

APPENDIX I

MODEL PERFORMANCE COMPARISON OF
CTDMPLUS AND CALPUFF VERSION 5

COMPARISON OF PERFORMANCE OF
CTDMPLUS AND CALPUFF VERSION 5 IN
THE VICINITY OF THE MARSHALL COUNTY,
WEST VIRGINIA FACILITIES OF THE
INDUSTRIAL SOURCES GROUP

Prepared for:
Industrial Sources Group

Prepared by:
Energy & Environmental Management, Inc.

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1.0 INTRODUCTION

The Industrial Sources Group (ISG) submitted a Model Protocol to the West Virginia Division of Environmental Protection (DEP) in October 1997 for conducting computer dispersion modeling of sulfur dioxide (SO₂) sources in and around Marshall County, West Virginia.¹ That Protocol contained the recommendation to use CALPUFF as the computer dispersion model. CALPUFF is under consideration by the U.S. Environmental Protection Agency (EPA) for inclusion as a listed Guidelines Model. As such, each applicant must perform an analysis to show how CALPUFF compares to approved and appropriate Guidelines Models. Appropriate Guidelines Models for the ISG setting are the Industrial Source Complex Short Term (ISCST3) model for flat terrain and CTDMPPLUS for complex terrain. Comparison results between ISCST3 and CALPUFF were submitted earlier.² CALPUFF was run in Complex Terrain Sub Grid (CTSG) mode to utilize the CTDMPPLUS terrain files. This document presents a comparison of results for CTDMPPLUS and CALPUFF.

2.0 METHODOLOGY

The comparison was developed as follows:

2.1 METEOROLOGICAL DATA

A "canned" set of meteorological data was developed from the CTSCREEN profile and surface data files. The two files were

¹"Dispersion Model Protocol for Industrial Sources Group Based in Marshall County, West Virginia," Energy & Environmental Management, Inc., October 1997. The ISG consists of Venco, Columbian Chemicals, PPG, Bayer and Ormet, each with a single facility in the study area.

²Letter (E²M-496-97) to Ms. Rosalyn Murzyn from Larry L. Simmons dated July 14, 1997.

modified to stable conditions by selecting only values with a positive Monin-Obukhov Length³ and then reformatted for CTDMPLUS. The profile contains vertical profiles of wind speed, wind direction, sigma-v and sigma-w. Wind direction in the original CTSCREEN file was set to 0.0 degrees and must be either adjusted to align with the line of receptors or the receptors adjusted to a wind direction of 0.0 degrees.

2.2 RECEPTORS

Receptors were placed along a line from the center of the facility to the highest terrain point on each hill that surrounds that facility. Receptors were selected at 10-foot elevation increments from the base elevation to the highest terrain point on each hill. Receptor elevations increased with distance along the line. The line of receptors was treated as if the line were a terrain array in the Rough Terrain Diffusion Model (RTDM); i.e., small "dips" in terrain were ignored.

2.3 TERRAIN CHARACTERISTICS

The CTDMPLUS software was used to create the terrain file for each hill. Individual hills were digitized in AutoCAD. These files were converted into the XY format specified in the CTDMPLUS DRIVEIT.EXE program. Ellipses were fit to each hill using the FITCON.EXE program. The resulting HCO file was then ready for CTDMPLUS and CALPUFF.

³"User's Guide to the Complex Terrain Dispersion Model Plus Algorithms For Unstable Situations (CTDMPLUS) Volume 1: Model Description and User Instructions," EPA/600/8-89/041, March 1989, page 2-17.

2.4 SOURCES

Emission sources were moved to the center of the plant to the point where the terrain line originated.

3.0 RESULTS

Results are presented in a series of figures. For each of the five ISG facilities, the receptor line to each hill is shown. Following these are Q-Q plots with a tabular listing for the hills run in this comparison. A Q-Q plot is a plot of the ranked impacts from highest to lowest for each model. The matching of impact distributions removes the spatial variable in comparing results.

Figure 1 shows the hills surrounding Columbian Chemicals. The proposed MACT source was used for model comparisons at Hill 01 (Figure 2), Hill 04 (Figure 3) and Hill 05 (Figure 4). Maximum impacts between the two models are close to the 1:1 line.

Figure 5 shows the hills surround Venco. Kiln Number 1 was used for model comparisons at Hill 09 (Figure 6) and Hill 10 (Figure 7). Again, the maximum impacts between the two models are close to the 1:1 line.

Figure 8 shows the hills on both sides of Bayer. Boiler No. 9 was used for model comparisons at Hill 12 (Figure 9). Maximum 1-hour CTDMPPLUS impacts are slightly greater than those from CALPUFF.

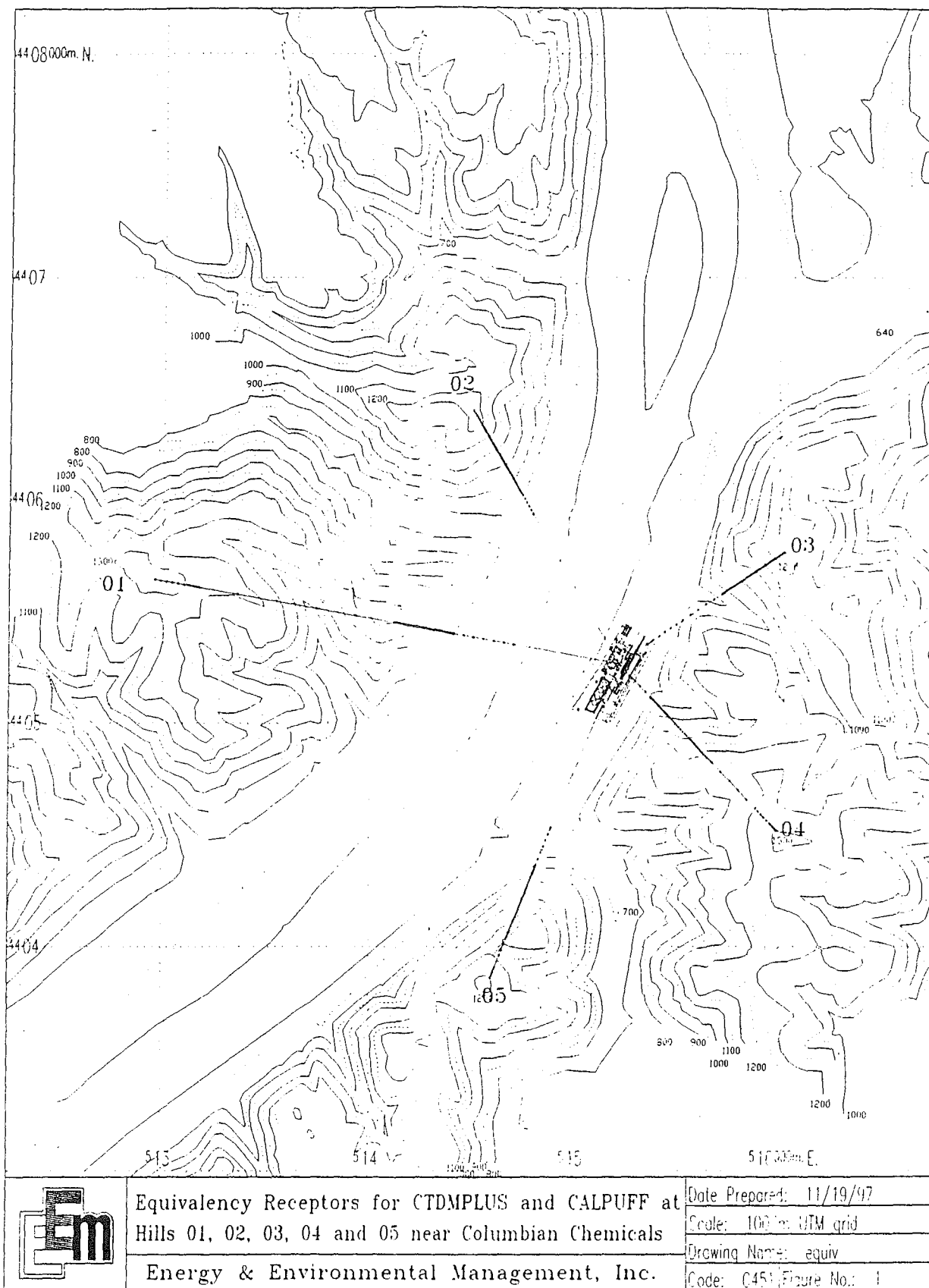
Figure 10 shows two hills across the Ohio River from PPG. The single stack from PPG Boilers No. 3 and 4 was used for model comparisons at Hill 13 (Figure 11) and at Hill 14 (Figure 12). Both models compared better at Hill 14 than at Hill 13.

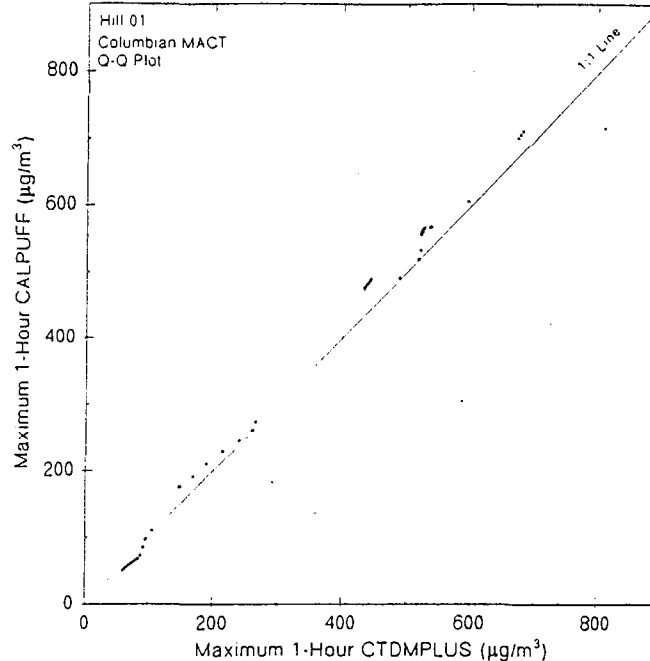
Figure 13 shows several hills surrounding Ormet. The original configuration for the Anode Furnace No. 1, 2 and 3 was used for a model comparison at Hill 19 (Figure 14). Maximum 1-hour impacts are very close.

These Q-Q plots are merged into a single Q-Q plot in Figure 15. Overall, the comparison between the two models is good. Model performance could be improved if the Marshall County FITCON ellipses were replaced with "cleaner" terrain, i.e., smooth elevation increases with height and no "cuts" into the terrain as is found along the Ohio River. A "smoother" set of terrain ellipses would eliminate a major difference between how CTDMPPLUS "sees" the terrain and how CALPUFF, in CTSG mode, "sees" the terrain. FITCON creates a series of stacked ellipses that influence the wind flow past the terrain. The real-world terrain in Marshall County results in stacked ellipses that can rotate about a central point. CTDMPPLUS can adjust wind flow to the rotation angle of the ellipses while CALPUFF in CTSG mode cannot. Model comparison would be expected to improve noticeably if synthetic, cleaner terrain were used in the analysis.

4.0 CONCLUSION AND RECOMMENDATIONS

CTDMPPLUS and CALPUFF Version 5 were compared for the local terrain in the river valley in Marshall County, West Virginia. Model comparisons were very good considering how each model handles terrain and that CALPUFF Version 5 properly represents maximum impact in the area when compared to CTDMPPLUS. Clearly, the CALPUFF model is appropriate for the setting. It is the ISG's recommendation that CALPUFF be used for the West Virginia State Implementation Plan studies for Marshall County.





Receptors (Km)			1-Hr ($\mu\text{g}/\text{m}^3$)		Receptors (Km)			1-Hr ($\mu\text{g}/\text{m}^3$)	
Rec #	East	North	Elev (ft)	CTDM+ CALPUF5	Rec #	East	North	Elev (ft)	CTDM+ CALPUF5
1	514.308	4405.418	860.	60. 51.4	26	514.179	4405.440	1120.	438. 483.6
2	514.298	4405.420	870.	63. 53.6	27	514.173	4405.441	1130.	437. 481.6
3	514.289	4405.421	880.	66. 55.9	28	514.167	4405.442	1140.	435. 479.7
4	514.280	4405.423	890.	69. 58.3	29	514.161	4405.443	1150.	434. 478.0
5	514.271	4405.424	900.	73. 60.8	30	514.157	4405.444	1160.	434. 476.8
6	514.267	4405.425	910.	76. 63.4	31	514.144	4405.445	1170.	811. 716.0
7	514.263	4405.426	920.	80. 66.0	32	514.135	4405.447	1180.	681. 710.6
8	514.259	4405.427	930.	84. 68.7	33	514.126	4405.448	1190.	677. 705.3
9	514.255	4405.427	940.	88. 73.3	34	514.118	4405.450	1200.	673. 700.6
10	514.252	4405.428	950.	92. 85.2	35	513.929	4405.481	1210.	597. 606.3
11	514.247	4405.429	960.	96. 97.7	36	513.739	4405.513	1220.	537. 532.9
12	514.243	4405.429	970.	106. 110.8	37	513.550	4405.545	1230.	489. 474.8
13	514.238	4405.430	980.	149. 176.9	38	513.361	4405.576	1240.	519. 519.6
14	514.233	4405.431	990.	149. 176.4	39	513.172	4405.608	1250.	529. 561.2
15	514.229	4405.431	1000.	149. 176.1	40	513.158	4405.610	1260.	526. 558.4
16	514.226	4405.432	1010.	150. 175.9	41	513.144	4405.612	1270.	539. 556.6
17	514.224	4405.432	1020.	170. 191.1	42	513.130	4405.615	1280.	523. 561.3
18	514.221	4405.433	1030.	191. 210.5	43	513.116	4405.617	1290.	523. 561.0
19	514.218	4405.433	1040.	214. 229.0	44	513.102	4405.619	1300.	522. 561.3
20	514.216	4405.434	1050.	239. 245.8	45	513.074	4405.624	1310.	523. 564.3
21	514.211	4405.434	1060.	265. 260.5	46	513.045	4405.629	1320.	524. 566.2
22	514.206	4405.435	1070.	260. 273.6	47	513.017	4405.633	1330.	525. 567.3
23	514.201	4405.436	1080.	444. 491.3	48	512.989	4405.638	1340.	526. 567.8
24	514.196	4405.437	1090.	443. 489.5	49	512.960	4405.643	1350.	528. 568.3
25	514.191	4405.438	1100.	441. 487.7					

Source as tested

Stack Height (m)	Base Elev (m)	Stack Diam (m)	Exit Vel. (m/s)	Exit Temp. (deg K)	Emit Rate (g/s)
65.53	195.1	4.27	16.79	1224.	187.70



Q-Q Plot and Tabular Listing for Impact
at Hill 01

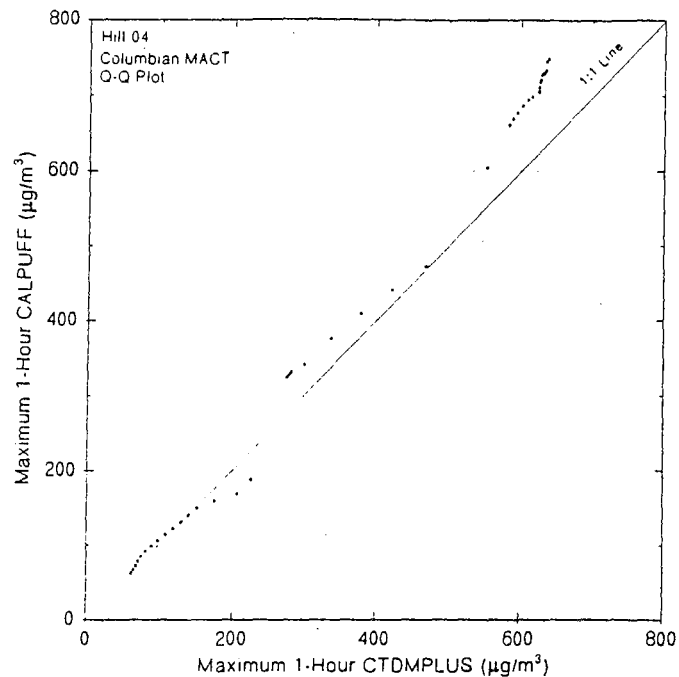
Energy & Environmental Management, Inc.

Date Prepared: 12/03/97

Scale: N/A

Drawing Name: hills

Code: C-451/Flare No.: 2



Rec #	Receptors (Km)		Elev (ft)	1-Hr ($\mu\text{g}/\text{m}^3$)		Rec #	Receptors (Km)		Elev (ft)	1-Hr ($\mu\text{g}/\text{m}^3$)	
	East	North		CTDM+	CALPUF5		East	North		CTDM+	CALPUF5
1	515.447	4405.045	860.	63.	61.5	24	515.629	4404.870	1090.	422.	441.1
2	515.452	4405.040	870.	66.	66.7	25	515.636	4404.863	1100.	469.	471.5
3	515.458	4405.035	880.	69.	72.3	26	515.644	4404.855	1110.	609.	693.6
4	515.463	4405.030	890.	72.	78.2	27	515.652	4404.848	1120.	602.	685.8
5	515.468	4405.025	900.	76.	84.5	28	515.660	4404.840	1130.	595.	677.2
6	515.477	4405.016	910.	82.	91.3	29	515.667	4404.832	1140.	589.	668.9
7	515.485	4405.008	920.	91.	98.4	30	515.675	4404.825	1150.	583.	660.8
8	515.494	4404.999	930.	99.	105.9	31	515.718	4404.784	1160.	553.	705.7
9	515.503	4404.991	940.	109.	113.8	32	515.760	4404.743	1170.	615.	729.1
10	515.512	4404.982	950.	119.	122.1	33	515.802	4404.702	1180.	634.	748.8
11	515.522	4404.973	960.	130.	130.7	34	515.845	4404.661	1190.	638.	733.5
12	515.532	4404.963	970.	141.	139.8	35	515.887	4404.620	1200.	635.	745.0
13	515.543	4404.953	980.	153.	149.1	36	515.901	4404.607	1210.	633.	729.0
14	515.553	4404.943	990.	176.	158.9	37	515.914	4404.594	1220.	631.	717.9
15	515.563	4404.933	1000.	207.	168.9	38	515.928	4404.580	1230.	630.	604.5
16	515.571	4404.926	1010.	226.	188.2	39	515.942	4404.567	1240.	628.	720.9
17	515.578	4404.919	1020.	282.	331.7	40	515.956	4404.554	1250.	627.	732.0
18	515.585	4404.912	1030.	280.	328.8	41	515.963	4404.547	1260.	626.	727.3
19	515.593	4404.905	1040.	277.	326.0	42	515.970	4404.541	1270.	626.	717.3
20	515.600	4404.897	1050.	275.	323.6	43	515.976	4404.534	1280.	625.	710.7
21	515.607	4404.890	1060.	301.	341.8	44	515.983	4404.527	1290.	625.	704.5
22	515.614	4404.884	1070.	338.	376.0	45	515.990	4404.521	1300.	625.	697.9
23	515.622	4404.877	1080.	379.	409.4						

Source as tested

Stack Height (m)	Base Elev (m)	Stack Diam (m)	Exit Vel. (m/s)	Exit Temp. (deg K)	Emit Rate (g/s)
65.53	195.1	4.27	16.79	1224.	187.70



Q-Q Plot and Tabular Listing for Impact
at Hill 04

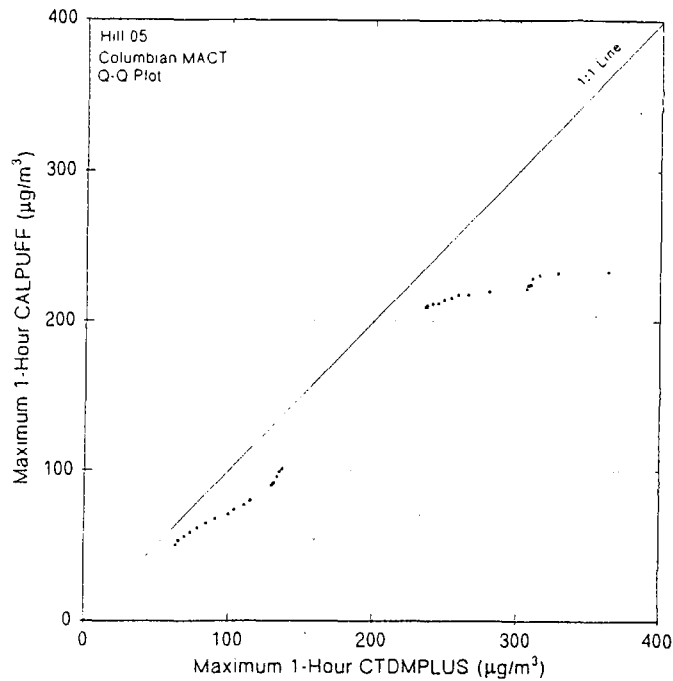
Energy & Environmental Management, Inc.

Date Prepared: 12/03/97

Scale: N/A

Drawing Name: hills

Code: C-451 Figure No.: 3



Rec #	Receptors (Km)		Elev (ft)	1-Hr ($\mu\text{g}/\text{m}^3$)		Rec #	Receptors (Km)		Elev (ft)	1-Hr ($\mu\text{g}/\text{m}^3$)	
	East	North		CTDM+	CALPUF5		East	North		CTDM+	CALPUF5
1	514.770	4404.254	860.	64.	50.8	19	514.696	4404.084	1040.	266.	221.8
2	514.766	4404.246	870.	66.	53.5	20	514.692	4404.074	1050.	259.	217.8
3	514.763	4404.238	880.	70.	56.2	21	514.688	4404.067	1060.	254.	214.2
4	514.759	4404.222	890.	74.	59.0	22	514.684	4404.059	1070.	249.	211.9
5	514.756	4404.221	900.	79.	61.9	23	514.681	4404.051	1080.	245.	210.5
6	514.752	4404.213	910.	85.	64.8	24	514.677	4404.043	1090.	241.	209.6
7	514.748	4404.205	920.	91.	67.8	25	514.674	4404.035	1100.	237.	209.5
8	514.745	4404.196	930.	100.	70.8	26	514.663	4404.010	1110.	236.	211.5
9	514.741	4404.187	940.	104.	73.8	27	514.652	4403.985	1120.	237.	215.6
10	514.737	4404.179	950.	111.	76.8	28	514.641	4403.960	1130.	364.	218.0
11	514.732	4404.168	960.	115.	79.7	29	514.630	4403.934	1140.	328.	219.9
12	514.727	4404.156	970.	137.	90.0	30	514.620	4403.909	1150.	315.	224.3
13	514.723	4404.145	980.	135.	90.8	31	514.615	4403.899	1160.	310.	224.0
14	514.718	4404.134	990.	133.	91.5	32	514.611	4403.890	1170.	309.	224.6
15	514.713	4404.123	1000.	131.	95.7	33	514.607	4403.880	1180.	308.	230.8
16	514.709	4404.113	1010.	130.	99.0	34	514.603	4403.870	1190.	307.	232.2
17	514.704	4404.104	1020.	129.	101.0	35	514.598	4403.861	1200.	306.	233.2
18	514.700	4404.094	1030.	280.	228.8						

Source as tested

Stack Height (m)	Base Elev (m)	Stack Diam (m)	Exit Vel. (m/s)	Exit Temp. (deg K)	Emit Rate (g/s)
65.53	195.1	4.27	16.79	1224.	187.70



Q-Q Plot and Tabular Listing for Impact
at Hill 05

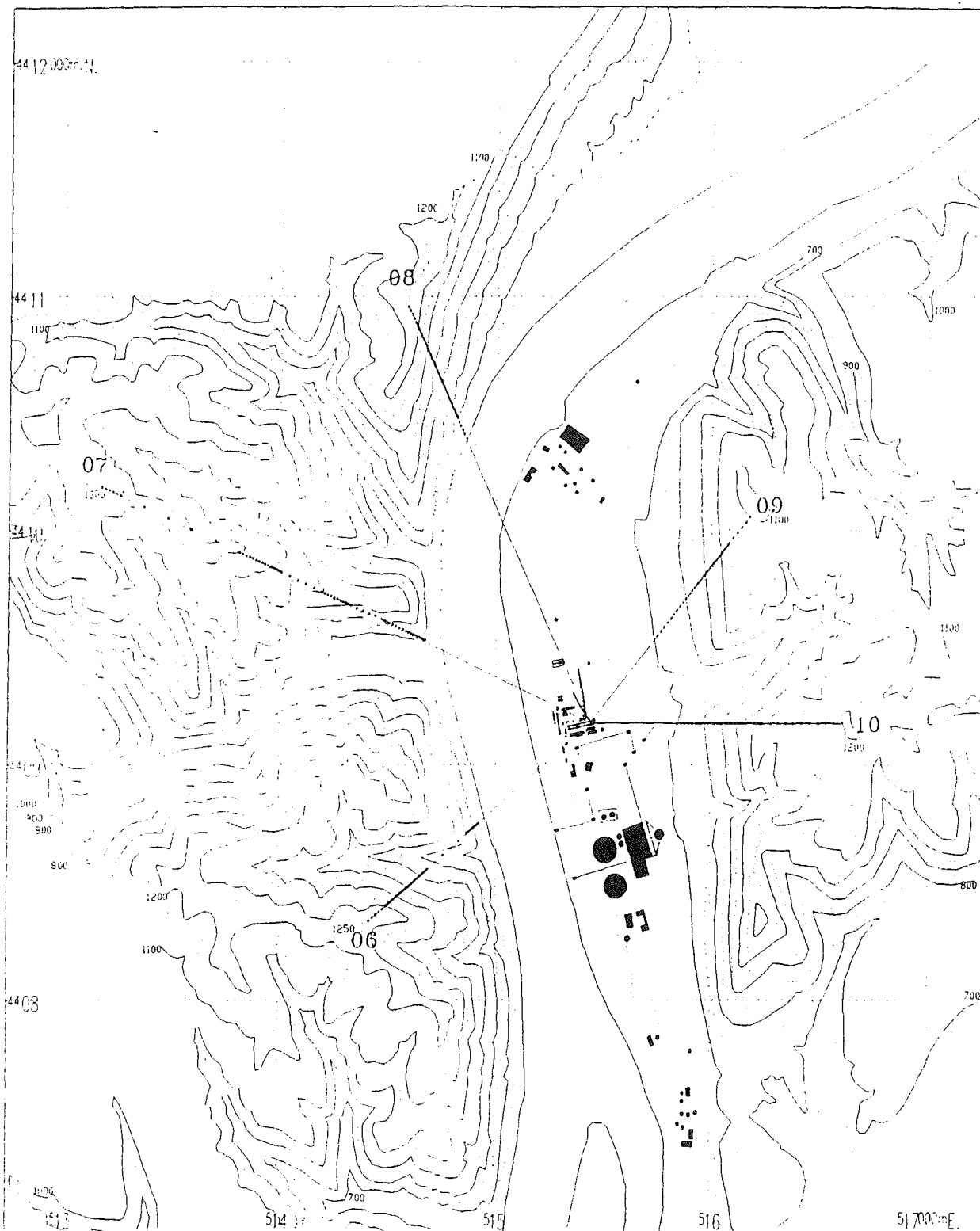
Energy & Environmental Management, Inc.

Date Prepared: 12/03/97

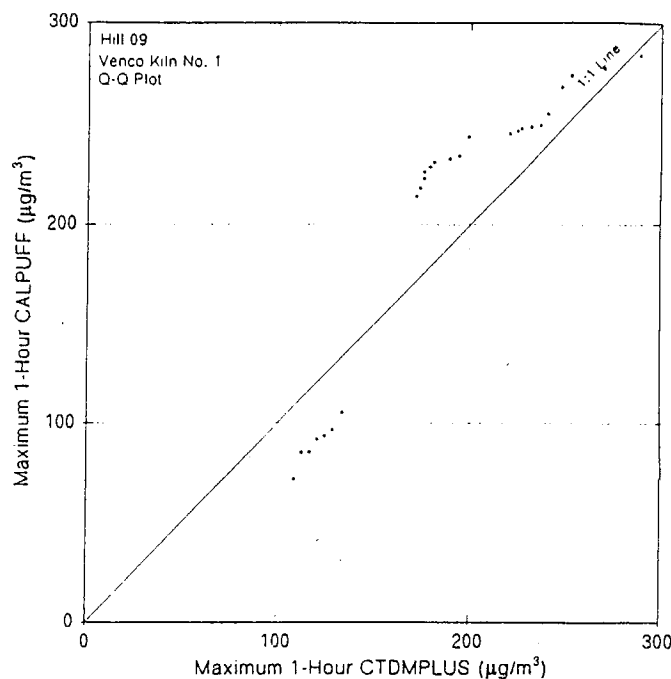
Scale: N/A

Drawing Name: hills

Code: C-451 Figure No: 4



	Equivalency Receptors for CTDMPPLUS and CALPUFF at Hills 06, 07, 08, 09 and 10 near VENCO	Date Prepared: 11/20/97
		Scale: 1000m UTM grid
		Drawing Name: equiv2
		Code: C451 Figure No.: 5
	Energy & Environmental Management, Inc.	



Rec #	Receptors (Km)		Elev (ft)	1-Hr (ug/m^3)		Rec #	Receptors (Km)		Elev (ft)	1-Hr (ug/m^3)	
	East	North		CTDM+	CALPUF5		East	North		CTDM+	CALPUF5
1	515.933	4409.765	850.	109.	71.7	14	516.030	4409.881	980.	189.	232.5
2	515.940	4409.774	860.	113.	85.2	15	516.037	4409.889	990.	194.	233.9
3	515.948	4409.783	870.	117.	85.4	16	516.044	4409.897	1000.	199.	243.1
4	515.956	4409.793	880.	121.	91.8	17	516.051	4409.906	1010.	289.	244.5
5	515.964	4409.802	890.	125.	93.5	18	516.059	4409.916	1020.	270.	246.0
6	515.972	4409.812	900.	129.	96.5	19	516.067	4409.925	1030.	252.	247.1
7	515.979	4409.821	910.	134.	105.4	20	516.075	4409.934	1040.	236.	247.8
8	515.987	4409.829	920.	181.	214.2	21	516.082	4409.943	1050.	224.	248.6
9	515.994	4409.838	930.	179.	218.3	22	516.101	4409.966	1060.	220.	254.2
10	516.002	4409.847	940.	176.	223.0	23	516.120	4409.989	1070.	226.	267.6
11	516.009	4409.856	950.	174.	226.2	24	516.140	4410.011	1080.	231.	273.4
12	516.016	4409.864	960.	172.	228.6	25	516.159	4410.034	1090.	240.	277.2
13	516.023	4409.873	970.	176.	230.8	26	516.178	4410.057	1100.	247.	283.7

Source as tested

Stack Height (m)	Base Elev (m)	Stack Diam (m)	Exit Vel. (m/s)	Exit Temp. (deg K)	Emit Rate (g/s)
57.91	199.9	3.96	18.09	1219.	315.73



Q-Q Plot and Tabular Listing for Impact
at Hill 09

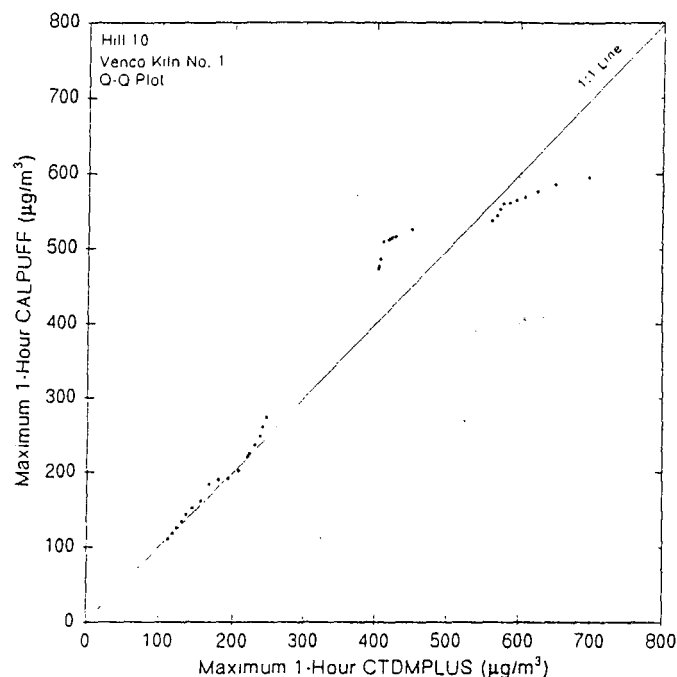
Energy & Environmental Management, Inc.

Date Prepared: 12/03/97

Scale: N/A

Drawing Name: hills

Code: C-451 Figure No.: 6



Rec #	Receptors (Km)		Elev (ft)	1-Hr ($\mu\text{g}/\text{m}^3$)		Rec #	Receptors (Km)		Elev (ft)	1-Hr ($\mu\text{g}/\text{m}^3$)	
	East	North		CTDM+	CALPUF5		East	North		CTDM+	CALPUF5
1	516.018	4409.177	850.	113.	111.0	19	516.174	4409.177	1030.	421.	473.1
2	516.025	4409.177	860.	119.	118.5	20	516.187	4409.177	1040.	406.	486.5
3	516.032	4409.177	870.	124.	126.3	21	516.199	4409.177	1050.	404.	509.9
4	516.039	4409.177	880.	131.	134.5	22	516.207	4409.177	1060.	405.	512.3
5	516.045	4409.177	890.	137.	143.1	23	516.215	4409.177	1070.	411.	514.0
6	516.052	4409.177	900.	145.	152.0	24	516.223	4409.177	1080.	418.	515.4
7	516.061	4409.177	910.	156.	161.3	25	516.231	4409.177	1090.	423.	516.9
8	516.069	4409.177	920.	168.	189.6	26	516.239	4409.177	1100.	428.	525.9
9	516.077	4409.177	930.	181.	183.9	27	516.273	4409.177	1110.	698.	561.7
10	516.085	4409.177	940.	194.	191.5	28	516.308	4409.177	1120.	651.	544.7
11	516.094	4409.177	950.	208.	202.3	29	516.343	4409.177	1130.	625.	553.1
12	516.102	4409.177	960.	223.	221.0	30	516.378	4409.177	1140.	608.	537.8
13	516.111	4409.177	970.	237.	224.8	31	516.413	4409.177	1150.	596.	569.4
14	516.120	4409.177	980.	246.	236.5	32	516.452	4409.177	1160.	587.	560.5
15	516.129	4409.177	990.	241.	248.5	33	516.491	4409.177	1170.	578.	586.0
16	516.137	4409.177	1000.	221.	260.9	34	516.529	4409.177	1180.	570.	577.0
17	516.150	4409.177	1010.	230.	273.5	35	516.568	4409.177	1190.	562.	565.1
18	516.162	4409.177	1020.	450.	476.7	36	516.607	4409.177	1200.	574.	594.5

Source as tested

Stack Height (m)	Base Elev (m)	Stack Diam (m)	Exit Vel. (m/s)	Exit Temp. (deg K)	Emit Rate (g/s)
57.91	199.9	3.96	18.09	1219.	315.73



Q-Q Plot and Tabular Listing for Impact
at Hill 10

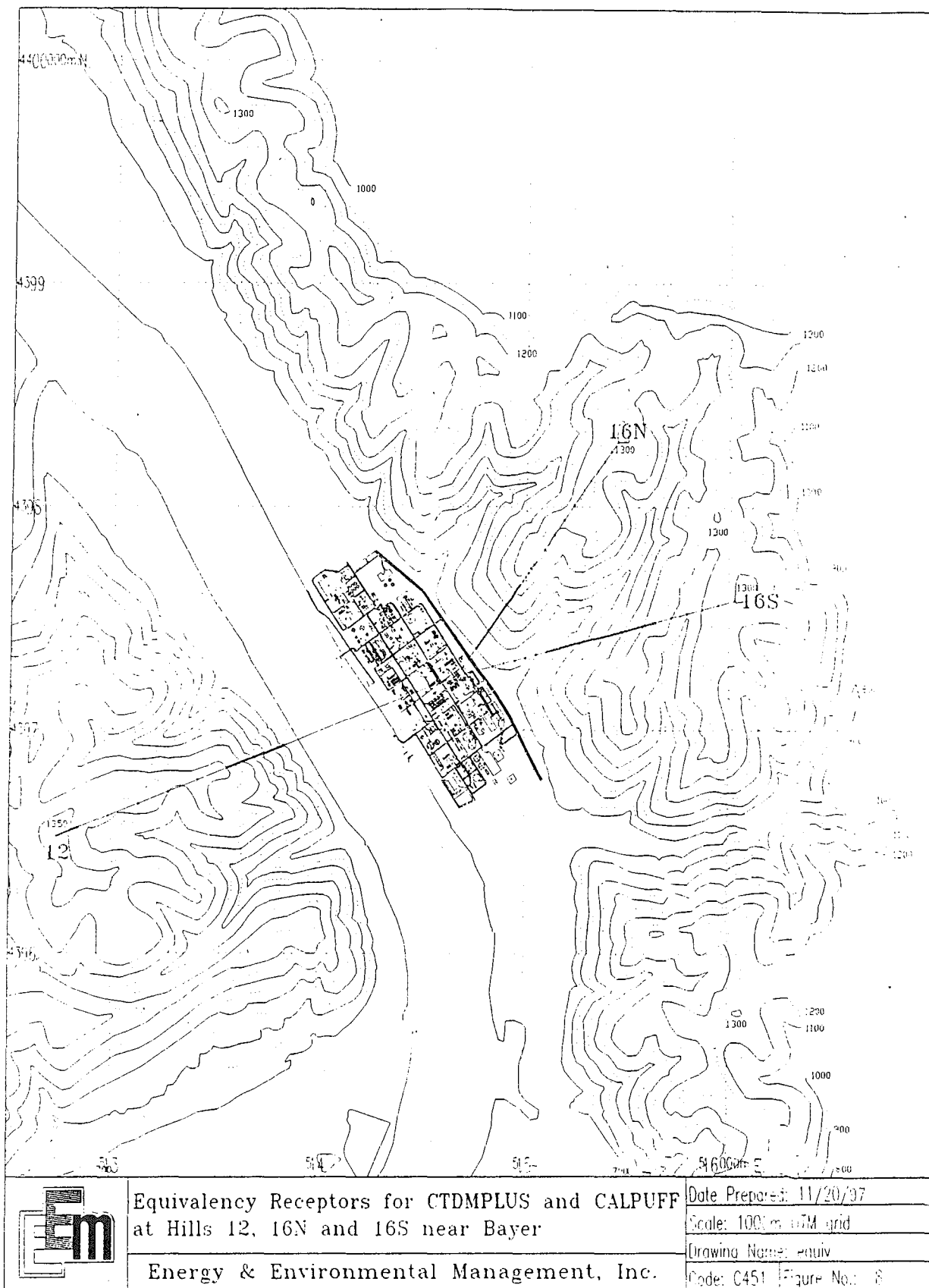
Energy & Environmental Management, Inc.

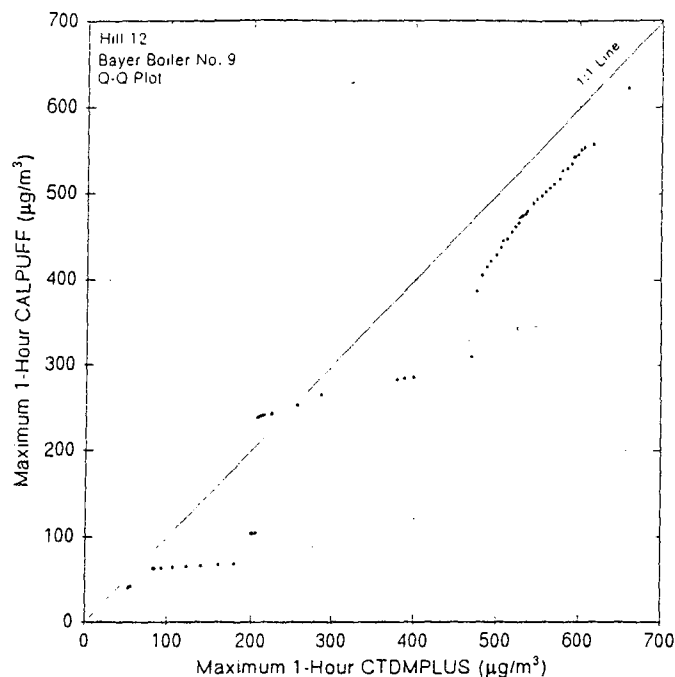
Date Prepared: 12/03/97

Scale: N/A

Drawing Name: hills

Code: C-451 Figure No.: 7





Rec #	Elev (ft)	1-Hr ($\mu\text{g}/\text{m}^3$)		Rec #	Elev (ft)	1-Hr ($\mu\text{g}/\text{m}^3$)		Rec #	Elev (ft)	1-Hr ($\mu\text{g}/\text{m}^3$)	
		CTDM+	CALPUF5			CTDM+	CALPUF5			CTDM+	CALPUF5
1	700.	53.	40.2	23	920.	599.	550.4	45	1140.	505.	445.1
2	710.	54.	42.5	24	930.	595.	545.1	46	1150.	500.	437.0
3	720.	56.	42.2	25	940.	593.	542.0	47	1160.	493.	428.3
4	730.	85.	68.4	26	950.	591.	542.8	48	1170.	488.	421.6
5	740.	84.	67.3	27	960.	585.	534.6	49	1180.	482.	414.8
6	750.	83.	66.4	28	970.	579.	528.8	50	1190.	476.	405.1
7	760.	83.	65.4	29	980.	576.	526.8	51	1200.	470.	386.2
8	770.	93.	64.5	30	990.	569.	517.5	52	1210.	379.	309.5
9	780.	107.	64.0	31	1000.	564.	511.6	53	1220.	286.	264.7
10	790.	123.	63.8	32	1010.	559.	507.2	54	1230.	224.	242.4
11	800.	140.	63.6	33	1020.	554.	502.6	55	1240.	201.	237.5
12	810.	160.	63.4	34	1030.	548.	494.1	56	1250.	205.	238.2
13	820.	179.	63.3	35	1040.	544.	488.8	57	1260.	206.	238.7
14	830.	199.	104.0	36	1050.	537.	476.2	58	1270.	206.	238.0
15	840.	224.	103.8	37	1060.	535.	498.6	59	1280.	207.	237.8
16	850.	257.	103.6	38	1070.	531.	479.5	60	1290.	208.	252.5
17	860.	399.	285.0	39	1080.	528.	473.8	61	1300.	209.	240.2
18	870.	388.	283.8	40	1090.	526.	471.7	62	1310.	210.	240.4
19	880.	660.	282.5	41	1100.	522.	466.3	63	1320.	212.	241.1
20	890.	618.	621.5	42	1110.	518.	461.6	64	1330.	212.	241.4
21	900.	606.	556.7	43	1120.	513.	455.3	65	1340.	214.	241.2
22	910.	602.	553.4	44	1130.	507.	447.3	66	1350.	215.	240.2

Source as tested

Stack Height (m)	Base Elev (m)	Stack Diam (m)	Exit Vel. (m/s)	Exit Temp. (deg K)	Emit Rate (g/s)
15.24	195.4	1.83	13.81	622.	21.67



Q-Q Plot and Tabular Listing for Impact
at Hill 12

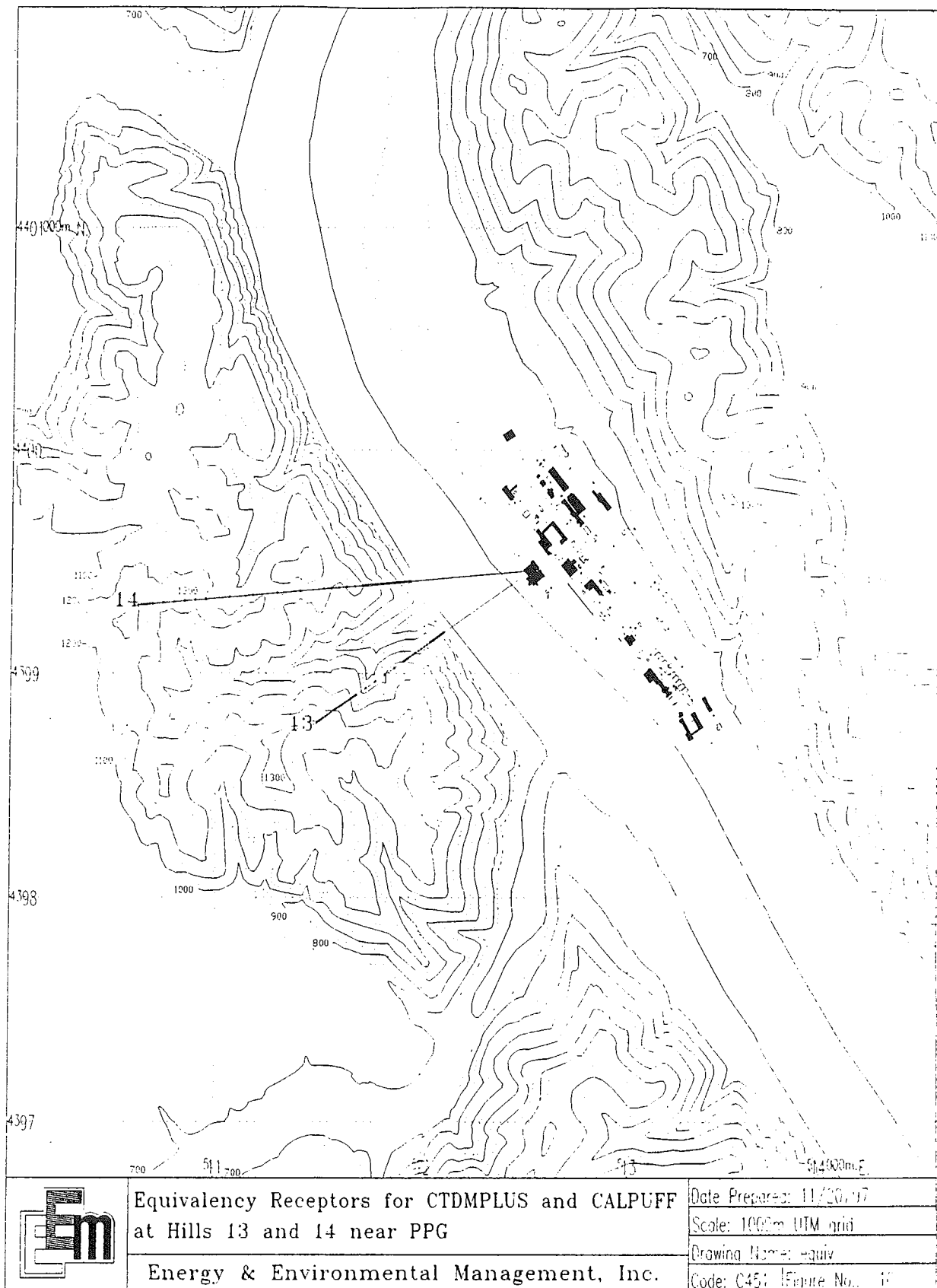
Energy & Environmental Management, Inc.

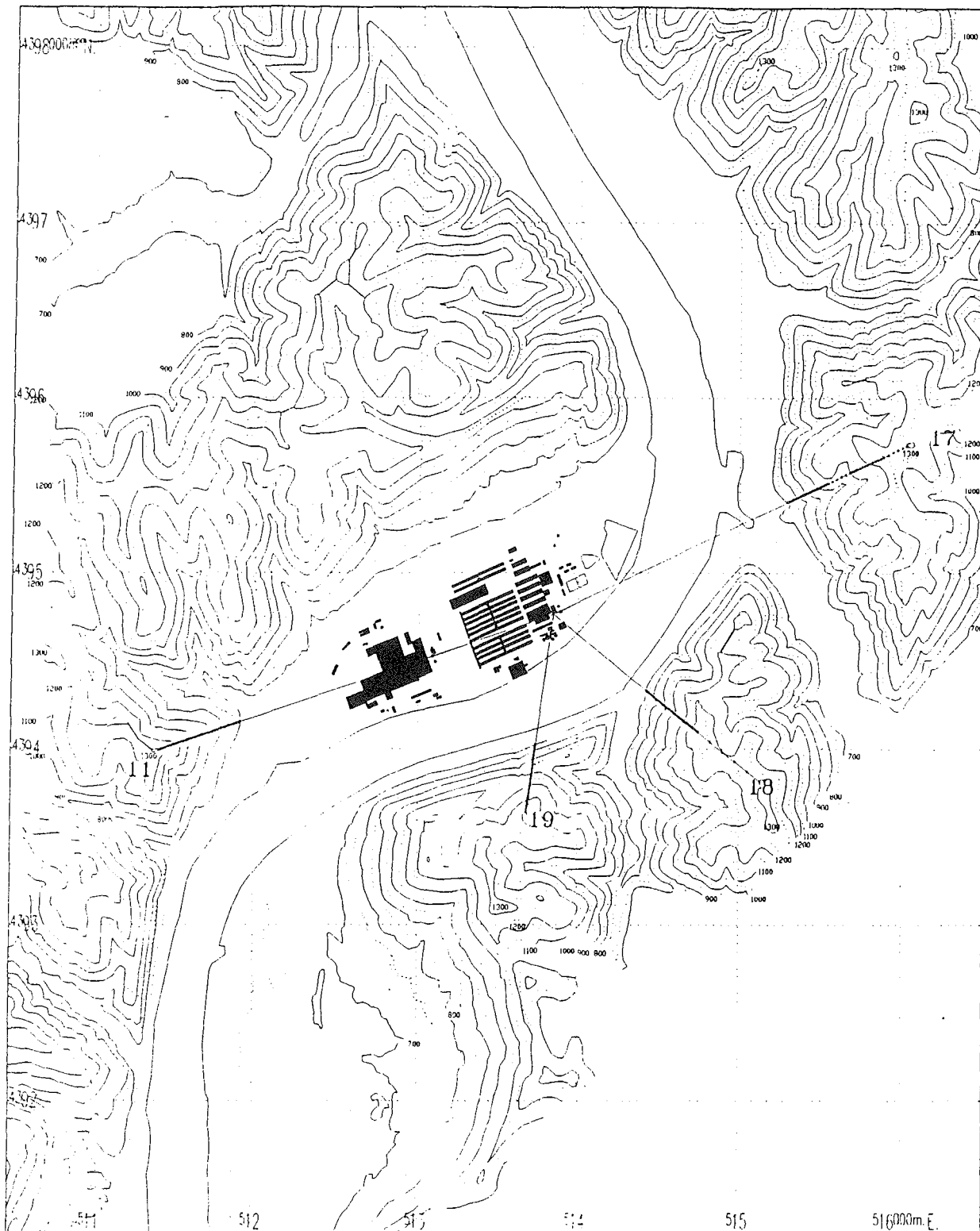
Date Prepared: 12/03/97

Scale: N/A

Drawing Name: hills

Code: C-451 Figure No.: 9





Equivalency Receptors for CTDMPUS and CALPUFF
at Hills 11, 17, 18 and 19 near Ormet

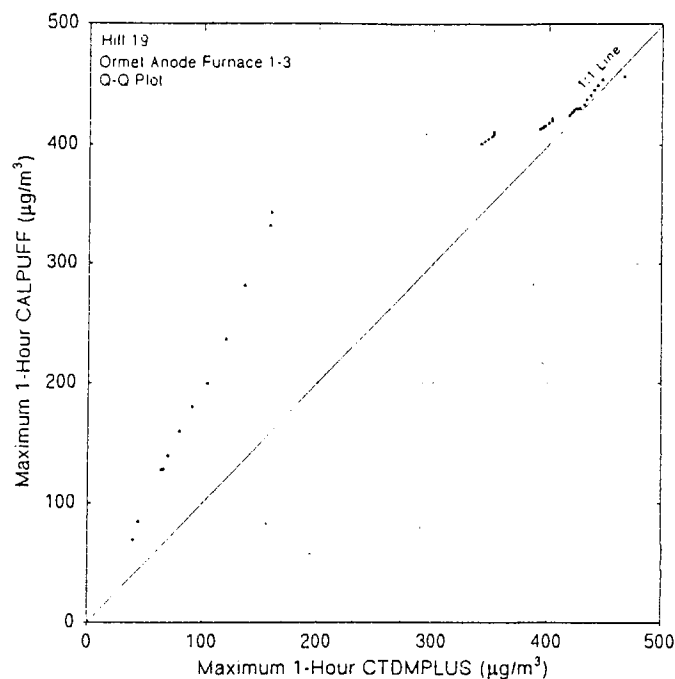
Energy & Environmental Management, Inc.

Date Prepared: 11/20/97

Scale: 1000m UTM grid

Drawing Name: equiv

Code: C451 Figure No.: 13



Rec #	Receptors (Km)		Elev (ft)	1-Hr ($\mu\text{g}/\text{m}^3$)		Rec #	Receptors (Km)		Elev (ft)	1-Hr ($\mu\text{g}/\text{m}^3$)	
	East	North		CTDM+	CALPUF5		East	North		CTDM+	CALPUF5
1	513.724	4393.931	910.	38.	60.2	21	513.702	4393.780	1110.	400.	429.3
2	513.723	4393.927	920.	40.	69.7	22	513.700	4393.772	1120.	403.	429.7
3	513.722	4393.920	930.	44.	84.6	23	513.699	4393.763	1130.	467.	429.2
4	513.721	4393.913	940.	66.	128.0	24	513.698	4393.754	1140.	447.	427.6
5	513.720	4393.906	950.	64.	127.4	25	513.697	4393.745	1150.	443.	425.6
6	513.718	4393.897	960.	70.	139.4	26	513.695	4393.737	1160.	440.	423.5
7	513.717	4393.887	970.	80.	159.9	27	513.694	4393.730	1170.	437.	421.2
8	513.716	4393.878	980.	91.	180.3	28	513.693	4393.722	1180.	433.	419.0
9	513.714	4393.868	990.	104.	199.5	29	513.692	4393.715	1190.	431.	417.1
10	513.713	4393.858	1000.	120.	236.4	30	513.691	4393.707	1200.	427.	414.9
11	513.712	4393.853	1010.	136.	281.3	31	513.690	4393.701	1210.	425.	414.8
12	513.711	4393.848	1020.	158.	331.3	32	513.689	4393.696	1220.	423.	413.6
13	513.711	4393.842	1030.	159.	342.4	33	513.689	4393.690	1230.	421.	412.0
14	513.710	4393.837	1040.	353.	456.0	34	513.688	4393.685	1240.	419.	412.5
15	513.709	4393.832	1050.	351.	453.4	35	513.687	4393.679	1250.	417.	410.1
16	513.708	4393.823	1060.	348.	448.8	36	513.686	4393.671	1260.	403.	408.1
17	513.707	4393.815	1070.	345.	444.9	37	513.685	4393.664	1270.	397.	406.3
18	513.705	4393.806	1080.	342.	440.5	38	513.684	4393.656	1280.	396.	404.3
19	513.704	4393.798	1090.	353.	436.9	39	513.683	4393.649	1290.	395.	402.5
20	513.703	4393.789	1100.	392.	433.1	40	513.682	4393.641	1300.	393.	400.5

Source as tested

Stack Height (m)	Base Elev (m)	Stack Diam (m)	Exit Vel. (m/s)	Exit Temp. (deg K)	Emit Rate (g/s)
76.20	201.1	2.01	19.78	344.	15.75



Q-Q Plot and Tabular Listing for Impact
at Hill 19

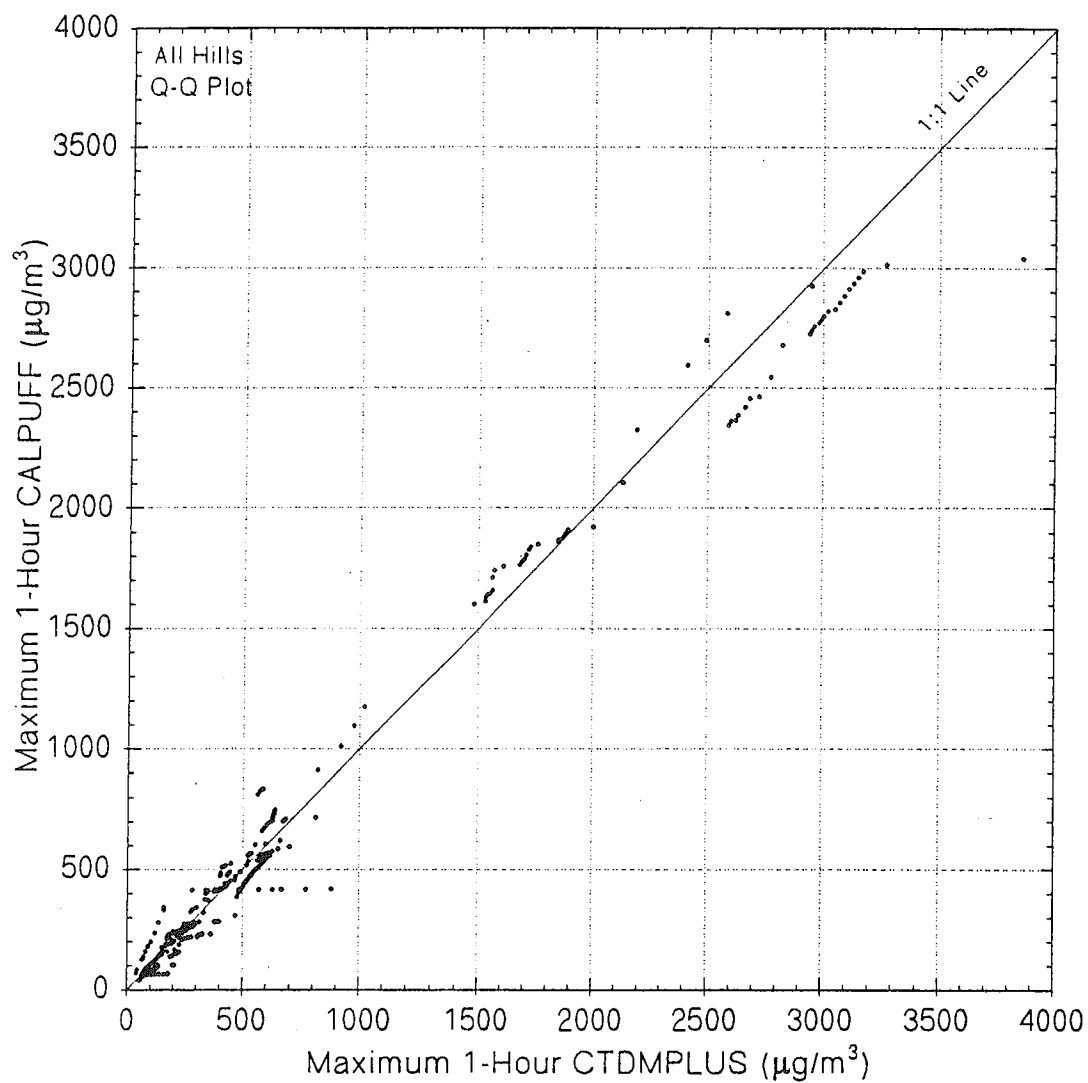
Energy & Environmental Management, Inc.

Date Prepared: 12/05/07

Scale: N/A

Drawing Name: Hills

Code: C-451|Figure No.: 14



Q-Q Plot for all Hills

Energy & Environmental Management, Inc.

Date Prepared: 12/03/97

Scale: N/A

Drawing Name: hills

Code: C-451 Figure No.: 15