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REP-P312-B-1

TVOC emission dispersion modelling

United Silicon, Iceland

Purenviro 2017

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Key data

Client:	Multiconsult
Ordered by:	Thor Martin Bjarnøe
Dato:	15. Jan 2018
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Project id:	P312
Scope:	Compilation of meteorological data and terrain data. Dispersion modelling based on VOC concentration data and air flow data provided by the client

Introduction

United Silicon in Iceland emits various volatile organic compounds, VOC. The concentrations of the VOC in the flue gas has been measured by the client.

The modelling in this report studies dispersion of VOC from the existing discharge point which is a roof top opening, as well as dispersion from a hypothetical emergency stack.

Off gas volumes and temperatures varies with oven load and discharge point. The current discharge is by forced ventilation, whereas an emergency stack would be by natural draft. After a hypothetical shut down, the gas emission will take some time cool off. The effect of these different variations has been studied in the present report.

The modelling has been done with aermod using local meteorological data. Emission data has been provided by the client.

Methodology

The modelling has been performed using aermod. Details are listed in the table below:

Table 1: *Model details*

Components:	TVOC				
Model type:	Concentration				
Averaging time:	Hourly				
Statistic:	annual max and annual average				
Modellering:	Aermod	**versjon:**	16216r	**Referanse:**	Link
	Aermap	**versjon:**	11103	**Referanse:**	Link
	Aermet	**versjon:**	15181	**Referanse:**	Link
	BPIP-PRIME			**Referanse:**	Link
Weather data:	KEFLAVIK NAVAL AIR STATION	**Station no:**	040180 16201	**Referanse:**	Link
		Lat:	63.967		
		Lon:	-22.6		
		Elevation [m]:	52.1		
		Year:	2015		
		Cloud cover:	Interpolated		
Koordinatystem:	UTM27	X: 423673			
		Y: 7100687			
Terrengdata:	National Land Survey of Iceland 10x10m EPSG:3057			**Referanse:**	Link
Emission data:	Submitted by client				

Terrain data has been obtained from National Land Survey of Iceland. The dataset has 10x10m spatial resolution.

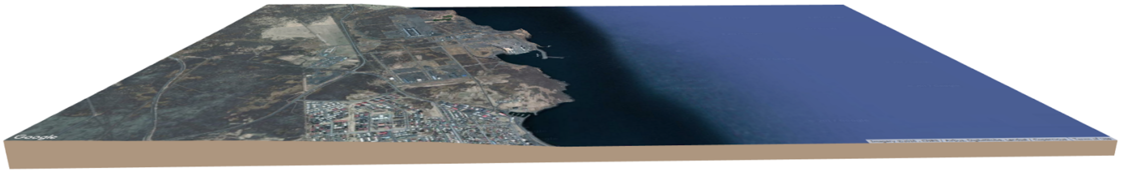

Figure 1. *Terrain data from National Land Survey of Iceland*

Weather data has been sourced from the station at KEFLAVIK NAVAL AIR STATION using Purenviro's globale weather database[1].

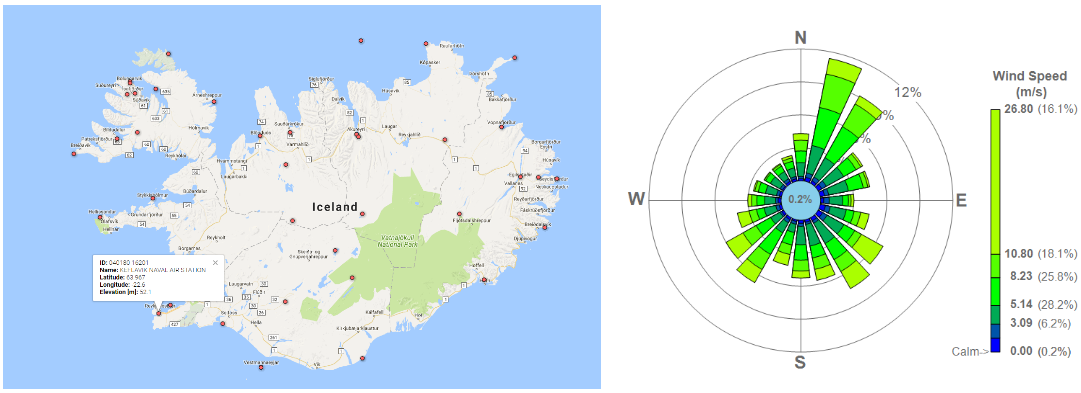

Figure 2. *Weather data from KEFLAVIK, 2015*

The model setup was based on site layout 3D model provided by the client. The official terrain data set would put the entire area on elevation 20m a.s.l. According to data provided by the client, the lower level of the site is at 8.4 masl and the upper level is at 26.4 m a.s.l.

The hypothetical emergency stack height was assumed to be 57m above terrain level.

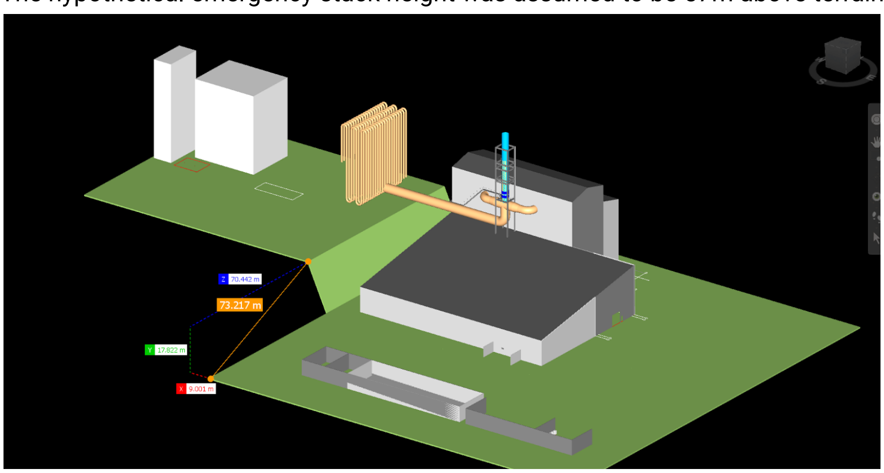

Figure 3. *Model of the site showing the modified terrain*

[1] "Globale værdata - Purenviro." https://www.purenviro.com/no/bibliotek/verktoy/80-vaerdata. Accessed 6 Jan. 2017.

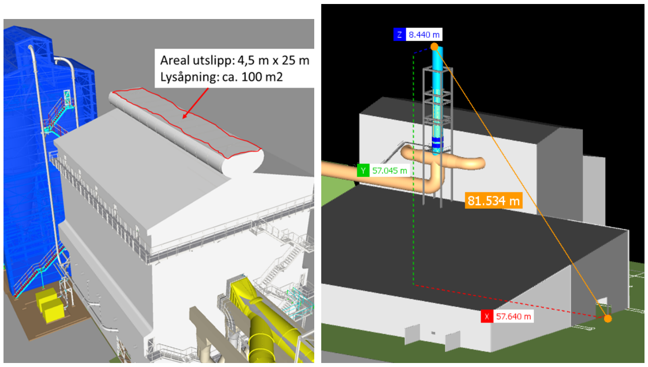

Figure 4. *The two alternative emission points: rooftop (left) and future stack (right)*

Emission levels

The emission levels were provided by the client. Only one set VOC values were measured. These were for full production. To comply with the principle of a *conservative, worst case approach* the same absolute flux was assumed for all cases.

Table 2: *Emission data to be modelled*

Discharge through filter bag house			**Concentration**	**Flux**	
Temp [oC]	**Nm3/h**	**Am3/h**	**TVOC [ug/m3]**	**TVOC [g/s]**	**Description**
180	205 000	340 165	1297	0.123	32 MW
120	100 000	143 956	3065	0.123	10 MW
100	72 000	98 374	4485	0.123	0.5 hr after shut down
70	38 000	47 744	9241	0.123	1 hr after shut down
50	20 000	23 663	18645	0.123	1.5 hr after shut down

Discharge through hypothetical stack			**Concentration**	**Flux**	
Temp [oC]	**Nm3/h**	**Am3/h**	**TVOC [ug/m3]**	**TVOC [g/s]**	**Description**
450	215 228	570 000	774	0.123	32 MW
250	224 455	430 000	1026	0.123	20 MW
200	219 323	380 000	1161	0.123	15 MW
150	206 525	320 000	1379	0.123	10 MW
100	161 019	220 000	2005	0.123	3 hr after shut down
50	84 520	100 000	4412	0.123	6 hr after shut down

The model has been set up as a model for total volatile organic compounds TVOC. The concentrations in the plots are all for TVOC. In order to assess concentrations of specific compounds, the concentrations in the plots must be multiplied with a corresponding factor. These factors are listed in the table below.

Table 3: *Scaling factors to calculate concentrations for individual VOC from the TVOC plots*

	Actual concentration in emission [ug/m3]	Multiply results in dispersion plots with factor to get real concentration [factor]
Benzoic acid	353.4	0.272
Phenylmaleic anhydride	144	0.111
Acetophenone	119.9	0.092
Benzonitrile	48.7	0.0375
Naphthalene	42.6	0.0328
Phthalic anhydride	40.7	0.0314
Benzaldehyde	26.6	0.0205
Benzeneacetonitrile,alpha oxo	21.6	0.0167
sulfur dioxide	19.2	0.0148
Cyclotrisiloxane, hexamethyl-	16.3	0.0126
Diethyl Phthalate	16.2	0.0125
Phenol, 2-nitro-	14.5	0.0112
1-Butanol	13.8	0.0106
Ethanedione, diphenyl-	13.6	0.0105
Acetic acid	13.3	0.0103
Phenol	11.5	0.00887
Dibenzofuran	10.8	0.00833
Octanoic acid	9.7	0.00748
Cyclotetrasiloxane, octamethyl-	9.5	0.00732
5-Methyl-2-nitrophenol	8.3	0.00640
Biphenyl	8.2	0.00632
Tridecane	7.9	0.00609
Nonanenitrile	7	0.00540
Phenanthrene	5.7	0.00439
Toluene	5.4	0.00416
Dodecane	5.2	0.00401
Undecane	5	0.00385
2-methylhexane	5	0.00385
Ethanedione, diphenyl-	4.5	0.00347
decamethyl cyclopentasiloxane (D5)	4.5	0.00347

Dispersion results

Figure 5. *Discharge through filter bag house rooftop assuming the oven running on 32MW. The concentrations plotted represent annual* *maximum* *value. Emission details are provided in Table 2.*

Figure 6. *Discharge through filter bag house rooftop assuming the oven running on 32MW. The concentrations plotted represent annual* *average* *value. Emission details are provided in Table 2.*

Figure 7. *Discharge through filter bag house rooftop assuming the oven running on 10MW. The concentrations plotted represent annual maximum value. Emission details are provided in Table 2.*

Figure 8. *Discharge through filter bag house rooftop assuming the oven running on 10MW. The concentrations plotted represent annual average value. Emission details are provided in Table 2.*

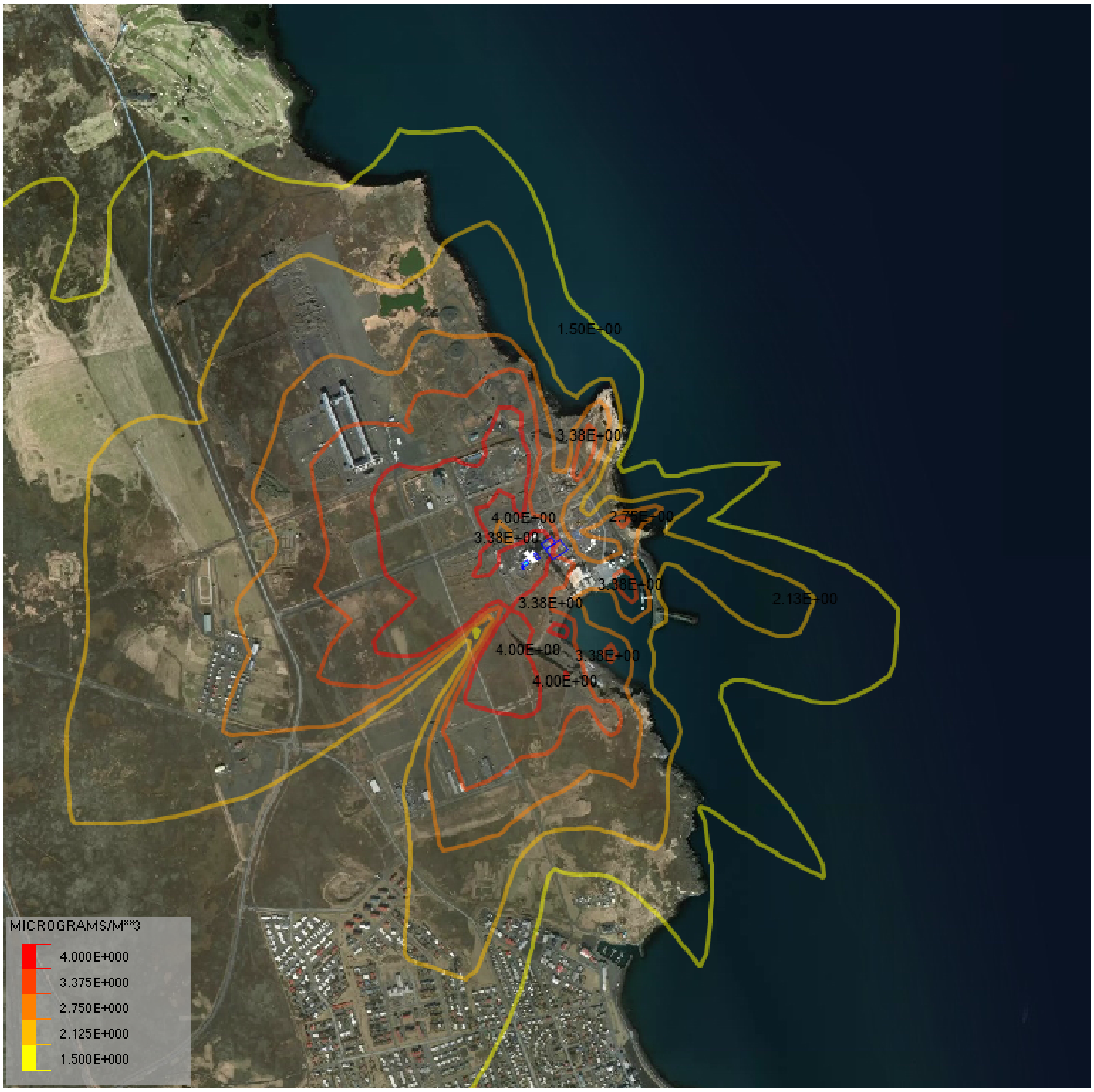

Figure 9. *Discharge through filter bag house rooftop assuming the oven was shut down 0.5 hr ago. The concentrations plotted represent annual* *maximum* *value. Emission details are provided in Table 2.*

Figure 10. *Discharge through filter bag house rooftop assuming the oven was shut down 0.5 hr ago. The concentrations plotted represent annual* <u>*average*</u> *value. Emission details are provided in Table 2.*

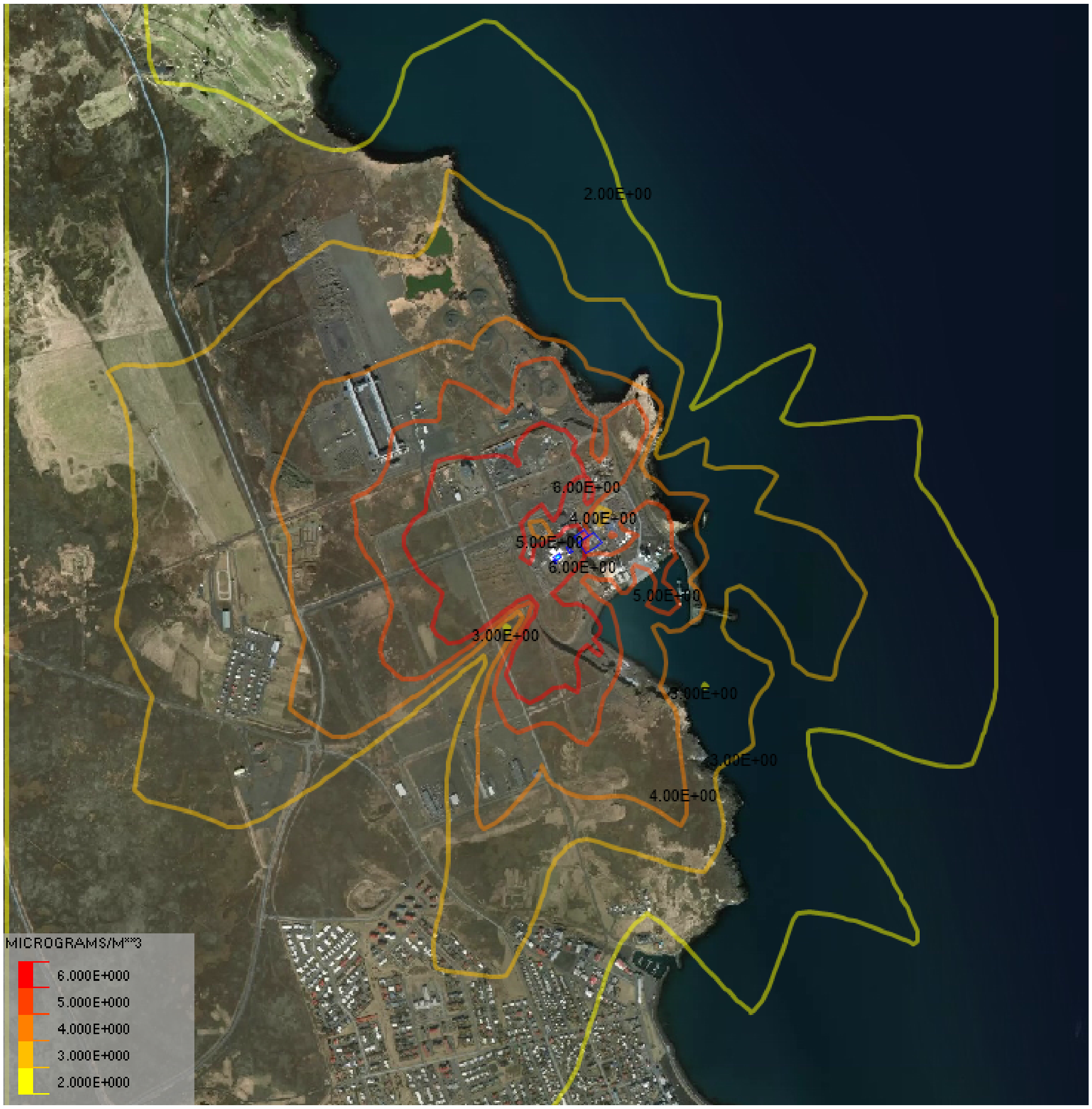

Figure 11. *Discharge through filter bag house rooftop assuming the oven was shut down 1 hr ago. The concentrations plotted represent annual* *<u>maximum</u>* *value. Emission details are provided in Table 2.*

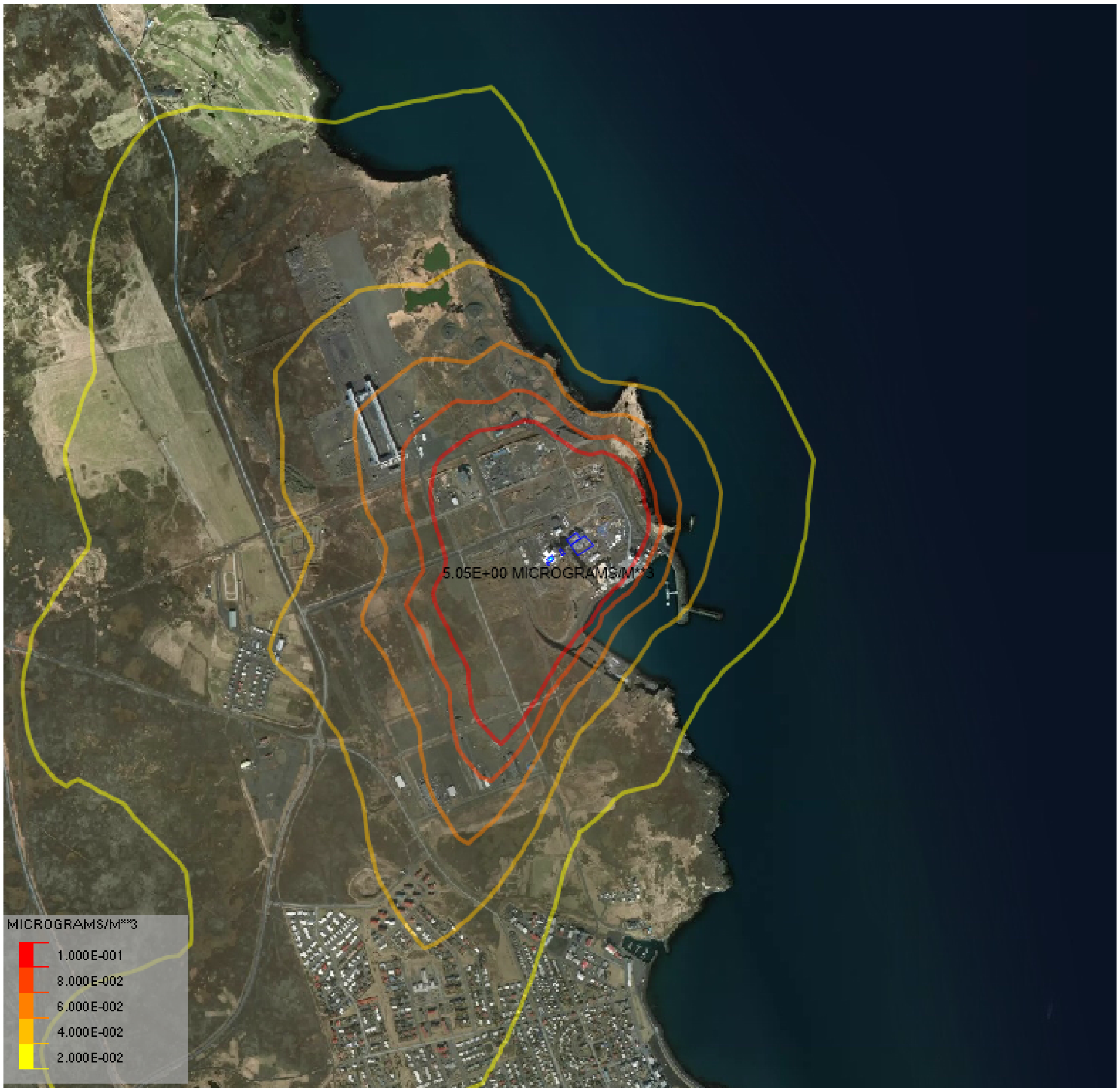

Figure 12. *Discharge through filter bag house rooftop assuming the oven was shut down 1 hr ago. The concentrations plotted represent annual average value. Emission details are provided in Table 2.*

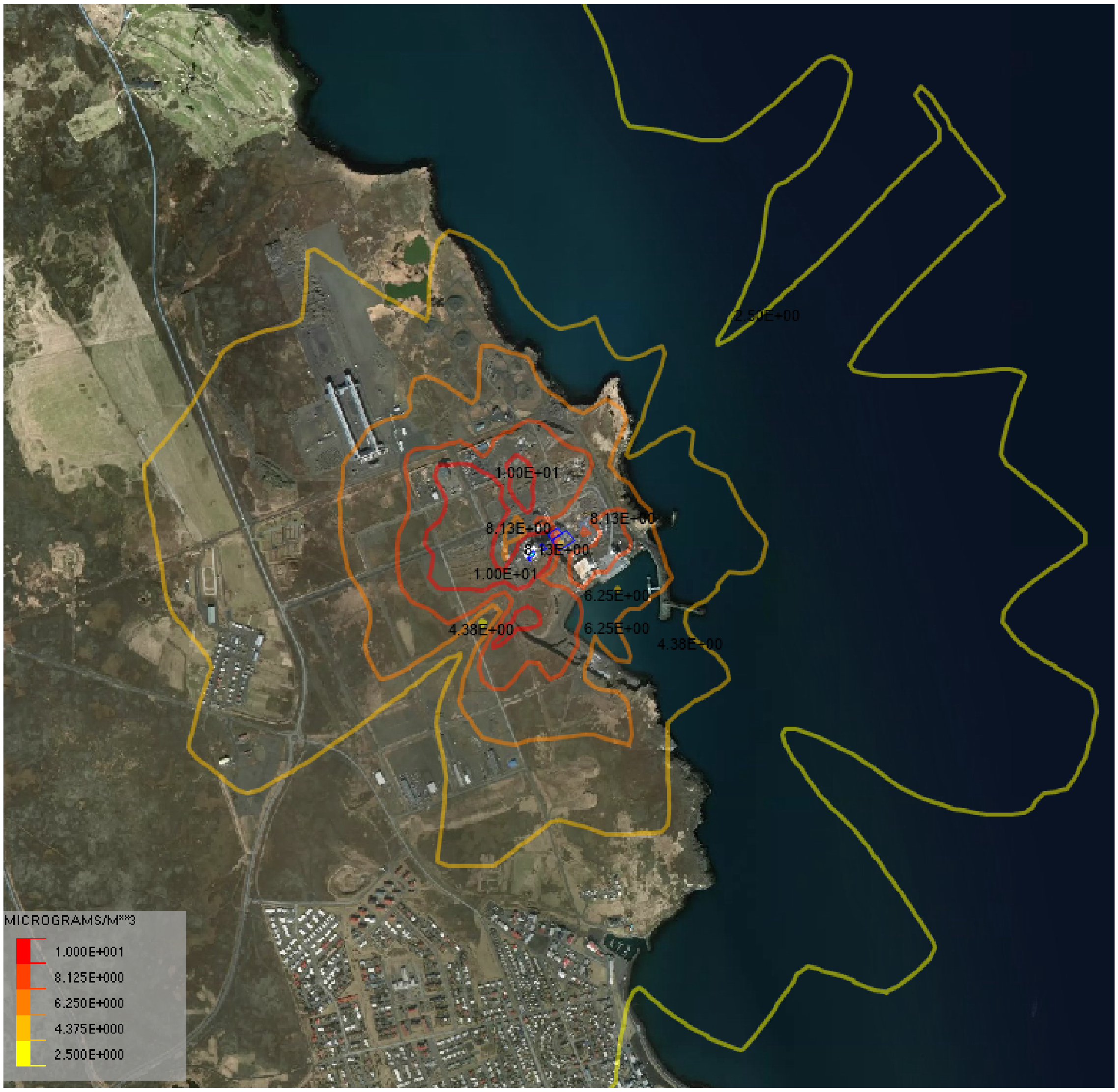

Figure 13. *Discharge through filter bag house rooftop assuming the oven was shut down 1.5 hr ago. The concentrations plotted represent annual maximum value. Emission details are provided in Table 2.*

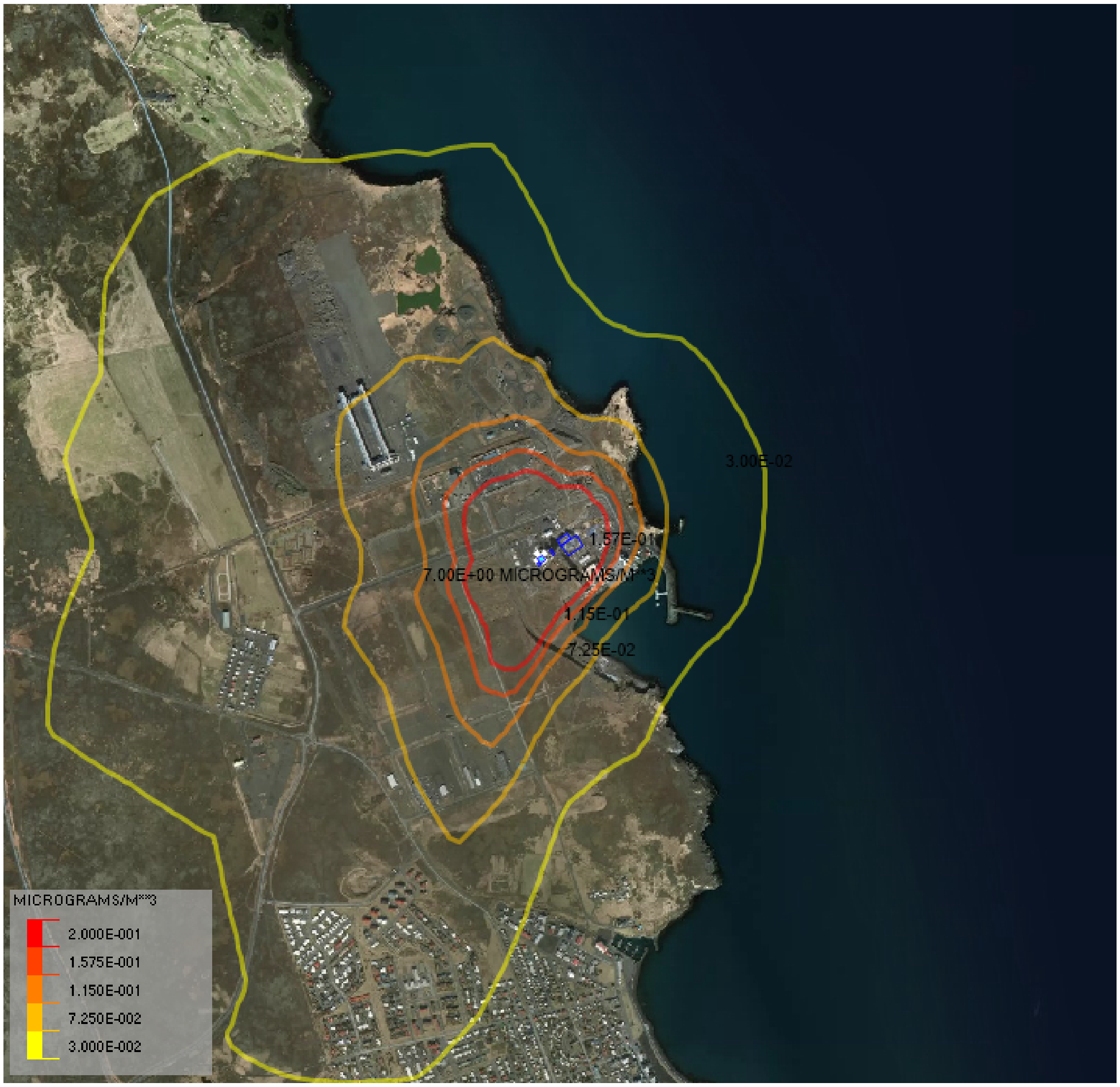

Figure 14. *Discharge through filter bag house rooftop assuming the oven was shut down 1.5 hr ago. The concentrations plotted represent annual average value. Emission details are provided in Table 2.*

Figure 15. *Discharge through a hypothetical emergency stack assuming the oven runs 32MW . The concentrations plotted represent annual <u>maximum</u> value. Emission details are provided in Table 2.*

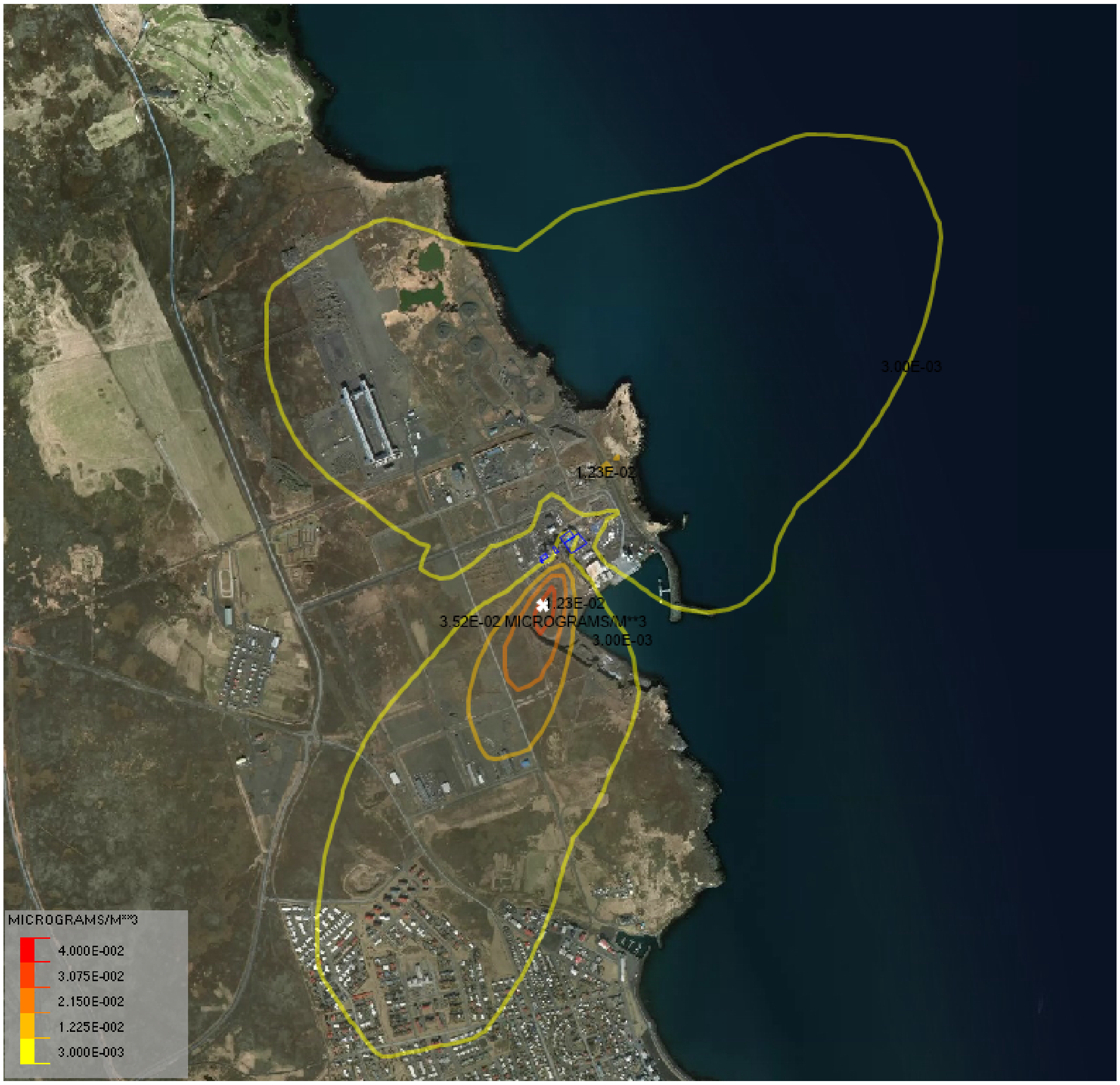

Figure 16. *Discharge through a hypothetical emergency stack assuming the oven runs 32MW . The concentrations plotted represent annual* ***average*** *value. Emission details are provided in Table 2.*

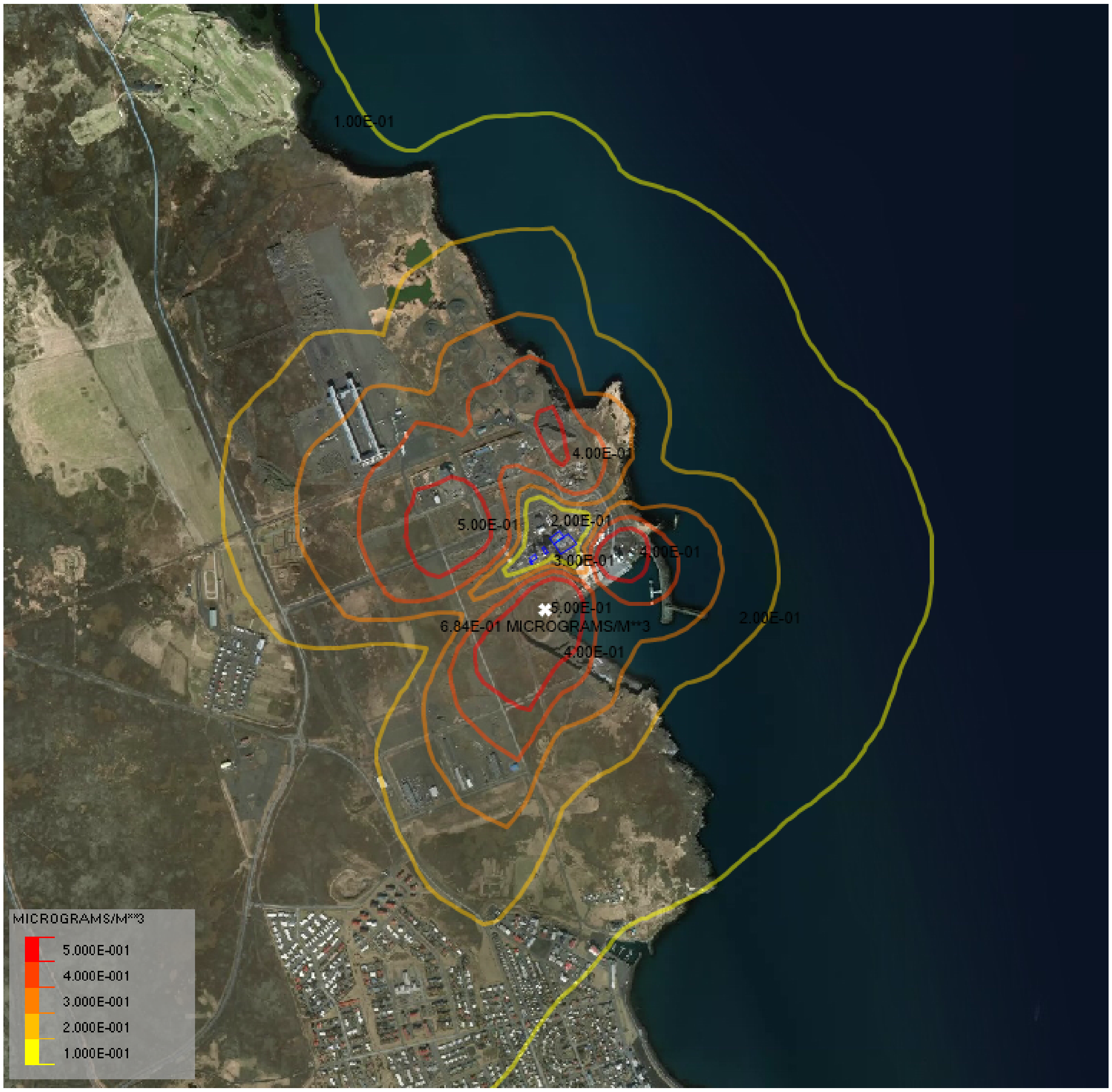

Figure 17. *Discharge through a hypothetical emergency stack assuming the oven runs 20MW . The concentrations plotted represent annual <u>maximum</u> value. Emission details are provided in Table 2.*

Figure 18. *Discharge through a hypothetical emergency stack assuming the oven runs 20MW . The concentrations plotted represent annual* <u>*average*</u> *value. Emission details are provided in Table 2.*

Figure 19. *Discharge through a hypothetical emergency stack assuming the oven runs 15MW . The concentrations plotted represent annual* *maximum* *value. Emission details are provided in Table 2.*

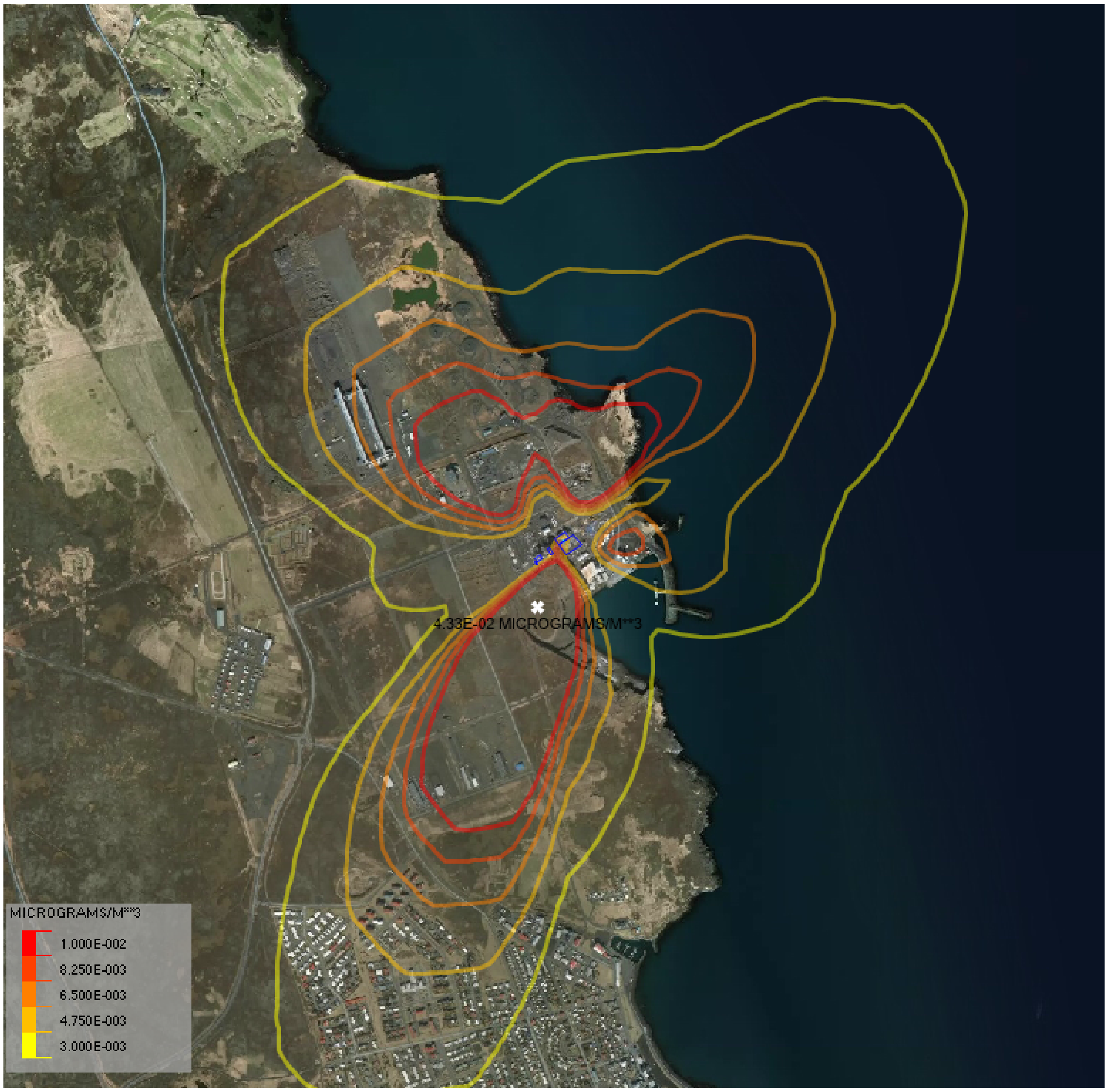

Figure 20. *Discharge through a hypothetical emergency stack assuming the oven runs 15MW . The concentrations plotted represent annual average value. Emission details are provided in Table 2.*

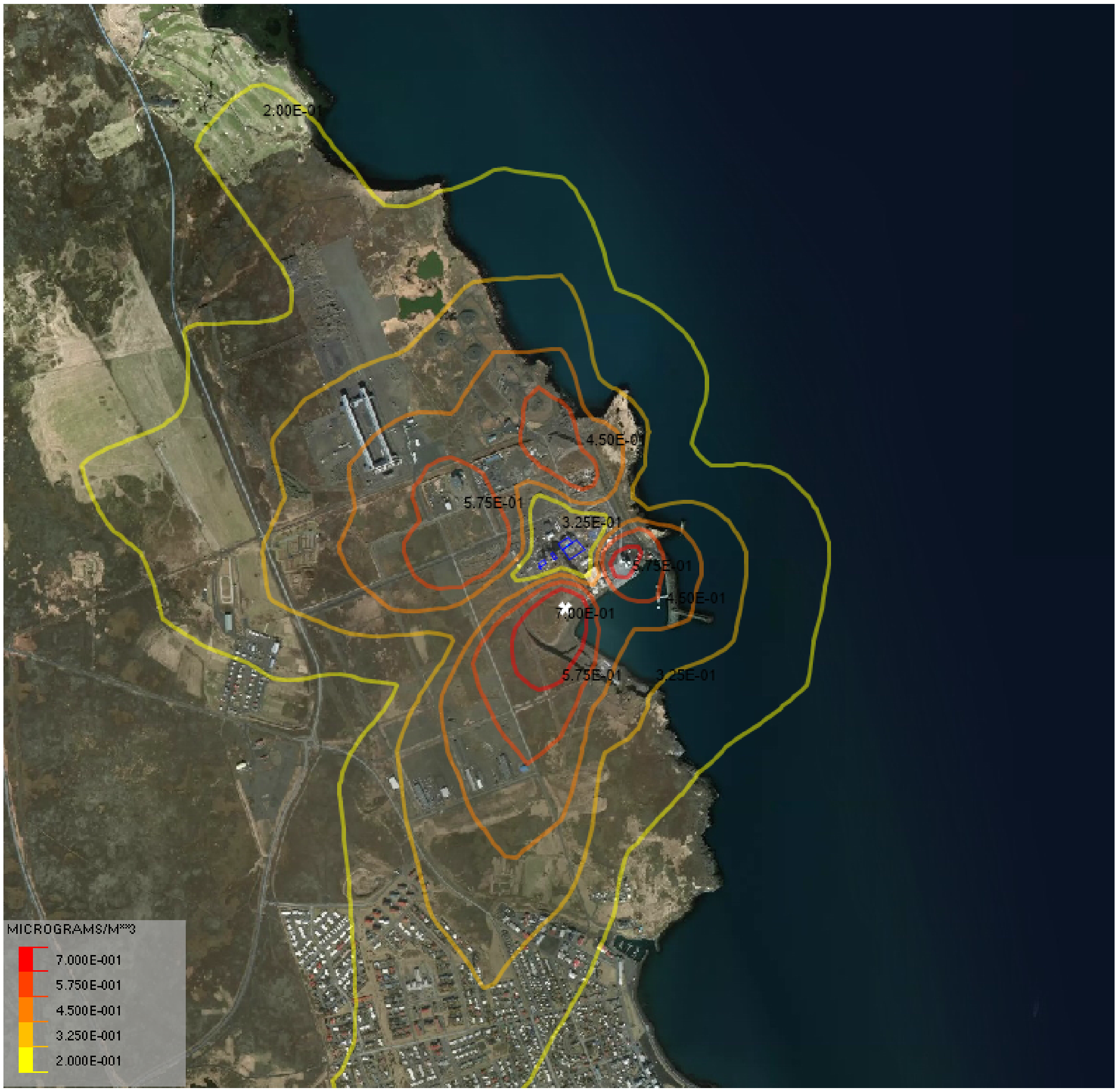

Figure 21. *Discharge through a hypothetical emergency stack assuming the oven runs 10MW . The concentrations plotted represent annual* <u>*maximum*</u> *value. Emission details are provided in Table 2.*

Figure 22. *Discharge through a hypothetical emergency stack assuming the oven runs 10MW . The concentrations plotted represent annual* <u>*average*</u> *value. Emission details are provided in Table 2.*

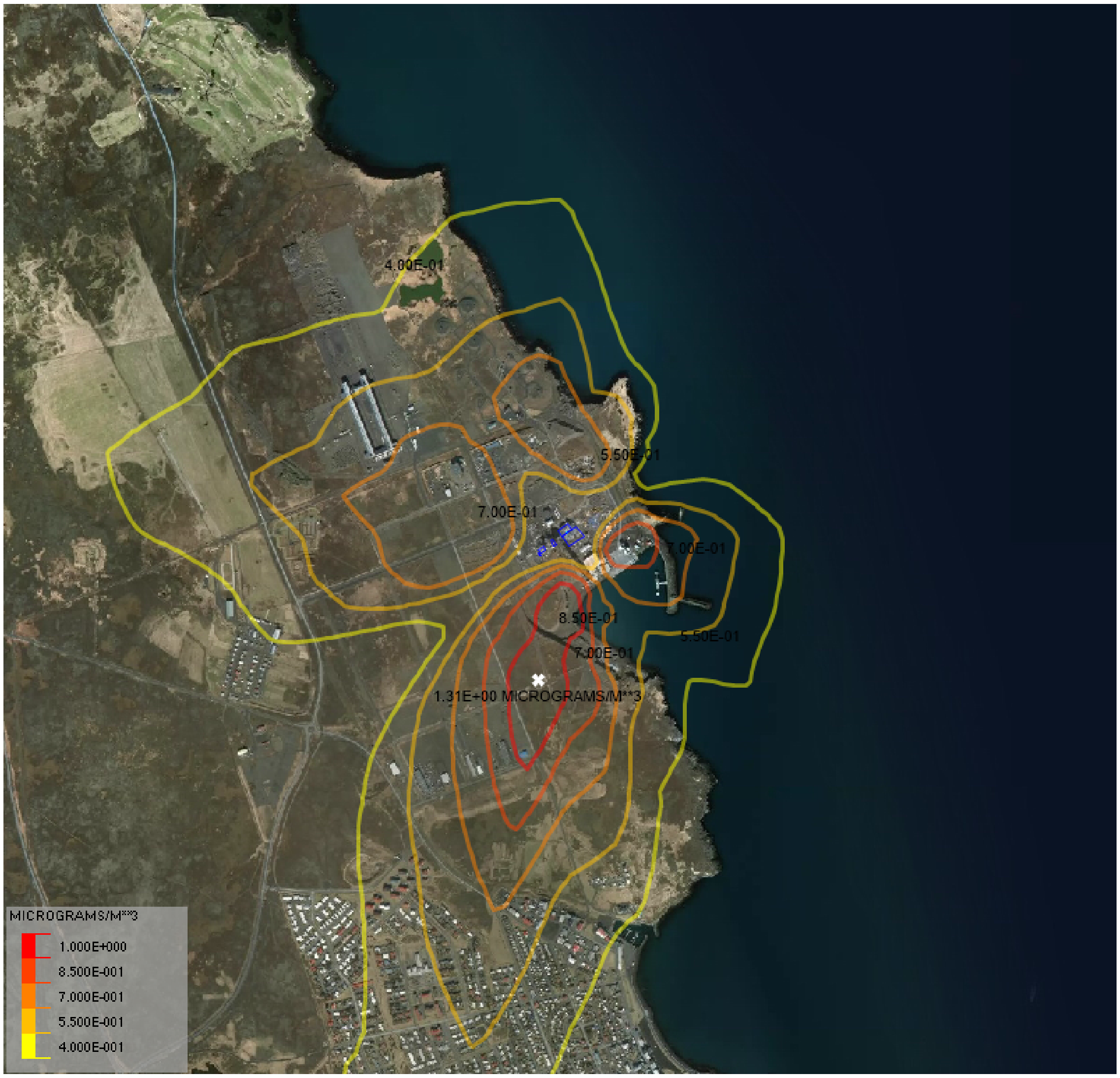

Figure 23. *Discharge through a hypothetical emergency stack assuming the oven was shut down 3 hr ago. The concentrations plotted represent annual <u>maximum</u> value. Emission details are provided in Table 2.*

Figure 24. *Discharge through a hypothetical emergency stack assuming the oven was shut down 3 hr ago. The concentrations plotted represent annual* *<u>average</u>* *value. Emission details are provided in Table 2.*

Figure 25. *Discharge through a hypothetical emergency stack assuming the oven was shut down 6 hr ago. The concentrations plotted represent annual maximum value. Emission details are provided in Table 2.*

Figure 26. *Discharge through a hypothetical emergency stack assuming the oven was shut down 6 hr ago. The concentrations plotted represent annual* <u>*average*</u> *value. Emission details are provided in Table 2.*

Concluding remarks

The current report shows dispersion plots for 11 scenarios, each of which is reported with two plots, one for annual maximum value and one for annual average value. Each of the 22 plots can be multiplied with a factor from table 3 in order to represent the respective pollutant.

Emissions from the existing discharge point generally results in higher ground level concentrations than the hypothetical stack. The reason being slow vertical gas velocity and discharge close to the roof height which makes the plume susceptible to building downwash.

The scenarios with lower flow and lower temperatures result in higher ground level concentration. Low temperature means less buoyant plume. The lower flow means higher concentrations since the assumption was made the the total flux is constant for all cases.