Technical Note

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Table of Contents

1. Introduction

1.1. Background and regulatory guidance

This document presents the air quality management plan for the Next Generation Data Limited (NGD) data centre facility at Celtic Way, Marshfield, Duffryn, Newport NP10 8BE.

Backup power facilities for the data centre are provided by 12 banks of diesel engine powered generators (77 engines in total) with a combined thermal input of over 50 MW. The installation is a Schedule 1 listed activity under the Industrial Emissions Directive (IED) and requires an environmental permit to operate.

An air quality management plan is required for managing a response to potential exposure to diesel engine emissions during an emergency power outage. It was requested by Natural Resources Wales (NRW), in the environmental permit improvement condition (IC2). The condition is worded as follows:

"The operator shall develop and submit a site-specific Air Quality Management Plan (AQMP) in conjunction with the Local Authority which identifies the emergency operating conditions (grid failure) when Local Air Quality may be adversely impacted by emissions to air from the installation. This shall include but not be limited to the following considerations:

- *predicted potential impacts indicated by the air modelling at individual receptors;*
- *timescales for response measures;*
- *how local conditions during a grid failure might influence the response required, for example meteorological conditions or time of day;*
- *contingency for how the response will be carried out in the event scenario i.e. loss of power; and*
- *timescales for continued review of the management plan*.

The agreed AQMP shall be submitted to Natural Resources Wales for approval."

NRW stated in the Environmental Permit Decision Document that the emergency outage operating scenario could pose a risk to local air quality at identified receptors for short term nitrogen dioxide (NO_2), albeit such an occurrence being for a very short period of time and is extremely unlikely. This is because NGD manages the risk of an emergency power outage through having in place dual connections to the Super Grid, and onsite measures to prevent on-site power failures such that a conservative estimate is that a two hour grid outage is a one in twenty year event. Regular switchgear and engine testing and maintenance, including testing of rapid load-shedding procedures, further minimise the potential effects of grid power failures.

In line with the adopted "*Data centre FAQ Headline Approach*" (internal Environment Agency draft guidance, dated July 2017, a written action plan is required to manage prolonged emergency running of the plant in the rare event of a grid failure. The plan includes identification of sensitive receptors, assessment and impact evaluation against modelled risk conditions, i.e. those periods of most concern in the year for potential emergency occurrences) and proposed actions to ensure mitigation is in place.

The Environment Agency draft guidance for data centres states that the plan should be developed in conjunction with the Local Authority and its Local Air Quality Management (LAQM) process and where relevant (in extreme circumstances) their "Major Incident Procedures". Given the extremely low likelihood of an emergency outage due to the dual connection to the Super Grid and considering the nature of the diesel exhaust that may be emitted, the latter is not deemed relevant. The local authority has been consulted on this document but has stated they do not have any capacity to provide comment at this stage.

1.2. Approach to development of the AQMP

Dispersion of pollutants from stacks is primarily influenced by wind direction and wind speed. There are seasonal differences in such weather conditions. Another important factor is the degree of turbulence in the atmosphere acting to dilute the exhaust plumes, which may differ markedly between daytime and night time unless local conditions are overcast. The broad categories of atmospheric conditions are classified using the Pasquill stability classes of stable, neutral and unstable, and further categorised with reference to wind speed and cloud cover into six or seven classes; A to G/F.

The dispersion model scenario for an initial hour of emergency operation with load shedding, as addressed in the permit application, has been further evaluated for the purposes of developing a risk matrix to inform the operator's understanding of the potential for exceedances of public health criteria, under different specific classes of meteorological conditions. A comparison with this criterion allows for identification of potentially affected areas.

A four year hourly meteorological data set was used to evaluate the number of potential exceedances in winter, spring, summer and autumn; hence providing a count for each season comprising twelve months of meteorological data. The cumulative total counts for four years provide a robust estimate for conditions at the NGD site in Newport. These findings were subsequently broken down to evaluate the day time and night time exceedance counts within each of the four seasons. In the context of the Pasquill stability classes, night time is defined as the period from one hour before sunset to one hour after sunrise.

The analyses are presented as a series of isopleth plots showing the counts of exceedances of the adopted threshold concentration, by season, and also by day and night for each season, overlaid on a local map showing receptors.

A further investigation of the effect of wind speeds was carried out for the four year meteorological dataset. This looked at the number of exceedances for the four-year period in several wind speed bands. Again, the results are presented as a second series of isopleth plots, in this case showing the counts of exceedances in the entire four-year period for the wind speed band in question.

1.3. Application of findings

In developing an AQMP it has been necessary to consider how to feasibly manage what is an emergency event, to limit the potential for significant effects on sensitive receptors. This document identifies in further detail the areas at most risk of breaches in the initial hours of a power outage and sets out appropriate actions by the site team to inform NRW and where appropriate, to minimise harm.

The exceedance count contour plots (Appendix B) have been used to define a risk matrix which feeds into a set of simple steps to be incorporated within NGD's integrated management system. The set of tiered operator actions has been designed to be capable of implementation within a few minutes of a power outage. This will enable a rapid understanding of the relative risks, given the prevailing meteorological conditions at the time of the event.

NGD has confirmed that load ramp down will occur under all power outage scenarios within ten minutes. It is not possible for NGD to select which engines would operate following ramp down, and there is no flexibility in operation of different banks of engines. The priority will be to immediately understand the risk presented by prevailing conditions and throughout the likely duration of the power outage.

In the event of an emergency, the existing wind speed and direction will be established from consultation of online sources (with a view in future to automate this step). The operator will use the prevailing conditions to identify if the event is a low, medium or high risk of exceedance of air quality exposure criteria and, where this may be the case, report to the regulator.

If the outage is potentially of long duration (over two hours), the contour plots can provide further detail for the regulator with regard to the potential extent of the downwind region that may be subject to exceedances of the criterion during the emergency event. With reference to the second series of plots and the actual wind speed at the time, the initial apparent potential for exceedances from the seasonal/diurnal plots may be either discounted or confirmed by the operator in discussion with the regulator.

Community engagement, in terms of raising local awareness of emergency operation and understanding of local sensitivities (e.g. existing health conditions), is not deemed to be appropriate at this stage, given the extremely low likelihood of an emergency power outage event of brief (two hour) duration coinciding with the least favourable meteorological conditions. The plan therefore includes the procedure for notifying NRW and Local Authority as appropriate during the event. Any decision regarding community liaison should be made in consultation with NRW and the Local Authority according to the risk to receptors identified at the time of the event (i.e. according to the conditions prevailing at the time).

2. Local environs

Receptors relevant to the NGD AQMP are the surrounding residential areas, industrial/commercial operations which would not be protected by enclosed structures, schools and other locations of short term exposure such as hotels and nurseries. The industrial units close to the NGD facility are considered of low sensitivity due to the enclosed nature of these buildings and the expectation of them being fitted with mechanical ventilation systems and filters.

The air dispersion modelling undertaken for the NGD data centre facility, which uses a hypothetical emergency outage operating scenario, indicated a potential (although extremely low likelihood) risk of exceedances at nearby sensitive receptors for local air quality when downwind of the wind direction and other conditions prevailing at the time of the outage event.

The nearest sensitive receptors considered in the permit application are included here for reference and are numbered 1 to 6 in Table 2-1. Additional nearby receptors identified for the AQMP are numbered 7 to 10.

Table 2-1 – Selected local human health receptors

These discrete receptors are shown in plan view in **Figure 2-1** as numbered blue triangles. The NGD facility is highlighted in sand colour and the building itself is grey with the stacks denoted by red dots. Other surrounding industrial facilities are also shown in grey.

When determining the risk matrix for the AQMP, receptors were considered more broadly by sector within a polar grid, as indicated in **Figure 2-2**.

Figure 2-1 - Selected local human health receptors

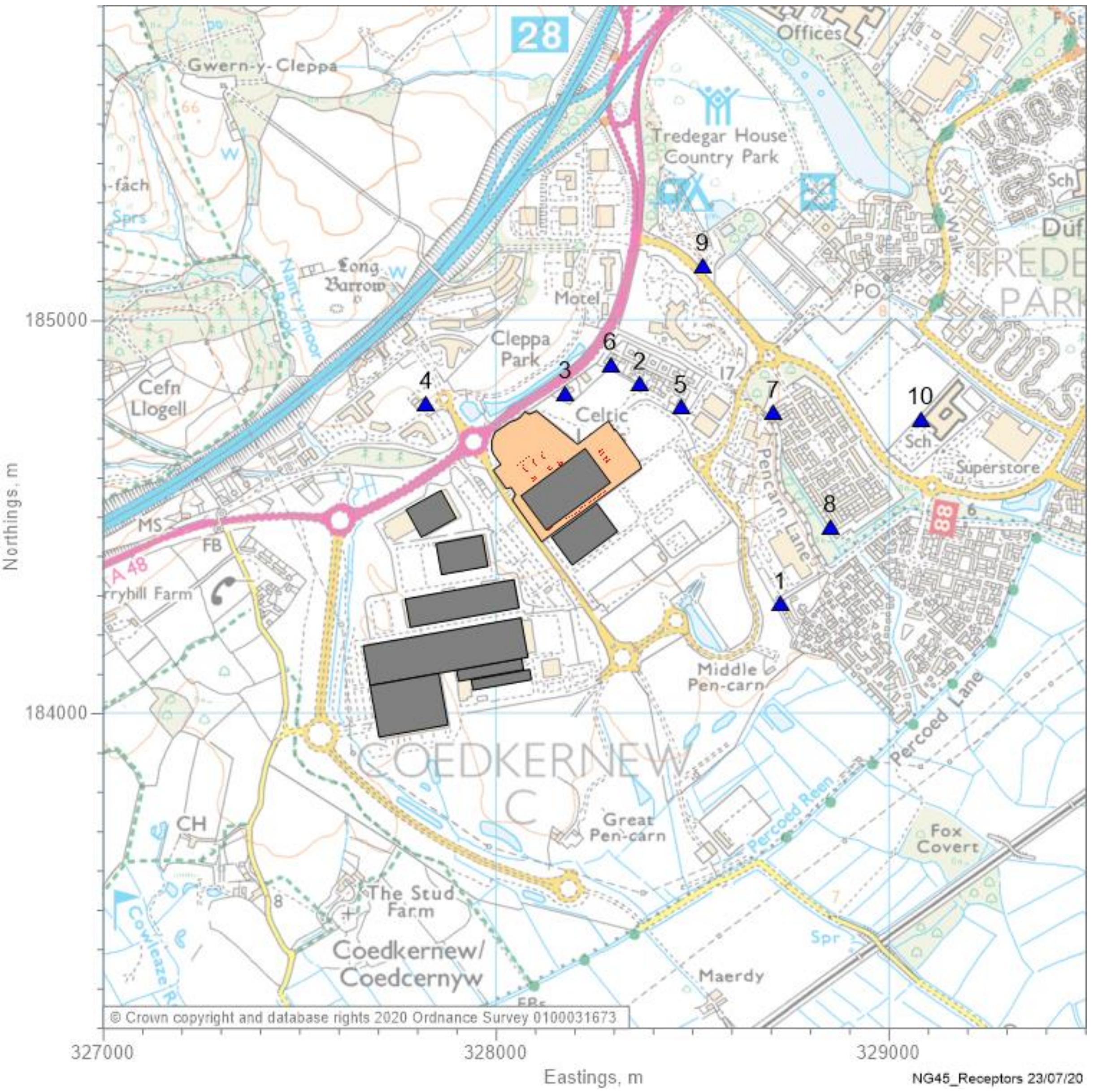
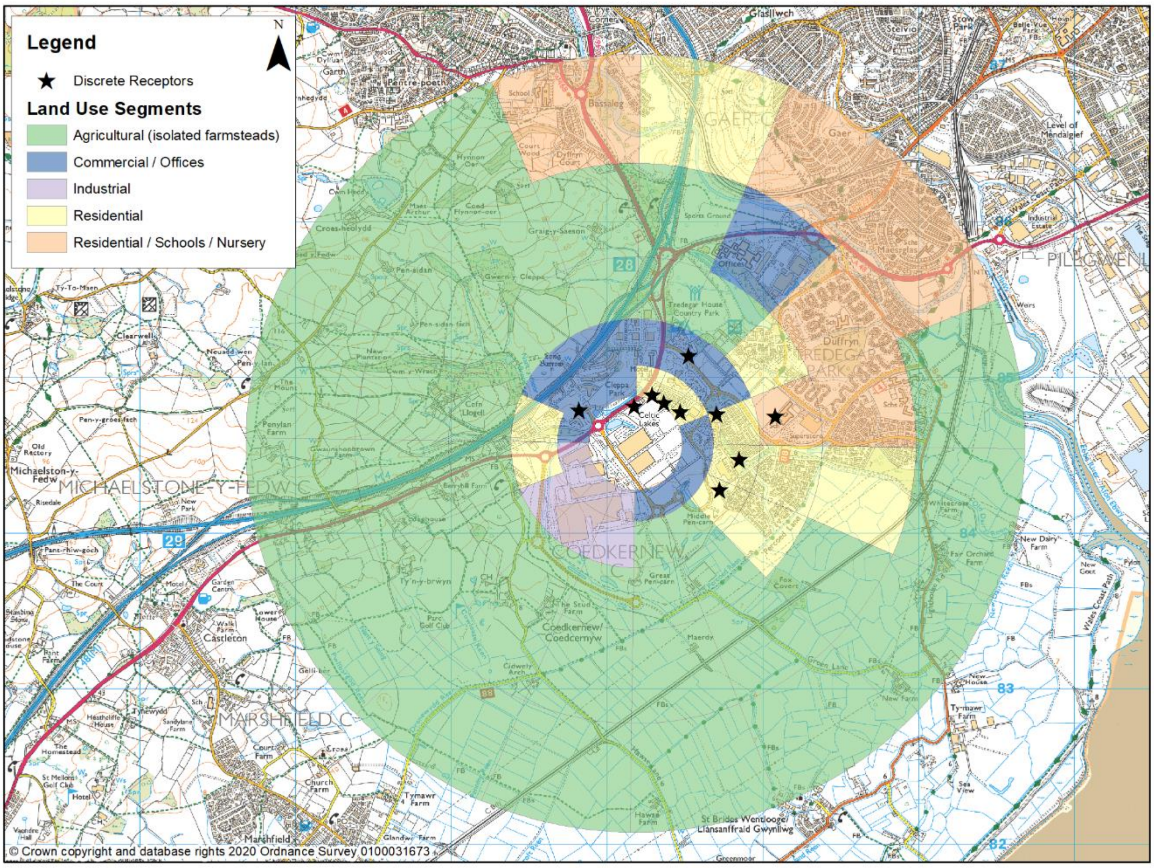


Figure 2-2 – Broad land use segments for human health receptor risk classification



3. Evaluation of emergency scenario

To evaluate, on a precautionary basis, the environmental impact of the operation of the engines during grid failure, the findings from the emergency scenario provided to NRW in the Schedule 5 response during permit determination were used. These results were further evaluated for the purposes of developing a risk matrix to inform the air quality management plan.

During an emergency power outage, all diesel generators may come into operation followed by load shedding to the required load after an initial 10 minutes. This entails certain engines within each bank of engines being turned off after approximately 10 minutes. This scenario was addressed in the permitting application where 29 of the 77 engines are ramped down in this manner, leaving 48 engines running at full load in the second hour.

The emergency condition considered in the modelling undertaken for the permit application was for a period of up to one hour; although emergency outages may last longer the impact of subsequent hours may be assumed to be lower thereafter, as load shedding to match site power demand is initiated in the few minutes of the onset of the emergency. The emission rates modelled for each hour of the year to identify the highest hourly average concentration, necessarily relate to the initial hour of an emergency. Were the emergency condition to persist beyond one hour, the subsequent hours do not reflect the actual stable site demand load and hence would overestimate by an amount approximately equivalent to five additional engines running continuously.

A four year meteorological data set has been used in the modelling for the AQMP, thus analysing a composite of twelve months of data (approximately 8760 hours) for each of four seasons. As in the previous regulatory submissions, the modelled oxides of nitrogen concentrations were factored by 0.35 to convert to NO_2 concentrations, and a value of 45 µg/m^3 added to derive the total concentration or “Predicted Environmental Concentration, (PEC)” which comprises the plant contribution and an allowance for local background concentrations.

The PEC results were evaluated with respect to the selected short term acute exposure guideline; or more precisely, the counts of modelled exceedances of that criterion at each of the receptor points. These exceedance counts are displayed graphically to enable the relative risks of an exceedance to be determined in the downwind area.

3.1. Assessment criteria

The key pollutant of concern during a power outage is nitrogen dioxide (NO_2) which is formed by the conversion of NO to NO_2 following release from the engine stacks.

The Environmental Permit application considered the National Air Quality Strategy Objective for NO_2 which is 200 µg/m^3, to be exceeded fewer than 18 times in a year. However, the Environment Agency draft guidance for data centres (2017) states that the assessment criterion most applicable to emergency exposures are Acute Exposure Guidance Levels (AEGL). These are threshold exposure limits i.e. exposure levels below which adverse health effects are not likely to occur in the general public. The values are intended to protect most individuals in the general population, including those that might be particularly susceptible to the harmful effects of the chemical.

There are three levels for nitrogen dioxide, shown in Table 3-1, which vary according to the severity of toxic effects. AEGL-1 is the atmospheric concentration of a substance above which the general population, including sensitive individuals, could experience notable discomfort, irritation, or asymptomatic effects. However, the effects are transient and reversible upon cessation of exposure. The AEGL-1 for nitrogen dioxide is 940 µg/m^3 (0.5 ppm) and is the same for exposures of 10 minutes to 8 hours duration.

The Health and Safety Executive (HSE) occupational exposure level over 15 minutes is 1,910 µg/m^3 as nitrogen dioxide, approximately twice the AEGL-1 criterion.

Significant concern for public health and non-reversible damage for nitrogen dioxide over an 8-hour period starts at around 12,600 µg/m^3 (6.7 ppm). This AEGL-2 value is two orders of magnitude higher than AEGL-1. The AEGL-2 value is not applicable to the scale of results seen for the NGD emergency scenario, which are at most approximately one tenth of the threshold as hourly average concentration.

Table 3-1 - Summary of AEGL values for nitrogen dioxide[1]

	Unit	10 mins	30 mins	1 hour	4 hours	8 hours
AEGL 1	ppm	0.50	0.50	0.50	0.50	0.50
(non disabling)	mg/m^3	0.94	0.94	0.94	0.94	0.94
AEGL 2	ppm	20	15	12	8.2	6.7
(disabling)	mg/m^3	38	28	23	15	13
AEGL 3	ppm	34	25	20	14	11
(lethal)	mg/m^3	64	47	38	26	21

3.2. Assessment of impacts

An outage occurrence has been modelled for all hours of meteorological data based on fundamentals of dispersion under the following scenarios to identify the number of exceedances of AEGL-1 during:

- Seasonal variation:
  - Winter (Dec, Jan, Feb);
  - Spring (Mar, Apr, May);
  - Summer (June, July, Aug);
  - Autumn (Sept, Oct, Nov);
- Seasonal and diurnal variation:
  - based on Pasquill stability classes;
  - night time refers to the period from 1 hour before sunset to 1 hour after sunrise;
  - specified for each season using Newport sunrise and sunset data and cross referenced to initial seasonal model output;
- Wind speed categories:
  - < 1.54 m/s;
  - 1.54 to 3.09 m/s;
  - 3.09 to 5.14 m/s;
  - 5.14 to 8.23 m/s;
  - > 8.23 m/s.

The modelling showed no significant difference in the maximum hourly mean nitrogen dioxide concentration in terms of the nearfield maxima under different seasons, all around 3,000 $\mu g/m^3$ or up to three times the AEGL-1. In no scenario does the maximum approach the higher AEGL-2 therefore the relevant health threshold for action is AEGL-1, which concerns non-disabling, reversible impacts.

The exceedance isopleth are shown in full in Appendix B. Exceedances were found to occur predominantly at night-time and during low wind speeds (< 3 m/s). There were found to be no exceedances of the threshold at wind speeds above 5.14 m/s.

The risk matrix in Table 3-2 summarises the outcome of this evaluation for certain risk conditions i.e. likelihood of an occurrence of exceedance of AEGL-1 threshold in different time periods and during different dispersion conditions throughout the year. This matrix can readily be reviewed by the site / operations manager when identifying the relevant actions to take in the event of a catastrophic power outage. The associated summary plots (simplified to show just the three risk categories, high, medium and low) are shown Appendix B.1.

Note that given the four-year meteorological data set used in the assessment, each season contains approximately 8,760 hours, thus putting these counts of exceedances into a frequency context. The three bands of risk categories proposed are based on stratifying the exceedance count data, as modelled for this specific facility, to allow a hierarchy of responses in the AQMP.

[1] https://www.epa.gov/sites/production/files/2015-09/documents/nitrogen_oxides_volume_11_1.pdf

Note also that the use of terms "high", "medium" and "low" are merely relative descriptors of risk, based on the modelling findings, and do not represent a direct toxicological risk to a receptor. The following risks assume a sensitive receptor is present downwind based on the land use segments in **Figure 2-2**. In the event of a prolonged outage, further detail should be obtained from the contour plots.

- A **high** risk was considered to be a number of hours of exceedance above 90, i.e. approximately 1% of the modelled hours and this is indicated in **orange**.
- A **medium** risk was defined by a number of hours of exceedance between 10 and 90, i.e. approximately 0.1 to 1% of the modelled hours and is indicated in **yellow**.
- A **low** risk was defined by a number of hours of exceedance below 10, i.e. approximately 0.1% of the modelled hours, indicated in **green**.

Table 3-2 – Risk matrix for *downwind* exceedances

	Time of day	Day time							
	Wind from	N	NE	E	SE	S	SW	W	NW
Season	Spring								
	Summer								
	Autumn								
	Winter								

	Time of day	Night time							
	Wind from	N	NE	E	SE	S	SW	W	NW
Season	Spring								
	Summer								
	Autumn								
	Winter								

Definitions

Season	Month	Day time (hour commencing)
Spring	M, A, M	07:00 to 18:00
Summer	J, J, A	07:00 to 19:00
Autumn	S, O, N	09:00 to 17:00
Winter	D, J, F	08:00 to 15:00

4. Emergency procedure

4.1. Actions and reporting

In the event of an outage, the operator is required to immediately inform the regulator of the number of banks running and if load shedding has been activated. They will then check the prevailing conditions and consult the appropriate risk matrix to identify the air quality risk level.

If during the emergency event, a high risk is identified, the operator will inform the regulator and where appropriate, further action may be taken. This may comprise examination of the relevant risk exceedance plot for the prevailing conditions to obtain a more detailed understanding on the likelihood of receptors being affected. If the event is likely to be of prolonged duration, the operator should discuss actions to be taken with the regulator and local authority.

The following steps will be put in place in the event of any emergency power outage at the NGD Newport site:

- Open an incident diary
  - Note start time of outage, local conditions;
  - Use proforma provided to record actions;
  - Notify regulator of outage;
- Identify likely duration of outage and enact mitigation
  - Check with UK Power Networks, normal repair times for works, how critical is the fault;
  - Ensure load shedding of generators has begun (within initial ten minutes);
- Report Outage Impacts Risk;
  - Initially report to the NRW permitting officer and if unavailable the National Incident Help Line;
  - Report to Local Authority (NCC);
  - Number of nests running, number of sets initially run up and number that have load banked
- Identify air quality risk category
  - Check weather conditions (wind speed, direction) currently and over next few hours;
  - Identify whether adverse conditions with a **high** risk (>1%) of exceeding AEGL-1;
  - Note that a high risk would only occur during night-time and wind speed < 5 m/s;
- In the extremely unlikely event of a power outage and where UK Power Networks advises NGD of a potential **prolonged** interruption to mains power (over 2 hours) under high risk conditions, NGD will discuss any relevant further actions with NRW and the Local Authority. This may include:
  - Assess likely geographical extent by comparing to contour plots and considering weather/time factors ;
  - Identify sensitive receptor areas downwind, based on the specific circumstances;
  - Take appropriate and proportionate action as advised by NRW and the Local Authority;
- Keep up to date on changing circumstances by:
  - Checking online forecast and revise risk category if wind direction/speed changes or outage continues into a higher risk time period;
  - Check if diesel fume or odour is noticeable off site

NGD will review the effectiveness and suitability of the AQMP after an emergency outage event and annually in the case of plant reconfiguration / development in the interim period.

4.2. Management plan flow chart

The flow chart shows the actions required and the responsible person. This procedure is to be adopted as part of the NGD Emergency Management Procedure PM03-01, within NGD's Integrated Management Plan.

Power outage occurs	Site manager	Start incident diary	See pro-forma in Appendix A
Alert regulator	Site manager	NRW, NCC	If officer unavailable / out of hours,
Find out outage duration	Site manager	Contact UKPN	Check websites – Met Office, Windfinder
Ensure mitigation in place	Ops manager	Check load shedding	Call
Identify AQ risk category	Ops manager	Check wind condition	www.Windfinder.com OR Scada
IF HIGH RISK* *(at night, low wind & relevant direction)*	Ops manager	Inform NRW	Indicates possible risk of exceedance at receptors
Report, monitor, review	Site manager	Check risk hourly	Discuss risk with NRW / Local Authority (NCC)

HIGH RISK

Night-time PLUS wind speed **5 m/s or below** PLUS wind direction FROM:

SW↗, W→, NW↘, N↓, NE↙ (except **NE↙** summer) **OR SE↖** (Spring only)

https://www.windfinder.com/ (left click on NGD site location to view wind direction and speed)

Night-time definition

Spring (March to May)	19:00 to 06:59
Summer (June to Aug)	20:00 to 06:59
Autumn (Sept to Nov)	18:00 to 08:59
Winter (Dec to Feb)	16:00 to 07:59

4.3. Training

NGD employees at the Newport site will receive appropriate training with regard to the AQMP procedures and how to quickly check wind conditions in the event of an emergency.

A toolbox talk will be presented to all staff to raise awareness of the potential for impacts and the actions within the AQMP including completion of a report.

Relevant documents and forms will be made available on the NGD internal Sharepoint site.

How to check wind conditions

To check direction and speed, you can use the Windfinder website.

Navigate to the site location (NP10 8BE) and left click on the page – you should see the following pop up:

In this example, the arrow  shows the wind is coming from the **NE** direction and speed is **8 m/s**.

Useful websites

NRW https://naturalresources.wales/about-us/contact-us/report-an-environmental-incident/?lang=en

UK Power Networks https://www.ukpowernetworks.co.uk/power-cut

Appendices

Appendix A. Pro-forma reporting template

Power outage	Format	Comment
Date of outage	DD/MM/YYYY	
Start time	xx:xx	
Number of engines operating upon outage	X no.	
Load shedding actioned	Y / N	
Number of engines operating after two hours	X no. full load X no. part load	
UK Power Network contacted?	Y / N	
Anticipated duration of outage (hours) *("prolonged" if >2 hours)*		
Wind direction	N / E / S / W NE / SE / SW / NW	
Wind speed	Low (<5 m/s) / High (> 5 m/s)	
Season	Spring / Summer / Autumn / Winter	
Time category (*check seasonal differences in timings*)	Day / Night	
Air quality risk category	Low / Medium / High	
Regulator informed? *(state NRW and/or Local Authority)*	Y / N	
Further action required? *(Y if high risk, >2 hours and sensitive receptors)*	Y / N	
Sensitive receptors nearby *(give type & locations)*		
Further action agreed with regulator and/or LA *(give detail)*	Y / N	
Outage end time	xx:xx	
Total number of hours' outage		

Appendix B. Exceedance plots

B.1. Risk plots

The following plots show the counts of exceedances of the AEGL-1 for nitrogen dioxide of 940 µg/m^3, based on the calculated total concentration (the PEC), under different conditions (season, time of day and wind speed category). The colours correspond to the three risk categories.

B.1.1. Spring

Spring daylight hours were modelled as hour commencing 07:00 to 18:00 inclusive for day time, and 19:00 to 06:00 inclusive for night time.

Figure B-1 - Summary risk plot for Spring and day time outage

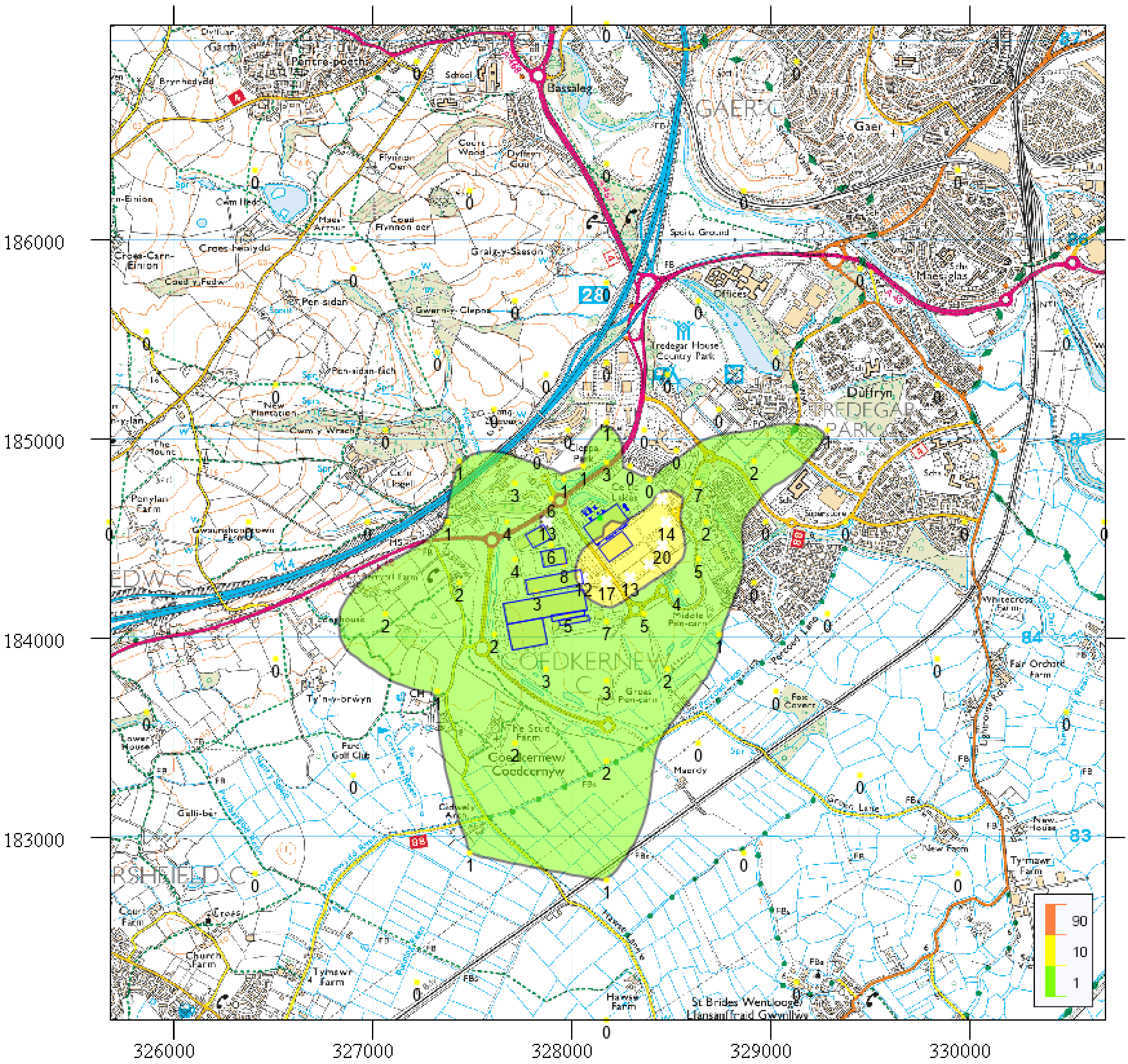
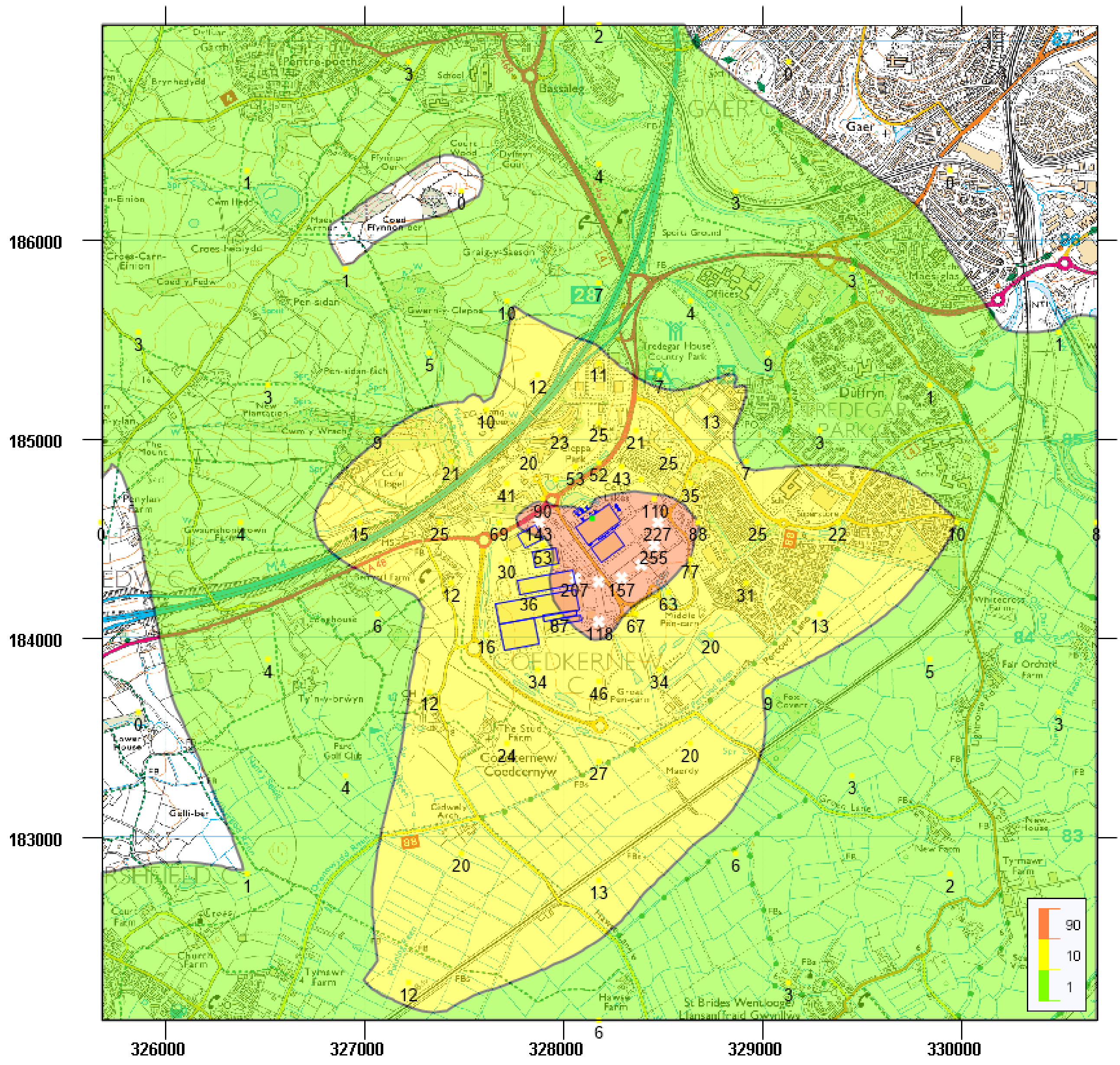


Figure B-2 - Summary risk plot for spring and night time outage



B.1.2. Summer

Summer daylight hours were modelled as 07:00 to 19:00 inclusive for day time, and 20:00 to 06:00 inclusive for night time.

Figure B-3 - Summary risk plot for summer and day time outage

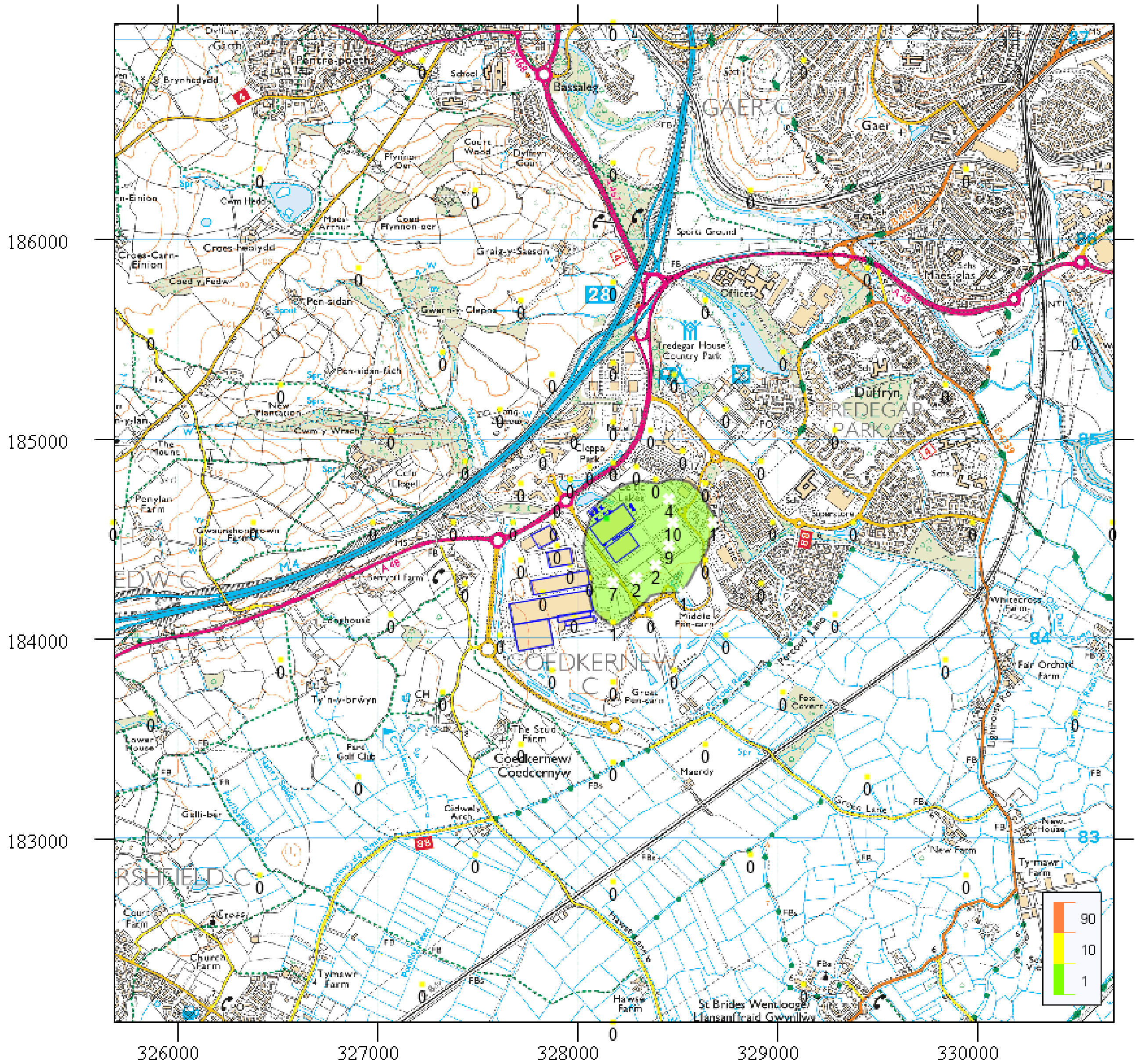
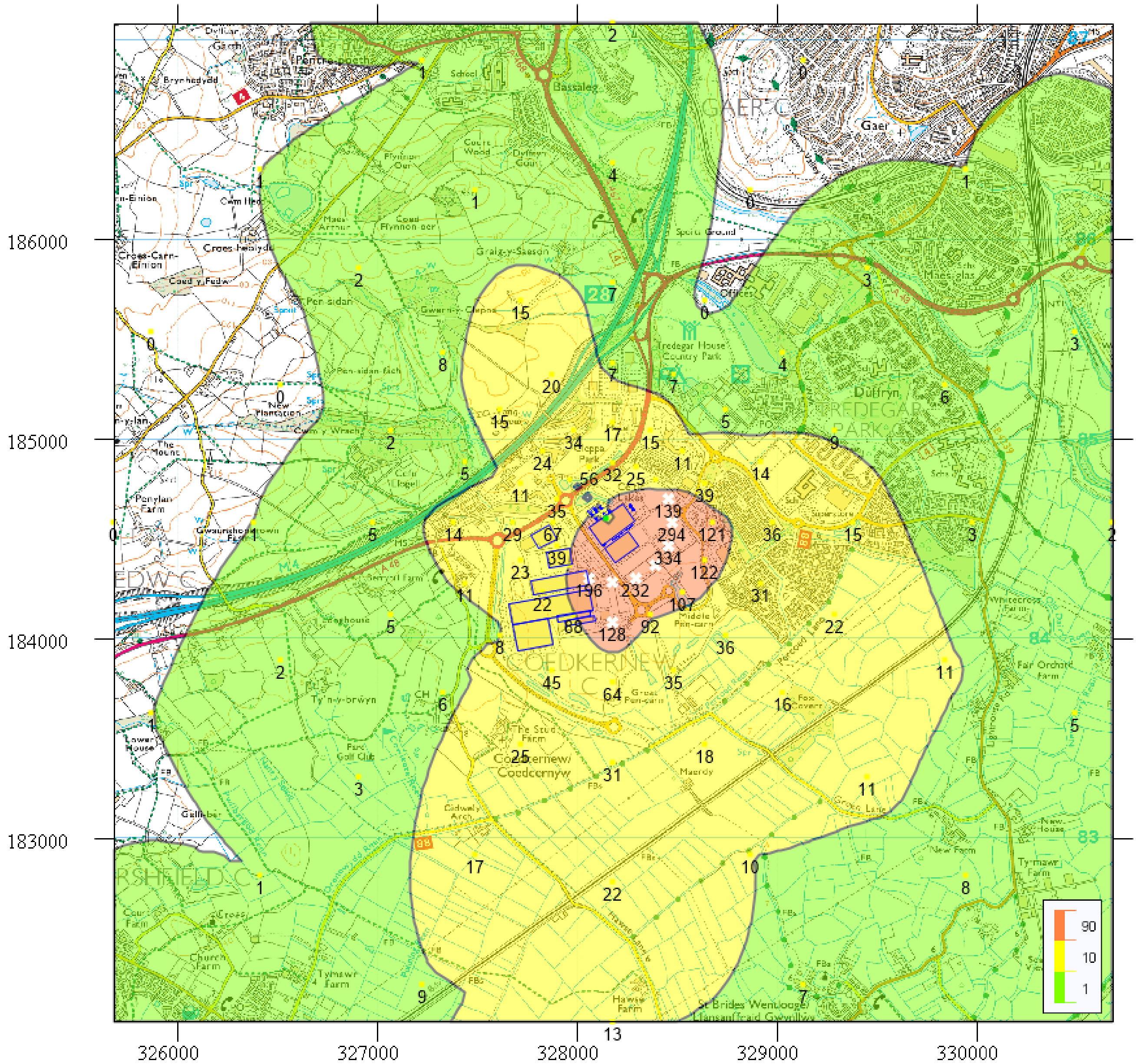


Figure B-4 – Summary risk plot for summer and night time outage



B.1.3. Autumn

Autumn daylight hours were modelled as 09:00 to 17:00 inclusive for day time, and 18:00 to 08:00 inclusive for night time.

Figure B-5 – Summary risk plot for autumn and day time outage

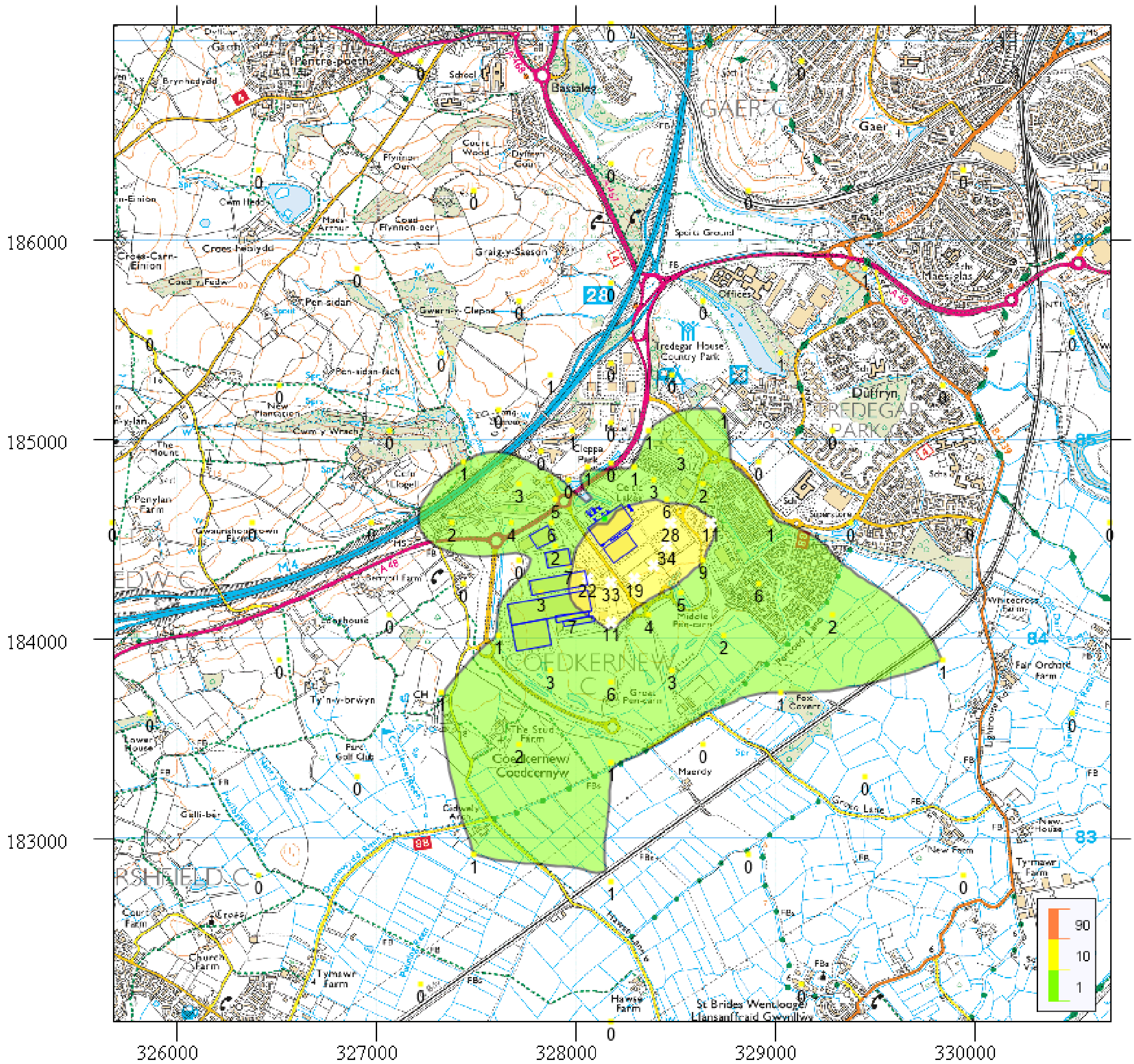
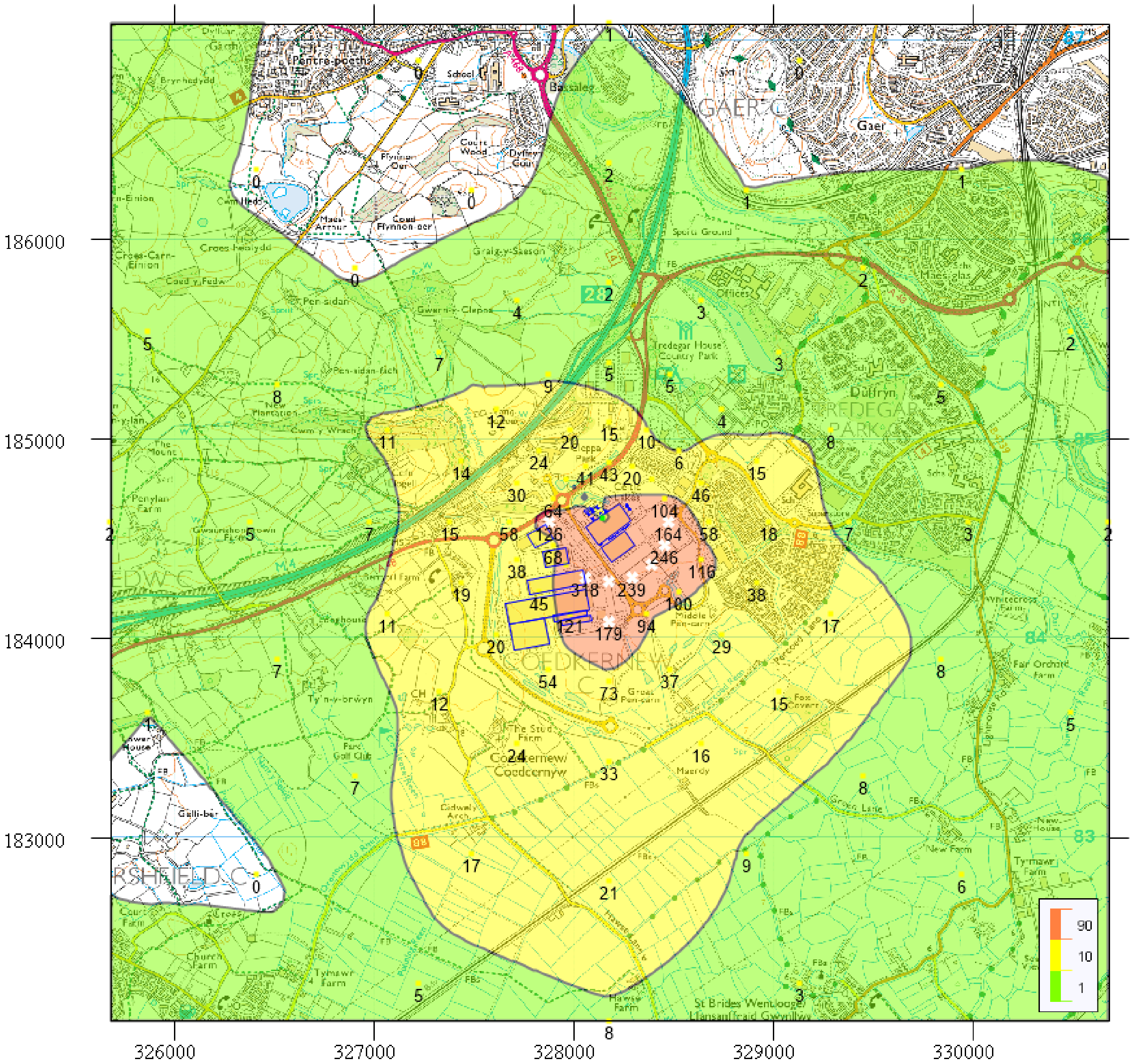


Figure B-6 - Summary risk plot for Autumn and night time outage



B.1.4. Winter

Winter daylight hours were modelled as 08:00 to 15:00 inclusive for day time, and 16:00 to 07:00 inclusive for night time.

Figure B-7 – Summary risk plot for Winter and day time outage

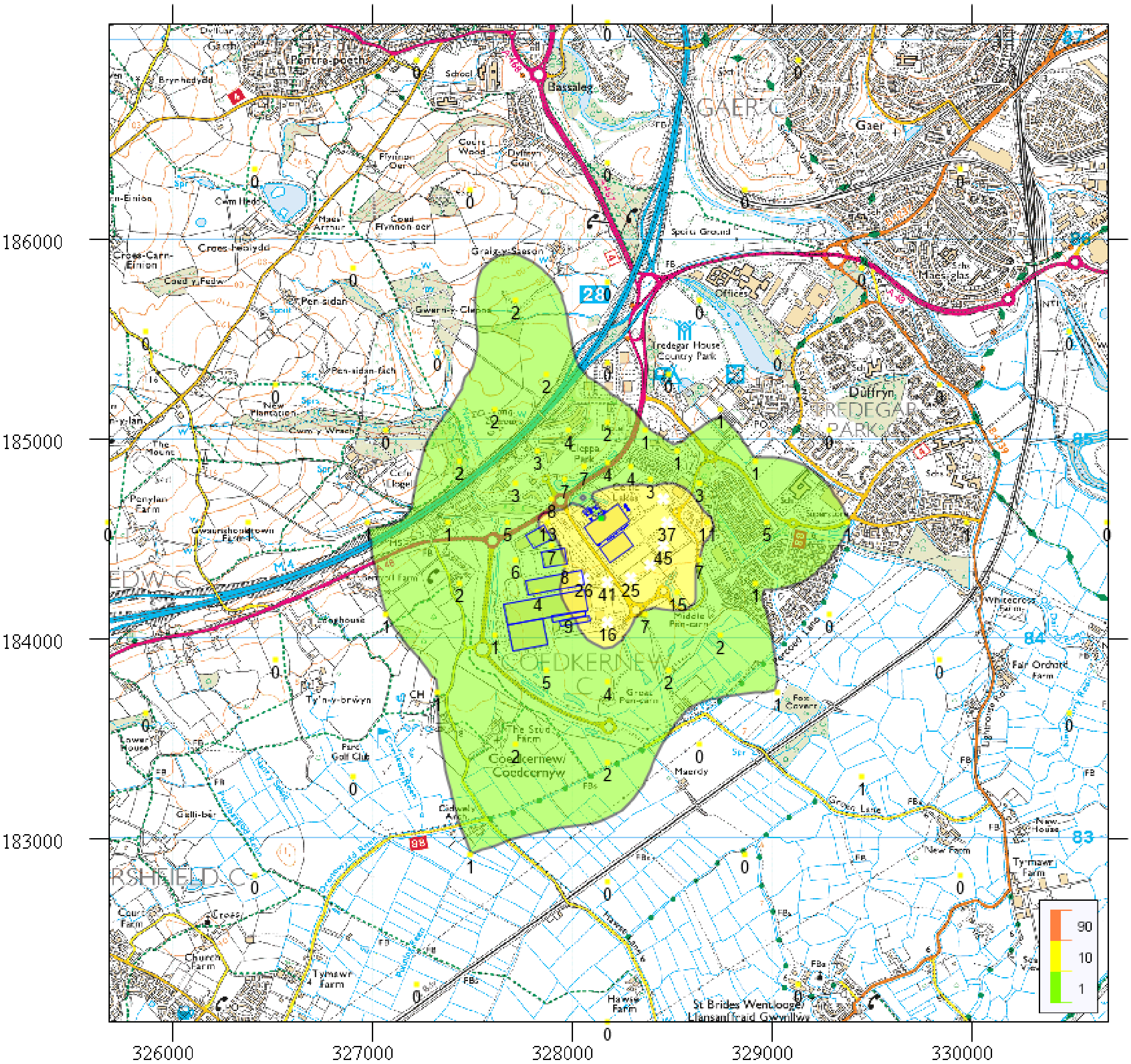
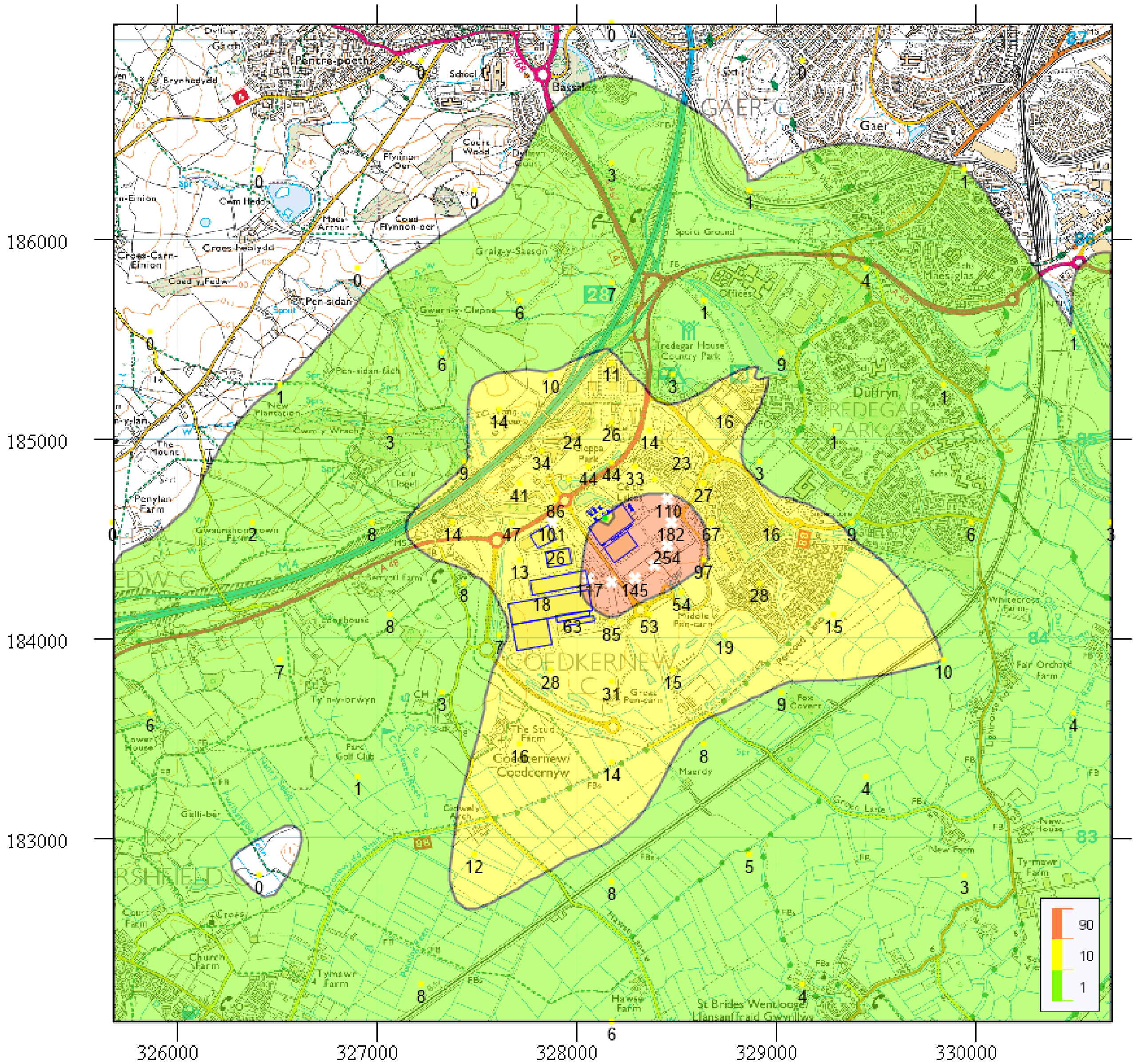


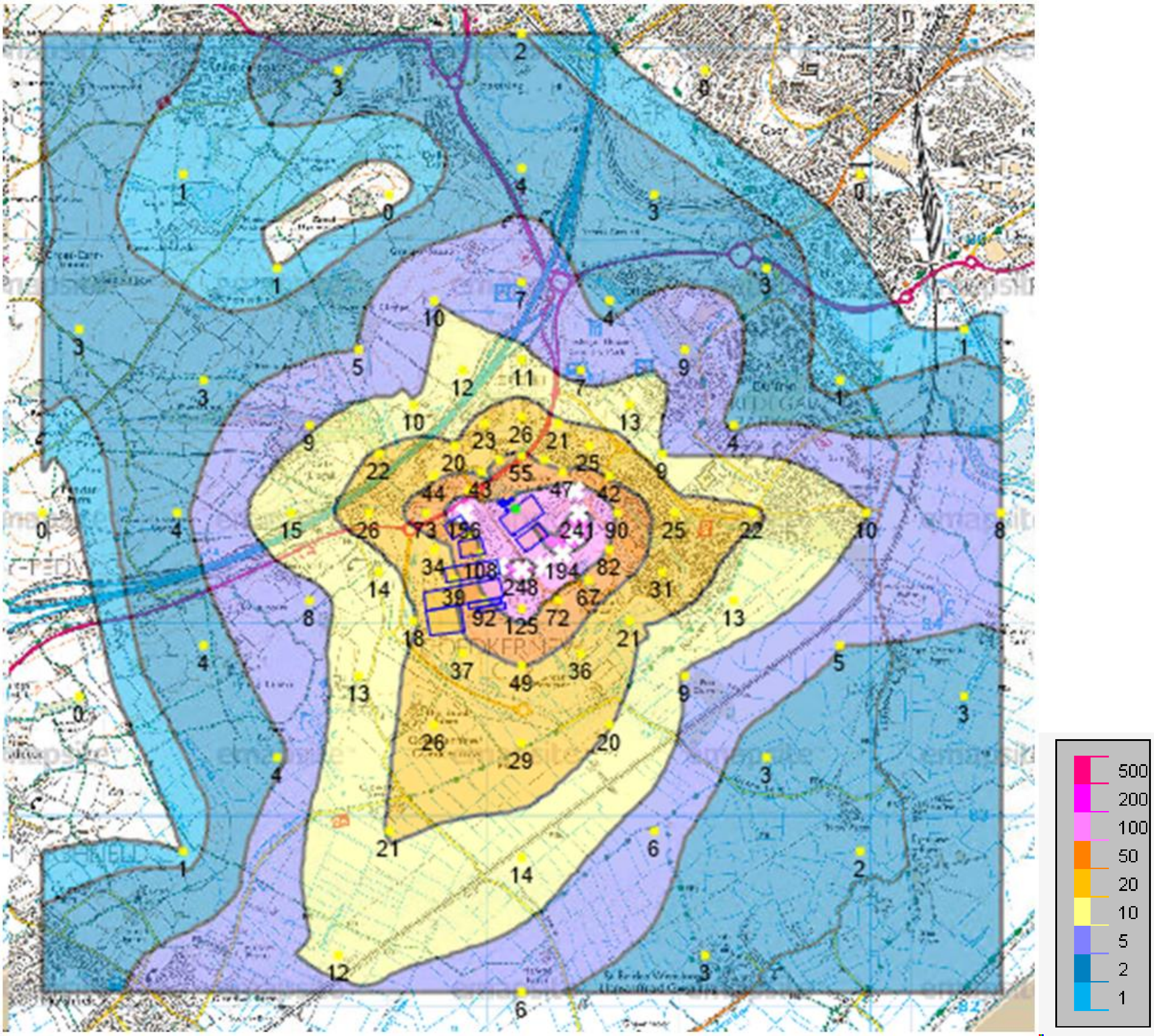
Figure B-8 - Summary risk plot for Winter and night time outage



B.2. Exceedance plots

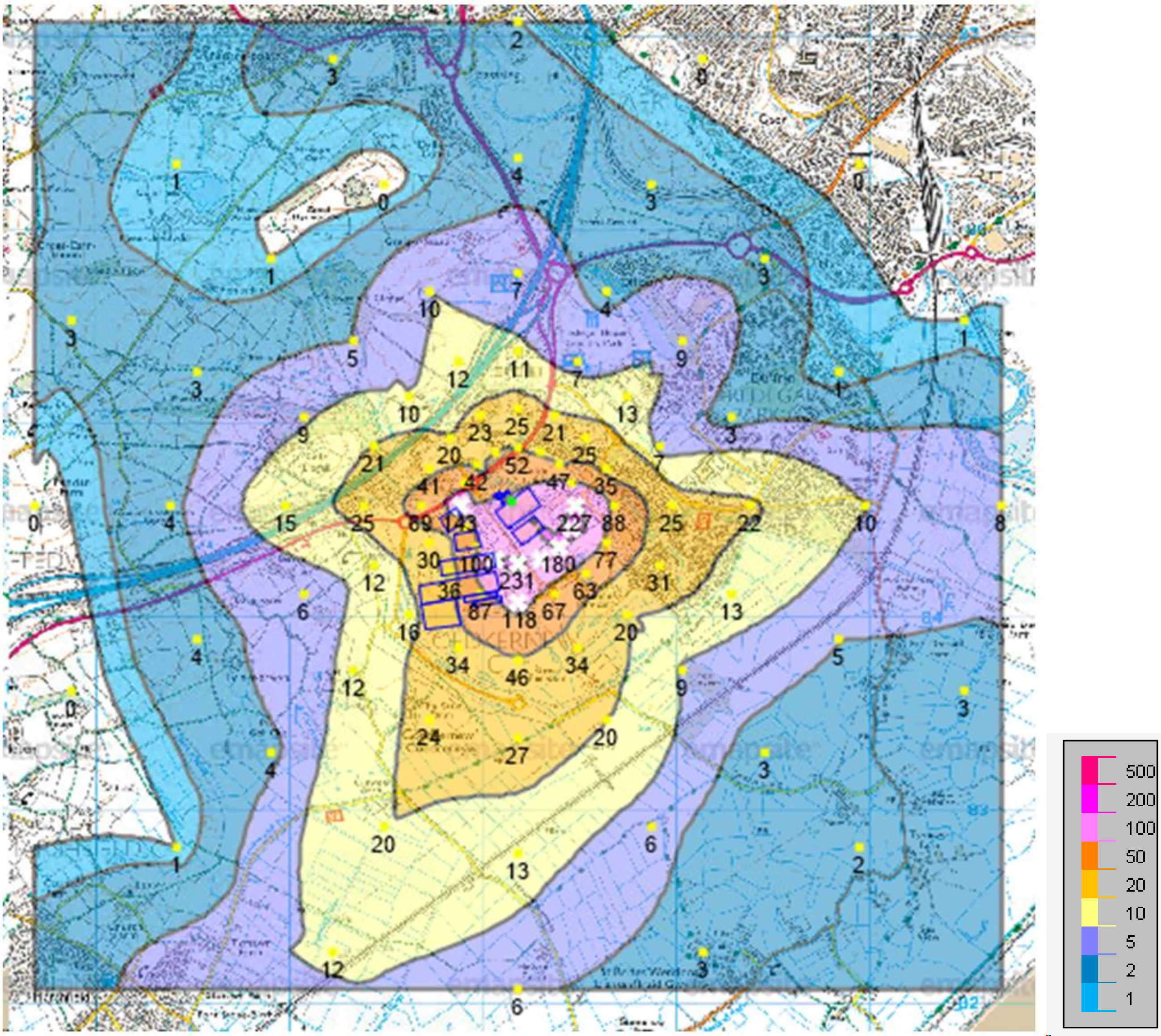
The following plots show the counts of exceedances of the AEGL-1 for nitrogen dioxide of 940 µg/m³, based on the calculated PEC, under different conditions (season, time of day and wind speed category). For context, each season represents approximately 8,760 hours of local meteorological data modelled

B.2.1. Spring: four-year period



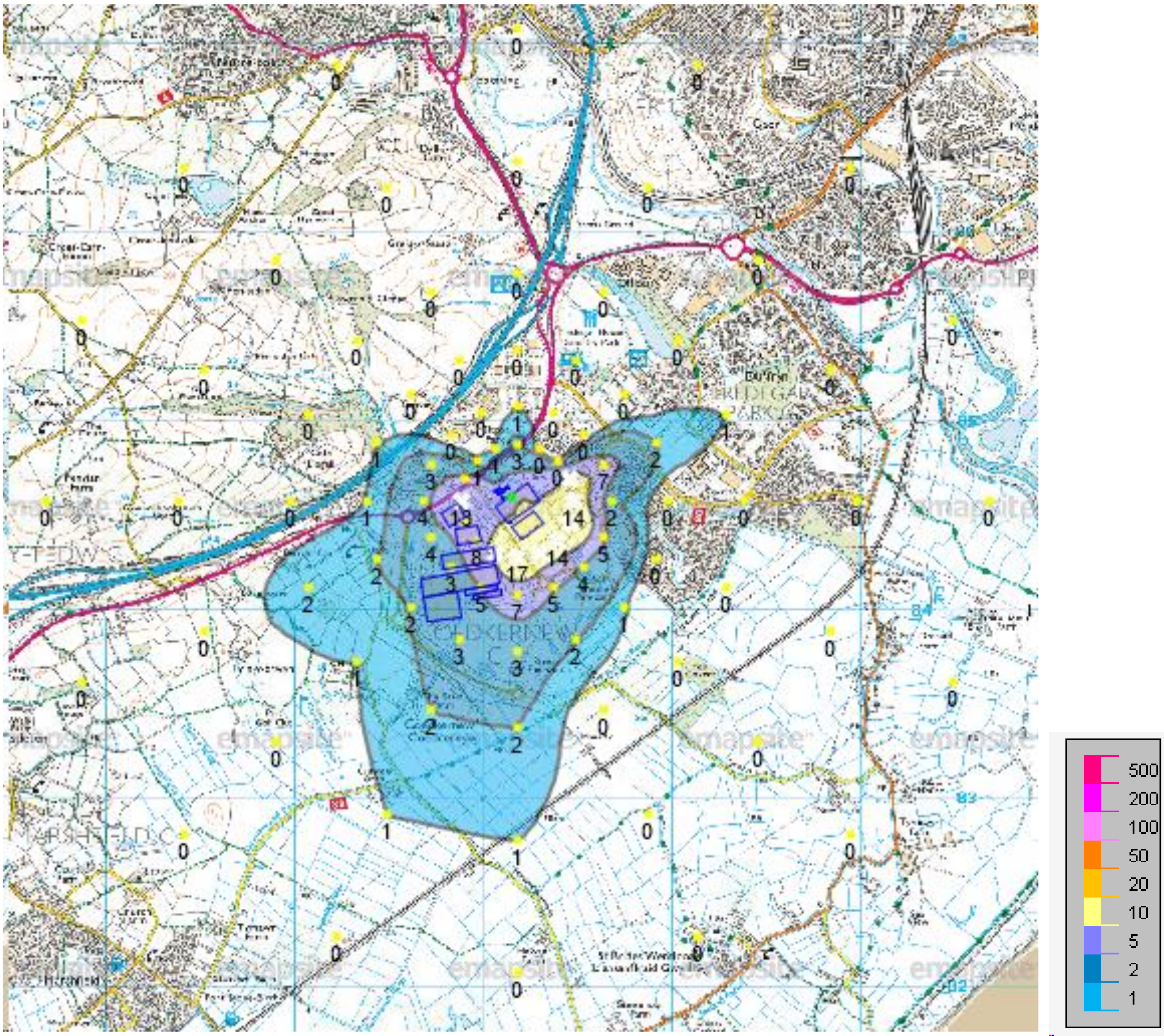
B.2.2. Spring: night time

Spring night time hours were modelled as 19:00 to 06:00 inclusive.

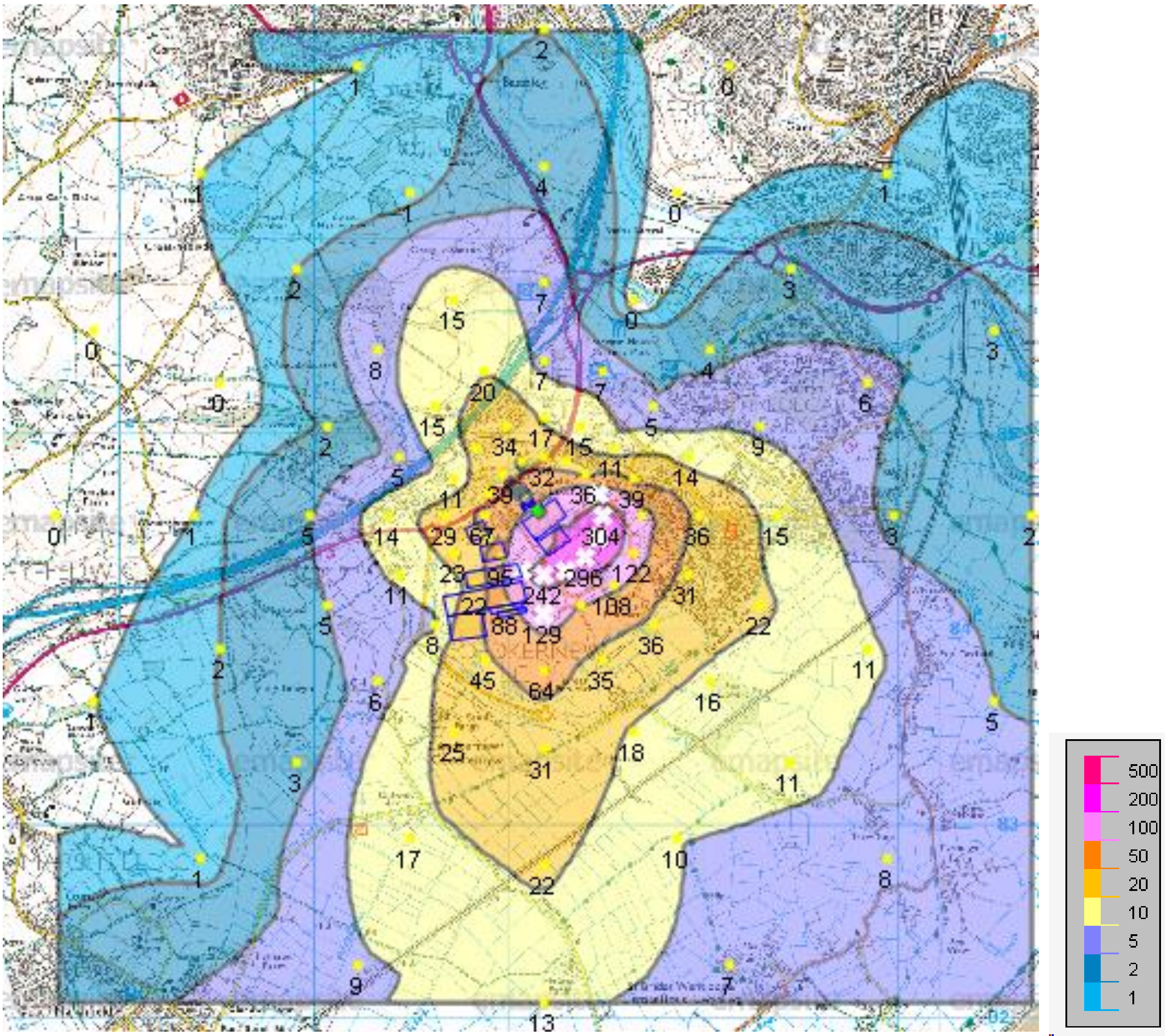


B.2.3. Spring: day-time

Spring day time hours were modelled as 07:00 to 18:00 inclusive.

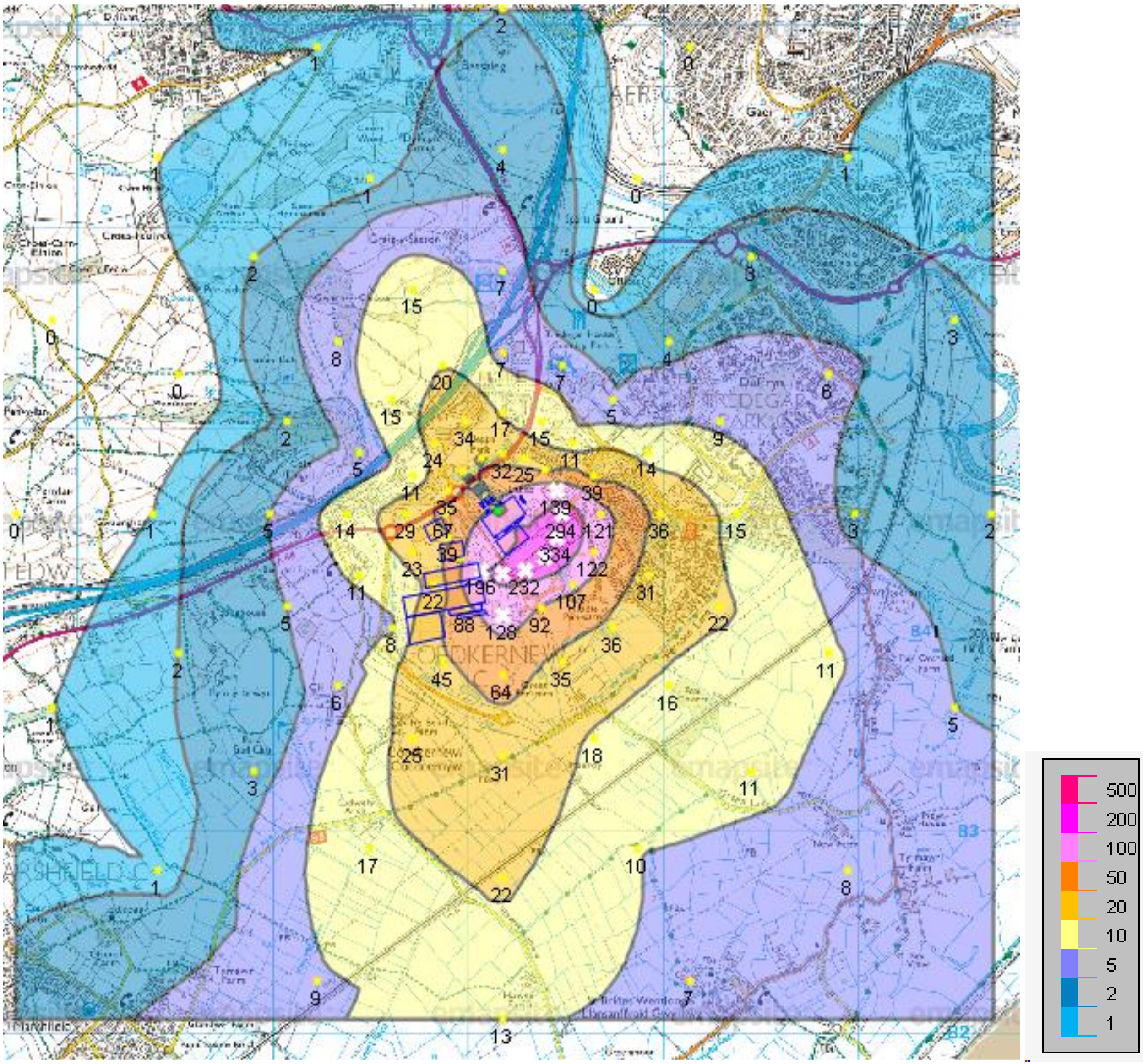


B.2.4. Summer: four-year period



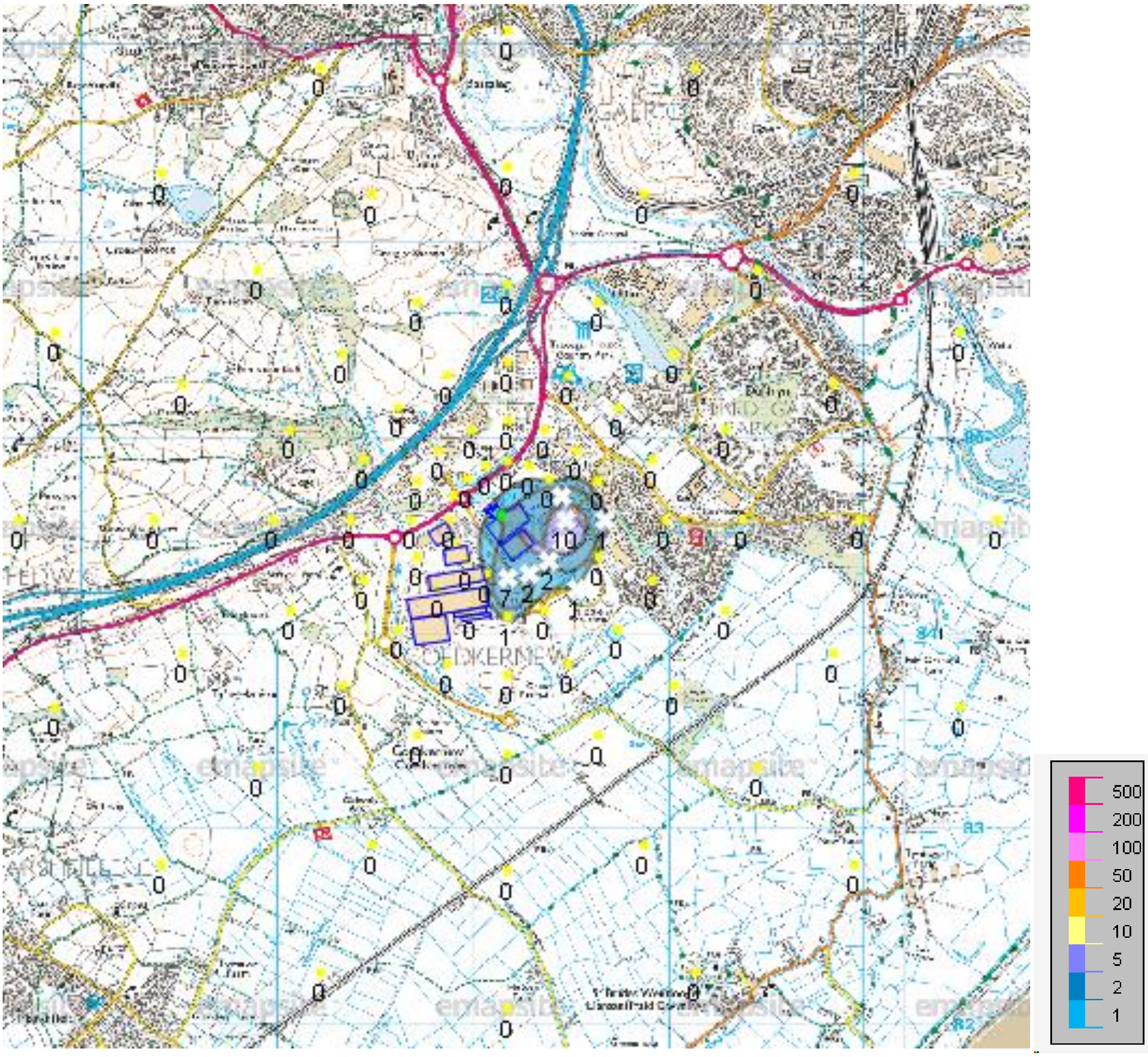
B.2.5. Summer: night time

Summer night time hours were modelled as 20:00 to 06:00 inclusive.

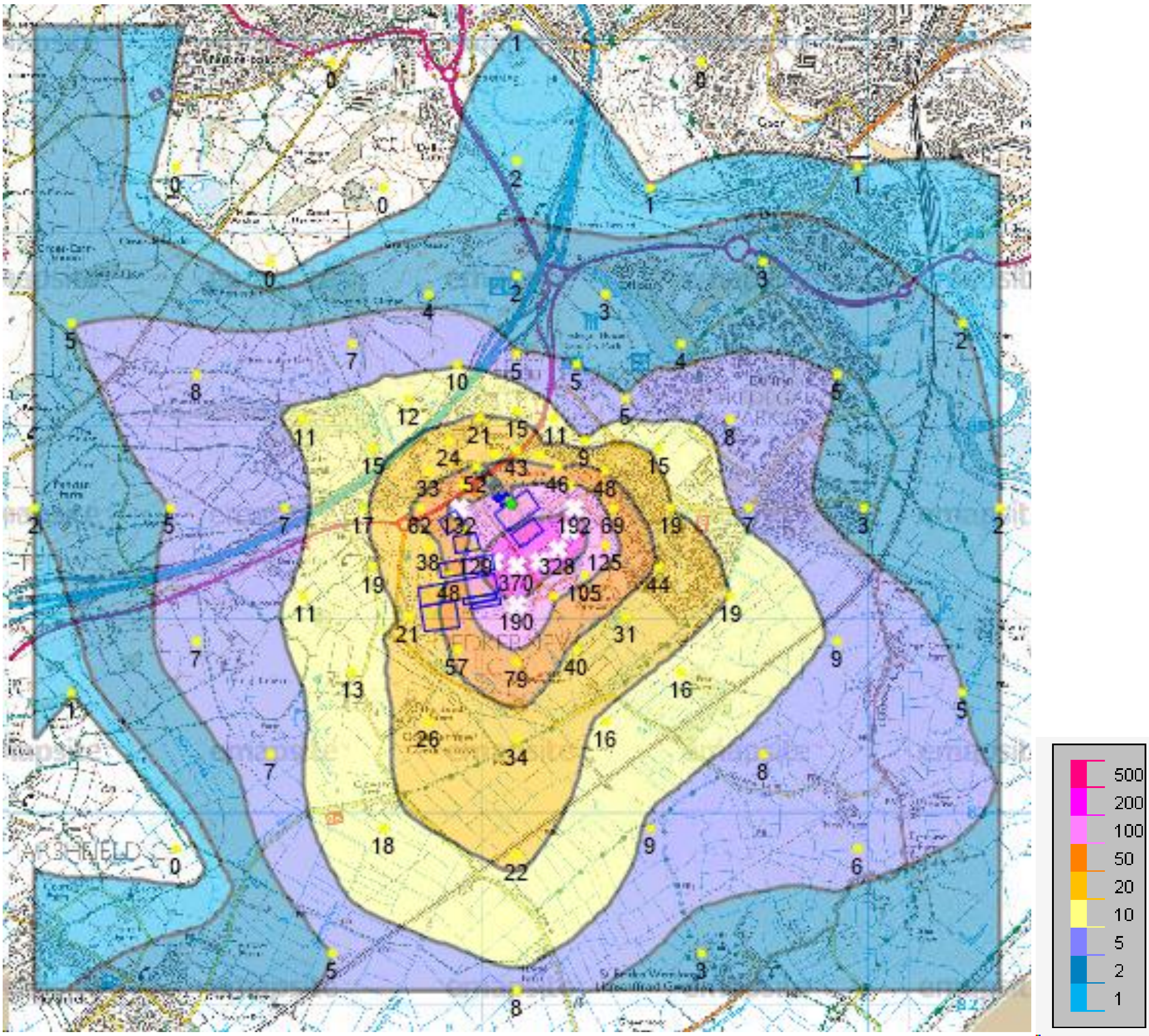


B.2.6. Summer: daytime

Summer day time hours were modelled as 07:00 to 19:00 inclusive.

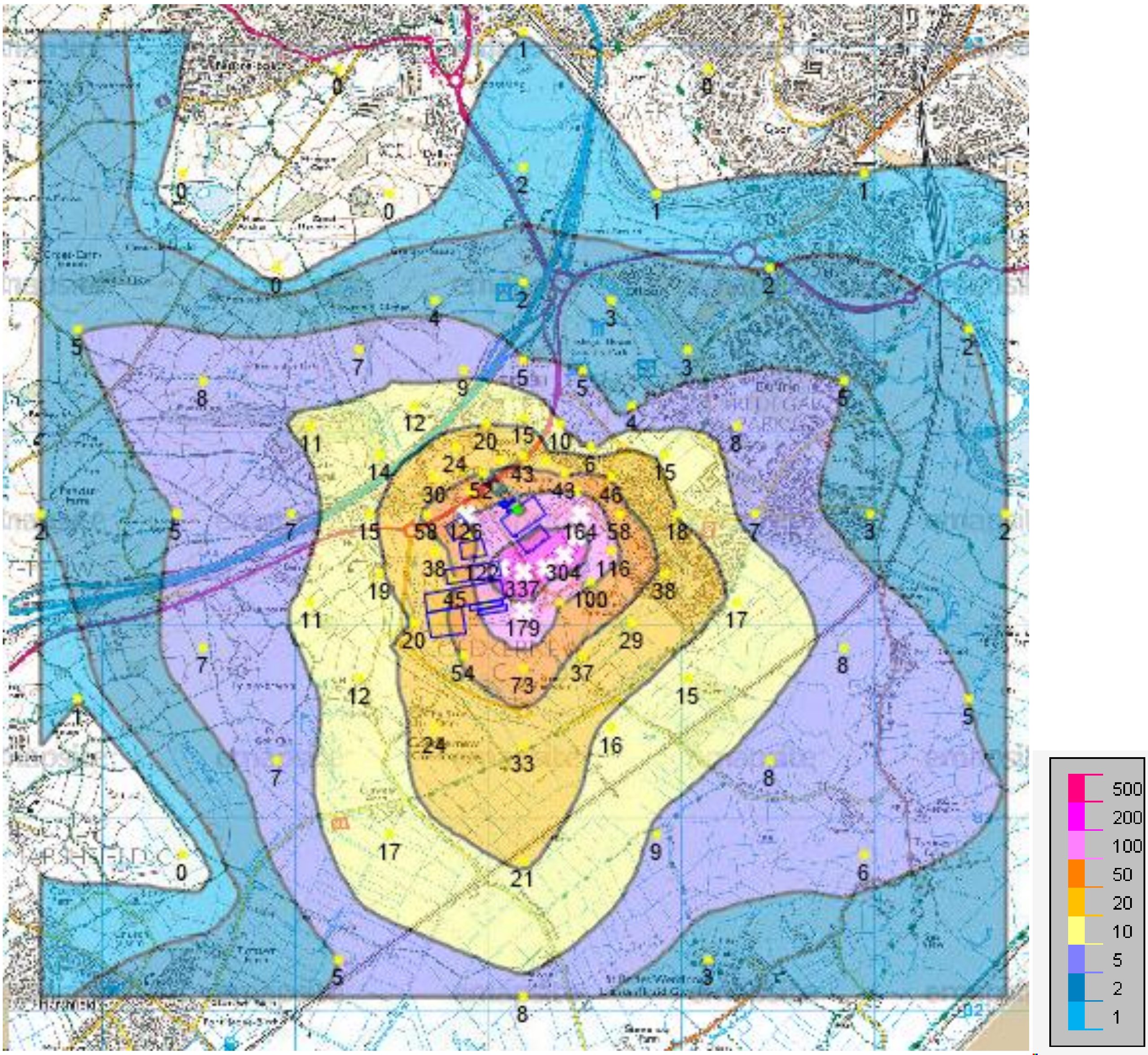


B.2.7. Autumn: four-year period



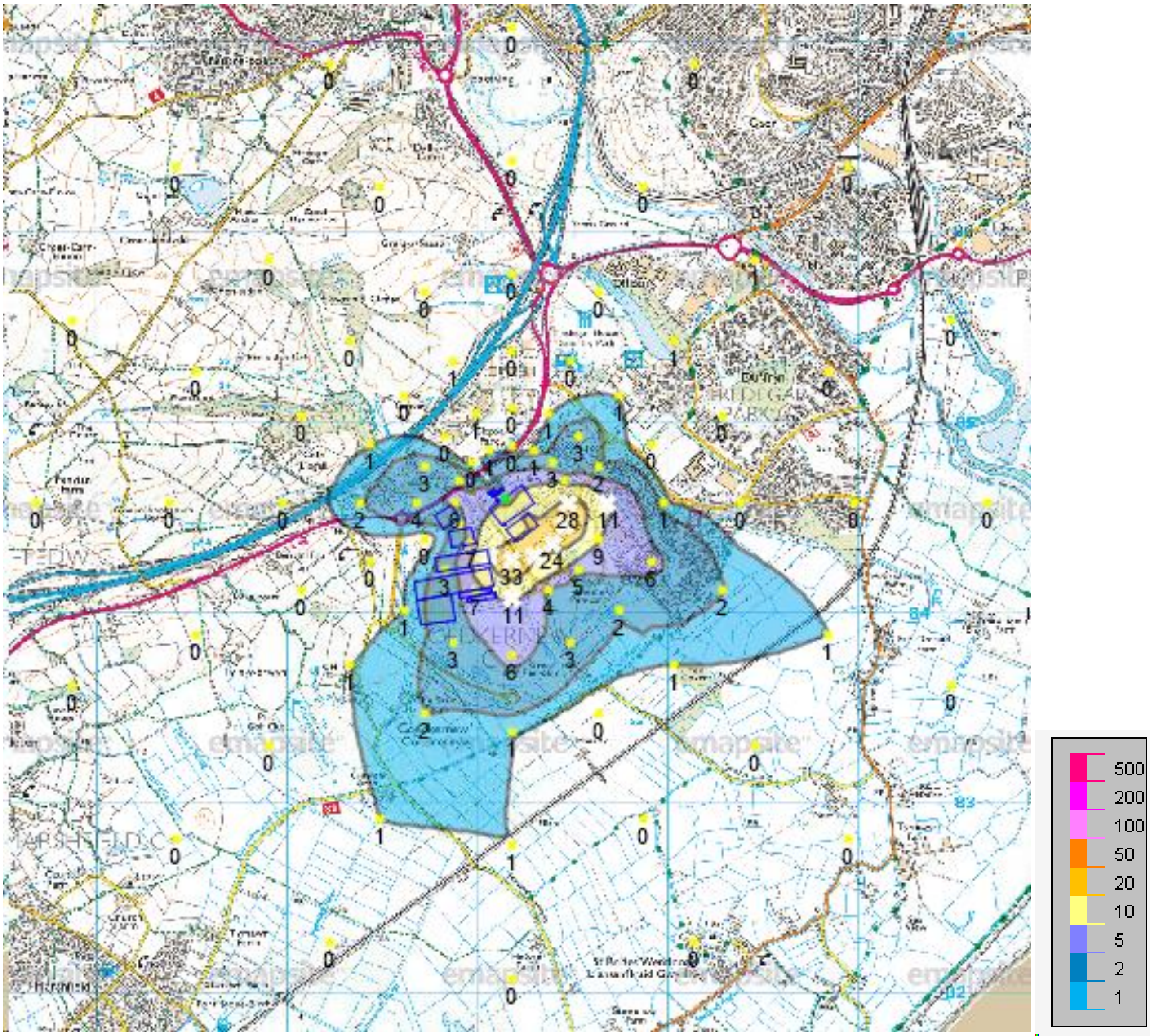
B.2.8. Autumn: night time

Autumn night time hours were modelled as 20:00 to 08:00 inclusive.

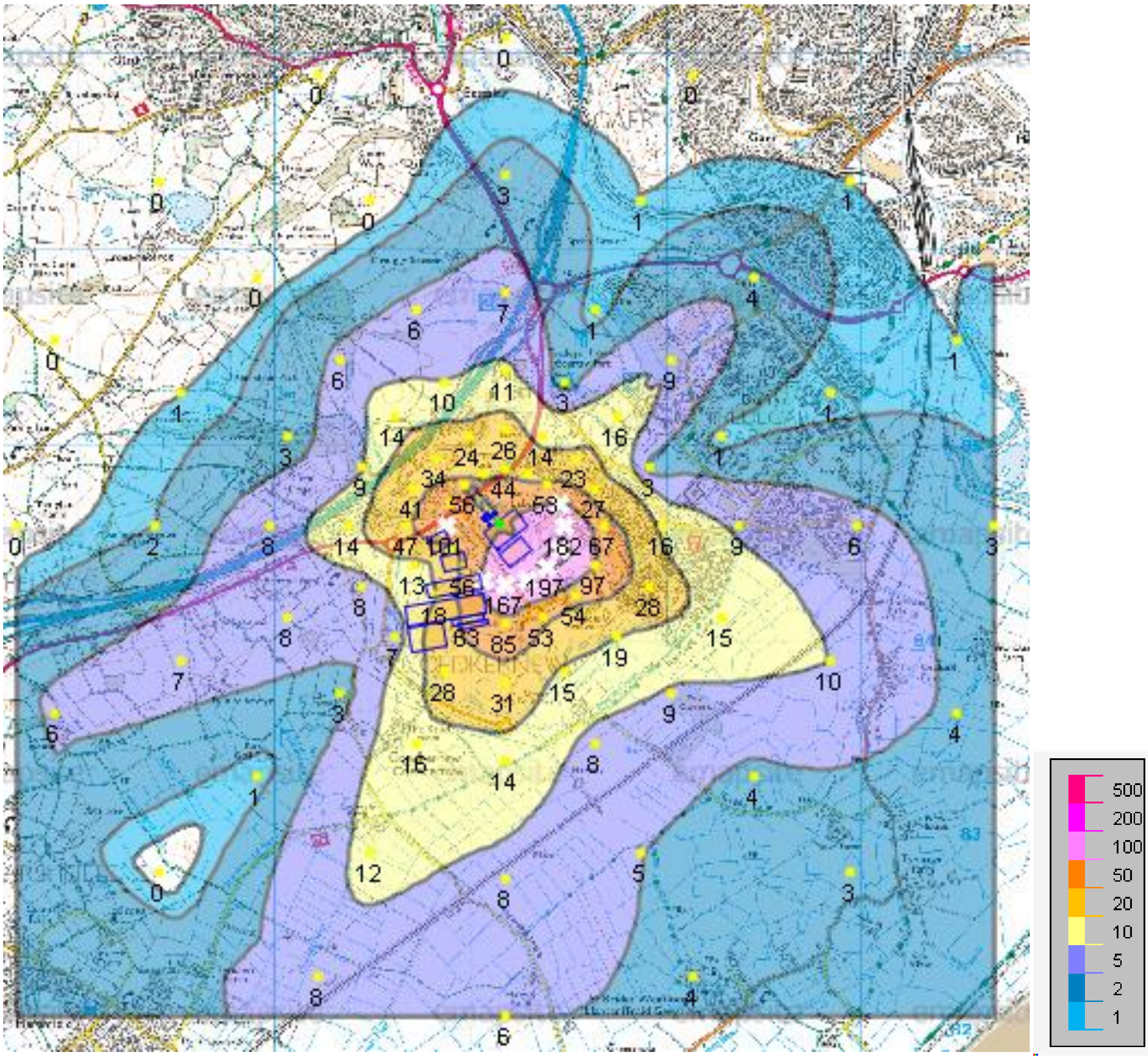


B.2.9. Autumn: daytime

Autumn day time hours were modelled as 09:00 to 17:00 inclusive.

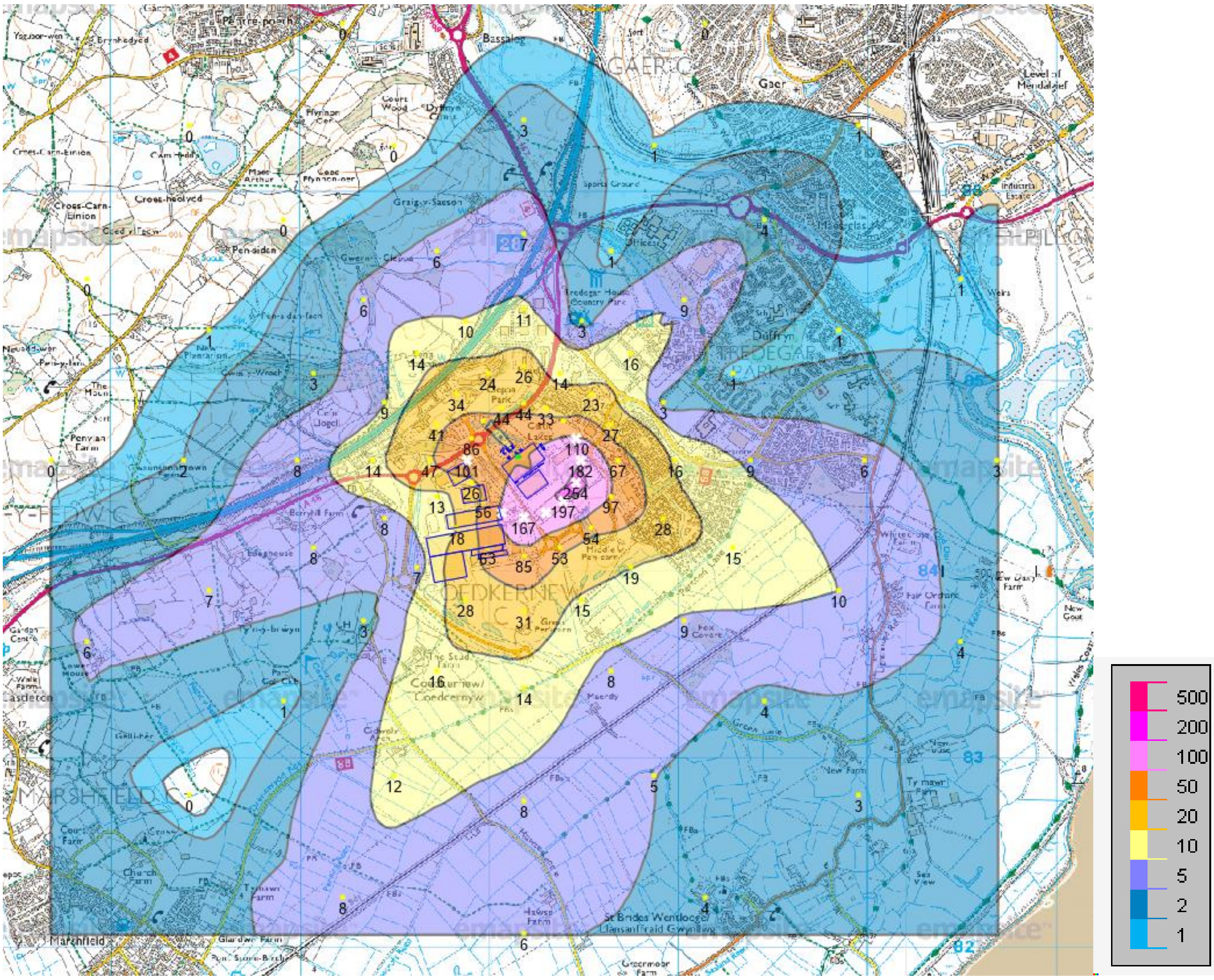


B.2.10. Winter: four-year period



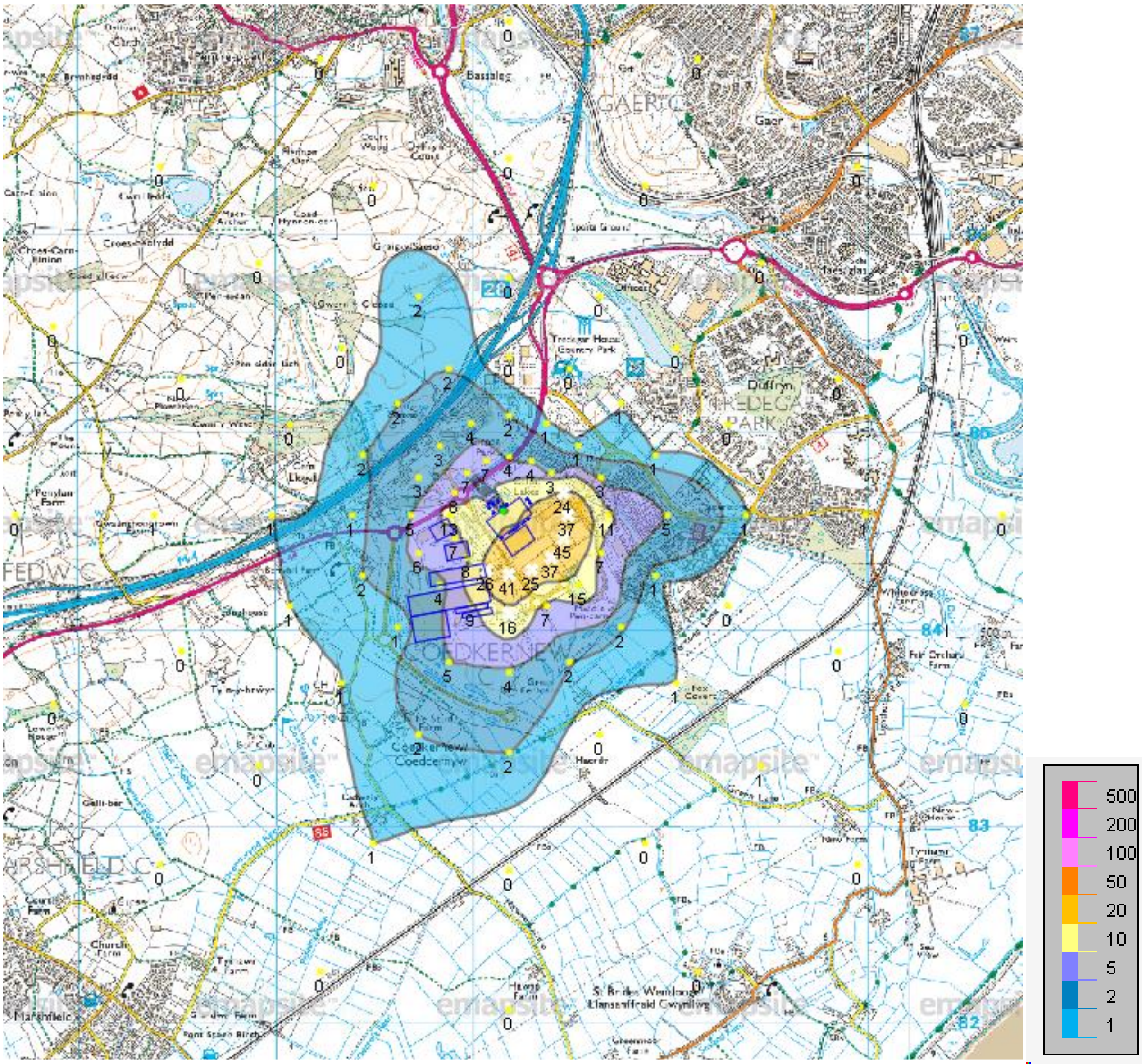
B.2.11. Winter: night time

Winter night time hours were modelled as 16:00 to 07:00 inclusive.



B.2.12. Winter: daytime

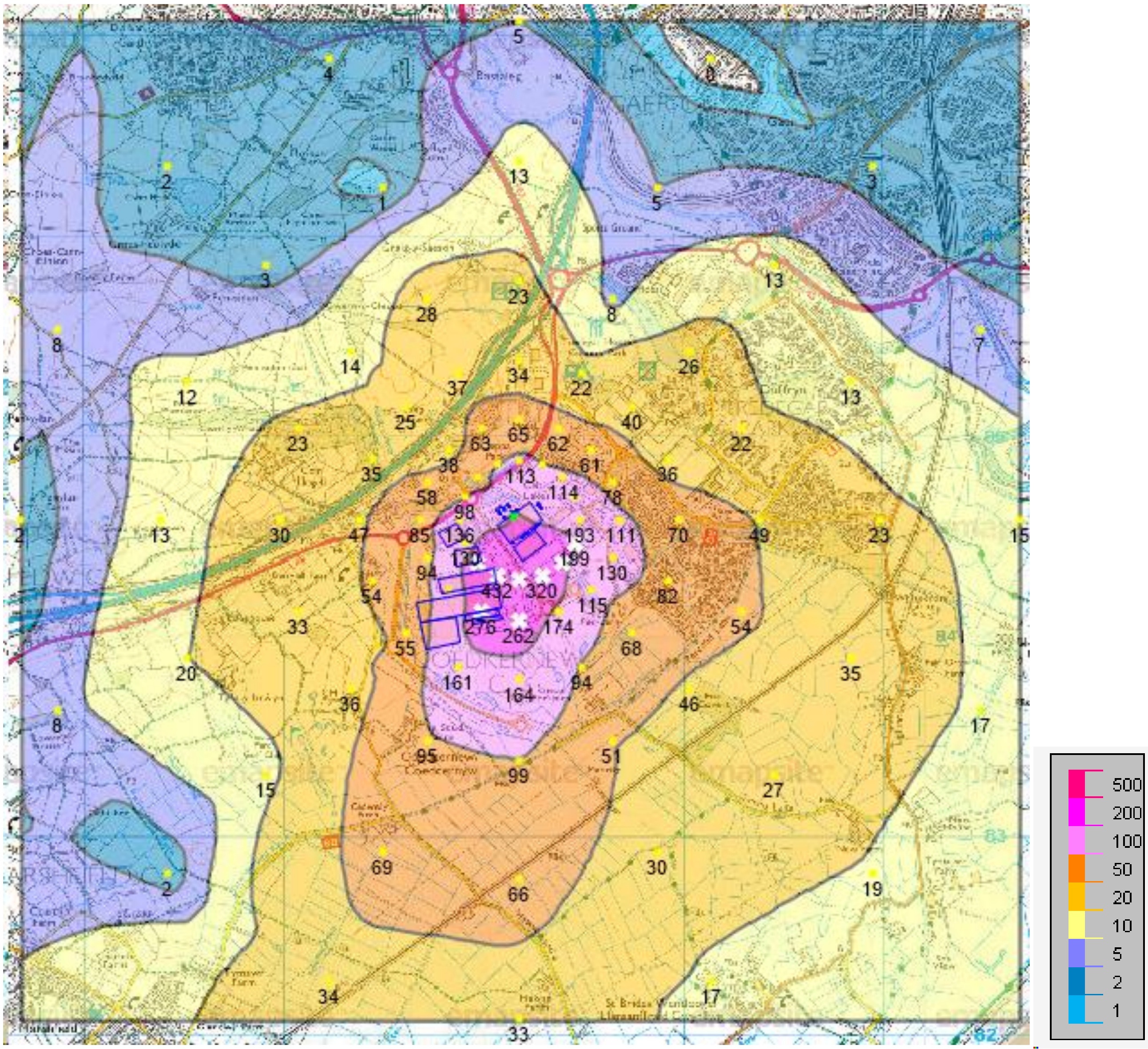
Winter day time hours were modelled as 08:00 to 15:00 inclusive.



B.3. Wind speed

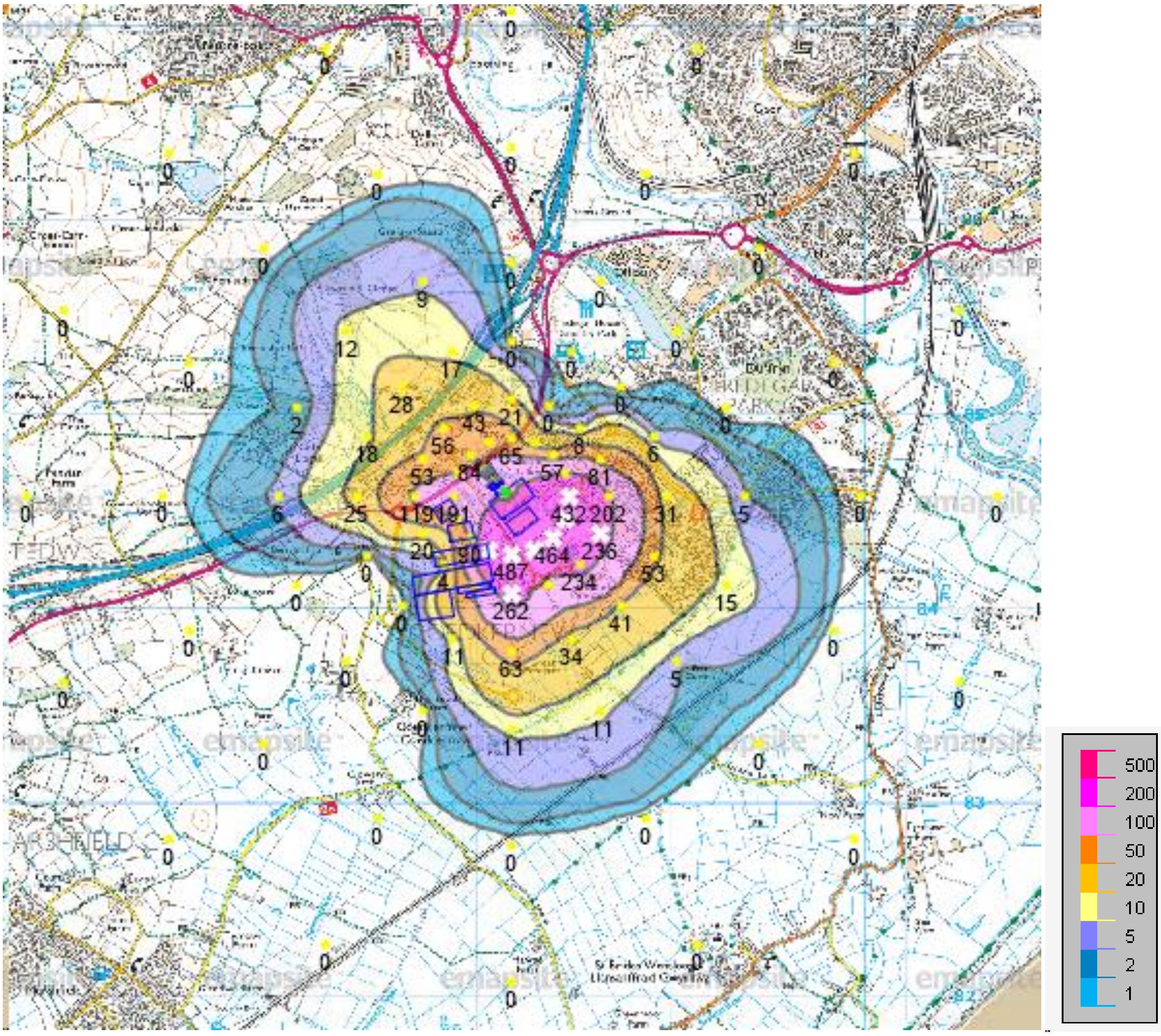
B.3.1. Category 1

Wind speed <1.54 m/s or <3 knots



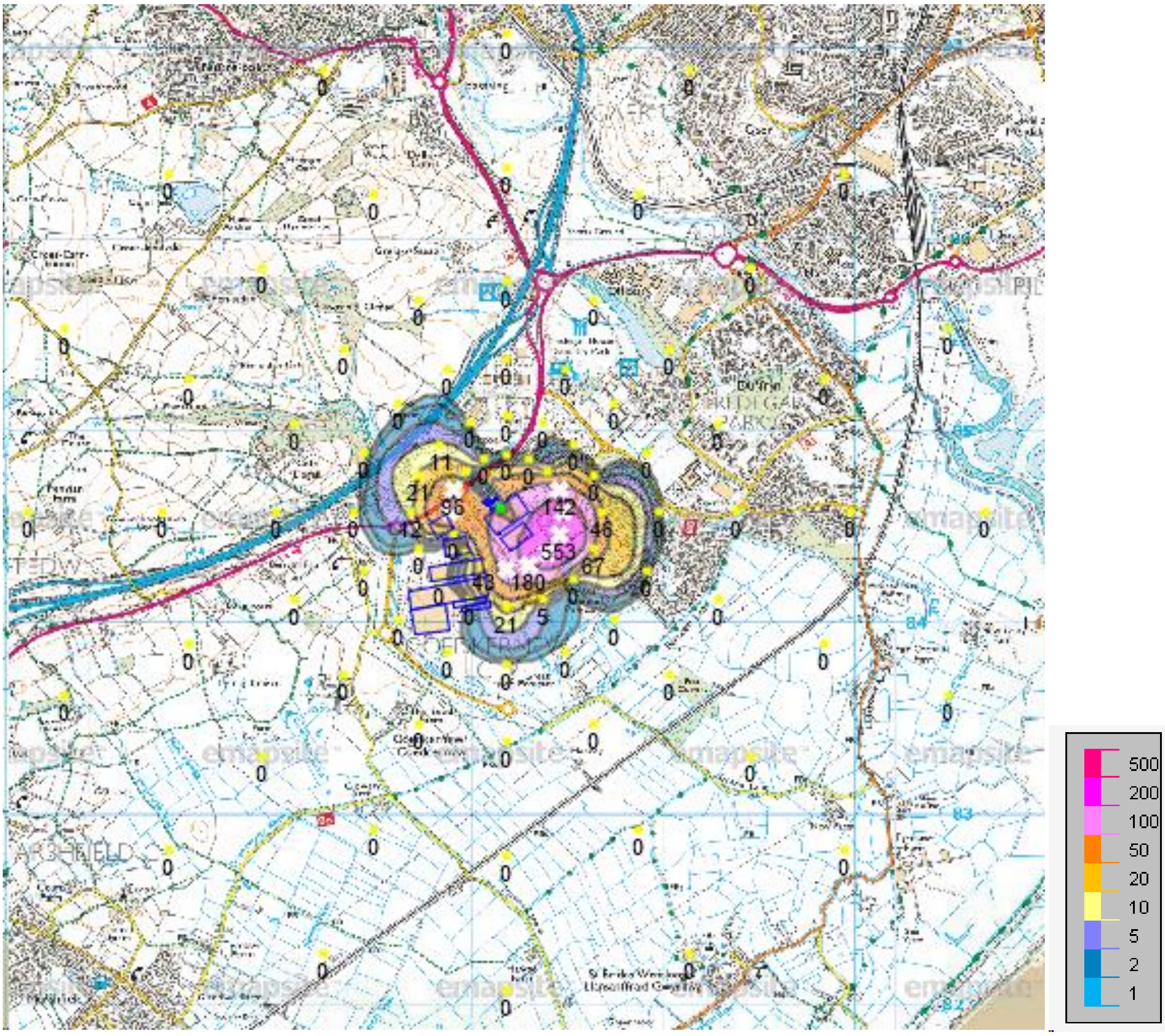
B.3.2. Category 2

Wind speed 1.54 to 3.09 m/s or 3 to 6 knots



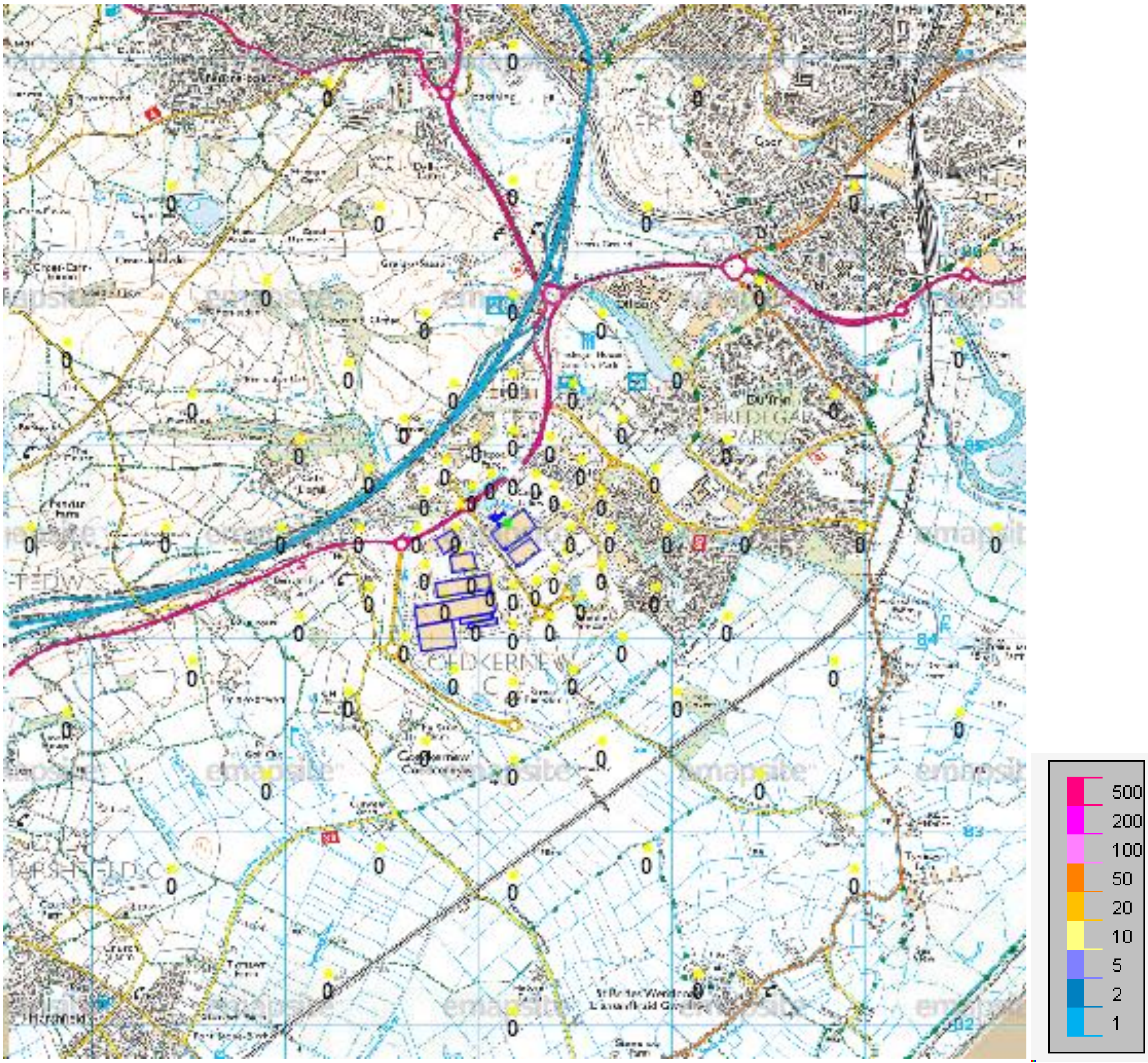
B.3.3. Category 3

Wind speed 3.09 to 5.14 m/s or 6 to 10 knots



B.3.4. Category 4

Wind speed 5.14 to 8.23 m/s or 10 to 16 knots



B.3.5. Categories 5 & 6

Wind speed above 8.23 m/s or more than 16 knots