

# **Appendix C**

## **Geospatial Modelling of Soil TCDD**

A geostatistical model was used to create a basis for estimating TCDD concentrations at individual residences that were not directly sampled and tested. ArcView Geospatial Analyst software was used to conduct Ordinary Kriging of all of the available measured TCDD soil data. The spatial model provided a visual representation to assist in identification of the point source, as well as the general area of interest for sampling. For the modelling, we included 34 data points from the 2002 soil sampling (PDP 2002), and 39 data points from sampling that was conducted in 1985, 1986, and 1997. A 25-year half-life correction was applied to the earlier samples to bring them to approximate 2002 levels for the combined map. In all, 73 measured soil TCDD values served as inputs to the model.

One sample from the 2002 soil testing was excluded from the analysis, as it was the only sample that did not fit the pattern of aerial dispersion emanating from the IWD plant. Therefore, and in consultation with all technical persons involved with the study, we treated this point as an extreme outlier that probably has another source for contamination. It should be noted that even if this one outlier had been included, the overall kriging pattern would not have differed greatly from that shown.

**Table 3.** Surface (0-75 mm) Soil Sample Data Used for the Geospatial Modelling of TCDD in Paritutu.

No.	ID	TCDD Concentration at time of measurement (ng/kg soil)	Date of sample	TCDD Concentration at 2002 assuming a 25 yr half life (ng/kg soil)
1	Pt1a	50	04/1985	30
2	Pt2	140	04/1985	85
3	Pt4	100	04/1985	61
4	Pt4	100	04/1985	61
5	Pt5	90	04/1985	55
6	Pt6	20	04/1985	12
7	Pt6	20	04/1985	12
8	Pt6	20	04/1985	12
9	Pt6	20	04/1985	12
10	Pt6	20	04/1985	12
11	Pt7	60	04/1985	36
12	Pt8	5	04/1985	3
13	Pt8	5	04/1985	3
14	Pt8	5	04/1985	3
15	Pt9	170	04/1985	103
16	Pt9	170	04/1985	103
17	Pt10	110	04/1985	67
18	Pt10	110	04/1985	67
19	Pt10	110	04/1985	67
20	S8	15	15/04/1986	9
21	S9	40	15/04/1986	25
22	S10	15	15/04/1986	9
23	MfE 97b	31	1997	27
24	Sec Ac	100	16/04/1986	62
25	Sec A	100	16/04/1986	62

No.	ID	TCDD Concentration at time of measurement (ng/kg soil)	Date of sample	TCDD Concentration at 2002 assuming a 25 yr half life (ng/kg soil)
26	Sec A	100	16/04/1986	62
27	Sec A	100	16/04/1986	62
28	Sec B	10	16/04/1986	6
29	Sec B	10	16/04/1986	6
30	Sec B	10	16/04/1986	6
31	Sec B	10	16/04/1986	6
32	Sec C	60	16/04/1986	37
33	Sec C	60	16/04/1986	37
34	Sec C	60	16/04/1986	37
35	Sec C	60	16/04/1986	37
36	Sec E	310	16/04/1986	193
37	Sec E	310	16/04/1986	193
38	Sec E	310	16/04/1986	193
39	Sec E	310	16/04/1986	193
40	01d	5.9	28/05/2002	5.9
41	02	4.8	28/05/2002	4.8
42	03	5.8	28/05/2002	5.8
43	04	7.4	28/05/2002	7.4
44	05	92	28/05/2002	92
45	06	15	28/05/2002	15
46	07	3.4	28/05/2002	3.4
47	08	6.1	28/05/2002	6.1
48	09	17	28/05/2002	17
49	10	3.6	28/05/2002	3.6
50	11	2.0	28/05/2002	2.0
51	12	2.9	28/05/2002	2.9
52	13	6.2	28/05/2002	6.2
53	14	8.0	28/05/2002	8.0
54	15	1.9	28/05/2002	1.9
55	16	1.8	28/05/2002	1.8
56	17	0.93	28/05/2002	0.93
57	18	4.5	28/05/2002	4.5
58	19	1.0	28/05/2002	1.0
59	20	4.8	28/05/2002	4.8
60	21	0.75	28/05/2002	0.75
61	22	0.76	28/05/2002	0.76
62	23	0.71	28/05/2002	0.71
63	24	2.7	28/05/2002	2.7
64	25	2.2	28/05/2002	2.2
65	26	3.0	28/05/2002	3.0
66	27	27	28/05/2002	27
67	28	0.88	28/05/2002	0.88
68	29	3.3	28/05/2002	3.3
69	30	2.4	28/05/2002	2.4
70	31	0.81	28/05/2002	0.81

No.	ID	TCDD Concentration at time of measurement (ng/kg soil)	Date of sample	TCDD Concentration at 2002 assuming a 25 yr half life (ng/kg soil)
71	32	6.1	28/05/2002	6.1
72	33	10	28/05/2002	10
73	34	7.3	28/05/2002	7.3
74	35	2.3	28/05/2002	2.3

a

b 1997 Ministry for the Environment OCP survey

c

d 2002 Pattle Delamore Partners, Ltd. (for Ministry for the Environment)

In the spatial model, we used the New Zealand Map Grid as the coordinate system. Individual parameters for the geospatial model are shown in Table 4 and Figure 1 below.

**Table 4.** Parameters used in geospatial modeling of TCDD soil concentrations in Paritutu

False Easting:	2510000.000000
False Northing	6023150.000000
Longitude of Origin	173.000000
Latitude of Origin	-41.000000
GCS	New Zealand 1949
Datum	D New Zealand 1949
Prime Meridian	0

#### *Ordinary Kriging Function*

A kriging function provides a ‘best fit’ estimate model to a geographical data set. This means that individual geographical data points are weighted according to their ability to predict neighbouring values, considering distance and direction. Thus, some outliers can receive less weight than would be seen with a contour map of a spline function which treats every point with equal weight; tending to ignore the overall pattern of the data. The kriging function applied to the Paritutu soil TCDD data used parameters as follows:

Number of Points: 73

Semivariogram/Covariance:

Model:  $1950.2 * \text{Spherical}(688.85, 239.42, 66.4) + 613 * \text{Nugget}$

Error modeling:

Microstructure: 613 (100%)

Measurement error: 0 (0%)

Searching Neighborhood:

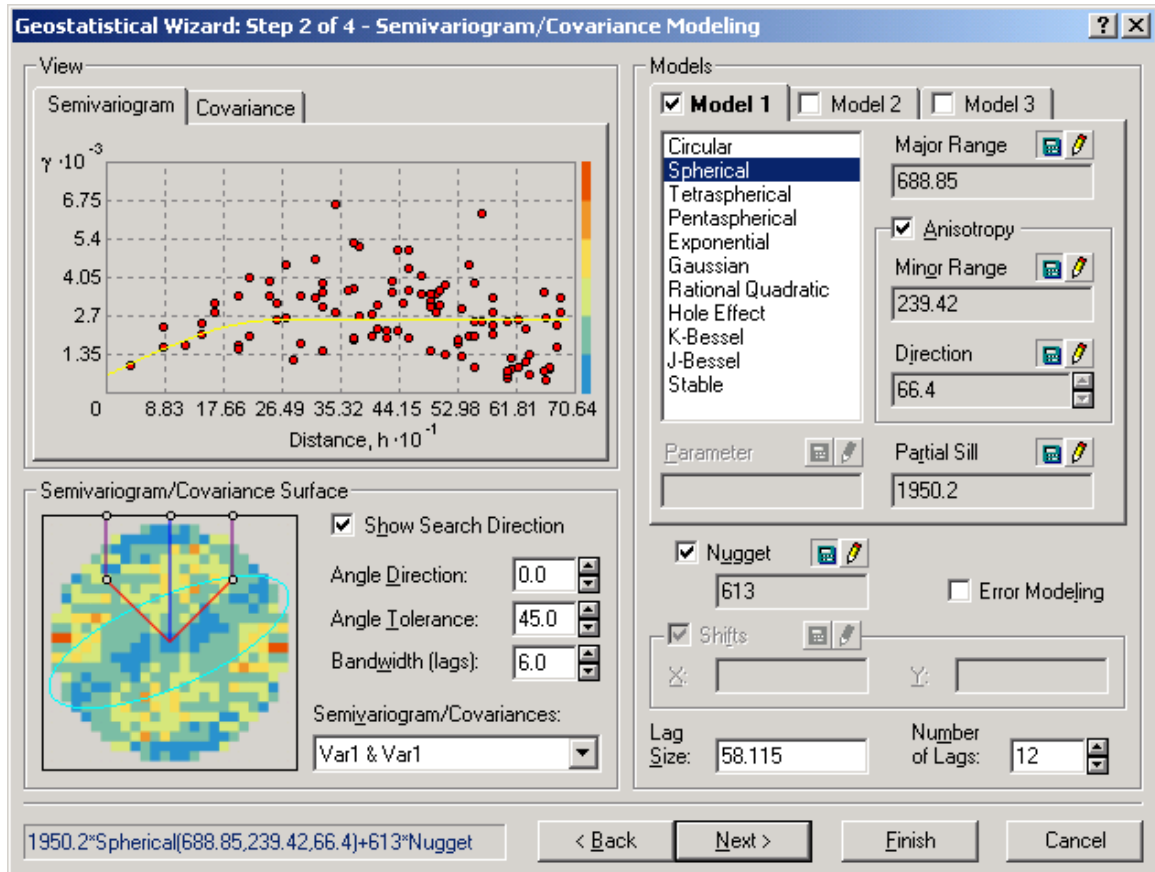
Neighbors to Include: 6 or at least 1 for each angular sector

Searching Ellipse:

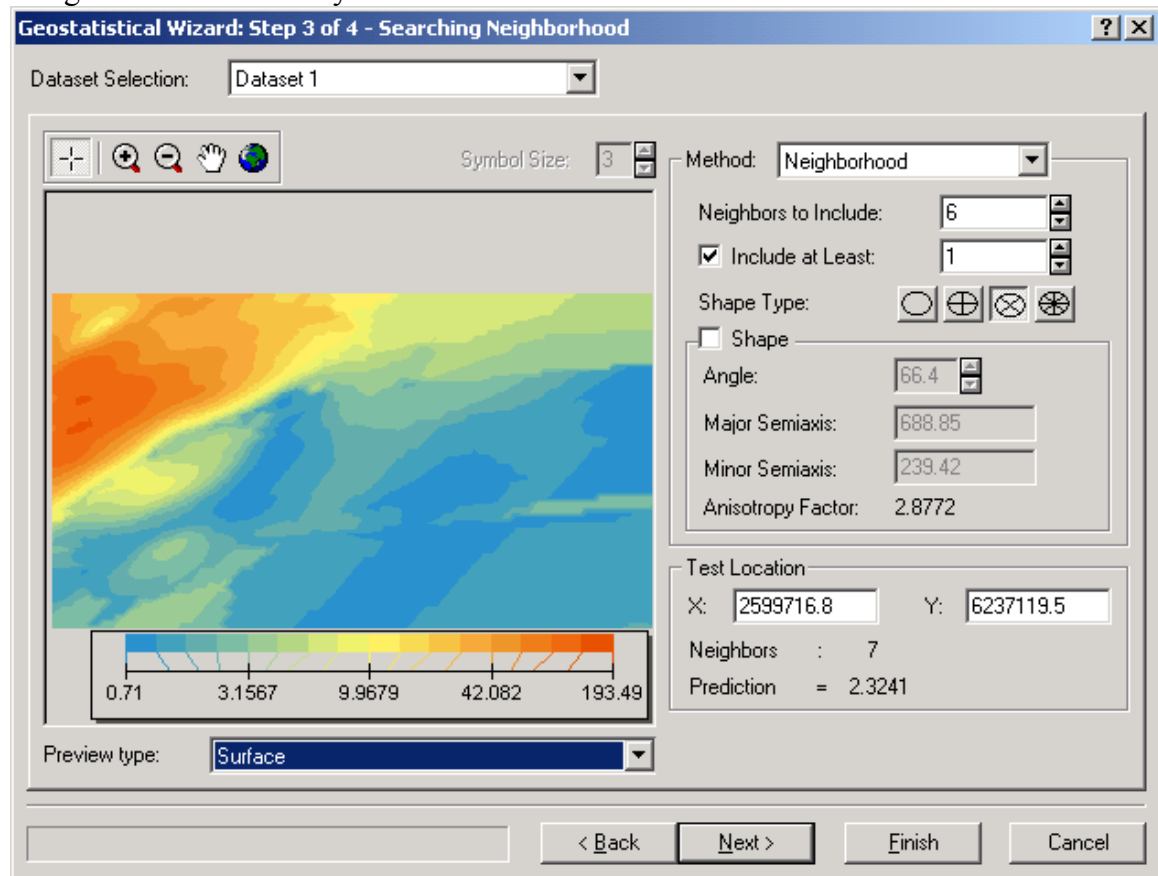
Angle: 66.4

Major Semiaxis: 688.85  
Minor Semiaxis: 239.42  
Angular Sectors: 4

**Figure 1a.** Geostatistical Analyst semivariogram/covariance model results for TCDD soil concentrations in Paritutu.



**Figure 1b.** Parameters for ordinary kriging of soil TCDD concentrations in Paritutu using Geostatistical Analyst.

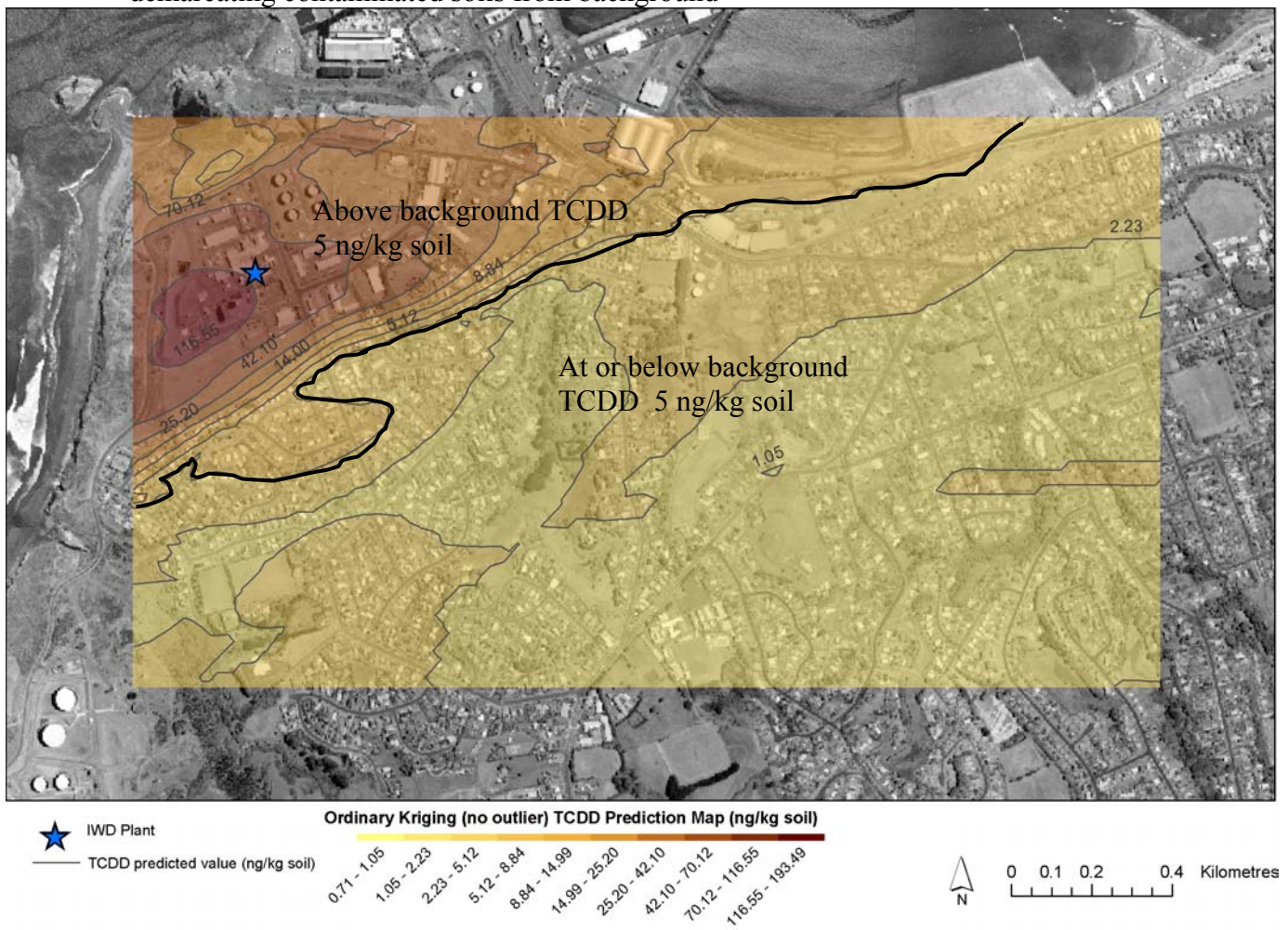


### *Validation of Kriging Function*

The geospatial model was cross-validated using a random subset of data points... as shown in Figure 3.

The spatial analysis of the 2002 soil testing data is broadly consistent with the AES air dispersal modelling, but again shows soil TCDD concentrations that are far too high to be accounted for by the modelled incinerator plume. The pattern of soil TCDD is consistent with a plume of TCDD emanating from the IWD plant, and extending up to about 1000 meters away, predominantly to the East, and about 400 meters to the South. The geostatistical map (Figure 3 and Figure 4) illustrates this pattern and has been cross-validated statistically in Arcview. In Figure 3, a soil TCDD estimate of 5 ng/kg was taken to represent the upper end of a normal background soil concentration for TCDD. Figure 4 illustrates the statistical error involved in the model, the lighter coloured areas having the least amount of statistical error associated with them, as these had more data points available for the modelling.

**Figure 3.** Prediction soil TCDD map of Paritutu area showing the demarcation of areas above background for New Zealand (lightest yellow) and New Plymouth (one shade darker), and the area of study. A value of 5 ng/kg is taken to be a level demarcating contaminated soils from background





**Figure 4.** Prediction standard error map of kriging function of TCDD soil concentrations in Paritutu. Light yellow indicates areas with the least statistical uncertainty in the model (i.e. light areas are those where we have the greatest degree of confidence in the predicted modelled value).

