Appendix A: Current air discharge permits

AUCKLAND REGIONAL COUNCIL

RESOURCE CONSENT

Granted pursuant to the Resource Management Act 1991

PERMIT NO. 14317

CONSENT HOLDER:	**New Zealand Steel Limited**
FILE REFERENCE:	**8046**
STATUS OF ACTIVITY	Discretionary

CONDITIONS OF CONSENT:

Duration of Consent:	This consent shall expire on 1 November 2021 unless it has lapsed, been surrendered or been cancelled at an earlier date pursuant to the Resource Management Act 1991.
Date of Lapsing of Consent	1 August 2008
Purpose of Consent:	To authorise the discharge of contaminants to air from the production of iron and steel and associated activities within the Glenbrook Iron and Steel Zone, in accordance with Section 15 (1)(c) of the Resource Management Act 1991.
Site Location:	Mission Bush Rd, Glenbrook
Legal Description of Land:	Lots 1, 2 and 3 Deposited Plan (DP) 202203; Lot 1 DP 20738; Lot 1 DP 27248; lot 1 DP 146074; Lots 1, 2 and 3 DP 29372; lot 1 and 2 DP 110268; lot 5 DP 102560; Allotments 363, 364, 285; allotment 122, part allotment 123 and middle part allotment 123 of the Parish of Waiuku East.
Territorial Authority:	Franklin District Council
Approximate Map Reference:	NZTM 1753097 mE 5880319 mN (NZMS 260 R12 637 423)

DEFINITIONS:

Council:	Means the Auckland Regional Council
Manager:	Means the Group Manager, Consent and Consents compliance, Auckland Regional council or nominated ARC staff acting on the managers behalf.
Hazardous Air Pollutants:	Are defined in Schedule 7 – Hazardous Air Pollutants of the Proposed Auckland Regional Plan: Air, Land and Water (June 2005).
Iron and Steel Zone:	Means the area zoned "Iron and Steel Industry" under the Franklin District Plan. (February 2000) that is contained within the boundaries of the site.
Glenbrook steel mill:	Means the facility within the Iron and Steel Zone used for the production of iron and steel.
Site:	Means all of the area shown on figure 1, owned by New Zealand Steel Limited in Glenbrook. This area includes the farm property, which provides a green belt and buffer.
IANZ	International Accreditation New Zealand

GENERAL CONDITIONS:

1. That the servants or agents of the Council shall be permitted access to the relevant parts of the property at all reasonable times, for the purpose of carrying out inspections, surveys, investigations, tests, measurements or taking samples.

2. That the Consent Holder shall, operate the plant and associated processes generally in accordance with the documentation submitted to Council as part of application number 14317, where not amended by the conditions of this resource consent. No alterations shall be made to the plant or processes that do not, or are not likely to, comply with the provisions of this consent, a regional rule, or regulations under the Resource Management Act 1991, except as approved by the manager in accordance with Conditions 41, 46 and 47.

3. That the Consent Holder shall be responsible for discharges of contaminants to air from the Site and shall make any person undertaking activities on site, on its behalf, aware of any relevant conditions of this consent.

4. That the Consent Holder shall at all times operate, maintain, supervise, monitor and control all processes on site so that emissions authorised by this consent are maintained at the minimum practicable level.

5. That the Consent Holder shall adopt the best practicable option to remove or minimise any adverse effects on the environment beyond the boundary of the Site that arise from the exercise of this consent.

LIMIT CONDITIONS:

6. That without prejudice to the generality of Condition 4, the discharge of specified air pollutants from the specified sources shall not exceed the corresponding emission rates set out hereto:

SOURCE	Pollutant	Emission not to exceed (mg/m^3)
Multiple hearth furnaces	Particulate matter	75
Kilns	Particulate matter	75
	Carbon monoxide	3,750
Vanadium Converter	Particulate matter	25
Melter metalside baghouse	Particulate matter	50
Melter slagside baghouse	Particulate matter	50
KOBM primary waste gas scrubber	Particulate matter	200
(Flare stack)	Particulate matter (annual average of all results)	160
Pipe mill zinc blow-out system	Particulate matter	125
Pipe mill zinc pot Baghouse	Particulate matter	10
Millscale & iron sand drier (steelserv)	Particulate matter	125
Acid Regeneration Plant	Hydrogen chloride	45
Pickle line fume scrubber	Hydrogen chloride	20

All emission concentrations shall be corrected to zero degrees Celsius, one atmosphere pressure and dry gas basis. All individual tests shall not exceed the above limit conditions.

7. That beyond the boundary of the Site there shall be no odour, dust, particulate, smoke, ash or fume caused by discharges from the Iron and Steel Zone which, in the opinion of an enforcement officer, is noxious, dangerous, offensive or objectionable.

8. That no discharges from any activity on site shall give rise to visible emissions, other than water vapour and clean steam, to an extent which, in the opinion of an enforcement officer, is noxious, dangerous, offensive or objectionable.

9. That beyond the boundary of the Site there shall be no discharge into air of any hazardous air pollutant, caused by discharges from the Iron and Steel Zone, which is present at a concentration that is, or is likely to be, detrimental to human health or the environment.

PROCESS CONDITIONS:

10. That dust generation by vehicle movements shall be maintained at the minimum practicable level. The measures adopted shall include procedures for watering unsealed roads, watering or cleaning of sealed roads, and restricting vehicle speeds on unsealed roads.

11. That fugitive emissions of particulate matter from pollution control equipment and from handling and transfer of dusty materials shall be maintained at the minimum practicable level. In particular, conveyors carrying dusty materials shall be fitted with drop chutes, and enclosures or covers as appropriate.

12. That emissions arising from the dumping of raw primary concentrate and char (RPCC), and from the plating of molten iron shall be kept to a practicable minimum.

13. That the flaring of melter gas shall be kept to a practicable minimum.

14. That Oxygen Steel Making Furnace (KOBM) primary waste gas flare outages and Melter flare outages shall be kept to a practicable minimum to ensure discharges of unburnt carbon monoxide are minimised.

15. That the Consent holder shall not dispose of material by open burning in the Iron and Steel Zone.

16. That the sulphur content of the coal used in the Multi Hearth Furnaces shall not exceed 0.5% by weight.

Operation of Air Pollution Control Equipment

17. That, with the exception of the Pan Conveyer scrubbers, no part of the process shall commence operation without the associated air pollution control equipment being fully operational and functioning correctly. Should a breakdown of control equipment occur during processing, the Consent Holder shall cease operation of all associated plant as soon as practicable and shall repair the control equipment as soon as practicable.

18. That the Pan Conveyer scrubbers shall be fully operational and functioning correctly as much as practicable when the pan conveyer systems are operating. Any scrubber down-time that occurs during process operation shall be for maintenance purposes only.

19. That all air pollution control equipment and associated ducting shall be maintained in good condition and as far as practicable be free from leaks in order to prevent the escape of fugitive emissions.

20. That all ducting to air pollution control equipment shall draw sufficient negative pressure to ensure that fugitive emissions are kept to a practicable minimum.

21. That the paint coating line afterburner(s) shall be operated so that all waste gases from solvent-based paint application and curing are held at a minimum temperature of 750°C, in excess oxygen for a minimum period of 0.5 seconds.

MONITORING CONDITIONS:

Process Monitoring

22. The Consent Holder shall monitor and record:

(a) The flaring of Melter gas as a percentage of total Melter gas produced.

(b) The mass of raw primary concentrate and char (RPCC) that is dumped and the amount of plating that occurs on a daily basis, and the reasons for each dumping or plating incident.

(c) Pan Conveyer scrubber maintenance downtimes.

(d) The times and dates that explosion flap lifts occur at kilns and Multi Hearth Furnaces, including the reason for the flap lift incident and any remedial action taken to minimise recurrence.

(e) The temperature of the waste gases at the exit of the (or each) afterburner (incinerator) shall be continuously monitored and recorded.

(f) Daily inspections of the KOBM baghouse for visible emissions and damaged bags.

Stack emission testing

23. That in addition to the regular process monitoring, emission tests shall be conducted on the sources specified below, in accordance with the specified frequency to determine compliance with Condition 6:

Source	Contaminant	Minimum Test Frequency
Multiple hearth furnaces	Particulate matter	6 monthly
	Oxides of nitrogen	1 yearly
Kilns	Particulate matter	6 monthly
	Carbon monoxide	6 monthly
	Oxides of nitrogen	1 yearly
Melter metal-side baghouses	Particulate matter	3 monthly
Melter slag-side baghouse	Particulate matter	3 monthly
Vanadium Converter	Particulate matter	3 monthly
	Oxides of nitrogen	1 yearly
KOBM primary waste gas scrubber	Particulate matter	3 monthly
(Flare stack)	Oxides of nitrogen	1 yearly
Pipe mill zinc blow-out system	Particulate matter	3 monthly
Pipe mill Baghouse	Particulate matter	annually
Slab re-heat Furnace	Oxides of nitrogen	1 yearly
Millscale & iron sand drier	Particulate matter	6 monthly
Acid Regeneration Plant	Hydrogen chloride	3 monthly
Pickle line fume scrubber	Hydrogen chloride	annually

24. All emission tests carried out in accordance with Condition 23 shall:

(a) Be conducted during process conditions that are representative of normal process emissions.

(b) Comprise not less than three separate samples taken on the same day with the concentration results corrected to zero degrees Celsius, one atmosphere pressure and a dry gas basis.

(c) Be carried out by person/s who are IANZ accredited for the sampling methods.

25. The Consent Holder shall maintain permanent and safe access to all sampling points that are necessary to enable compliance with Condition 23.

26. The Consent Holder shall ensure that dye testing of the Iron making and Steelmaking baghouses is conducted when the associated plant is not operating and where vent emissions are visible or a stack limit is exceeded. As a minimum, testing will be done at least once every twelve months.

Ambient Air Monitoring:

27. The Consent Holder shall continuously measure and record wind speed and direction in the vicinity of the Glenbrook Steel Mill. The data shall be in a form that is immediately retrievable.

28. The Consent Holder shall measure total suspended particulate (TSP) at two sites in the vicinity of the Glenbrook Steel Mill. The monitoring shall be undertaken using equipment taking continuous measurements from 1 February 2007. The monitoring method and location of the sites shall be determined through consultation with the ARC and the Consent Holder.

29. The Consent Holder shall measure PM_{10} at three locations in the vicinity of the Glenbrook Steel Mill. On of these locations will use the existing site at Glenbrook School. Each monitoring site shall continuously measure and record wind speed and direction. The monitoring shall be undertaken as follows:

(a) The monitoring shall be undertaken using continuous measurements at one site from 1 February 2007.

(b) That the monitoring shall be undertaken using continuous measurements at all three sites from 1 June 2007.

(c) Any new monitors shall be run concurrently with the existing monitors for a minimum period of three months.

(d) The monitoring method and location of the sites shall be determined through consultation with the ARC and the Consent Holder.

30. That after 12 months of continuous monitoring the Consent Holder shall undertake an analysis of the results of the monitoring required under Conditions 28 and 29. A report shall be provided to the Manager by 1 September 2008 outlining the results of the analysis.

31. In the event that monitoring in accordance with Condition 28 shows that TSP levels exceed 80μg/m^3, the Consent Holder shall conduct an investigation into the cause of the elevated levels. If the cause of the elevated levels of total suspended particulate is identified as being an activity undertaken within the Iron and Steel Zone, then as far as practicable, action shall be taken by the Consent Holder to reduce discharges from that activity. Any action taken shall be to the satisfaction of the Manager.

32. In the event that monitoring in accordance with Condition 29 shows that PM_{10} levels exceed 33μg/m^3 at Glenbrook School or 50μg/m^3 at any other site, the Consent Holder shall conduct an investigation into the cause of the level of PM_{10} at those sites. If the cause of the elevated levels is identified as being an activity undertaken within the Iron and Steel Zone, the Consent Holder shall prepare and submit to the Manager a remedial action plan within 3 months of the exceedence detailing methods to reduce PM_{10} levels to below relevant levels. The remedial action plan shall include a discussion on the contributions of the KOBM baghouse. The remedial action plan shall be to the satisfaction of the Manager.

General Monitoring

33. All monitoring undertaken in accordance with Conditions 28 and 29 shall be undertaken by an IANZ accredited agency.

34. All monitoring and testing shall be carried out to the satisfaction of the Manager.

LOGGING AND REPORTING CONDITIONS

35. That all documentation, records, monitoring and test results that are required by the conditions of this consent shall be made available on request, during operating hours, to an enforcement officer.

36. That all ambient monitoring and stack emission test results including raw data, all calculations, and assumptions that are required by the conditions of this consent shall be kept for at least the duration of this consent; and all other logs and records that are required by the conditions of this consent shall be kept for a minimum period of 24 months from the date of each entry.

37. That the Consent Holder shall notify an enforcement officer as soon as practicable in the event of any significant increase in the discharge of contaminants into air which may result in adverse effects on the environment.

38. That the Consent Holder shall log all air pollution complaints received. The complaint details shall include:

    (a) The date, time, position and nature of the complaint.

    (b) The name, phone number and address of the complainant, unless the complainant elects not to supply these details.

    (c) The details of any investigation, the cause of the complaint and corrective actions undertaken in response to the complaint.

39. Details of any complaints received shall be provided to the Manager within 24 hours or as soon as practicable after the receipt of the complaint.

40. A summary of all information required by the conditions of this consent shall be provided to the Manager at least once every three months, unless otherwise stated. The summary shall include:

    (a) Results of the ambient monitoring and meteorological monitoring, including details of any exceedences of ambient monitoring trigger levels and any subsequent action to investigate and if necessary to remedy the exceedences.

    (b) Provide an electronic copy of all raw data from ambient air and weather monitoring stations.

    (c) That the Consent Holder shall report at least annually on the peak concentrations and the annual mass emissions of PM_{10} and NO_x (as NO_2). The report for the previous calendar year shall be submitted to the Manager as part the next three monthly report required by this condition. Any major changes, both increases and decreases, in the potential mass emissions shall be included in the latest three monthly report.

    (d) Results of stack emissions testing as specified in Condition 23.

    (e) A summary of process monitoring as specified in Condition 22 including all process monitoring exceptions.

    (f) A summary of any complaints received.

    (g) A report on progress on implementation of either Condition 46 or Condition 47, as required by Condition 45.

    The format of the report shall be agreed with the Manager and the first report shall be provided to the Manager within three months from the commencement of this consent.

41. The Consent Holder shall review all site major sources of air emissions and their associated pollution control equipment, including the KOBM baghouse. The information provided in the review should include but not be limited to:

    (a) The techniques applied to control emissions

    (b) The current emission concentration after the control equipment

    (c) The current emission concentration before the control equipment

    (d) The current emission rate after the control equipment

    (e) A rank of best to worst performing control equipment

    (f) Relevant best practice

The review shall evaluate the results and compare them to current best practice. Where the results of the review are not the BPO, the report shall also address the steps to be taken to adopt the BPO and a timetable in which those steps shall be taken. The first review shall be submitted to the Manager for his approval by 30 September 2008 and every three years thereafter.

Note: the Manager may review (internally or externally) the assessment required by this condition. The cost of any such review will be borne by the Consent Holder.

42. That the Consent Holder shall, with the agreement of the Manager, determine the major point sources of PM_{10} and NO_X and major fugitive sources of PM_{10} from the Site. The Consent Holder shall then provide the Manager, by 31 December 2006 with either:

(a) A measurement of maximum daily and annual mass emissions of PM_{10} and NO_X from all major point and fugitive sources, or

(b) If measurements are not practicable, an estimate of maximum daily and annual mass emissions of PM_{10} and NO_X from all major point and fugitive sources based on robust emissions factors or proxy measurements.

Details of any measurements and the calculation methods used, including specifying all assumptions made and outlining the accuracy of any emission factors used, shall also be included with this information.

43. That the Consent Holder shall model the effects of PM_{10} emitted from all major sources on the site. The modelling shall be done using the PM_{10} emissions provided as part of consent Condition 42. The results shall be compared to known ambient PM_{10} field measurements and shall be submitted by 30 March 2007. The type of modelling and the methodology shall be submitted to the Manager for approval.

44. That the Consent Holder shall review the PM_{10} and NO_X emissions for all the major point and fugitive sources in September 2008 and every 3 years thereafter. If the mass emissions of PM_{10} from any one of theses major sources is found to be more than 25% higher than a previous review, or if there appears to be a major source of PM_{10} on site not accounted for in a previous review, then further modelling may be required at the discretion of the Manager.

Note: The requirement for additional modelling will not be initiated without prior consultation with the Consent Holder.

PROPOSED PLANT MODIFICATIONS OR UPGRADE AND PEER REVIEW:

45. Should the proposed modification to the vanadium extraction and slabmaking facilities (referred to in the documentation submitted by the Consent Holder to the Council in June 2006 as addendum to 1999 AEE) proceed, then Condition 46 shall apply. In the event that the proposed plant modifications are not to proceed then

Condition 47 shall apply. The Consent Holder shall report progress on implementation of either Condition 46 or 47 in the three -monthly compliance reports to the to the council, which are required by Condition 40.

46. Within 6 months of commissioning the Vanadium Converter the Consent Holder shall provide the Council with a report on reductions in Slabmaking Plant air emissions (including product dumping and KOBM Baghouse emissions). The Consent Authority may request that the report be independently reviewed by a suitably qualified person or person(s) (the Peer Reviewer) approved by the Manager.

47. In the event that the proposed plant modifications do not proceed then the Consent Holder shall investigate options for upgrading the air pollution control facility of the existing Vanadium Recovery Station in order to reduce mass emissions. The Consent Holder shall select one of those options for implementation and shall prepare a report to the Consent Authority on the investigation undertaken, the options available, the option selected and a timetable for implementation. The report shall be lodged with the Consent Authority not later than 31 December 2009.

48. The Consent Holder shall provide the Manager with all records, plans, designs and other information referred to in Conditions 41, 46 and 47 that the Peer Reviewer(s) require(s) to be able to undertake their peer review(s).

ENVIRONMENTAL MANAGEMENT SYSTEM CONDITIONS:

49. That the Consent Holder shall maintain an Environmental Management System (EMS) to an ISO 14000 or an equivalent standard. The EMS shall be updated to make it consistent with the conditions of this consent and shall be submitted to the Manager for review within 12 months of the consent being granted. The Manager will advise the Consent Holder in writing if any aspects of the Plan are considered to be inconsistent with achieving the provisions of this consent. The EMS shall accurately record all management and operational procedures, methodologies and contingency plans necessary to comply with the conditions of this consent including, but not limited to, the following:

    (a) Methods to ensure that air pollution control systems are functioning correctly and consistently in accordance with Conditions 17, 18, 19, 20, and 21, (including but not limited to: preventative maintenance; critical process checks; responses to faults or alarm conditions; discharge monitoring; and preventative checks or inspections of interlocks, sensors, level controllers, switches etc).

    (b) Actions that will be taken in response to any faults or alarm conditions that have the potential to effect discharges to air.

    (c) Daily visual inspections of all stacks and vents discharging to air, including the KOBM bag house.

(d) At least 12-monthly dye testing of the Iron and Steelmaking bag houses to detect any bag failures.

(e) Monitoring of gas leaks around the Kilns Co-generation Plant by-pass damper to ensure that carbon monoxide emissions are kept to a practicable minimum.

(f) Setting objectives and targets to minimise waste and process interruptions, as agreed with the Manager, and shall include the following:

  i) Methods to ensure that fugitive dust emissions are maintained at a minimum practicable level as required by conditions 10, 11, 19 and 20.

  ii) Targets and methods for limiting dumping of raw primary concentrate and char (RPCC) to a practicable minimum as per condition 12.

  iii) Targets and methods for limiting plating.

  iv) Targets and methods for lowering the number of pressure release flap lift incidents at the material-hearth furnaces.

  vi) Targets and methods for minimising the flaring of melter gas as a percentage of total melter gas produced.

  vii) Targets and methods for minimising the frequency of flare failures on the melters and on the KOBM primary waste gas ventilation.

  viii) Targets and methods for minimising the frequency of Pan Conveyer scrubber maintenance downtimes.

REVIEW CONDITION:

50. That the conditions of this consent may be reviewed by the Manager pursuant to Section 128 of the Resource Management Act 1991, by the giving of notice pursuant to Section 129 of the Act, in August 2007 and during every second August thereafter in order:

(a) Deal with any significant adverse effect on the environment arising from the exercise of the consent, which was not foreseen at the time the application, was not considered and which is appropriate to deal with at the time of the review.

(b) Consider the adequacy of conditions which prevent adverse effects beyond the boundary of the site, particularly if regular or frequent complaints have been received and validated by an enforcement officer.

(c) Consider developments in control technology and management practices that would enable practical reductions in the discharge of contaminants into air.

(d) To require the Consent Holder to adopt the best practicable option to remove or reduce any adverse effect on the environment arising from the exercise of this consent.

(e) Alter the monitoring requirements, including further monitoring, or increasing or reducing the frequency of monitoring.

(f) Consider the adequacy of conditions in the event that the ambient monitoring undertaken indicates that exceedences of the Resource Management (National Environmental Standards relating to Certain Air Pollutants, Dioxins, and Other Toxics) Regulations 2004 (NES) and any subsequent amendments have occurred or are likely.

The Consent Holder shall meet the reasonable costs of any such reviews in accordance with section 36 of the RMA.

ADVICE NOTES:

1. The Consent Holder is advised that it will be required to pay to the Council any administrative charge fixed in accordance with Section 36(1) of the Resource Management Act 1991, or any additional charge required pursuant to Section 36(3) of the Resource Management Act 1991 in respect of this consent.

2. The Consent Holder is advised that the date of the commencement of this consent will be as determined by Section 116 of the Resource Management Act 1991, unless a later date is stated as a condition of consent. The provisions of Section 116 of the Resource Management Act 1991 are summarised in the covering letter issued with this consent.

3. The Consent Holder is advised that, the Council may at any time undertake source emission testing and/or any other monitoring to investigate compliance with the conditions of this consent. The Consent Holder is advised that it will be required to pay for the costs of this monitoring as per Advice Note 1.

4. The Consent Holder is advised that, the Council may at any time seek independent expert advice in relation the exercise of the resource consent. The Consent Holder is advised that it will be required to pay for the costs of expert advice as per Advice Note 1.

This consent has been granted by the Auckland Regional Council pursuant to the Resource Management Act 1991.

pp

Pieter Tuinder
Manager
Consents and Consents Compliance
Auckland Regional Council

Date: 29/11/06

New Zealand Steel Ltd

Figure 1

Legend

▨ NZ Steel Ltd Site

Map Produced by GIS
Information Services
Auckland Regional Council

Auckland
Regional Council
TE RAUHITANGA TAIAO

Resource consent is required for the following reason:

Air Discharge Permit (s15) – DIS60363772

Auckland Unitary Plan (Operative in part)

Air Discharge Permit (operative plan provisions)

Air Quality

- To undertake iron plating, being the refining of any metal, is a **discretionary** activity under rule E14.4.1(A41).

Note: The Site is not within an airshed that is considered to be polluted under the NES:AQ, and therefore Regulation 17 of the NES:AQ is not relevant to this application.

Decision

I have read the application, supporting documents, and the report and recommendations on the application for resource consent. I am satisfied that I have adequate information to consider the matters required by the Resource Management Act 1991 (RMA) and make a decision under delegated authority on the application.

Acting under delegated authority, under sections 104, 104B, 105, and 107 and Part 2 of the RMA, the resource consent is **GRANTED**.

Reasons

The reasons for this decision are:

1. In accordance with an assessment under ss104(1)(a) and (ab) of the RMA, the actual and potential effects from the proposal will be acceptable as:
    a. Council's Specialist for Air Discharge has stated that despite the increased frequency of plating during COVID-19 Level 4 restrictions, the PM_{10} concentrations measured at Glenbrook Beach Rd (GBR), Glenbrook School, and Sandspit Rd monitoring sites during Alert Level 4 were generally lower than the long-term average. The total PM_{10} and $PM_{2.5}$ particulates, when combined with existing discharges, are within the ambient levels identified within the AUP(OP) and human health levels. Adverse effects are therefore acceptable on human health.

    b. Council's Specialist for Air discharge has assessed nuisance dust emissions, being particulates greater than 10 microns. The actual contribution from the plating process to hourly ambient Total Suspended Particulate (TSP) concentrations (Training Centre) was estimated to be up to 2 $\mu g/m^3$ for each ladle, and cumulatively below the threshold of 80 $\mu g/m^3$ as set out in the conditions of the existing consent. In terms of dust settlement, is noted that the discharges rise quickly into the atmosphere due to the hot temperatures of the molten metal. Subsequently, when dispersed into the atmosphere, the particles are further diluted and spread further apart by wind. Should any dust eventually settle, it is unlikely to be noticeable.

c. The applicant's Air Quality Report details briefly the effects of iron deposition, particularly ferric oxide, on offsite aquatic ecosystems. Council's Specialist for Air discharge has stated that given the negligible predicted increase in overall offsite TSP concentrations, as identified above, any ecosystem effects from the additional commercial iron plating activities are considered to be negligible.

d. Conditions of consent have been offered by the applicant to continue to monitor air discharges to ensure human health and ambient air quality standards are not exceeded. This ensures continued management of effects of the commercial plating activity.

e. In terms of visual effects, when molten iron is plated, a cloud that is orange/brown in colour is emitted into the atmosphere. This discharge is temporary (lasting less than 10minutes for each ladle), and when viewed in conjunction with existing discharges on the site (including Steel Mill's chimneys, and existing consented iron plating), is considered to be acceptable in this instance.

f. In terms of positive effects, New Zealand Steel contributes to the local, regional, and national economies in the following ways:

    - Contributes over 4000 jobs (directly and indirectly) within Auckland;
    - Contributes over $600 million per annum to the New Zealand economy;
    - For every tonne of steel produced in New Zealand, 80% of the dollars spent on that steel stay within New Zealand, compared to only 5% of the dollars spent on imported steel.

    The continued operation of the steel mill therefore translates into providing for the South Auckland community's social, economic, and cultural wellbeing.

g. With reference to s104(1)(ab), there are no specific offsetting or environmental compensation measures proposed or agreed to by the applicant to ensure positive effects on the environment.

2. In accordance with an assessment under s104(1)(b) of the RMA, the proposal is consistent with the relevant statutory documents. In particular:

    Auckland Unitary Plan (Operative in Part)

    B7. Toitū te whenua, toitū te taiao – Natural resources
    B7.5.1(1-3): Objectives – Air
    B7.5.2(1-2): Policies - Air

    E14. Air Quality
    E14.2(1-4): Objectives
    E14.3(1,5,8,9): Policies

    Overall, it is considered that the proposal is consistent with the above objectives and policies. The proposal, being a commercial iron plating activity, will emit particles into the air within the Business – Heavy Industry Zone, which is enabled by the plan and recognised as having low air quality. Particulates discharged by the iron plating activity will be below levels that would adversely affect human or ecosystem health. Additionally, there is a significant distance between the discharge point and the nearest sensitive receiver, thus ensuring that incompatible activities are sufficiently separated, and adverse effects effectively mitigated or avoided. Given the limited timeframe of the proposal, being until 1 November 2021, it is considered that the best practicable option has been chosen to manage adverse effects.

3. In accordance with an assessment under s104(1)(c) of the RMA, no other matters are considered relevant.

4. In terms of section 105 of the RMA, it has been determined that there are no significant effects on the receiving environment. Alternative locations for the iron plating discharges are not relevant as steel mill activities have occurred on the site since 1968 and it is therefore considered that there are no other locations more suitable for the iron plating. It is further considered the applicant's reasons for the proposed discharges of contaminants into air are appropriate in the circumstances. In particular, a balancing of positive social and economic benefits arising from the proposal.

5. In terms of section 107 of the RMA, there are restrictions on the granting of certain discharge permits that would contravene sections 15 or 15A of the RMA. The proposed discharge is to air and not water or land. The discharges consist of iron oxide particles and will not result in the production of any conspicuous oil or grease films, scums or foams, or floatable or suspended materials within water, any conspicuous change in the colour or visual clarity of water, any emission of objectionable odour, the rendering of fresh water unsuitable for consumption by farm animals, or any significant adverse effects on aquatic life. It is therefore considered that section 107 matters are not relevant to the type of discharge which will result from the proposal. Therefore, there is no restriction on granting this consent in accordance with s107.

6. In the context of this discretionary activity application air discharges, where the objectives and policies of the relevant statutory documents were prepared having regard to Part 2 of the RMA, they capture all relevant planning considerations and contain a coherent set of policies designed to achieve clear environmental outcomes. They also provide a clear framework for assessing all relevant potential effects and there is no need to go beyond these provisions and look to Part 2 in making this decision as an assessment against Part 2 would not add anything to the evaluative exercise.

7. Overall, the proposal is considered to be in keeping with the objectives and policies of the Auckland Unitary Plan (Operative in Part). The proposed commercial iron plating activity will be undertaken in conjunction with existing activities on the site, where cumulatively, adverse effects arising from total suspended particulates, PM_{10}, and $PM_{2.5}$, will be less than health and air quality limits as identified within the AUP(OP). Continued monitoring will ensure these limits are not exceeded. Adverse effects on the environment will be less than minor.

Conditions

Definitions

Commercial Iron Plating	*Means the plating of molten iron specifically for commercial purposes as more particularly described in the application for*

	this consent (for clarification, this does not include process plating of molten iron that is necessary as part of the Glenbrook steel mill's normal operations).
Council:	*Means the Auckland Council*
Manager:	*Means the Group Manager, Consent and Consents compliance, Auckland Council or nominated AC staff acting on the managers behalf*
Hazardous Air Pollutants:	*Are defined in Schedule 7 – Hazardous Air Pollutants of the Proposed Auckland Regional Plan: Air, Land and Water (June 2005).*
Iron and Steel Zone:	*Means the area zoned "Iron and Steel Industry" under the Franklin District Plan. (February 2000) that is contained within the boundaries of the site.*
Glenbrook steel mill:	*Means the facility within the Iron and Steel Zone used for the production of iron and steel.*
Site:	*Means all of the area shown on figure 1, owned by New Zealand Steel Limited in Glenbrook. This area includes the farm property, which provides a green belt and buffer.*
IANZ	*International Accreditation New Zealand*

General Conditions

Under sections 108 and 108AA of the RMA, this consent is subject to the following conditions:

Advice note:

The conditions set out below reflect the structure and content of the conditions of Permit 14317. Where a condition is [blank], that particular condition of air discharge consent DIS80296529 [NRSI-14317] is not applicable to this Commercial Iron Plating resource consent. The numbering has been retained to provide consistency with air discharge consent DIS80296529 [NRSI-14317].

1. That the servants or agents of the Council shall be permitted access to the relevant parts of the property at all reasonable times, for the purpose of carrying out inspections, surveys, investigations, tests, measurements or taking samples.

2. That the Consent Holder shall, undertake Commercial Iron Plating activity generally in accordance with the documentation submitted to Council as part of application number DIS60363772, where not amended by the conditions of this resource consent.

   - Application Form and Assessment of Environmental Effects prepared by Mikayla Woods (Tonkin and Taylor), dated September 2020.

Report title and reference	Author	Rev	Dated
Air Quality Assessment: Commercial Plating at the Glenbrook Steel Mill. Ref: 1010577.0000	Tonkin and Taylor	2	17 September 2020

Other additional information	Author	Rev	Dated
Proposed Commercial Iron Plating Resource Consent Conditions	Tonkin and Taylor	-	-

2A. Under section 125 of the RMA, this consent lapses twelve (12) months after the date it is granted unless:

   a. The consent is given effect to; or

   b. The council extends the period after which the consent lapses.

2B. Under section 123 of the RMA, this consent expires on 1 November 2021, unless it has been surrendered or been cancelled at an earlier date pursuant to the Resource Management Act.

2C. The consent holder shall pay the council an initial consent compliance monitoring charge of $1020 (inclusive of GST), plus any further monitoring charge or charges to recover the actual and reasonable costs incurred to ensure compliance with the conditions attached to this consent.

Advice note:

The initial monitoring deposit is to cover the cost of inspecting the site, carrying out tests, reviewing conditions, updating files, etc., all being work to ensure compliance with the resource consent. In order to recover actual and reasonable costs, monitoring of conditions, in excess of those covered by the deposit, shall be charged at the relevant hourly rate applicable at the time. The consent holder will be advised of the further monitoring charge. Only after all conditions of the resource consent have been met, will the council issue a letter confirming compliance on request of the consent holder.

3. That the Consent Holder shall be responsible for discharges of contaminants to air from the Site and shall make any person undertaking activities on site, on its behalf, aware of any relevant conditions of this consent.

4. That the Consent Holder shall at all times operate, maintain, supervise, monitor and control all processes on site so that emissions authorised by this consent are maintained at the minimum practicable level.

5. [blank]

Limit Conditions

6. [blank]

7. That beyond the boundary of the Site there shall be no odour, dust, particulate, smoke, ash or fume caused by discharges from the Commercial Iron Plating activity which, in the opinion of an enforcement officer, is noxious, dangerous, offensive or objectionable.

8. That no discharges from any Commercial Iron Plating activity on site shall give rise to visible emissions, other than water vapour and clean steam, to an extent which, in the opinion of an enforcement officer, is noxious, dangerous, offensive or objectionable.

9. That beyond the boundary of the Site there shall be no discharge into air of any hazardous air pollutant, caused by discharges from the Commercial Iron Plating activity, which is present at a concentration that is, or is likely to be, detrimental to human health or the environment.

Process Conditions

10. [blank]

11. [blank]

12. [blank]

12A. The consent holder shall ensure that the maximum daily volume of Commercial Iron Plating produced does not exceed 500 tonnes per day and to a maximum of 210 tonnes an hour.

13. [blank]

14. [blank]

15. [blank]

16. [blank]

Operation of Air Pollution Control Equipment

17. [blank]

18. [blank]

19. [blank]

20. [blank]

21. [blank]

Monitoring Conditions

Process Monitoring

22. The consent holder shall monitor and record:

    a. [blank]

    b. The amount of Commercial Iron Plating that occurs on a daily basis.

    c. [blank]

    d. [blank]

    e. [blank]

    f. [blank]

Stack Emission Testing

23. [blank]

24. [blank]

25. [blank]

26. [blank]

Ambient Air Monitoring

27. The Consent Holder shall continuously measure and record wind speed and direction in the vicinity of the Glenbrook Steel Mill. The data shall be in a form that is immediately retrievable.

28. The Consent Holder shall measure total suspended particulate (TSP) at two sites in the vicinity of the Glenbrook Steel Mill. The monitoring shall be undertaken using equipment taking continuous measurements. The monitoring method and location of the sites shall be consistent with the monitoring method and location of sites utilised for air discharge consent DIS80296529 [NRSI-14317].

29. The Consent Holder shall measure PM_{10} at three locations in the vicinity of the Glenbrook Steel Mill. The monitoring method and location of the sites shall be consistent with the monitoring method and location of sites utilised for air discharge consent DIS80296529 [NRSI-14317]. Each monitoring site shall continuously measure and record wind speed and direction.

30. [blank]

31. In the event that monitoring in accordance with Condition 28 shows that TSP levels exceed 80 $\mu g/m^3$, the Consent Holder shall conduct an investigation into the cause of the elevated levels. If the cause of the elevated levels of total suspended particulate is identified as being as a result of the Commercial Iron Plating activity, then as far as practicable, action shall be taken by the Consent Holder to reduce discharges from that activity. The incident and remedial action taken shall be reported to Council.

32. In the event that monitoring in accordance with Condition 29 shows that PM_{10} levels exceed 33$\mu g/m^3$ at Glenbrook School or 50 $\mu g/m^3$ at any other site, the Consent Holder shall conduct an investigation into the cause of the level of PM_{10} at those sites. If the cause of the elevated levels is identified as being as a result of the Commercial Iron Plating activity, the Consent Holder shall prepare and submit to the Manager a remedial

action plan within 3 months of the exceedance detailing methods to reduce PM10 levels to below relevant levels. The remedial action plan shall be to the satisfaction of the Council.

General Monitoring

33. All monitoring undertaken in accordance with Conditions 28 and 29 shall be undertaken by an IANZ accredited agency.

34. All monitoring and testing shall be carried out to the satisfaction of the Council.

Logging and Reporting Conditions

35. That all documentation, records, monitoring and test results that are required by the conditions of this consent shall be made available on request, during operating hours, to an enforcement officer.

36. That all ambient monitoring results including raw data, all calculations, and assumptions that are required by the conditions of this consent shall be kept for at least the duration of this consent; and all other logs and records that are required by the conditions of this consent shall be kept for a minimum period of 24 months from the date of each entry.

37. That the Consent Holder shall notify an enforcement officer as soon as practicable in the event of any significant increase in the discharge of contaminants into air from Commercial Iron Plating which may result in adverse effects on the environment.

38. That the Consent Holder shall log all air pollution complaints received. The complaint details shall include:

    a. The date, time, position and nature of the complaint.

    b. The name, phone number and address of the complainant, unless the complainant elects not to supply these details.

    c. The details of any investigation, the cause of the complaint and corrective actions undertaken in response to the complaint.

39. Details of any complaints received shall be provided to the Manager within 24 hours or as soon as practicable after the receipt of the complaint.

40. A summary of all information required by the conditions of this consent, shall be provided to the Manager at least once every three months, unless otherwise stated. The summary shall include:

    a. Results of the ambient monitoring and meteorological monitoring, including details of any exceedances of ambient monitoring trigger levels and any subsequent action to investigate and if necessary to remedy the exceedances.

    b. Provide an electronic copy of all raw data from ambient air and weather monitoring stations.

    c. [blank]

    d. [blank]

    e. [blank]

    f. A summary of any complaints received.
    g. [blank]

41. [blank]
42. [blank]
43. [blank]
44. [blank]

Proposed Plant Modifications or Upgrade and Peer Review

45. [blank]
46. [blank]
47. [blank]
48. [blank]

Environmental Management System Conditions:

49. That the Consent Holder shall maintain an Environmental Management System (EMS) to an ISO 14000 or an equivalent standard. The EMS shall be reviewed to ensure it is consistent with the conditions of this consent. The EMS shall accurately record all management and operational procedures, methodologies and contingency plans necessary to comply with the conditions of this consent.
    a. [blank]
    b. [blank]
    c. [blank]
    d. [blank]
    e. [blank]
    f. [blank]
        (i) [blank]
        (ii) [blank]
        (iii) [blank]
        (iv) [blank]
        (v) [blank]
        (vi) [blank]
        (vii) [blank]
        (viii) [blank]

Review Condition

50. Under Section 128 of the RMA, the conditions of this consent may be reviewed by the Manager Resource Consents at the consent holder's cost in order to:

    a. Deal with any significant adverse effect on the environment arising from the exercise of the consent, which was not foreseen at the time the application was considered, and which is appropriate to deal with at the time of the review.

    b. Consider the adequacy of conditions which prevent adverse effects beyond the boundary of the site, particularly if regular or frequent complaints have been received and validated by an enforcement officer.

    c. Consider developments in control technology and management practices that would enable practical reductions in the discharge of contaminants into air.

    d. [blank]

    e. Alter the monitoring requirements, including further monitoring, or increasing or reducing the frequency of monitoring.

    f. [blank]

    g. Take into account any Act of Parliament, regulation, national policy statement, regional policy statement or relevant regional plan that relates to limiting, recording or mitigating emissions by this consent.

    Or, the consent may be reviewed by the Manager Resource Consents at any time, if it is found that the information made available to the council in the application contained inaccuracies which materially influenced the decision and the effects of the exercise of the consent are such that it is necessary to apply more appropriate conditions.

Advice notes

1. *The Consent Holder is advised that it will be required to pay to the Council any administrative charge fixed in accordance with Section 36(1) of the Resource Management Act 1991, or any additional charge required pursuant to Section 36(3) of the Resource Management Act 1991 in respect of this consent.*

2. *The Consent Holder is advised that the date of the commencement of this consent will be as determined by Section 116 of the Resource Management Act 1991, unless a later date is stated as a condition of consent. The provisions of Section 116 of the Resource Management Act 1991 are summarised in the covering letter issued with this consent.*

3. *The Consent Holder is advised that, the Council may at any time undertake source emission testing and/or any other monitoring to investigate compliance with the conditions of this consent. The Consent Holder is advised that it will be required to pay for the costs of this monitoring as per Advice Note 1.*

4. *The Consent Holder is advised that, the Council may at any time seek independent expert advice in relation the exercise of the resource consent. The Consent Holder is*

advised that it will be required to pay for the costs of expert advice as per Advice Note 1.

5. *Any reference to number of days within this decision refers to working days as defined in s2 of the RMA.*

6. *For the purpose of compliance with the conditions of consent, "the council" refers to the council's monitoring inspector unless otherwise specified. Please email monitoring@aucklandcouncil.govt.nz to identify your allocated officer.*

7. *For more information on the resource consent process with Auckland Council see the council's website: www.aucklandcouncil.govt.nz. General information on resource consents, including making an application to vary or cancel consent conditions can be found on the Ministry for the Environment's website: www.mfe.govt.nz.*

8. *If you disagree with any of the above conditions, and/or disagree with the additional charges relating to the processing of the application(s), you have a right of objection pursuant to sections 357A and/or 357B of the Resource Management Act 1991. Any objection must be made in writing to the council within 15 working days of your receipt of this decision (for s357A) or receipt of the council invoice (for s357B).*

9. *The consent holder is responsible for obtaining all other necessary consents, permits, and licences, including those under the Building Act 2004, and the Heritage New Zealand Pouhere Taonga Act 2014. This consent does not remove the need to comply with all other applicable Acts (including the Property Law Act 2007 and the Health and Safety at Work Act 2015), regulations, relevant Bylaws, and rules of law. This consent does not constitute building consent approval. Please check whether a building consent is required under the Building Act 2004.*

Delegated decision maker:

Name: Tracey Grant

Title: Principal Project Lead, Resource Consents

Signed:

Date: 8/10/2020

Appendix B: Air quality assessment criteria

B1 Introduction

This appendix provides details on the potential health effects of the identified contaminants and sets out the derivation of assessment criteria as summarised in **Table 7.1**.

B2 Particulate matter

The particulate matter emissions of interest, with respect to potential for health effects, are those smaller than ten microns in aerodynamic diameter (PM_{10}) and the sub-set of even smaller particles less than 2.5 microns in aerodynamic diameter ($PM_{2.5}$). Epidemiological studies have provided no evidence for the existence of a threshold value below which no adverse health effects are observed for either PM_{10} or $PM_{2.5}$.

The NESAQ set a particulate standard for 24-hour average PM_{10}, and there is consultation currently underway to set new NESAQ standards for 24-hour average and annual average $PM_{2.5}$. The AAQG include an annual average guideline value, which is also included in Chapter E14 of the AUP as an AAAQT.

TSP is generally used as an indicator of nuisance dust, as it includes the larger, non-respirable fraction of particulate matter. The Main Air Permit held by NZ Steel includes an investigative trigger level of 80 µg/m^3 (24-hour average) that applies to TSP concentrations measured at the Training Centre and Boundary Road monitoring sites (set up under the Main Air Permit). This value is recommended in the GPG Dust as a trigger level to manage chronic dust effects in moderate sensitivity receiving environments.

A summary of the relevant air quality criteria for evaluating the effects of particulate emissions to air is set out in **Table 14.1** below.

Table 14.1: Air quality criteria for particulate

Substance	Averaging period	Value (µg/m^3)	Source of standard/guideline
PM_{10}	24-hour	50*	NESAQ
	Annual	20	AAQG / AAAQT
$PM_{2.5}$	24-hour	25	Proposed NESAQ / AAAQT
	Annual	10	Proposed NESAQ / AAAQT

* The NESAQ allows for 1 exceedance of the concentration limit in a 12-month period

B3 Products of combustion

B3.1 Sulphur dioxide

SO_2 is of interest with respect to potential human health effects because it is a potent respiratory irritant when inhaled. Asthmatics are particularly susceptible. SO_2 acts directly on the upper airways (nose, throat, trachea and major bronchi), producing rapid responses within minutes. It achieves maximum effect in 10 to 15 minutes, particularly in individuals with significant airway reactivity, such as asthmatics and those suffering similar bronchospastic conditions.

Environmental impacts from emissions of sulphur oxides relate to impacts on sensitive vegetation and acid deposition, which may cause damage to materials, terrestrial ecosystems, and aquatic ecosystems.

The following ambient air quality guideline values for SO_2 have been adopted in New Zealand:

- The NESAQ include 1-hour average standards for SO_2. The ambient air quality standards apply anywhere in the open air where people may be exposed to a contaminant, except that the standards do not apply to a site that is the subject to a resource consent.
- The AAQG include the same 1-hour average values adopted in the NESAQ and, in addition, set a 24-hour average guideline value of 120 µg/m3. This 24-hour value is also adopted in the AAAQT.
- The AAQG include guidelines for the protection of ecosystems as annual or winter averages.

In 2006, the WHO reduced its recommended 24-hour average guideline value[31] from 125 µg/m^3 to 20 µg/m^3. This was based on a review of new information about adverse effects of chronic exposure to SO_2, which was further supported by a comprehensive technical review in 2013[3]. This new and lower guideline value has not been formally evaluated or adopted in New Zealand and has been discussed in Section 7.1 for relevance in New Zealand.

Appendix B Table 2: Ambient air quality standards and guidelines for SO_2

Averaging period	Value (µg/m^3)	Permissible exceedances*	Source of standard/guideline
1-hour average	200	9	NESAQ
24-hour average	120	-	AAQG / AAAQT
24-hour average	20	-	WHO
Annual and winter average	30	-	UNECE/WHO (Agricultural crops)
	20	-	UNECE/WHO (Forest and natural vegetation)
Annual average	10	-	UNECE/WHO (Lichen)

* The NESAQ includes a number of permissible exceedances in a 12-month period before it is considered that the standard has been breached.

B3.2 Nitrogen dioxide

Exposure to NO_2 has been shown to cause reversible effects on lung function and airway responsiveness. It may also increase reactivity to natural allergens. Inhalation of NO_2 by children increases their risk of respiratory infection and may lead to poorer lung function in later life. Recent epidemiological studies have shown an association between ambient NO_2 exposure and increases in daily mortality and hospital admissions for respiratory disease. NO_2 has also been shown to increase the effects of exposure to other known irritants, such as ozone and respirable particles.

The following ambient air quality guideline values for NO_2 have been adopted in New Zealand:

- The NESAQ include a 1-hour average standard for NO_2. The ambient air quality standards apply anywhere in the open air where people may be exposed to a contaminant, except that the standards do not apply to a site that is the subject to a resource consent.

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[31] Air Quality Guidelines Global Update 2005, World Health Organization 2006

- The AAQG includes the same 1-hour average values adopted in the NESAQ and, in addition, sets a 24-hour average guideline value of 100 µg/m^3. Both values are to protect public health from air quality effects.
- The AAQG also include a guideline value for protecting ecosystems, based on the UNECE/WHO (1996) and Australia and New Zealand Environment and Conservation Council (ANZECC) guideline values.
- The AAAQT also includes the same 24 hour average standard as recommended in AAQG. Additionally, it includes an annual average guideline for the protection of public health.

Table 3: Ambient air quality standards and guidelines for NO_2

Averaging period	Value (µg/m^3)	Permissible exceedances*	Source of standard/guideline
1-hour average	200	9	NESAQ
24-hour average	100	-	AAQG / AAAQT
Annual average	40	-	AAAQT
Annual average	30	-	AAQG (ecosystems)

* The NESAQ includes a number of permissible exceedances in a 12-month period before it is considered that the standard has been breached.

B3.3 Carbon monoxide

High exposures to carbon monoxide (CO) can cause acute poisoning, with coma and eventually collapse occurring. However, ambient exposures to CO are typically several orders of magnitude lower than those associated with acute poisoning, although some exposures in urban settings have been shown to adversely affect the heart, brain and central nervous system.

Adverse cardiovascular effects of CO inhalation include decreased blood oxygen uptake and decreased work capacity. Those with angina may suffer decreased exercise capacity and increased duration of angina. Adverse neuro-behavioural effects of CO include a decrease in vigilance, visual perception, manual dexterity, ability to learn and perform complex sensorimotor tasks in healthy individuals, and reduced birth weight in non-smoking mothers.

The following ambient air quality guideline values have been adopted in New Zealand:

- The NESAQ and AAQG include an 8-hour average guideline value of 10,000 µg/m^3; and
- The AAQG and AAAQT include a 1-hour average value of 30,000 µg/m^3.

Appendix B Table 3: Ambient air quality standards and guidelines for CO

Averaging period	Value (µg/m^3)	Permissible exceedances	Source of standard/guideline
1-hour average	30,000	-	AAQG / AAAQT
8-hour average	10,000	1	NESAQ

B4 Other contaminant discharges from iron and steel processes

B4.1 Metals

The adverse effects of ambient concentrations of metals are varied and depends on the specific metal and may include both acute and chronic exposure toxicity effects. Some metals are also recognised carcinogens.

Monitoring for deposited metals has been undertaken to estimate the theoretical metal concentrations in drinking water. These concentrations are compared with drinking water standards and guidelines to assess the health risk posed to residents in the area using roof collected drinking water. Samples of roof collected drinking water have also been tested to validate the estimates.

Minimum standards for the quality of drinking water in New Zealand to protect public health are set out in the Drinking Water Standards for New Zealand 2005 (revised 2018) (DWSNZ). Maximum Allowable Values (MAVs) are specified for concentrations of metal contaminants a (in milligrams per litre) that are considered to *constitute no significant risk to the health of a person who consumes 2 litres of that water a day over their lifetime (usually taken as 70 years)*.

The MAVs and source of the value for all deposited metals monitored by NZ Steel are shown in **Appendix E Section 9.2**.

Suspended metal concentration is evaluated through particulate filter testing (ref) and through modelling of mercury emissions from the MHFs (mercury from coal).

The AAQG and AAAQT include guidelines for ambient concentrations of some metals shown in **Appendix B Table 4** below. Where New Zealand guidance is not available, reference to relevant WHO standards, the OEHHA Acute Reference Exposure Level and the Texas Commission on Environmental Quality Effects Screening Level (TCEQ ESL) where available.

Appendix B Table 4: Ambient air quality standards and guidelines for metals

Metal	Averaging period	Value (µg/m^3)	Source of standard/guideline
Arsenic (inorganic)	Annual average	0.0055	AAQG / AAAQT
Chromium (VI)	Annual average	0.0011	AAQG / AAAQT
Chromium (III)	Annual average	0.11	AAQG / AAAQT
Lead	3-month moving average	0.2	AAQG / AAAQT
Manganese	Annual average	0.15	WHO
Mercury (inorganic)	Annual average	0.33	AAQG / AAAQT
Cadmium	Annual average	0.3	WHO
Nickel	Annual average	0.0025	WHO – 1 in 1,000,000 excess lifetime cancer risk
Vanadium	24-hour average	1	WHO
Zinc	Annual average	2	TCEQ ESL

B4.2 Dioxins and PAHs

Dioxins occur in the environment as a mixture of ‘congeners’ with different toxicity. These cogeners are bio-accumulative and build up in the fatty tissues of animals. Dioxins can cause reproductive and developmental problems, interfere with hormone production and are carcinogenic.

In assessing the effects of exposure to a mixture of dioxins, each congener is assigned a Toxic Equivalence Factor (TEFs) to, which indicates its toxicity relative to 2,3,7,8-TCDD. The concentration of each congener is multiplied by its TEF and these are then added together to give the total dioxin concentration expressed as the Toxic Equivalent[32] (TEQ).

Historically, there have been two TEQ systems - the "International" system referred to as I-TEQ and the WHO regime referred to as WHO-TEQ. The most recent review of toxic equivalence was undertaken by WHO in 2005 and this is now the internationally accepted preferred system. Unlike the older I-TEQ system, the 2005 WHO TEQ system includes 12 dioxin-like poly-chlorinated biphenols (PCBs). Apart from the inclusion of the dioxin-like PCBs, the differences between TEQs calculated using the two systems are relatively small, typically no more than about 10%. In this report, the term "TEQ" is used to refer to the WHO-TEQ.

The resulting WHO-TEQ level for dioxins is compared against the California OEHHA annual guideline of 40 picograms per cubic metre (pg/m³ - equivalent to 4x10-5 µg/m³) as shown in **Appendix B Table 6** below.

Appendix B Table 5: Ambient air quality standards and guidelines for dioxin WHO-TEQ

Substance	Averaging period	Value (µg/m³)	Source of standard/guideline
Dioxins (TEQ)	Annual average	0.00004	OEHHA

Long term exposure to PAHs is considered carcinogenic and can cause cataracts, kidney and liver damage, and jaundice.

Benzo[a]pyrene is considered the most toxic PAH, and an annual average guideline value is set in the AAQG and AAAQT for protection of human health as shown in **Appendix B Table 6**. As with dioxins, individual PAH species are assigned a benzo-a-pyrene TEF to enable comparison with the guideline.

Appendix B Table 6: Ambient air quality standards and guidelines for benzo[a] pyrene equivalents

Averaging period	Value (µg/m³)	Permissible exceedances*	Source of standard/guideline
Annual average	0.0003	-	AAQG / AAAQT

B5 Contaminant discharges from the Finishing Plants

B5.1 Hydrogen chloride and chlorine

HCl and Cl_2 emissions are associated with the Pickle Line process where HCl solution is used to clean metal oxides from steel products prior to surface finishing. The spent HCl from the Pickle Line is regenerated in the Acid Regeneration Plant (ARP) where the scrubber vent contains residual levels of HCl and Cl_2.

HCl is an acidic gas and acts as an irritant in the respiratory tract. Cl_2 gas is moderately water soluble, and it can form hypochlorous acid and HCl as it dissolves into airway surface liquid when contacting mucosal surfaces and airways, causing similar irritation in the respiratory tract.

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[32] The TEQ is the amount of 2,3,7,8-TCDD it would take to equal the combined toxic effect of all the dioxins in the mixture.

There are no New Zealand guideline values for ambient concentrations of hydrogen chloride or chlorine. In the absence of local guidance, the California OEHHA Acute Reference Exposure Level has been used for hydrogen chloride and chlorine gas for short term exposure, and Ontario (Canada) ambient air quality criteria (Ontario AAQC) used for 24-hour average periods, as set out in **Appendix B Table 7** below.

Appendix B Table 7: Ambient air quality standards and guidelines for hydrogen chloride and chlorine gas

Substance	Averaging period	Value (µg/m^3)	Source of standard/guideline
Hydrogen chloride	1-hour average	2100	OEHHA
	24-hour average	20	Ontario AAQC
Chlorine	1-hour average	210	OEHHA
	24-hour average	10	Ontario AAQC

B5.2 Volatile Organic Compounds (VOCs)

VOCs include a variety of aromatic hydrocarbons, some of which have short- and long-term adverse health effects. VOCs may also react with nitrogen oxides emitted mainly from vehicles and industrial activities to form ozone, which in turn helps the formation of fine particulates.

The potential effects of exposure to different VOCs are human health effects, which at low to moderate exposures can cause irritation of the nose and throat, shortness of breath, nausea and dizziness, and at higher concentrations can damage the kidneys and lungs. VOCs also can have nuisance effects from odour. The specific VOCs treated in the incinerator are dependent on the particular paints and coatings used within the Prime and Finish ovens on the Paint Line.

The only New Zealand guideline value for ambient concentrations of VOCs is for benzene. In the absence of local guidance, the OEHHA Acute Reference Exposure Level and the Texas Commission on Environmental Quality Effects Screening Level (TCEQ ESL) have been used for other relevant VOCs as set out in **Appendix B Table 8** below.

Appendix B Table 8: Ambient air quality standards and guidelines for VOCs

Substance	Averaging period	Value (µg/m^3)	Source of standard/guideline
Benzene	Annual average	3.6	AAQG / AAAQT
Toluene	1-hour average	5000	CA OEHHA
	8-hour average	830	
	Annual average	420	
Ethylbenzene	1-hour average	2000	CA OEHHA
Total xylenes	1-hour average	22000	CA OEHHA (technical mixture of m,o,p-xylenes)
	Annual average	700	
Styrene	1-hour average	21000	CA OEHHA
	Annual average	900	
Iso-propylbenzene (cumene)	1-hour average	250	TCEQ ESL

Substance	**Averaging period**	**Value (µg/m^3)**	**Source of standard/guideline**
n-Propylbenzene	1-hour average	2500	TCEQ ESL
1,3-5-Trimethlybenzene	1-hour average	4400	TCEQ ESL (surrogated to trimethylbenzene)
1,2,4-Trimethylbenzene	1-hour average	4400	TCEQ ESL (surrogated to trimethylbenzene)
Sec-Butylbenzene	1-hour average	2740	TCEQ ESL (surrogated to butylbenzene)
Napthalene	1-hour average	9	CA OEHHA
Methyl isobutyl ketone (MIBK)	1-hour average	820	TCEQ ESL
2-Chlorotoluene	1-hour average	260	TCEQ ESL (surrogated to chlorotoluene)
n-Butylbenzene	1-hour average	2740	TCEQ ESL (surrogated to butylbenzene)

Appendix C: Dispersion modelling study – Existing activities

REPORT

Tonkin+Taylor

Air Quality Assessment Appendix C - Dispersion Modelling Study

Glenbrook Steel Mill - Existing Activities

Prepared for
New Zealand Steel
Prepared by
Tonkin & Taylor Ltd
Date
October 2021
Job Number
1010577.0000.v2

Exceptional thinking together
www.tonkintaylor.co.nz

Document Control

Title: Air Quality Assessment Appendix C - Dispersion Modelling Study					
Date	**Version**	**Description**	**Prepared by:**	**Reviewed by:**	**Authorised by:**
22/04/2021	1	Submission report	S Lo	R Turnwald	J Simpson
18/10/2021	2	Updated report post lodgement	S Lo	R Turnwald	J Simpson

Distribution:

New Zealand Steel	1 electronic copy
Tonkin & Taylor Ltd (FILE)	1 electronic copy

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Appendix D : Q-Q plots of modelled and measured concentrations

Glossary

Term used in this report	Definition
Air dispersion modelling	The mathematical simulation of how air contaminants emitted from a source disperse in the ambient atmosphere.
BPIP-PRIME model	The Building Profile Input Programme (BPIP) Plume Rise Model Enhancements (PRIME) model is used to simulate building downwash impacts.
Building downwash	The influence of building (or structure) configuration in changing the trajectory of an emitted plume from a stack/vent, bringing the plume to the ground more rapidly than where there is an absence of buildings.
CALMET model	The CALPUFF meteorological pre-processor. It is a diagnostic, meteorological model which provides a construction of 3-dimensional wind and temperature fields, and a 2-dimensional determination of micro meteorological variables (such as mixing height) needed to carry out dispersion modelling.
CALPUFF model	The California Puff (CALPUFF) model is an advanced non-steady state, Lagrangian puff air dispersion model.
Ground level concentration (GLCs)	The concentration in air of a pollutant to which a human being is normally exposed, typically taken to be between the ground and a height of some 2 metres above ground.
Operational Area	Area within the wider NZ Steel landholdings that is used for Steel Mill operations. This area does not include areas that are farmed, or the area currently used as a landfill for waste materials generated at the Site.
Point source	A point source is an identifiable stationary source of air pollution that emits air contaminants through a stack or vent.
Site	The New Zealand Steel landholding
Stack (may also be referred to as vent)	A hollow column or opening used to discharge gaseous and/or particulate matter emissions to atmosphere.
WRF model	The Weather Research and Forecast (WRF) model is a prognostic mesoscale numerical weather prediction model.

1 Introduction

New Zealand Steel Limited (NZ Steel) is the New Zealand-based subsidiary of Australasian company Bluescope Steel, producing steel slab, billets and a variety of processed steel products at the Steel Mill at Mission Bush Road, Glenbrook. NZ Steel is seeking replacement consents for the continuation of the discharges from the Site authorised by both the Main Air Permit (DIS80296529) and the Commercial Iron Plating Air Permit (DIS60363772).

This report, which forms Appendix C to the Air Quality Assessment (AQA), describes the methodology and results of the dispersion modelling study of discharges to air from the main stack emission sources at the site. The results of the dispersion modelling study are used in the AQA to inform the technical assessment of air quality effects.

Air dispersion modelling is the mathematical simulation of how air contaminants emitted from a source disperse in the ambient atmosphere. The outputs from the dispersion model are the predicted ground level concentrations (GLC) of air contaminants from the modelled sources, which can be calculated for different averaging periods to align with the relevant assessment criteria.

Air quality monitoring has been undertaken for a range of contaminants in the vicinity of the site (for over a decade for certain contaminants/locations) as summarised in Appendix E to the AQA. This monitoring data provides the most reliable real-world basis for assessing the effects of the discharges to air from the Site. Given this context, the main objectives for the dispersion modelling study are described in the following table.

Table 1.1: Objectives of dispersion modelling study

Objective	Section of this report
Evaluate the performance of the dispersion model by comparing the model predictions with measured data.	Section 5
Investigate whether air quality measured at 64 Glenbrook Beach Rd (Site 20) is representative of worst-case impacts at sensitive receptors and provide a basis for inferring likely air concentrations at other (un-monitored) locations if needed.	Section 6
Understand the relative impacts of different stack emission sources to measured air quality at 64 Glenbrook Beach Rd (Site 20).	Section 7
For contaminants where air quality monitoring data is not available, to provide a basis for assessing their potential effects by comparing model predictions (and background concentrations where relevant) against assessment criteria.	Section 8

2 Dispersion modelling approach

2.1 Introduction

Dispersion modelling has been undertaken using the most recent (non-beta) version of the CALPUFF air dispersion model (version 7.2.1). CALPUFF is an advanced dispersion model that is widely used in New Zealand, especially in areas of complex terrain and coastal situations.

The Steel Mill is an integrated steel-making facility and comprises a number of different manufacturing processes. As such, there are a relatively large number of stack emission sources of varying scale in terms of both the nature and quantum of emissions to air and their physical parameters. The dispersion modelling study focuses on the major sources that account for the vast majority of stack emissions. Some minor sources have been included where reliable emission data was available. However, it is not practical or necessary to include every stack and vent in the dispersion model. The omission of some minor sources does not alter the conclusions of the assessment.[1]

Two modelling scenarios have been considered:

- Average emission rates based on stack testing data; and
- Maximum emission rates based on stack testing data. If any maximum permitted emission rate under the current Main Air Permit is marginally higher than the corresponding maximum measured rate, then the former has been used in lieu of the latter as a conservative assumption.

The dispersion modelling has not been used to evaluate the appropriateness of the existing consent limits, as it would be unrealistic to model all sources emitting concurrently at the maximum allowable rate. The appropriateness of the existing consent limits has been evaluated in the AQA based on ambient air quality monitoring data.

In accordance with the *Good Practice Guide for Atmospheric Dispersion Modelling*[2] (GPG Modelling), the 99.9th percentile predicted 1-hour results are reported as the maximum GLC and the maximum (100th percentile) for other averaging periods.

2.2 Stack emission sources and contaminants

The stack emission sources and contaminants considered in the dispersion modelling study are summarised in **Table 2.1**. The location of the stacks is shown in **Figure 2.4**.

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[1] The source contribution to GLCs have been assessed in Section 7. The MHF/ kiln stack emissions contribute the majority of the modelled GLCs of particulate matter and combustion products, and hence omitting minor sources is unlikely to materially alter the predicted GLCs or the overall findings of the dispersion modelling assessment.

[2] Good Practice Guide for Atmospheric Dispersion Modelling. (2004). Ministry for the Environment. Publication number ME 522.

Table 2.1: Modelled stack sources and contaminants

Stack	Stack ID	Particulate matter	Oxides of nitrogen	Carbon monoxide	Sulphur dioxide	Chlorine/ Hydrochloric acid	Volatile Organic Compounds	Mercury
MHF stacks	IP1-IP4	✓	✓		✓			✓
Kilns stacks	IP23-IP26	✓	✓	✓	✓			
Metalside Baghouse	IP33-IP34	✓						
Slagside Baghouse	IP32	✓						
Steel Plant Baghouse	SP4A-SP4F	✓						
KOBM Flarestack	SP1	✓	✓	✓	✓			
Slab Reheat Furnace	HSM1	✓	✓					
Pipe Mill Blowdown Scrubber[a]	PM3	✓						
Pipe Mill Galvanising Baghouse[a]	PM2	✓						
Acid Regeneration Plant	CSM1	✓						
Primary Concentrate Drier Baghouse	SR1	✓						
Paint Line Oven Incinerators	CCL3/CCL4		✓				✓	
Pickle Line Scrubber	CSM3					✓		
Acid Regeneration Plant (ARP)	CSM1					✓		

Notes:

[a] The Pipe Mill was fully decommissioned in September 2020, but the two stacks (PM2 and PM3) have been included in the dispersion model for completeness as they are a (minor) contributor to historical measured particulate matter concentrations.

2.3 Stack parameters

The physical parameters of the stack discharges are summarised in **Table 2.2**.

The representative exit temperatures and exit velocities have been based on stack testing data. Stack heights and diameters are based on site drawings and information from NZ Steel.

A modified approach has been necessary to simulate the emissions from the Steel Plant Baghouse vents and the KOBM Flarestack, which are not conventional stack sources, as follows:

- The Steel Plant Baghouse does not have a stack. Instead, emissions are vented from six square vents (approximately 2.15 m x 2.15 m, equivalent to cross-sectional area of 4.6225 m^2) fitted with louvres that point at a 45° angle downwards. An effective exit diameter of 2.43 m has been calculated based on the cross-sectional area of the square vent. The louvre configuration can be treated as a horizontal discharge and has been assigned zero vertical momentum in the model. In addition, stack tip downwash option was also considered not to be applicable[3].
- Flare sources can be treated in a similar way as point sources, except that there are buoyancy flux adjustments associated with radiative heat and heat losses. The thermal effects of the flame with its lift and expansion of the plume require an effective stack height and effective stack diameter to be calculated. The KOBM Flarestack has been modelled as a pseudo point source using the following settings in CALPUFF:
  - Assumed model default flaring temperature of 1000 °C and default exit velocity of 20 m/s from model-recommended settings.
  - Adjusted for effective stack height and effective exit diameter by taking into account heat release rate from the flame (based on the composition of the flare input gas) and the buoyancy flux from the flare. The plume rise is added to the physical flare stack height for an effective stack height of 86.4 m, and the adjusted exit diameter is 3.7 m.[4]

Table 2.2: Summary of stack discharge parameters

Stack	Stack ID	Stack height (m)	Exit diameter (m)	Exit temperature (°C)	Exit velocity (m/s)
MHF stacks	IP1-IP4	60	2.3	70	10.0
Kiln stacks	IP23-IP26	60.25	1.7	60	13.9
Metalside Baghouses	IP33-IP34	22.9	1.6	41	14.8
Slagside Baghouse	IP32	12	1.8	36	8.9
Steel Plant Baghouse	SP4A-SP4F	21.0 (vent height)	2.43[c]	58	22.3
KOBM Flarestack	SP1	69[a] 86.4[b]	1.1[c] 3.7[d]	65[e] 1000[f]	18.2[e] 20[f]
Slab Reheat Furnace	HSM1	60	3.0	183	3.6
Pipe Mill Blowdown Scrubber	PM3	13.72	0.8	43	4.6

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[3] Stack tip downwash, which reduces the initial plume rise, can occur when the stack exit velocity is small compared to the wind speed at stack height. This effect is not considered applicable to the horizontal discharge from the Steel Plant baghouse.

[4] CALPUFF internally calculates the effective stack height and exit diameter based on composition of flare input gas.

Stack	**Stack ID**	**Stack height (m)**	**Exit diameter (m)**	**Exit temperature (°C)**	**Exit velocity (m/s)**
Pipe Mill Galvanising Baghouse	PM2	19.4	0.9	39	21.7
Acid Regeneration Plant	CSM1	25.5	0.7	77	5.8
Primary Concentrate Drier baghouse	SR1	17	0.8	72	3.6
Pickle Line Scrubber	CSM3	25.5	1.1	35	7.8
Paint Line Prime Oven Incinerator stack	CCL3	8[g]	0.78	343	15.1
Paint Line Finish Oven Incinerator stack	CCL4	8[g]	0.78	353	19.3

Notes:

[a] Physical stack height.

[b] Effective stack height, taking into account plume rise from flaring.

[c] Physical exit diameter.

[d] Effective exit diameter.

[e] Measured during non-flaring conditions, upstream of the flare.

[f] CALPUFF default assumption/calculation.

[8] Actual stack height is 3 m but the effective stack height is set at 8 m above ground level as the stack sits on top of a 5 m building.

2.4 Modelled receptor locations

The CALPUFF model was configured to predict GLCs for the following receptor types (illustrated in **Figure 2.1** and **Figure 2.2**):

- Site boundary receptors – these enable the worst case GLC beyond the site boundary to be predicted, which is important for contaminants that are assessed against a 1-hour average assessment criterion.
- Discrete sensitive receptors – these locations represent a selection of nearby sensitive receptors (principally dwellings). This selection is not intended to be exhaustive. Concentrations at other sensitive locations not explicitly included in the model can be estimated using contour plots derived from nested receptor grids. The modelled discrete receptors are shown in **Figure 2.2** and further information is provided in **Appendix A**.
- Nested receptor grids - five grids of evenly spaced receptors at increasing resolution are set-up within the model (2.3). The nested receptor grid approach provides a high level of resolution close to the site where the magnitude and spatial variation in impacts is typically greatest, with decreasing resolution in grid spacing further afield.

Table 2.3: Nested receptor grids

Distance from centre (m)	**Receptor spacing (m)**
2000	100
3000	200
4000	400
5000	800
8000	1600

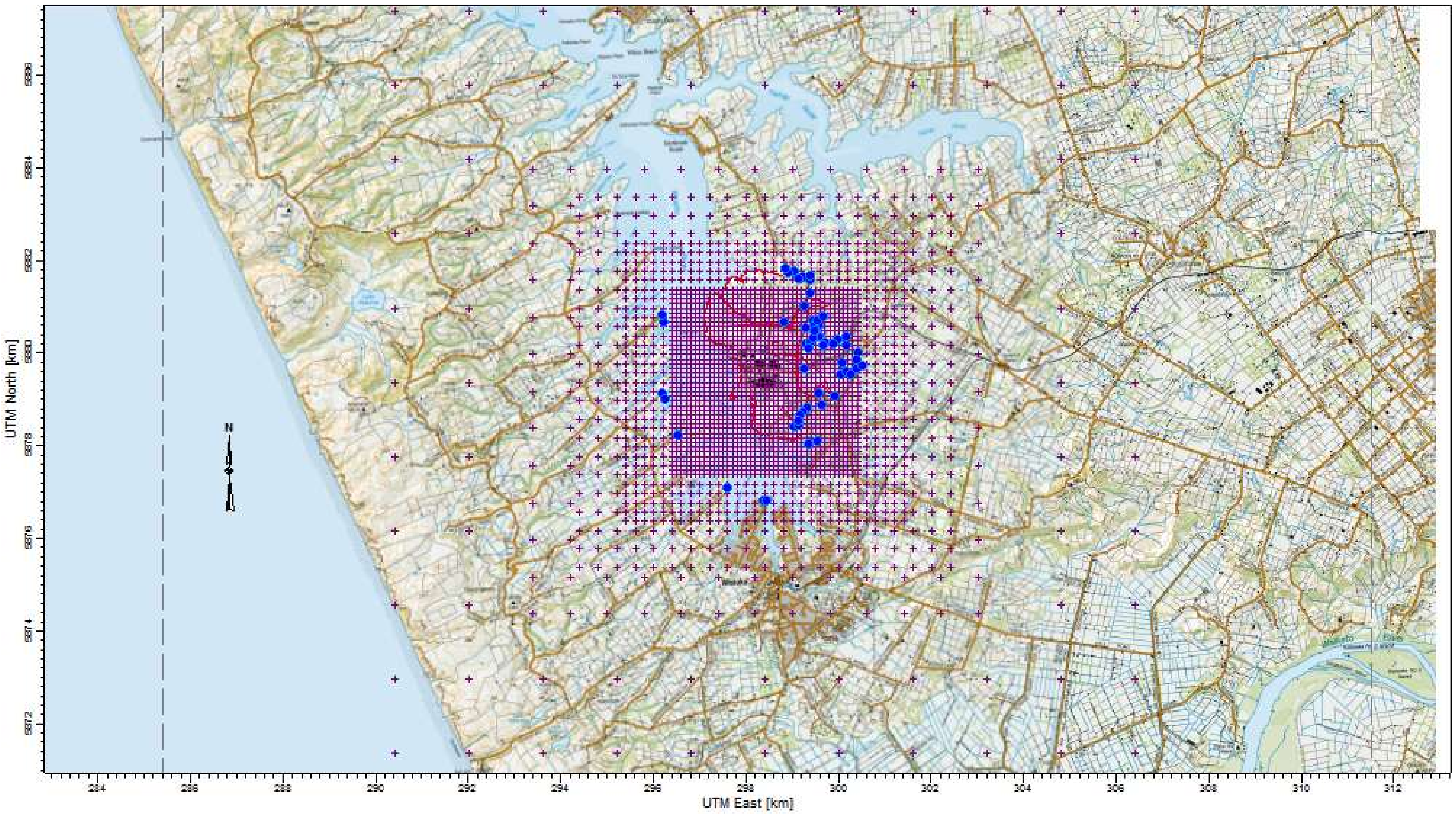

Figure 2.1: Location of modelled discrete receptors/monitoring locations (blue circles) and nested receptor grids (small purple crosses).

Figure 2.2: Modelled discrete receptors (denoted as R1 etc) and monitoring locations

2.5 Building downwash

Buildings and structures can affect the dispersion of a plume from a stack under certain circumstances due to enhanced turbulence, modified wind speeds and modified plume trajectories. This effect, known as ‘building downwash’, may cause a plume to be brought down to the ground rapidly and result in higher GLC than would otherwise have occurred without these obstacles. **Figure 2.4** illustrates the buildings that were included for downwash effects assessment purposes in the dispersion model.

To account for building downwash effects, the BPIP-PRIME algorithm (version 04274, which is the latest version approved for regulatory use) is used to simulate this effect for modelling in CALPUFF. The role of the BPIP algorithm is to try and find the building shape and position that places the stack of concern into the correct Snyder and Lawson database flow region (i.e. the database used to develop the PRIME downwash algorithm[5]). The associated PRIME algorithm is the recommended option for incorporation of building downwash in dispersion modelling in the GPG Modelling.

The PRIME equations predict plume dispersion and plume rise due to the presence of a nearby structure. These equations are based on calculations of the building wake/cavity length and streamline slope which in turn are based on the input building height, width, length and position relative to the stack. Coupled with a numerical plume rise model, PRIME determines the change in plume centreline location with downwind distance.

The BPIP-PRIME model has some known limitations[5,6,7] that may affect prediction of GLCs:

- The building wake algorithms within PRIME were developed based on a limited set of building shapes and configuration, but the model is applied for all shapes and building configurations based on building dimension inputs determined by BPIP. For buildings that have a large aspect ratio (such as an elongated building where the length is much larger than the height and width) and large oblique wind angles, PRIME substitutes a building that can have a large footprint in relation to the actual building. This in turn may have an unrealistically large impact on the streamlines and wake parameterisations. This limitation is not relevant for this study, as the aspect ratio of the buildings that may influence the main stack sources (and are included in the model) are within the recommended range.
- Turbulence intensity used by PRIME to calculate the horizontal and vertical dispersion coefficients increases unrealistically by a constant factor from the ground to the height of the wake boundary, which will be significantly larger for long and narrow buildings. A related issue is the depth of the high turbulence region in PRIME which is sometimes exaggerated and extends too far above the building height (see **Figure 2.3**). In modelling assessments, this can exaggerate building downwash in higher concentrations in the near-wake for shorter stacks. A much higher stack would have theoretically been needed to clear that turbulent zone that will force the plume down to the ground faster than in reality. Again, this limitation is unlikely to

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[5] Petersen, R.L and Beyer-Lout, A. AERMOD Building Downwash Theoretical Limitations and Possible Solutions, Paper #2012-A-387-AWMA, 105th Annual Conference and Exhibition of the Air & Waste Management Association, San Antonio, Texas, USA, June 2012 (https://www.researchgate.net/publication/286410368_AERMOD_BUILDING_DOWNWASH_THEORETICAL_LIMITATIONS_AND_POSSIBLE_SOLUTIONS)

[6] Petersen, R.L., Guerra, S.A and Bova A.S. Critical Review of the Building Downwash Algorithms in AERMOD, Journal of the Air & Waste Management Association, 2017, Vol. 67, No.8, 826-835. (https://www.tandfonline.com/doi/pdf/10.1080/10962247.2017.1279088)

[7] Monbureau, E.M., Heist, D.K., Perry, S.G., Brouwer, L.H., Foroutan, H. and Tang, W. Enhancements to AERMOD’s Building Downwash Algorithms based on Wind-Tunnel and Embedded-LES Modeling, Atmos Environment, Volume 179, April 2018, 321-330.

be relevant for this study, as the aspect ratio of the buildings that may influence the main stack sources (and are included in the model) are within the recommended range.

- The formulation of the BPIP pre-processor creates an artificially large building when wind blows at an angle, contributing to an exaggerated wake height (which is used to calculate downwash) at the lee (i.e. downwind) edge of the building and overstated turbulence enhancement. With a dominant south-westerly wind direction at the Site (Section 3.2.1.1), the oblique orientation of the buildings (as shown in **Figure 2.4**), especially the ones near the largest emission sources (Kilns/MHFs), in relation to the dominant wind direction is likely to result in elevated turbulence that is not realistic.
- For stacks located on or near several buildings of different shapes and heights, BPIP's formulations merge buildings and ultimately calculate one effective width, length, height and position to represent all buildings for each of 36 wind direction. The PRIME algorithm is not able to adequately replicate these complex building environments. A review of **Figure 2.4** shows that the modelled buildings (with varying heights) tend to cluster together, and hence complex building environments are expected to influence plume trajectories.

The latter two issues with BPIP-PRIME discussed above are relevant to this modelling study and may result in conservatively high model predictions under certain wind directions. This is discussed further in Section 5.2, which compares the model predictions with measured concentrations of sulphur dioxide at two locations in different downwind directions (64 Glenbrook Beach Rd (Site 20) and Glenbrook School (Site 17)).

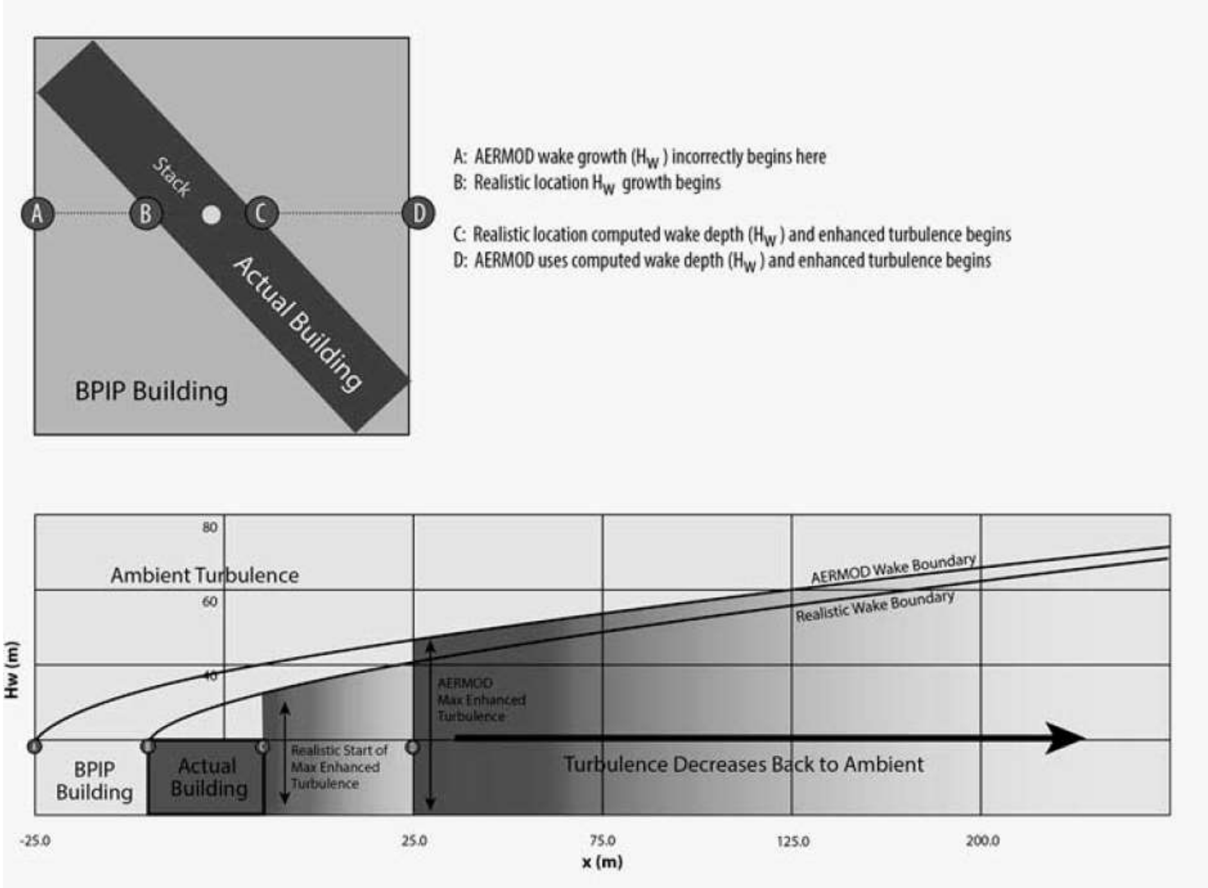

Figure 2.3: Top picture is a plan view of an actual building (dark grey) and the corresponding BPIP-generated building (light grey) when wind is flowing at an angle to the building. The bottom picture is the corresponding elevation view showing the resulting AERMOD/BPIP and realistic wake heights and enhanced turbulence zone[8]*.*

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[8] Sourced from Petersen, R.L., Guerra, S.A and Bova A.S. Critical Review of the Building Downwash Algorithms in AERMOD, Journal of the Air & Waste Management Association, 2017, Vol. 67, No.8, 826-835 (Figure 5 within this paper).

Figure 2.4: Stacks (green crosses) and buildings (outlined in blue line) included in the model

3 Terrain and meteorology

3.1 Terrain

Terrain data is used both in the development of the modelling meteorological dataset (as it influences windflows) and in the dispersion modelling (as pollutant plumes interact with terrain).

The Site is bordered to the west by the Waiuku Estuary, which is a long and relatively narrow tidal arm of the Manukau Harbour. To the west of the Waiuku Estuary, lies the Awhitu Peninsula comprising ancient sand dunes which form the barrier between the Manukau Harbour and the Tasman Sea. This is an area of moderate local relief. To the east of the Site, the Franklin lowlands stretch eastwards all the way to Papakura. The Franklin lowlands are generally rolling to relatively flat but there are some areas of local relief, particularly associated with water courses.

Figure 3.1 illustrates the terrain surrounding the Site (expressed in metres above mean sea level (ASL). For context, the two red boxes in **Figure 3.1** denote a 5 km × 5 km and a 26 km × 26 km area approximately centred on the Site.

Due to the estuarial system of the Waiuku Estuary, the terrain to the west of the Site is relatively flat and is only a few metres above mean sea level. To the east, the terrain is gently sloping upwards, gradually increasing from approximately 35 m ASL at the centre of the site to approximately 60 m ASL at a distance of about 3 km away.

An exploration of the wider terrain context (26 km × 26 km) shows that the highest terrain - of greater than 100 m elevation - occurs near to the coastline westwards on the Awhitu Peninsula (approximate distance of 9.7 km) and near to Pukekohe township towards the east (over 15 km away).

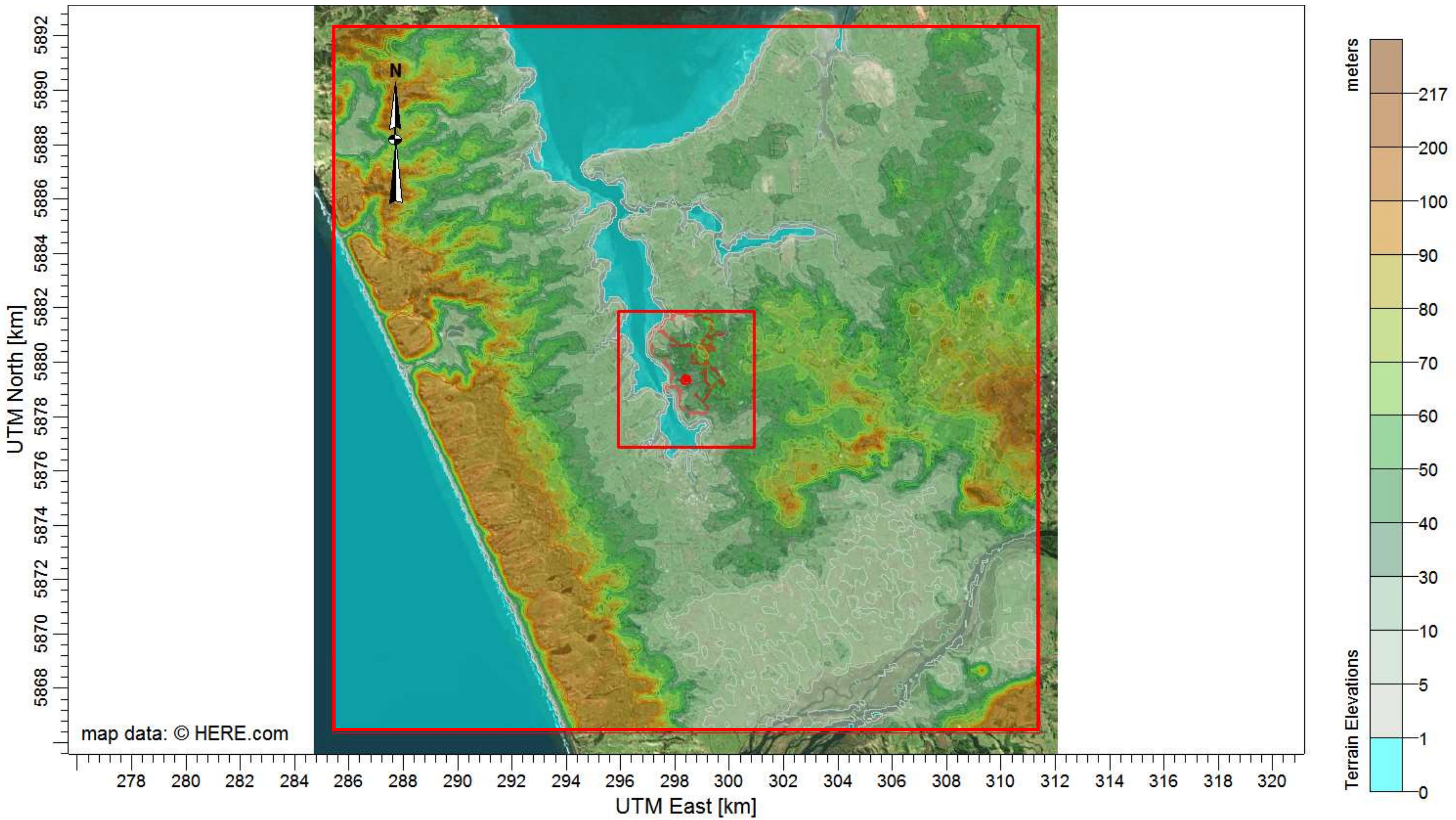


Figure 3.1: Surrounding terrain (red dot denotes approximate centre of NZ Steel operational area; small and big red boxes denote 5 km × 5 km and 26 km × 26 km, respectively, surrounding NZ Steel)

3.2 Meteorology

3.2.1 Surface observational data

3.2.1.1 On-site meteorological monitoring

There has been a weather station installed at the Site for many years. However, closer inspection of the data found that the performance of the weather station had deteriorated, and the resulting wind speed/direction data was not reliable.

Meteorological data is collected concurrently with the air quality monitoring data (i.e. at a number of locations around the site) However the wind mast height on these stations is 4 m above ground level (AGL) compared to the recommended height of 10 m for accurate definition of wind speeds. As such, it was concluded that historical meteorological data was not able to be used for the purposes of dispersion modelling.

In June 2019, a new meteorological station with a 10 m AGL wind mast height was installed at the Training Centre. The annual wind rose for 2020 for the 10 m mast at the Training Centre is presented in **Figure 3.2**. This wind rose shows that there are generally high occurrences of wind blowing from the south-southwestern to western directional arc, as well as from the north-northeastern to northeastern directional arc. Overall, southwesterlies form the most dominant local wind direction. This wind pattern is consistent with the location of the Site where coastal winds from the Tasman Sea generally face no significant impediment as they travel inland, due to the lack of mountain masses between Glenbrook and the coastline which would otherwise provide a wind sheltering effect (**Figure 3.3**). This dominant local wind direction is in line with the dominant southwesterly airflows over the wider Auckland region.

Average local wind speed is generally around 3.7 m/s, with calm winds (<0.5 m/s) of about 2.5%. Wind speed/direction data collected from the Training Centre weather station has been used to validate the meteorological modelling output (see Section 3.2.3).

3.2.1.2 Pukekohe electronic weather station

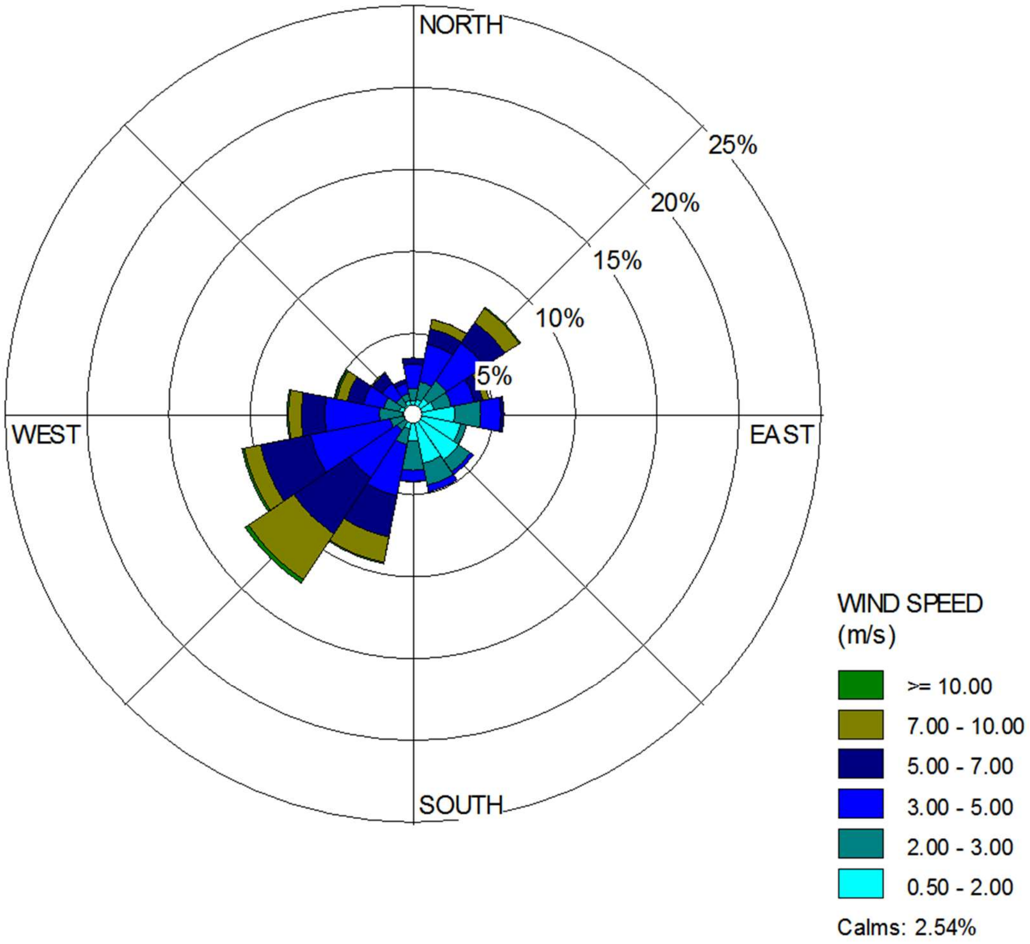
The National Institute of Water and Atmospheric Research (NIWA) operates an electronic weather station (EWS) at Pukekohe, approximately 11 km to the east of the Site.

The 10-year (2010 to 2019) trend of the Pukekohe EWS wind patterns are provided in **Figure 3.4**. Over this 10-year period, there is no appreciable change in annual average wind speed, ranging from 2.4 to 2.7 m/s with an average of 2.5 m/s over this timeframe. This average wind speed is broadly similar to the 2020 average wind onsite at the Training Centre (3.7 m/s); the lower wind speed at Pukekohe is likely a reflection of the distance further inland compared to the Training Centre. The annual calm incidences are variable as measured at Pukekohe EWS, ranging from 2% to 15% with an average of 4.8% over the 10-year period, which is broadly similar to the calm incidences at the Training Centre (2.5%).

Wind speed/direction data from the Pukekohe EWS has also been used to validate the meteorological modelling output (see Section 3.2.3).

3.2.1.3 Changes in weather patterns due to climate change

Future climate change projections (at 2040 and at 2090)[9] broadly predict minimal changes in western wind speed over the winter period in the North Island[10], and no change to the prevailing wind direction across New Zealand (west-southwest). Overall, current dispersion patterns of emissions upon exiting NZ Steel stacks are expected to remain broadly similar in the foreseeable future.



Calms – 2.54%

Average wind speed – 3.71 m/s

Figure 3.2: Onsite wind rose (January to December 2020) at the NZ Steel Training Centre (Site 3) monitoring site (Note: data reported for a 10 m mast)

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[9] Climate change effects and impacts assessment: A guidance manual for local government in New Zealand, Publication number ME 870, May 2008 (https://www.mfe.govt.nz/publications/climate-change/climate-change-effects-and-impacts-assessment-guidance-manual-local-52)

[10] Projected changes in the north-south wind component are less clear. There is a tendency for more northerly flow in future, but the changes are not large enough to alter the prevailing wind direction from the west-southwest.

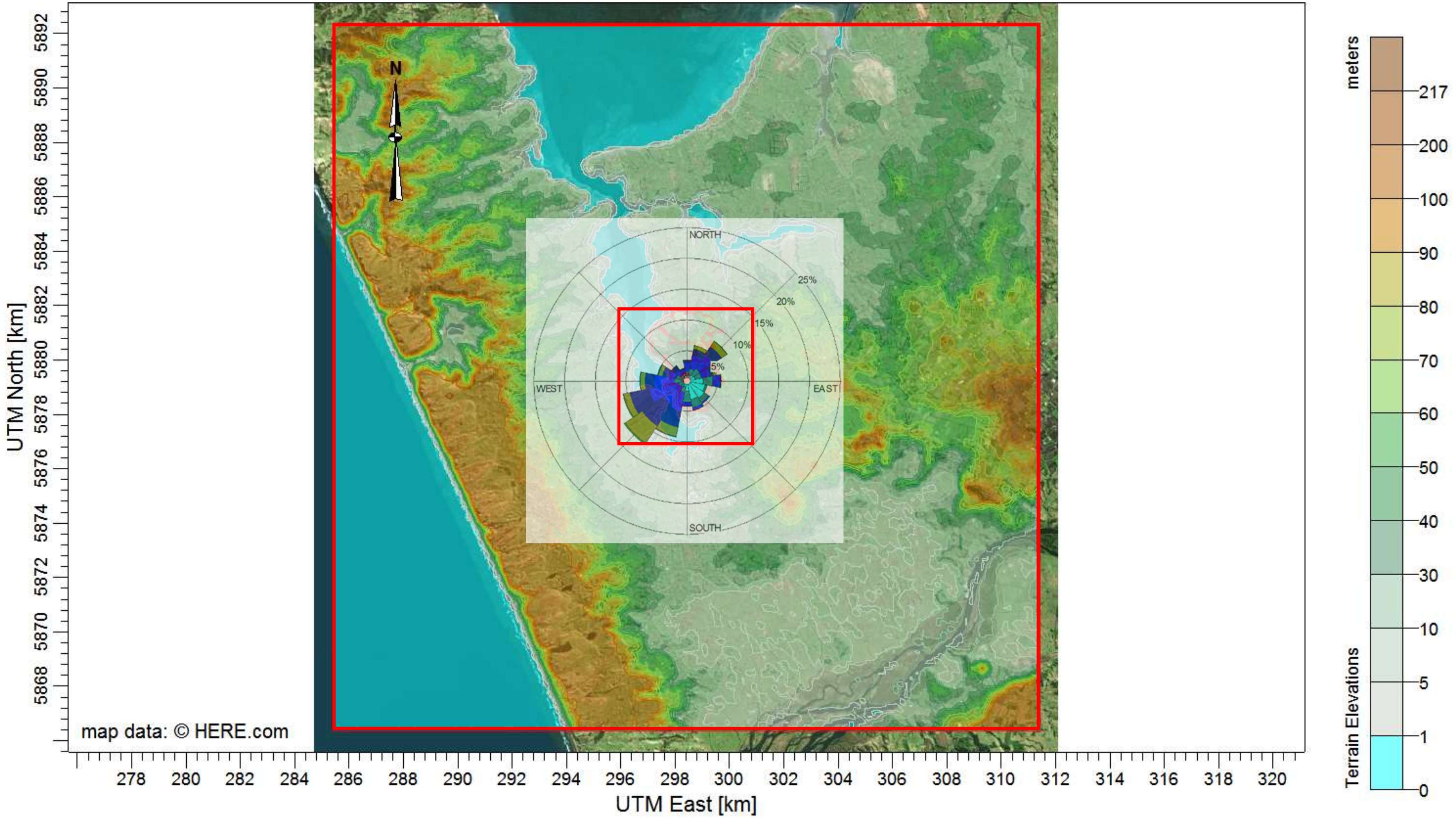


Figure 3.3: On-site 2020 wind rose at the Training Centre overlaid on terrain map (small and big red boxes denote 5 km × 5 km and 26 km × 26 km, respectively, surrounding NZ Steel)

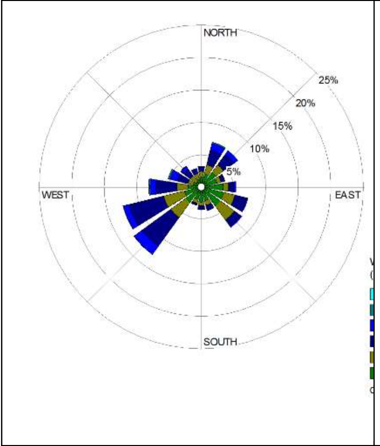
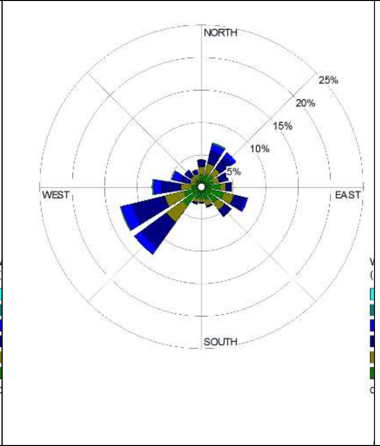
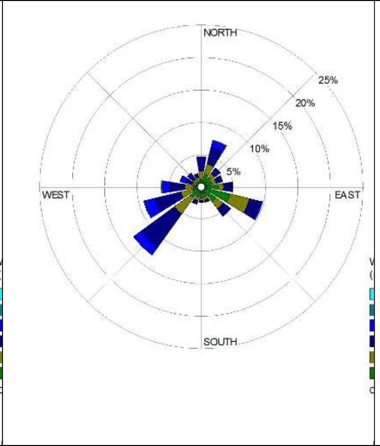
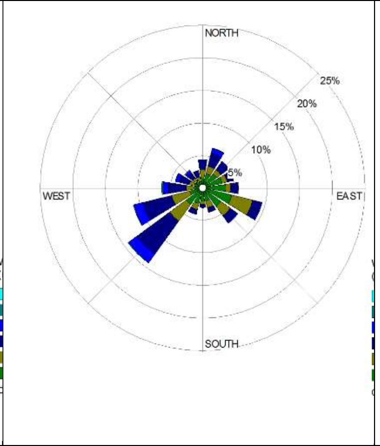
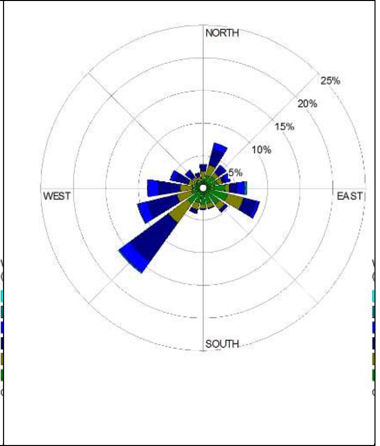
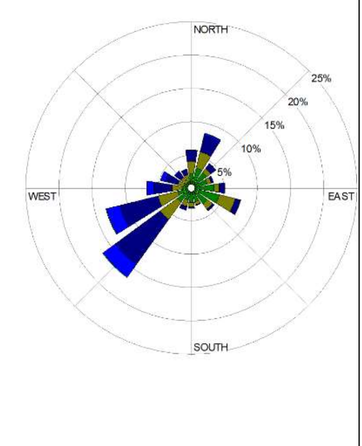
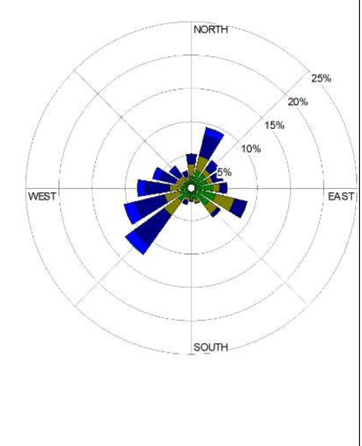
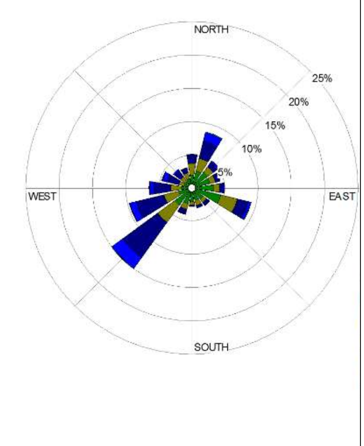
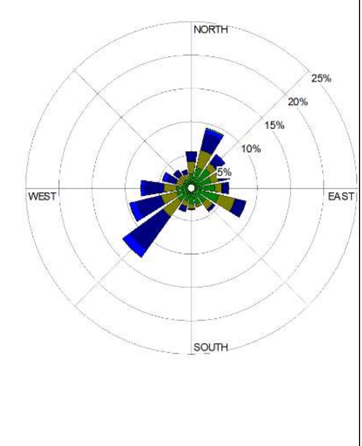
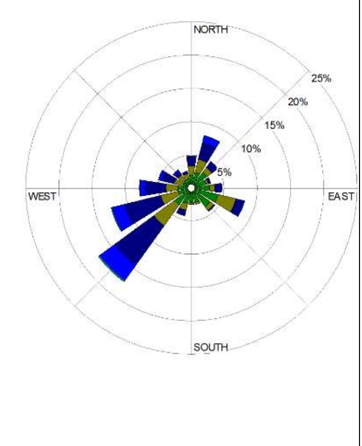
				
2010 Calms – 1.82% Average wind speed – 2.64 m/s	2011 Calms – 6.52% Average wind speed – 2.54 m/s	2012 Calms – 15.34% Average wind speed – 2.36 m/s	2013 Calms – 3.77% Average wind speed – 2.48 m/s	2014 Calms – 2.18% Average wind speed – 2.71 m/s
				
2015 Calms – 3.17% Average wind speed – 2.54 m/s	2016 Calms – 4.06% Average wind speed – 2.60 m/s	2017 Calms – 6.07% Average wind speed – 2.44 m/s	2018 Calms – 2.34% Average wind speed – 2.41 m/s	2019 Calms – 2.81% Average wind speed – 2.54 m/s

Figure 3.4: 10-year trend of Pukekohe EWS wind patterns (2010 to 2019 annual wind roses) [Note: Pukekohe EWS mast height is at 10 m]

3.2.2 Meteorological modelling (CALMET)

Meteorological information is one of the key inputs for dispersion modelling. Meteorological inputs to the CALPUFF model are generated using the CALMET model (version 6.5.0). The CALMET model generates hourly, three-dimensional fields of meteorological parameters that are used by CALPUFF.

The CALMET dataset was developed using the following inputs:

- Three meteorological years were selected (2015 to 2017). The justification for selecting these years of data is provided in **Appendix B1.1**.
- The prognostic meteorological model, Weather Research and Forecasting Model (WRF) was used to generate upper air and surface data. The WRF model outputs were purchased from Lakes Environmental Inc. (Canada), with a resolution of 1 km × 1 km and a domain of 50 km × 50 km centred on the Site.
- The CALMET model covers an area that is 26 km x 26 km centred at the Site and extends up from the surface to the atmospheric boundary layer. It has been run at horizontal grid resolution of 200 m, which is considered sufficiently refined to capture variations in the meteorology caused by terrain and land use.
- Land use and terrain were incorporated into the CALMET model.
- Radius of influence of terrain features (TERRAD) = 3 km
- Thirteen cell face heights = 0, 20, 50, 100, 200, 400, 600, 800, 1000, 1500, 2000, 2500, 3000 m

Date from surface weather stations were not used as inputs to the CALMET model for the following reasons:

- The nearest automatic/electronic weather station is the Pukekohe EWS, which is located over 10 km away from the Site in the eastern (inland) direction. At this relatively large distance, it is considered that the Pukekohe dataset should not be used to influence the definition of the modelled wind field. Instead, Pukekohe EWS data was used for to verify the performance of the CALMET model for far-field winds[11].
- The observed wind data at the Training Centre weather station (at 10 m standard wind mast height) do not cover the calendar years of 2015 to 2017 (as described at Section 3.2.1). Instead, the Training Centre 2020 data has been used for model verification of near-field winds.

3.2.3 Validation of CALMET-generated meteorological dataset

The performance of the CALMET meteorological model was validated using the following:

- Far-field wind field: Extraction of a CALMET-generated wind rose at the location of Pukekohe EWS and comparing it against the wind rose from observed wind data at the same location (**Figure 3.5**); and
- Near-field wind field: Extraction of a CALMET-generated wind rose at the location of the NZ Steel Training Centre (June 2019 – Jan 2021) and comparing it against the wind rose from observed wind data at the same location (**Figure 3.6***)*.

Accounting for a degree of variability between modelling and monitoring (as well as the different meteorological year for the NZ Steel Training Centre data), the modelled and observed wind roses

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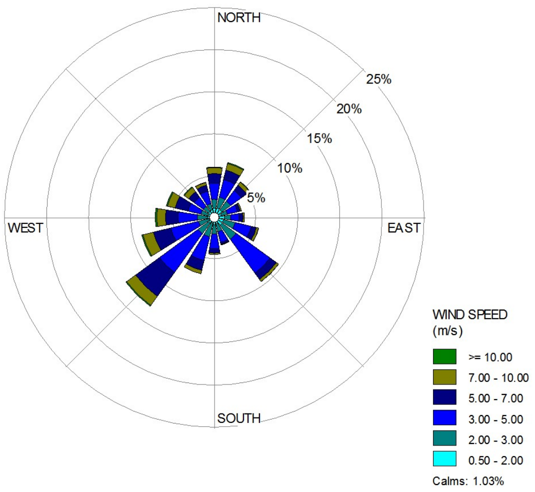
[11] Typically, data that is used for model verification is not simultaneously used as model input to avoid bias in the comparison.

are in good general agreement with each other. The predominant wind directions (between southwesterlies and westerlies) are generally well replicated. The modelled and observed calm hours/average wind speeds are similarly in good general agreement with each other.

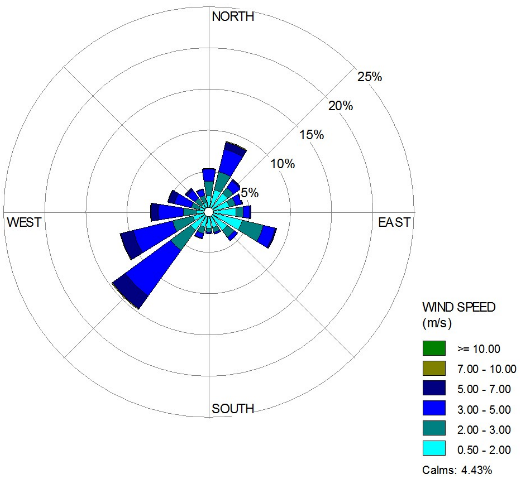
Overall, it is considered that the CALMET meteorological dataset is representative of real-world conditions at the Site.



CALMET-predicted wind rose at Pukekohe EWS location (2015-2017)

Calms - 1.03%

Average wind speed – 4.0 m/s

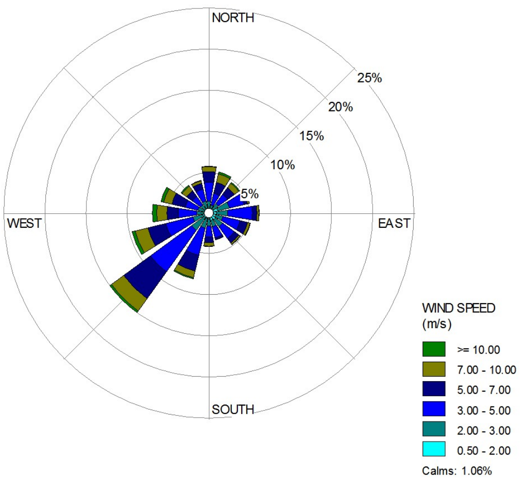


Observed wind at Pukekohe EWS (2015-2017)

Calms – 4.43%

Average wind speed – 2.5 m/s

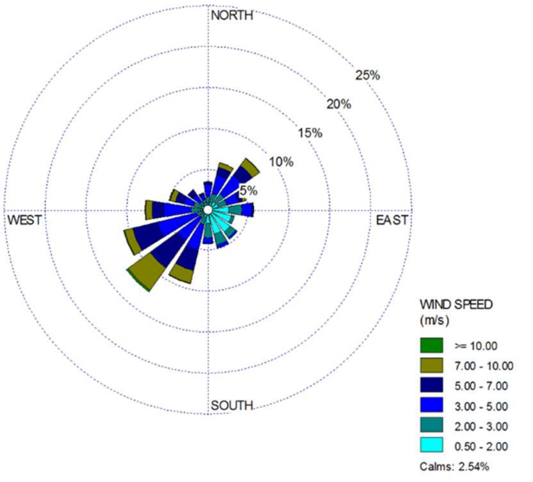
Figure 3.5: CALMET predicted wind rose (2015 – 2017) at Pukekohe EWS versus monitored wind rose at the same location (2015 – 2017)



CALMET-predicted wind rose at the NZ Steel Training Centre location (2015-2017)

Calms - 1.06%

Average wind speed – 4.4 m/s



Observed wind at NZ Steel Training Centre (2020)

Calms – 2.54%

Average wind speed – 3.71 m/s

Figure 3.6: CALMET predicted wind rose (2015 – 2017) at the NZ Steel Training Centre versus monitored wind rose at the same location (2020)

4 Stack emission rates used in dispersion modelling

4.1 Introduction

The derivation of stack emission rates for dispersion modelling is set out in **Appendix C**. The general approach used is as follows:

- Where available, stack testing data up to June 2020 form the basis of the derivation of the stack emission rates (average and maximum). This approach pertains to most of the contaminants assessed in the modelling.
- Average emission rates have been derived using average emission concentrations and volumetric flowrates from **Table 2.2**.
- Maximum emission rates have been derived using maximum emission concentrations and volumetric flowrates from **Table 2.2**.
- Where stack testing data is not available, alternative means such as mass balance and emission factors have been used to derive stack emission rates. This pertains to derivation of mercury emission rates (using mass balance) and KOBM flare-related emissions (using emission factors).
- Maximum permitted emission rates, where applicable, have been derived using existing consent limits (where they exist) and volumetric flowrates from **Table 2.2**.

For the purposes of dispersion modelling, all stacks have been conservatively assumed to simultaneously emit at a constant rate throughout the year.

4.2 Particulate matter

The historical stack testing of particulate matter for all stacks has primarily focused on total suspended particulates (TSP) as this is required by the Main Air Permit. It is not possible to undertake size-speciated stack testing for PM_{10} and $PM_{2.5}$ using normal stack testing equipment in stacks that are saturated with water vapour, such as the MHFs, Kilns and KOBM Primary off-gas system (which discharges to the KOBM Flare stack). This is because the sampling train uses a cascade impactor, which consists of a series of nozzles and impaction plates that separate particles into different size fractions. If the impaction plates become wet, particles can adhere to them, which affects the accuracy of the test method.

PM_{10} and $PM_{2.5}$ testing has only been undertaken for stacks where particulate matter speciation is possible (i.e. Metalside baghouses, Slagside baghouse and Steel Plant baghouse).

As such, where TSP, PM_{10} and $PM_{2.5}$ have not been individually measured for any given stack, the following assumptions have been applied in a stepped order to derive PM_{10} and $PM_{2.5}$ emission rates:

- Step 1: Wherever the emission rates of TSP, PM_{10} and $PM_{2.5}$ have been tested at any given stack, they have been taken into consideration, with the provision that the emission rates of $PM_{2.5}$ or PM_{10} cannot exceed that of TSP and the emission rates of $PM_{2.5}$ cannot exceed that of PM_{10}.
- Step 2: If PM_{10} and $PM_{2.5}$ have not been tested at any given stack, the conservative assumption was that PM_{10} and $PM_{2.5}$ emission rates were the same as that of TSP (i.e. both the ratio of PM_{10} to TSP and of $PM_{2.5}$ to TSP was considered to be 1).

The particulate matter dispersion modelling results have been used to understand the relative contribution of different stack sources and identify worst impacted locations with respect to the location of ambient air quality monitors. The ambient air quality monitoring results have been used as the primary assessment technique for effects of discharges of particulate matter.

Discussion of the compliance of the various stack emission sources with the particulate matter limits in the current consent is set out in Section 4.3 of the AQA.

Table 4.1 provides a summary of emission rates of PM_{10} and $PM_{2.5}$ used for dispersion modelling. PM_{10} and $PM_{2.5}$ emission rates have been set to be the same for the modelling, as a worst-case assumption.

Table 4.1: Emission rates of PM_{10} and $PM_{2.5}$ used in dispersion modelling

Stack	Stack ID	Average (kg/hr)	Maximum (kg/hr)
		PM_{10}/$PM_{2.5}$	PM_{10}/$PM_{2.5}$
MHF stacks	IP1-IP4	2.5	5.2
Kiln stacks	IP23-IP26	2.8	5.3
Metalside Baghouses	IP33-IP34	0.3	1.1
Slagside Baghouse	IP32	0.4	1.0
Steel Plant Baghouse[1]	SP4A-SP4F	0.5	0.8
KOBM Flarestack	SP1	3.4	5.1
Slab Reheat Furnace	HSM1	0.2	0.3
Pipe Mill Blowdown scrubber	PM3	0.2	0.3
Pipe Mill Galvanising Baghouse	PM2	0.1	0.2
Acid Regeneration Plant[2]	CSM1	0.4	1.0
Primary Concentrate Drier baghouse	SR1	0.02	0.04

Notes:

1. Accounts for the six louvres of KOBM secondary baghouse. The emission rates are shown per louvre.

2. The test for particulate at this source has not been carried out using a standard method and are expected to overstate particulate emissions, however the results have been conservatively included in modelling.

4.3 Sulphur dioxide

In terms of sulphur oxides (SO_X), the stack emissions will contain principally SO_2 from the combustion processes at the MHFs and Kilns. The MHFs are the largest emission source as this is where coal enters the ironmaking process and undergoes "charring" during sub-stochiometric combustion where most of the sulphur is released.

Table 4.2 provides a summary of emission rates of SO_2 used for dispersion modelling.

Table 4.2: Emission rates of SO_2 used in dispersion modelling

Stack	Stack ID	Average (kg/hr)	Maximum (kg/hr)
MHF stacks	IP1-IP4	30.0	65.8
Kiln stacks	IP23-IP26	2.0	7.3
KOBM Flarestack	SP1	0.1	0.3

4.4 Nitrogen oxides

Combustion processes produce nitrogen oxides (NO_X), which consist mainly of nitric oxide (NO) and typically of the order of 5 to 10% nitrogen dioxide (NO_2). Once emitted, some of the NO converts to NO_2 in the atmosphere through reactions with ozone (O_3).

From a human health perspective, NO_2 is the component of NOx of greatest interest because it is a more potent respiratory irritant than NO (which is present in greater amounts in the discharges). Therefore, to assess the effects of NOx emissions, we are principally interested in the resulting NO_2 concentrations. However, to evaluate the performance of the dispersion model it is more useful to consider the total NO_X emissions because this allows model predictions to be compared to the NOx monitoring results without the complications of atmospheric chemistry.

NO and NO_2 have different molecular weights. Therefore, to avoid the issue of NO/NO_2 ratios being different in the stack emissions compared to at the monitoring locations, the NOx emissions (and monitored concentrations) are expressed as NO_2-equivalent (ie the NO component is calculated as if it were all converted to NO_2).

NO_X emissions from the Site arise dominantly from the combustion processes in the MHFs and Kilns, with some further contribution from the KOBM Flarestack, the Slab Reheat Furnace and the Paint Lines. NO_X emissions rates from the MHFs, Kilns, Slab Reheat Furnace and Paint Lines have been estimated based on stack testing data. However, NO_X emissions from the KOBM Flarestack are not easily tested because of the high temperature (typically 1000 °C as a default assumption), therefore NO_X emissions from the KOBM Flarestack have been estimated from emission factors (see **Appendix C**, Section C1.2).

Table 4.3 provides a summary of emission rates of NO_X used for dispersion modelling.

Table 4.3: Emission rates of NO_X (as NO_2) used in dispersion modelling

Stack	Stack ID	Average (kg/hr)	Maximum (kg/hr)
MHF stacks	IP1-IP4	47.6	75.0
Kiln stacks	IP23-IP26	7.4	13.7
KOBM flarestack	SP1	0.42	0.42
Slab Reheat Furnace	HSM1	12.4	19.3
Paint Line Prime Oven Incinerator stack	CCL3	0.55	0.70
Paint Line Finish Oven Incinerator stack	CCL4	0.69	0.88

4.5 Carbon monoxide

Emissions of CO have been measured at the Kiln stacks and have been estimated using emission factors for the KOBM Flarestack (see **Appendix C**, Section C1.2). **Table 4.4** provides a summary of emission rates of CO used for dispersion modelling.

Previous tests undertaken at the Kiln stacks have indicated that over a period of time, leakage starts to occur around the boiler bypass dampers. NZ Steel has put in place a monitoring programme to ensure that the CO concentrations in the stacks do not exceed the current consent limit of 3750 mg/m^3 at the Kiln stacks. The maximum measured and maximum permitted emission rates are similar, and the 10 years of stack test data have likely included measurements when the leakage was occurring. As the maximum permitted CO emission rates are only marginally higher than the maximum measured rates, the modelling has used the former as a conservative assumption.

The amount of CO leakage that occurs at each Kiln is a function of the age and condition of the damper. The condition is regularly checked, and dampers replaced as part of the maintenance cycle. In reality, there is only likely to be material leakage around any one (out of the four) kiln dampers at any given time, given the maintenance schedule. However, for the purposes of this assessment, the same emission rates have been used for all Kiln stacks. This approach will overstate potential effects for the maximum emission scenario.

Table 4.4: Emission rates of CO used in dispersion modelling

Stack	Stack ID	Average (kg/hr)	Maximum permitted (kg/hr)
Kiln stacks	IP23-IP26	122.1	285.7
KOBM Flarestack	SP1	134.4	134.4*

* There is no consent limit for CO assigned to the KOBM Flarestack

4.6 Hydrogen chloride and chlorine

HCl and Cl_2 emissions are associated with the pickling process where hydrochloric acid solution is used. The spent HCl from the pickle line is regenerated in the Acid Regeneration Plant. Waste gas from the Acid Regeneration Plant adsorption column is cleaned in a packed tower scrubber and mist eliminator before discharge to atmosphere. Fume captured at the Pickle Line is also cleaned in a scrubber and mist eliminator. The final discharge from each source contains residual levels of HCl and Cl_2.

Table 4.5 provides a summary of emission rates of HCl and Cl_2 used for dispersion modelling.

Table 4.5: Emission rates of HCl and Cl_2 used in dispersion modelling

Stack	Stack ID	Average (kg/hr)		Maximum (kg/hr)	
		HCl	Cl_2	HCl	Cl_2
Acid Regeneration Plant	CSM1	0.063	0.64	0.31	1.3
Pickle Line scrubber	CSM3	0.02	0.008	0.04	0.01

4.7 Volatile organic compounds

The Paint Line includes a separate Prime Oven and Finish Oven for application of solvent paints to steel products. The emissions to air from the drying ovens are treated through their respective incinerators to reduce emissions of volatile organic compounds (VOCs) at the outlet. Condition 21 of the existing Main Air Permit requires these two incinerators to be operated at a minimum of 650°C for the Finish Oven, and 750°C for the Prime Oven.

Emission testing has been undertaken annually on the Prime and Finish Incinerator stacks since 2014 for a suite of VOCs. VOC results will vary depending on the paint product being used at the time of the testing. Results from seven tests (speciated to the different VOCs) for the Prime Incinerator stack and nine results for the Finish Incinerator stack have been evaluated (on an average basis) to determine their representative emission rates, respectively. Where tests indicate a test value to be below a detection limit, a conservative assumption has been adopted whereby the test value will be considered to be 50% of the detection limit (e.g. if a test value is less than 10 $\mu g/m^3$, a concentration of 5 $\mu g/m^3$ has been adopted).

Representative VOC emission rates are summarised in **Table 4.6** below.

Table 4.6: VOC emissions from the Paint Line Prime and Finish oven incinerators used in dispersion modelling

VOC	Prime Oven Incinerator stack (CCL3)		Finish Oven Incinerator stack (CCL4)	
	Average kg/hr	Maximum kg/hr	Average kg/hr	Maximum kg/hr
Benzene	0.0014	0.0038	0.15	0.34
Toluene	0.0028	0.0072	0.015	0.026
Ethylbenzene	0.0017	0.0040	0.0017	0.0031
m-,p-Xylene	0.0074	0.020	0.0049	0.010
o-Xylene	0.012	0.051	0.0061	0.014
Styrene	0.0003	0.0006	0.010	0.021
Iso-Propylbenzene (cumene)	0.0029	0.0100	0.0008	0.0012
n-Propylbenzene	0.0089	0.042	0.0012	0.0025
1,3,5 - Trimethylbenzene	0.0086	0.035	0.0016	0.0048
1,2,4 - Trimethylbenzene	0.020	0.078	0.0048	0.018
sec- Butylbenzene	0.0006	0.0012	0.0002	0.00023
4-iso-Propyltoluene (p-Cymene)	0.0008	0.0024	0.0003	0.00035
Naphthalene	0.0003	0.0005	0.0012	0.0049
Methyl isobutyl ketone (MIBK)	0.014	0.014	0.0054	0.0091
2-Chlorotoluene	-	-	0.0062	0.0062
n-Butylbenzene	-	-	0.0006	0.001

4.8 Mercury

Mercury emissions occur from the trace amounts of mercury in the coal and, to a lesser extent limestone raw materials. Consequently, as for the reasons stated in Section 4.3 for SO_2, the main source of mercury emissions will be the MHFs. Mercury emission rates for dispersion modelling have been estimated based on a mass balance assuming all of the mercury in the coal and limestone is released to air (see **Table 4.7**).

Table 4.7: Emission rates of mercury used in dispersion modelling

Stack	Stack ID	Average (kg/hr)	Maximum (kg/hr)
MHF stacks	IP1-IP4	0.00133	0.00231

5 Evaluation of model performance

5.1 Method

The performance of the dispersion model has been evaluated by comparing the modelled GLCs at the 64 Glenbrook Beach Road (Site 20) and Glenbrook School (Site 17) monitoring sites with monitoring data.

The most common method of model validation is to compare the ranked modelled results with the ranked measured ambient concentrations in a quantile-quantile (Q-Q) plot. A Q-Q plot is a scatterplot that can be used to compare whether two sets of quantiles (modelled concentrations versus monitored concentrations) have the same distribution. If the distribution is the same, the two sets of data form a straight line. A 1-to-1 reference line is also plotted. If the scatterplot is:

- above the reference line, there is, on average, an over-prediction of modelled results compared to monitored concentrations; and
- below the reference line, there is, on average, an under-prediction of modelled results compared to monitored concentrations.

The most reliable basis for model validation will be against the SO_2 monitoring data for the following reasons:

- The Site is the only significant source of SO_2 in the area and the monitored data includes minimal contribution from other sources, which would confound the evaluation.
- SO_2 monitoring data is available at two monitoring locations (64 Glenbrook Beach Road (Site 20) and Glenbrook School (Site 17), which enables model performance at different locations to be considered. This is particularly useful if there are large difference in the modelled and measured values and there is a need to consider adjusting the model results to be more realistic.

The model performance can also be validated using NOx monitoring data at 64 Glenbrook Beach Rd (Site 20). The modelling includes the main process emission sources of NOx at the site, but there will be other, likely relatively minor, contributions of NOx at the monitoring site from smaller combustion processes at the site and from motor vehicles, including heavy trucks.

The model has not been validated against the measured $PM_{2.5}$ and PM_{10} concentrations because the dispersion modelling only considers the Site's stack emission sources. Natural sources of PM_{10} and $PM_{2.5}$ (such as marine aerosols) and fugitive emissions from the Site, which are not included in the modelling, are a significant contributor to measured PM_{10} concentrations at 64 Glenbrook Beach Road (Site 20) (see Section 7.2.2 of the AQA). This means that the model would not be expected to accurately predict measured off-site PM_{10} and $PM_{2.5}$ concentrations.

The modelling has been undertaken using 3 years of meteorological data (2015, 2016 and 2017). The year with the highest predicted maximum concentration has been chosen as the year for model validation. It is note that sometimes the “worst case” model year differs between averaging periods or, whether the “average” or “maximum” emissions scenario is being considered. Monitoring data is available for a full year for NOx (Site 20) and SO_2 (Sites 17 and 20) for 2019. The differences in meteorology between the modelled years and they years where monitoring data is available will introduce a small amount of uncertainty, however this will not affect the overall validity of the conclusions given other aspects of uncertainty in the emission rates and dispersion modelling..

5.2 Sulphur dioxide model performance

The Q-Q plots for both monitoring sites (64 Glenbrook Beach Rd (Site 20) and Glenbrook School (Site 17)) and both averaging periods (1-hour average and 24-hour average) are provided in **Appendix D**. The model performance has been evaluated for both the average emissions scenario and the maximum emissions scenario. The maximum emissions scenario resulted in such a high degree of over-prediction that it has not been considered further.

For ease of reference, the 1-hour average and 24-hour average plots (average emissions scenario only) are reproduced in **Figure 5.1** and **Figure 5.2** for 64 Glenbrook Beach Rd (Site 20) and Glenbrook School (Site 17), respectively. The key features and interpretation of these graphs are:

- The coefficient of determination (R^2) values of the linear correlations are higher at 64 Glenbrook Beach Rd (Site 20) (0.95 and 0.90 for the 1-hour and 24-hour average, respectively) compared to Glenbrook School (Site 17) (0.86 and 0.84 for the 1-hour and 24-hour average, respectively). This means there is an overall better fit of the distribution of the modelled and measured datasets at 64 Glenbrook Beach Rd (Site 20) compared to Glenbrook School.
- The slope of the linear regression correlation represents the overall average degree of model over- or under-prediction. On average, the model tends to significantly over-predict measured SO_2 concentration over both averaging periods at both sites.
- The model slightly under-predicted the worst-case 24-hour average concentration measured at 64 Glenbrook Beach Rd (Site 20) (28 µg/m^3 compared to a measured concentration of 31 µg/m^3).
- The model tends to over-predict by a greater margin at Glenbrook School (Site 17) compared to 64 Glenbrook Beach Rd (Site 20). The worst case modelled 24-hour average concentration at Glenbrook School (Site 17) was 16 µg/m^3 compared to a measured maximum concentration of 9 µg/m^3.

The slope of the linear regression correlation is shown in **Table 5.1**. This value represents the average degree of model over- or under-prediction, for example a slope of 1.8 suggests that the model tends to overpredict by nearly double, on average. This over-prediction applies to the model output dataset as a whole and is different to the model's performance at predicting the highest GLC.

Table 5.1: Slope of linear regression correlation of modelled and measured data for SO_2

Averaging period	64 Glenbrook Beach Road (Site 20)	Glenbrook School (Site 17)
1-hour	1.8	3.2
24-hour	1.5	2.1

The greater degree of over-prediction at Glenbrook School (Site 17) compared to 64 Glenbrook Beach Rd (Site 20) is likely to be related to conservatism in the building downwash simulation (BPIP-PRIME algorithm) discussed in Section 2.5. This effect has been investigated in more detail and is discussed further in Section 6.2.

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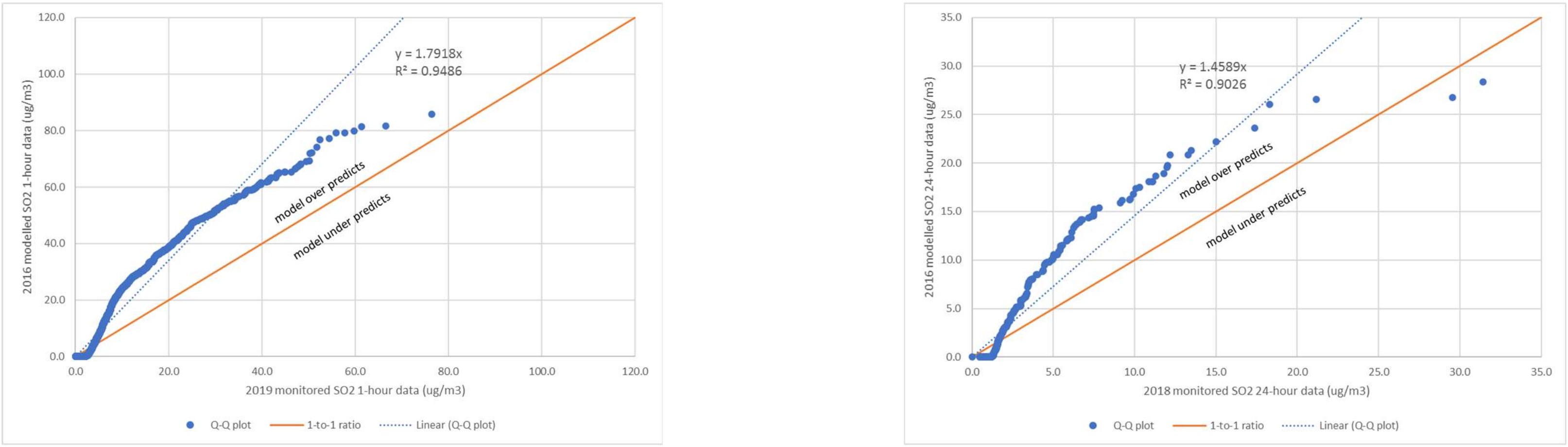

Figure 5.1: SO_2 Q-Q plots for 64 Glenbrook Beach Rd (Site 20) – Average emission rate scenario, 1 hour average (left) and 24-hour average (right)

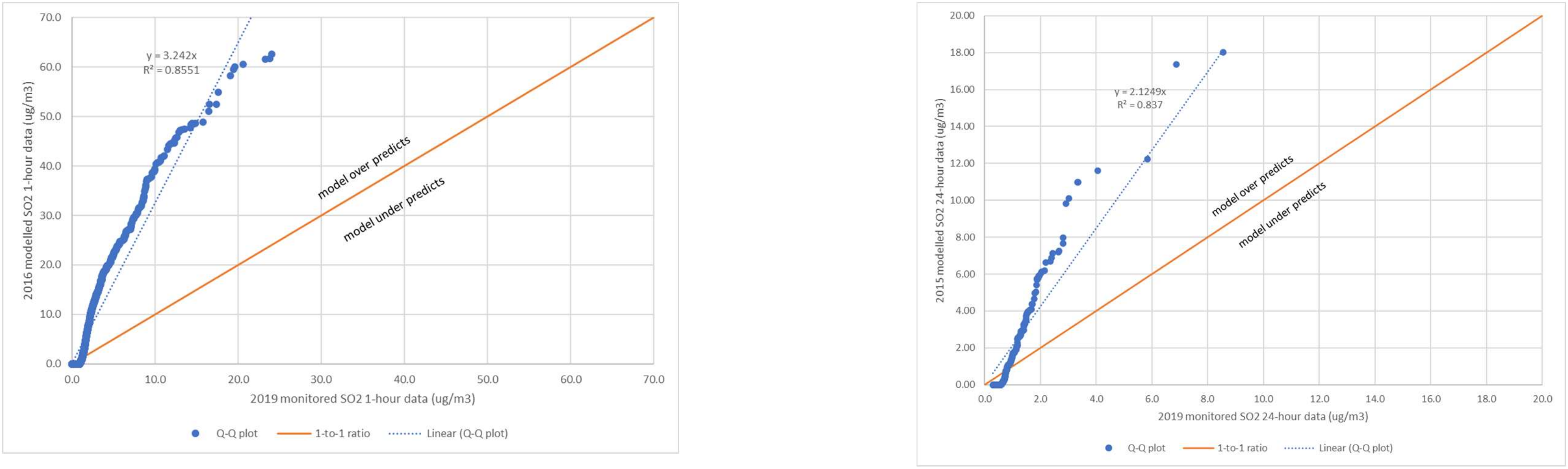

Figure 5.2: SO_2 Q-Q plots for Glenbrook School (Site 17)– Average emission rate scenario, 1 hour average (left) and 24-hour average (right)

5.3 Nitrogen oxides model performance

The main emission sources of NO_X are similar to the main emission sources of SO_2 (MHF and Kiln stacks), although the proportional contributions differ.

The Q-Q plots for Glenbrook Beach Rd (Site 17) are provided in **Appendix D** for 1-hour and 24-hour averaging periods. The key features and interpretation of these graphs are:

- The R^2 values of the linear correlations show a good correlation (0.94 and 0.91 for the 1-hour and 24-hour average, respectively).
- For the 1-hour average, the model performs well over the whole range with a tendency to slightly over-predict.
- For the 24-hour average, the model performs well over most of the range but tends to under-predict the highest concentrations. For context, while the model does not predict the highest measured concentration (73.8 $\mu g/m^3$), this day appears to be an outlier compared to the rest of the data. The second and third highest measured concentrations of 58.9 and 51.6 $\mu g/m^3$ (24-hour average) are relatively close to the highest model prediction 51.1 $\mu g/m^3$ (24-hour average).

Comparing the slope of the linear regression correlation (Table 5.2 and Figure 5.3), the model showed very good performance for 1-hour average concentrations but tends to under-predict the highest 24-hour average concentrations.

Table 5.2: Slope of linear regression correlation of modelled and measured data for NO_X at 64 Glenbrook Beach Road (Site 20)

Averaging period	Slope of linear regression correlation
1-hour	1.04
24-hour	0.83

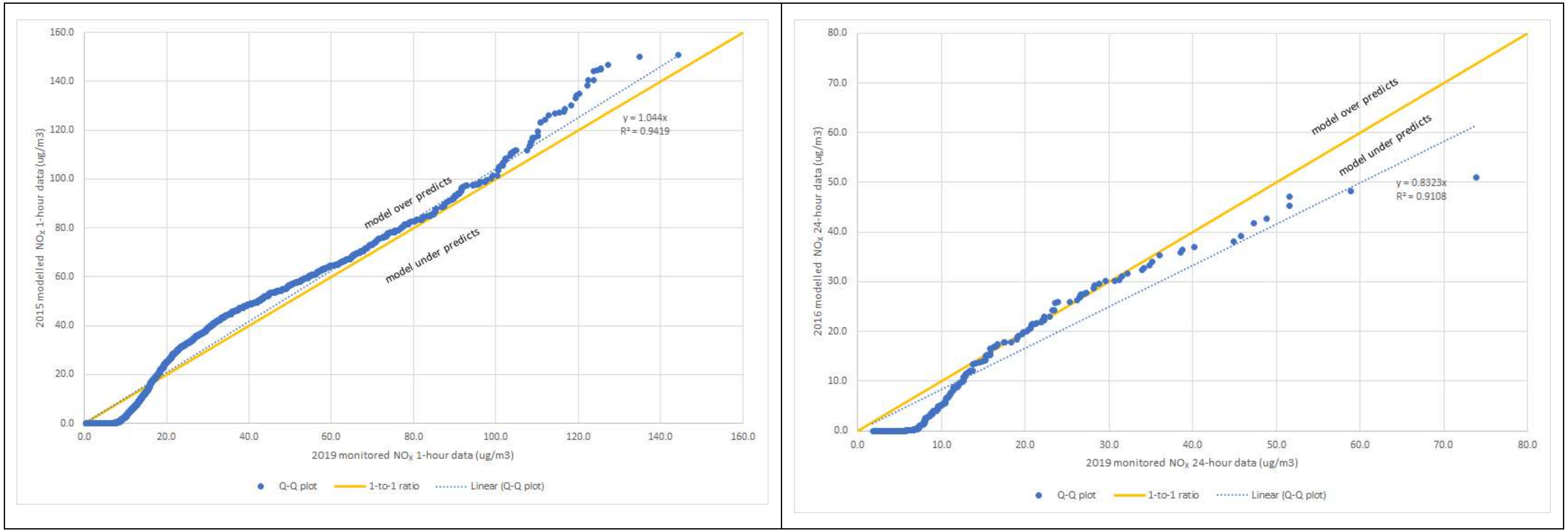

Figure 5.3:NO$_x$ Q-Q plots for 64 Glenbrook Beach Rd (Site 17)– Average emission rate scenario, 1 hour average (left) and 24-hour average (right)

5.4 Discussion

Overall, the dispersion model, based on the average emissions scenario, produces a reasonably good overall fit to the monitored datasets at 64 Glenbrook Beach Rd. The model tends to over-predict SO_2 concentrations by a greater margin at Glenbrook School (Site 17) compared to 64 Glenbrook Beach Rd (Site 20). This is most likely due to the way that the model simulates building downwash effects. This effect is discussed further in Section 6.2, particularly as it relates to whether the monitoring location at 64 Glenbrook Beach Rd is likely to be representative of air quality that may be experienced at residential dwellings near the Site.

There are differences in the model performance for SO_2 and NOx, which is interesting because the MHFs and Kilns are the main sources of emissions in both cases. However, there are a number of additional, smaller contributing point sources to NOx emissions, as well as the potential for sources not included in the model (such as truck exhaust emissions) to influence the monitoring data. There are two key inferences from the model validation work:

- Given that the model performs reasonably well at predicting 1-hour average NOx concentrations, the significant over-prediction of SO_2 concentrations suggests that the modelled average emission rates of SO_2 may be conservatively high. The MHF stacks are the main contribution to stack emissions, and the stack testing data shows a wide range of reported concentrations (see Appendix C1.4). In practice, the average emissions may be lower than the average of the available dataset.
- For both SO_2 and NOx, the highest measured 24-hour average concentrations were slightly greater than the model predictions. However, the magnitude of the under-prediction is relatively small, particularly given the highest measured NOx concentration appears to be an outlier (25% higher than the second highest concentration). For both SO_2 and NO_x at Glenbrook Beach Rd, the highest modelled 24-hour average concentration was greater than the third highest measured concentration.

The overall conclusions are that the model performance is adequate and that it provides a useful and, generally, somewhat conservative tool for the purpose of predicting GLCs for contaminants where air quality monitoring data is not available.

6 Comparison of model predictions at 64 Glenbrook Beach Rd (Site 20) monitoring site and at discrete receptors

6.1 Introduction

The AQA relies on ambient monitoring data from 64 Glenbrook Beach Road (Site 20) and, in the case of metals in suspended particulate matter, at the NZS Northern Boundary (Site 4B) monitoring site to represent the worst-case possible exposure at any sensitive receptor (sensitive receptors include Glenbrook School and nearby dwellings).

This assumption has been investigated by comparing the modelled GLCs at 64 Glenbrook Beach Rd (Site 20) with the modelled GLCs at sensitive receptors. If the modelled concentrations at sensitive receptors are significantly higher than at 64 Glenbrook Beach Rd (Site 20), then this will need to be considered when evaluating the effects at sensitive receptors based on ambient air monitoring results.

This comparative assessment has been based on the modelling of PM_{10} and SO_2 emissions. As discussed in Section 5.1, the model would not be expected to accurately predict off-site PM_{10} and $PM_{2.5}$ concentrations because the measurements will include the contribution from a range of other sources. However, because there are a large number of PM_{10} stack emission sources included in the modelling, it is useful to understand the relative combined impact of these stack sources at the different modelled locations. This will help inform whether concentrations at 64 Glenbrook Beach Rd (Site 20) are likely to represent the worst-case possible exposure at any sensitive receptor.

6.2 PM_{10} model predictions

Table 6.1 sets out the maximum predicted PM_{10} GLCs at sensitive receptors and the percentage difference with the GLC predicted at 64 Glenbrook Beach Rd (Site 20), which is located approximately 630 m northwest of the operational area. As the model has been run for 3 years of meteorological data, the maximum predicted GLCs used in this analysis are the average of the maximum 24-hour average modelled concentrations over the 3 modelled years (2015 to 2017).

A threshold of +10% has been used to identify sensitive receptors where the contribution of stack sources of PM_{10} may be greater than at 64 Glenbrook Beach Rd (Site 20) monitoring site. Values exceeding 10% are shown bold underlined in **Table 6.1**.

To illustrate the pattern of dispersion, a graphical representation of the PM_{10} 24-hour average concentration contours is provided in **Figure 6.1**.

This analysis shows that there are 9 dwellings located to the northeast and east of the Site (at distances between 330 m and 730 m from the edge of the Operational Area) that are predicted to have a PM_{10} contribution (expressed as a 24-hour average) from stack emission sources that is greater than the contribution predicted at 64 Glenbrook Beach Rd (Site 20). The most impacted receptor is at 190 Mission Bush Rd (R6), which is located approximately 340 m from the closest edge of the Operational Area at the Site. At this location, the worst case modelled 24-hour average concentration from stack sources is predicted to be 54% higher than at 64 Glenbrook Beach Rd.

With the known building downwash limitations of BPIP-PRIME (Section 2.5), the model results have been further evaluated to assess the impact of building downwash and whether these higher model predictions are likely to be realistic. This analysis concentrates on the two main stack groups, being the Kilns and MHFs[12]. These are the sources with the highest PM_{10} emission rates and are the main source contributors of modelled GLCs at the sensitive receptors.

The Kilns and MHF Stacks have similar emission rates (2.8 kg/hr and 2.5 kg/hr respectively), similar heights (60.25 m and 60 m respectively) and similar exit temperature (332 K and 343 K). Therefore, in the absence of building downwash effects, the plumes from these two stack groups would be expected to have similar dispersion patterns. Concentration contour plots (24-hour average) for the Kiln Stack emissions and the MHF Stack emissions are presented in **Figure 6.2** and Figure **6.3**, respectively. The difference in the predicted contours illustrates the modelled impact of building downwash. The Kiln Stacks, being closest to a building cluster (the main building being of an elongated shape), experiences more pronounced plume spreading and generates higher GLCs. The orientation of the dominant wind direction (southwest) gives an oblique angle approach to the building cluster, resulting in increased wake height and enhanced turbulence effect as mentioned previously in Section 2.5.

The MHF stacks, being further west of the building cluster, shows a different plume distribution. As the plumes from the MHFs rises following release from the stacks, it is likely that by the time the plumes reach the location of the building cluster (a distance of approximately 200 m to the main elongated building), most of the plume would have cleared the turbulent zone in the near wake of the buildings. While there is some building downwash, its effects are much less pronounced, resulting in a north-south plume concentration orientation that replicates the orientation of the main elongated building.

The model performance evaluation showed a greater degree of model over-prediction for SO_2 concentrations at Glenbrook School (Site 17) compared to 64 Glenbrook Beach Rd (Site 20). Based on this, it is likely that the higher modelled PM_{10} concentrations compared to Glenbrook Breach Rd at receptors to the northeast and east of the Site are over-stated. However, for the purposes of the AQA, the possibility of stack emissions resulting in higher PM_{10} concentrations at some locations compared to at 64 Glenbrook Beach Rd (Site 20) will need to be considered. For completeness, it is noted that worst case 24-hour average PM_{10} concentrations from all sources combined (cumulative exposure) may still be greater at 64 Glenbrook Beach Rd (Site 20) compared to other sources to the northeast and east of the Site because of the significant contribution from fugitive sources on the worst-case days.

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[12] The six louvres of the Steel Plant baghouse and the KOBM Flarestack provide comparable emission rates. However, the former has low vertical momentum rise due to the horizontal orientation of discharge and hence subjected to different building downwash effects; the emitted plumes are unlikely to travel a comparable distance before the plumes hits the ground level. On the other hand, the KOBM Flarestack has a pseudo stack height of almost 30 m higher than the stack heights of MHFs/Kilns and hence unlikely to be subjected to the same degree of building downwash. As such, both these sources are not included.

Table 6.1: **Comparison of PM_{10} maximum GLC at off-site discrete receptors with 64 Glenbrook Beach Rd (Site 20) monitoring site (average emissions scenario)**

Location	Maximum modelled GLC (µg/m^3)		Difference compared to 64 Glenbrook Beach Rd (Site 20) GLC	
	24-hour average	annual average	24-hour average	annual average
64 Glenbrook Beach Road (Site 20)	6.9	1.2	-	-
Northern Boundary (Site 4B)	5.3	0.7	-22%	-38%
R2	6.3	0.5	-9%	-56%
R3	4.7	0.4	-32%	-63%
R5	4.5	0.3	-34%	-71%
R6	10.6	1.3	**54%**	6%
R8	7.6	1.1	**11%**	-10%
R9	8.9	1.1	**30%**	-4%
R10	6.4	1.0	-6%	-16%
R11	4.3	0.6	-37%	-54%
R12	4.7	0.5	-32%	-54%
R13	3.8	0.4	-44%	-63%
R14	5.0	0.4	-27%	-64%
R15	5.4	0.8	-21%	-34%
R16	5.1	0.7	-25%	-40%
R17	5.5	0.4	-20%	-64%
R18	5.3	0.4	-23%	-64%
R19	4.2	0.4	-39%	-66%
R20	4.3	0.4	-37%	-67%
R21	4.7	0.4	-32%	-69%
R22	3.2	0.2	-53%	-81%
R23	2.9	0.2	-57%	-81%
R24	5.0	0.7	-27%	-40%
R25	3.9	0.3	-43%	-76%
R26	4.1	0.2	-41%	-83%
R27	4.7	0.3	-31%	-75%
R28	4.1	0.3	-40%	-77%
R29	3.2	0.3	-53%	-79%
R30	2.4	0.2	-65%	-84%
R31	9.2	1.1	**34%**	-8%
R32	7.2	0.9	5%	-26%
R33	7.5	0.9	9%	-23%
R34	7.0	1.0	2%	-17%

Location	Maximum modelled GLC (µg/m³)		Difference compared to 64 Glenbrook Beach Rd (Site 20) GLC	
	24-hour average	annual average	24-hour average	annual average
R35	7.2	1.0	5%	-17%
R36	7.4	1.0	8%	-14%
R37	8.5	1.1	**24%**	-8%
R38	8.5	1.0	**23%**	-12%
R29	6.8	0.9	-1%	-28%
R40	7.2	0.8	5%	-36%
R41	7.3	0.8	6%	-34%
R42	4.9	0.5	-29%	-61%
R43	5.4	0.5	-22%	-62%
R44	5.1	0.4	-27%	-64%
R45	4.4	0.4	-36%	-68%
R46	4.4	0.4	-37%	-69%
R47	4.9	0.4	-29%	-67%
R48	8.2	1.0	**20%**	-12%
R49	6.2	0.6	-9%	-48%
R50	5.6	0.5	-18%	-54%
R51	5.5	0.5	-20%	-55%
R52	6.5	0.7	-6%	-44%
R53	7.7	1.1	**13%**	-10%
R54	9.4	1.1	**37%**	-9%

Notes:

a. Average of the maximum 24-hour average modelled concentrations over the 3 modelled years (2015 to 2017).

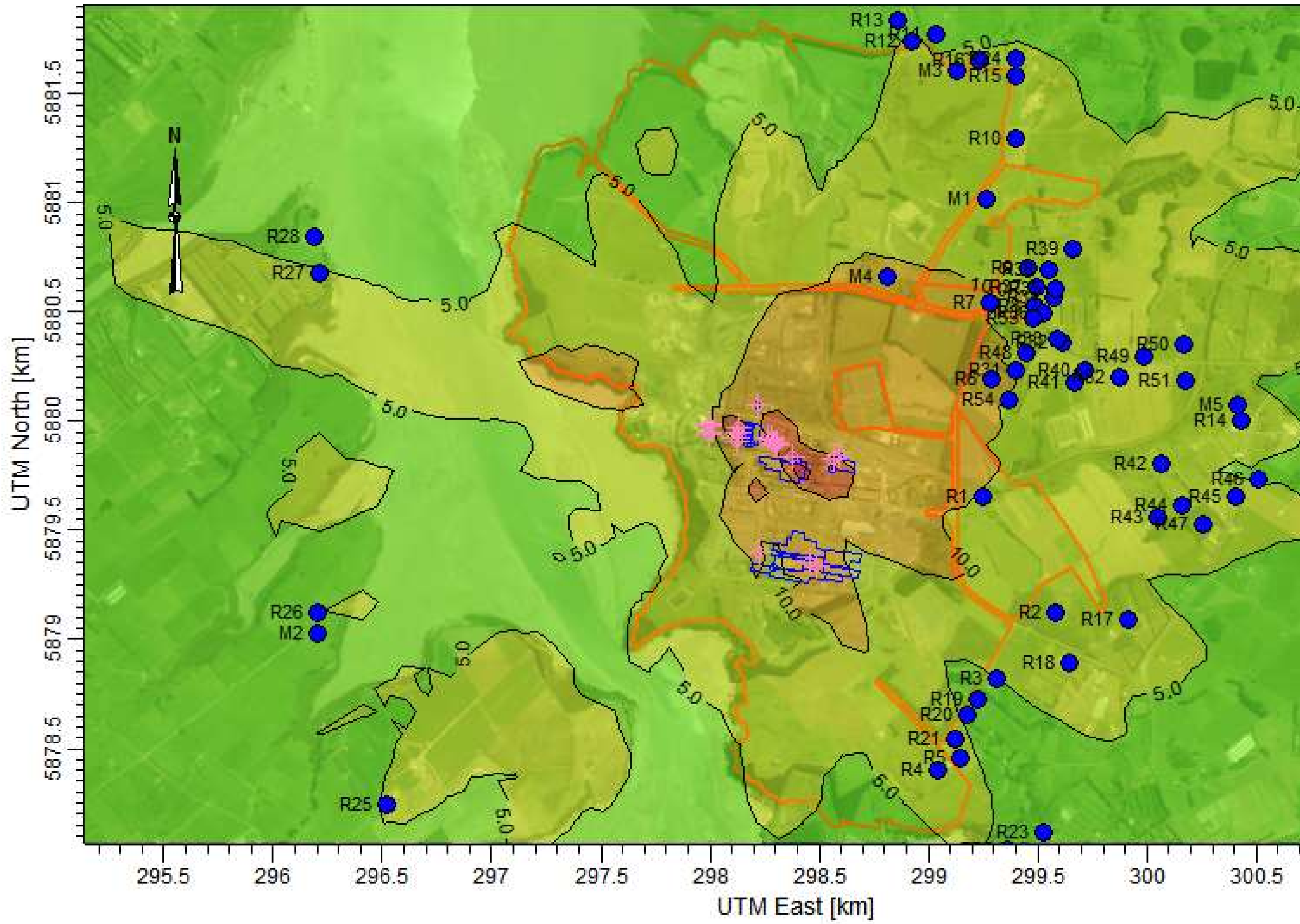

Figure 6.1: 24-hour contour plot for PM10 for average emissions scenario. Highest concentration over 3 modelled years. (Note: blu monitoring locations included in the modelling, pink crosshairs are the emission sources, blue lines are the buildings modelled and

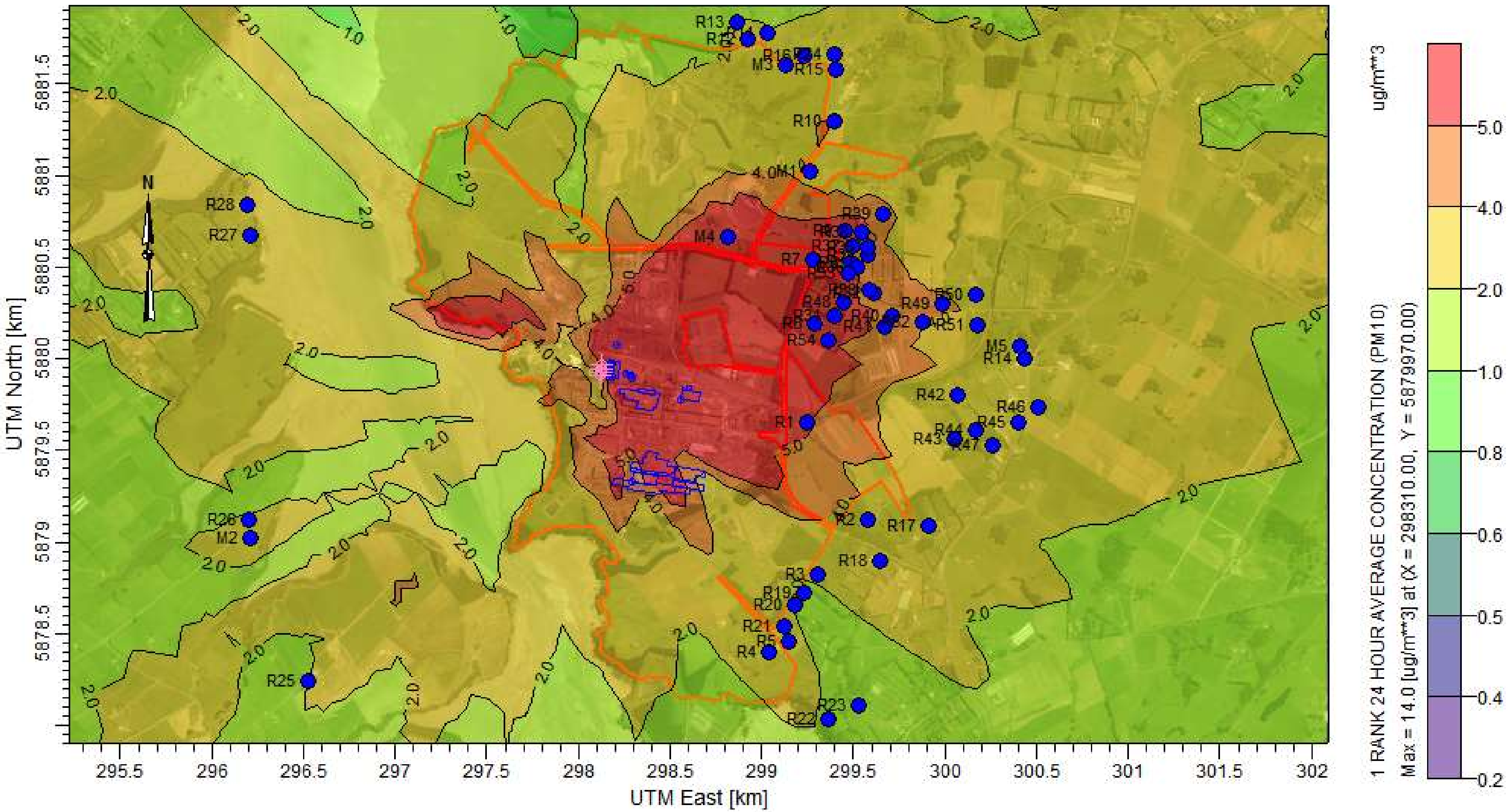

Figure 6.2: 24-hour contour plot for PM_{10} for Kilns only for average emissions scenario (both the Kilns only and MHFs only contours have the same contour intervals). The orange/red contour bands are oriented eastwards/northeast-wards. Compared to the MHFs only contour plots, the spatial spread of the higher concentration levels (red/orange) is larger. (Note blue dots indicate sensitive receptors and monitoring locations included in the modelling, pink crosshairs are the emission sources, blue lines are the buildings modelled and the red line is the site boundary)

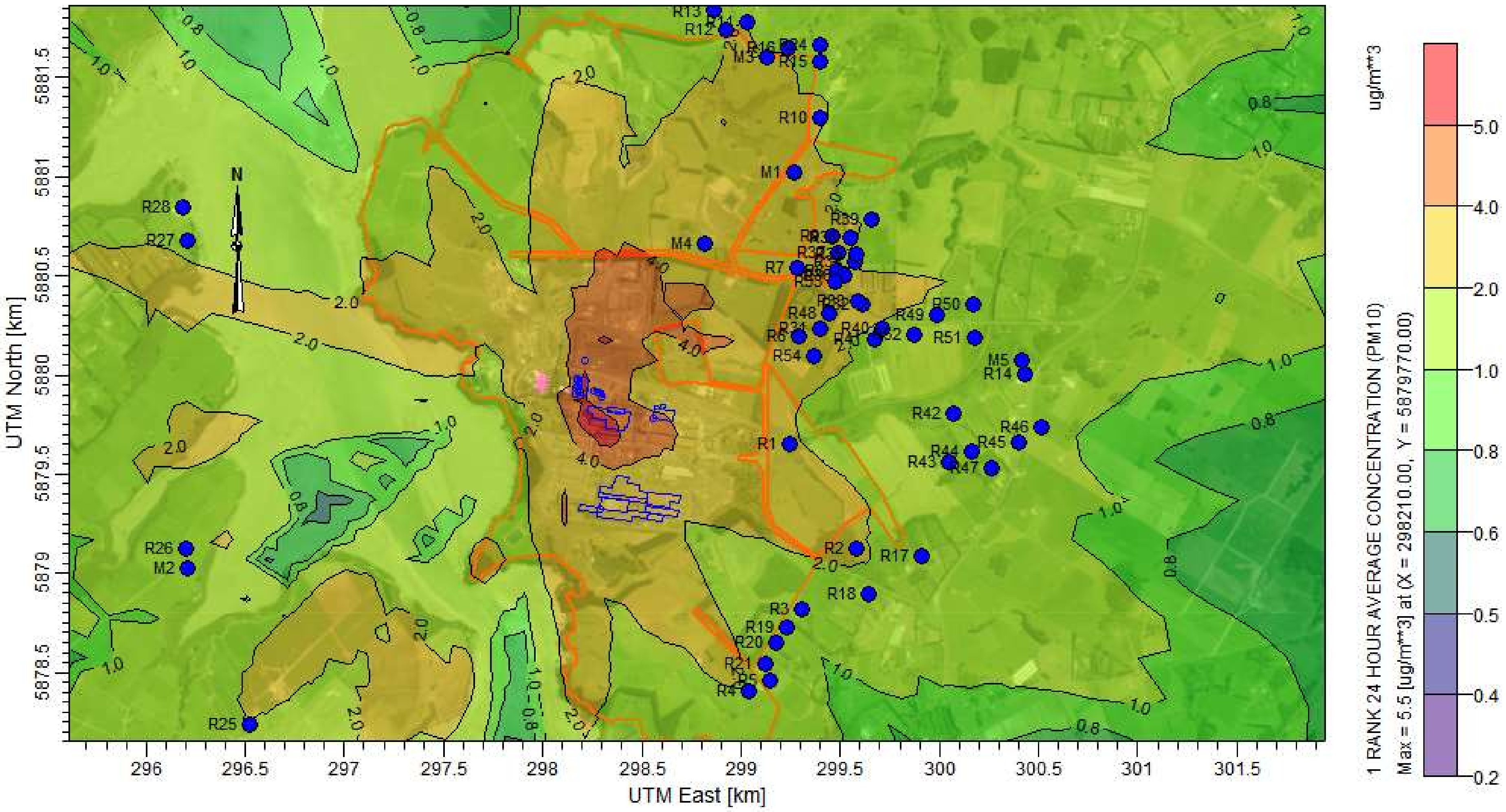

Figure 6.3: 24-hour contour plot for PM_{10} for MHFs only for average emissions scenario (both the Kilns only and MHFs only contours have the same contour intervals). The orange/red contour bands are oriented northwards/southwards. Compared to the Kilns only contour plots, the spatial spread of the highest concentration level (red) of MHFs is limited to the near-wake of the buildings next to the Kilns. (Note blue dots indicate sensitive receptors and monitoring locations included in the modelling, pink crosshairs are the emission sources, blue lines are the buildings modelled and the red line is the site boundary)

6.3 Sulphur dioxide model predictions

Table 6.2 sets out the maximum predicted SO_2 GLCs at sensitive receptors and the percentage difference compared to the GLC at 64 Glenbrook Beach Rd (Site 20). A graphical representation of the 24-hour average concentration contours is provided in **Figure 6.4**.

The only off-site receptors where there is a more than 10% difference (higher) GLC than predicted at the 64 Glenbrook Beach Rd (Site 20) monitoring site are 190 Mission Bush Rd (R6), 198 Mission Bush Rd (R31), 127 Brookside Rd (R48). These higher concentrations generally relate to the 24-hour average concentration only (11% to 28% higher), apart from at 190 Mission Bush Rd where the model also predicts a slightly higher 1-hour average concentration (17% higher).

Annual average concentrations are generally lower at all of the modelled receptors, which will reflect the relatively lower frequency of winds towards this group of dwellings compared to the frequency of winds towards 64 Glenbrook Beach Rd (Site 20).

As previously discussed in relation to PM_{10}, the higher predicted concentrations at receptors to the northeast/east is likely to be due to the conservative way that the model simulates building downwash. However, for the purposes of this assessment, the possibility of stack emissions resulting in slightly higher SO_2 concentrations at these locations compared to at Glenbrook Beach Rd (Site 20) has been considered in the AQA.

Table 6.2: Comparison of SO_2 maximum GLC at sensitive receptors with 64 Glenbrook Beach Rd (Site 20) monitoring site (average emissions scenario)

Location	**Maximum modelled GLC (µg/m³)**			**Ratio - with 64 Glenbrook Beach Rd (Site 20) GLC**		
	1- hour average (9th ranked)	**24-hour average**	**annual average**	**1- hour average**	**24-hour average**	**annual average**
64 Glenbrook Beach Rd (Site 20)	85.3	26.1	3.9	-	-	-
Northern Boundary (Site 4B)	75.5	23.9	2.9	-11%	-8%	-26%
R2	70.4	22.6	1.6	-17%	-13%	-59%
R3	57.7	16.0	1.4	-32%	-39%	-66%
R5	54.5	17.5	1.1	-36%	-33%	-73%
R6	99.5	33.3	3.4	**17%**	**28%**	-14%
R8	82.2	23.8	3.0	-4%	-8%	-24%
R9	78.4	28.7	3.3	-8%	10%	-16%
R10	84.7	23.5	3.4	-1%	-10%	-13%
R11	72.2	20.2	2.2	-15%	-23%	-43%
R12	74.7	21.3	2.2	-12%	-18%	-43%
R13	73.1	18.9	1.8	-14%	-27%	-53%
R14	56.2	15.6	1.2	-34%	-40%	-69%
R15	73.3	22.5	2.9	-14%	-14%	-26%

Location	Maximum modelled GLC (µg/m³)			Ratio - with 64 Glenbrook Beach Rd (Site 20) GLC		
	1- hour average (9th ranked)	24-hour average	annual average	1- hour average	24-hour average	annual average
R16	71.5	22.4	2.8	-16%	-14%	-30%
R17	62.6	19.5	1.3	-27%	-25%	-67%
R18	59.9	18.9	1.3	-30%	-27%	-66%
R19	59.4	14.4	1.3	-30%	-45%	-68%
R20	59.3	16.1	1.2	-30%	-38%	-69%
R21	56.7	18.0	1.1	-33%	-31%	-71%
R22	41.3	12.3	0.7	-52%	-53%	-82%
R23	40.6	11.8	0.7	-52%	-55%	-81%
R24	68.2	22.0	2.7	-20%	-15%	-31%
R25	86.2	17.4	0.9	1%	-33%	-78%
R26	89.7	17.5	0.5	5%	-33%	-88%
R27	70.9	17.0	0.8	-17%	-35%	-80%
R28	65.4	15.1	0.7	-23%	-42%	-82%
R29	84.4	13.9	0.7	-1%	-47%	-83%
R30	39.6	9.9	0.6	-54%	-62%	-85%
R31	93.5	29.9	3.0	10%	**15%**	-24%
R32	78.9	25.7	2.5	-7%	-1%	-37%
R33	80.6	26.4	2.6	-5%	1%	-35%
R34	79.2	22.2	2.8	-7%	-15%	-30%
R35	76.7	22.2	2.8	-10%	-15%	-30%
R36	81.1	24.9	2.9	-5%	-4%	-28%
R37	80.3	25.2	3.1	-6%	-3%	-22%
R38	75.6	26.0	3.0	-11%	0%	-24%
R29	63.7	22.9	2.5	-25%	-12%	-36%
R40	73.1	22.3	2.2	-14%	-15%	-45%
R41	74.5	22.4	2.2	-13%	-14%	-43%
R42	61.6	14.2	1.3	-28%	-46%	-66%
R43	63.2	17.4	1.3	-26%	-33%	-67%
R44	59.4	15.6	1.2	-30%	-40%	-69%
R45	55.1	13.2	1.1	-35%	-49%	-73%
R46	58.2	12.2	1.0	-32%	-53%	-74%
R47	61.8	15.8	1.1	-27%	-39%	-71%
R48	86.9	28.8	2.9	2%	**11%**	-27%
R49	64.2	19.9	1.8	-25%	-24%	-55%
R50	60.4	18.5	1.6	-29%	-29%	-60%

Location	Maximum modelled GLC (µg/m³)			Ratio - with 64 Glenbrook Beach Rd (Site 20) GLC		
	1- hour average (9th ranked)	24-hour average	annual average	1- hour average	24-hour average	annual average
R51	63.7	17.8	1.5	-25%	-32%	-61%
R52	69.0	19.9	1.9	-19%	-24%	-52%
R53	84.4	26.3	3.0	-1%	1%	-24%
R54	93.3	28.7	2.9	9%	10%	-25%

6.4 Conclusions

The dispersion model predicts greater impacts of stack emission sources on 24-hour average concentrations (but not annual average concentrations) of PM_{10} and SO_2 at several receptors to the northeast and east of the Site compared to the model predictions at the 64 Glenbrook Beach Rd (Site 20) monitoring location. The difference in GLCs is related to the way the model simulates the effects of building downwash on the dispersion of stack emissions.

The building downwash effect is more significant for the Kiln Stack emissions compared to the MHF Stacks, as the MHF Stacks are located farther from any significant building complexes. The Kiln Stacks have similar PM_{10} emission rates to the MHF Stacks, but lesser SO_2 emission rates. Consequently, the building downwash impacts have a greater influence on modelled PM_{10} concentrations than SO_2 concentrations.

Given the finding that there was a greater degree of model over-prediction for SO_2 concentrations at Glenbrook School (Site 17) compared to 64 Glenbrook Beach Rd (Site 20), it is likely that the building downwash effects are over-stated. However, for the purposes of the AQA, the possibility of stack emissions resulting in higher 24-hour average PM_{10} concentrations (and to a lesser extent 24-hour average SO_2 concentrations) at some locations compared to at 64 Glenbrook Beach Rd (Site 20) will need to be considered.

For completeness, it is noted that worst case 24-hour average PM_{10} concentrations from all sources combined (cumulative exposure) is still expected to be greater at 64 Glenbrook Beach Rd (Site 20) because of the significant contribution from fugitive sources on the worst-case days.

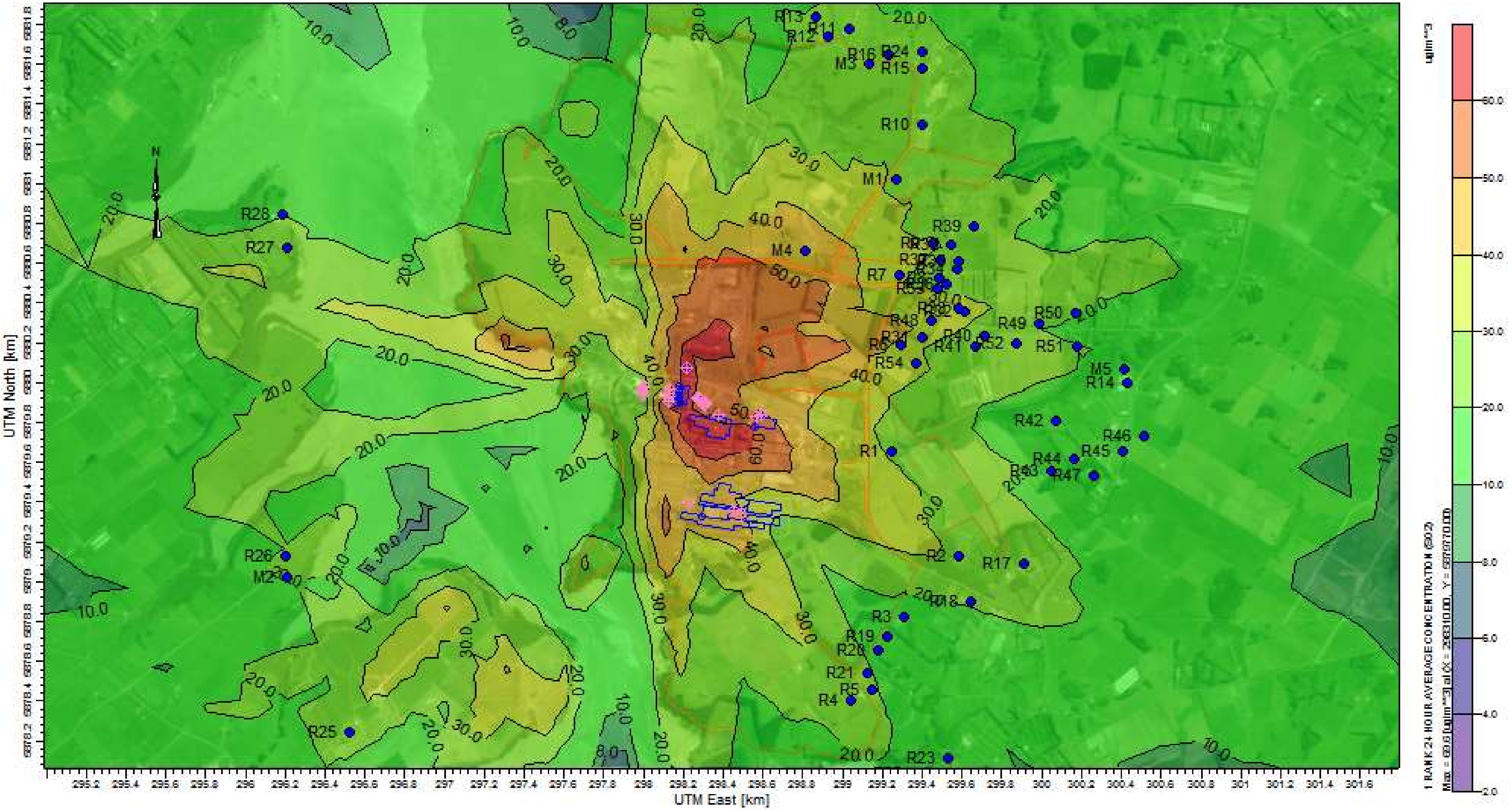

Figure 6.4: 24-hour contour plot for SO_2 for average emissions scenario. (Note: blue dots indicate sensitive receptors and monitoring locations included in the modelling, pink crosshairs are the emission sources, blue lines are the buildings modelled and the red line is the site boundary)

7 Relative contribution of different stack sources

This section assesses the relative contribution of different stack emission sources of PM_{10} to the modelled concentrations at the 64 Glenbrook Beach Rd (Site 20) monitoring site. The dispersion characteristics of different sources will vary depending on stack height and parameters such as exit velocity and temperature, as well as influence from building downwash. Therefore, the impact of stack emissions on GLCs is not necessarily proportional to emission rates.

PM_{10} has been selected for source contribution analysis as there are eleven different stack sources included in the model. The analysis is based on maximum emission rate scenario (rather than the average emission scenario) because the larger input emission rates will better help to identify the potential for contribution, at times, from some of the smaller stack emission sources.

Two different approaches have been used:

- **Table 7.1** shows the contribution from each source on the day with the highest modelled cumulative concentration of PM_{10} at 64 Glenbrook Beach Rd (Site 20). In this case, the contribution from each source adds up to the cumulative modelled concentration.
- **Table 7.2** shows the highest GLC of PM_{10} predicted at 64 Glenbrook Beach Rd (Site 20) for each source. These highest modelled concentrations do not occur on the same day, so should not be added together.

This assessment showed that the MHFs and Kilns are the most significant stack emission sources of PM_{10}, followed by the Steel Plant Baghouse, Metalside Baghouses and Slagside Baghouse. The contributions from other sources are very low.

The individual 24-hour average PM_{10} contour plots for the two largest source contribution (i.e. Kilns and MHFs) were previously shown in **Figure 6.2** and **Figure 6.3**.

Table 7.1: Source contribution (stack emissions) of maximum 24-hour PM_{10} GLCs at 64 Glenbrook Beach Road – maximum emissions scenario

Stack	Stack ID	Maximum emission rate (kg/hr)	Percentage of total PM_{10} emissions	Maximum modelled GLC ($\mu g/m^3$, 24-hour average)	Percentage of modelled GLC (%)
All stacks combined	-	56.6		14.6	-
Kiln stacks (4)	IP23-IP26	20.6	37.4%	7.2	50%
MHF stacks (4)	IP1-IP4	21.2	36.3%	3.1	21%
Steel Plant Baghouse	SP4A-SP4F	4.8	8.6%	1.6	11%
Metalside Baghouses (2)	IP33-IP34	2.1	3.8%	1.6	11%
Slagside Baghouse	IP32	1.0	1.8%	0.73	5%
Acid Regeneration Plant	CSM1	1.0	1.7%	0.12	1%
Pipe Mill Blowdown scrubber	PM3	0.3	0.6%	0.1	1%

Stack	Stack ID	Maximum emission rate (kg/hr)	Percentage of total PM_{10} emissions	Maximum modelled GLC (µg/m^3, 24-hour average)	Percentage of modelled GLC (%)
Pipe Mill Galvanising Baghouse	PM2	0.2	0.3%	0.04	0.3%
Primary Concentrate Drier Baghouse	SR1	0.04	0.1%	0.02	0.2%
KOBM Flarestack	SP1	5.1	9.0%	0.02	0.1%
Slab Reheat Furnace	HSM1	0.3	0.6%	0.02	0.1%

Table 7.2: Maximum source contribution of 24-hour PM_{10} GLCs at 64 Glenbrook Beach Road from individual stacks – maximum emissions scenario

Stack	Stack ID	Glenbrook Beach Road - Maximum 24-hour GLC (µg/m^3)
Kiln stacks (4)	IP23-IP26	7.5
MHF stacks (4)	IP1-IP4	4.4
Steel Plant Baghouse	SP4A-SP4F1	1.9
Metalside Baghouses (2)	IP33-IP34	1.7
Slagside Baghouse	IP32	1.2
Acid Regeneration Plant	CSM1	0.9
Pipe Mill Blowdown Scrubber	PM3	0.5
KOBM Flarestack	SP1	0.3
Pipe Mill Galvanising Baghouse	PM2	0.2
Slab Reheat Furnace	HSM1	0.07
Primary Concentrate Drier Baghouse	SR1	0.04

The five main stack source groups at the site account for 98% of the modelled maximum GLC at 64 Glenbrook Beach Rd (Site 20). The MHFs and Kilns contribute approximately 70% of the PM_{10} on the day with the highest modelled GLC. This is consistent with their relative contribution of approximately 74% of the combined PM_{10} emissions from all (modelled) stack sources.

Although the MHFs and Kilns have similar emission rates of PM_{10}, the GLCs from the Kiln emissions are almost double those of the MHFs. This is further evidence of the modelled impact of building downwash on the Kiln Stack emissions.

8 Model results for contaminants assessed using dispersion modelling

8.1 Introduction

The GLCs predicted using dispersion modelling have only been used to directly assess the effects of contaminants for which ambient air quality monitoring data is not available. The assessment of potential effects of other contaminants has been based on the monitoring data and taking into account the findings of the modelling study with regard to the location of worst-case impacts of stack emission sources.

The following contaminants have been assessed by comparing predicted off-site concentrations against relevant assessment criteria:

- CO
- HCl and Cl_2
- VOCs
- Mercury

Background concentrations of these contaminants, other than CO, have been assumed to be negligible (zero).

Assessment criteria have been adopted based on the hierarchy set out in relevant Ministry for the Environment good practice guidance (GPG Industry[13]), and include values from the National Environmental Standards for Air Quality (NESAQ), New Zealand Ambient Air Quality Guidelines (AAQG), Auckland Ambient Air Quality Targets (AAAQT) set in the Auckland Unitary Plan and international guidelines, where relevant.

Assessment criteria are available for a range of different averaging periods. For assessment criteria based on an annual average, the assessment is based on the model predictions for average emission rates. For shorter term averaging periods, the assessment is based on maximum emission rates (or consent limits in the case of CO).

The assessment criteria apply in different locations based on the likelihood of a person being present over the relevant averaging periods, as summarised in **Table 8.1**.

For consistency with the locations where these criteria apply, the GLCs are reported as follows:

- Maximum 1-hour (99.9th percentile) GLC are reported as the highest concentrations anywhere at or beyond the Site boundary; and
- Maximum 8-hour, 24-hour, 3-month and annual average GLC are reported as the highest concentration at any discrete sensitive receptor (residence).

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[13] Ministry for the Environment. (2016). Good Practice Guide for Assessing Discharges to Air from Industry.

Table 8.1: Location and applicability of the ambient standards for assessment purposes

Averaging period	Locations where assessment against the ambient standards should apply	Locations where assessment against the ambient standards should not apply
1-hour	This includes any outdoor areas where the public might reasonably be expected to spend one hour or longer, including pavements in shopping streets, as well as accessible facades (e.g., balconies, terraces).	Any industrial premises that have resource consents (for that pollutant)[14].
8-hour	This includes all outdoor locations where members of the public are likely to be exposed for eight hours as well as the facades of residential properties, schools, hospitals, libraries, etc.	Any industrial premises that have resource consents (for that pollutant). Any location where people are not likely to be exposed for eight hours – for example roads and footpaths.
24-hours (and greater)	This includes all outdoor locations where members of the public might reasonably be exposed for 24-hours.	Any industrial premises that have resource consents for that pollutant. Any location where people are not likely to be exposed for 24-hours – for example roads, footpaths and industrial areas where residential use is not allowed.

8.2 Assessment of carbon monoxide emissions

The relevant assessment criteria for emissions of CO are:

- 30,000 µg/m^3 as a 1-hour average (from the AAQG and AAAQT).
- 10,000 µg/m^3 as an 8-hour average (from the NESAQ).

Background concentrations of CO have been adopted from the default background concentrations recommended for rural areas in the GPG Industry (see AQA **Appendix C Table 4**).

The model predictions are based on the maximum emissions scenario and the maximum GLC predicted at the Site boundary. As shown in **Table 8.2**, the modelled concentrations of CO are low compared to the assessment criteria.

Table 8.2: Evaluation of GLC of CO against assessment criteria

Averaging period	Assessment criteria (µg/m^3)	GLC (µg/m^3)	Background concentration (µg/m^3)	Cumulative GLC (µg/m^3)	% of criterion
1-hour average	30000	2268 (8% of criterion)	5000	7268	24%
8-hour average	10000	1184 (12% of criterion)	2000	3184	32%

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[14] In this context, the NESAQ do not apply to locations within the Site.

8.3 Assessment of hydrogen chloride and chlorine emissions

The relevant assessment criteria for emissions of HCl and Cl_2 are set out below.

For HCl:

- 2100 µg/m^3 as a 1-hour average (from the California OEHHA).
- 20 µg/m^3 as a 24-hour average (from the Ontario (Canada) Ambient Air Quality Criteria).

For Cl_2:

- 210 µg/m^3 as a 1-hour average (from the California OEHHA).
- 10 µg/m^3 as a 24-hour average (from the Ontario (Canada) Ambient Air Quality Criteria).

Background concentrations of HCl and Cl_2 are expected to be negligible as there are no other identified sources in the area.

The assessment is based on the maximum measured concentrations from the two monitored stacks. The 1-hour average GLC are the maximum predicted at the site boundary and the 24-hour average GLC are the maximum predicted at a sensitive receptor.

As shown in **Table 8.3**, the modelled concentration of HCl and Cl_2 are low compared to the assessment criteria.

Table 8.3: Evaluation of GLC of HCl and Cl_2 against assessment criteria

Contaminant	Averaging period	GLC (µg/m^3)	Assessment criteria (µg/m^3)	% of criterion
HCl	1-hour	3.7	2100	0.2%
Cl_2		14.3	210	7%
HCl	24-hour	0.43	20	2%
Cl_2		1.6	10	16%

8.4 Assessment of emissions of volatile organic compounds

There is a variety of VOCs emitted from the Prime and Finish ovens on the Paint Line, depending on the particular paints and coatings that are used. The only New Zealand guideline value for ambient concentrations of VOCs is for benzene. In the absence of local guidance, the OEHHA Acute Reference Exposure Level and the Texas Commission on Environmental Quality Effects Screening Level (TCEQ ESL) have been used for other relevant VOCs. The specific sources of each of the assessment criteria are listed in Appendix B.5.2 of the AQA.

Background concentrations of VOCs are expected to be negligible as there are no other identified sources in the area.

The assessment of the model predictions of VOCs is set out in **Table 8.4**.

The 1-hour average GLC are the maximum predicted at the site boundary and the 24-hour average GLC are the maximum predicted at a sensitive receptor.

As shown in **Table 8.4**, the concentrations of VOCs are all less than 1% of the relevant assessment criterion and, in most cases, many orders of magnitude below the criterion.

Table 8.4: Evaluation of VOCs against assessment criteria

Contaminant	1-hour average			8-hour average			Annual average		
	1-hour GLC	Assessment criterion	% of criterion	8-hour GLC	Assessment criterion	% of criterion	Annual GLC	Assessment criterion	% of criterion
Benzene	-	-		-	-	-	0.03	3.6	0.9%
Toluene	0.098	5000	0.002%	0.0036	830	0.0004%	0.004	420	0.001%
Ethylbenzene	0.019	2000	0.0009%	-	-	-	-	-	-
Total xylenes	0.169	22000	0.0008%	-	-	-	0.01	700	0.001%
Styrene	0.057	21000	0.0003%	-	-	-	0.002	900	0.0002%
Iso-Propylbenzene (cumene)	0.021	250	0.008%	-	-	-	-	-	-
n-Propylbenzene	0.058	2500	0.002%	-	-	-	-	-	-
1,3,5 - Trimethylbenzene	0.058	4400	0.001%	-	-	-	-	-	-
1,2,4 - Trimethylbenzene	0.14	4400	0.0032%	-	-	-	-	-	-
sec- Butylbenzene	0.004	2740	0.0002%	-	-	-	-	-	-
Naphthalene	0.008	9	0.09%	-	-	-	-	-	-
Methyl isobutyl ketone (MIBK)	0.109	820	0.01%	-	-	-	-	-	-
2-Chlorotoluene	0.034	260	0.01%	-	-	-	-	-	-
n-Butylbenzene	0.003	2740	0.0001%	-	-	-	-	-	-

8.5 Assessment of mercury emissions

The relevant assessment criterion for emissions of mercury is 0.33 µg/m^3 as an annual average (for inorganic mercury) from the New Zealand AAQG and AAAQT. The predicted GLC of mercury (at the nearest sensitive receptor) is 0.0002 µg/m^3 (annual average), which as shown in **Table 8.5**, is 0.05% of the assessment criterion.

Table 8.5: Evaluation of GLC of mercury against assessment criterion

Averaging period	Assessment criteria (µg/m^3)	GLC (µg/m^3)	% of criterion
Annual	0.33	0.0002	0.05%

9 Conclusions

Objective	Conclusions
Evaluate the performance of the dispersion model by comparing the model predictions with measured data.	Overall, the dispersion model conservatively over-predicts the measured concentrations of SO_2 (at 64 Glenbrook Beach Rd (Site 20) and Glenbrook School (Site 17)) and mostly over-predicts the measured concentrations of NO_X (at 64 Glenbrook Beach Rd). The model tends to over-predict by a greater margin at Glenbrook School compared to 64 Glenbrook Beach Rd. This is most likely due to the way that the model simulates building downwash effects. The overall conclusions are that the model performance is adequate and that it provides a useful and somewhat conservative tool for the purpose of predicting GLCs for contaminants where air quality monitoring data is not available
Investigate whether air quality measured at 64 Glenbrook Beach Rd (Site 20) is representative of worst-case impacts at sensitive receptors and provide a basis for inferring likely air concentrations at other (un-monitored) locations if needed.	The dispersion model predicts greater impacts of stack emission sources on 24-hour average concentrations (but not annual average concentrations) of PM_{10} and SO_2 at several receptors to the northeast and east of the Site compared to the model predictions at the Glenbrook Beach Rd (Site 20) monitoring location. The difference in GLCs is related to the way the model simulates the effects of building downwash on the dispersion of stack emissions. The building downwash effect is more significant for the Kiln Stack emissions compared to the MHF Stacks, as the MHF Stacks are located farther from any significant building complexes. The Kiln Stacks have similar PM_{10} emission rates to the MHF Stacks, but lesser SO_2 emission rates, which explains why the building downwash impacts have a greater influence on modelled PM_{10} concentrations than SO_2 concentrations. These findings can also be related to the effects of NO_2. The main sources of NOx emissions are the KOBM Flarestack, which will not be affected by building downwash due to its high effective stack height, and the MHF Stacks. Given the finding that there was a greater degree of model over-prediction for SO_2 concentrations at Glenbrook School (Site 17) compared to 64 Glenbrook Beach Rd (Site 20), it is likely that the building downwash effects are over-stated. However, for the purposes of the AQA, the possibility of stack emissions resulting in higher 24-hour average PM_{10} concentrations at some locations compared to at 64 Glenbrook Beach Rd (Site 20) will need to be considered. **Table 6.1** provides a basis for adjusting the measured PM_{10} concentrations at 64 Glenbrook Beach Rd (Site 20) to infer likely concentrations at other locations. However, it is important to note that this only applies to the stack emission component of the measured concentrations (not the total measured concentration, which will include contributions from a variety of sources).

Objective	Conclusions
	64 Glenbrook Beach Rd (Site 20) is likely to be reasonably representative of worst-case impacts of SO_2 and NO_2 at discrete receptors, although the possibility of slightly higher 24-hour average SO_2 concentrations at 190 Mission Bush Rd cannot be discounted.
Understand the relative impacts of different stack emission sources to measured air quality at 64 Glenbrook Beach Rd (Site 20).	The five main stack source groups at the site account for 98% of the modelled maximum GLC at 64 Glenbrook Beach Rd (Site 20). The MHFs and Kilns contribute approximately 70% of the PM_{10} on the day with the highest modelled GLC. This is consistent with their relative contribution of approximately 74% of the combined PM_{10} emissions from all (modelled) stack sources. Although the MHFs and Kilns have similar emission rates of PM_{10}, the GLCs from the Kiln emissions are almost double those of the MHFs. This is further evidence of the modelled impact of building downwash on the Kiln Stack emissions. As previously noted, it is likely that these effects are being over-stated by the model.
For contaminants where air quality monitoring data is not available, to provide a basis for assessing their potential effects by comparing model predictions (and background concentrations where relevant) against assessment criteria.	The GLCs predicted by the dispersion model for CO, HCL, Cl_2, VOCs and mercury (contaminants for which air quality monitoring data is not available) have been compared with relevant assessment criteria. Background concentrations of CO have been adopted based on recommended good practice guidance, and background concentrations of other contaminants are expected to be negligible because there are no sources in the area. The modelled concentrations of these contaminants are low, or very low, compared to relevant assessment criteria.

10 Applicability

This report has been prepared for the exclusive use of our client New Zealand Steel, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

We understand and agree that our client will submit this report as part of an application for resource consent and that Auckland Council as the consenting authority will use this report for the purpose of assessing that application.

Tonkin & Taylor Ltd

Report prepared by:	Authorised for Tonkin & Taylor Ltd by:
....	....
Suk-yi Lo	Jenny Simpson
Associate Environmental Engineer	Project Director

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Appendix A: Discrete receptors

Appendix A Table 1: Modelled discrete receptors

Receptor ID (off-site dwelling unless otherwise stated)	Address	Approximate distance from the nearest Operational Area boundary (m)
R1 (on-site dwelling)	130 Mission Bush Rd	135
R2	60 Mission Bush Rd	415
R3	27 Williams Rd	340
R4 (on-site dwelling)	67 Williams Rd	530
R5	65 Williams Rd	500
R6	190 Mission Bush Rd	500
R7 (on-site dwelling)	152 Brookside Rd	549
R8	17 Reg Bennett Rd	725
R9	29 Reg Bennett Rd	765
R10	78 Glenbrook Beach Rd	1070
R11	160 Glenbrook Beach Rd	1255
R12	159 Glenbrook Beach Rd	1190
R13	185 Glenbrook Beach Rd	1265
R14 (Glenbrook School)	459 Glenbrook-Waiuku Rd	1320
R15	118 Glenbrook Beach Rd	1275
R16	134 Glenbrook Beach Rd	1235
R17	341 Glenbrook-Waiuku Rd	750
R18	37 Mission Bush Rd	560
R19	39 Williams Rd	335
R20	45 Williams Rd	350
R21	65 Williams Rd	420
R22	36C Waitangi Falls Rd	980
R23	36D Waitangi Falls Rd	995
R24	122 Glenbrook Beach Rd	1340
R25	56 Mayhead Rd	1770
R26	2 Boundary Rd	1615
R27	194 Waipipi Wharf Rd	1420
R28	203 Waipipi Wharf Rd	1500
R29	133 Marae O Rehia Rd	1900
R30	13 Rangiwhea Rd	2190
R31	198 Mission Bush Rd	560
R32	120 Brookside Rd	790
R33	116 Brookside Rd	750
R34	22 Reg Bennett Rd	720

Receptor ID (off-site dwelling unless otherwise stated)	Address	Approximate distance from the nearest Operational Area boundary (m)
R35	22 Reg Bennett Rd	730
R36	17 Reg Bennett Rd	670
R37	27 Reg Bennett Rd	640
R38	30 Reg Bennett Rd	710
R39	30A Reg Bennett Rd	840
R40	103 Brookside Rd	780
R41	103 Brookside Rd	700
R42	413B Glenbrook-Waiuku Rd	960
R43	377 Glenbrook-Waiuku Rd	940
R44	411B Glenbrook-Waiuku Rd	1050
R45	435 Glenbrook-Waiuku Rd	1290
R46	434 Glenbrook-Waiuku Rd	1400
R47	411A Glenbrook-Waiuku Rd	1130
R48	127 Brookside Rd	630
R49	76 Brookside Rd	1030
R50	62 Brookside Rd	1220
R51	61 Brookside Rd	1150
R52	91 Brookside Rd	890
R53	17 Reg Bennett Rd	630
R54	190 Mission Bush Rd	430

Figure Appendix A.1: Modelled receptor and monitoring site locations

Appendix B: Selection of years for meteorological modelling

B1 Selection of meteorological years

B1.1 Southern Oscillation Index

A significant driver in the annual variation in meteorology in New Zealand is the presence of El Niño or La Niña conditions. The Southern Oscillation Index (SOI) is a measure of the variation in sea surface temperature over the tropical eastern Pacific Ocean, which in turn affects much of the climate of adjacent tropical and sub-tropical areas. The warming phase of the tropical eastern Pacific Ocean is referred to as El Niño, whereas the cooling phase is La Niña.

Over a period of 3 months or more, SOI values below -1 correspond to El Niño conditions, while values above 1 correspond to La Niña conditions. Values between -0.5 and -1.0 lean toward El Niño, while values between 0.5 and 1.0 lean toward La Niña. Values between -0.5 and 0.5 are considered neutral[15].

The meteorological years selected for the modelling were 2015 to 2017. The three continuous calendar years of meteorological modelling were selected to account for a reasonably wide range of meteorological variability in the locality of the Site, including incorporation of El Niño Southern Oscillation (ENSO) climate oscillations that influence New Zealand's weather and climate as shown in the SOI values in **Figure Appendix B.1**, namely:

- Strong El Niño systems in 2015 (3 months or more of SOI values below -1); and
- Weak La Niña systems in 2017 (3 months of more of SOI values between 0.5 and 1.0).

From 1990 to 2019, the most recent El Niño phases of the southern oscillation index (SOI) were in 2015/16[16]. Generally, during El Niño, New Zealand tends to experience stronger or more frequent winds from the west in summer; in winter, the winds tend to blow more from the south; and in spring and autumn, south-westerly winds are more common. North-easterly winds tend to become more common during La Niña events[19].

B1.2 Influence of El Niño and La Niña on local wind patterns

Wind roses for each year from 2015 through to 2017 are provided in **Figure Appendix B.2** for the Pukekohe EWS. Compared to 2016/2017, the El Niño year of 2015 shows characteristic increases in southwesterlies/west-southwesterlies, which blows the emissions from the Steel Mill inland. In 2017, the La Niña effects were relatively brief and weak, and hence the wind rose showed no distinct increase in the frequency of northeasterlies compared to 2015/2016.

On balance, it is considered that the choice to model the years 2015 to 2017 covers an appropriate range of meteorological conditions likely to occur at the Site.

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[15] Source: https://niwa.co.nz/climate/information-and-resources/elnino

[16] Source: https://stats.govt.nz/indicators/el-nino-southern-oscillation

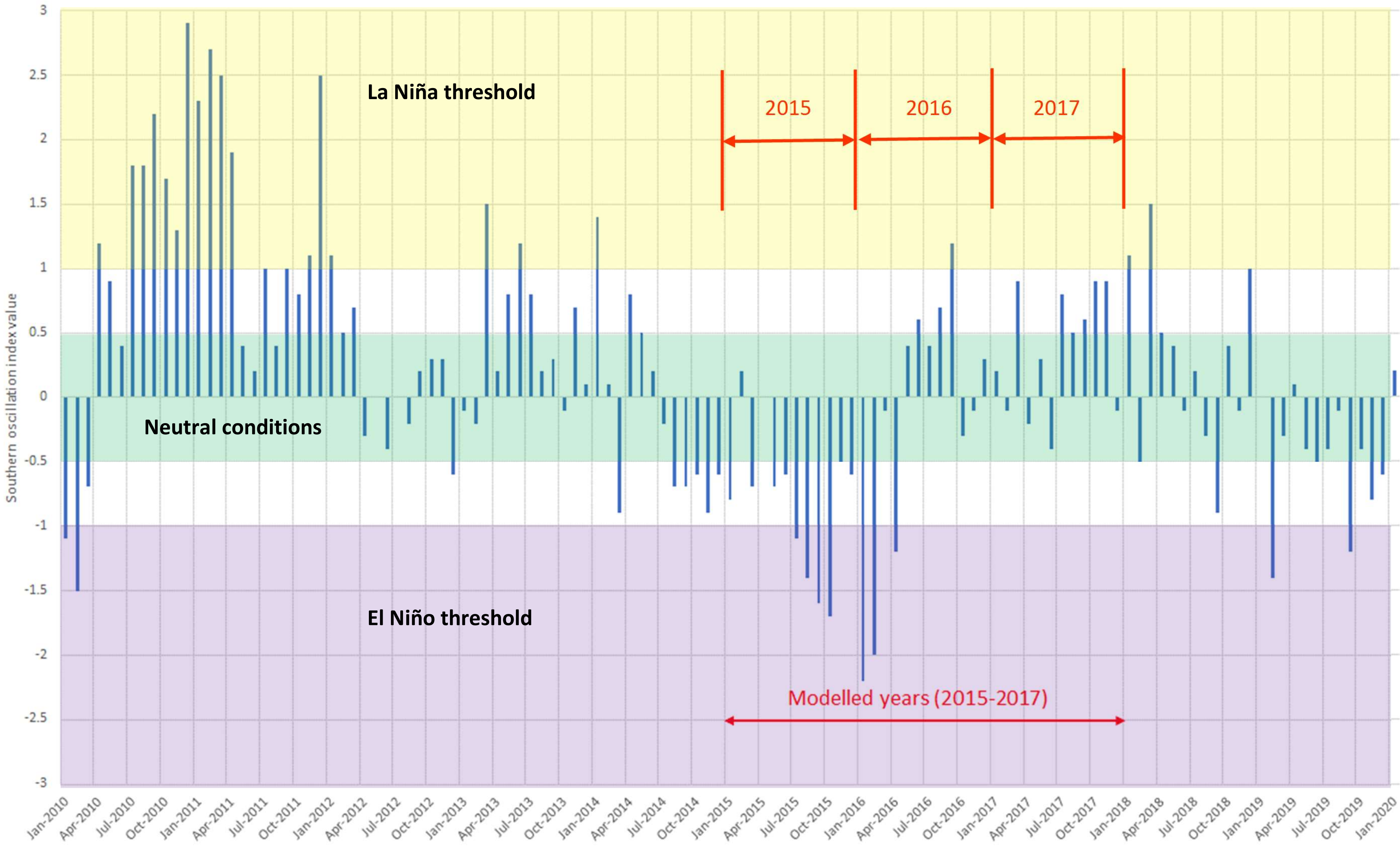
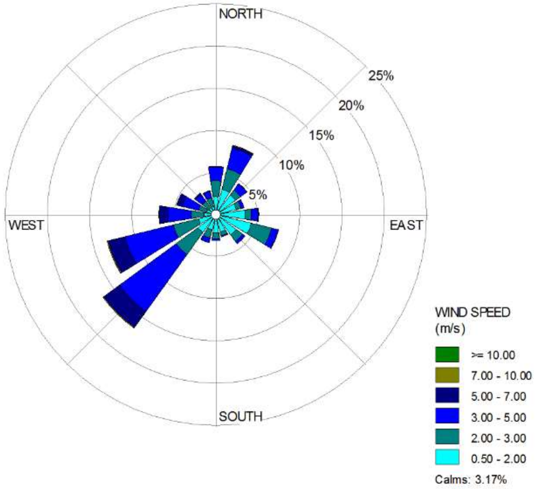


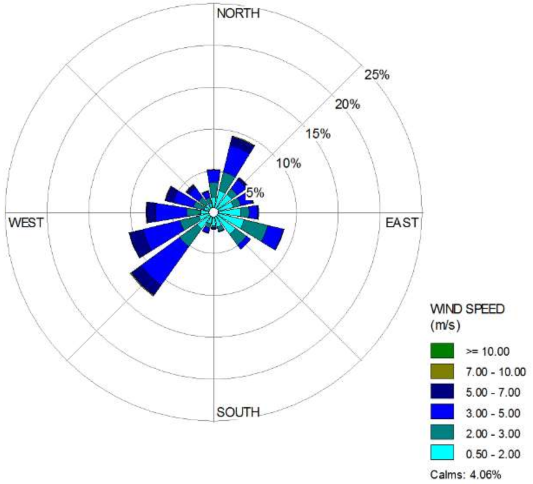
Figure Appendix B.1: Southern oscillation index value (Source: https://www.ncdc.noaa.gov/teleconnections/enso/indicators/soi/)



2015

Calms – 3.17%

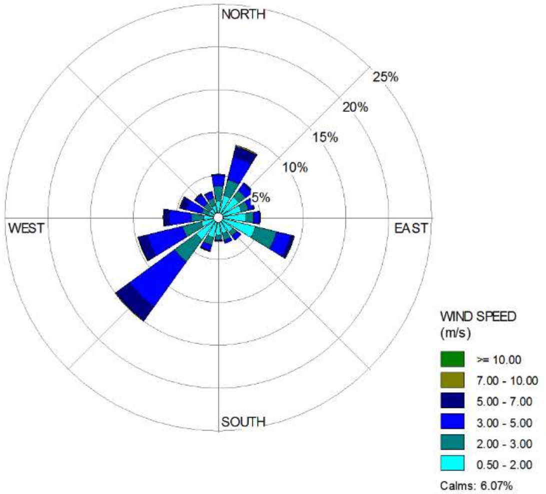
Average wind speed – 2.54 m/s



2016

Calms – 4.06%

Average wind speed – 2.60 m/s



2017

Calms – 6.07%

Average wind speed – 2.44 m/s

Figure Appendix B.2: Wind roses at Pukekohe EWS

Appendix C: Selection of representative stack emission rates

C1 Detailed derivation of emission rates

C1.1 Introduction

This Appendix provides analysis of the stack testing results for each contaminant, which has informed the selection of representative emission rates for dispersion modelling. Some of the information in this Appendix is similar to the information presented in Section 4 of the AQA for readability.

For each contaminant average and maximum emission rates are derived using the average and maximum measured concentration and the average volumetric flowrate (rounded to nearest 10 m^3/hr) of the dataset as shown in **Appendix C Table 1.**

Maximum permitted emission rates are also derived in this way where concentration limits have been set in the existing Main Air Permit.

Appendix C Table 1: Volumetric flowrates, consent limit concentrations and corresponding mass emission rates

Stack	Stack ID	Volumetric flow rate STP (m^3/hr)	TSP limit mg/m^3	TSP limit kg/hr	CO limit mg/m^3	CO limit kg/hr	HCl limit mg/m^3	HCl limit kg/hr
MHF stacks	IP1-IP4	83230	75	6.2				
Kiln stacks	IP23-IP26	76190	75	5.7	3750	285.7		
Metalside Baghouses	IP33-IP34	87970	50	4.4				
Slagside Baghouse	IP32	70720	50	3.5				
Steel Plant Baghouse	SP4A-SP4F	100530						
KOBM Flarestack	SP1	42990	200	8.6				
Slab Reheat Furnace	HSM1	52260						
Pipe Mill Blowdown Scrubber	PM3	6560	125	0.8				
Pipe Mill Galvanising Baghouse	PM2	41720	10	0.4				
Acid Regeneration Plant	CSM1	3050					45	0.14
Primary Concentrate Drier baghouse	SR1	4420	10	0.04				
Pickle Line Scrubber	CSM3	20490					20	0.41
Paint Line Prime Oven Incinerator stack	CCL3	10950						
Paint Line Finish Oven Incinerator stack	CCL4	13770						

C1.2 Emissions from KOBM Flarestack

The KOBM Flarestack discharge profile to the atmosphere changes according to the ‘heat’ cycle within the KOBM process.

Each ‘heat’ in the KOBM process takes about 30 minutes (i.e. two ‘heats’ per hour), and within these 30 minutes, there is approximately 10 – 12 minutes where CO is being generated. Outside of this window (18 – 20 minutes in duration), CO concentration is essentially 0%. This is because when the 'skirt' of the KOBM hood is lifted, excess air enters the waste gas system above KOBM vessel, whereby the temperature from primary post combustion above the metal bath within the vessel exceeds the gas auto-ignition temperature and any CO within the vessel readily reacts with the excess oxygen and secondary post combustion occurs.

During the 10-to-12-minute window when the CO is generated as the iron is de-carburised, the concentration of CO affects the flammability of the exit stream at the KOBM flare tip. At the start of the 'heat', CO rapidly rises from 0% to 30% within about 30 seconds, with CO concentration peaking at about 50% during the 10-to-12-minute window. Within the flammability envelope in **Figure Appendix C.1** starting at about 13% CO concentration and depending on the oxygen concentration, there is potential for the exit stream to start flaring as a worst-case assumption. As such, over the course of an hour (i.e. two 'heats'), a maximum of about 23 minutes flaring may occur.

During flaring, very high temperatures are reached (default modelling temperature of 1000 degrees Celsius is typically assumed) and flare combustion is often hard to capture in real-time, rendering emissions testing onsite extremely difficult (if not impossible) and therefore not typically undertaken. Instead, the approach used for this assessment is to apply similar emission factors[17] to provide indicative flare emissions.

The hourly timeline of the KOBM flaring/non-flaring profile relating to the 'heat', which forms the basis of the assumptions for calculating emissions from the KOBM Flarestack, is summarised in **Figure Appendix C.2**. **Appendix C Table 2** provides a summary of emission rates from KOBM Flarestack used for dispersion modelling.

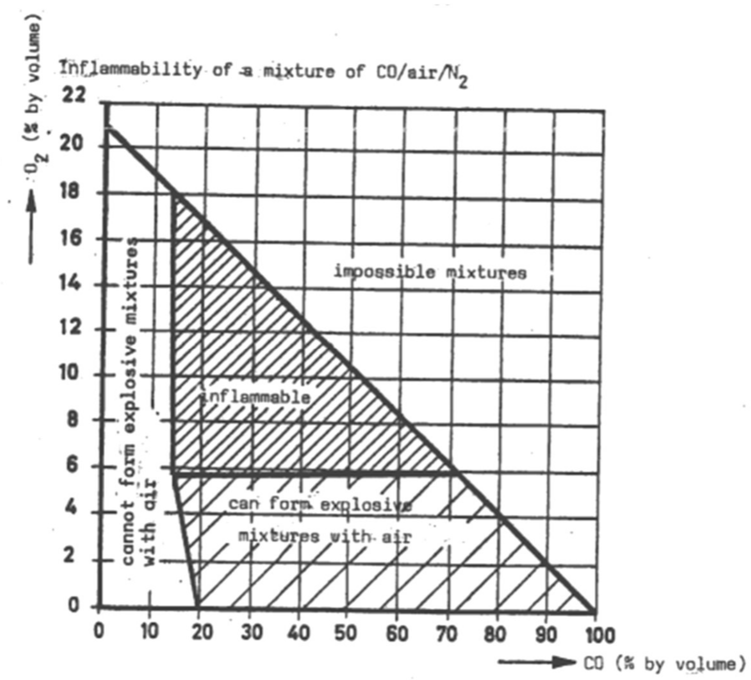


Figure Appendix C.1: Flammability chart of a mixture of CO/air/nitrogen

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[17] The USEPA emission factors are established based on combustion of hydrocarbons, and as such there may be some inherent uncertainties in applying them to the CO-rich combustion stream in the case of this modelling.

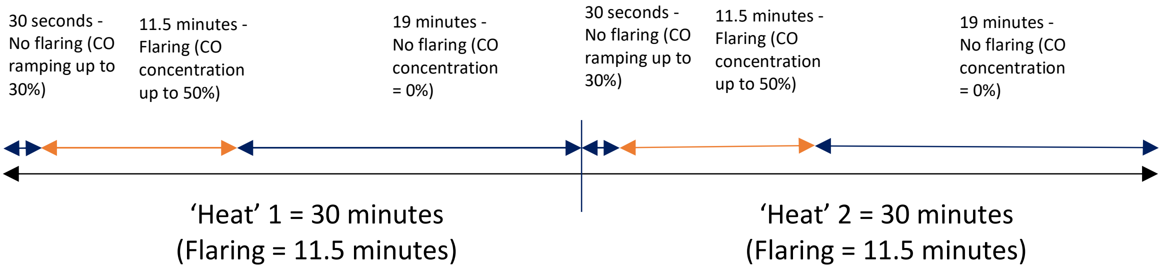

Figure Appendix C.2: Assumed hourly KOBM flaring/non-flaring profile for dispersion modelling (rounding up of timeframes have occurred to simplify the assumptions)

Appendix C Table 2: Emission rates from KOBM flare used in dispersion modelling

Flaring mode	TSP (kg/hr)	PM_{10} (kg/hr)	$PM_{2.5}$ (kg/hr)	SO_2 (kg/hr)	NO_X (kg/hr)	CO (kg/hr)	Basis
Non-flaring	4.8	3.4	3.4 (assumed same as PM_{10})	0.12	-	-	Measured upstream of KOBM flare
Flaring	4.8	3.4	3.4 (assumed same as PM_{10})	0.12	0.42	134	NO_X and CO calculated using typical gas composition of gas flow upstream of KOBM flare, and flaring emission factors from United State Environmental Protection Agency (USEPA), AP-42, Chapter 13.5 Industrial Flares. Assumed 99% flaring efficiency (i.e. 1% unflared) for CO calculations. Assumed thermal NO_X as main NO_X formation pathway.

C1.3 Particulate matter

C1.3.1 Overview

Emissions of TSP from selected stacks have been measured as part of the stack testing required under the Main Air Permit. Measurement of PM_{10} and $PM_{2.5}$ has not been required as part of historic stack testing for the site and is not possible for stacks which utilise wet scrubbing technology such as the MHFs, Kilns and KOBM Primary off-gas system.

Since 2012, NZ Steel have undertaken size-speciated testing to determine the ratio of PM_{10} to TSP for the Steel Plant Baghouse, and since December 2018 to confirm the ratio of $PM_{2.5}$ to TSP for the Steel Plant Baghouse, Melter Metalside Baghouses and Melter Slagside Baghouse.

The fraction of measured TSP found to be PM_{10} or $PM_{2.5}$ is shown in **Appendix C Table 3** below.

Appendix C Table 3: PM_{10} and $PM_{2.5}$ fraction of TSP at monitored stacks

Stack ID	Stack name	Fraction PM_{10}/TSP	Fraction $PM_{2.5}$/TSP	Number of results PM_{10}/$PM_{2.5}$
IP33/IP34	Melter Metalside Baghouse	-	0.42	0 / 10
IP32	Melter Slagside Baghouse	-	0.62	0 / 10
SP4	Steel Plant Baghouse	0.52	0.57	12 / 4

For the purposes of dispersion modelling it has been assumed that all PM_{10} emissions from processes at the Steel Mill are $PM_{2.5}$. Testing at the Steel Plant baghouse for PM_{10} and $PM_{2.5}$ were not conducted concurrently, so the slightly higher $PM_{2.5}$ fraction is adopted as the PM_{10} fraction.

The fraction of TSP that is PM_{10} for the KOBM primary off-gas system (emitted at the KOBM flarestack) is thought to be 70% based on USEPA AP42 publication[18], specifically Figure 12.5-3 which shows the cumulative mass percentage of particulate below 10 micrometres for a basic oxygen furnace operated with a scrubber. The fraction of TSP that is PM_{10}/$PM_{2.5}$ for all other stacks that have not been the subject of size analysis is presumed to all be PM_{10}. The fraction of PM_{10} in the TSP for each stack is shown in **Appendix C Table 4** below.

Appendix C Table 4: Fraction of TSP presumed to be PM_{10} for monitored stacks

Stack ID	Stack name	Fraction PM_{10}/TSP
IP1 - IP4	MHF stacks	1.0
IP23 - IP26	Kiln stacks	1.0
IP33/IP34	Metalside Baghouse	0.42
IP32	Slagside Baghouse	0.62
SP4	Steel Plant Baghouse	0.57
SP1	KOBM Flarestack	0.7
HSM1	Slab Reheat Furnace	1.0

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[18] USEPA, Compilation of Air Pollutant Emissions Factors (AP-42), United States of America, 1995.

Stack ID	**Stack name**	**Fraction PM_{10}/TSP**
PM3	Pipe Mill Blowdown scrubber	1.0
PM2	Pipe Mill Galvanising Baghouse	1.0
CSM1	Acid Regeneration Plant	1.0
SR1	Primary Concentrate Drier Baghouse	1.0

C1.3.2 PM_{10} and $PM_{2.5}$

The representative emission rate of PM_{10} from each of the measured stacks is shown in **Appendix C Table 5** and illustrated in the box and whisker plot in **Figure Appendix C.3** below. The consent limit emission rate is found using the applicable concentration limit in the current Air Permit and the average volumetric flowrate.

Appendix C Table 5: PM_{10}/ $PM_{2.5}$ emission rates used in modelling

Stack	**Number of tests**	**Emission rate (kg/hr)**		
		Average	**Maximum**	**Consent limit**
MHF stacks	96	2.50	5.15	6.24
Kiln stacks	94	2.81	5.29	5.71
Metalside Baghouse	43	0.30	1.08	1.81
Slagside Baghouse	38	0.36	1.00	2.18
Steel Plant Baghouse	16	0.48	0.81	-
KOBM Flarestack	48	3.39	5.08	6.02
Slab Reheat Furnace	6	0.22	0.32	-
Pipe Mill Blowdown scrubber	46	0.17	0.35	0.82
Pipe Mill Galvanising Baghouse	11	0.13	0.16	0.42
Acid Regeneration Plant[1]	15	0.45	0.97	-
Primary Concentrate Drier Baghouse	7	0.02	0.04	-

1. Particulate testing at this stack uses non-standard method due to interaction with the acid testing method. It has conservatively been included in the modelling.

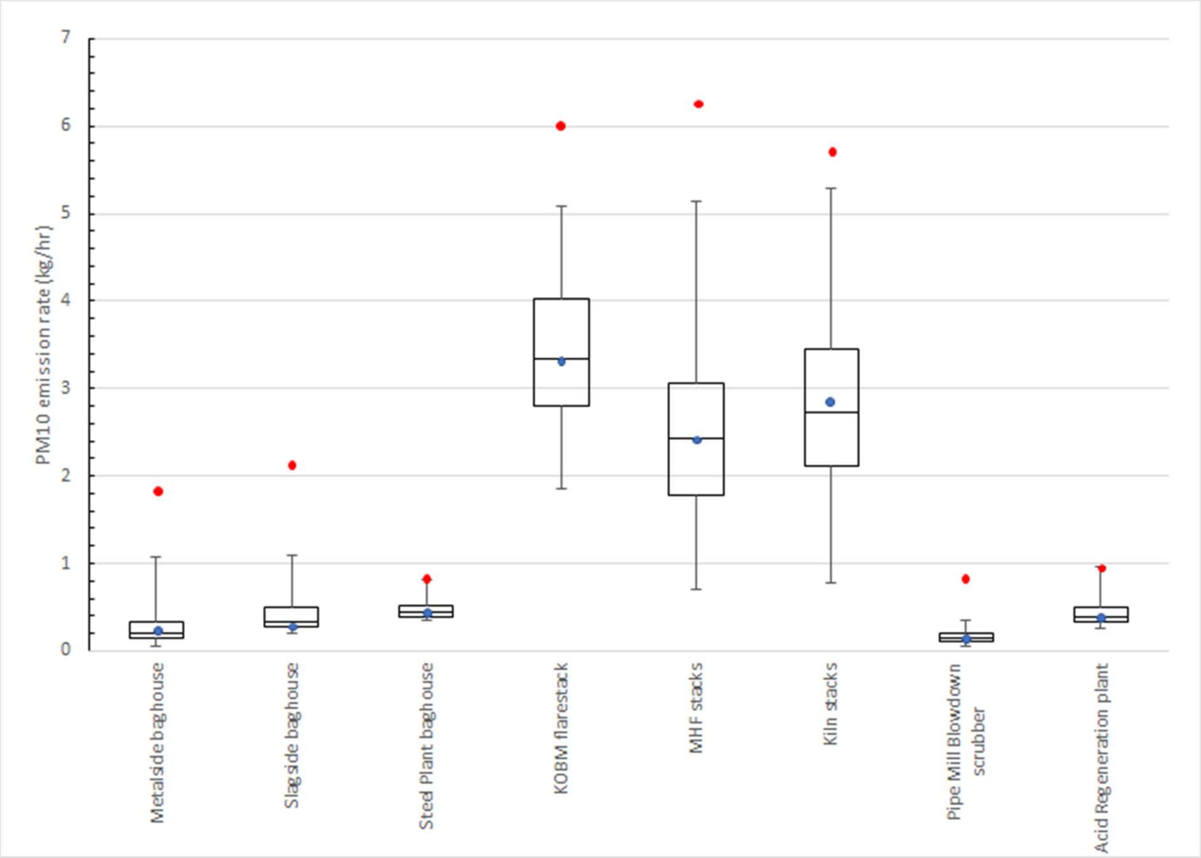

Figure Appendix C.3: Box and whisker of PM_{10} emission rates from monitored stacks. The red dots denote the consent limit or peak measured emission rate, while the blue dots indicate the average emission rate.

There is a wide range of variability in the emission rates from the three largest sources. At the KOBM flarestack, this is expected to be due to the nature of the batch process for producing steel and the fluctuating emissions at the different stages of the batch (gas addition from tuyeres, raw material additions, slag and metal tapping) across the hour of measurement for each sample. Variability at the Iron Plant processes and in particular the MHFs has been reviewed and a relationship with coal feedrates and waste gas flow rate identified. Higher coal feedrates cause a higher waste gas flowrate (as the coal produces the gas), and the increased waste gas flow contributes to greater elutriation (pick up) of particulate from the raw material. This elutriation also results in lowered energy efficiency as more coal is lost as particulate. Coal feedrates are optimised to improve process efficiency by maintaining a slightly lower feedrate (37 tph vs 40 tph).

C1.4 Sulphur dioxide

SO_2 emissions from the Site are a function of the sulphur content of the coal, and the key sources of sulphur dioxide are consequentially the front end coal-reduction processing that occurs in the Iron Plant in particular the MHFs, with the Kilns constituting a secondary source. SO_2 concentrations from the MHF stacks, Kiln stacks (waste gases from the Kilns and Melters) have been measured on a six monthly basis since 2017, using a barium-thorin titration method[19]. There were infrequent test results from prior to this period, some collected as early as 2013, using a combustion gas analyser. Six measurements have been taken at the KOBM Flarestack since 2015, however readings of SO_2 at this stack are typically low, as expected given that the majority of releases are from the Iron Plant processes.

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[19] USEPA Method 6 for determination of sulphur dioxide emissions from stationary sources

The distribution of the measured stack testing data is presented for the MHF stacks and Kilns stacks in **Appendix C Table 6** below. The second highest concentration reading from the MHF stacks has been used for modelling the "maximum emissions" scenario, as the highest reading is considered a spurious outlier. The measurements from the KOBM Flarestack could not be plotted as there are only three data points.

Appendix C Table 6: SO_2 emission rates used in modelling

Stack	Number of tests	Calculated emission rate (kg/hr)	
		Average	Maximum
MHF stacks	31	30	66
Kilns stacks	27	2.0	7.3
KOBM Flarestack	4	0.11	0.3

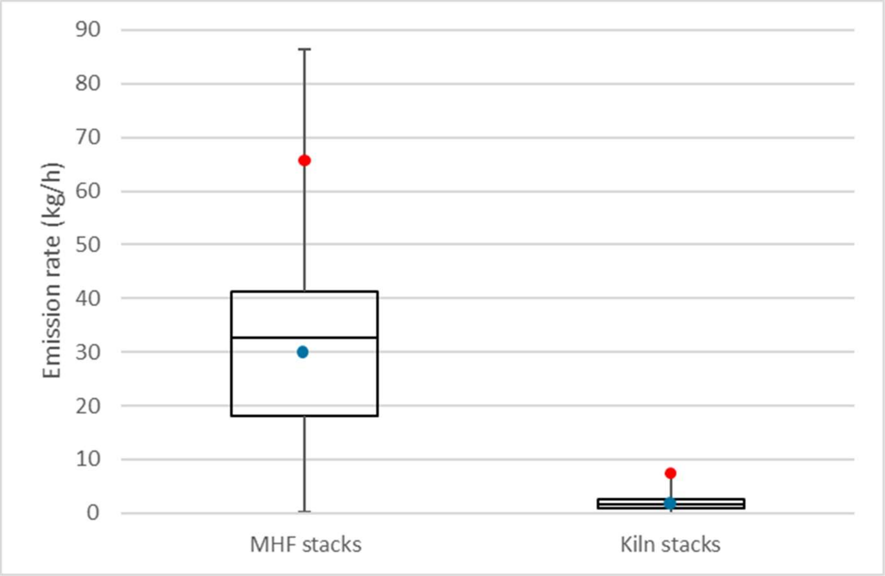

Figure Appendix C.4: Box and whisker of SO_2 emission rates from the MHF and Kiln stacks for the last seven years at NZ Steel. The red dots denote the peak emission rate and the blue dots indicate the average emission rate.

C1.5 Oxides of nitrogen

The main sources of NO_X emissions at the site are associated with the use of coal in the iron plant, primarily in the four MHF, with the four Kiln stacks and the associated cogeneration plant as a secondary but still significant source. Other sources of NO_X at the site include various natural gas combustion processes, such as the Slab Reheat Furnace, the ladle preheaters and the Paint Line incinerators.

Stack testing for NO_X using a combustion gas analyser is undertaken for the MHF stacks, the Kiln stacks, the KOBM Flarestack (pre-combustion) and the Slab Reheat Furnace. The combustion gas analyser detects NO_X and NO; for the purpose of this assessment the balance has been assumed to be all NO_2. Emission rates for the monitored stacks have been derived from the maximum measured NO_2 concentration from the stack testing data. Because the maximum values are used, the results are expected to be conservative when assessing against criteria with a long-term averaging period.

Measurements in the KOBM Flarestack post-combustion are difficult to obtain due to difficulty operating the testing equipment in the high CO and high moisture gas stream. Additionally, the post-flare combustion NO_X is not able to be measured by stack testing, hence the post-flare emission rate is estimated from literature. A description of method used to model the emissions from the KOBM Flarestack is set out in Section C1.2, above.

Appendix C Table 7: NO_X (as NO_2) emission rates used in modelling

Stack	Number of tests	Calculated emission rate (kg/hr)	
		Average	Maximum
MHF stacks	33	47.6	75.0
Kiln stacks	28	7.4	13.7
KOBM Flarestack	3	0.02[a] 0.42[b]	0.03[a] 0.42[b]
Slab Reheat Furnace	6	12.4	19.3
Paint Line Prime Oven Incinerator stack	1	0.55	0.70
Paint Line Finish Oven Incinerator stack	1	0.69	0.88

a. Rate from three combustion gas analyser tests upstream of the flare

b. Emission rate used in modelling for NO_X post-flare. See Section C1.2.

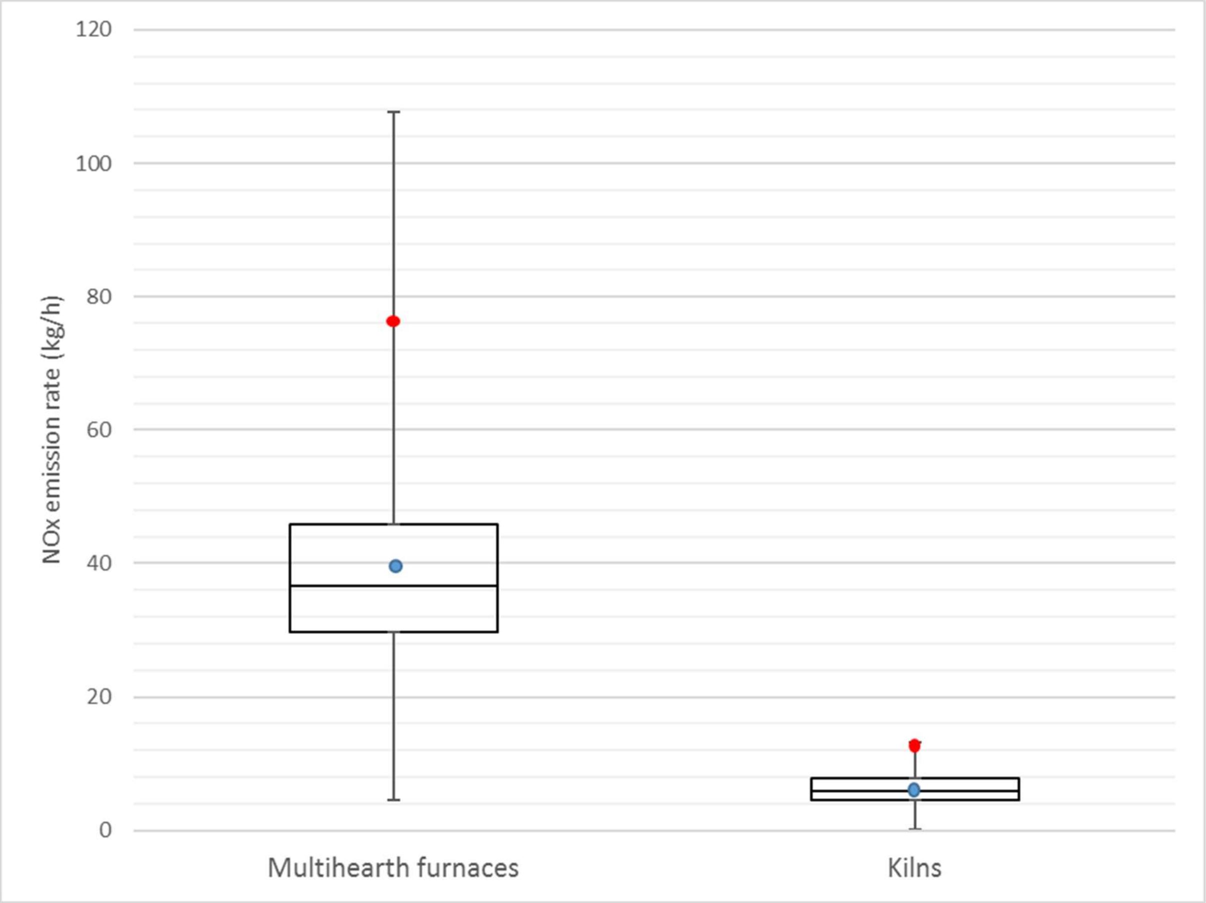

Figure Appendix C.5: Box and whisker of NO_X emission rates from the MHF and kiln stacks at NZ Steel. The red dots denote the peak emission rate and the blue dots indicate the average emission rate.

C1.6 Carbon monoxide

CO is a component of the waste gas of the MHFs, Kilns, Melters and the KOBM. Waste gases from the MHFs and Melters are burnt in the MHF afterburners prior to discharge via the MHF stacks, both to raise steam for site supply and for electricity generation, and waste gases from the Kilns and Melters are combusted in the Kilns Cogeneration plant solely for electricity generation and discharged via the Kilns stack. The cleaned waste gas from the KOBM is combusted via the flarestack which is ignited by the 3 pilot flares once the mixture reaches the lower flammability concentration of approximately 12%. The KOBM waste gas composition traces during a heat show that the concentration of the waste gas is lower than 12 percent (and therefore venting to atmosphere without combustion) for a negligible amount of time, approximately two 30 second periods in the hour. A small amount of Melter waste gas may also be flared via the Melter flare stacks as a pressure control mechanism.

CO emissions discharged from the Kiln stacks have been measured by combustion gas analyser as part of the stack testing programme, with 18 test results collected since 2014. The Kiln stacks discharge waste gas from the kilns and from the Melters which contains a high proportion of CO from the final reduction step of RPCC. The waste gases are combusted for energy capture at the cogeneration plant. The Kiln stacks are considered the most significant mass emission source of carbon monoxide at the site, as there is potential for non-combusted waste gas to leak at the damper of each Kiln outlet. Damper performance is monitored by operators using a flue gas analyser and the damper on each Kiln is replaced on a maintenance schedule. The different damper configuration of the older MHF afterburners mean that there is much less potential far waste gas to bypass the afterburner for those stacks.

The maximum allowable concentration from the Kiln stacks authorised by the Main Air Permit is 3750 mg/m^3. The potential peak off-site effects of emissions from NZ Steel have been modelled assuming that all of the kilns are emitting 3750 mg/m^3 CO, a highly conservative scenario.

Appendix C Table 8: CO emission rates used in modelling

Stack	Number of tests	Emission rate (kg/hr)		
		Average	Maximum	Consent limit
Kiln stacks	20	120	283	285

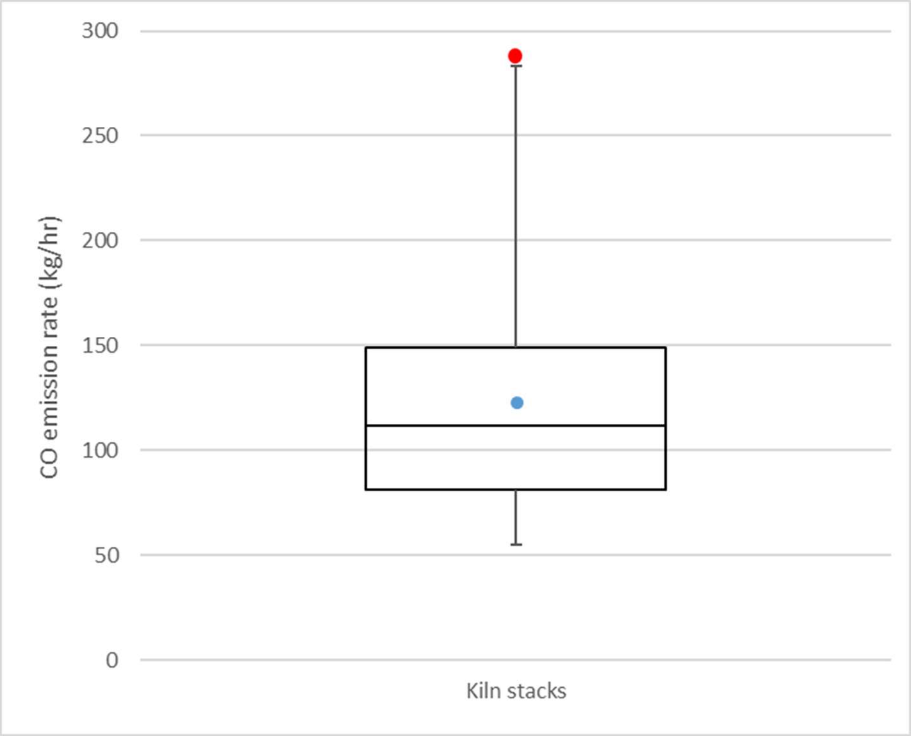

Figure Appendix C.6: Box and whisker of CO emission rates since 2014 for NZ Steel. The red dot denotes the peak emission rate and the blue dot indicates the average emission rate.

C1.7 Hydrogen chloride and chlorine

HCl and Cl_2 emissions are associated with the pickling process where hydrochloric acid solution is used to clean metal oxides from the products prior to surface finishing. The spent HCl from the Pickle Line is regenerated in the Acid Regeneration Plant where the scrubber vent contains residual levels of HCl and Cl_2.

Monitoring has been undertaken at the Acid Regeneration Plant on a quarterly basis and the Pickle Line Scrubber on an annual basis under the current consent, the stack results since 2009 have been reviewed to determine the modelling parameters which are summarised in the following tables.

Appendix C Table 9: HCl emission rates used in modelling

Stack	Number of tests	Emission rate (kg/hr)	
		Average	Maximum
Acid Regeneration Plant	41	0.063	0.31
Pickle Line Scrubber	8	0.017	0.04

Appendix C Table 10: Cl_2 emission rates used in modelling

Stack	Number of tests	Emission rate (kg/hr)	
		Average	Maximum
Acid Regeneration Plant	41	0.64	1.31
Pickle Line Scrubber	8	0.008	0.013

The emission rates from the Acid Regeneration Plant have been presented in a box and whisker plot in **Figure Appendix C.7** below. There are too few data points collected for the Pickle Line Scrubber to present a meaningful plot, however notably the results for the Pickle Line Scrubber are far lower than those measured at the Acid Regeneration Plant.

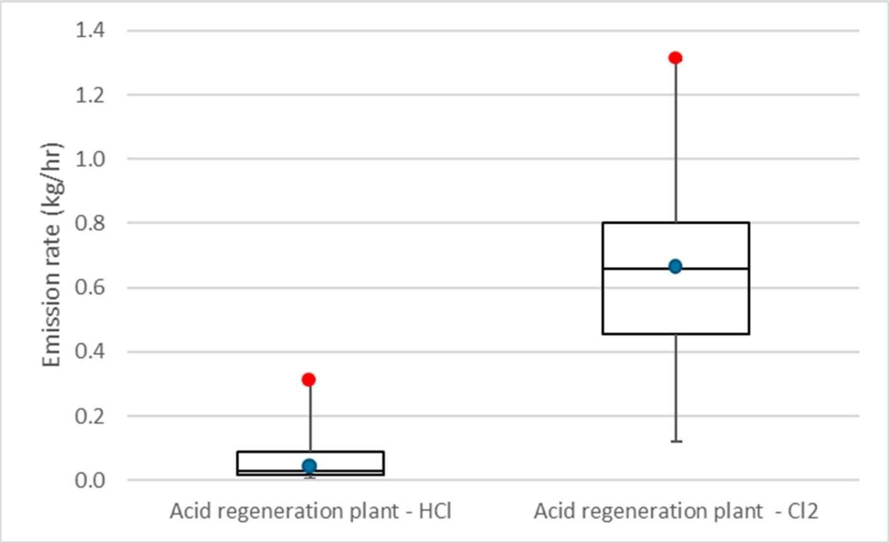

Figure Appendix C.7: Box and whisker of HCl and CL_2 emission rates measurements at the Acid Regeneration Plant since 2009 for NZ Steel. The red dots denote the peak emission rate and the blue dots indicate the average emission rate.

C1.8 VOCs

Volatile Organic Compounds (VOCs) include a variety of aromatic hydrocarbons, some of which have short- and long-term adverse health effects. VOCs may also react with nitrogen oxides emitted mainly from vehicles and industrial activities to form ozone, which in turn helps the formation of fine particulates.

The Paint Line at the Finishing Plants includes a separate Prime Line and Finish Line for application of solvent paints to steel products. The emissions to air from the drying ovens are treated through incinerators to reduce emissions of VOCs at the outlet. Condition 21 of the existing Main Air Permit requires these two incinerators to be operated at a minimum of 650°C for the Finish Oven, and

750°C for the Prime Oven. Prior to 2014, the minimum incineration temperature for both was 750°C.

The potential effects of exposure to different VOCs are human health effects and nuisance effects from odour. The specific VOCs treated in the incinerator are dependent on the particular paints and coatings used within the prime and finishing line.

Emission testing has been undertaken annually on the Prime and Finish Oven Incinerator stacks since 2014 for a suite of VOCs. VOC results will vary depending on the paint product being used at the time of the testing. Results from seven tests have been evaluated to determine representative emission rates for the Prime line, and 9 results were available for the Finish line. Representative rates are summarised in **Appendix C Table 11** below. There are not enough data points at each stack to produce representative box and whisker plots.

Appendix C Table 11: VOC emission rates used in modelling

Stack name	**Prime Oven Incinerator stack (CCL3)**		**Finish Oven Incinerator stack (CCL4)**	
VOC species	**Average kg/hr**	**Maximum kg/hr**	**Average kg/hr**	**Maximum kg/hr**
Benzene	0.0014	0.0038	0.15	0.34
Toluene	0.0028	0.0072	0.015	0.026
Ethylbenzene	0.0017	0.0040	0.0017	0.0031
m-,p-Xylene	0.0074	0.020	0.0049	0.010
o-Xylene	0.012	0.051	0.0061	0.014
Styrene	0.0003	0.0006	0.010	0.021
Iso-Propylbenzene (cumene)	0.0029	0.0100	0.0008	0.0012
n-Propylbenzene	0.0089	0.042	0.0012	0.0025
1,3,5 - Trimethylbenzene	0.0086	0.035	0.0016	0.0048
1,2,4 - Trimethylbenzene	0.020	0.078	0.0048	0.018
sec- Butylbenzene	0.0006	0.0012	0.0002	0.00023
4-iso-Propyltoluene(p-Cymene)	0.0008	0.0024	0.0003	0.00035
Naphthalene	0.0003	0.0005	0.0012	0.0049
Methyl isobutyl ketone (MEBK)	0.014	0.014	0.0054	0.0091
2-Chlorotoluene	-	-	0.0062	0.0062
n-Butylbenzene	-	-	0.0006	0.001

C1.9 Mercury

Mercury emissions occur from the trace amounts of mercury in the coal and limestone raw materials. Consequently, the MHFs in the Iron Plant, and possibly to a lesser extent the kilns where limestone is added, are the main point sources.

The emission rate of mercury has been estimated on a mass balance basis. This is similar to the approach used in the Mercury Inventory for New Zealand: 2016 (NZ Mercury Inventory), which estimated total annual mercury emissions to air from the site at between 21.4 and 85.6 kg per year assuming that 50% of the volatilised mercury was retained in the particulate captured in air pollution control devices[20]. For this assessment, a more conservative assumption has been made that 100% of the input mercury is volatilised and released to air.

The mercury content of different coal sources and the relative proportion of overall coal use at the Steel Mill in 2019 is set out in **Appendix C Table 12** below. Based on the relative contribution of different of coal sources, the average mercury content of coal used in ironmaking was 0.06 ppm and the maximum content 0.1 ppm.

Appendix C Table 12: Mercury content of coal sources used at NZ Steel

Parameter	Mine name				
	BT Rotowaro mine	**BT Kopako mine**	**Glencore - JMB mine**	**Banpu - EMB mine**	**Baramulti - Malinau mine**
Mercury content	<0.1 ppm	<0.1ppm	0.02 ppm	0.02 ppm	0.04 ppm
Approximate percentage used at the Site*	40%	10%	12%	26%	12%

*Based on data from August 2019

Limestone used in the iron and steel making processes has a mercury content of between 0.005 ppm and 0.02 ppm. In 2019, NZ began replacing some of the limestone used in the Iron Plant with recycled lime-rich KOBM slag, a co-product from the steelmaking process. This will reduce the quantity of limestone used at the site over the long term and further reduce mercury emissions.

The calculations for the mass balance of mercury is shown in **Appendix C Table 13**. The average and maximum hourly emission rates have been estimated assuming 100% volatilisation of the mercury and using the average annual operational hours (total) of the four MHFs, i.e. 30862 hours (see **Appendix C Table 14**). For the purpose of dispersion modelling, the total mercury emissions are assumed to occur continuously and be evenly distributed across the 4 MHF stacks.

This calculation produces mercury emission rates of a similar order of magnitude to those presented in the NZ Mercury Inventory (20 – 81 kg/year). Based on the maximum emission rate estimate provided in the mass balance below of 71 kg Hg/year, the Steel Mill's contribution equates to 2% of the total estimated emissions to air of mercury in NZ.

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[20] Bingham, A and Graham B. (2017). Mercury Inventory for New Zealand: 2016. Ministry for the Environment. Wellington. p18

Appendix C Table 13: Mercury input mass balance

Source	Activity rate (tonnes per year)	Mercury content (mg/kg)		Mercury input (kg/year)	
		Average	Upper	Average	Upper
Coal					
2017	692,174	0.06	0.1	42	69
2018	667,531	0.06	0.1	40	67
2019	654,671	0.06	0.1	39	65
Projected maximum	701,200	0.06	0.1	42	70
Limestone					
2017	54,150	0.013	0.02	0.7	1.1
2018	55,779	0.013	0.02	0.7	1.1
2019	54,687	0.013	0.02	0.7	1.1
Projected maximum	59,000	0.013	0.02	0.7	1.2

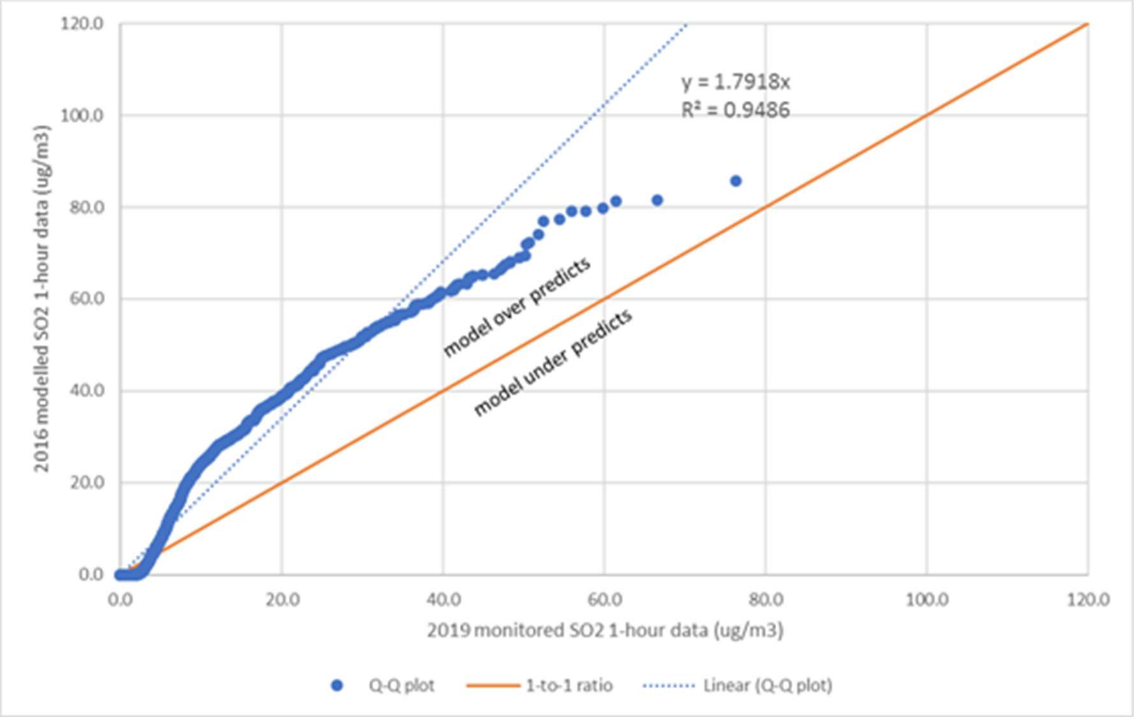
Appendix C Table 14: Mercury emission rates used in modelling

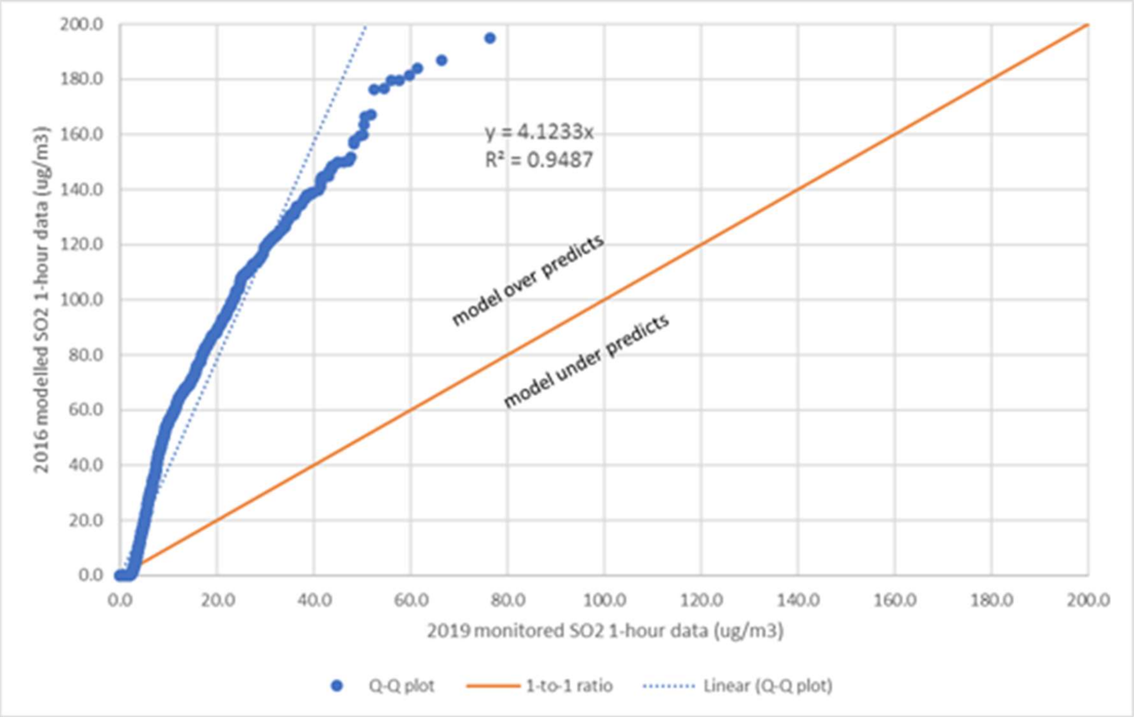
Scenario	Coal		Limestone		Mercury input, kilograms (kg/year)	Mercury emission rate (kg/hr)*
	Activity rate (tonnes per year)	Mercury content (mg/kg)	Activity rate (tonnes per year)	Mercury content (mg/kg)		
Average case	671,459	0.06	54,872	0.013	41	0.00133
Maximum case	701,200	0.1	59,000	0.02	71	0.00231

* Assuming 100% loss to air and operating hours of 30862 hours per year

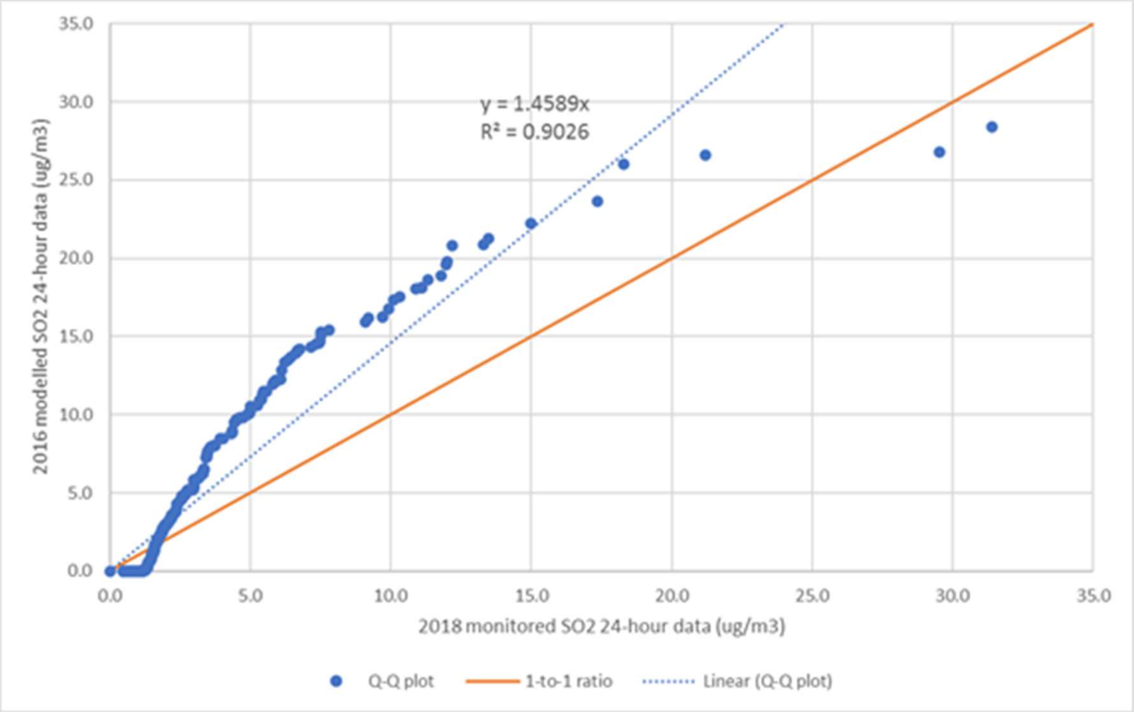
Appendix D: Q-Q plots of modelled and measured concentrations

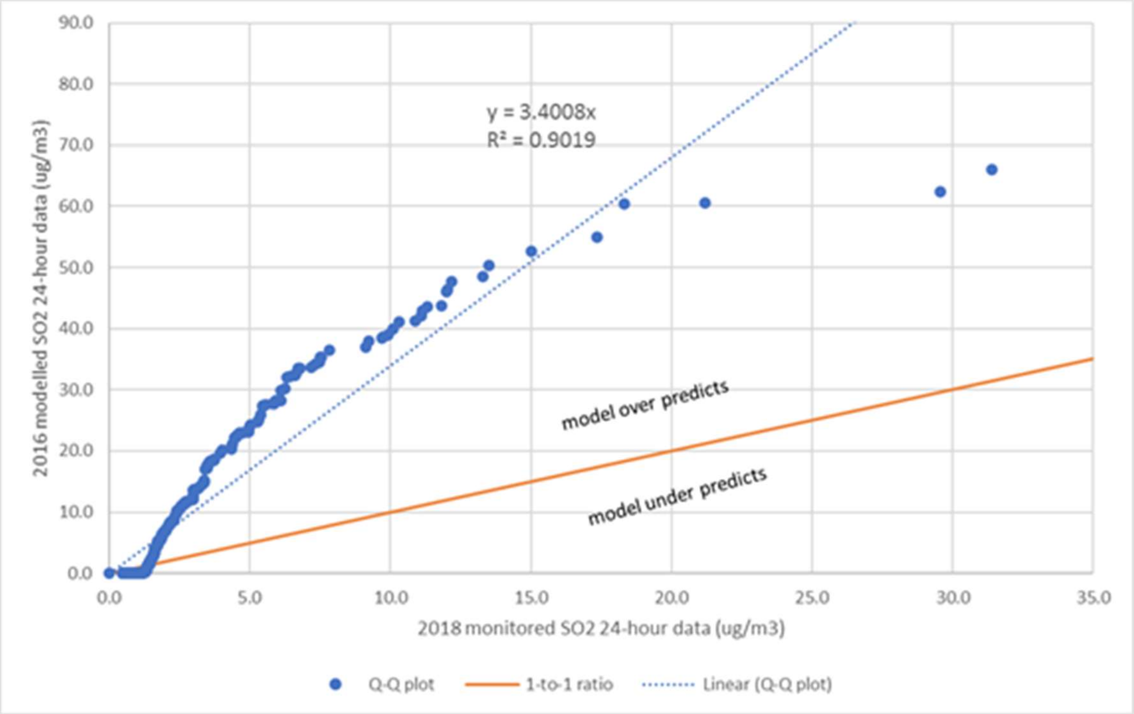
- SO_2 (1 hour average) Q-Q plots for 64 Glenbrook Beach Road (Site 20)
- SO_2 (24-hour average) Q-Q plots for 64 Glenbrook Beach Road (Site 20)
- SO_2 (1-hour average) Q-Q plots for Glenbrook School (Site 17)
- SO_2 (24-hour average) Q-Q plots for Glenbrook School (Site 17)
- NO_X (1-hour average) Q-Q plots for 64 Glenbrook Beach Rd (Site 20)
- NO_X (24-hour average) Q-Q plots for 64 Glenbrook Beach Rd (Site 20)



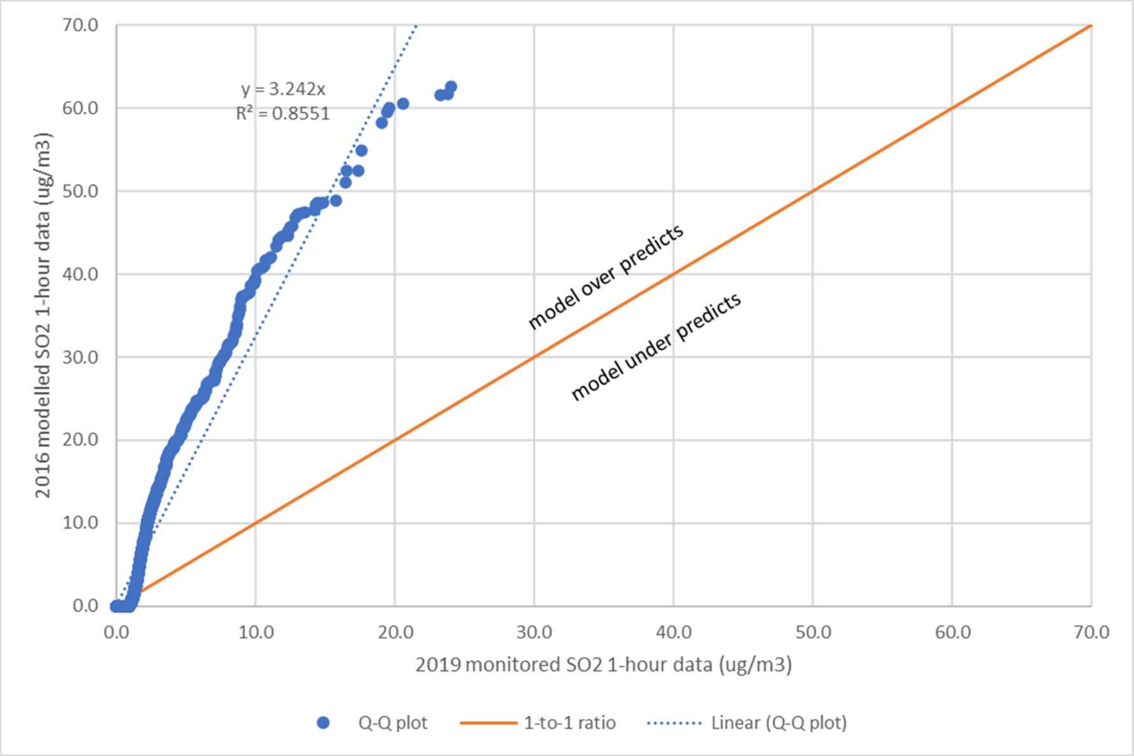


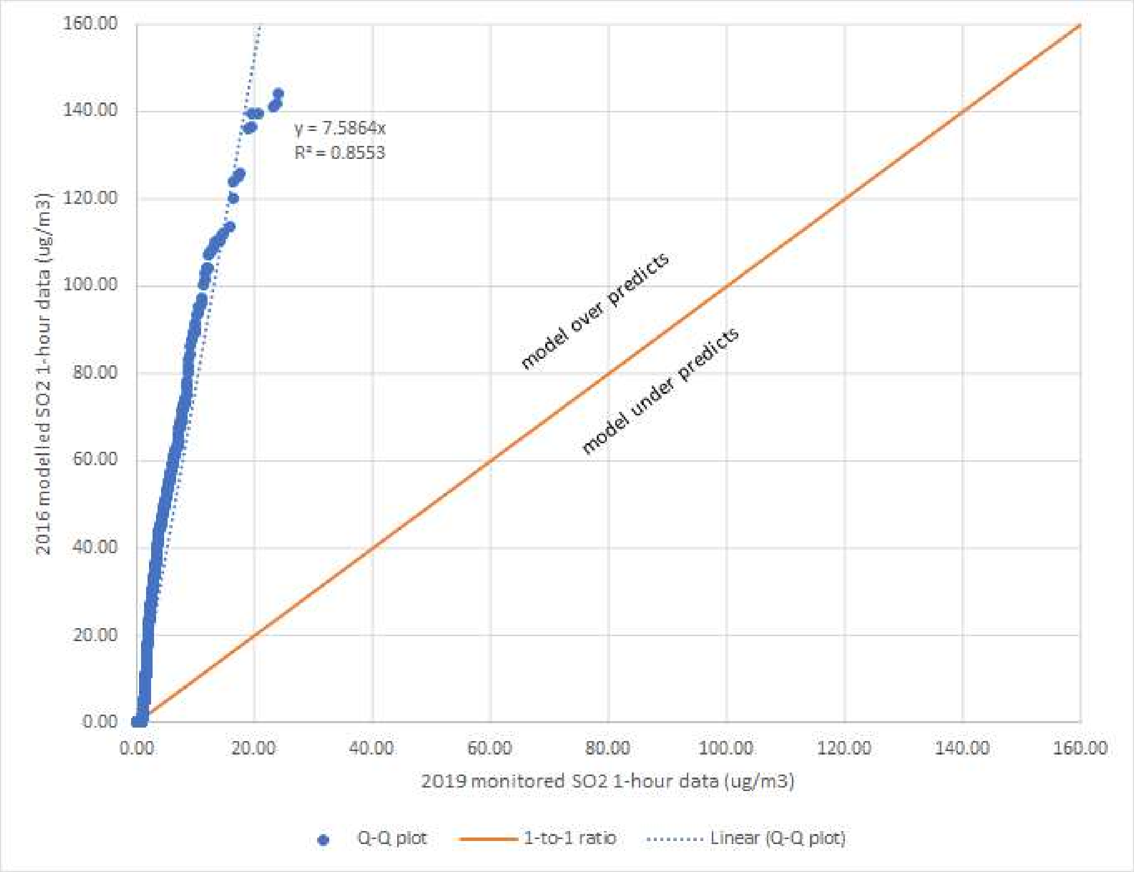
Appendix D Figure 1: SO_2 (1 hour average) Q-Q plots for 64 Glenbrook Beach Road (Site 20) – average emissions scenario (top) and maximum emissions scenario (bottom)



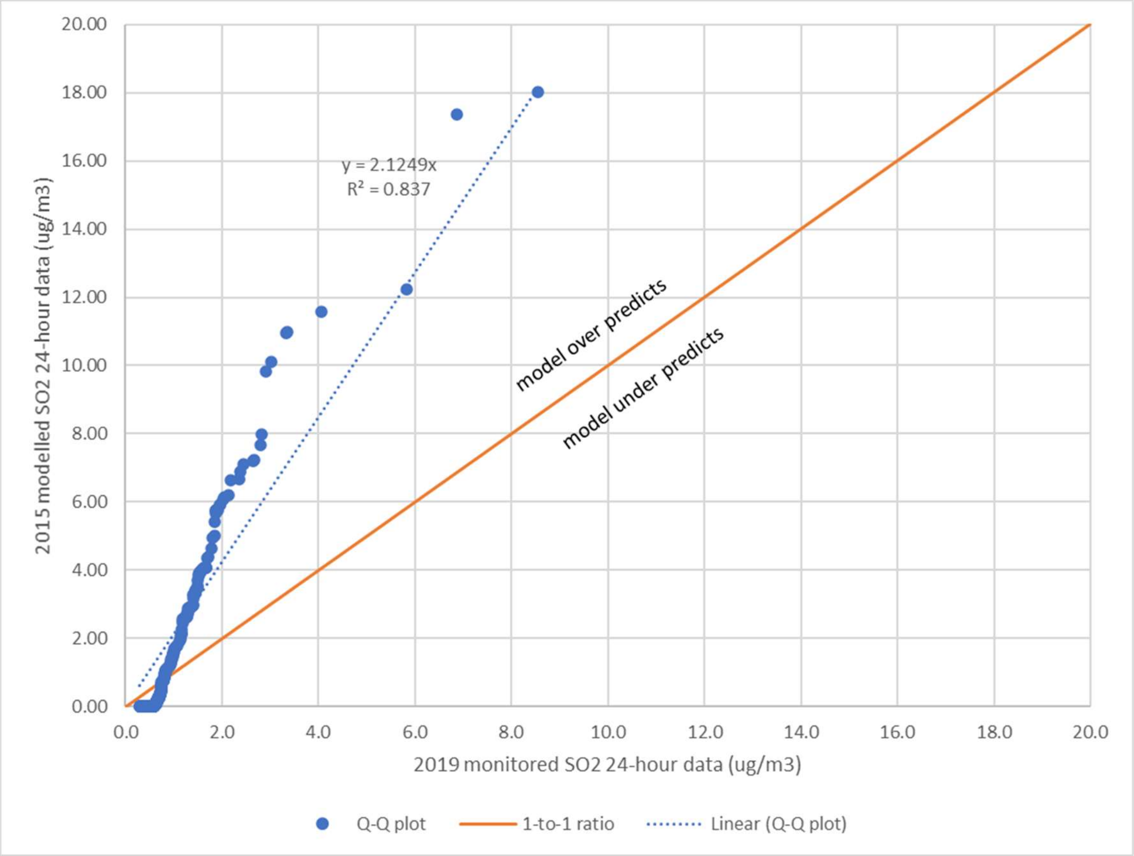


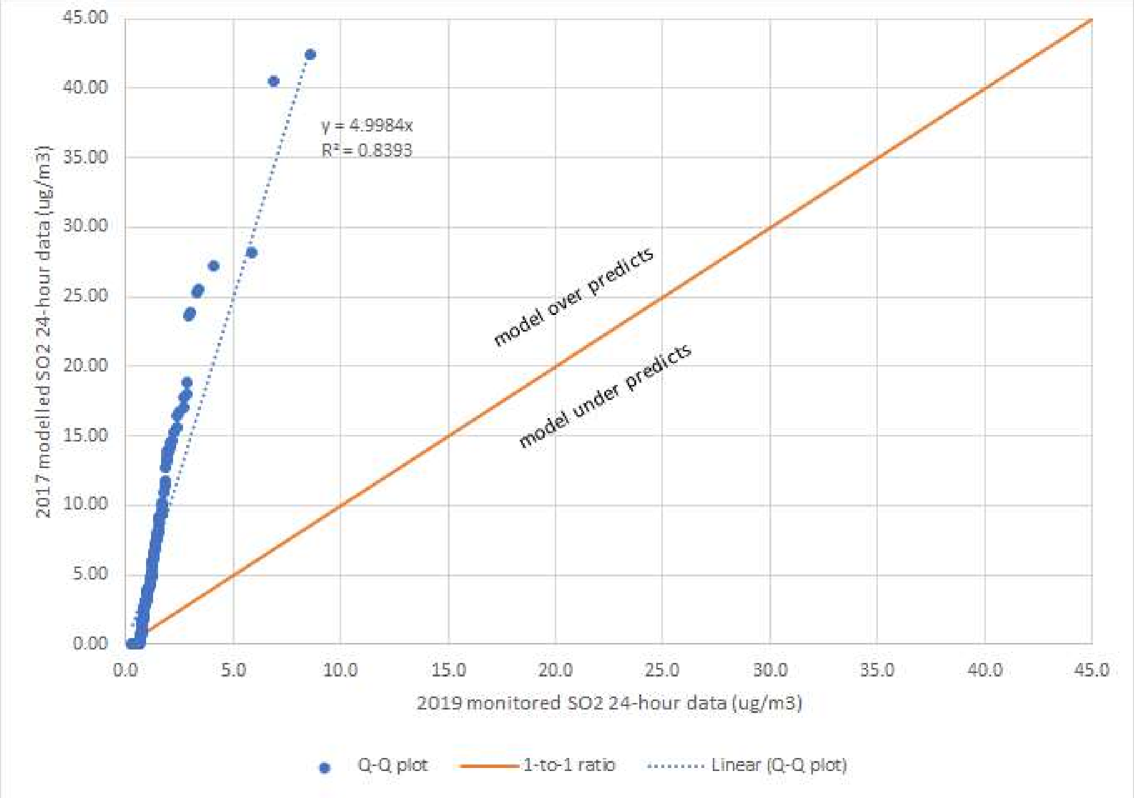
Appendix D Figure 2: SO_2 (24-hour average) Q-Q plots for 64 Glenbrook Beach Road (Site 20) – average emissions scenario (top) and maximum emissions scenario (bottom)



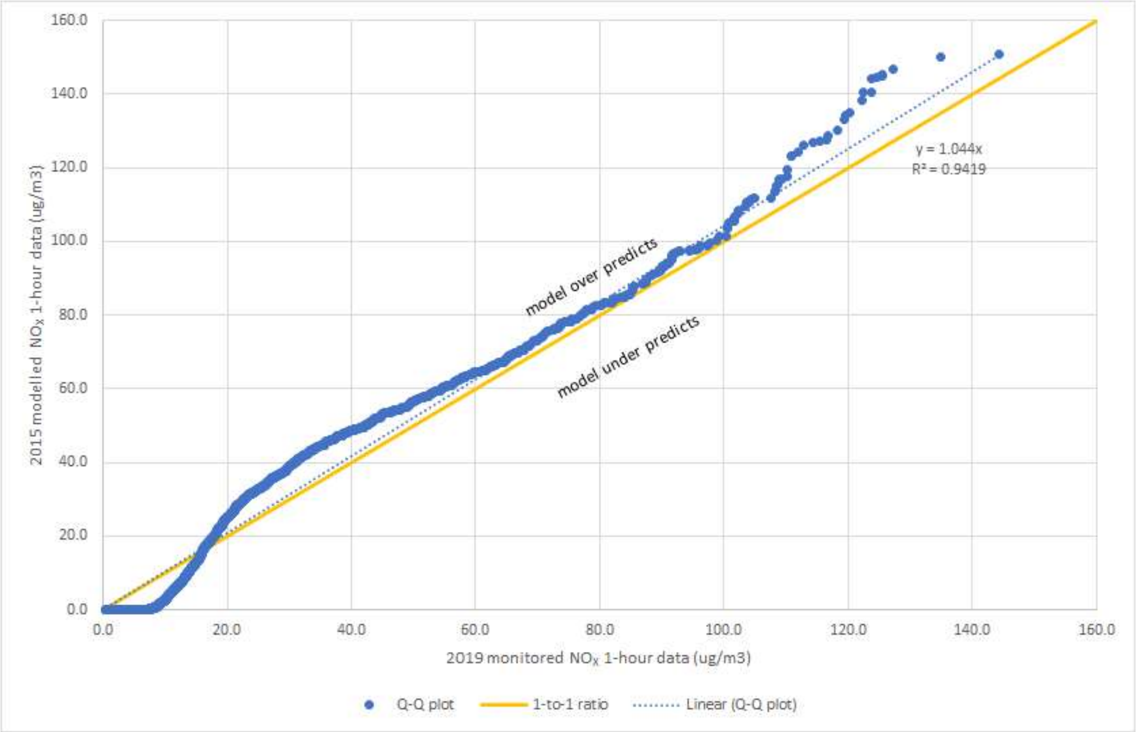


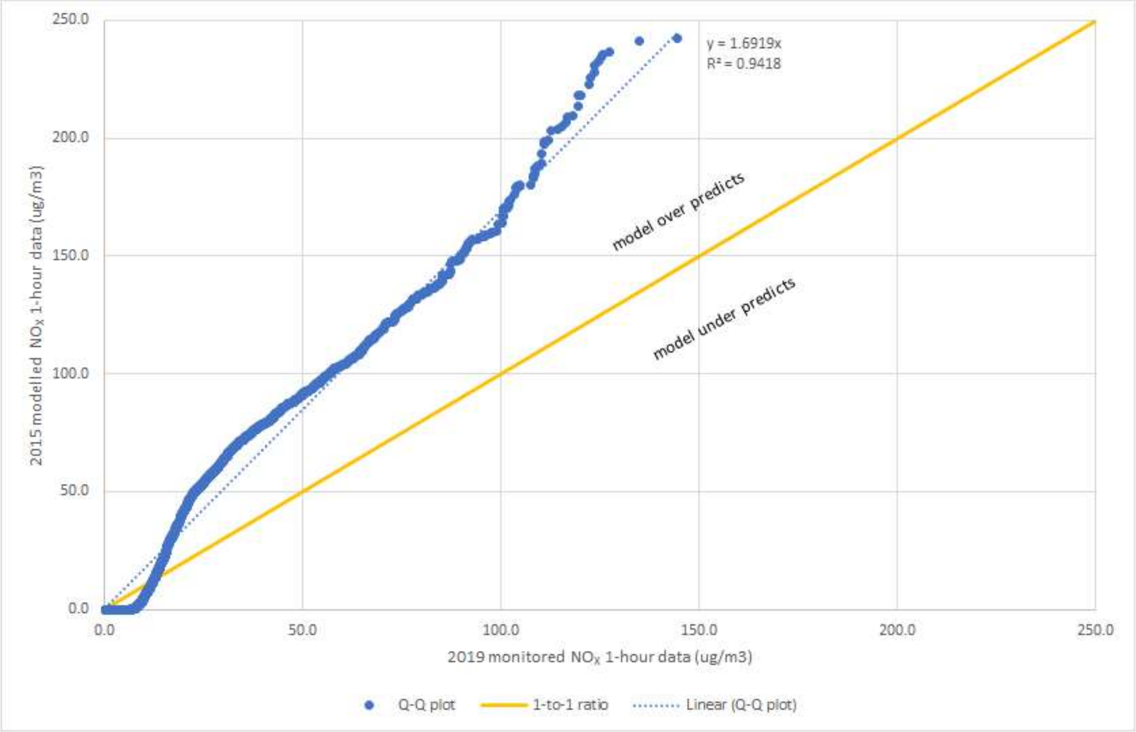
Appendix D Figure 3: SO_2 (1-hour average) Q-Q plots for Glenbrook School (Site 17) – average emissions scenario (top) and maximum emissions scenario (bottom)



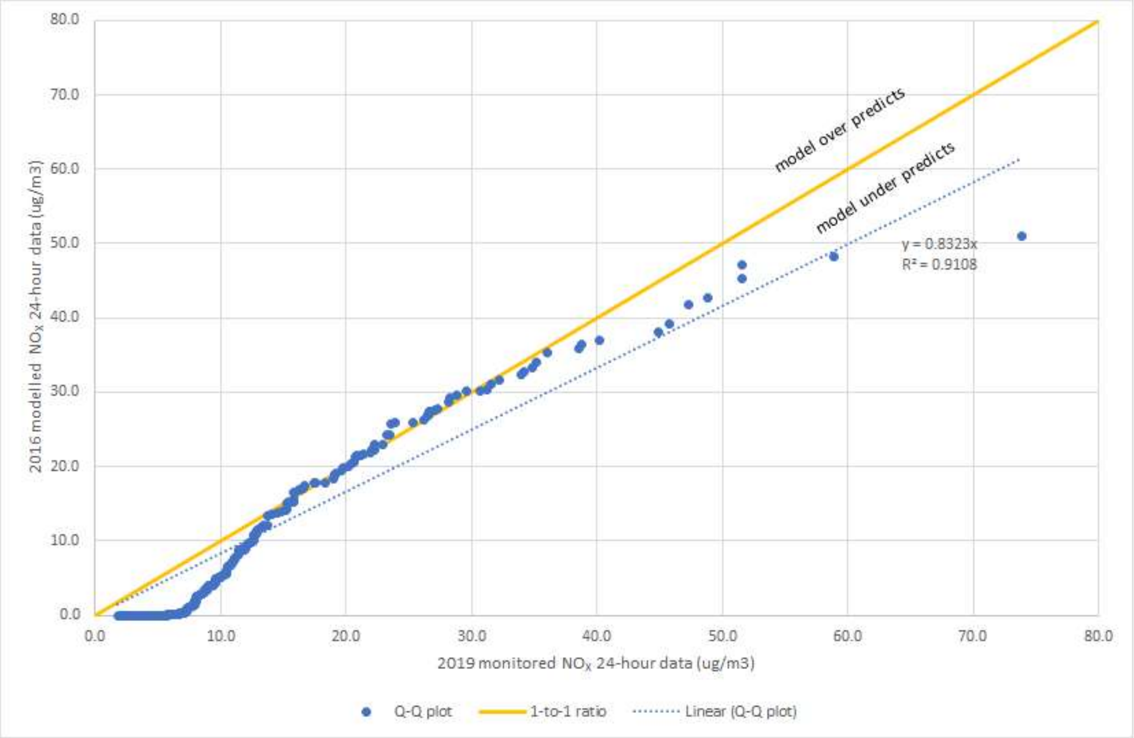


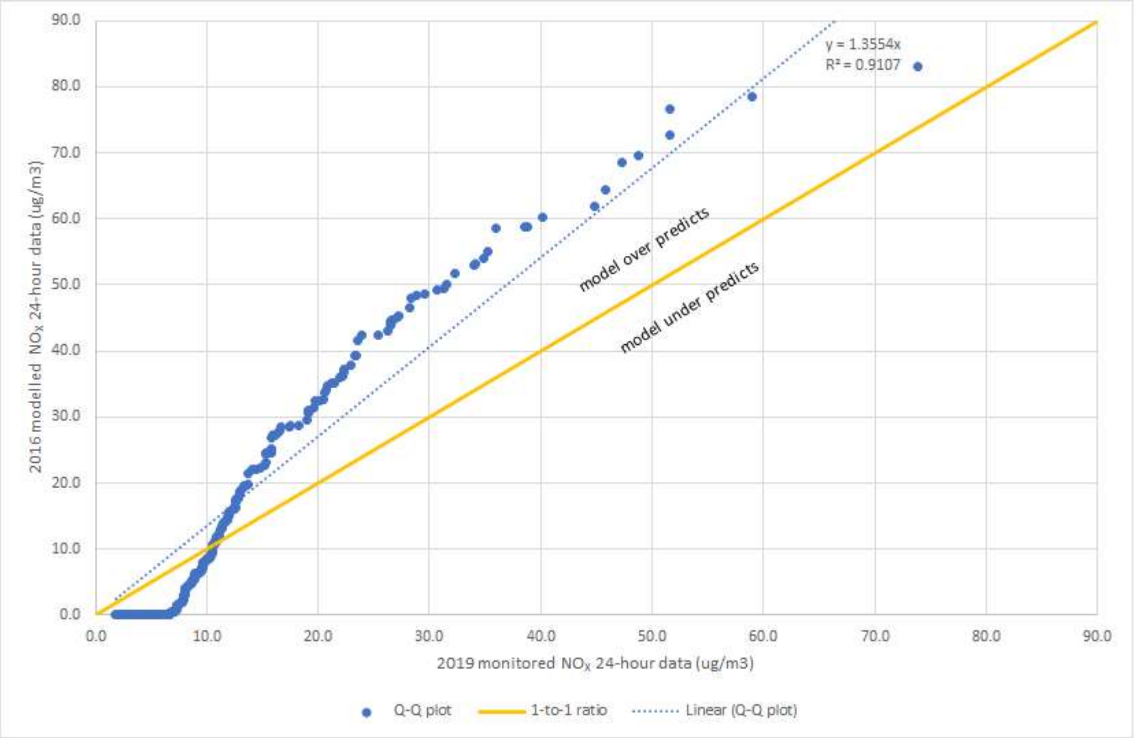
Appendix D Figure 4: SO_2 (24-hour average) Q-Q plots for Glenbrook School (Site 17) – average emissions scenario (top) and maximum emissions scenario (bottom)





Appendix D Figure 5: NO_X (1-hour average) Q-Q plots for 64 Glenbrook Beach Rd (Site 20) – average emissions scenario (top) and maximum emissions scenario (bottom)





Appendix D Figure 6: NO$_X$ (24-hour average) Q-Q plots for 64 Glenbrook Beach Rd (Site 20) – average emissions scenario (top) and maximum emissions scenario (bottom)

Appendix D: Dispersion modelling study – Generators

REPORT

Air Quality Assessment Appendix D - Dispersion Modelling Study

Diesel generators at Glenbrook Steel Mill

Prepared for
New Zealand Steel Limited
Prepared by
Tonkin & Taylor Ltd
Date
October 2021
Job Number
1010577.5000

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Document Control

Title: Air Quality Assessment Appendix D - Dispersion Modelling Study					
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Table of contents

Glossary

Term used in this report	Definition
Air dispersion modelling	The mathematical simulation of how air contaminants emitted from a source disperse in the ambient atmosphere.
BPIP-PRIME model	The Building Profile Input Programme (BPIP) Plume Rise Model Enhancements (PRIME) model is used to simulate building downwash impacts.
Building downwash	The influence of building (or structure) configuration in changing the trajectory of an emitted plume from a stack/vent, bringing the plume to the ground more rapidly than where there is an absence of buildings.
CALMET model	The CALPUFF meteorological pre-processor. It is a diagnostic, meteorological model which provides a construction of 3-dimensional wind and temperature fields, and a 2-dimensional determination of micro meteorological variables (such as mixing height) needed to carry out dispersion modelling.
CALPUFF model	The California Puff (CALPUFF) model is an advanced non-steady state, Lagrangian puff air dispersion model.
Ground level concentration (GLCs)	The concentration in air of a pollutant to which a human being is normally exposed, typically taken to be between the ground and a height of some 2 metres above ground.
Operational Area	Area within the wider NZ Steel landholdings that is used for Steel Mill operations. This area does not include areas that are farmed, or the area currently used as a landfill for waste materials generated at the Site.
Point source	A point source is an identifiable stationary source of air pollution that emits air contaminants through a stack or vent.
Site	The New Zealand Steel landholding
Stack (may also be referred to as vent)	A hollow column or opening used to discharge gaseous and/or particulate matter emissions to atmosphere.
WRF model	The Weather Research and Forecast (WRF) model is a prognostic mesoscale numerical weather prediction model.

1 Introduction

New Zealand Steel Limited (NZ Steel) is the New Zealand-based subsidiary of Australasian company Bluescope Steel, producing steel slab, billets and a variety of processed steel products at the Steel Mill at Mission Bush Road, Glenbrook. NZ Steel is proposing to use diesel generators at the Steel Mill in order to provide an alternative power source. Alternative electricity supply options provide additional resilience for the Steel Mill, including enabling NZ Steel to respond to changes in the electricity market and to maintain continuity of supply where electrical connection is not feasible or when existing transformers are being serviced.

This report, which forms Appendix E to the Resource Consent Application and Assessment of Effects on the Environment (AEE), describes the methodology and results of the dispersion modelling study of discharges to air from the vents of the proposed new diesel generators to be placed at the Site. The results of the dispersion modelling study are used to inform the assessment of air quality effects.

Air dispersion modelling is the mathematical simulation of how air contaminants emitted from a source disperse in the ambient atmosphere. The outputs from the dispersion model are the predicted ground level concentrations (GLCs) of air contaminants from the modelled sources, which can be calculated for different averaging periods to align with the relevant assessment criteria.

The objective of the dispersion modelling is to assess the potential effects of air discharges of contaminants from the diesel generators by comparing the predicted GLCs (and added to background concentrations where relevant) against assessment criteria.

2 Dispersion modelling approach

2.1 Introduction

Dispersion modelling has been undertaken using the most recent (non-beta) version of the CALPUFF air dispersion model (version 7.2.1). CALPUFF is an advanced dispersion model that is widely used in New Zealand, especially in areas of complex terrain and coastal situations.

In accordance with the Good Practice Guide for Atmospheric Dispersion Modelling[1] (GPG Modelling), the 99.9th percentile predicted 1-hour results are reported as the maximum GLC and the maximum (100th percentile) for other averaging periods.

2.2 Emission sources modelled

It is anticipated that some (if not all) of the new generators will be leased and brought on and off the Site as needed. Consequently, the rated output and specific model of generator(s) at each location may vary. For the purposes of the dispersion modelling study, a typical representative scenario has been used, based on generator models currently available for lease that match the power supply requirements at each location.

The emission sources (vents) of the diesel generators considered in the dispersion modelling study are summarised in **Table 2.1**, with the locations of the vents shown in **Figure 2.3**. The diesel generators considered in this study are:

- Existing diesel generators located within Building 60 on site and at the Northside Outfall
- Proposed new diesel generators to be placed within portable enclosures at the following locations:
  - Pipe and light plate (P&LP) west product storage yard,
  - Alinta car park,
  - Café car park,
  - North of 6 Hi-Building,
  - Southeast of central workshops,
  - Northwest of central workshops, and
  - South of metal coating line.

Aside from the Northside outfall generator, whose purpose is to continuously power water recycling pumps, the other diesel generators are proposed to provide an alternative power source to offset high electricity prices from the National Grid. These generators have been assumed to only operate during the hours below (for a total of 8 hours/day):

- Morning peak hours: between 6 am and 9 am (3 hours)
- Evening/night peak hours: between 6 pm and 11pm (5 hours).

There may be occasions that may require operation of up to 11 hours/day (such as during exceptional demand on the grid which requires a longer period of load shedding, but these are infrequent occurrences). Operation of 8 hours/day is considered to be representative of the upper end of the normal operational regime of the generators.

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[1] Good Practice Guide for Atmospheric Dispersion Modelling. (2004). Ministry for the Environment. Publication number ME 522.

The modelling for the diesel generators has been undertaken based on emission rates estimated from the respective power output (at 100% capacity, 50 Hertz) of the generators, and hence can be considered as a maximum emission rate modelling scenario. All generators are considered as 4-stroke combustion engines. As a worst-case assumption for modelling, all the generators are assumed to be emitting simultaneously at maximum load.

Table 2.1: Summary of modelled diesel generators

#	Diesel generator locations	Generator model	Status	Power output per generator (kW)	Vent ID	Number of generator units	Number of vents per enclosure	Total vents	Operating hours
1	Building No. 60 generators	Mirrlees National KSS8	Existing	2100	IP21 to IP22	2	N/A [a]	2	Peak hours only (6am – 9am and 6pm – 11pm, 7 days/week)
2	P&LP west product storage yard	Cummins KTA50-GS	Proposed	800	WPSY1_A/B to WPSY2_A/B	2	2	4	
3	Alinta car park	Cummins KTA50-GS	Proposed	800	ACP1_A/B to ACP8_A/B	8	2	16	
4	Café car park	Caterpillar XQ2000	Proposed	1400	CCP1_A/B to CCP2_A/B	2	2	4	
5	North of 6 Hi-Building	Aggreko containerised GHP generator set	Proposed	800	HB1/HB2	2	1	2	
6	Northside outfall	Caterpillar C9 DE330E0	Proposed	240	NO1	1	1	1	Continuously throughout the year
7	Central workshops (Southeast)	Cummins KTA50-GS	Proposed	800	CW_SE1	1	2	2	Peak hours only (6am – 9am and 6pm – 11pm, 7 days/week)
8	Central workshops (Northwest)	Cummins KTA50-GS	Proposed	800	CW_NW1	1	2	2	
9	Metal coating line (South)	Cummins KTA50-GS	Proposed	800	MCL_S1	1	2	2	

Notes:

a These existing generators are not within portable enclosures. The stacks are located on the side of Building 60.

The modelled generator scenario was based on early information from NZ Steel regarding the type and number of generators at each location. The proposal has since changed for one of the locations (Location 4) such that instead of two generators with a combined gross heat release of 7.8 MW, one generator is proposed with a gross heat release of 5.8 MW. This would result in reduced emissions from this location, and therefore the modelled output remains conservatively representative of the proposed discharges to air.

2.2.1 Stack discharge parameters

The physical parameters of the vent discharges from the diesel generators are summarised in **Table 2.2**. The derivation of the parameters has been based on the following:

- Physical parameters of vent exit diameter and vent exit height are based on manufacturer's information. Aside from the existing Building No. 60 generator stacks, all vents are located on top of the portable diesel enclosures.
- Where manufacturer's specifications for exhaust gas flow rates were not provided, exhaust gas flow rates have been calculated based on displacement and revolutions per minute (RPM) of the engines for a 4-stroke engine[2]:

$$Exhaust\ flow\ rate\ \left(\frac{m^3}{s}\right) = L * \frac{(\frac{R}{2})}{60}$$

  Where L = displacement (m^3) and R = RPM.

  The 1500 RPM is based on 50 Hertz and the displacement is based on manufacturer's specifications. Where the displacement is not available, it has been pro-rated based on the power output of the diesel generator.

- Exit temperature of the exhaust gas flow rate has been based on the manufacturer's specification for the Northern Outfall generator.

2.2.2 Emission rates

Emission rates are provided for the following:

- Carbon monoxide (CO);
- Nitrogen oxides (NO_X);
- Inhalable particulate matter of aerodynamic diameters <10 µm (PM_{10}) and <2.5 µm ($PM_{2.5}$);
- Sulphur dioxide (SO_2); and
- Polyaromatic hydrocarbons (PAHs).

Derivation of emission rates are provided in Appendix A. Emission rates have been calculated based on the following order of hierarchy:

- Manufacturer's specifications (including regulatory emission factors of the generator engines pertaining to Euro II and United States Environmental Protection Agency (USEPA) Tier 2 emission standards).

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[2] Singh. G. Calculation of Exhaust Gas Flow Rate in an Internal Combustion Engine. Department of Mechanical Engineering, University of Iowa, June 2019. DOI: 10.13140/RG.2.2.25594.13764. (https://www.researchgate.net/publication/333951938_Calculation_of_Exhaust_Gas_Flow_Rate_in_an_Internal_Combustion_Engine)

- Where manufacturer's specifications for emissions concentrations were not available, emission rates have been calculated based on emission factors (as presented in Table 2.2 from Australia's National Pollutant Inventory (NPI) Emission estimation technique manual for Combustion engines, Version 3.0, June 2008[3]). The NPI emission factors are derived from USEPA AP-42 emission factors.

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[3] http://www.npi.gov.au/system/files/resources/afa15a7a-2554-c0d4-7d0e-d466b2fb5ead/files/combustion-engines.pdf

Table 2.2: Summary of vent discharge parameters

Diesel generator locations	Vent ID	Vent height above ground level (m)[a]	Exit diameter (m/s) [a]	Displacement (m^3)[b]	RPM[d]	Vent exhaust flowrate (m/s)[e]	Vent exit velocity (m/s)	Exit temperature (°C)[f]
Building No. 60 generators	IP21 to IP22	18	0.70	0.11[c]	1500	1.34	3.48	545
P&LP west product storage yard	WPSY1_A/B to WPSY2_A/B	2.8	0.25	0.05	1500	0.31	6.37	545
Alinta car park	ACP1_A/B to ACP8_A/B	2.8	0.25	0.05	1500	0.31	6.37	545
Café car park	CCP1_A/B to CCP2_A/B	4.2	0.40	0.07	1500	0.43	3.43	545
North of 6 Hi-Building	HB1/HB2	4.1	0.45	0.05	1500	0.63	3.93	545
Northside outfall	NO1	2.3	0.13	0.01	1500	0.11	8.29	545[g]
Central workshops (Southeast)	CW_SE1_A/B	2.8	0.25	0.05	1500	0.31	6.37	545
Central workshops (Northwest)	CW_NW1_A/B	2.8	0.25	0.05	1500	0.31	6.37	545
Metal coating line (South)	MCL_S1_A/B	2.8	0.25	0.05	1500	0.31	6.37	545

Notes:

a Information provided by NZ Steel.

b Information from manufacturer specifications, unless otherwise stated.

c No manufacturer specification available. Pro-rated based on power output.

d Based on 50 Hz.

e Calculated based on exhaust flow rate equation (as a function of displacement and RPM) in Section 0. For portable enclosures with two vents, it is assumed that exhaust flowrate from the generator is equally divided between the two vents.

f Exhaust temperature assumed to be similar to manufacturer specifications for generator at Northside Outfall.

Table 2.3: Summary of vent emission rates[a]

Diesel generator locations	Generator model	Vent ID	Emission rates (kg/hr)					
			CO	NO_X[b]	PM_{10}	$PM_{2.5}$	SO_2	PAHs
Building No. 60 generators	Mirrlees – National KSS8	IP21 to IP22	6.9	16.6	0.88	0.90	1.03×10^{-2}	1.26×10^{-7}
P&LP west product storage yard	KTA50-GS (Cummins)	WPSY1_A/B to WPSY2_A/B	1.4	2.4	0.048	0.048	1.84×10^{-3}	2.40×10^{-8}
Alinta car park	KTA50-GS (Cummins)	ACP1_A/B to ACP8_A/B	1.4	2.4	0.048	0.048	1.84×10^{-3}	2.40×10^{-8}
Café car park	Caterpillar XQ2000	CCP1_A/B to CCP2_A/B	2.5	4.5	0.14	0.14	3.43×10^{-3}	4.20×10^{-8}
North of 6 Hi-Building	Aggreko containerised GHP generator set	HB1/HB2	0.58	4.6	0.040	0.040	3.92×10^{-3}	4.80×10^{-8}
Northside outfall	Caterpillar C9 DE330E0	NO1	0.22	0.83	0.0064	0.0064	1.18×10^{-3}	1.44×10^{-8}
Central workshops (Southeast)	KTA50-GS (Cummins)	CW_SE1_A/B	1.4	2.4	0.048	0.048	1.84×10^{-3}	2.40×10^{-8}
Central workshops (Northwest)	KTA50-GS (Cummins)	CW_NW1_A/B	1.4	2.4	0.048	0.048	1.84×10^{-3}	2.40×10^{-8}
Metal coating line (South)	KTA50-GS (Cummins)	MCL_S1_A/B	1.4	2.4	0.048	0.048	1.84×10^{-3}	2.40×10^{-8}

Notes:

a Derivation of emission rates provided in Appendix A.

b The modelled emissions are assumed to comprise 7.5% NO_2

2.3 Modelled receptor locations

The CALPUFF model was configured to predict GLCs for the following receptor types (illustrated in Figure 2.1):

- Site boundary receptors – these enable the worst case GLC beyond the Site boundary to be predicted, which is important for contaminants that are assessed against a 1-hour average assessment criterion.
- Discrete sensitive receptors – these locations represent a selection of nearby sensitive receptors (principally dwellings). This selection is not intended to be exhaustive. Concentrations at other sensitive locations not explicitly included in the model can be estimated using contour plots derived from nested receptor grids. The modelled discrete receptors are shown in **Figure 2.2** and further information is provided in **Appendix B**.
- Nested receptor grids - five grids of evenly spaced receptors at increasing resolution are set-up within the model (Table 2.4). The nested receptor grid approach provides a high level of resolution close to the Site where the magnitude and spatial variation in impacts is typically greatest, with decreasing resolution in grid spacing further afield.

The receptors as described above are consistent with those modelled in the Glenbrook Steel Mill Air Discharge Permit Replacement report[4].

Table 2.4: Nested receptor grids

Distance from centre (m)	Receptor spacing (m)
2000	100
3000	200
4000	400
5000	800
8000	1600

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[4] Appendix C - Dispersion Modelling Study, Air Quality Assessment, Glenbrook Steel Mill Air Discharge Permit Replacement, April 2021.

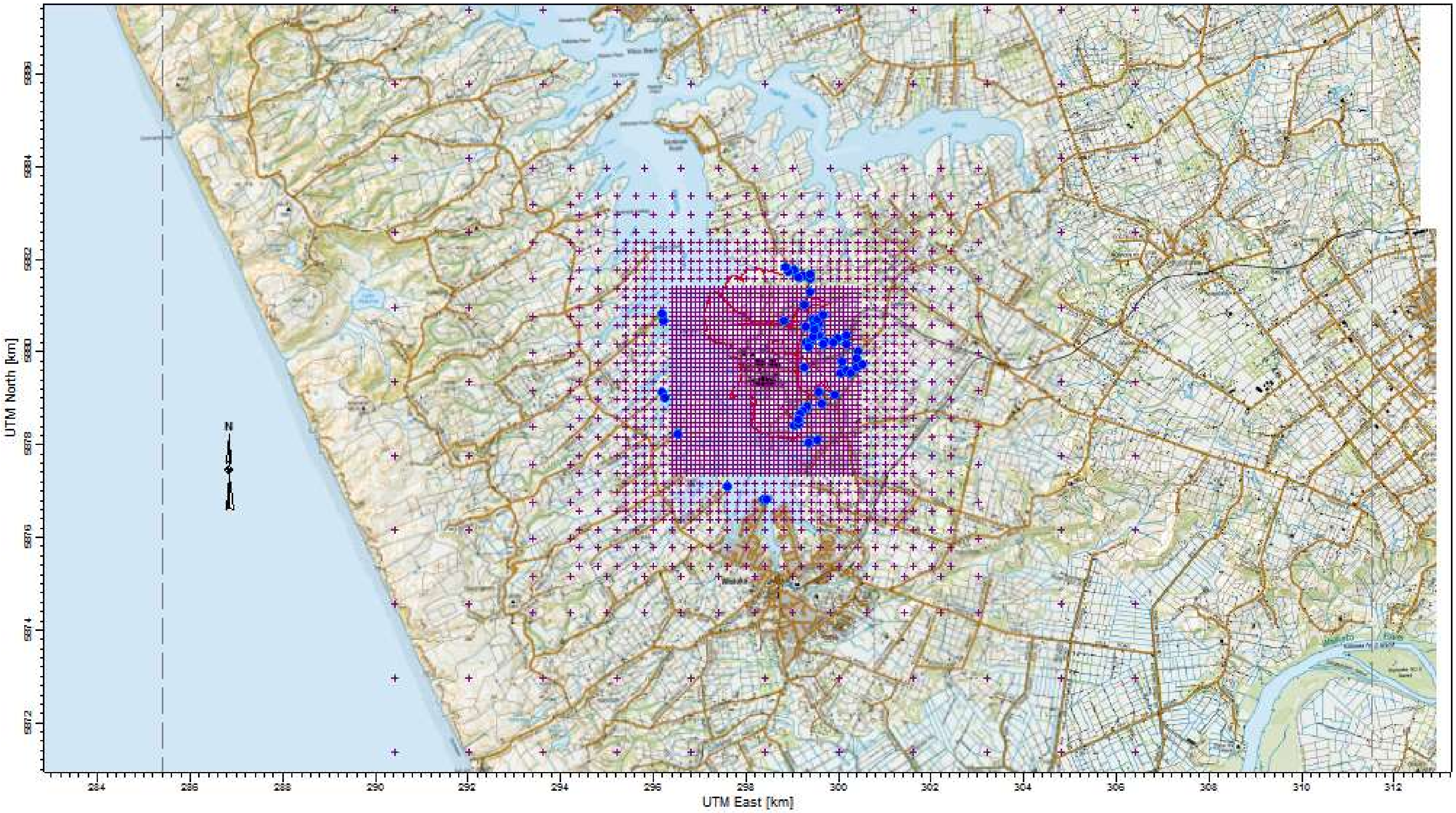

Figure 2.1: Location of modelled discrete receptors/monitoring locations (blue circles) and nested receptor grids (small purple crosses).

Figure 2.2: Modelled discrete receptors (denoted as R1 etc) and monitoring locations

2.4 Building downwash

Buildings and structures can affect the dispersion of a plume from a stack under certain circumstances due to enhanced turbulence, modified wind speeds and modified plume trajectories. This effect, known as ‘building downwash’, may cause a plume to be brought down to the ground rapidly and result in higher GLC than would otherwise have occurred without these obstacles.

Figure 2.3 illustrates the buildings that were included for downwash effects assessment purposes in the dispersion model. These buildings include the portable enclosures where the vents are located.

To account for building downwash effects, the BPIP-PRIME algorithm (version 04274, which is the latest version approved for regulatory use) is used to simulate this effect for modelling in CALPUFF. The associated PRIME algorithm is the recommended option for incorporation of building downwash in dispersion modelling in the GPG Modelling.

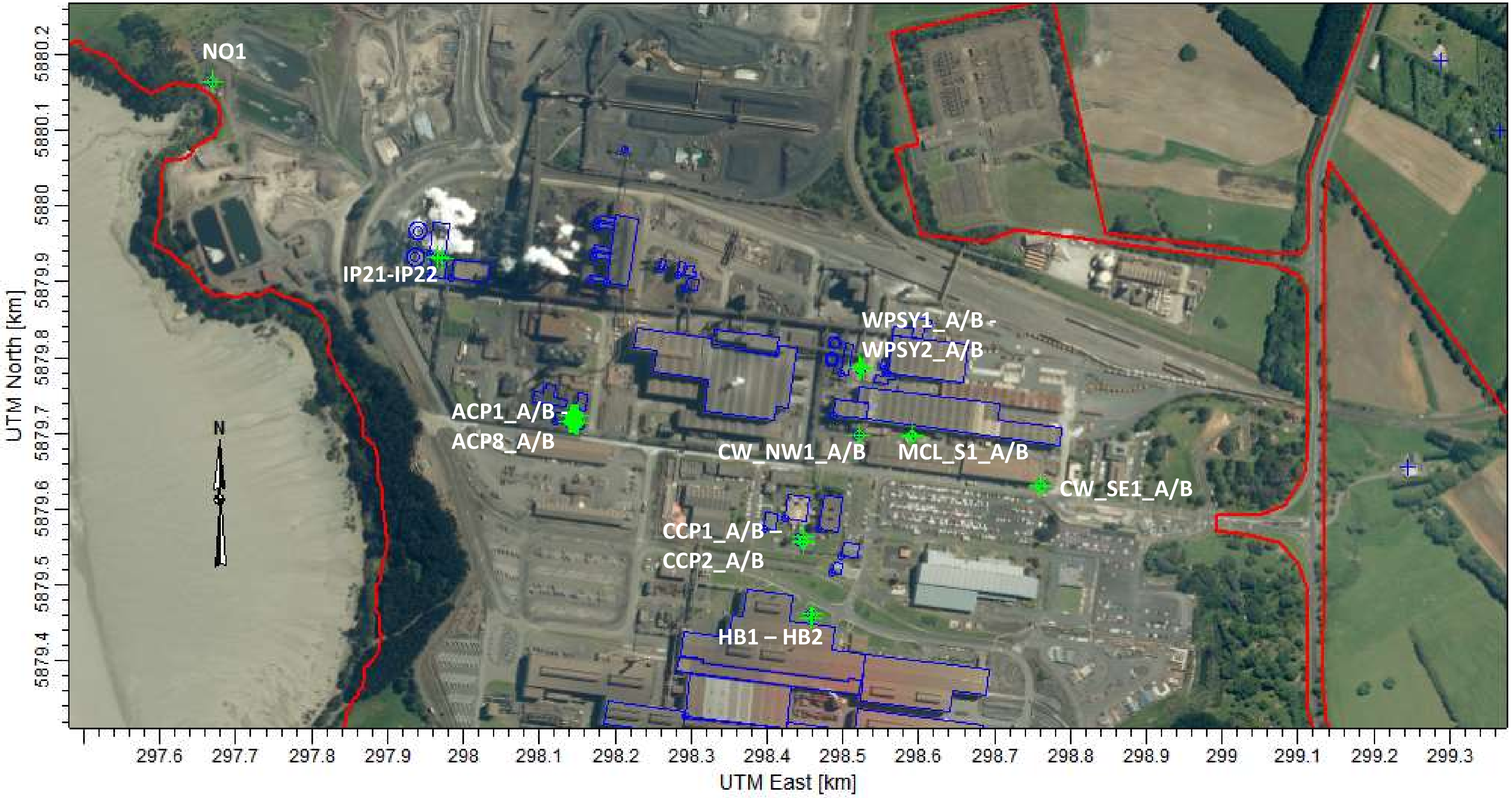

Figure 2.3: Diesel generator vents (green crosses) and buildings (outlined in blue line) included in the model

2.5 Accounting for atmospheric conversion of nitric oxide to nitrogen dioxide

Combustion processes produce nitrogen oxides (NO_X), which consist mainly of nitric oxide (NO) and typically of the order of 5 to 10% nitrogen dioxide (NO_2). Once emitted, some of the NO converts to NO_2 in the atmosphere through reactions with available ozone (O_3).

From a human health perspective, NO_2 is the component of NOx of greatest interest because it is a more potent respiratory irritant than NO (which is present in greater amounts in the discharges). In order to predict GLCs of NO_2, it is necessary to take into account both the direct emission of primary NO_2 and the atmospheric conversion of emitted NO to secondary NO_2.

The *Good Practice Guide for Assessing Discharges to Air from Industry*[5] (GPG Industry) recommends using the NO_2 proxy method to estimate NO_2 GLCs. The proxy method assumes that the conversion of NO to NO_2 occurs instantaneously but is limited by the availability of atmospheric O_3 as follows: [6]

$$[NO_2] = [NO_X]_{mod} \times F(NO_2) + [Proxy\ NO_2]$$

Where:

- $[NO_x]_{mod}$ = The NO_X concentration at the receptor from the modelled NO_X emissions.
- $F[NO_2]$ = The mass fraction of NO_2 in the NO_X emissions from the source. The $F[NO_2]$ is assumed to be an average of 7.5%, based on typical NO_2/NO_X ratio of 5% to 10% for diesel combustion[7].
- $[Proxy\ NO_2]$ = Combined NO_2 with ozone (as NO_2 equivalents) from a suitable background monitoring site (i.e. $[Proxy\ NO_2] = [NO_2]_{ambient} + [O_3]$)

This simplified equation is most suited to modelling a single source, or multiple sources with the same mass fraction of NO_2 in each source.

Being O_3 limited, it is a reasonable assumption that the much larger magnitude of NO_X emissions from the main emission sources at the Steel Mill has ‘exhausted’ the atmospheric O_3 through the oxidation of NO emitted from these main sources. As such, there is no remaining O_3 left for the conversion of emitted NO from diesel generators. This means that aside from the directly emitted NO_2 from diesel combustion (denoted as $[NO_X]_{mod} \times F(NO_2)$), no further contribution to ambient concentration of NO_2 from diesel combustion emissions is assumed. The measured background concentration of NO_2 (See Section 4.2) is therefore adopted as the proxy NO_2 concentration (denoted as $[NO_2]_{ambient}$).

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[5] Good Practice Guide for Assessing Discharges to Air from Industry. (2016). Ministry for the Environment. Publication number: ME 1276

[6] Square brackets are used to indicate the term refers to a concentration, i.e. $[NO_2]$ is the concentration of NO_2.

[7] Guide to Diesel Exhaust Emissions Control of NO_X, SO_X, Particulates, Smoke and CO_2. Seagoing Ships and Large Stationary Diesel Power Plants. The International Council on Combustion Engines. October 2008. (https://www.cimac.com/cms/upload/Publication_Press/Recommendations/Recommendation_28.pdf)

3 Terrain and meteorology

3.1 Terrain

Terrain data is used both in the development of the modelling meteorological dataset (as it influences windflows) and in the dispersion modelling (as pollutant plumes interact with terrain).

The Site is bordered to the west by the Waiuku Estuary, which is a long and relatively narrow tidal arm of the Manukau Harbour. To the west of the Waiuku Estuary, lies the Āwhitu Peninsula comprising ancient sand dunes which form the barrier between the Manukau Harbour and the Tasman Sea. This is an area of moderate local relief. To the east of the Site, the Franklin lowlands stretch eastwards all the way to Papakura. The Franklin lowlands are generally rolling to relatively flat but there are some areas of local relief, particularly associated with water courses.

Figure 3.1 illustrates the terrain surrounding the Site (expressed in metres above mean sea level (ASL). For context, the two red boxes in Figure 3.1 denote a 5 km × 5 km and a 26 km × 26 km area approximately centred on the Site.

Due to the estuarial system of the Waiuku Estuary, the terrain to the west of the Site is relatively flat and is only a few metres above mean sea level. To the east, the terrain is gently sloping upwards, gradually increasing from approximately 35 m ASL at the centre of the Site to approximately 60 m ASL at a distance of about 3 km away.

An exploration of the wider terrain context (26 km × 26 km) shows that the highest terrain - of greater than 100 m elevation - occurs near to the coastline westwards on the Āwhitu Peninsula (approximate distance of 9.7 km) and near to Pukekohe township towards the east (over 15 km away).

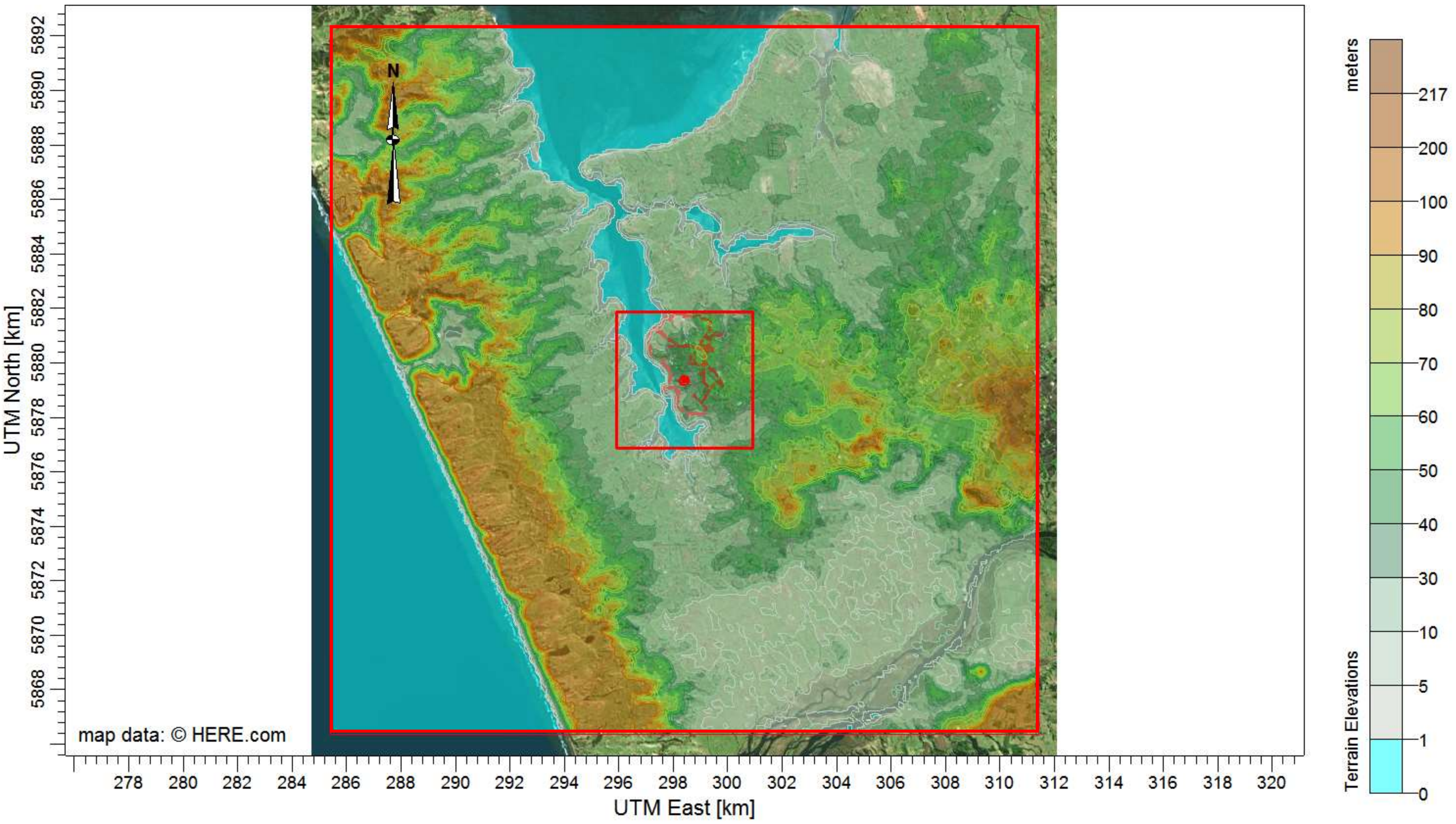


Figure 3.1: Surrounding terrain (red dot denotes approximate centre of NZ Steel operational area; small and big red boxes denote 5 km × 5 km and 26 km × 26 km, respectively, surrounding NZ Steel)

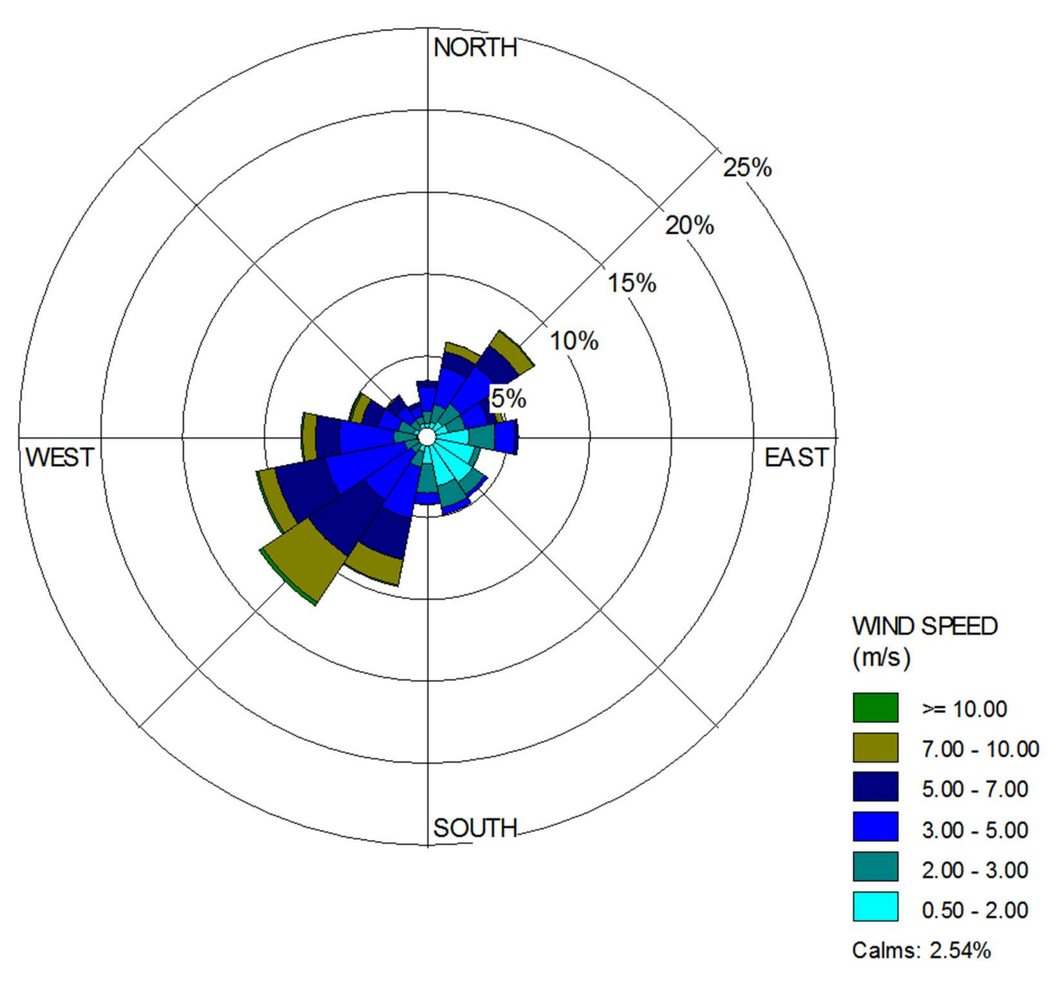
3.2 Meteorology

3.2.1 On-site meteorological monitoring

Wind conditions are observed on-site at the Training Centre since June 2019 using a 10 m mast. The annual wind rose for 2020 for this location is presented in Figure 3.2. This wind rose shows that there are generally high occurrences of wind blowing from the south-southwestern to western directional arc, as well as from the north-northeastern to northeastern directional arc.

Overall, southwesterlies form the most dominant local wind direction. This wind pattern is consistent with the location of the Site where coastal winds from the Tasman Sea generally face no significant impediment as they travel inland, due to the lack of mountain masses between Glenbrook and the coastline which would otherwise provide a wind sheltering effect (Figure 3.3). This dominant local wind direction is in line with the dominant southwesterly airflows over the wider Auckland region.

Average local wind speed is generally around 3.7 m/s, with calm winds (<0.5 m/s) occurring about 2.5% of the time (ie about 219 hours per year).



Calms – 2.54%

Average wind speed – 3.71 m/s

Figure 3.2: Onsite wind rose (January to December 2020) at the NZ Steel Training Centre (Site 3) monitoring site (Note: data reported for a 10 m mast)

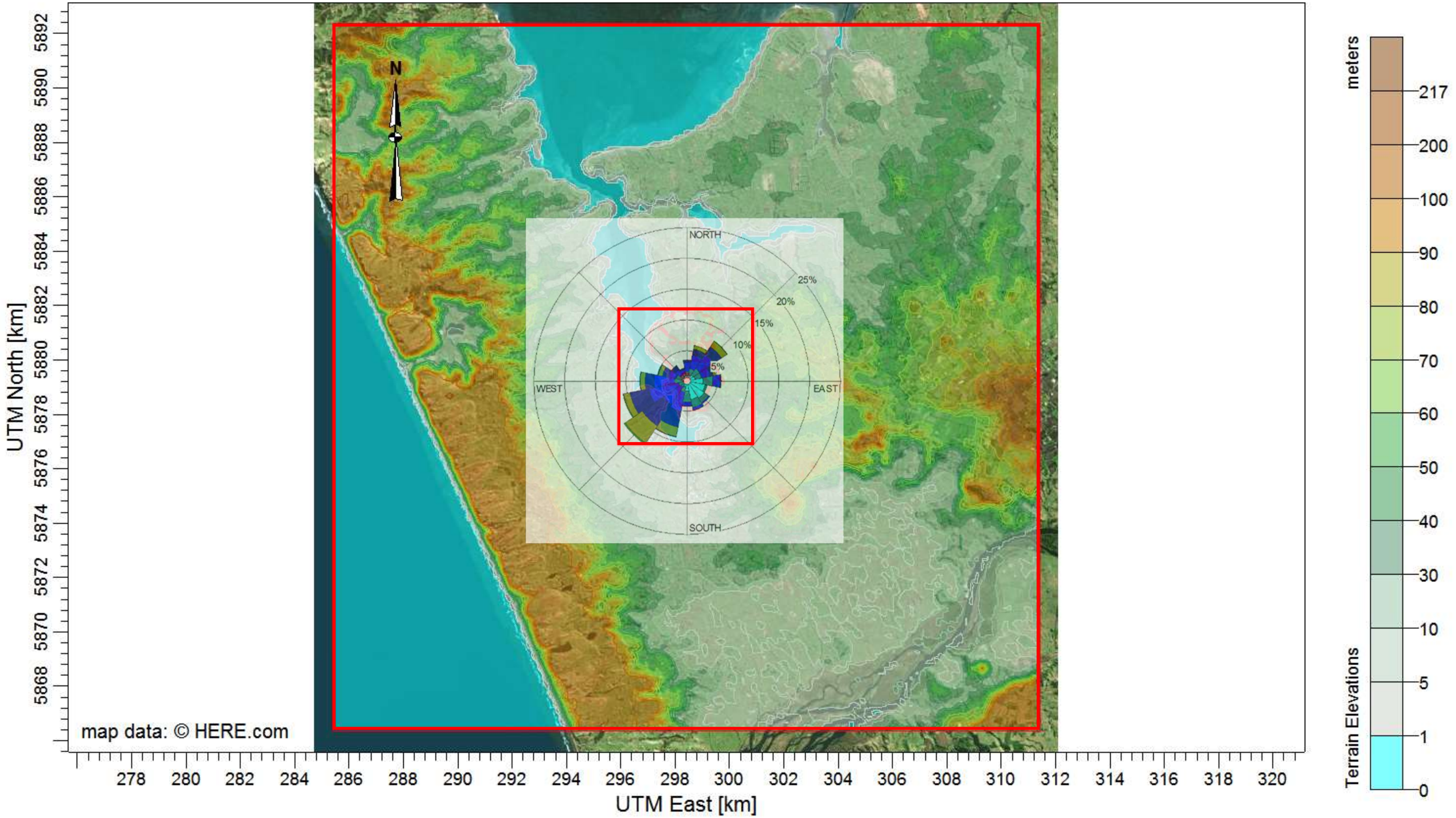


Figure 3.3: On-site 2020 wind rose at the Training Centre overlaid on terrain map (small and big red boxes denote 5 km × 5 km and 26 km × 26 km, respectively, surrounding NZ Steel)

3.2.2 Meteorological modelling (CALMET)

Meteorological information is one of the key inputs for dispersion modelling. The meteorological modelling dataset used in this study was developed to support the current application to replace the Main Air Permit for the Site. A summary of the CALMET dataset inputs is provided as follows:

- The prognostic meteorological model, Weather Research and Forecasting Model (WRF) was used to generate upper air and surface data.
- The CALMET model (version 6.5.0) has been used to generate meteorological data for the dispersion modelling for the years 2015 to 2017.
- The CALMET model covers an area that is 26 km x 26 km centred at the Site and extends up from the surface to the atmospheric boundary layer, with a horizontal grid resolution of 200 m.
- Land use and terrain were incorporated into the CALMET model.

Further details of the CALMET modelling can be obtained from the Dispersion Modelling Study (Appendix C) of the Glenbrook Steel Mill Air Discharge Permit Replacement report (T+T, 2021).

4 Model results and assessment

4.1 Introduction

The GLCs predicted using dispersion modelling have been used to assess the effects of contaminants by comparing predicted off-site concentrations, added to background concentrations, against relevant assessment criteria. Background concentrations of these contaminants, other than CO, are based on the ambient air quality monitoring undertaken at Glenbrook Beach Road (Section 4.2).

Assessment criteria have been adopted based on the hierarchy set out in relevant Ministry for the Environment good practice guidance (GPG Industry[8]), and include values from the National Environmental Standards for Air Quality (NESAQ), New Zealand Ambient Air Quality Guidelines (AAQG), and international guidelines from the World Health Organization (WHO) and Texas Commission on Environmental Quality (TCEQ), where relevant.

Assessment criteria are available for a range of different averaging periods. The assessment criteria apply in different locations based on the likelihood of a person being present over the relevant averaging periods, as summarised in Table 4.1.

Table 4.1: Location and applicability of the ambient standards for assessment purposes

Averaging period	Locations where assessment against the ambient standards should apply	Locations where assessment against the ambient standards should not apply
1-hour	This includes any outdoor areas where the public might reasonably be expected to spend one hour or longer, including pavements in shopping streets, as well as accessible facades (e.g., balconies, terraces).	Any industrial premises that have resource consents (for that pollutant)[9].
8-hour	This includes all outdoor locations where members of the public are likely to be exposed for eight hours as well as the facades of residential properties, schools, hospitals, libraries, etc.	Any industrial premises that have resource consents (for that pollutant). Any location where people are not likely to be exposed for eight hours – for example roads and footpaths.
24-hours (and greater)	This includes all outdoor locations where members of the public might reasonably be exposed for 24-hours.	Any industrial premises that have resource consents for that pollutant. Any location where people are not likely to be exposed for 24-hours – for example roads, footpaths and industrial areas where residential use is not allowed.

For consistency with the locations where these criteria apply, the GLCs are reported as follows:

- Maximum 1-hour (99.9th percentile) GLCs are reported as the highest concentrations anywhere at or beyond the Site boundary; and
- Maximum 8-hour, 24-hour and annual average GLCs are reported as the highest concentration at any discrete sensitive receptor (residence).

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[8] Ministry for the Environment. (2016). Good Practice Guide for Assessing Discharges to Air from Industry.

[9] In this context, the NESAQ do not apply to locations within the Site.

The contour plots for the GLCs of the contaminants are provided in **Appendix B**, which show that the highest GLCs are localised to within the Site boundary.

4.2 Background concentrations

Ambient concentrations of air contaminants (aside from CO) are measured at the Glenbrook Beach Road (Site 20) monitoring station. These measured concentrations include the current air quality impacts from the Steel Mill operation and other background sources[10].

In order to assess the cumulative effects of the emissions from the generators, the modelled GLCs for each contaminant are added to existing background concentrations. In the case of PM_{10}, there is continuous PM_{10} monitoring data available for the same years as the dispersion modelling. Therefore, daily model predictions and background concentrations can be added together giving a contemporaneous assessment of cumulative effects for the 24-hour average concentration. For the annual average, the highest annual average for PM_{10} (19.3 $\mu g/m^3$) recorded at the monitoring site was used for the background concentration.

For other contaminants where monitoring is not available for the modelled years, it is necessary to adopt a "representative" background concentration. Apart from PM_{10} and CO (which is not monitored), the 99th percentile of the measured concentrations has been adopted as the representative background concentration for this assessment (see Table 4.2). These values will be conservatively high because the highest background concentrations of contaminants are likely to be associated with the effects of emissions from the tall stacks at the Steel Mill. The worst-case dispersive conditions for these tall stacks will differ from those for the short generator stacks, and therefore, at a given location, the worst case modelled GLCs and background concentrations are unlikely to occur at the same time.

As described in Section 2.5, the "Proxy method" for allowing for the oxidation of emitted NO to NO_2 is not considered to be applicable in this case due to assumed 'exhaustion' of ambient O_3 concentrations from conversion of NO from the main Steel Mill stack emissions. Hence the background NO_2 concentration in Table 4.2 is added to the NO_2 modelled GLCs (i.e. the NO_2 fraction which is directly emitted, i.e. denoted as $[NO_X]_{mod} \times F(NO_2)$).

Representative values of existing air quality have been adopted from dispersion modelling of the effects of the emissions from the Steel Mill, based on modelling the highest measured CO emission rates. This approach is likely to over-predict actual CO concentrations as it is unlikely that all sources will be emitting at the maximum possible rate at the same time. The modelled concentrations have been added to the default background concentrations recommended for rural areas in the Good Practice Guide for Assessing Discharges to Air from Industry (2016) (GPG Industry). The resulting concentrations are 7.27 mg/m^3 (1-hour average) and 3.18 mg/m^3 (8-hour average).

Table 4.2: Existing air concentrations adopted for this assessment

Averaging period	NO2 (µg/m3)	SO2 (µg/m3)	PM2.5 (µg/m3)	PAHs (µg/m3)
1-hour average (99th percentile)	32.3	31.0	-	-
24-hour average (99th percentile)	20.1	19.4	16.0	-
Annual (maximum)	-	-	6.5	1.12×10^{-5}

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[10] The emissions from the two existing diesel generators at Building 60 will have negligible impacts upon the measured concentrations at Glenbrook Beach Road, when compared to the other major emission sources at NZ Steel.

Averaging period	NO2 (µg/m3)	SO2 (µg/m3)	PM2.5 (µg/m3)	PAHs (µg/m3)
Date range	20/11/2018 – 28/2/2021	4/4/2017 – 30/6/2020	16/3/2018 – 28/2/2021	November 2019 to February 2020, October 2020, January 2021, February 2021

4.3 Screening threshold of insignificance

There is no specific guidance in New Zealand to assess the degree of significance of modelled GLCs as part of an air quality assessment. To provide context for the model results, we have adopted a tiered approach to describe the degree of significance:

- As a first-level screening approach, the air emissions risk assessment process for environmental permit applications in England[11,12] has been used for both short-term and long-term GLCs, as follows:
    - For short-term (i.e 1 hour, 8 hours and 24 hours) averaging period, the predicted GLC (of emissions from the diesel generators only) is considered to be insignificant if it is less than 10% of the short-term assessment criteria.
    - For long-term (i.e. annual) averaging period, the predicted GLC (of emissions from the diesel generators only) is considered to be insignificant if it is less than 1% of the long-term assessment criteria.
- If the GLC exceeds the screening "significance" criteria, the cumulative effects of the generator emissions along with background concentrations are considered against the assessment criteria.

4.4 Assessment of emissions

4.4.1 Carbon monoxide

The relevant assessment criteria for emissions of CO are:

- 30000 µg/m^3 as a 1-hour average (from the AAQG and AAAQT).
- 10000 µg/m^3 as a (running) 8-hour average (from the NESAQ).

As shown in Table 4.3, the modelled maximum CO GLCs from the operation of the generators are 2% of the assessment criteria for both averaging periods considered and are assessed at a screening level as insignificant. It is concluded that the effects of CO emissions are negligible.

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[11] Environment Agency and Department of Environment, Food & Rural Affairs (England), published 1 February 2016, last updated 19 May 2021 (https://www.gov.uk/guidance/air-emissions-risk-assessment-for-your-environmental-permit#screening-for-protected-conservation-areas).

[12] The original intention of the screening methodology of insignificant GLCs is for assessing whether detailed assessment (dispersion modelling) is needed, based on a conservative initial estimation of GLCs from dispersion factors. In the context of this assessment, the screening thresholds of insignificance has been conservatively adopted to apply to dispersion modelling results.

Table 4.3: Comparison of GLCs and cumulative effects of CO against assessment criteria

Averaging period	Assessment criteria ($\mu g/m^3$)	Maximum GLC from generators ($\mu g/m^3$)	Background concentration ($\mu g/m^3$)	Total GLC ($\mu g/m^3$)	Total GLC as a % of criterion
1-hour average (99.9th percentile)	30000	578.8 (2% of criterion)	7270 (24% of criterion)	7849	26%
8-hour (running) average	10000	175.2 (2% of criterion)	3180 (32% of criterion)	3355	34%

4.4.2 Nitrogen dioxide

NO_X emissions from the generators consist of mainly nitric oxide (NO), with the remainder (5 to 10%) as nitrogen dioxide (NO_2) which is the contaminant of most interest with respect to effects on human health. The relevant assessment criteria for emissions of NO_2 are:

- 200 $\mu g/m^3$ as a 1-hour average (from the NESAQ and AAQG).
- 100 $\mu g/m^3$ as a 24-hour average (from the NESAQ and AAQG).

As shown in Table 4.4, the modelled maximum 24-hour NO_2 GLC is less than 10% of the assessment criterion and are assessed at a screening level as insignificant.

The maximum modelled 1-hour average NO_2 concentration is greater than 10% of the assessment criterion and therefore requires more detailed consideration. The cumulative impact of the generator emissions and background NO_2 concentrations (largely from the Steel Mill) is 55% of the assessment criterion. This worst-case modelled concentration, however, occurs at the western Site boundary in a location (at the estuary) where a member of the public would be unlikely to be present. The highest modelled concentration at the eastern Site boundary where most sensitive receptors are located is 42.3 $\mu g/m^3$ (1-hour average). Conservatively assuming the same background NO_2 concentration, the maximum cumulative impact at any sensitive receiver is 74.6 $\mu g/m^3$ (1-hour average), which is 37% of the assessment criterion. This level of effect is considered to be less than minor.

This concentration assumes coincidence of high contributions from generators and high background levels from other sources on site such as the tall stacks in the Iron Plant. In reality, this is unlikely due to the different locations and characteristics of background sources and the different meteorological conditions at which the peak impacts from these sources and the generators will occur. This provides a level of conservatism to this maximum prediction, therefore it is unlikely that NO_2 levels would approach the criterion off site.

Table 4.4: Comparison of GLCs and cumulative effects of NO_2 against assessment criteria

Averaging period	Assessment criteria (µg/m^3)	Maximum NO_2 (directly emitted from generators) GLC (µg/m^3)	Background concentration (µg/m^3)	Total GLC (µg/m^3)	Total GLC as a % of criterion
1-hour average (99.9th percentile)	200	42.3 (21% of criterion)[b]	32.3 (16% of criterion)	74.6	37%
24-hour average	100	7.7 (8% of criterion)	27.9 (28% of criterion)	35.6	36%

Notes:

a

The value for maximum NO_2 concentration reported here is for the eastern boundary where sensitive receptors are located.

4.4.3 Inhalable particulates (PM_{10} and $PM_{2.5}$)

The relevant assessment criteria to evaluate emissions of PM_{10} and $PM_{2.5}$ are:

- PM_{10}:
  - 50 µg/m^3 as a 24-hour average (from the NESAQ and AAQG).
  - 20 µg/m^3 as an annual average (from the AAQG).
- $PM_{2.5}$:
  - 25 µg/m^3 as a 24-hour average (from the WHO).
  - 10 µg/m^3 as an annual average (from the WHO).

The model results are shown in Table 4.5 and Table 4.6. All modelled GLC are below 10% of the assessment criterion apart from 24-hour average $PM_{2.5}$, which is at 10% of the assessment criterion. All of the cumulative results are dominated by existing background concentrations and the incremental impact of the generator emissions does not cause an exceedance of the relevant criteria. For the reasons discussed below regarding the likely coincidence of worst-case dispersive conditions, the cumulative effects assessment is expected to be conservative. The assessment of $PM_{2.5}$ emissions is also conservative as it assumes that all of the PM_{10} emissions comprise of $PM_{2.5}$.

The modelled 24-hour average PM_{10} concentrations have been presented in Table 4.6 for:

- The highest cumulative concentration; and
- The day with the highest contribution from the generators.

This comparison illustrates that the conditions for the worst-case impacts of the generator emissions do not coincide with the worst-case background conditions. Previous analysis to support the application for replacement consent for the Steel Mill has shown that the worst-case background PM_{10} concentrations are related to fugitive dust emissions from storage and handling of raw materials (such as coal) and co-products (such as slag materials). The additional impact of the generator emissions would not materially alter the off-site PM_{10} concentrations under these conditions. Therefore, it is concluded that the effects of PM_{10} and $PM_{2.5}$ emissions are less than minor.

Table 4.5: Comparison of GLCs and cumulative effects of PM_{10} and $PM_{2.5}$ using representative background concentrations against assessment criteria

Inhalable particle fraction	Averaging period	Assessment criteria ($\mu g/m^3$)	Maximum GLC from generators ($\mu g/m^3$)	Background concentration ($\mu g/m^3$)	Total GLC ($\mu g/m^3$)	Total GLC as a % of criterion
PM_{10}	Annual average	20	0.3 (1% of criterion)	19.3 (97% of criterion)	19.6	98%
$PM_{2.5}$	24-hour average	25	2.5 (10% of criterion)	16.0 (64% of criterion)	18.7	74.8%
	Annual average	10	0.3 (3% of criterion)	6.5 (65% of criterion)	6.8	68%

Table 4.6: Comparison of GLCs and cumulative effects of PM_{10} (24-hour average) using contemporaneous background concentrations against assessment criteria

Inhalable particle fraction	Assessment criteria ($\mu g/m^3$)	Generator contribution ($\mu g/m^3$)	Background contribution ($\mu g/m^3$)	Maximum cumulative modelled concentration ($\mu g/m^3$)	Maximum total (contemporaneous) GLC as a % of criterion
Highest cumulative concentration	50	0.1 (2% of criterion)	68.4	68.5	137%
Highest contribution from generator emissions		2.5 (5% of criterion)	15	17.5	35%

4.4.4 Sulphur dioxide

The relevant assessment criteria for evaluating emissions of SO_2 are:

- 570 $\mu g/m^3$ as a 1-hour average (from the NESAQ),
- 350 $\mu g/m^3$ as a 1-hour average (from the NESAQ and AAQG),
- 120 $\mu g/m^3$ as a 24-hour average (from the AAQG).

As shown in Table 4.7, the modelled SO_2 GLCs from the generators are less than 1% of the assessment criteria and hence the hourly/daily impacts of SO_2 emissions are assessed at a screening level as insignificant. It is concluded that the effects of SO_2 emissions are negligible.

Table 4.7: First-level screening of GLCs of SO_2 against assessment criteria

Averaging period	Assessment criteria (µg/m³)	Maximum GLC from generators (µg/m³)	Background concentration (µg/m³)	Total GLC (µg/m³)	Total GLC as a % of criterion
1-hour average (99.9th percentile)	570	0.8 (0.1% of criterion)	31.0 (5% of criterion)	31.8	6%
	350	0.8 (0.2% of criterion)	31.0 (9% of criterion)	31.8	9%
24-hour average	120	0.08 (0.07% of criterion)	19.4 (16% of criterion)	19.5	16%

4.4.5 Polycyclic aromatic hydrocarbons

The relevant assessment criterion for emissions of PAHs is:

- 0.0003 µg/m³ as an annual average for benzo(a)pyrene as an indicator of PAHs (from the AAQG).

As shown in Table 4.8, the modelled annual GLC of benzo(a)pyrene (with the assumption that all PAHs are benzo(a)pyrene) is less than 0.1% of the assessment criterion and hence the long-term effect of PAH emissions are assessed as negligible.

Table 4.8: Evaluation of GLCs of benzo(a)pyrene against assessment criterion

Averaging period	Assessment criteria (µg/m³)	GLC from generators (µg/m³)	Background concentration (µg/m³)	Total GLC (µg/m³)	Total GLC as a % of criterion
Annual	0.0003	9.43×10^{-8} (0.03% of criterion)	1.12×10^{-5}	1.13×10^{-5}	4%

4.5 Conclusions

Based on the modelling results, the following are concluded:

- Concentrations of CO, SO_2 and PAHs from the generator emissions at off-site locations are well below the assessment criteria and the effects on air quality are considered to be negligible.
- The effects of NO_x emissions from the generators on ambient 24-hour average NO_2 concentrations are insignificant. However, the NO_x emissions are predicted to cause cumulative 1-hour average NO_2 concentrations that are up to 37% at the (eastern) Site boundary location where it is accessible to the public. As the modelled cumulative concentrations remain well below the assessment criteria, these effects on air quality are assessed as less than minor.
- The modelled concentrations of PM_{10} and $PM_{2.5}$ are at or below 10% of the assessment criteria and cumulative concentrations are dominated by existing background concentrations. The incremental impact of the generator emissions does not cause exceedance of the relevant criteria. The assessment of 24-hour average PM_{10} concentrations using contemporaneous background concentrations demonstrated that the worst-case effects of the generator emissions do not occur under the same conditions as worst-case background concentrations. The additional impact of the generator emissions would not materially alter the off-site PM_{10} concentrations under these worst-case conditions. Therefore, it is concluded that the effects of PM_{10} and $PM_{2.5}$ emissions on air quality are less than minor.

5 Applicability

This report has been prepared for the exclusive use of our client New Zealand Steel Limited, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

We understand and agree that our client will submit this report as part of an application for resource consent and that Auckland Council as the consenting authority will use this report for the purpose of assessing that application.

Tonkin & Taylor Ltd

Report prepared by:	Authorised for Tonkin & Taylor Ltd by:
....	....
Suk-yi Lo	Jenny Simpson
Associate Environmental Engineer	Project Director

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Appendix A: Derivation of emission rates

Appendix A Table 1: Derivation of emission rates for Building 60 diesel generators (Mirrlees National KSS8, 2100 kW power rating each)

Contaminant	Emission factors[a] (kg/kWh)	Emission rates per stack (kg/hr)
CO	0.0033	6.9
NO_X	0.0079	16.6
PM_{10}	0.00043	0.90
$PM_{2.5}$	0.00042	0.88
SO_2[b]	4.9×10^{-6}	1.03×10^{-2}
PAHs	6×10^{-11}	1.26×10^{-7}

Notes:

a Source: Table 42, NPI Emission estimation technique manual for Combustion engines, Version 3.0, June 2008.

b Assumption of 10 ppm sulphur content in diesel based on Engine Fuel Specifications Regulations 2011 (https://www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-generation-and-markets/liquid-fuel-market/engine-fuel-quality/).

Appendix A Table 2: Derivation of emission rates for P&LP West Product Storage Yard/Alinta Car Park/Central Workshops/Metal Coating Line diesel generators (Cummins KTA50-G3, 800 kW power rating each)

Contaminant	Emission factors[a] (kg/kWh)	Emission rates per vent[b] (kg/hr)
CO	0.0036	1.4
NO_X[c]	0.0060	2.4
PM_{10}	0.00012	0.048
$PM_{2.5}$	0.00012	0.048
SO_2[d]	4.6×10^{-6}	1.84×10^{-3}
PAHs[e]	6×10^{-11}	2.40×10^{-8}

Notes:

a Source: Manufacturer's specifications, unless otherwise stated.

b Two vents per enclosure, each enclosure houses one generator. Assumed emissions equally distributed between the two vents.

c Source: Euro Stage 2 emission factors (https://dieselnet.com/standards/eu/nonroad.php#s1)

d Adjusted from 350 ppm (manufacturer's specifications) to 10 ppm sulphur.

e Source: Table 42, NPI Emission estimation technique manual for Combustion engines, Version 3.0, June 2008

Appendix A Table 3: Derivation of emission rates for Café Car Park diesel generators (Caterpillar XQ2000, 1400 kW power rating each)

Contaminant	Emission factors[a] (kg/kWh)	Emission rates per vent[b] (kg/hr)
CO	0.0035	2.5

Contaminant	Emission factors[a] (kg/kWh)	Emission rates per vent[b] (kg/hr)
NO_X	0.0064	4.5
PM_{10}	0.00020	0.14
$PM_{2.5}$	0.00020	0.14
SO_2[c,d]	4.9×10^{-6}	3.43×10^{-3}
PAHs[c]	6×10^{-11}	4.20×10^{-8}

Notes:

a Source: EPA Tier 2 specifications (https://dieselnet.com/standards/us/nonroad.php#tier3), unless otherwise stated.

b Two vents per enclosure, each enclosure houses one generator. Assumed emissions equally distributed between the two vents.

c Source: Table 42, NPI Emission estimation technique manual for Combustion engines, Version 3.0, June 2008

d 10 ppm sulphur.

Appendix A Table 4: Derivation of emission rates for North of 6 Hi-Building diesel generators (Aggreko containerised GHP generator set, 800 kW power rating each)

Contaminant	Emission factors[a] (kg/kWh)	Emission rates per vent (kg/hr)
CO	0.00072	0.58
NO_X	0.0058	4.6
PM_{10}	0.00005	0.040
$PM_{2.5}$	0.00005	0.040
SO_2[b,c]	4.9×10^{-6}	3.92×10^{-3}
PAHs[b]	6×10^{-11}	4.80×10^{-8}

Notes:

a Source: Manufacturer's specifications, unless otherwise stated.

b Source: Table 42, NPI Emission estimation technique manual for Combustion engines, Version 3.0, June 2008

c 10 ppm sulphur.

Appendix A Table 5: Derivation of emission rates for Northside outfall diesel generator (Caterpillar C9 DE330E0, 240 kW power rating each)

Contaminant	Emission factors[a]	Emission rates per vent (kg/hr)
CO	832.1 mg/Nm^3	0.22
NO_X	3132 mg/Nm^3	0.83
PM_{10}	24.4 mg/Nm^3	0.0064
$PM_{2.5}$	24.4 mg/Nm^3	0.0064
SO_2[b,c]	4.9×10^{-6} kg/kWh	1.18×10^{-3}
PAHs[b]	6×10^{-11} kg/kWh	1.44×10^{-8}

Notes:

a Source: Manufacturer's specifications, unless otherwise stated.

b Source: Table 49, NPI Emission estimation technique manual for Combustion engines, Version 3.0, June 2008

c 10 ppm sulphur.

Appendix B: Discrete receptors

Appendix B Table 1: Modelled discrete receptors

Receptor ID (off-site dwelling unless otherwise stated)	Address	Approximate distance from the nearest Operational Area boundary (m)
R1 (on-site dwelling)	130 Mission Bush Rd	135
R2	60 Mission Bush Rd	415
R3	27 Williams Rd	340
R4 (on-site dwelling)	67 Williams Rd	530
R5	65 Williams Rd	500
R6	190 Mission Bush Rd	500
R7 (on-site dwelling)	152 Brookside Rd	549
R8	17 Reg Bennett Rd	725
R9	29 Reg Bennett Rd	765
R10	78 Glenbrook Beach Rd	1070
R11	160 Glenbrook Beach Rd	1255
R12	159 Glenbrook Beach Rd	1190
R13	185 Glenbrook Beach Rd	1265
R14 (Glenbrook School)	459 Glenbrook-Waiuku Rd	1320
R15	118 Glenbrook Beach Rd	1275
R16	134 Glenbrook Beach Rd	1235
R17	341 Glenbrook-Waiuku Rd	750
R18	37 Mission Bush Rd	560
R19	39 Williams Rd	335
R20	45 Williams Rd	350
R21	65 Williams Rd	420
R22	36C Waitangi Falls Rd	980
R23	36D Waitangi Falls Rd	995
R24	122 Glenbrook Beach Rd	1340
R25	56 Mayhead Rd	1770
R26	2 Boundary Rd	1615
R27	194 Waipipi Wharf Rd	1420
R28	203 Waipipi Wharf Rd	1500
R29	133 Marae O Rehia Rd	1900
R30	13 Rangiwhea Rd	2190
R31	198 Mission Bush Rd	560
R32	120 Brookside Rd	790
R33	116 Brookside Rd	750
R34	22 Reg Bennett Rd	720

Receptor ID (off-site dwelling unless otherwise stated)	Address	Approximate distance from the nearest Operational Area boundary (m)
R35	22 Reg Bennett Rd	730
R36	17 Reg Bennett Rd	670
R37	27 Reg Bennett Rd	640
R38	30 Reg Bennett Rd	710
R39	30A Reg Bennett Rd	840
R40	103 Brookside Rd	780
R41	103 Brookside Rd	700
R42	413B Glenbrook-Waiuku Rd	960
R43	377 Glenbrook-Waiuku Rd	940
R44	411B Glenbrook-Waiuku Rd	1050
R45	435 Glenbrook-Waiuku Rd	1290
R46	434 Glenbrook-Waiuku Rd	1400
R47	411A Glenbrook-Waiuku Rd	1130
R48	127 Brookside Rd	630
R49	76 Brookside Rd	1030
R50	62 Brookside Rd	1220
R51	61 Brookside Rd	1150
R52	91 Brookside Rd	890
R53	17 Reg Bennett Rd	630
R54	190 Mission Bush Rd	430

Figure Appendix B.1: Modelled receptor and monitoring site locations

Appendix C: Contour plots

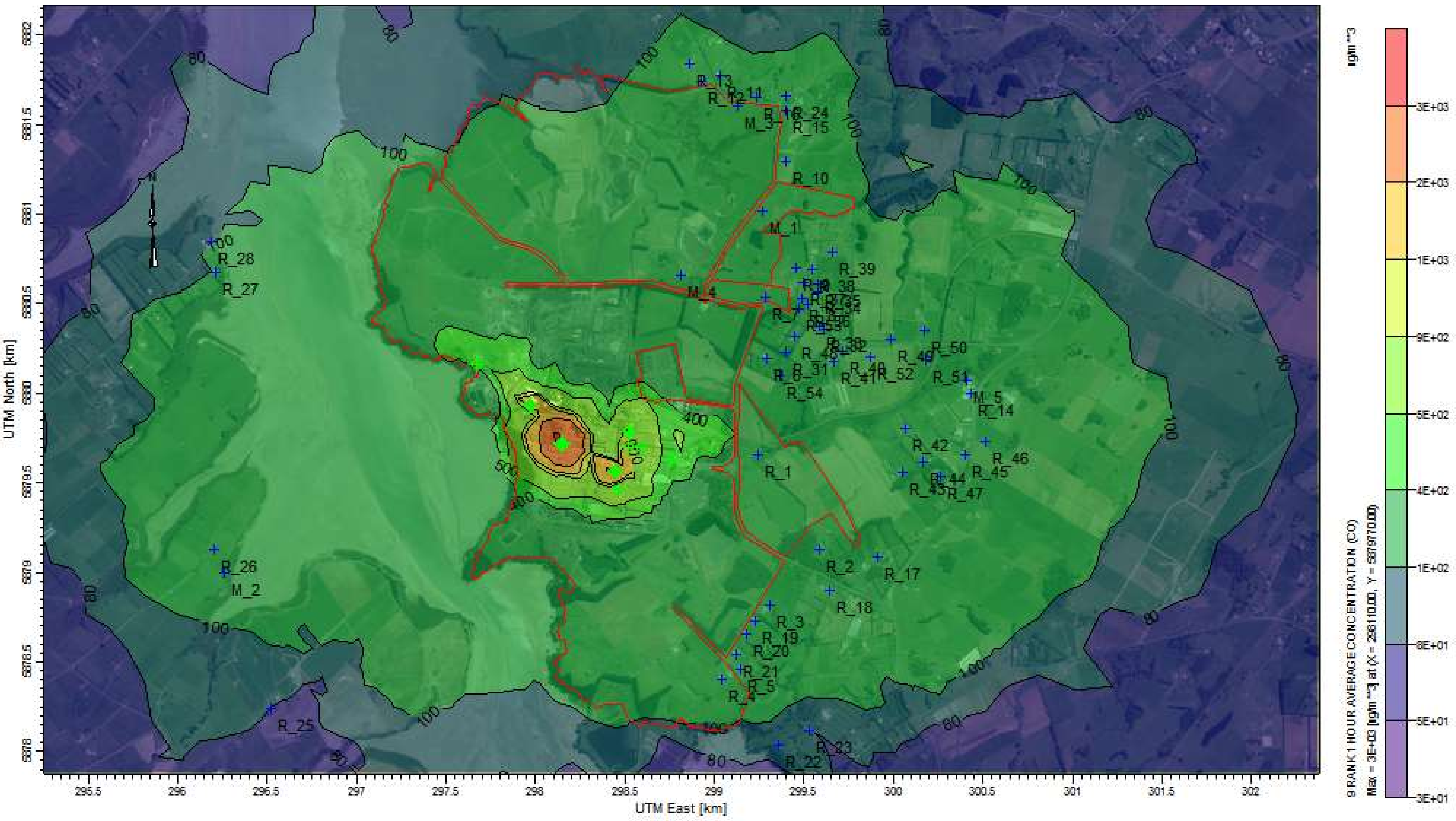

Figure Appendix C.1: Contour plot for CO (1-hour averaging period, 9th rank)

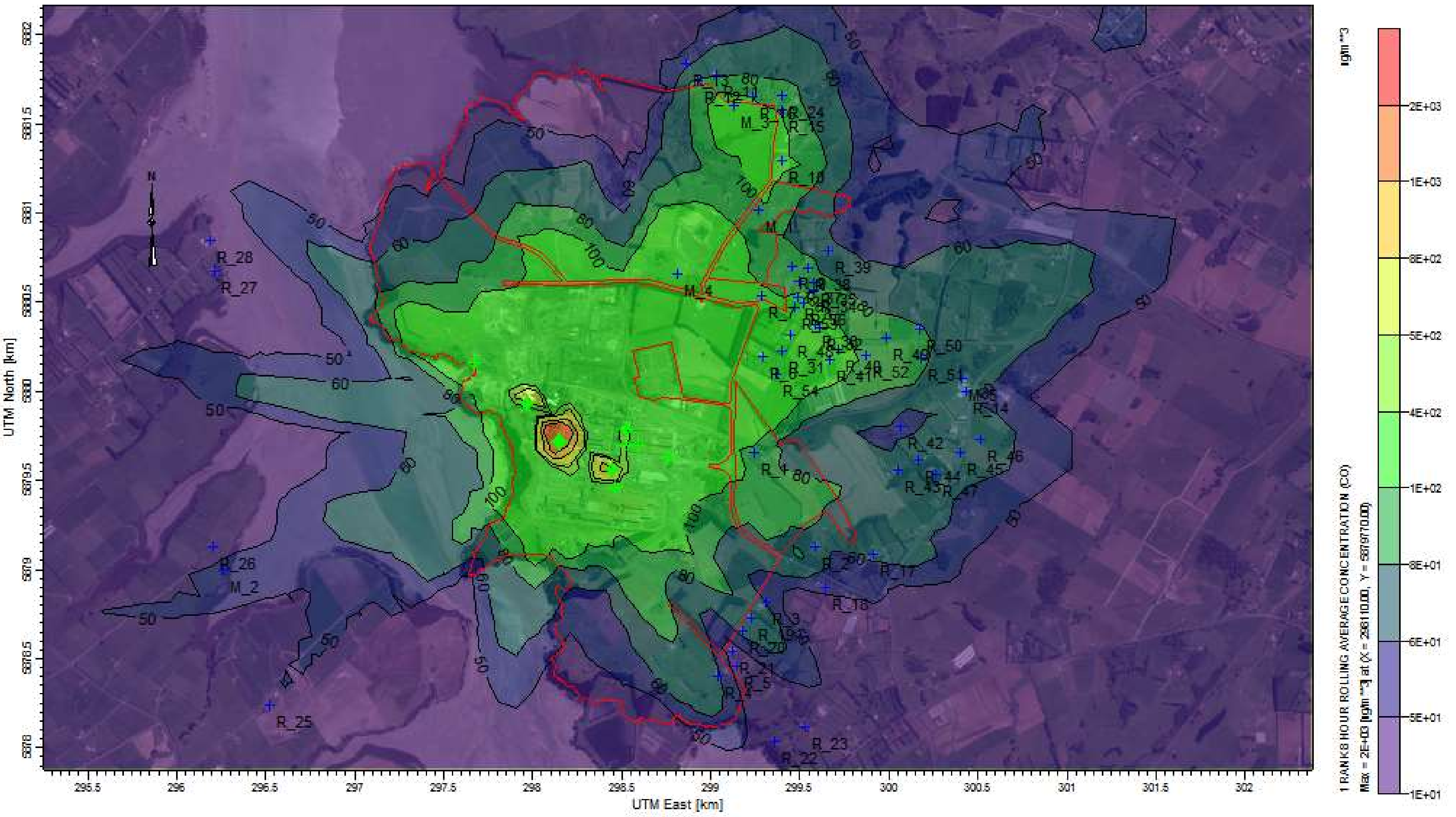

Figure Appendix C.2: Contour plot for CO (8-hour averaging period, rolling)

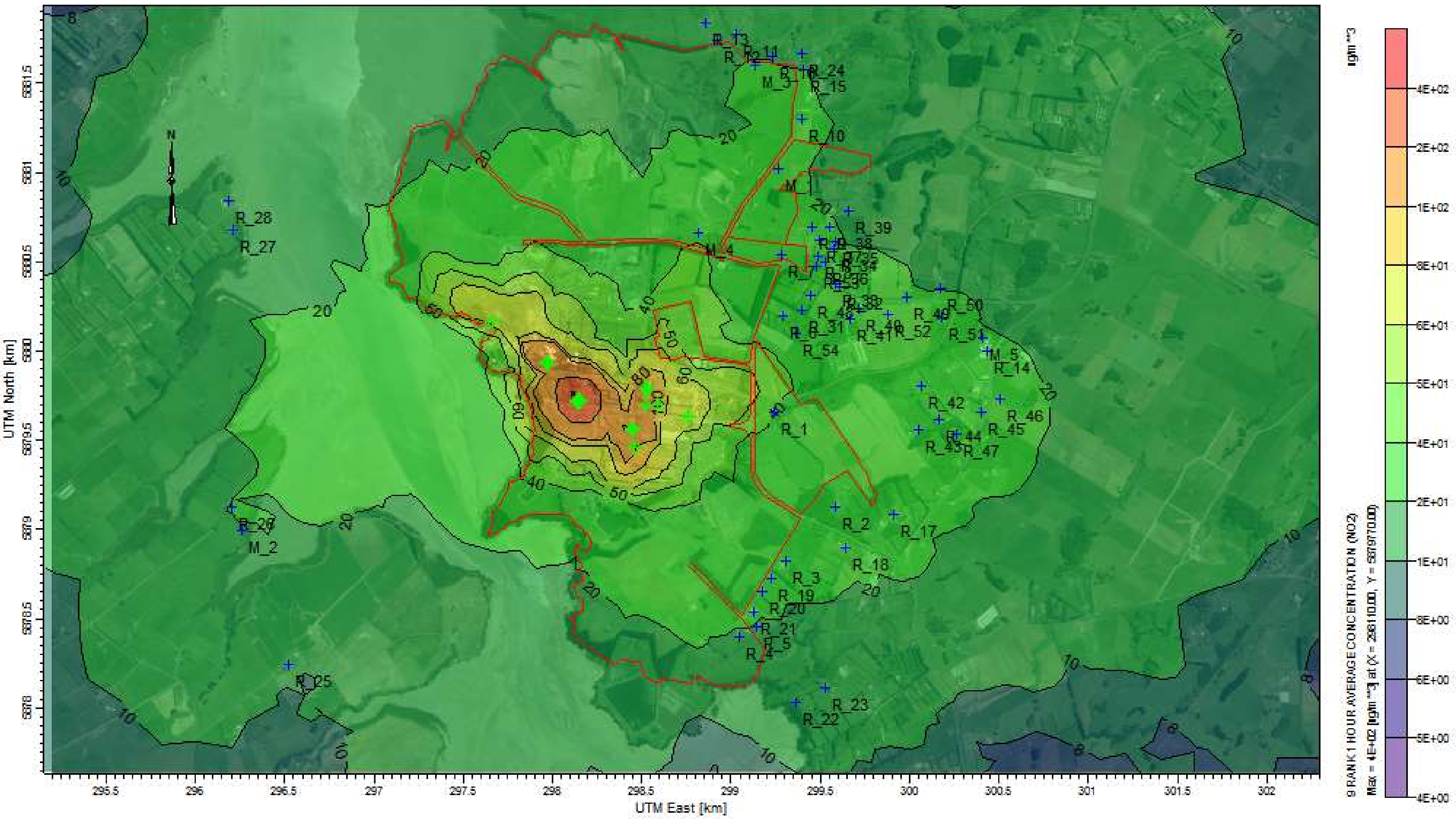

Figure Appendix C.3: Contour plot for NO_2 (1-hour averaging period, 9th rank)

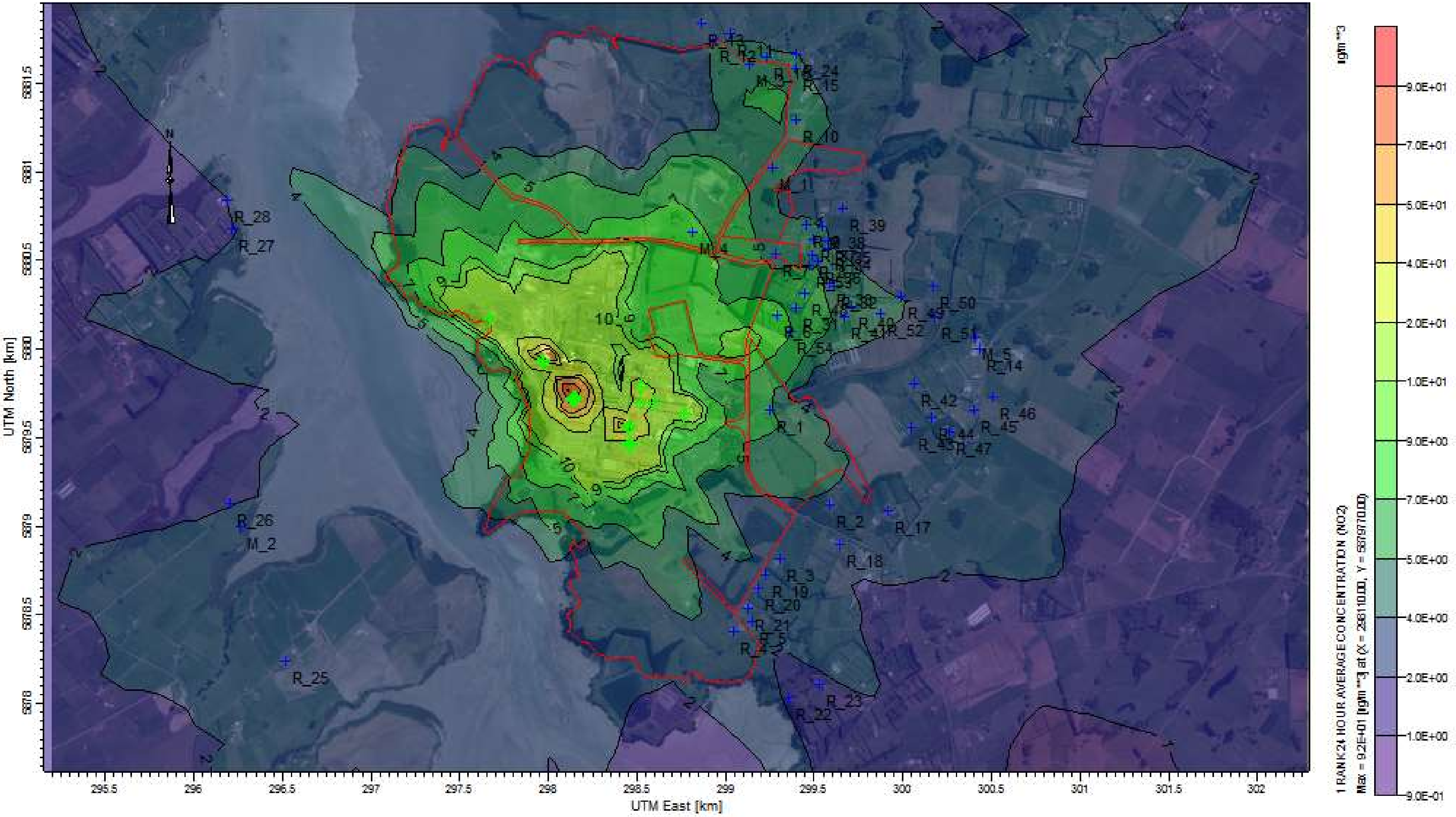

Figure Appendix C.4: Contour plot for NO_2 (24-hour averaging period)

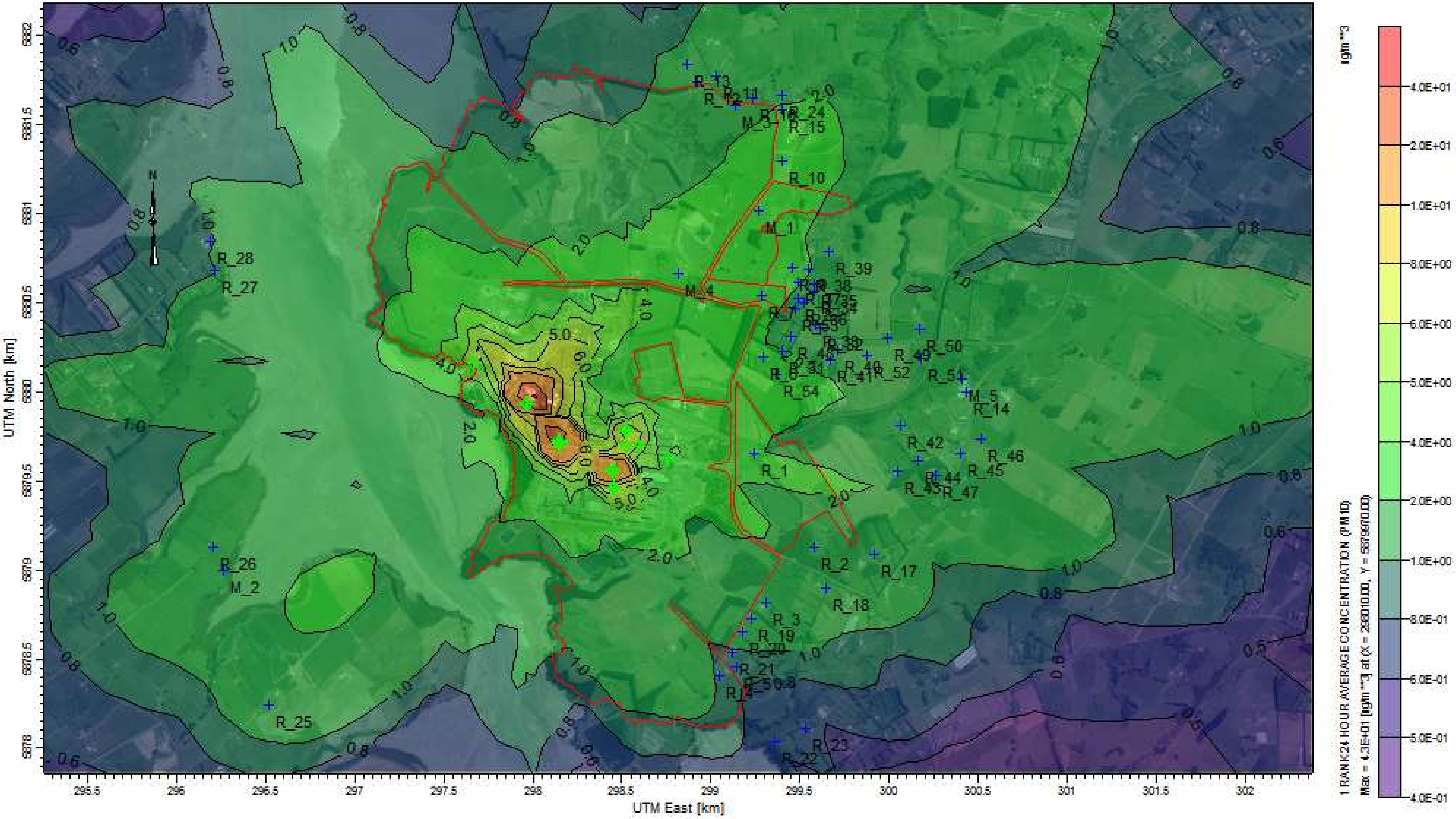

Figure Appendix C.5: Contour plot for PM_{10}/$PM_{2.5}$ (24-hour averaging period)

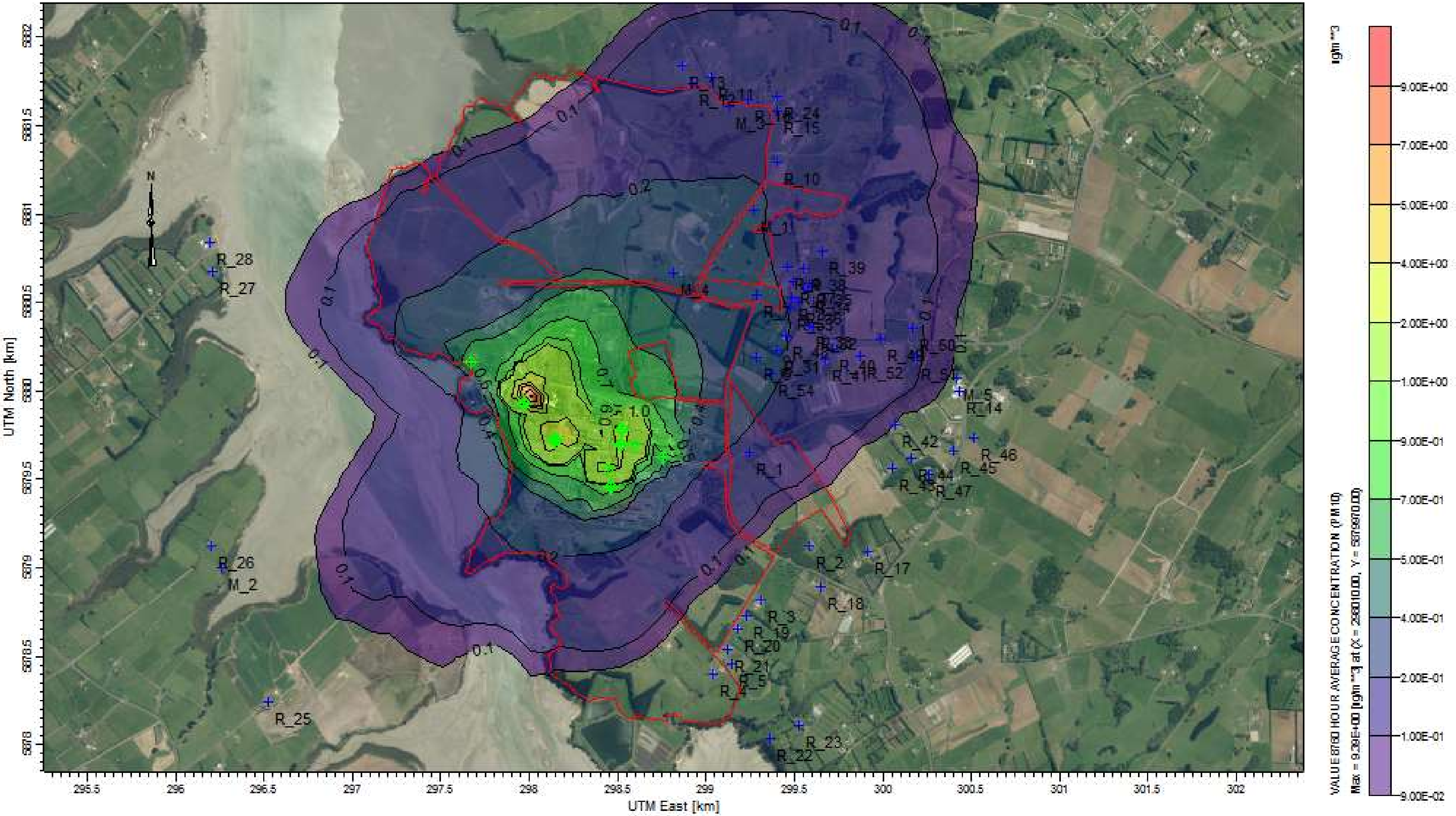

Figure Appendix C.6: Contour plot for PM_{10}/$PM_{2.5}$ (annual averaging period)

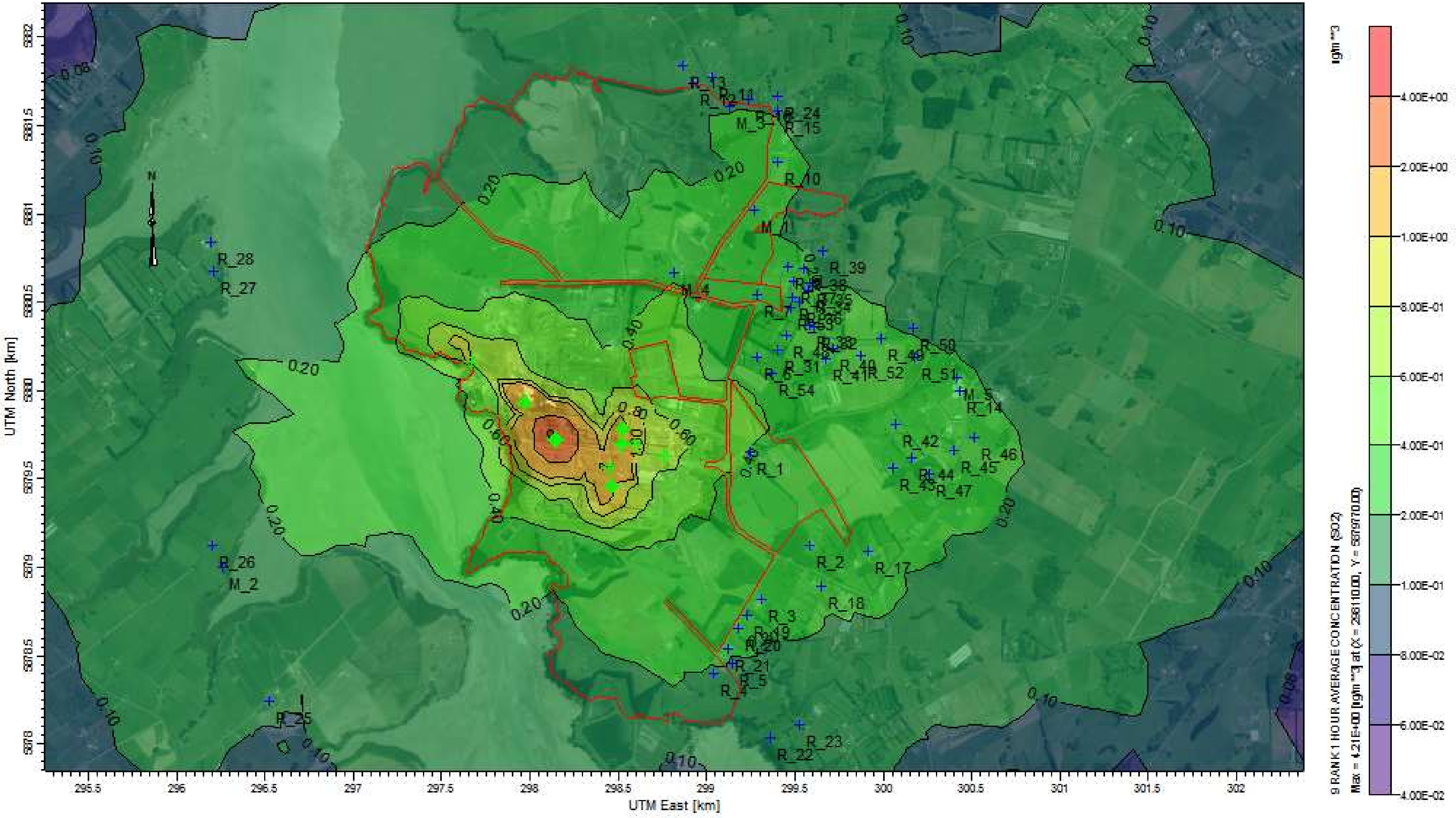

Figure Appendix C.7: Contour plot for SO$_2$ (1-hour averaging period, 9th rank)

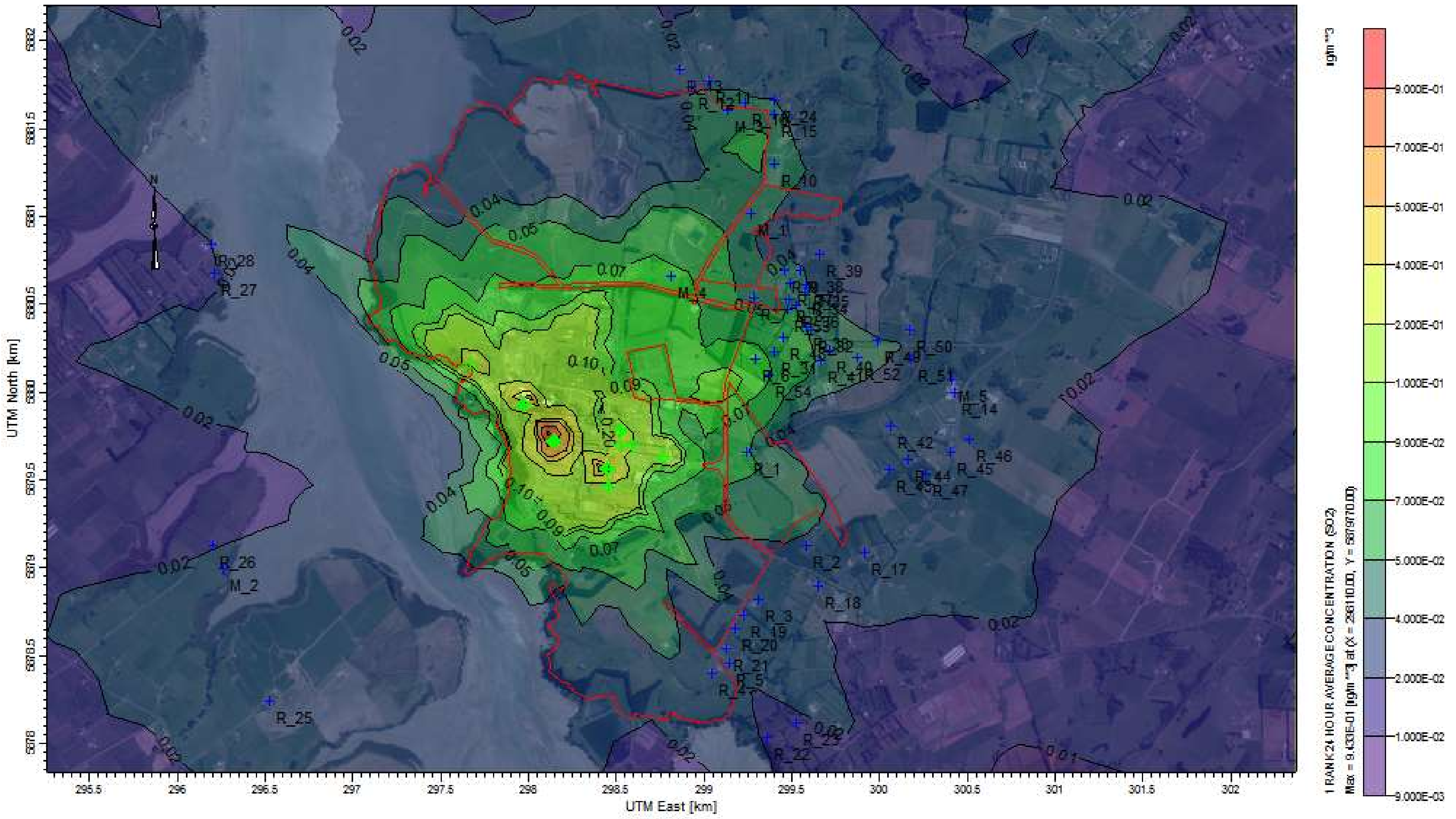

Figure Appendix C.8: Contour plot for SO_2 (24-hour averaging period)

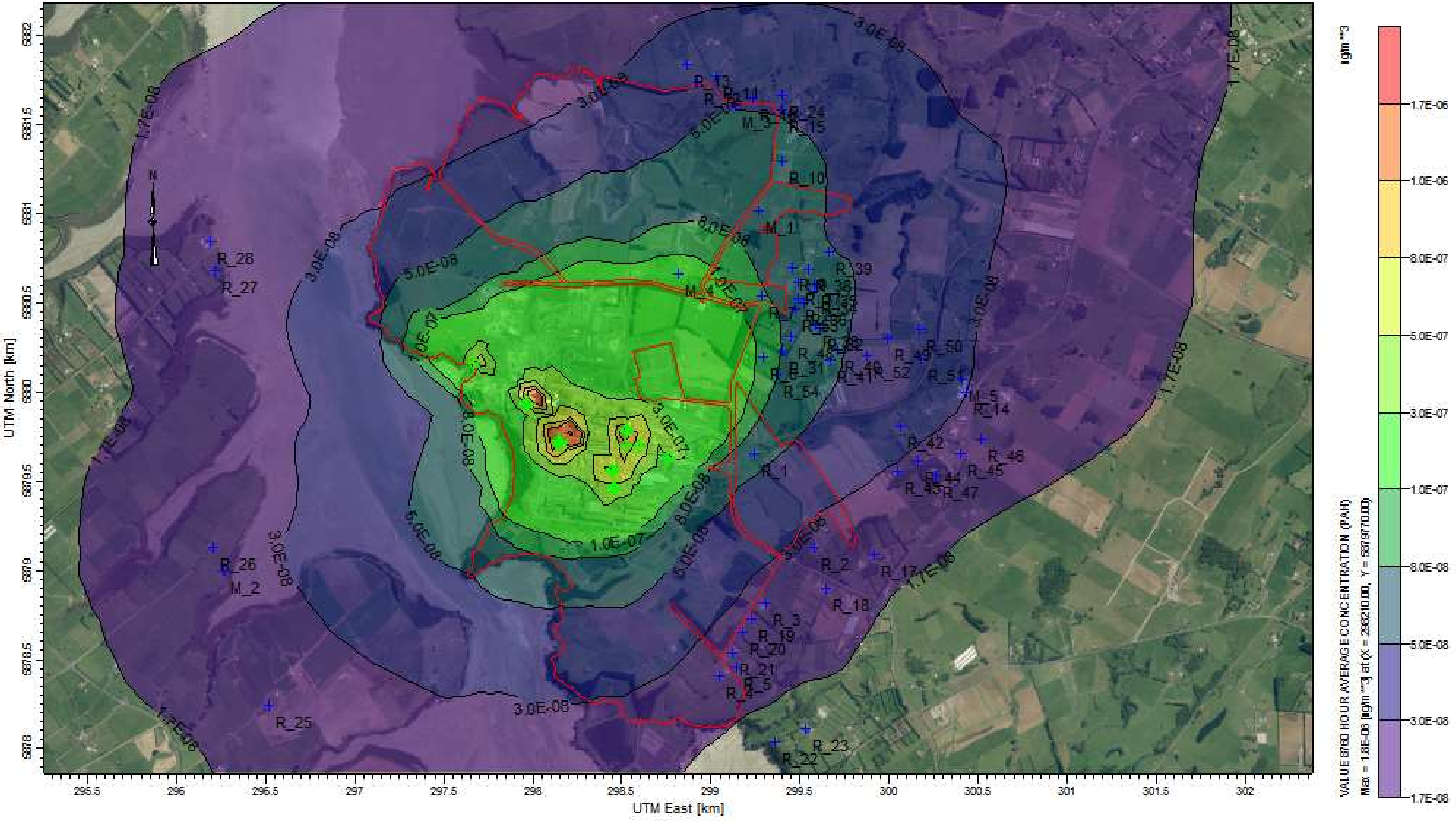

Figure Appendix C 9: Contour plot for PAHs (annual averaging period