2026 CLEAN AIR AND ENVIRONMENT CONFERENCE · 2026 ASIA-PACIFIC ODOUR CONFERENCE

Bridging dispersion modelling and field odour observations using statistical regression

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THE PROBLEM

Publication 1883 says Dispersion Modelling and Field Odour surveys correlate.
It doesn't give how.

EPA 1883 · Level 3 assessment

- i Comparison with similar operations
- **ii Risk assessment using field odour surveillance**
- iii Complaint data analysis
- iv Community surveys
- **v Dispersion modelling**

Modelling not recommended as only evidence.
It has to be validated against field odour surveillance data.
Yet where no analogous facility exists, comparison, complaint analysis and community surveys are all unavailable: modelling is the only realistic option.

! **The gap**

No prescriptive methodology is given for how the correlation should be developed or validated

Odour remains one of the most common sources of environmental complaint in Victoria (CES 2023).

Not predicting a concentration: Looking at the likelihood

Observer's perception

1. **Intensity in the field**
   - 0 – no odour
   - 1 – subtle
   - 2 – obvious
2. **Frequency over the period** %
   of observation time odour detected
3. **Character**
   "unwelcome" defined using Appendix B
4. **Risk of exposure potential**
   Tables 12 & 13 lookup from % of Subtle or Obvious detected

0	**No odour**	No odour detected: the lower bound for calibration
1	**Negligible**	Almost no chance of odour exposure
2	**Low**	Odour exposure unlikely
3	**Moderate**	Likely chance of odour exposure
4	**High**	Highly likely to have odour exposure
5	**Very high**	Odour exposure near certain

Risk categories after EPA Publication 1883. Category 0 was added to capture plume-traced points where the model predicts odour and the observer smells nothing.
Extracted from Table 11: Risk of odour exposure potential – colour key

THE FRAMEWORK

Four steps from field to risk category

01

Field odour survey

Following principles of Transect and area surveillance, EPA 1881. Intensity, frequency and character recorded at each point.

02

AERMOD, onsite met

Nominal emission rates. Matching field observation with recorded met.

03

Dynamic peak-to-mean

AODM ratio, varying with stability class and plume travel time. One hour → five-minute peak.

04

Ordinal logistic regression

Proportional odds model: one slope, five cut-points, cumulative probability of each risk level.

OUTPUT

A calibrated set of five-minute concentration bands that map dispersion model output onto the risk categories of EPA Publication 1883:

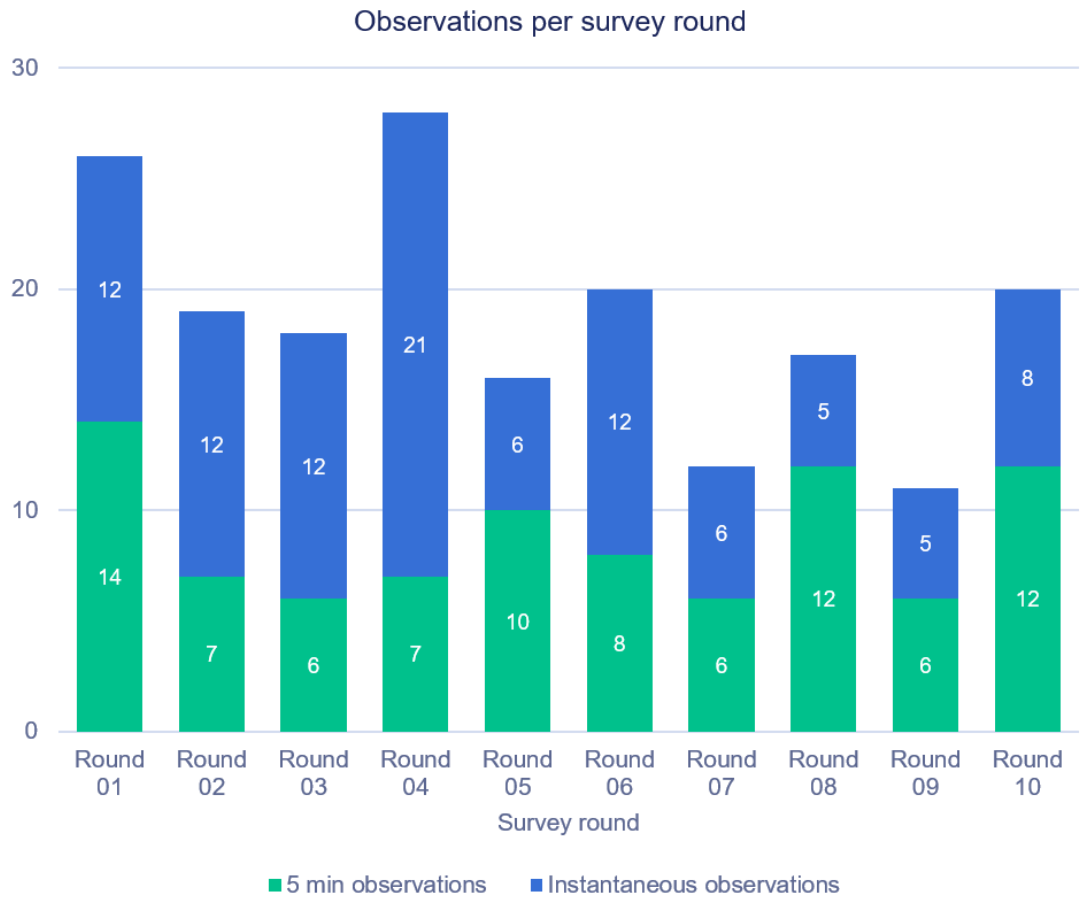
- usable on scenarios that have never been surveyed.

Ten rounds, 187 paired observations

- Ten survey rounds across a range of wind conditions
- Observers walked downwind
- Where odour was detected, a five-minute observation was recorded
- Where the plume was traced and no odour was detected, an instantaneous zero was logged

88 five-minute + **99** instantaneous = **187**

Land access varies by direction and detection depends on the conditions on the day, so the number of points per round could not be set in advance.



AERMOD calibrations, using the onsite measurement

1 Onsite met station

Continuous five-minute wind speed, wind direction, temperature and other parameters

2 AERMET processing

Surface and profile files generated from the onsite record, so stability and boundary layer conditions match the hour of each observation.

3 Nominal emission rates

Set from the aggregate character and frequency observed across all ten rounds, then held constant. No per-round iterative tuning.

4 Receptor-matched output

One-hour average concentrations at the coordinates of every field observation point.

STEP 03 · PEAK-TO-MEAN CONVERSION

One hour of model. Five minutes of observation.

The mismatch

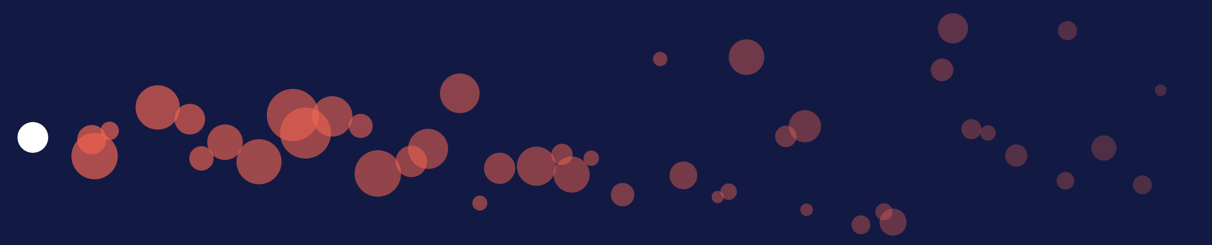
AERMOD output	**1-hour average**
Human perception	**seconds to minutes**
Field observation	**5-minute period**

Not a fixed factor

The AODM ratio (Piringer et al. 2015) is non-linear and varies with atmospheric stability class and downwind plume travel time. With several source groups at different distances, an emission - and distance-weighted effective factor is used - and the same conversion is applied to both observation types, each on its own paired met hour.

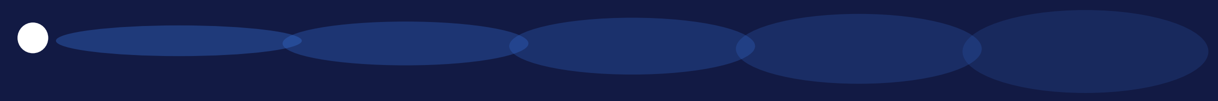
Unstable

Strong vertical mixing → intermittent plume, sharp near-source peaks that decay with distance



Stable

Coherent plume, less intermittency → lower peak factors



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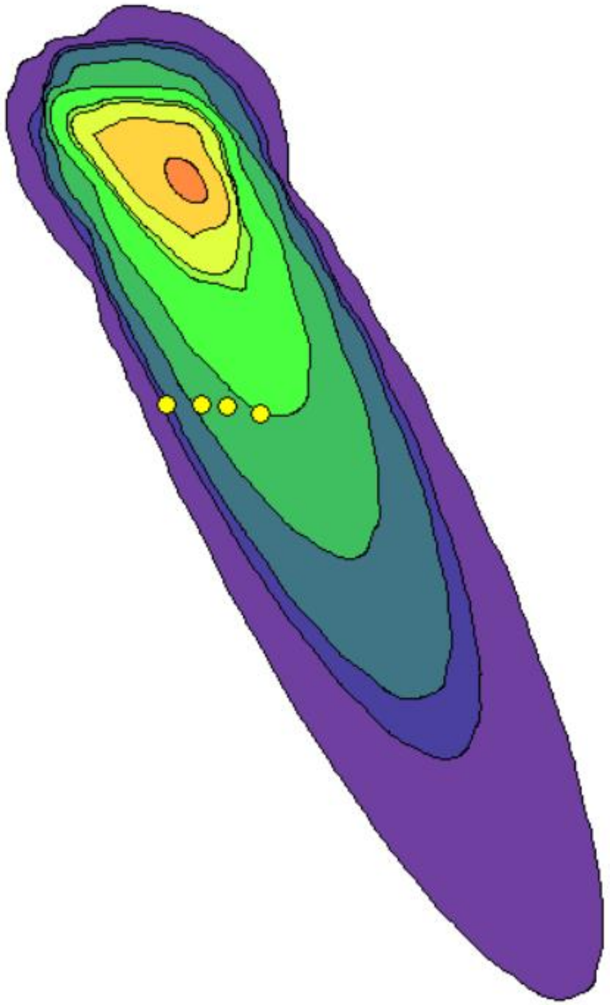

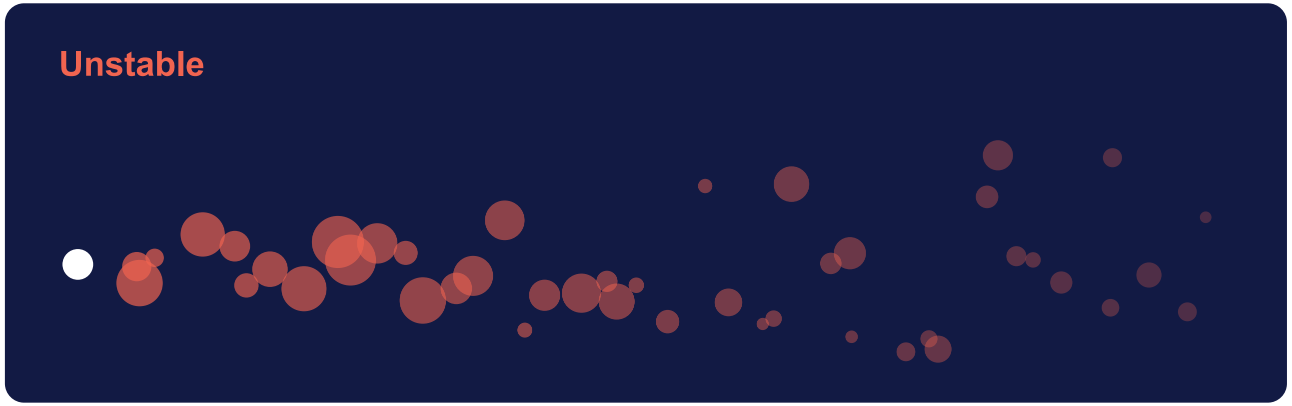

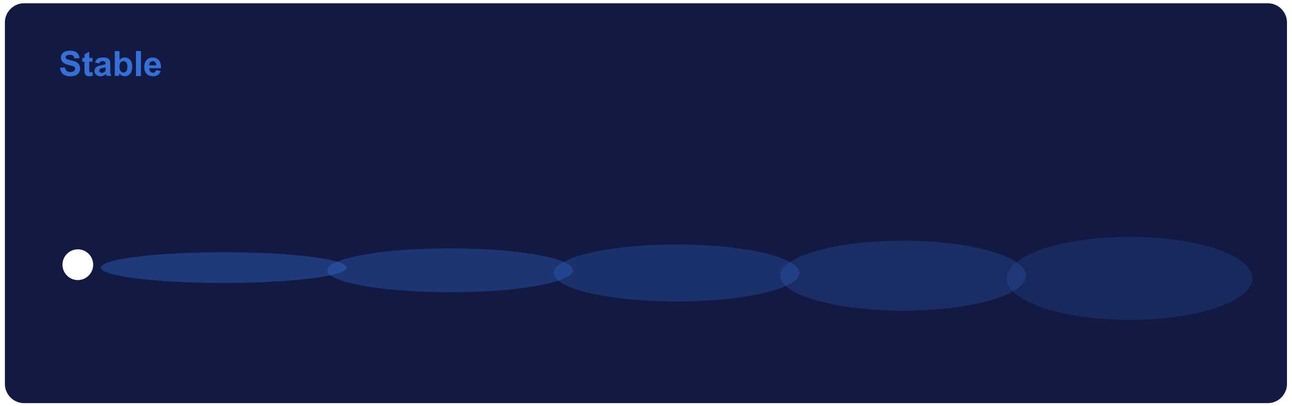

Why ordinal logistic regression

Linear regression

The response (risk rating 0 to 5) is ordinal, not continuous.

Binary classification

Collapsing to odour / no odour throws away the ordered structure that 1883 depends on.

Proportional odds model

Models the cumulative probability of being at or above each risk level as a logistic function of concentration.

What the model estimates

- One regression coefficient for the single continuous predictor
- Cut-points defining the boundaries between adjacent categories
- Probability distribution across the risk levels at any concentration

Strongly right-skewed, and lumpy

Risk	n	Mean (OU/m³)	Max	Min	25th %ile	Median	75th %ile
0	**107**	1.84	40.9	0.0028	0.05	0.28	1.45
1	**5**	0.23	0.66	0.003	0.10	0.11	0.25
2	**8**	2.66	12.8	0.272	0.71	1.04	1.83
3	**17**	3.51	11.8	0.0843	0.23	2.42	4.83
4	**20**	3.28	34.5	0.0473	0.16	0.48	2.36
5	**30**	9.94	87.9	0.0092	0.36	1.42	10.5
Overall	**187**	**3.44**	**87.9**	**0.0028**	**0.10**	**0.49**	**2.47**

Table 1 · Five-minute peak modelled odour concentrations (OU/m³) by observed odour exposure risk level, n = 187

Median 0.49 vs mean 3.44

A pronounced right skew: most points sit low, a handful of near-source locations stretch the tail to 87.9 OU/m³.

Risk 5 stands apart

Mean 9.94 and 75th percentile 10.5 OU/m³ — roughly triple every other category.

107 at Risk 0, 30 at Risk 5

Only 5 to 20 observations populate each of Risk 1 to 4. Descriptive statistics are volatile at that size.

Escalating overall - not monotonic in the middle

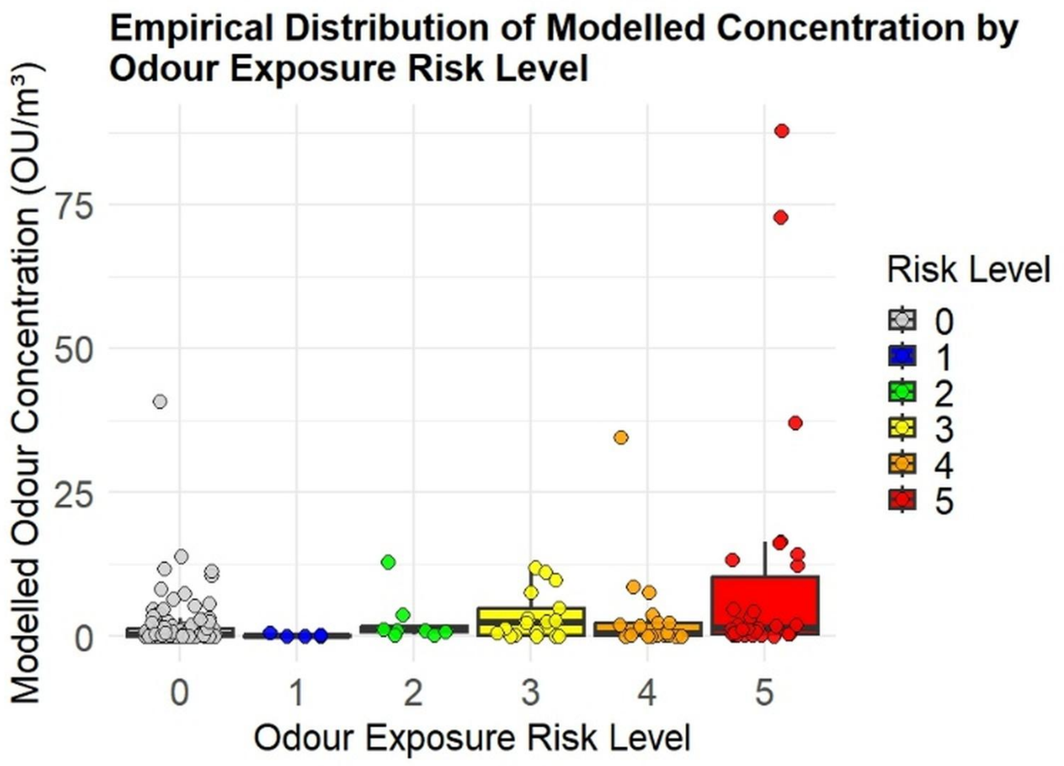

Figure 1 · Empirical distribution of five-minute peak modelled concentration by observed risk level

1 The trend is there

Concentration escalates from Risk 0 through to Risk 5, and Risk 5 sits clearly apart from every other category

2 But Risk 1 to 4 wander

Medians and means do not increase consistently between adjacent levels. A simple percentile-banding approach would not produce monotonic thresholds.

3 And the cause is structural

Three field intensity levels are mapped onto five risk levels. No-odour resolves to 0; obvious intensity at even moderate frequency resolves to 3 or above. The middle is left to subtle-intensity points split by frequency.

Escalating overall - not monotonic in the middle

Table 12: Risk of odour based on character, obvious odour intensity and frequency of predicted odour.

Frequency	Hours per year (indicative)	Obvious odour character		
		unsafe	unwelcome	innocuous
0.5 - 2.0%	< 200			
2.1% - 6.0%	200 to 525.			
6.1% - 10%	526 to 875			
> 10%	(> 875 hrs/yr.)			

Table 13: Risk of odour based on character, subtle odour intensity and frequency of predicted odour.

Frequency	Hours per year (indicative)	Subtle odour character (Obvious odour is < 2%)		
		unsafe	unwelcome	innocuous
0 - 2.0%	< 200			
2.1% - 6.0%	200 to 525.			
6.1% - 10%	526 to 875			
> 10%	(> 875 hrs/yr.)			

From one slope to six probability curves

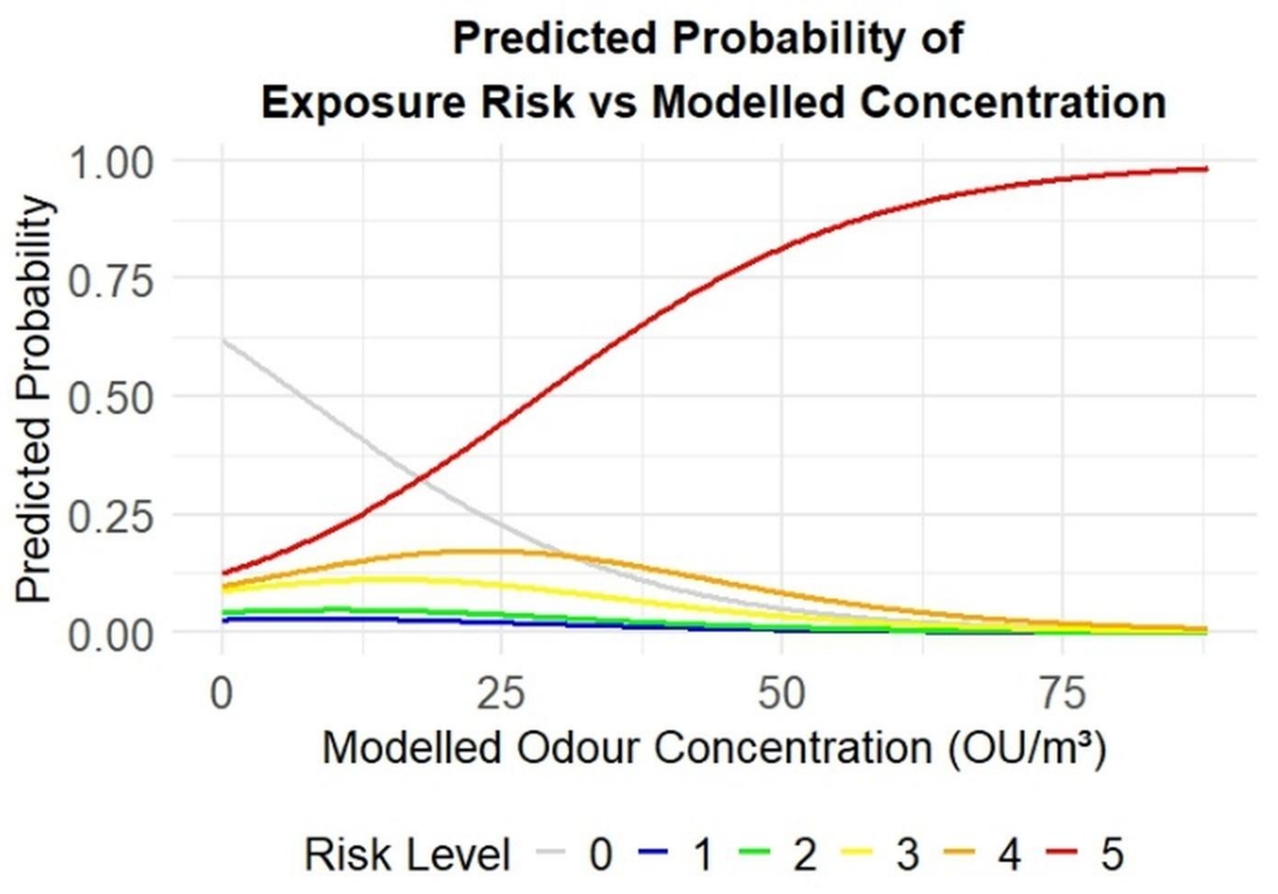

Figure 2 · Predicted probability of each risk level against five-minute peak modelled concentration

At zero concentration

Risk 0 carries the highest predicted probability, around 0.60.

Above ~30 OU/m³

Risk 5 becomes the dominant predicted category as the Risk 0 curve falls away from all other risks.

Two crossovers only

Risk 0 / Risk 5 at 18 OU/m³ and Risk 0 / Risk 4 at 31 OU/m³. No crossover with Risk 1, 2 or 3 anywhere in range.

So bands cannot come from crossovers

Risk 1 to 4 never become the single most probable category : the boundaries had to be derived from cumulative probability instead.

Lower bound of each band = the concentration at which $P(Y \geq j)$ first exceeds 0.5 (Agresti 2010; McCullagh 1980).

Calibrated concentration bands

Table 5 · Calibrated concentration bands for odour exposure risk level classification

Risk	Category	5-min conc. (OU/m^3)	Basis in the fitted model
0	No odour	< 1.0	Pragmatic threshold for no significant impact - below the concentration at which any exposure becomes more probable than not
1	Negligible	1.0 – 7.2	Upper bound where P(Risk ≥ 2) first exceeds 50%
2	Low	7.2 – 8.8	Upper bound where P(Risk ≥ 3) first exceeds 50%
3	Moderate	8.8 – 11.6	Upper bound where P(Risk ≥ 4) first exceeds 50%
4	High	11.6 – 18	Upper bound where P(Risk 5) first exceeds 50%
5	Very high	≥ 18	P(Risk 5) exceeds 50% and surpasses P(no odour) - corroborated by the Risk 0 / Risk 5 crossover at 18 OU/m^3

Site-specific. These are not universal thresholds and not a general conversion table for EPA 1883.

Calibrated concentration bands

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0	No odour	< 1.0
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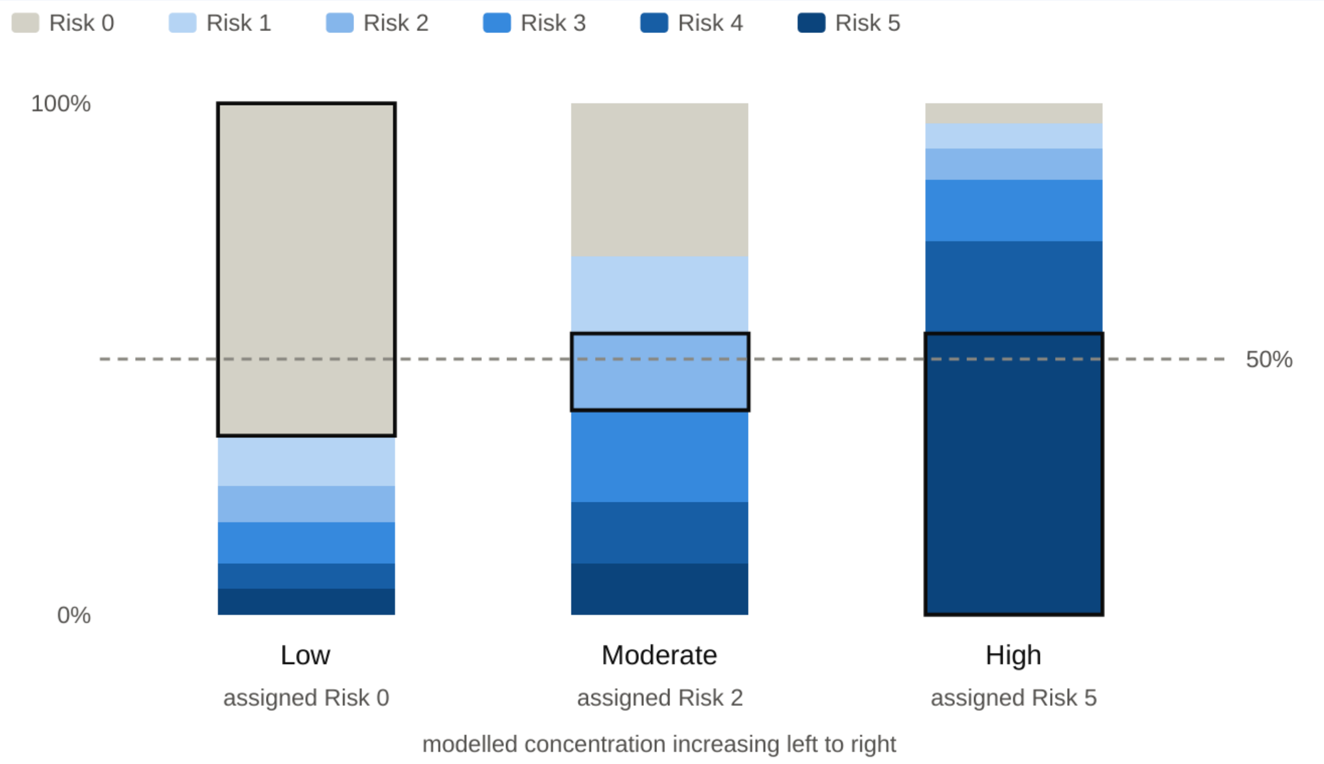
3	Moderate	8.8 – 11.6
4	High	11.6 – 18
5	Very high	≥ 18



0	1	2
no odour	subtle	obvious

CONCLUSIONS

What this gives practitioners

1

A method where none was prescribed

Statistically defensible and it respects the ordinal structure of the regulatory categories rather than working around it.

2

Forward-looking assessment

Operational changes, production increases, expansions and greenfield sites where no analogous operating facility exists to benchmark against.

3

Honest about its limits

Bands are facility-specific. A uniform bias in assumed emission rates is absorbed into the fitted coefficient, but the shallow slope means concentration is a weak discriminator at mid levels.

SNIFFING FOR FUTURE GUIDANCE UPDATES:

Risk levels 1 and 2 are reachable only through a narrow combination of inoffensive character, subtle intensity and the lowest frequency band. That biases outcomes toward the upper categories independently of true impact (finer resolution at the low end of the scale would help everyone).

FOR FUTURE WORK: WOULD THE VDI SYSTEM PROVIDE A BETTER FITTING?

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Thank you

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Is 187 observations enough?

ESS = 150.8

Whitehead (1993) effective sample size for this category distribution. The 187 paired observations carry the information of roughly 151 observations of a continuous response.

EPV = 30 vs ≥ 10

Peduzzi et al. (1996) found no major estimation problems above ten events per variable. The sparsest cumulative comparison, Risk ≥ 5, holds 30 observations against a single predictor.

187 vs 184 needed

Harrell (2015) benchmark for predicted probabilities to fall within ten percentage points of their true values at 95% confidence.

The regression does not require stable means or medians within each category — the proportional odds model estimates a single slope across the full ordinal scale.

Statistical fit

β = 0.069

SE 0.024 · t = 2.86 · p = 0.0047

Positive slope: as modelled concentration rises, so do the log-odds of a higher risk category. Significant at the 1% level.

Intercept	Value	Std. error	t value
0 | 1	0.487	0.163	2.995
1 | 2	0.603	0.165	3.659
2 | 3	0.795	0.169	4.694
3 | 4	1.247	0.185	6.728
4 | 5	1.945	0.225	8.635

Table 4 · Cut-points. Residual deviance 472.9 · AIC 484.9

Monotonic cut-points

Intercepts increase steadily from 0.487 at the 0|1 boundary to 1.945 at 4|5, confirming the ordered structure is internally consistent.

Brant test: p = 1.0

No evidence against the proportional odds assumption. One slope adequately describes the full ordinal scale.

Read with care

p = 1.0 does not mean a perfect predictor. With one predictor and sparse intermediate categories, the Brant test has limited power to detect a departure.