APPENDIX A

SEMP 001 Air Quality Management Plan

NZ TRANSPORT AGENCY
WAKA KOTAHI

CEMP Appendix A SEMP001

Christchurch Southern Motorway Stage 2 and Main South Road Four Laning

Draft Construction Air Quality Management Plan

November 2012

Quality Assurance Statement			
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Record of amendment

Amendment number	Description of change	Effective date	Updated by

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Glossary of Terms

CAQMP	Construction Air Quality Management Plan
CEMP	Construction Environmental Management Plan
CSM2	Stage 2 of the Christchurch Southern Motorway, between Halswell Junction Road and Main South Road
MSRFL	Four-laning of Main South Road between CSM2 and Rolleston
HAPs	Hazardous air pollutants
HCV	Commercial vehicles with a gross laden weight of over 3.5 tonnes
FIDOL	Factors used in the assessment dust or odour discharges: • the **frequency** of dust nuisance events • the **intensity** of events, as indicated by dust quantity and the degree of nuisance • the **duration** of each dust nuisance event • the **offensiveness** of the discharge, having regard to the nature of the dust • the **location** of the dust nuisance, having regard to the sensitivity of the receiving environment
Hazardous air pollutants	Include fine particles (PM10 and PM2.5) and a wide range of chemicals that may cause adverse effects on human health
Highly sensitive air pollution land use	A location where people or surroundings may be particularly sensitive to the effects of air pollution. Examples include residential dwellings, hospitals, schools, early childhood education centres, childcare facilities, rest homes, marae, other cultural facilities and sensitive ecosystems.
LTMA	Land Transport Management Act
$\mu g/m^3$	Micrograms per cubic metre
mg/m^3	Milligrams per cubic metre
MfE	Ministry for the Environment
MfE Dust GPG	Ministry for the Environment Good Practice Guide for the Assessment of Effects of Dust
NRRP	Natural Resources Regional Plan
NoR	Notice of Requirement
NZTA	The New Zealand Transport Agency

RMA	Resource Management Act 1991
Sensitive receptor	Highly sensitive air pollution land use
TSP	Total suspended particulate matter, typically with an aerodynamic diameter of less than 30 micrometres

1. Introduction

The NZ Transport Agency (NZTA) seeks to improve access for people and freight to and from the south of Christchurch via State Highway 1 (SH1) to the Christchurch City Centre and Lyttelton Port by constructing, operating and maintaining the Christchurch Southern Corridor. The Government has identified the Christchurch motorway projects, including the Christchurch Southern Corridor, as a road of national significance (RoNS).

The proposal forms part of the Christchurch Southern Corridor and is made up of two sections: Main South Road Four Laning (MSRFL) involves the widening and upgrading of Main South Road (MSR), also referred to as SH1, to provide for a four-lane median separated expressway; and the construction of the Christchurch Southern Motorway Stage 2 (CSM2) as a four-lane median separated motorway. The proposed construction, operation and maintenance of MSRFL and CSM2, together with ancillary local road new construction and improvements, are referred to hereafter as 'the Project'.

A Construction Environmental Management Plan (CEMP) has been prepared to provide the framework, methods and tools for avoiding, remedying or mitigating environmental effects of the construction phase of the Project. The CEMP is supported by six SEMP including this document relating to Construction Air Quality.

1.1 Proposal description

1.1.1 MSRFL

Main South Road will be increased in width to four lanes from its intersection with Park Lane north of Rolleston, for approximately 4.5 km to the connection with CSM2 at Robinsons Road. MSRFL will be an expressway consisting of two lanes in each direction, a median with barrier separating oncoming traffic, and sealed shoulders. An interchange at Weedons Road will provide full access on and off the expressway. MSFRL will connect with CSM2 via an interchange near Robinsons Road, and SH1 will continue on its current alignment towards Templeton.

Rear access for properties fronting the western side of MSRFL will be provided via a new road running parallel to the immediate east of the Main Trunk rail corridor from Weedons Ross Road to just north of Curraghs Road. For properties fronting the eastern side of MSRFL, rear access is to be provided via an extension of Berketts Drive and private rights of way.

The full length of MSRFL is located within the Selwyn District.

1.1.2 CSM2

CSM2 will extend from its link with SH1 / MSRFL at Robinsons Road for approximately 8.4 km to link with Christchurch Southern Motorway Stage 1 (CSM1, currently under construction) at Halswell Junction Road. The road will be constructed to motorway standard comprising four lanes, with two lanes in each direction, with a median and barrier to separate oncoming traffic and provide for safety.[1] Access to CSM2 will be limited to an interchange at Shands Road and a half-interchange with eastward facing ramps at Halswell Junction Road. At four places along

[1] CSM2 will not become a motorway until the Governor-General declares it to be a motorway upon request from the NZTA under section 71 of the Government Roading Powers Act 1989 (GRPA). However, for the purposes of this report, the term "motorway" may be used to describe the CSM2 section of the Project.

the motorway, underpasses (local road over the motorway) will be used to enable connectivity for local roads, while at Robinsons / Curraghs Roads, an overpass (local road under the motorway) will be provided. CSM2 will largely be constructed at grade, with a number of underpasses where elevated structures provide for intersecting roads to pass above the proposed alignment.

CSM2 crosses the Selwyn District and Christchurch City Council boundary at Marshs Road, with approximately 6 km of the CSM2 section within the Selwyn District and the remaining 2.4 km within the Christchurch City limits.

An overview of the air quality components along the Project length is indicated in Figure 1.

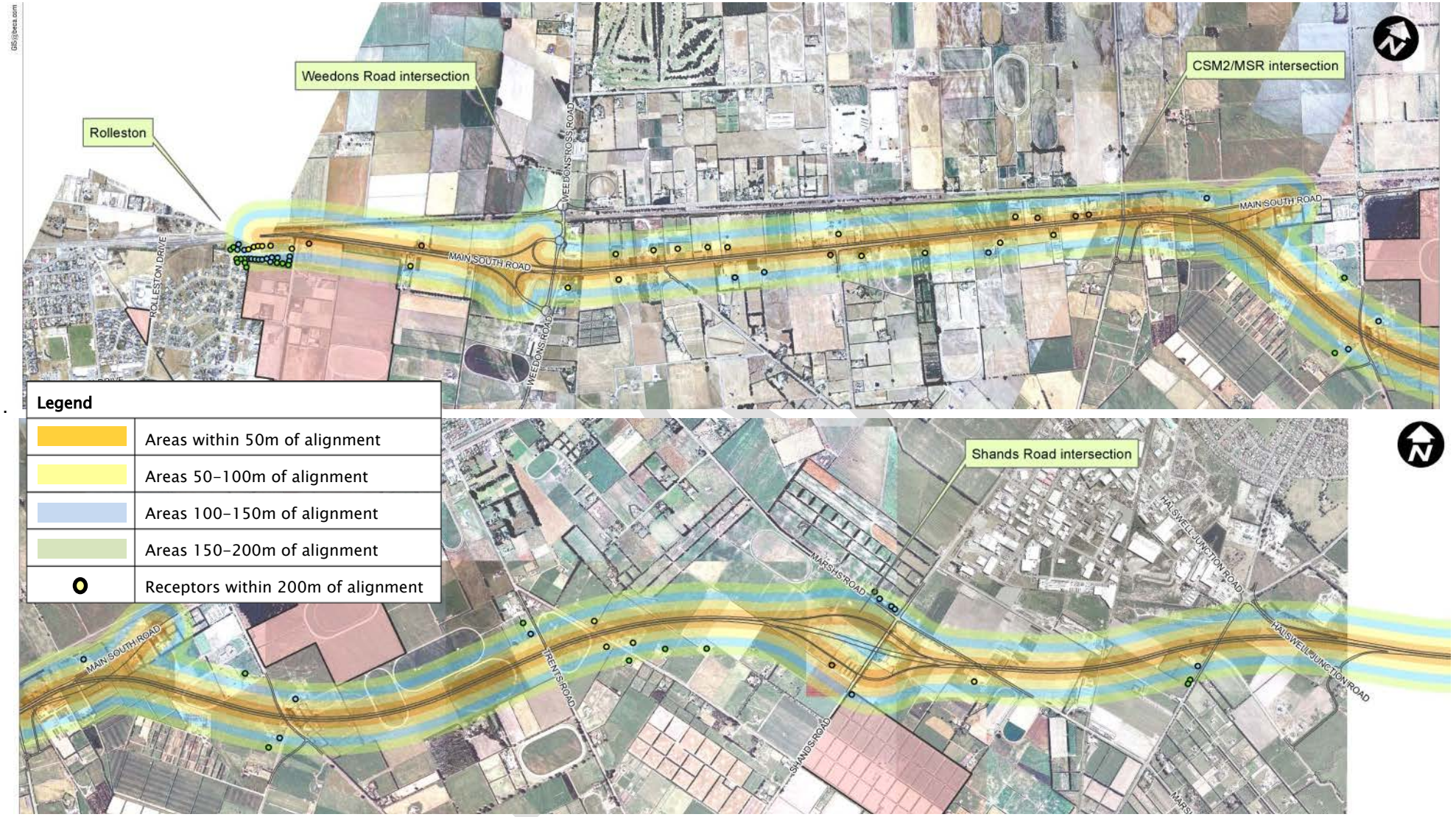

Figure 1: Residential premises in the vicinity of the Project

1.2 Purpose and Scope

SEMP 001, this Construction Air Quality Management Plan (CAQMP or the Plan) forms part of a comprehensive suite of environmental controls within the Construction Environmental Management Plan (CEMP, Volume 4) for the construction phase of the Project. The potential for dust discharges associated with the construction of the Project is somewhat elevated due to the relatively flat topography of the area, with relatively high wind speeds and fine soils The CAQMP addresses the potential construction air quality impacts associated with earthworks and construction activities of the Project, particularly related to earthworks.

The purpose of this CAQMP is to facilitate the avoidance, remediation and mitigation of any adverse effects of discharges of dust generated from the construction activities, and to promote proactive solutions to the control of dust discharges from the site.

The CAQMP identifies the following:

- Various sources of dust that may be created during the construction project.
- Dust mitigation and prevention methods.
- Monitoring methods
- Methods for managing complaints regarding discharges into air and keeping records related to compliance.

The CAQMP will provide an overall framework for the control of discharges into air on site. The CAQMP will be updated, with the necessary approvals, throughout the course of the Project to reflect material changes associated with construction techniques or to the natural environmental. Any relevant revisions of a material nature for the CAQMP will be submitted to the Selwyn District Council and / or the Christchurch City Council for review (as appropriate). A formal review process is described in section 5 of the CAQMP.

This CAQMP is also focussed on the protection of human health and amenity values from the effects of dust (and odour) discharges. A parallel document, the Erosion and Sediment Control Plan (SEMP002) addresses the issue of avoiding potentially sediment laden water from discharging to land or directly to water.

1.3 Performance standards

The CEMP identifies relevant legislative requirements associated with management of dust, odour and hazardous air pollutants.

The requirements of the statutes, regulations, designations and resource consents have a common aim which is to avoid, remedy or mitigate adverse effects on the environment, including effects on the health of people and ecosystems and amenity effects. In order for the construction of the Project to comply with all statutory requirements, the discharge of dust from the site must comply with the following, which is commonly known as the "no nuisance policy"[2]:

"The dispersal or deposition of particles shall not cause an objectionable or offensive effect beyond the boundary of the property where the discharge originates."

[2] This is taken from the conditions attached to Permitted Activity Rule AQL38 of the Environment Canterbury Natural Resources Regional Plan (NRRP), which relates to discharges of dust from unsealed aces on industrial or trade premises and/or from industrial or trade processes.

There are no national air quality standards or guidelines for nuisance dust; however the Ministry for the Environment (MfE) has recommended trigger levels which can be applied to individual dust sources[3]. The recommended trigger levels for airborne dust (total suspended particulate matter or TSP) are shown in Table 1.

Table 1: MfE TSP trigger levels

Sensitivity of Area	Standard/Guideline
High sensitivity	80 µg/m³ (fixed 24-hour average)
Moderate sensitivity	100 µg/m³ (fixed 24-hour average)
Low sensitivity	120 µg/m³ (fixed 24-hour average)

High sensitivity areas are defined by the MfE to be typically areas in which there is significant residential development. Low sensitivity areas are typically sparsely populated rural areas.

The MfE trigger levels for TSP are designed to avoid dust discharges causing a dust nuisance (i.e. to avoid offensive or objectionable discharges of dust). However, because they are measured as 24-hour averages, they cannot readily be used as management tools to prevent dust nuisance – the typical response to exceedences of MfE trigger levels is to investigate the cause of the exceedence with a view to preventing a recurrence.

It should be noted that continuous dust monitoring instruments do not form part of the standard suite of recommended monitoring for this Project. The MfE trigger values have been included in this CAQMP for reference only if continuous ambient monitoring is undertaken in response to specific dust management issues.

1.4 Environmental plans / maps

The only area within 100m of the construction footprint that is considered to be likely to be highly sensitive or moderately sensitive to discharges of dust is the residential area on the northeastern fringe of Rolleston and the adjacent land zoned Living Z under the Selwyn District Plan (if residential development has occurred on that land before the Project is completed). These are indicated in Figure 2.

[3] Ministry for the Environment "Good Practice Guide for Assessing and Managing the Environmental Effects of Dust Emissions", 2001.

Figure 2: Sensitivity of receiving environment between Rolleston and Weedons Road

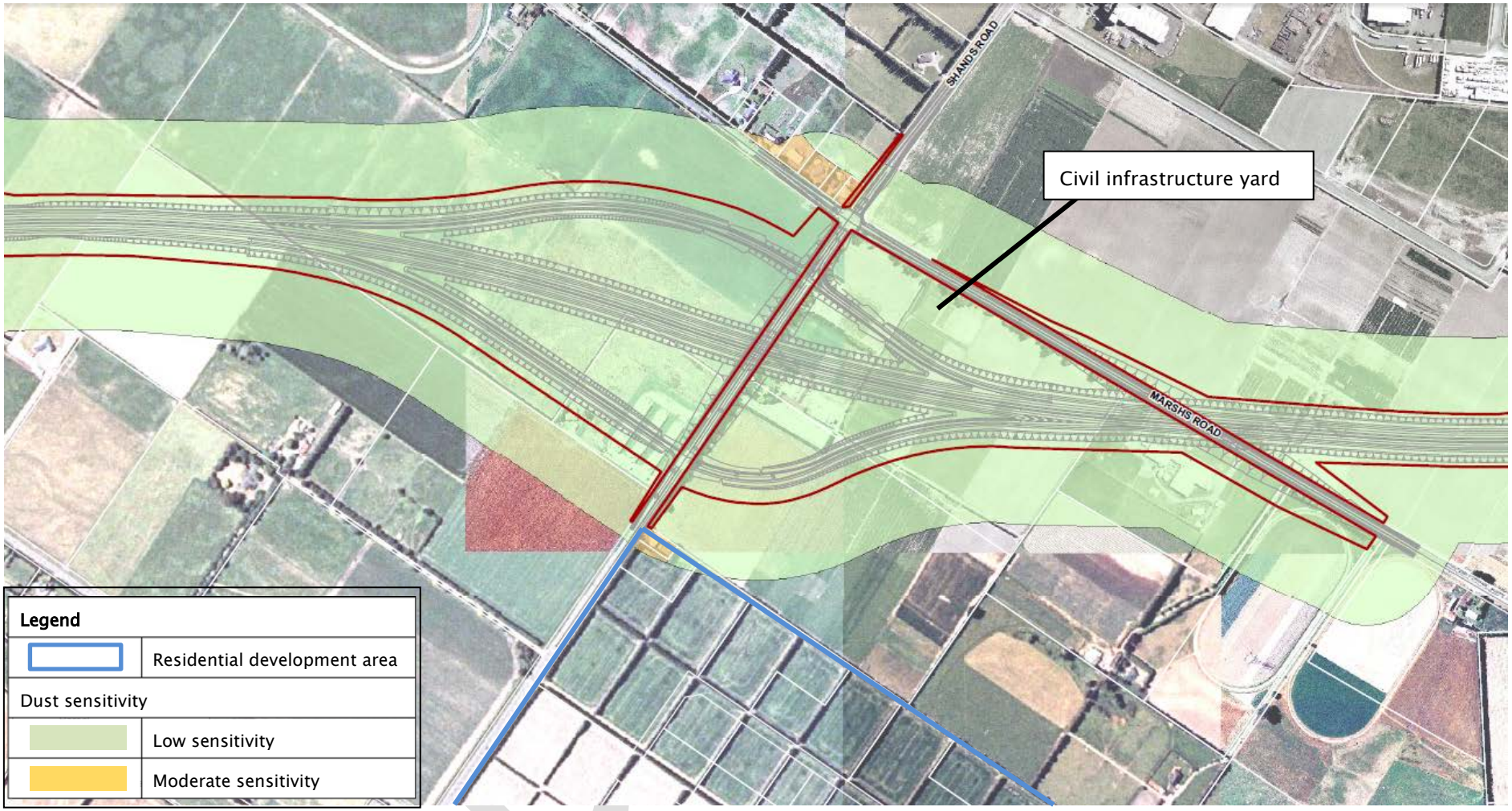

Figure 3: Sensitivity of receiving environment at Shands Road intersection

2. Environmental impacts summary

2.1 Dust

When considering the potential environmental effects of dust emissions, the main issue relates to residential areas. Section 5 of the Assessment of Air Quality Effects (Technical Report 10, Volume 3) outlines the nature of dust discharges from road construction activities. The main issues relate to the visual soiling of clean surfaces, such as cars, window ledges, and household washing; dust deposits on flowers, fruit or vegetables; and the potential for contamination of roof-collected water supplies. Excessive discharges of dust may also impact on visibility on roads in the immediate vicinity of the Project.

Due to the relatively large size of construction dust particles, only areas within about 100m of the construction footprint are likely to be at high risk of significant exposure to dust discharges. Most of these sensitive receptors are located along Main South Road, especially on the northeastern fringe of Rolleston.

There are a number of large residential developments under way in areas adjacent to the Project, the construction of which will also be sources of dust discharges that are outside the control of the Project.

Figure 2 of this CAQMP identifies those parts of the alignment between Rolleston and Weedons Road where there are sensitive receptors (mostly residential dwellings) and, consequently, effective dust control measures are most critical. Figure 3 indicates the sensitivity of areas around the Shands Road intersection: there are several residential dwellings to the northwest of the civil infrastructure yard by the Marshs Road / Shands Road intersection, all of which are within 100m of the designation; while the northern extremity of the Aberdeen subdivision is also within 100m of the designation.

2.2 Contaminated soil

There are no known or suspected contaminated sites on any part of the Project alignment. If any such sites are identified during the course of construction, specific measures related to air discharges from such sites will be incorporated into this CAQMP.

2.3 Odour

There are no known or suspected sources of odour associated with the construction of the Project.

2.4 Vehicle exhaust emissions

Engine exhaust emissions from construction vehicles contain a range of hazardous air pollutants, including fine particles, oxides of nitrogen, carbon monoxide and organics such as benzene, which can adversely affect human health. Poorly maintained vehicle engines discharge many times the amount of air pollutants than well maintained engines; and unnecessary idling of vehicle engines while parked can also cause significant local effects.

3. Implementation and operation

3.1 Operating/management procedures

3.1.1 Dust

This section of the CAQMP provides further explanation of the causes of dust nuisance and of methods that may be used to control dust discharges.

Potential sources of dust and other air contaminant discharges which may cause nuisance beyond the site boundary during adverse conditions, if adequate controls and mitigation measures are not adopted, are:

- Dust from roads and access areas generated by trucks and other mobile machinery movements during dry and windy conditions
- Excavation and disturbance of dry material
- Loading and unloading of dusty materials to from trucks
- Stockpiling of materials including material placement and removal
- Smoke and odour from diesel engine machinery and truck exhausts

There are five primary factors which influence the potential for dust to be generated from the site. These are:

- **Wind speed across the surface**. Dust emissions from exposed surfaces generally increase with increasing wind speed. However dust pick up by winds is only significant at wind speeds above 5 m/s (11 knots or a Beaufort scale number of 3 – see Appendix A). Above wind speeds of 10 m/s (20 knots) dust pick up increases rapidly.
- **Moisture content of the material**. Moisture binds particles together preventing them from being disturbed by winds or vehicle movements. Similarly, vegetated surfaces are less prone to wind erosion than bare surfaces.
- **The area of exposed surface**. The larger the areas of exposed surfaces the more potential there will be for dust emissions.
- **The percentage of fine particles in the material on the surface**. The smaller the particle size of material on an exposed surface the more easily particles are able to be picked up and entrained in the wind.
- **Disturbances such as traffic and loading and unloading of materials**. Vehicles travelling over exposed surfaces tend to pulverise any surface particles. Particles are lifted and dropped from rolling wheels to the surface. Dust is also sucked into turbulent wake created behind moving vehicles.

Systems for controlling dust emissions include:

- Methods that modify the condition of the materials (e.g. use of water sprays) so that it has a lesser tendency to lift with the wind or disturbances such as vehicle movements.
- Methods that reduce the velocity of the wind at the surface (e.g. the use of wind breaks).

Watering of exposed surfaces and materials that may be disturbed is a primary method of control ("wet suppression"). The main soil type across the Project area is alluvial silt, which contains a high proportion of relatively fine particles, although it is also readily wetted.

As a general guide, the typical water requirements for most parts of New Zealand are up to 1 litre per square metre per hour[4]. Watering of surfaces is most effective when the water is applied prior to strong winds occurring and prior to particularly dusty activities commencing (which therefore requires that weather forecasts are checked on a daily basis). In certain areas, polymer additives may be used in water sprays to assist the formation of a surface crust, particularly for exposed surfaces that will be undisturbed for periods of up to a month or two.

The discharge of dust from the Project has the potential to have effects on two scales. The first is individually from a source where the effects of dust discharges are localised in the immediate area surrounding the construction area. Secondly, cumulative effects may be observed where the dust generated from all nearby dust sources combine to affect local air quality as a whole. Therefore it is important that all dust sources be minimised as far as practicable, including those well separated from sensitive locations, as all dust generated will have an effect on the overall air quality in the area.

The dust prevention methods recommended in Table 2 below are methods that have been found to be effective for many sites across New Zealand. The methods can be used alone or in combination depending on the circumstances. The methods summarised in Table 2 are considered to be sufficient to mitigate adverse effects of dust discharges from the Project. However, this list is not exhaustive and the Contractor's Environmental Manager or subcontractors may suggest other effective methods. If alternate methods are to be employed, the effectiveness of those methods must be demonstrated and this Plan updated accordingly, following the process laid down in Section 5.

[4] Section 8.2 of the MfE Good Practice Guide for Assessing and Managing the Environmental Effects of Dust Emissions, Ministry for the Environment, 2001

Table 2: Potential dust sources and controls

Dust Source	Control
Stockpiles	• Limit the height and slope of stockpiles to reduce wind entrainment. Stockpiles exceeding 3m in height have a higher risk of discharging dust. • Orientate stockpiles to maximise wind sheltering as much as possible. • Maximise shelter from winds as far as practicable. • Keep active stockpiles damp at all times or cover stockpiles of fine materials. • Dampen inactive stockpiles if they are producing visible dust emissions. Use polymer additives to assist in forming a surface crust or cover with mulch or straw. • Vegetate stockpiles if inactive for more than three months. Supply adequate water to support optimum vegetation growth.
Unpaved Surfaces such as Roads and Yards	• Limit the amount of exposed surfaces as much as possible. • Retain as much vegetation as possible. • Keep unpaved roads and exposed surfaces damp. Typical water requirements for most parts of New Zealand are up to 1 litre per square metre per hour. • Cover surfaces with coarse materials where practicable. • Compact all unconsolidated surfaces where practical. • Regularly maintain roads by grading and the laying of fresh gravel. • In very high risk areas, haul roads should be sealed. • Stabilise cleared areas not required for construction, access or for parking, if liable to cause excessive dust during windy conditions. Methods may include wetting with polymer additives to facilitate crusting, metalling, grassing, mulching or the establishment of vegetative cover.
Sealed Surfaces	• Regular removal of dust through washing or vacuum sweeping.
Vehicles	• Limit vehicle speeds on unsealed surfaces to 10 km/h. • Limit load sizes to avoid spillages. • Cover loads of fine materials. • Minimise travel distances through appropriate site layout and design. • Minimise mud and dust track out from unsealed areas to sealed areas by establishing stabilised entranceways at all ingress and egress points to sealed roads. • If necessary, provide wheel wash facilities.
Earthmoving and Construction	• Limit the extent of earthworks in sand carried out during dry conditions as far as practicable. • Adequate irrigation systems must be available on each site to dampen areas that are to be earthworked prior to any earthwork commencing and shall be used permanently on sites until the final site shape has been established and further earthworks are not required. • Limit drop heights.

Dust Source	Control
Miscellaneous	• Ensure sufficient water is available on site. • Take account of daily forecast wind speed, wind direction and soil conditions before commencing an operation that has a high dust potential. • Install windbreak fences where practicable and appropriate. Effectiveness is greatest where fencing is perpendicular to the prevailing wind direction with a porosity of about 50%. • Minimise the area of surfaces covered with fine materials.

3.1.2 Vehicle Exhaust Emissions

Poorly maintained vehicle engines discharge many times the amount of air pollutants than well maintained engines; and unnecessary idling of vehicle engines while parked can also cause significant local effects. In consequence, the following key actions should be carried out to minimise emissions:

- All construction machinery used on the site must be maintained at least in accordance with manufacturers' requirements.
- Where excessive exhaust smoke is identified from any construction vehicle, that vehicle should be serviced as soon as is practicable and taken out of use until such maintenance has been completed.
- Construction vehicles should not be left idling while parked or unattended.

3.2 Monitoring

Table 3 outlines the dust monitoring programme that is to be implemented. The application of this monitoring will be the responsibility of the Environmental Manager in conjunction with site personnel. The frequency of the monitoring is defined but in the instance of strong winds, discharges of dust that cross the site boundary or a complaint, the monitoring programmes will be undertaken more regularly.

Table 3: Dust monitoring programme

Monitoring Activity	Frequency
Inspect land adjacent to the site, construction exits and adjoining roads for the presence of dust deposits.	Twice Daily in highly sensitive areas, daily in all other locations.
Check weather forecasts for strong winds and rainfall to plan appropriate dust management response (7 day forecasts available on www.metvuw.co.nz)	Daily
Observe weather conditions, wind via observations and data outputs from weather stations and presence of rain.	Daily and as conditions change
Inspect all unsealed surfaces (including earthworks sites) for dampness and to ensure that surface exposure is minimised.	Daily and as conditions change

Monitoring Activity	Frequency
Inspect all sealed surfaces to ensure that they are clean and all spillages have been cleared.	Daily
Inspect stockpiles to ensure enclosure, covering, stabilisation or dampness. Ensure stockpile height is less than 3m or appropriately stabilised.	Weekly and at times of expected high winds
Inspect dust generating activities (as listed in section 3.1 – Table 2) to ensure dust emissions are effectively controlled.	Daily and as new activities are commenced
Inspect watering systems (sprays and water carts) to ensure equipment is maintained and functioning to effectively dampen exposed areas.	Weekly
Inspect site access and egress points to ensure effective operation of wheelwash/truckwash systems and/or judder bars (if installed).	Weekly
Ensure site windbreak fences, if used, are intact.	Weekly
Review effectiveness of contractors' site induction training related to dust management	Monthly

Additional monitoring of dust generating activities and water application rate may be required in winds over 5.5 m/s (11 knots or a Beaufort scale number of 3 – see Appendix B).

3.3 Reporting

General reporting requirements are included in the CEMP. The specific reporting requirements associated with managing dust, odour and hazardous air pollutants include the following:

Site Staff to Environmental or Project Manager

Site personnel shall inform the Environmental Manager of the following:

- Any problems they observe or foresee with dust management on their site
- The measures taken for dust prevention and mitigation during the previous reporting period.
- Any complaints received regarding dust, odour or hazardous air pollutants within 24 hours of receipt of the complaint.

Environmental or Project Manager to the Regulatory Authority

- Any complaints received during the previous period regarding dust, odour or vehicle exhaust emission and the remedial actions taken

The Environmental Manager will also provide the Regulatory Authority with a copy of the CAQMP annually and if any significant revisions of the CAQMP are made during the year.

3.4 Training

Environmental training for all staff will be undertaken as part of the site induction programme. Details of training are included in the CEMP. The environmental induction will include the following information specific to this Plan:

- Information about the activities and stages of construction that may cause dust impacts within the construction area
- Consent requirements
- Complaints management procedures
- Dust and management procedures
- Description of dust monitoring for the Project.

3.5 Feedback

Feedback (complaints, comments or support) management procedures are detailed in the CEMP. The specific requirements for managing feedback associated with dust or vehicle exhaust nuisance effects are detailed further below.

In addition to recording general details of the incident on a Feedback Record Form, the person receiving the feedback must record:

- A description of the discharge from the respondent –constant or intermittent, how long it has been going on for, whether it is worse at any time of day and/or comes from an identifiable source
- Wind direction and strength and weather conditions.

The site inspection undertaken by the Environmental Manager should note:

- All dust/odour/vehicle exhaust producing activities taking place
- The dust/odour mitigation methods that are being used.
- If the complaint was related to an event in the recent past, note any dust/odour/vehicle exhaust producing activities that were underway at that time, if possible.

If it becomes apparent that there may be a source of dust/odour/vehicle exhaust other than the construction project causing the feedback, it is important to verify this.

4. Roles and responsibilities

All Site Staff

- Attending inductions, tool box talks and training to manage dust and odours
- Responsible for reporting all incidents involving dust and odours
- Ensuring processes for managing dust and odour are adhered to

Environmental or Project Manager

- Prepares, reviews and updates CAQMP
- Monitors and reports performance against the CAQMP
- Investigates and reporting of all complaints
- Ensure sufficient resources are provided to manage dust and odour in accordance with the CAQMP
- Provides leadership to the Project team in the area of dust and odour management

5. Review

This section describes how the CAQMP will be reviewed, including looking at the environmental controls and procedures to make sure that they are still applicable to the activities being carried out.

The CAQMP will be reviewed by the Principal Contractor(s) after confirmation of the resource consent and designation conditions and will be revised in accordance with those conditions. The CAQMP will be updated, with the necessary approval, throughout the course of the Project to reflect material changes associated with changes to construction techniques or the natural environment. Approval from the Selwyn District Council and/or the Christchurch City Council will be required for any relevant revisions of a material nature for the CAQMP.

A management review of the CAQMP will be undertaken at least annually by the Principal Contractor(s). The management review will be organised by the Environmental or Project Manager. The review will take into consideration:

- Any significant changes to construction activities or methods
- Key changes to roles and responsibilities within the Project
- Changes in industry best practice standards or recommended dust controls
- Changes in legal or other requirements (social and environmental legal requirements, consent conditions, NZTA objectives and relevant policies, plans, standards, specifications and guidelines)
- Results of inspection and maintenance programmes, logs of incidents, corrective actions, internal or external assessments
- The outcome of investigations into discharges of dust or odour.
- Recent building developments.

Reasons for making changes to the CAQMP will be documented. A copy of the original CAQMP document and subsequent versions will be kept for the Project records, and marked as obsolete. Each new/updated version of the CAQMP documentation will be issued with a version number and date to eliminate obsolete CAQMP documentation being used.

Appendix A
Beaufort Wind Scale

Beaufort scale	Wind speed			Label	Observations on land
	m/s	Knots	km/h		
0	0 - 0.2	<1	<1	Calm	Calm. Smoke rises vertically.
1	0.3-1.5	1-3	1-5	Light Air	Wind motion visible in smoke.
2	1.6-3.3	4-6	6-11	Light Breeze	Wind felt on exposed skin. Leaves rustle.
3	3.4-5.4	7-10	12-19	Gentle Breeze	Leaves and smaller twigs in constant motion.
4	5.5-7.9	11-15	20-28	Moderate Breeze	Dust and loose paper raised. Small branches begin to move.
5	8.0-10.7	16-21	29-38	Fresh Breeze	Branches of a moderate size move. Small trees begin to sway.
6	10.8-13.8	22-27	39-49	Strong Breeze	Large branches in motion. Whistling heard in overhead wires. Umbrella use becomes difficult. Empty plastic garbage cans tip over.
7	13.9-17.1	28-33	50-61	Near Gale	Whole trees in motion. Effort needed to walk against the wind. Swaying of skyscrapers may be felt, especially by people on upper floors.
8	17.2-20.7	34-40	62-74	Gale	Twigs broken from trees. Cars veer on road.
9	20.8-24.4	41-47	75-88	Severe Gale	Larger branches break off trees, and some small trees blow over. Construction/temporary signs and barricades blow over. Damage to circus tents and canopies.
10	24.5-28.4	48-55	89-102	Storm	Trees are broken off or uprooted, saplings bent and deformed, poorly attached asphalt shingles and shingles in poor condition peel off roofs.
11	28.5-32.6	56-63	103-117	Violent Storm	Widespread vegetation damage. More damage to most roofing surfaces, asphalt tiles that have curled up and/or fractured due to age may break away completely.
12	32.7-36.9	64-71	118-133	Hurricane	Considerable and widespread damage to vegetation, a few windows broken, structural damage to mobile homes and poorly constructed sheds and barns. Debris may be hurled about.

Appendix B
Wind Speed and Direction

Wind Speed and Direction – Christchurch Airport, 2006-2009

Figures B1 and B2 present a summary of hourly average wind speeds and directions recorded at Christchurch Airport between 2006 and 2009, as follows:

- Figure B1 – Annual wind roses for 2008, 2009 and 2010
- Figure B2 – Seasonal wind roses for spring, summer autumn and winter for the period 2006-2009.

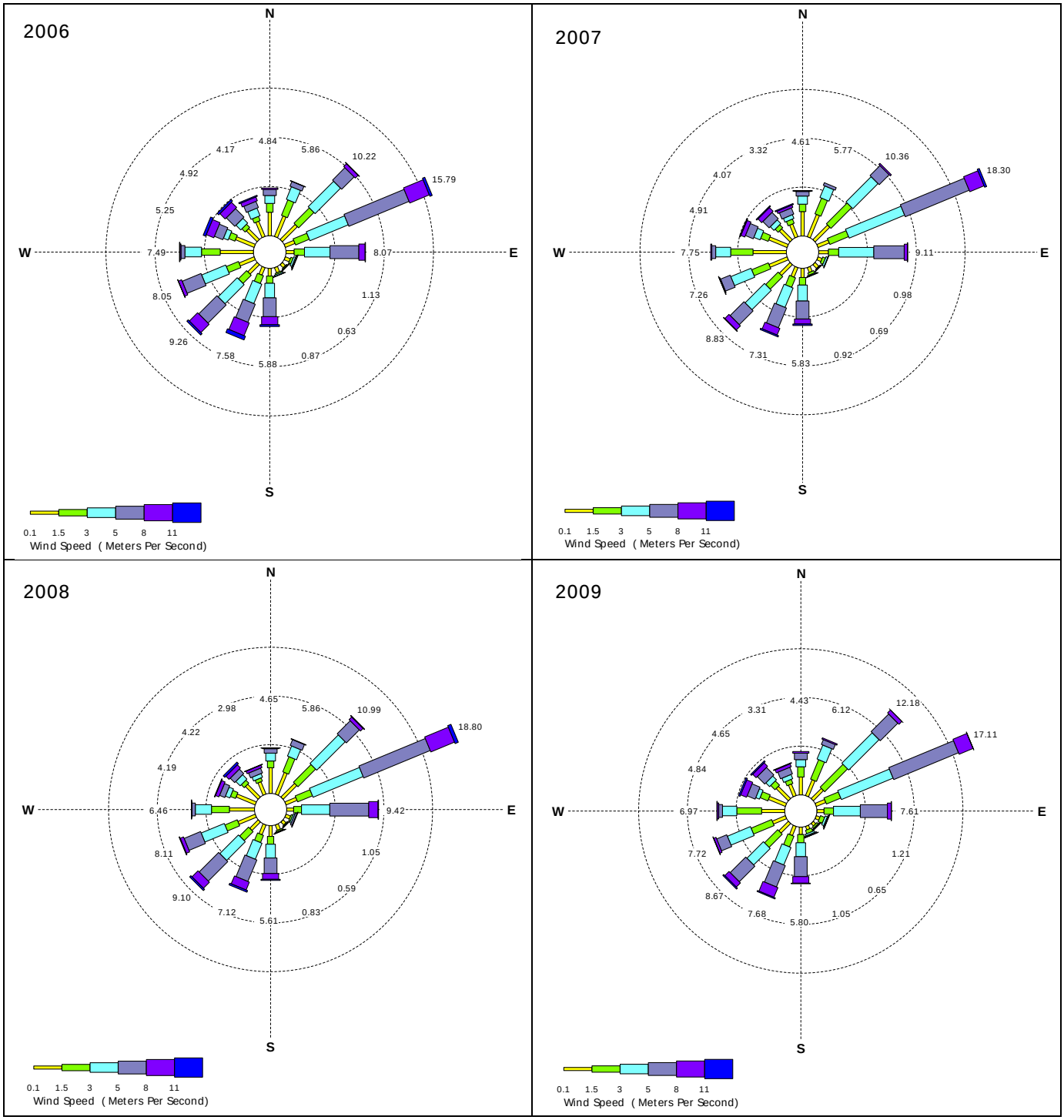

Figure B1: Annual wind roses showing wind speed and wind direction at Christchurch International

Airport, 2006-2009

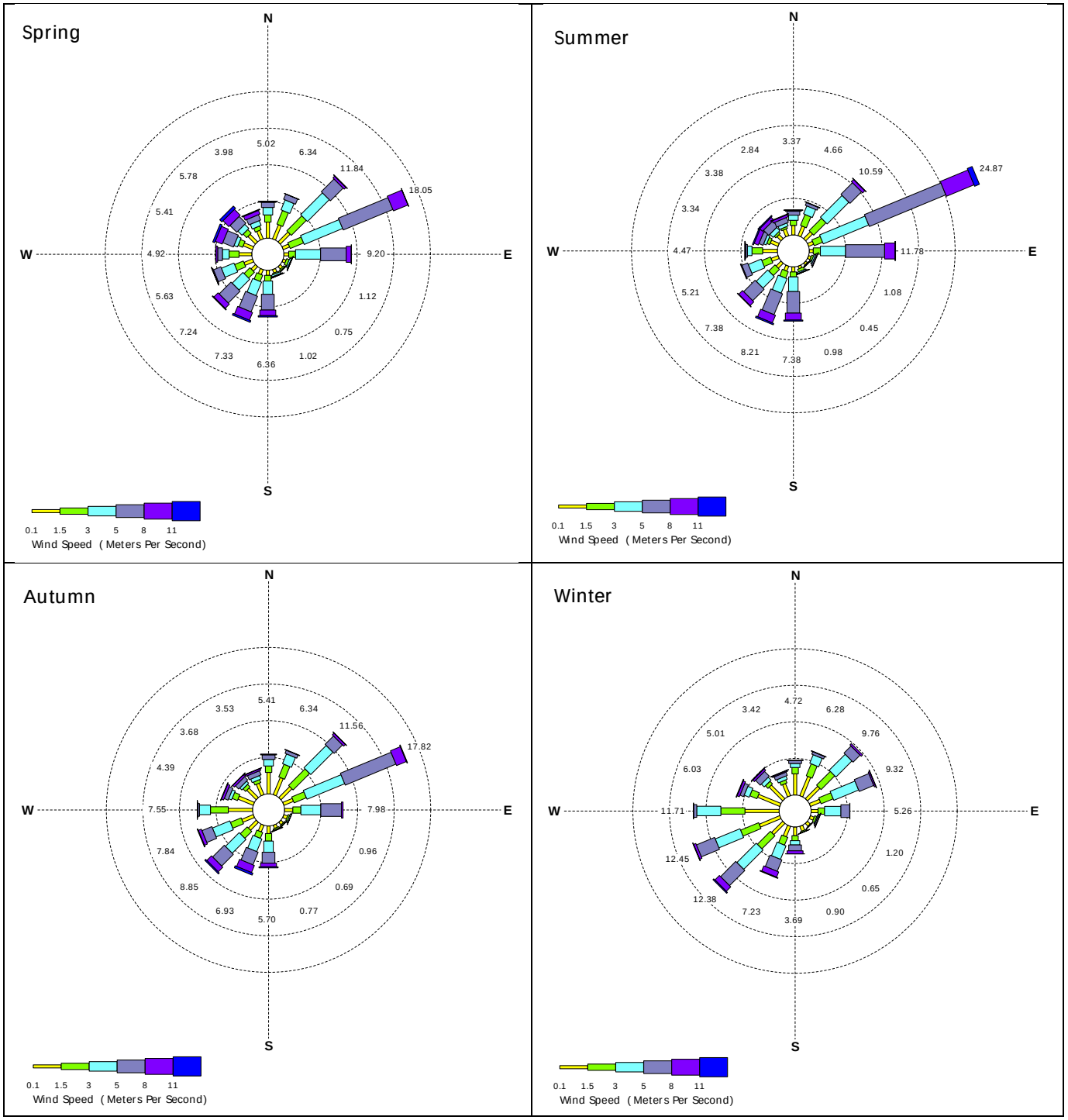

Figure B1: Seasonal wind roses showing wind speed and wind direction at Christchurch International Airport, 2006-2009

Appendix C
Relevant Project Conditions

[To be added when confirmed]