.3 million grid cells in the model. The resultant cell model size using this resolution was 50 m by 50 m by ~0.02 m (the vertical resolution varies along with the varying thickness of the sampled sediment bed, as the number of cells in the Z axis was fixed at 44 cells).

This model grid was referenced to Universal Transverse Mercator (UTM) Zone 11. The Y axis was rotated to align with a 327.6 degree azimuth, equal to a 57.6-degree clockwise rotation of the X axis. This approach allowed for the model grid to align with the predominant direction of ocean currents (and thus with the mode of deposition along PV Shelf) which also fits best with the current data set. This orientation is consistent with previous MVS modeling work and the work by Murray (1994) and Drake (1994), who used a rotation of approximately 60 degrees in the same coordinate system. Table C.1 presents dimensional features of the full monitored area.

2.4 INTERPOLATION OF STRATIGRAPHIC DATA

As in the previous MVS modeling work, kriging was chosen as the geostatistical interpolation mechanism for the stratigraphic data, because it allowed the grid to be established in the selected uniform spacing and interpolate between the spatially sparse data set. Stratigraphic data were kriged in 2-D only. The top of the sediment bed was set to zero depth and the bottom of the sediment bed was interpolated from the bottom depths of each sampled location, creating two surfaces. The two surfaces defined a volume within which all analytic and geotechnical data were interpolated. This volume was used for all COC mass calculations.

2.4.1 Variograms for Stratigraphic Data

The variogram is a graph illustrating the correlation between the sample results and the distances between sample locations. The graph plots the half of the average squared differences between paired sample results on the Y axis and the distance between the paired sample locations on the X axis. The variogram model is a best-fit curve to the variogram graph.

Horizontal-to-vertical anisotropy is one of the variogram variables affecting the variogram graph results. Anisotropy is a variable utilized to improve the variogram graph results by increasing the distance between values in the Z axis in relation to the distances in the XY axis. In modeling environmental analytical data, it is typical to use anisotropy values of 5 to 50 to accommodate the common sampling scenario where many samples exist at a single XY location (for example a borehole). These samples within a single borehole are much more closely spaced in the Z axis when compared to the nearest different XY location (a different boring) which also has numerous samples in Z. To improve the geospatial statistics, a horizontal-to-vertical anisotropy value is applied to the dataset to effectively stretch the Z space out to more closely match (but not necessarily equal) the distances between different borings. This stretching enables the variogram results to provide a better result than without the stretching.

As with all other modeling variables, the 2013 model replicated the anisotropy values used in the 2009 model. The horizontal-to-vertical anisotropy value of 20,000 was used in the 2009 model and thus was incorporated into the 2013 model. Higher and lower anisotropy values were evaluated on both the 2009 and 2013 datasets and 20,000 was determined to be the value that provided the most reasonable variogram results. Because of the physical properties of the sediment depositional environment combined with the extreme variation between the thickness of the sediment bed (~1 m) when compared to the XY distances between sample locations (ranging nearly as high as 16 km), it was necessary to incorporate a very high anisotropy value. Table C.2 summarizes parameters used in the model to interpolate the stratigraphic data, including values for range and sill.

2.4.2 Kriging Approach for Stratigraphic Data

The kriging parameters used in the MVS software for this model were recorded for use in future modeling efforts. The parameters include: pair search range, semi-variogram symmetry, XY minimum search range, reach/points, and Z minimum search range. Numbers of search pairs are listed in Table C.2.

2.5 INTERPOLATION OF ANALYTICAL DATA (CHEMICAL AND PHYSICAL)

Kriging was used as the geostatistical interpolation mechanism of both chemical and physical data due to its capabilities to grid in the selected uniform spacing and to interpolate between the spatially sparse data set.

2.5.1 Variograms for Analytical Data

Table C.2 summarizes the variogram parameters used in the model to interpolate the analytical data, including values for range and sill. Another parameter of a variogram model is the nugget value which is the Y-intercept of the variogram model curve. The nugget value has no impact on the predicted nominal model value, which is the value used for average concentration and total mass estimates. The nugget value has an impact on the uncertainty and confidence values of the interpolated values in the 3D model. MVS version 9.54, which was used for the 2009 sediment analysis, sets the nugget value to zero. This value was used in the analysis of the current (2013) sediment data set.

2.5.2 Kriging Approach for Analytical Data

Table C.2 lists parameters used in in the model to interpolate the analytical data, including values for range and sill. The kriging parameters used in the MVS software were recorded for use in future modeling efforts. These include the pair search range, semi-variogram symmetry, XY minimum range, reach/points, Z minimum range, and horizontal/vertical anisotropy.

3.0 MODEL OUTPUT

Model output is discussed in this section. Model results for average concentrations and mass of COCs are discussed in the main report and presented in Tables 3-7 and 3-8.

3.1 SUBSETTING AND VISUALIZATION

The interpolated results incorporated all of the available data. Estimated mass values for subset areas (e.g. the outfall area [OA] values), or 3D visualizations showing subset areas, of the model were ‘clipped’ out of this original all data interpolation and are not based on interpolations of the subsetted data. Visualizations of the MVS model output are presented as follows:

- Figures 3-2, 3-4, and 3-5 in the main report depict cross sections along the C (60-m) isobath for interpretive concentration contours of the groupings of Total DDTs, Total PCBs (2009 congener list), and Total PCBs (2013 congener list), respectively.
- Figures attached to this MVS report depict oblique views of the sediment bed showing the groupings of Total DDTs, Total DDT Compounds, Total PCBs (short congener list), and Total PCBs (expanded congener list), respectively.

3.2 METHODOLOGY FOR ESTIMATING AVERAGE CONCENTRATIONS AND MASS OF COCS

The volumetrics module within the MVS software was used to calculate values for the average (mean) concentration and the mass of COCs. To derive average concentrations of the main COC groupings (i.e., Total DDTs, Total DDT Compounds, and Total PCBs [both short and expanded lists]), the modeled concentrations at all nodes were summed and then divided by the total number of nodes. To derive the masses of the individual DDT analytes, Total DDTs, Total DDT Compounds, and Total PCBs (short and expanded lists), the calculated mass inventory volume (MIV) for each modeled cell was summarized. The equation for deriving MIV in kilograms per cubic meter (kg/m^3) is given below.

$$MIV = 10^{An(0)} \times Bn(0) \times 0.000001$$

where:

An(0) = kriged analyte concentration in logarithmic units
Bn(0) = kriged dry density in g/cm^3 (non-logarithmic units)
0.000001 = unit conversion factor of concentration (ug/kg) x density (g/cm^3) = (kg/m^3)

Tables 3-7 and 3-8 in the main report list the model output values.

3.3 CONFIDENCE AND UNCERTAINTY

As described in the 2009 MVS report (Appendix A of ITSI Gilbane, 2013), the use of kriging allowed model variability to be calculated and, specifically, the confidence in the model. Specifically, MVS was utilized by first computing the standard deviation for each estimated point. The standard deviation was then used to compute the confidence. The standard deviation is proportional to the square root of the sill in the variogram, because the standard deviation is computed as the square root of the variance and the variance is directly proportional to the sill.

To calculate confidence for the PV Shelf model, the model parameters are set to solve the question, “What is the confidence that the actual concentration will fall within a specified factor of the predicted concentration?” Confidence was calculated using a confidence bound factor of 2 for this exercise. In this way, the calculated confidence represents the confidence that the actual concentration falls within a factor of 2 of the predicted concentration, i.e., an actual value of 10 ug/kg may be represented in the model as a value between 5 ug/kg and 20 ug/kg.

The actual calculation to assign confidence requires the standard deviation of the concentration estimate at each node (as described above) and the confidence bound value. This approach provides a “statistical goodness” measure of the modeled result for current and future comparison. The model was used to derive confidence parameters for three analyte groupings: Total DDTs, Total DDT Compounds, and Total PCBs.

3.3.1 Confidence Results: Total DDTs

For Total DDTs in the entire data set, the confidence was seen to vary from a low of 35.1% to a high of 100%. The confidence values of 100% occurred only at actual sampling locations. The mean of the confidence for Total DDTs was 67.5%, with a median value of 66.5%. Overall, these values indicate that the site is reasonably well characterized, with predicted values likely falling within a factor of 2 of actual values 67.5% of the time.

The OA data set has a minimum confidence of 42%, a maximum of 100%, a mean of 75.6%, and a median of 76.3%. This indicates that the outfall area is well characterized for Total DDTs relative to the entire sediment bed.

3.3.2 Confidence Results: Total DDT Compounds

For Total DDT Compounds in the entire data set, the confidence was seen to vary from a low of 35% to a high of 100%. Again, the confidence values of 100% occurred only at actual sampling locations. The mean of the confidence for Total DDT Compounds was 67.7%, with a median value of 66.8%. Overall, these values indicate that the site is reasonably well characterized, with predicted values likely falling within a factor of 2 of actual values 67% of the time.

The OA data set has a minimum confidence of 42%, a maximum of 100%, a mean of 75.8%, and a median of 76.6%. These values indicate that the OA is well characterized for Total DDT Compounds relative to the entire sediment bed.

3.3.3 Confidence Results: Total PCBs

For Total PCBs in the entire data set, the confidence was seen to vary from a low of 37.2% to a high of 100%. Again, the confidence values of 100% occurred only at actual sampling locations. The mean of the confidence for Total PCBs was 70%, with a median value of 69%. Overall, these values indicate that the site is reasonably well characterized, with predicted values likely falling within a factor of 2 of actual values 70% of the time.

The OA data set has a minimum confidence of 44%, a maximum of 100%, a mean of 78%, and a median of 79%. This indicates that the OA is well characterized for Total PCBs relative to the entire sediment bed. Confidence values for Total DDTs, Total DDT Compounds, and Total PCBs are presented in Table A.3 for the full model and Table A.4 for the OA, respectively.

3.3.4 Alternative Method for Evaluating Confidence & Uncertainty: p,p-DDE

An alternative to the confidence and uncertainty method discussed in the subsections above is to utilize the min-max kriging capabilities within the MVS software. This min-max kriging method was not used in the 2009 report, but is used here with the 2013 modeling effort, for comparison. Kriging is an interpolation method that calculates a range of predicted (or interpolated) values for a given node in the model, and the values across this range can be used to calculate error bars associated with the various outputs produced from the model. For example, the values presented in Table 3-7 and Table 3-8 of the main report use the “nominal” value for the calculations. This nominal value is the value at the middle of the predicted range of values, with 50% error both above and below the predicted value.

By selecting a value from the range of predicted values either above or below the nominal value, the model is able to calculate a result where the error is biased either high or low. By selecting a statistically significant distance within the range to move up or down from the nominal (for example one standard deviation within a normal distribution or +/- 34.1% equaling a 68.2% confidence interval), we can estimate min and max output values (e.g., average concentrations or total masses) which provide the bounds within which we would expect the actual value to exist 68.2% of the time, or approximately 7 out of 10 times. This min-max analysis provides another way to evaluate the uncertainty and confidence in the model.

This min-max analysis was completed on the p,p-DDE results for the 2013 sample data. As presented in Table 3-8 of the main report, the nominal mass for p-p’-DDE within the 0-8 cm sediment bed is 2,500 kg. The +/- 34.1% values are 1,800 kg and 3,500 kg, respectively. The model is predicting that 68.2% (34.1% x 2) of the time the actual mass value will fall within the range of 1,800 kg to 3,500 kg, with the nominal value within this range equal to the reported value of 2,500 kg.

3.3.5 Confidence and Uncertainty Summary

The confidence values derived using the two different methods presented above are comparable. Additionally, the confidence and uncertainty in the 2013 data set are consistent with the 2009 confidence and uncertainty discussed in the 2009 report. The confidence and uncertainty parameters as described herein are based on the kriging results as reported by the MVS model. The “model” uncertainty (and confidence) does not address uncertainty associated with factors outside of the MVS model, such as heterogeneity of the sediment bed, sampling methodology, and variabilities in analytical laboratory test methods.

4.0 MODEL OUTPUT VARIABLES

Model output files (.4d extension) that can be opened with the 4D Interactive Model (4DIM) Player software are available upon request. The player is freeware developed by C Tech. The files allow the user to examine the model output as a 3D document. The files document the various components of the model, e.g., geologic framework, bathymetry, and analytic data, and provide a visual analysis of the semi-variogram through a 3D cloud plot. These files are licensed to be opened via the 4DIM Player, and provide full 3D zoom, translation, and rotation capability. The viewer is downloadable for free from C Tech at https://www.ctech.com/4d-interactivemodels.

5.0 REFERENCES

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TABLES

Table C.1 - Dimensional Features of the Geostatistical Model
First MNR Report
Palos Verdes Shelf (OU 5 of the Montrose Chemical Corp. Superfund Site)
Los Angeles County, California

Parameter	*Value*
Full model	
Modeled area (sq km)	29.8
Modeled volume (million cu m)	14.5
Number of cells	2,318,008
Number of nodes	2,393,820
Easting minimum (m)	365,798
Easting maximum (m)	380,694
Easting extent (m)	14,896
Northing minimum (m)	3,725,454
Northing maximum (m)	3,737,180
Northing extent (m)	11,726
Centroid coordinates (northing, easting, depth	3,731,317; 373,246; -0.44
Horizontal to Vertical Anisotropy	20,000

Abbreviations:

cu m	- Cubic meters
m	- Meters
sq km	- Square kilometers

Table C.2 - Parameters for Data Interpolation
First MNR Report
Palos Verdes Shelf (OU 5 of the Montrose Chemical Corp. Superfund Site)
Los Angeles County, California

Model	***Range (meters*)***	***Sill***	***Number of search pairs***
Stratigraphic data kriging (2D)			
Modeled area	4870	0.05	1,711
Analytical (chemical) data kriging (3D)			
Total DDTs	9,979	1.18	124,800
o,p'-DDE	8,744	1.20	124,800
o,p'-DDT	8,744	1.05	124,800
p,p'-DDD	8,744	1.20	124,800
p,p'-DDE	8,744	1.27	124,800
p,p'-DDT	8,744	1.91	124,800
p,p'-DDMU	8,744	1.18	124,800
p,p'-DDNU	8,744	0.95	124,800
Total PCBs (2009 congener list)	9,779	1.04	124,800
Total PCBs (2013 congener list)	9,779	1.15	124,800
Analytical (bulk density) data kriging (3D)			
Modeled area	8,753	0.05	124,063
Bathymetry			
Modeled area	4849	0.05	1,711

***Although the range is meters, it is after anisotropy has been applied to the model locations and thus is a post anisotropy measurement.**

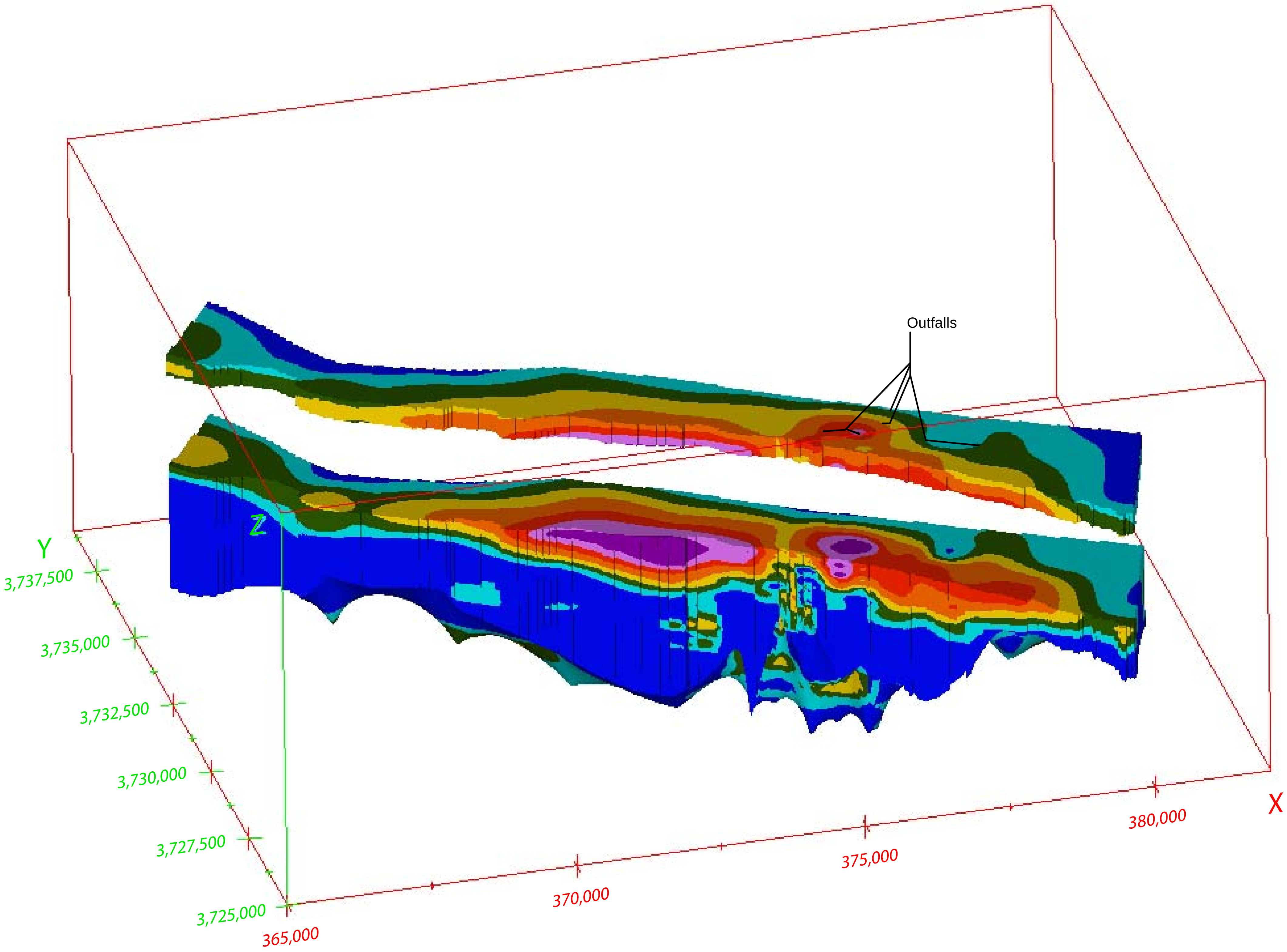
Table C.3 - Confidence Values of the Geostatistical Model - Full Model
First MNR Report
Palos Verdes Shelf (OU 5 of the Montrose Chemical Corp. Superfund Site)
Los Angeles County, California

Parameter	*Value (percent)*
Total DDT Compounds	
Mean	67.7
Median	66.8
Data minimum	35
Data maximum	100.0
Total DDTs	
Mean	67.5
Median	66.5
Data minimum	35.1
Data maximum	100.0
Total PCBs	
Mean	70
Median	69
Data minimum	37.2
Data maximum	100.0

Table C.4 - Confidence Values of the Geostatistical Model - Outfall Area
First MNR Report
Palos Verdes Shelf (OU 5 of the Montrose Chemical Corp. Superfund Site)
Los Angeles County, California

Parameter	*Value (percent)*
Total DDT Compounds	
Mean	75.8
Median	76.6
Data minimum	42
Data maximum	100.0
Total DDTs	
Mean	75.6
Median	76.3
Data minimum	42
Data maximum	100.0
Total PCBs	
Mean	78
Median	79
Data minimum	44
Data maximum	100.0

FIGURES



Legend

Total DDTs (ug/kg)

- 🟦 <230
- 🟦 230 - 500
- 🟩 500 - 1,000
- 🟨 1,000 - 2,000
- 🟧 2,000 - 5,000
- 🟥 5,000 - 10,000
- 🟪 10,000 - 20,000
- 🟪 >20,000

Notes

1. Top 8 cm of sediment is shown separated from the remainder of the monitored area sediment.
2. Concentrations are not normalized for organic carbon.

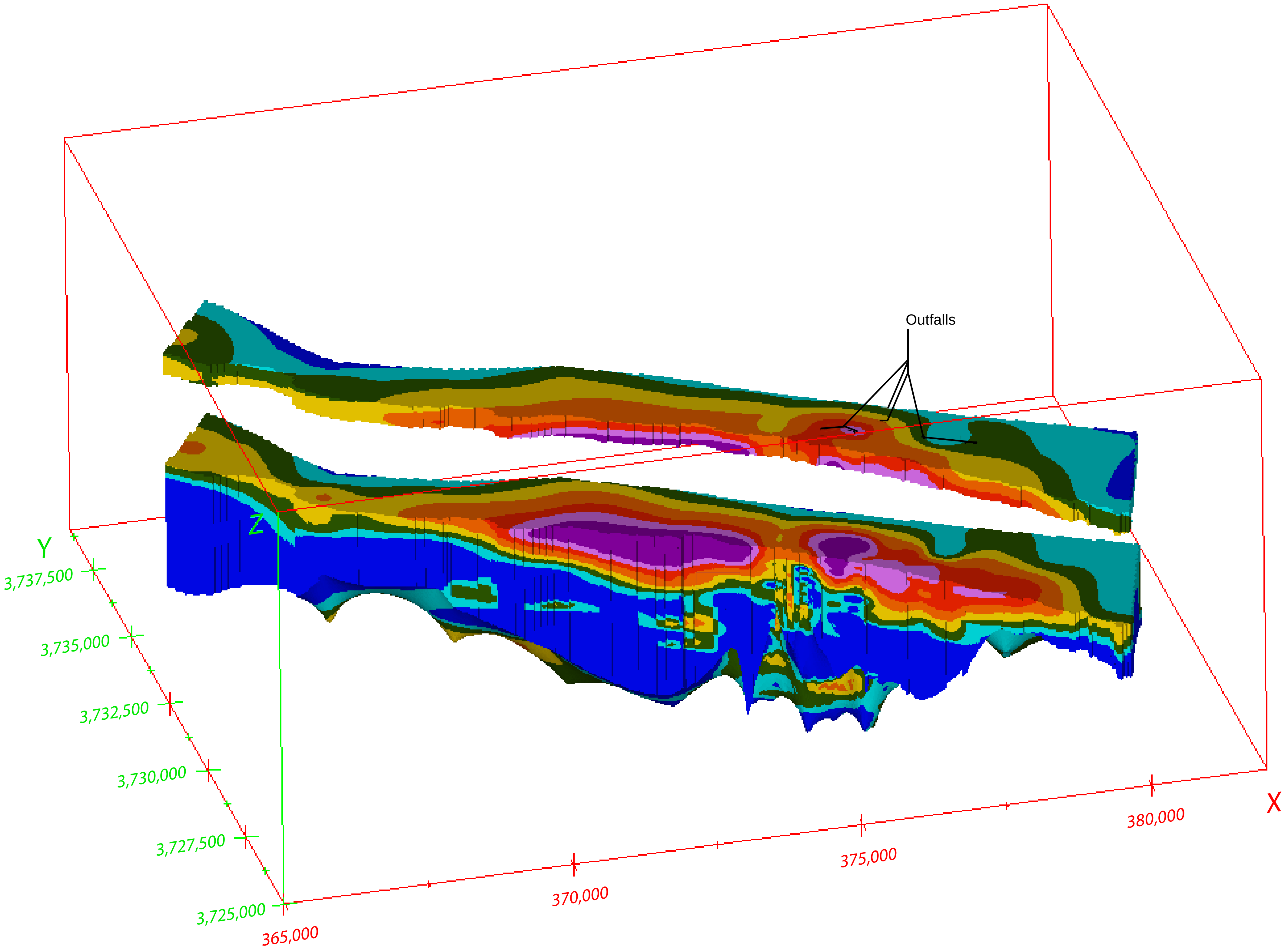
Abbreviations

cm	Centimeters
ug/kg	Micrograms per kilogram

Figure C.1
Interpretive Concentrations of
Total DDTs

MVS Model Report
2013 Sediment Sampling Program
Palos Verdes Shelf
Los Angeles County, California

EPA
United States
Environmental Protection
Agency



Legend

Total DDTs (ug/kg)

🟦	<230
🟦	230 - 500
🟩	500 - 1,000
🟨	1,000 - 2,000
🟧	2,000 - 5,000
🟥	5,000 - 10,000
🟪	10,000 - 20,000
🟪	>20,000

Notes

1. Top 8 cm of sediment is shown separated from the remainder of the monitored area sediment.
2. Concentrations are not normalized for organic carbon.

Abbreviations

cm	Centimeters
ug/kg	Micrograms per kilogram

Figure C.2
Interpretive Concentrations of
Total DDT Compounds

MVS Model Report
2013 Sediment Sampling Program
Palos Verdes Shelf
Los Angeles County, California

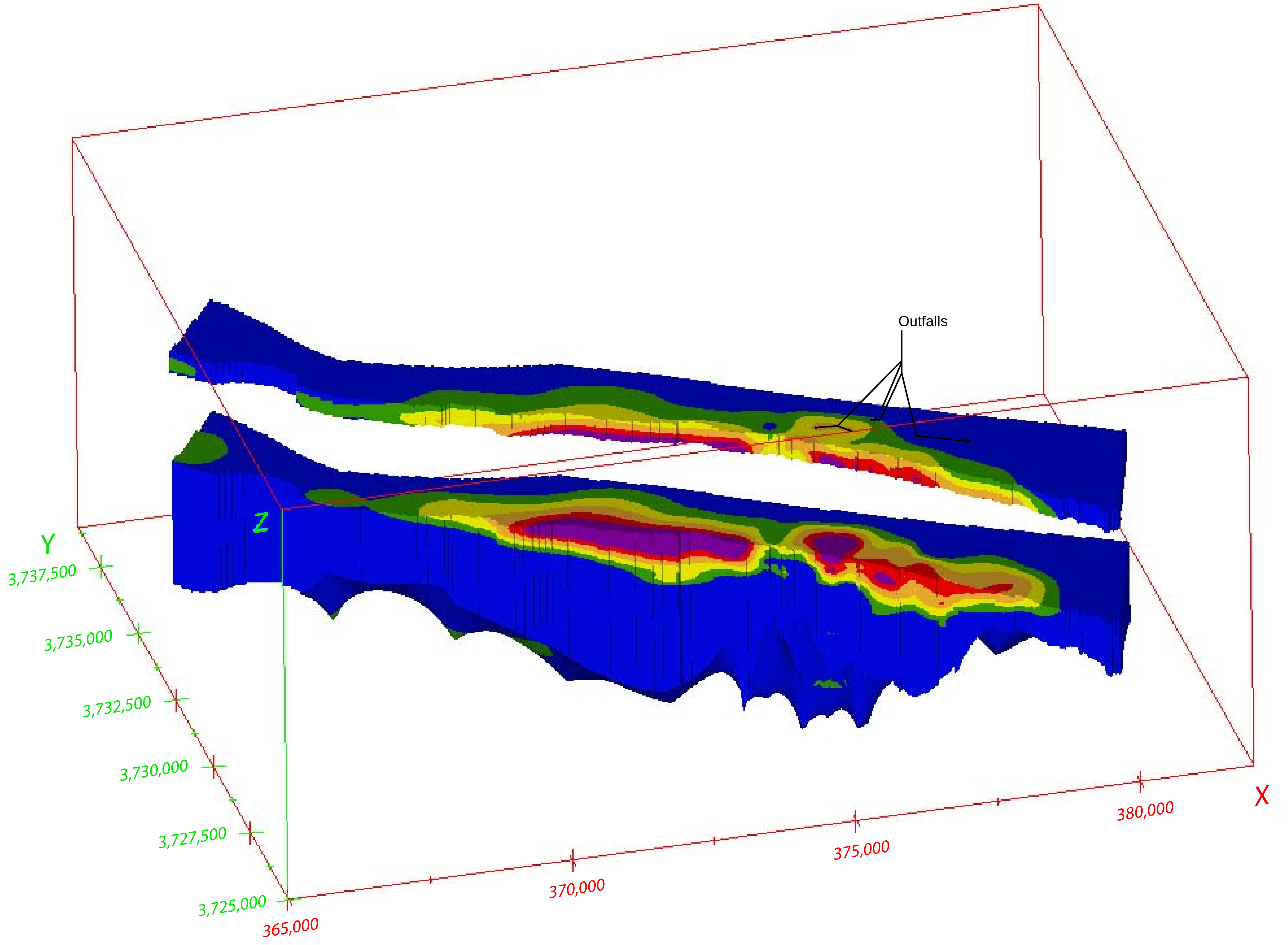
EPA United States
Environmental Protection
Agency

P:\EPAR9\0069 TO 068-RARA-09CA PV Shelf RA\13.0 Graphics\Total_DDT CPD.ai 10/27/2017

Figure C.3
Interpretive Concentrations of
Total PCBs (Short List)

MVS Model Report
2013 Sediment Sampling Program
Palos Verdes Shelf
Los Angeles County, California

EPA United States Environmental Protection Agency



Legend

Total PCBs (ug/kg)

- 🟦 5 - 70
- 🟩 70 - 150
- 🟨 150 - 300
- 🟧 300 - 600
- 🟥 600 - 1,000
- 🟪 >1,000

Notes

1. Top 8 cm of sediment is shown separated from the remainder of the monitored area sediment.
2. Concentrations are not normalized for organic carbon.

Abbreviations

cm	Centimeters
ug/kg	Micrograms per kilogram

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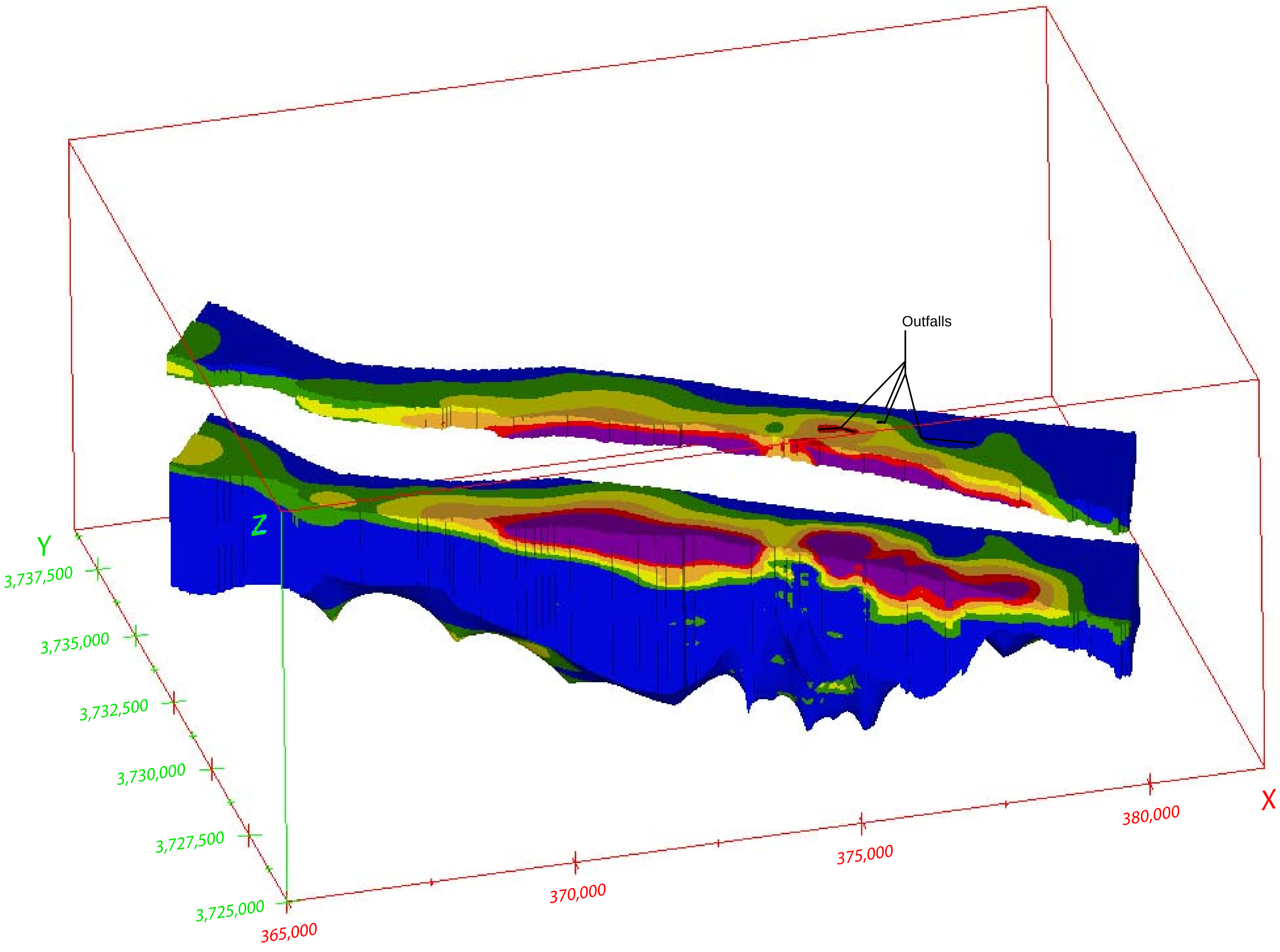
Figure C.4
Interpretive Concentrations of
Total PCBs (Expanded List)

MVS Model Report
2013 Sediment Sampling Program
Palos Verdes Shelf
Los Angeles County, California

United States
Environmental Protection
Agency



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P:\EPAR9\0069 TO 068-RARA-09CA PV Shelf RA\13.0 Graphics\Total_PCB EXP.ai 10/27/2017