HEGGIES

REPORT 20-2014-R1

Revision 4

Santos Gladstone LNG
Environmental Impact Statement
Noise and Vibration (Terrestrial)

PREPARED FOR

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Santos Gladstone LNG

Environmental Impact Statement

Noise and Vibration (Terrestrial)

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DOCUMENT CONTROL

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EXECUTIVE SUMMARY

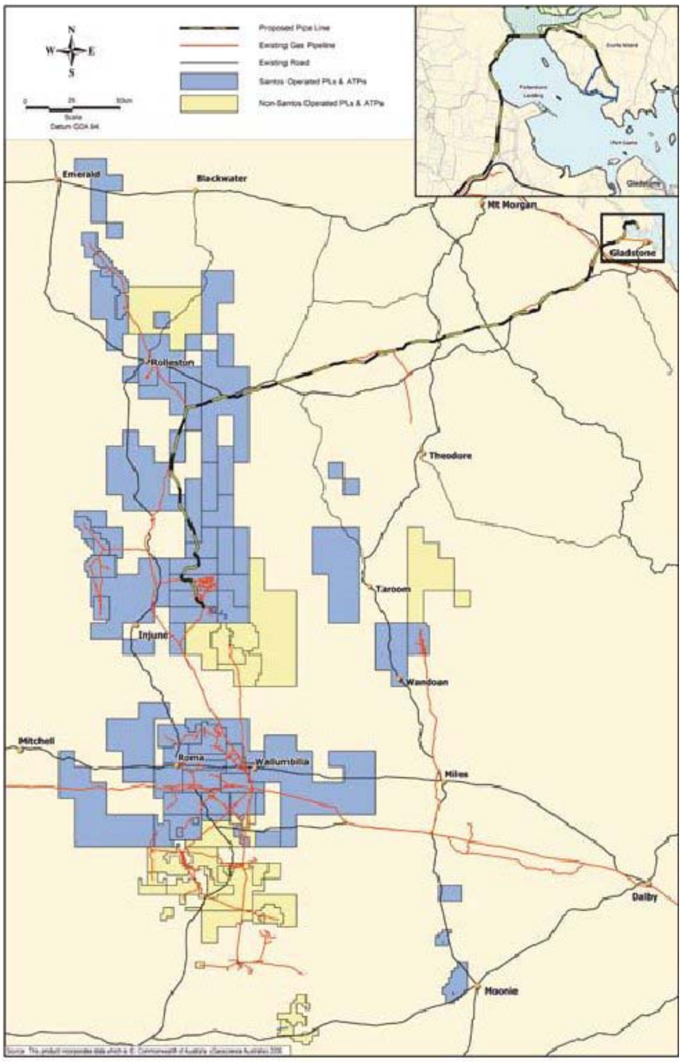
PROJECT OUTLINE

Santos Ltd (Santos) is proposing to develop a Liquefied Natural Gas (LNG) facility located on Curtis Island near Gladstone, Central Queensland. An initial production rate of approximately 3 million tonne per annum (mtpa) (one process train) is proposed, increasing to 10 mtpa at full capacity (three process trains).

Heggies Pty Ltd (Heggies) has been engaged by URS Australia Pty Ltd (URS) to conduct an assessment of the potential noise and vibration impacts associated with the proposed LNG project. The assessment also includes the Coal Seam Gas (CSG) fields and the gas transmission pipeline connecting the CSG fields to the LNG facility.

This report presents the terrestrial noise and vibration issues associated with both the construction and operational phases of this project and recommends mitigation measures to reduce impacts where appropriate.

Project Overview Showing LNG Facility, CSG Fields and the Gas Transmission Pipeline



AMBIENT NOISE ENVIRONMENT

Ambient noise monitoring has been conducted at (or near) fifteen (15) residential locations in the communities surrounding the proposed LNG facility, the gas transmission pipeline and CSG fields. Both attended and unattended noise measurements have been conducted in order to accurately document the existing ambient noise environment. In accordance with the requirements of the QLD EPA's *Ecoaccess Planning for Noise Control*, the ambient noise measurements were subsequently used to determine the "Rating Background Level" (RBL). The established RBL's are used to determine allowable project noise criteria taking into account the cumulative effect of existing industry or other noise sources and the proposed project.

Ambient Noise Monitoring Results (Adjusted)

Monitoring Location	Rating Background Level (dBA)		
	Day	Evening	Night
Plant 1	41 [4]	41 [4]	41 [4]
Plant 2	33	32	31
Plant 3	42	42	37
Plant 4	41	40	37
Plant 5	31 [3]	31 [2, 3]	33 [2]
Plant 6	45	42	38
Gas & Pipeline 1	37	34	28
Gas & Pipeline 2	23	18 [1]	17 [1]
Gas & Pipeline 3	24	18 [1]	18 [1]
Gas & Pipeline 4	27	19[1]	18[1]
Gas & Pipeline 5	21 [1]	18 [1]	17[1]
Gas & Pipeline 6	21 [1]	18 [1, 2]	18 [1]
Gas & Pipeline 7	29	27	27
Gas & Pipeline 8	29	21 [1, 2]	18 [1]
Gas & Pipeline 9	30	29	29

Note 1: Adjusted to account for the noise floor of logger (noise floor is described as the minimum noise level to which noise logger can record noise). Corrections to account for noise floor of logger are based on analysis of logger results, attended measurements and field observations.

2: Adjusted to correct for enhanced noise levels as a result of insect noise

3: Adjusted to correct for elevated wind levels and increased noise levels due to movement of trees

4: Adjusted to correct for elevated wind levels and increased noise levels due to lapping of harbour waves

NOISE AND VIBRATION CRITERIA

The limiting noise and vibration criteria for the construction and operational phases of the project are summarised in the tables below.

Summary of Construction Criteria

Construction Noise		Vibration			Blasting [1]	
Monday to Saturday (6:30am to 6:30pm)	**Monday to Saturday (6:30pm to 6:30am); Sundays and Public Holidays**	**Structural Damage (mm/s)**	**Human Comfort (mm/s)**		**Airblast (dB Linear Peak)**	**Vibration (mm/s PPV)**
			Day	Night		
No limit	50 dBA L_{Amax}	12.5	0.3 – 0.6	0.2	115	> 35 Hz - 25 < 35 Hz - 10

Note 1: Blasting should generally only be permitted during the hours of 9 am to 3 pm, Monday to Friday, and 9 am to 1 pm on Saturdays

Summary of the Limiting Operational Criteria

Assessment Location	**Background Noise Creep Criteria**	**Design Criteria[1]**	**Sleep disturbance[2]**	**Low Frequency Criteria[2]**
	$L_{A90(1hour)}$ (dBA)	**$L_{Aeq(1hour)}$ (dBA)**	**L_{Amax} (dBA)**	**$L_{pA,LF}$ (dBA)**
Plant 1	31	44	50	23
Plant 2	25	34	50	23
Plant 3	27	40	50	23
Plant 4	27	40	50	23
Plant 5	25	34	50	23
Plant 6	28	41	50	23
Plant 7 [3]	30	43	50	23
Gas & Pipeline 1	25	31	50	23
Gas & Pipeline 2	25	28	50	23
Gas & Pipeline 3	25	28	50	23
Gas & Pipeline 4	25	28	50	23
Gas & Pipeline 5	25	28	50	23
Gas & Pipeline 6	25	28	50	23
Gas & Pipeline 7	25	30	50	23
Gas & Pipeline 8	25	28	50	23
Gas & Pipeline 9	25	32	50	23

Note: Limiting operational criteria is defined as the most stringent of the day, evening and night-time project operational criteria (as discussed in **Section 6.3.6**).

1: Design criterion is the most stringent of the Planning Noise Level (PNL) and Specific Noise Level (SNL) (as defined in EcoAccess Guideline: Planning for Noise Control).

2: Sleep disturbance and low frequency criteria have been adjusted to represent outdoor levels.

3: Noise criteria are based on typical background noise levels for an "Industrial Area' as shown in Queensland's Environmental Protection Agency's (EPA) *Ecoaccess Guideline: Planning for Noise Control* 'Recommended Outdoor Planning Noise Levels' **Table 16**.

The road traffic noise criteria applicable for the assessment of noise from vehicle movements associated with the project are summarised below.

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Summary of Road Traffic Noise Criteria

Road Type		Criteria
State	Existing Road	68 dBA $L_{A10(18hour)}$ and ≤ 2 dBA change in existing $L_{A10(18hour)}$
	New Road	63 dBA $L_{A10(18hour)}$
Other public road	Existing Road	63 dBA $L_{A10(18hour)}$ and ≤ 2 dBA change in existing $L_{A10(18hour)}$
	New Road	63 dBA $L_{A10(18hour)}$

The railway traffic noise criteria applicable for the assessment of noise from rail movements associated with the optional rail transportation of pipe joints are summarised below.

Summary of Rail Traffic Noise Criteria

$L_{Aeq(24hours)}$ (dBA)	65
L_{Amax} (dBA)	87

CONSTRUCTION NOISE AND VIBRATION ASSESSMENT

Construction noise and vibration generating activities associated with the LNG facility, gas transmission pipeline and CSG field areas were assessed against the relevant construction criteria detailed above (see **Summary of Construction Criteria**). The assessment of construction noise and vibration impacts associated with the project revealed the following:

No mitigation measures are required to reduce vibration levels at residences in the communities surrounding the LNG facility. Vibration impact from construction activities associated with the gas transmission pipeline and CSG fields is expected to be minimal, with the possible exception of blasting.

LNG Facility – The construction noise and vibration associated with the LNG facility (including clear and grade, construction scenarios for erecting the LNG facility, pile driving for the jetty, truck traffic, dredging, bridge and gas transmission pipeline crossing) is predicted to meet the noise criteria at all assessment locations in the Gladstone area.

Gas Transmission Pipeline – The predicted off-set buffer distance at which the applicable construction noise criteria (50 dBA L_{Amax} sleep disturbance) is expected to be met for noise associated with the gas transmission pipeline construction works is 500 m. The predicted off-set buffer distance at which the applicable construction noise criteria (50 dBA L_{Amax} sleep disturbance) is expected to be met for noise associated with rail laydown areas is 400 m. Based on a blast with a 50 kg MIC the airblast criteria (115 dBL peak) is predicted to be exceeded at distances within 420 m of the blast.

Gas Wells – The predicted off-set buffer distance at which the applicable construction noise criteria (50 dBA L_{Amax} sleep disturbance) is expected to be met for noise associated with gas well construction works is 425 m.

Compressor Site – The predicted off-set buffer distance at which the applicable construction noise criteria (50 dBA L_{Amax} sleep disturbance) is expected to be met for noise associated with compressor site construction works is 425 m.

The road traffic noise assessment carried out for project related vehicle movements revealed that impacts from road traffic noise are predicted to be minimal. Therefore no noise mitigation measures are proposed to attenuate noise from road traffic.

The rail traffic noise assessment carried out for rail movements related to transporting pipe joints revealed that impacts from rail traffic noise are predicted to be minimal and only over a short period of time (ie approximately 6 months). Therefore no noise mitigation measures are proposed to attenuate noise from rail traffic.

OPERATIONAL NOISE AND VIBRATION ASSESSMENT

There are no major vibration sources associated with the operational phase of the project likely to generate vibrations at the sensitive receivers.

Operational noise generating activities associated with the LNG facility, gas transmission pipeline and CSG field areas were assessed against the relevant operational criteria detailed above (see **Summary of Limiting Operational Criteria**). A summary of the predicted noise impact from operational noise sources associated with the project is described below for the scenario without any noise mitigation measures.

OCP LNG Facility 1 Process Train –

- Neutral weather conditions - the noise criteria is exceeded at one (1) receiver by 2 dBA.
- “Worst case” weather conditions - the noise criteria are exceeded at three (3) receivers by 3 dBA to 7 dBA.

OCP LNG Facility 3 Process Train –

- Neutral weather conditions - the noise criteria is exceeded at three (3) receivers by 4 dBA to 8 dBA.
- “Worst case” weather conditions, the noise criteria is exceeded at six (6) receivers by 1 dBA to 13 dBA.

C3MR LNG Facility 1 Process Train –

- Neutral weather conditions - the noise criteria is exceeded at one (1) receiver by 4 dBA.
- “Worst case” weather conditions - the noise criteria is exceeded at four (4) receivers by 1 dBA to 9 dBA.

C3MR LNG Facility 3 Process Train –

- Neutral weather conditions - the noise criteria is exceeded at three (3) receivers by 4 dBA to 8 dBA.
- “Worst case” weather conditions - the above criteria is exceeded at six (6) receivers by 1 dBA to 13 dBA.

Gas Transmission Pipeline – The predicted off-set buffer distance at which the applicable operational noise criteria is expected to be met for noise associated with the operation of the mainline valves and blowdown vents is 1,500 m for the scenario without any noise mitigation measures.

Gas Wells – The predicted off-set buffer distance at which the applicable operational noise criteria is expected to be met for noise associated with the operation of the gas wells is 300 m for the scenario without any noise mitigation measures.

CSG Field Compressor Site – The predicted off-set buffer distance at which the applicable operational noise criteria is expected to be met for noise associated with the operation of the compressor sites is 3,400 m for the scenario without any noise mitigation measures.

EXECUTIVE SUMMARY

The road traffic noise assessment carried out for project related vehicle movements revealed that impacts from road traffic noise are predicted to be minimal. Therefore no noise mitigation measures are proposed to attenuate noise from road traffic.

Low Frequency

Where applicable, operational noise levels have been assessed against the low frequency noise criteria. Operational noise associated with the LNG facility operating with three (3) Process Trains is predicted to exceed the low frequency noise criteria for both LNG facility designs (OCP and C3MR) at the receivers for which there is an exceedance of the overall noise criteria (for 3 process trains as described above). The level of exceedance of the low frequency noise criteria is similar to the exceedance of the overall noise criteria.

For the CSG fields, low frequency noise from the compressor station has been assessed. The low frequency noise criterion is achieved at a shorter buffer distance from the compressor station than the distance at which the overall noise criteria will be achieved.

No assessment of low frequency noise was undertaken for the gas transmission pipeline, as the noise profile of the mainline valve and blowdown vents was considered to be all mid to high frequency noise (ie greater than 200 Hz).

MITIGATIONS

Construction

Additional noise mitigation measures beyond the implementation of "best practice" techniques (as discussed in AS 2436-1981 "*Guide to Noise Control on Construction, Maintenance and Demolition Sites"*), will generally not be required to attenuate construction noise and vibration from the project. The exception is for noise and vibration from blasting, where further investigation is required to determine the predicted impact from this activity.

Appropriate off-set buffer distances to limit the likelihood of construction noise and vibration impact are nominated for the relevant construction activities carried out during the evening and night time periods. These off-set distances should be adhered to where reasonable and feasible. The "best practice" noise management techniques (as discussed in AS 2436-1981 "*Guide to Noise Control on Construction, Maintenance and Demolition Sites"*) should be considered and implemented during construction work performed during the evening and night-time periods (6.30pm to 6.30am) and on Sundays/Public Holidays.

Operational

LNG Facility 3 Process Train – Extensive mitigation measures will be required for both the OCP and C3MR LNG facility designs (3 process trains) if background creep criteria are to be met at all assessment locations in the Gladstone region (including Tide Island). Details of the proposed noise mitigation measures for the LNG facility are provided in **Section 9.2.1**. The following noise mitigation scenarios have been considered to reduce noise emissions from the proposed LNG facility:

- **Mitigation Scenario 1** – reducing the noise emission from piping located close to the compressors by 20 dBA. This should be achievable by choosing appropriately designed silencers on both the intake and outlet pipes for the compressors as well as applying appropriate acoustic lagging on the piping.

- **Mitigation Scenario 2** – reducing the predicted noise levels to meet the background creep criteria at all assessment locations except Tide Island (P1). Reductions in noise emissions are required on the combustions turbines and air-cooled exchangers. These additional mitigation measures (to those proposed for Mitigation Scenario 1) are only required for the OCP LNG facility design.
- **Mitigation Scenario 3** - reducing the predicted noise levels to meet the background creep criteria at all assessment locations, including Tide Island (P1). Reductions in noise emissions are required on the following plant items:
  - Combustion turbines.
  - Air-cooled exchangers.
  - Piping close to the compressors.
  - Generators.
  - Compressors.
  - Pumps (lean solvent charge pump).
  - Boil off gas compressor.

The above mitigation measures are all examples only. Mitigation measures should be assessed in more detail during the detailed design phase for the LNG facility when more accurate noise emission data for the various part items is available.

CSG Field Compressor Site – Extensive noise mitigation measures are required in order to reduce the off-set buffer distance, at which the applicable background creep noise criteria would be met, to approximately 1,000 m. These noise mitigation measures are discussed in **Section 9.2.2** and include a "compressor building" for the compressor packages. It is noted that the calculation of required off-set buffer distances assumes noise propagation over flat, soft terrain and no dense vegetation or forest. If there was dense vegetation and/or local hilly terrain located between the compressor site and the receiver this off-set buffer distance could be reduced.

LNG Facility Flare Noise – A noise reduction of 4 dBA or more is required to achieve the applicable short-term intrusive noise criteria at all assessment locations for flare noise. The overall sound power level from the flare is required to be reduced to 143 dBA (or a sound pressure level of 96 dBA at 120 m) in order to achieve compliance with the noise criteria. The 4 dBA noise level reduction may be achieved using various mitigation techniques including (but not limited to) lagging of piping, muffling the gas stream jets (or via water injection) and incorporating design measures such as appropriate diameter flare ports.

Gas Transmission Pipeline – Mitigation is required for mainline valves and blowdown vents if the location of the valves is within 1,500m of a sensitive property. Due to the low number of mainline required, it is assumed that these valves can be located in areas which are greater than 1,500m from sensitive properties and therefore mitigation should not be required. If required, additional noise mitigation measures such as barriers/partial enclosure or pipeline lagging may be incorporated into the mainline valve design. This should be reviewed and assessed accordingly during the detailed design phase.

Gas Wells – Mitigation is required for the gas wells if the location of the gas well is within 300m of a sensitive property. Should a gas well be located within the 300m off-set distance referred to above, noise mitigation measures such as an enclosure or partial enclosure may be incorporated. This should be reviewed and assessed accordingly during the detailed design phase.

Low Frequency Noise

The low frequency noise predictions for the LNG facility show that there are significant low frequency components in the overall noise levels predicted at receiver locations in the Gladstone region.

Many assumptions were made regarding the frequency spectra (octave band data) for many of the major plant items due to a lack of data at the time of reporting. It is therefore recommended that the low frequency noise assessment component of this report be more closely assessed during the detailed design phase of this project when more accurate octave band data would be available.

However, based on the initial assessment of low frequency noise, it is expected that compliance with the applicable noise criteria is able to be achieved with the incorporation of appropriate noise mitigation measures to the LNG facility. The details of such noise mitigation measures would be determined during the detailed design phase, when more detailed information relating to plant items is available.

For the CSG fields, low frequency noise from the compressor station has been assessed. The low frequency noise criterion is achieved at a shorter buffer distance from the compressor station than the distance at which the overall noise criteria will be achieved. For this reason, standard mitigation measures required to achieve the overall operational noise criteria are considered to be sufficient to allow the low frequency noise criterion to be achieved.

No assessment of low frequency noise was undertaken for the gas transmission pipeline, as the noise profile of the mainline valve and blowdown vents was considered to be all mid to high frequency noise (ie greater than 200 Hz).

FINDINGS

The noise and vibration assessment has found that compliance with the applicable noise criteria is able to be achieved with the inclusion of the appropriate noise mitigation measures and allowing for the appropriate off-set buffer distances between construction and operational plant items and noise sensitive receivers.

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1 INTRODUCTION

Heggies Pty Ltd (Heggies) has been engaged by URS Australia Pty Ltd (URS) to conduct an assessment of the potential terrestrial noise and vibration impacts associated with the Santos Ltd (Santos) Gladstone Liquefied Natural Gas (GLNG) facility located on Curtis Island near Gladstone, central Queensland. The assessment also includes the Coal Seam Gas (CSG) fields and the gas transmission pipeline connecting the CSG fields to the LNG facility.

This report documents noise and vibration issues associated with both the construction and operational phases of this project and recommends mitigation measures where applicable.

The assessment is separated into three major sections, including:

- LNG Facility;
- Gas Transmission Pipeline; and
- CSG Fields.

2 DESCRIPTION OF THE PROJECT

For the noise and vibration assessment of the Project, three areas have been identified:

- LNG Facility;
- Gas Transmission Pipeline; and
- CSG Field.

These areas are described in the following Sections.

2.1 LNG Facility

The LNG facility consists of gas treatment and a liquefaction process as well as the storage and shipping of the liquefied gas.

Gas is initially fed through a scrubber section where impurities such as carbon dioxide and water are removed from the gas. After the impurities are removed, the gas is fed into the liquefaction process to produce the LNG. For this project, two (2) competitive liquefaction processes are considered:

- ConocoPhillips (CoP) Optimized Cascade Process (OCP); and
- Air Products Chemicals Incorporated (APCI) Propane Pre-cooled Mixed Refrigerant (C3MR) process.

Both these processes operate under the same cryogenic principles and require similar amounts of energy to liquefy the natural gas. The primary difference between the two processes is in the refrigerant compression processes used. Both processes will use air fin coolers for the removal of heat associated with the refrigerant compression process.

Initially, the LNG facility will consist of one process train and have a LNG production rate of approximately 3 million tonnes per annum (mtpa). Santos is proposing to expand the LNG facility to three process trains, with a capacity of 10 mtpa.

Each process train will generally consist of the following:

- Coolers;
- Combustion turbines;
- Compressors (gas);
- Piping; and
- Miscellaneous equipment

There is a proposed bridge option connecting the LNG facility with the mainland as shown in **Figure 1**. This option would require barging of materials, plant items and workforce during the construction phase of the LNG facility. An alternate “no bridge” option has also been proposed whereby barges and/or ferries would transport materials, plant items and workforce during both the construction and operational phase for the life of the project (unless other options are made available in the future).

2.1.1 LNG Shipping

LNG tankers will enter Port Curtis and proceed along the main shipping channel to the loading jetty. The turnaround time for vessels is estimated to be 24 hours, of which ship loading will take approximately 14 hours. A typical LNG tanker is approximately 285m in length, 43m in width and has a 12.5m water draft at a carrying capacity in the order 150,000 m^3 of LNG. Tugs will assist during berthing and departure. Initially, it is proposed that there will be approximately 40 to 50 ships per annum (one process train) although this is expected to increase to approximately 120 to 150 ships per annum when the LNG facility is at full capacity.

2.1.2 Flares

Flares will be used for emergency releases from the process and utilities.

The dry gas flare will be used to burn emergency hydrocarbon releases resulting from process upsets within the LNG facility or resulting from the unlikely event of emptying the gas transmission pipeline. The flare will be an elevated flare (stack) to protect plant personnel from overexposure to radiant heat generated during a flaring event.

2.2 Gas Transmission Pipeline

The proposed gas transmission pipeline route is from the CSG fields of the Surat and Bowen Basin in Central Western Queensland to Gladstone in Central Queensland. The total length of the gas transmission pipeline will be approximately 425 km. This gas transmission pipeline will be completely underground and where practical following a similar alignment to the existing Queensland Gas Company (QGC) pipeline. The proposed alignment of the gas transmission line is shown on **Appendix A**.

Construction of the gas transmission pipeline will require a number of operations to be undertaken consecutively as follows:

1. Survey and fencing;
2. Set up of temporary facilities;
3. Clear and grade of the right of way;
4. Trenching;
5. Pipe stringing and bending;
6. Pipe welding, inspection;
7. Onsite pipe coating;
8. Pipe placement in trench;
9. Backfilling and compaction; and
10. Hydro-testing and rehabilitation.

For standard pipeline laying (land clearing, trench digging and pipe placement) each crew works at the rate of about 1 km to 4 km per day depending on the terrain (ie if the ground is very rocky progress may be slower). To enable the crews to work safely and efficiently there is often a delay between the arrival dates of each crew. Typically it will take up to five weeks for all the crews to pass through an area and complete their tasks.

Blasting may also be required in areas of hard rock, which cannot be removed via mechanical methods.

Aspects of the construction program which have the potential to impact on nearby residences are summarised in **Table 1**.

Table 1 Typical Construction Methods

Construction Element	Details
Width of Corridor	30m
Depth of Trench	Normal Construction – 750 mm
	Road Easements – 1200mm
	Farming Land (ie cropping) – 1200mm
	Water crossings – 1200mm
	Major water crossings – 2000mm
	Road crossings – 1200mm to 2400mm
	Rail crossings – 2000mm
Construction Hours	Monday to Sunday – 6:30am – 6:30pm
Construction Duration	~ 18 months to 2 years
Refuelling	Mobile fuel truck and construction depot
Time between clear and grade and reinstatement	Typically 5 weeks[1]

Note 1: Work schedule as supplied to Santos by AJ Lucas shows a typical period of 5 weeks although this could be longer depending on locations, season timing and registered days off (RDOs) (28 days on, 9 days off).

It is proposed that construction would occur from 6:30 am to 6:30 pm, seven days per week and may work in a cycle (28 days on, 9 days off). Temporary accommodation will be erected along the gas transmission pipeline route to house the construction workforce.

There is a proposed rail traffic option for transporting the pipe joints for the construction of the gas transmission pipeline. This option would reduce the heavy vehicle traffic otherwise transporting the pipe joints out of Gladstone to laydown areas along the pipeline ROW (approximately 67 truck loads per day).

2.3 CSG Field

2,500+ gas wells are proposed for the field area and are located in the Surat and Bowen Basin. Santos already has over 200 existing operational wells in the Surat and Bowen Basin and this number would be increased as required over the duration of the CSG extraction works. Each operational gas well will be connected to the gas gathering network which feeds into the main gas transmission pipeline. The gathering network is made up of small, low pressure, HDPE pipes which will be buried underground.

Construction of the gas wells will require a number of operations to be undertaken as follows:

1. Survey and fencing;
2. Set up of temporary facilities (if required);
3. Clear and grade an approximate 100m x 100m pad and earthen pit;
4. Construct a flare pit;
5. Installing cellar (2m^3 space which the drilling assembly passes) and surface conductor pipe;
6. Drilling of well (approximate centre of 100mx100m pad);
7. If economic quantities of gas are discovered from this well, casings are inserted (usually steel pipes) and concrete is pumped in between the casing and the earth;
8. Completions drilling commences to complete well; and
9. Installing wellhead valve assembly and production casing string well be set.

It is noted that all construction activities occur on the Santos lease pad (approximately 100m x 100m)

The drilling process can last from anywhere between 2-3 days up to a couple of weeks depending on the depth of the well and the geology of the area. The drilling process operates on a 24 hour basis.

There are nominally 12 compressor sites proposed for the field area during full capacity operation of the LNG facility. These compressors are installed to help boost the gas coming from the well heads and gathering network to a pressure to allow it to flow through the gas transmission pipeline.

Construction of a field compressor site will require a number of operations to be undertaken as follows:

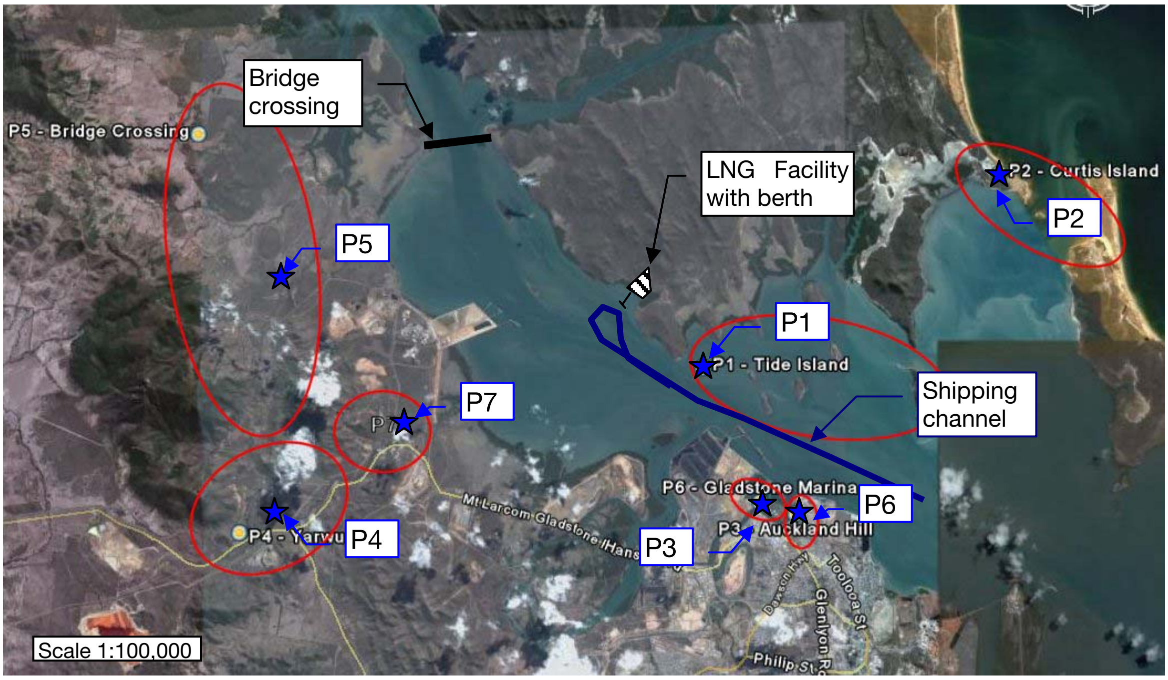
1. Survey and fencing;
2. Set up of temporary facilities (if required);
3. Clear and grade of site up to an area approximately 250m x 250m;
4. Concrete pads and foundations where required (much of the site is simply covered with gravel or remains as dirt); and
5. Construction of compressors, buildings and other facilities.

3 SITE DETAILS

3.1 LNG Facility

An aerial overview of the Gladstone region highlighting the location of the LNG facility, bridge crossing, shipping channel and monitoring locations is shown in **Figure 1**. The monitoring locations where the construction and operational phase noise levels from the LNG facility have been assessed are marked P1 to P7. These locations (P1 to P7) are representative of the nearest noise sensitive receptors surrounding the proposed LNG facility. The distance to the closest noise receptor (P1 - Tide Island) is 3.4 km with the next closest receptor (P7) being approximately 7 km from the site.

Figure 1 LNG Facility, Monitoring Locations (P1-P7), Bridge Crossing and Shipping Channel



The assessment locations (P1 to P7) are consistent with the ambient noise monitoring locations discussed in **Section 5** below.

3.2 Gas Transmission Pipeline

The gas transmission pipeline route is located between the CSG fields in the Surat and Bowen Basin of Central Western Queensland and Gladstone in Central Queensland. The total length of the gas transmission pipeline will be approximately 425 km and will pass through the surrounding communities of the towns of Rolleston, Moura, Banana, Biloela and Yarwun and Gladstone. The majority of the land the gas transmission pipeline will pass will be rural farming land and forest/vegetated areas.

For the majority of its length, the gas transmission pipeline will be located at significant distances from populated centres and rural residences. However, it passes adjacent to a number of towns along the route and, dependant on the separation distance, may have the potential to cause noise impacts during the construction and operational phases of the project. The gas transmission pipeline passes adjacent to, but not through, the rural towns of Rolleston, Moura, Banana, Biloela, Yarwun and Gladstone. As the route approaches Gladstone, the adjacent areas are generally more densely populated thereby increasing the likelihood of sensitive receptors being sufficiently close to the route to experience potential noise and vibration impacts.

Potential construction impacts on populated centres and isolated residences will be a function of the distance to the construction works.

Due to the vast spatial coverage of the gas transmission pipeline route, the methodology used to assess construction and operational noise and vibration impacts in this report is based on predicting noise and vibration emissions at various distances from the construction and operational works associated with the gas transmission pipeline and not at specific sensitive receptor locations as per the LNG facility section.

The gas transmission pipeline alignment used in this assessment is shown in **Appendix A**.

3.3 CSG Field

2,500+ gas wells and 12 compressor sites have been proposed for the CSG fields located in the Surat and Bowen Basin (total number will depend on the operational capacity of the LNG facility). The gas wells and compressor sites will be located near the towns/communities of Roma, Injune and Acadia Valley (south to north). Each of the operational gas wells will be connected to the gas gathering network which feeds into the main gas transmission pipeline. The gathering network is made up of small, low pressure, HDPE pipes which will be buried underground.

Santos tenements (Santos petroleum lease land) are shown in **Appendix A**.

The majority of Santos tenements are located on rural farming land and/or forest/vegetation land.

Due to the vast spatial covering of the CSG fields, the methodology used to assess construction and operational noise and vibration impacts in this report is based on predicting noise and vibration emissions at various distances from the construction and operational works associated with the CSG fields and not at specific sensitive receptor locations as per the LNG facility section.

4 TECHNICAL INFORMATION

4.1 Noise

4.1.1 Standard Noise Indices

This report makes reference to certain noise level descriptors, in particular the L_{A90}, L_{Aeq}, L_{A10} and L_{Amax} noise levels.

- The L_{Aeq} is essentially the average sound level. It is defined as the steady sound level that contains the same amount of acoustical energy as a given time-varying sound over the same measurement period.
- The L_{A90} noise level is the A-weighted sound pressure level exceeded 90% of a given measurement period and is representative of the average minimum background sound level (in the absence of the source under consideration), or simply the "background" level.
- The L_{A10} is the A-weighted sound pressure level exceeded 10% of a given measurement period.
- The L_{Amax} noise level is the maximum A-weighted noise level associated with site activity.

The $L_{Amax,adj\ T}$ noise level is the average of the maximum noise levels during time period T adjusted for tonality and impulsiveness.

The relationship between the L_{Aeq} and the L_{A90} is in general less than 1 dBA for steady state noise sources (ie compressor sites and LNG facility). For this project, a difference of less than 0.5 dBA was measured for the operational noise of the Fairview Compressor Site 2. Due to the steady state nature of operational noise levels from the compressor sites and LNG facility, it has therefore been assumed throughout this report that the L_{Aeq} and L_{A90} parameters are equivalent.

4.1.2 Typical Noise Levels

Table 2 presents examples of typical noise levels

Table 2 Typical Noise Levels

Sound Pressure Level (dBA)	Typical Source	Subjective Evaluation
130 120 110	Threshold of pain Heavy rock concert Grinding on steel	Intolerable Extremely noisy
100 90	Loud car horn at 3 m Construction site with pneumatic hammering	Very noisy
80 70	Kerb side of busy street Loud radio or television	Loud
60 50	Department store General Office	Moderate to Quiet
40 30	Inside private office Inside bedroom	Quiet to Very quiet
20	Unoccupied recording studio	Almost silent

4.1.3 A-Weighting or dBA Noise Levels

The overall level of a sound is usually expressed in terms of dBA, as is the case in Australian Standard AS 1055 Acoustics – *Description and measurement of environmental noise*, which is measured using the "A-weighting" filter incorporated in sound level meters. These filters have a frequency response corresponding approximately to that of human hearing. People's hearing is most sensitive to sounds at mid frequencies (500 Hz to 4000 Hz), and less sensitive at lower and higher frequencies. Thus, the level of a sound in dBA is a good measure of the loudness of that sound.

Different sources having the same dBA level generally sound about equally as loud, although the perceived loudness can also be affected by the character of the sound (eg the loudness of human speech and a distant motorbike may be perceived differently, although they are of the same dBA level).

4.1.4 Sensitivity of People to Noise Level Changes

A change of up to 3 dBA in the level of a sound is difficult for most people to detect, whilst a 3 dBA to 5 dBA change corresponds to a small but noticeable change in loudness. A 10 dBA change corresponds to an approximate doubling or halving in loudness.

4.2 Vibration

Humans are far more sensitive to vibration than is commonly realised. They can detect and possibly even be annoyed at vibration levels which are well below those causing any risk of damage to a building or its contents.

The actual perception of motion or vibration may not, in itself, be disturbing or annoying. An individual's response to that perception, and whether the vibration is "normal" or "abnormal", depends very strongly on previous experience and expectations, and on other connotations associated with the perceived source of the vibration. For example, the vibration that a person responds to as "normal" in a car, bus or train is considerably higher than what is perceived as "normal" in a shop, office or dwelling.

Human tactile perception of random motion, as distinct from human comfort considerations, was investigated by Diekmann and subsequently updated in German Standard *DIN 4150 Part 2 1975*. On this basis, the resulting degrees of perception for humans are suggested by the continuous vibration level categories given in **Table 3**.

Table 3 Vibration Levels and Human Perception of Motion

Approximate Vibration Level	Degree of Perception
0.10 mm/s	Not felt
0.15 mm/s	Threshold of perception
0.35 mm/s	Barely noticeable
1 mm/s	Noticeable
2.2 mm/s	Easily noticeable
6 mm/s	Strongly noticeable
14 mm/s	Very strongly noticeable

Note: These approximate vibration levels (in floors of building) are for vibration having frequency content in the range of 8 Hz to 80 Hz.

Table 3 suggests that people will just be able to feel continuous floor vibration at levels of about 0.15 mm/s and that the motion becomes "noticeable" at a level of approximately 1 mm/s.

5 NOISE MEASUREMENTS

This section presents the results of the ambient monitoring surveys and the attended near field measurements carried out for the project. Ambient noise monitoring was conducted at (or near) fifteen (15) residential locations in the communities surrounding the proposed LNG facility, gas transmission pipeline and CSG fields. Both attended and unattended ambient noise measurements have been conducted in order to accurately document the existing noise environment. The measured ambient noise levels are used to determine the applicable project noise criteria.

Attended near field measurements were carried out in the CGS field to obtain source noise levels for plant and equipment (ie Compressor Site 2 and Completions Drill Rig) associated with the operational and construction phases of the project in this area. The noise measurements were obtained in order to determine sound power levels (SWL) for these items of plant in order to predict noise impacts from their operation.

5.1 Methodology

In order to determine the existing ambient noise environment in the vicinity of the proposed LNG facility, the gas transmission pipeline and CSG fields, long-term unattended ambient noise monitoring was undertaken at fifteen (15) locations in the surrounding communities during the following periods:

- Wednesday 20 February to Thursday 6 March 2008 (Plant 1 & 3-6);
- 16 June to 30 June 2008 (Plant 2; Gas & Pipeline 1-8); and
- 15 July to 28 July 2008 (Gas & Pipeline 9).

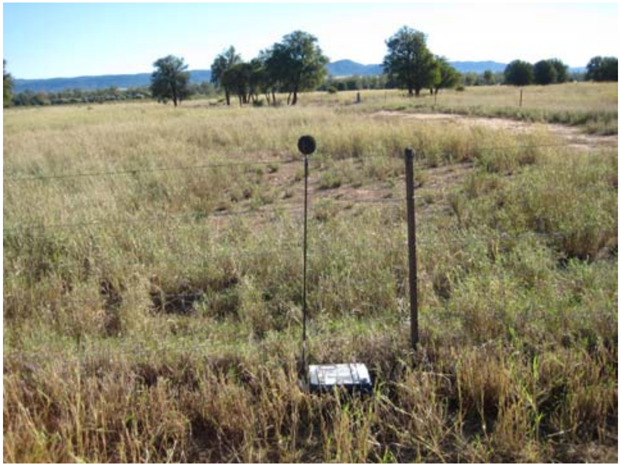
Table 4 summarises the ambient noise monitoring locations.

Table 4 Ambient Noise Monitoring Locations

Location	Site	Logger GPS Coordinates	Comments	Photo
Plant 1	Tide Island, Gladstone Harbour	-23.801253° 151.229304°	Logger located 5-6m from shed facing proposed LNG site	
Plant 2	South End Curtis Island (22 Poinciana Ave)	-23.754879° 151.306900°	Logger located in garden in front yard along fence	
Plant 3	Auckland Hill (1 Auckland St, Gladstone)	-23.836239° 151.253532°	Logger located 3-4m from North corner of house (NW end of Auckland St) and 3.5m above ground	

Location	Site	Logger GPS Coordinates	Comments	Photo
Plant 4	Yarwun (Mt Larcom Gladstone Rd, near Flynn Rd)	-23.840643° 151.108262°	Logger located in garden in front of yard	
Plant 5	Near Bridge Crossing (Northern end of Flinders Rd)	-23.745427° 151.097502°	Logger located 7-8 m from home facing towards Gladstone (SE)	
Plant 6	Gladstone Marina (Bryan Jordan Dr)	-23.833448° 151.244220°	Logger located on-top of shelter in front of Gladstone Water Police	

Location	Site	Logger GPS Coordinates	Comments	Photo
Gas & Pipeline 1	Santos Roma (Currey St)	-26.565928° 148.773695°	Logger located on fence in front corner of property	
Gas & Pipeline 2	North-East of Roma (Beverley Property, Beverley Rd)	-26.452863° 148.906830°	Located in paddock ~300m from house, was unable to sent up at house as there was constant machinery movement (in work sheds) and silo's in operation	
Gas & Pipeline 3	Fairview Rd (~400m west of intersection with Beilba Rd)	-25.604078° 148.794973°	Located on fence approximately 15m from house	

Location	Site	Logger GPS Coordinates	Comments	Photo
Gas & Pipeline 4	Carnarvon Hwy (~55km North of Injune)	-25.412463° 148.623078°	Located on fence approximately 100m from house	
Gas & Pipeline 5	Acadia Valley (Acadia Valley Rd)	-25.311035° 148.857967°	Located in paddock ~300m from house, was unable to sent up at house as there was constant movement close to home (as well as pumps), owner asked for it in this location	
Gas & Pipeline 6	North of Banana (Baralaba Banana Rd, ~15km North of Banana)	-24.359955° 150.047449°	Located in paddock ~300m from house, was unable to sent up at house as there was constant machinery movement (in work sheds) as well as dogs and pumps	

Location	Site	Logger GPS Coordinates	Comments	Photo
Gas & Pipeline 7	North of Biloela (Jambin Dakenba Rd, ~15km North of Biloela	-24.272246° 150.453302°	Located near house along fence on driveway	
Gas & Pipeline 8	West of Gladstone (Cnr of Mt Alma Rd & Kaluda Rd	-23.970074° 150.966315°	Located near house along fence	
Gas & Pipeline 9	Springwater Overseer's Cottage	-25.756953° 148.936257°	Located 50m away from house due to pumps and A/C units surround the house	

The ambient noise monitoring locations are illustrated in **Appendix B**.

The ambient noise monitoring locations were selected to provide spatial coverage of the communities surrounding the proposed LNG facility, the gas transmission pipeline and CSG fields. Each location is considered to be representative of the residential area in which it is located in terms of the existing noise environment and for assessment of any potential noise impacts associated with the proposed LNG facility, the gas transmission pipeline and CSG fields.

Attended ambient noise measurements were also conducted at each site to confirm background noise levels and to observe typical noise sources associated with the ambient noise environment during the daytime, evening and night-time periods. The attended ambient noise measurements were conducted for one 15 minute period during each of the day (7.00 am to 6.00 pm), evening (6.00 pm to 10.00 pm) and night (10.00 pm to 7.00 am) time periods at each location except where access to the site was not possible during the night-time period (ie three 15 minute attended measurements were undertaken at each location). The noise measurements were conducted on the following dates:

- 21 and 22 February 2008 (Plant 3 & Plant 6);
- 5 and 6 March 2008 (Plant 1, Plant 4 & Plant 5);
- 16 to 19 June 2008 (Gas & Pipeline 1-8);
- 25 and 26 June 2008 (Gas & Pipeline 8 (night only), Plant 2); and
- 15 July 2008 (Gas & Pipeline 9).

Attended near field measurements were obtained in close proximity to Fairview Compressor Site 2 and Completions Drill Rig No. 5 to quantify noise emissions from this plant in order to determine the level of noise impact from its operation.

5.2 Instrumentation

The monitoring was undertaken using Acoustic Research Laboratories Type EL-215 and EL-316 Environmental Noise Loggers programmed to record various statistical noise levels over consecutive 15-minute intervals. Each logger was checked for calibration before and after the survey with a Rion NC-73 Sound Level Calibrator and no significant drift (greater than 1 dBA) in calibration was detected.

ARL EL-215 Noise Loggers are NATA certified Type 2 Meters. ARL EL-316 Noise Loggers are NATA certified Type 1 meters. It is common practice to use Type 1 or 2 noise loggers for measuring background noise levels in accordance with the *Queensland Environmental Protection (Noise) Policy 1997* [EPP(Noise)]. The noise floor of EL-215 loggers is approximately 26 dBA and the noise floor of EL-316 loggers is approximately 20 – 22 dBA.

Attended measurements were undertaken using a Rion NA-27 Precision Sound Level Meter (SLM). The Rion NA-27 SLM is a Type 1 Sound Level Meter. The noise floor of a Rion NA-27 is approximately 10 dBA. The Rion-NA27 SLM was checked for calibration before and after each set of noise measurements using a Rion NC-73 Sound Level Calibrator and no significant drift (greater than 1 dBA) in calibration signal level was observed.

All items of acoustic instrumentation employed during the noise monitoring were set to ‘Fast’ response in accordance with the relevant Australian Standards and the Queensland EPA’s *Noise Measurement Manual*. All items of acoustic instrumentation employed during the noise measurement surveys were designed to comply with AS 1259.2 *Sound Level Meters* and carry current calibration certificates.

5.3 Ambient Noise Monitoring Results

5.3.1 Unattended Logging

The unattended ambient noise measurements were used to determine the “Rating Background Level” (RBL) for the daytime (7.00 am to 6.00 pm), evening (6.00 pm to 10.00 pm) and night-time (10.00 pm to 7.00 am) periods at each location. The RBL is the median of the 90th percentile background (L_{A90}) noise levels in each assessment period (day, evening and night) over the duration of the monitoring (as defined in the Queensland’s Environmental Protection Agency’s (EPA) *Ecoaccess Guideline: Planning for Noise Control*). **Table 5** contains the determined RBL for each measurement location.

Table 5 Measured Rating Background Levels

Monitoring Location	Rating Background Level (dBA)		
	Day	Evening	Night
Plant 1	43	49	44
Plant 2	33	32	31
Plant 3	42	42	37
Plant 4	41	40	37
Plant 5	35	36	36
Plant 6	45	42	38
Gas & Pipeline 1	37	34	28
Gas & Pipeline 2	23	21	21
Gas & Pipeline 3	24	20	20
Gas & Pipeline 4	27	22	22
Gas & Pipeline 5	23	22	22
Gas & Pipeline 6	27	27	27
Gas & Pipeline 7	29	27	27
Gas & Pipeline 8	29	32	26
Gas & Pipeline 9	30	29	29

On review of the measured RBLs in **Table 5**, the statistical noise plots (**Appendix C**), the 1/3 octave attended measurements and operator notes in **Table 8**, the measured RBLs have been adjusted to account for the following:

- Logger noise floor – A review of the statistical noise plots in **Appendix C** show that the measured ambient noise levels at many of the Gas and Pipeline sites included periods which were below the noise floor of the logger (ie the ambient noise level was lower than the logger could measure). The measured RBL at these locations have been adjusted to reflect a more appropriate RBL based on noise measurements obtained during attended surveys and a review of the statistical noise plot patterns over the monitoring period (including those at similar sites).
- Elevated noise levels due to extraneous noise source such as insects and wind movement in trees (resulting from sustained moderate wind speeds). Tide Island was a unique monitoring location as elevated wind levels caused increased noise levels due to lapping of harbour waves onto the island.

The most significant seasonal influence on noise levels along the project is due to the presence (or otherwise) of insect noise (usually most prevalent during the summer months) and from the prevailing weather conditions.

The methodology used to determine the appropriate rating background noise levels for the project, includes eliminating noise levels measured during periods when extraneous noise sources (such as from insects and adverse weather conditions) are present. By removing the noise levels measured during periods where extraneous noise sources were present, we are obtaining noise levels representative of those expected during the season in which background noise levels would be lowest. This allows a conservative assessment to be carried out for potential noise impact from the project.

It is expected that there would be periods during the year when ambient and background noise levels along the project would be higher than those shown in **Table 6**.

The adjusted RBLs are shown in **Table 6** and include an explanation for their adjustment.

Table 6 Adjusted Rating Background Level

Monitoring Location	Rating Background Level (dBA)		
	Day	Evening	Night
Plant 1	41 [4]	41 [4]	41 [4]
Plant 2	33	32	31
Plant 3	42	42	37
Plant 4	41	40	37
Plant 5	31 [3]	31 [2, 3]	33 [2]
Plant 6	45	42	38
Gas & Pipeline 1	37	34	28
Gas & Pipeline 2	23	18 [1]	17 [1]
Gas & Pipeline 3	24	18 [1]	18 [1]
Gas & Pipeline 4	27	19[1]	18[1]
Gas & Pipeline 5	21 [1]	18 [1]	17[1]
Gas & Pipeline 6	21 [1]	18 [1, 2]	18 [1]
Gas & Pipeline 7	29	27	27
Gas & Pipeline 8	29	21 [1, 2]	18 [1]
Gas & Pipeline 9	30	29	29

Note 1: Adjusted to account for the noise floor of logger (noise floor is described as the minimum noise level to which noise logger can record noise). Corrections to account for noise floor of logger are based on analysis of logger results, attended measurements and field observations.

2: Adjusted to correct for enhanced noise levels as a result of insect noise

3: Adjusted to correct for elevated wind levels and increased noise levels due to movement of trees

4: Adjusted to correct for elevated wind levels and increased noise levels due to lapping of harbour waves

The maximum $L_{Aeq(1hour)}$ noise level representative of the ambient noise environment was noted for the daytime, evening and night-time periods. The representative maximum $L_{Aeq(1hour)}$ noise levels at each location are shown in **Table 7**.

Table 7 Maximum $L_{Aeq(1hour)}$ Noise Levels

Monitoring Location	Maximum $L_{Aeq(1hour)}$ (dBA)		
	Day	Evening	Night
Plant 1	61	58	54
Plant 2	56	42	52
Plant 3	56	57	50
Plant 4	53	50	51
Plant 5	57	51	52
Plant 6	54	50	53
Gas & Pipeline 1	58	53	55
Gas & Pipeline 2	55	45	45
Gas & Pipeline 3	54	37	41
Gas & Pipeline 4	52	38	43
Gas & Pipeline 5	46	29	40
Gas & Pipeline 6	55	32	43
Gas & Pipeline 7	51	58	46
Gas & Pipeline 8	54	52	50
Gas & Pipeline 9	49	40	47

The long term unattended noise monitoring results at some locations show that the measured noise levels during the evening or night time period are higher than that measured during the daytime. This is often due to increased noise from insects during the evening and night during the warmer months. As greater levels of noise control are generally expected for the more sensitive evening and night time periods than the less sensitive daytime period, the appropriate noise level criteria has been calculated using the following principles:

- The evening criteria are not greater than the daytime criteria.
- The night-time criteria are not greater than the daytime or evening criteria.

Graphs showing the statistical noise levels measured at the monitoring locations over the whole monitoring period are presented in **Appendix C** for each 24-hour period. The graphs show various statistical noise levels, including the background (L_{A90}) noise level at each site.

15-minute weather data during noise monitoring periods was sourced from the Bureau of Meteorology (Gladstone, Biloela and Roma Met Stations). The weather conditions during the monitoring periods were generally fine. Some rainfall and periods of increased wind were recorded during the monitoring period (these periods have been excluded from the measurement results). The weather conditions during the remainder of the monitoring period are considered to be suitable for obtaining ambient noise measurements.

5.3.2 Attended Ambient Noise Measurements

Attended measurements were undertaken at each of the fifteen (15) ambient monitoring locations in order to confirm background noise levels and to observe typical noise sources associated with the ambient noise environment. The results of these measurements are summarised in **Table 8.**

Table 8 Attended Ambient Measurement Results – Day, Evening and Night-Time Periods

Monitoring Location	Date	Time (end of 15 min period)	Measured Noise Level (dBA)			Comments
			LA90	LAeq	LA10	
Plant 1	21/02/08	8:30am	41	45	46	Industry from Gladstone audible, Insect and bird noise; occasional passing power boat.
	-	-	-	-	-	No evening attended measurement due to site access restrictions.
	-	-	-	-	-	No night time attended measurement due to site access restrictions.
Plant 2	19/06/08	4:30pm	31	46	50	Birds and insects dominant noise source; distant ocean movement audible; domestic noise occasionally audible (talking, TV, movement etc)
	26/06/08	6:45pm	36	39	39	Insects and bats (squawking and movement in trees) dominant noise source; ocean movement audible; distant industry noise just audible (spiking 315Hz band); domestic noise occasionally audible (cooking dinner, TV, movement etc)
	27/06/08	2:45am	32	33	34	Bat squawking and movement in trees; insects; 'ocean' movement within harbour (SW breeze), ocean side not audible; industry audible in SW breeze.
Plant 3	05/03/08	5:15pm	44	51	53	Bird noise dominant; low traffic on Flinders Parade; minimal domestic noise.
	21/02/08	7:00pm	46	58	61	Insects, birds and coal loading industrial noise dominant; insects loud in the last 2-3 minutes on measurement; low traffic on Flinders Parade.
	22/02/08	2:00am	45	47	51	Coal loading industrial noise dominant; insects and low traffic on Flinders Parade.
Plant 4	06/03/08	4:45pm	51	55	58	Industrial noise audible; occasional traffic on Mt Larcom – Gladstone Rd; insects dominant at times; occasional birds; tree movement.
	05/03/08	8:30pm	41	47	50	Insects dominant noise; distant industrial noise audible; occasional traffic on Mt Larcom – Gladstone Rd; low tree movement.
	05/03/08	11:45pm	40	49	54	Insects and distant industrial noise dominant noise sources.
Plant 5	06/03/08	3:15pm	45	49	52	Insect and birds noise audible; tree movement.
	05/03/08	7:15pm	50	51	52	Insects dominant noise source; tree movement.
	06/03/08	10:45pm	41	44	46	Insects dominant noise source; distant industry noise just audible; tree movement.

Monitoring Location	Date	Time (end of 15 min period)	Measured Noise Level (dBA)			Comments
			LA90	LAeq	LA10	
Plant 6	06/03/08	11:15am	44	48	50	Bird noise; tree movement; audible industrial noise; occasional power boat audible.
	05/03/08	7:30pm	49	50	52	Coal loading facility audible and dominant at times; Insect and frog noise.
	06/03/08	2:30am	48	49	50	Coal loading facility audible and dominant at times; Insect and frog noise.
Gas & Pipeline 1	16/06/08	9:45am	41	60	60	Traffic along Currey St dominant noise source; construction noise from nearby building site; and birds active.
	16/06/08	6:15pm	43	57	57	Traffic along Currey St dominant noise source; and birds and insects active (dominant with no traffic).
	16/06/08	11:15pm	34	38	40	Insects and bird noise; distant traffic noise (not Currey St, possibly Warrego Hwy / main street through Roma).
Gas & Pipeline 2	16/06/08	2:45pm	20	32	32	Insects and birds dominant; 1 passing 4WD. Very quiet at this locations.
	16/06/08	9:45pm	17	23	19	Very quiet at this locations. Minor bird noise.
	16/06/08	10:30pm	16	29	19	Very quiet at this locations. Minor bird noise.
Gas & Pipeline 3	17/06/08	12:45pm	27	42	37	Birds active and dominant; minor insect noise; truck pass-by on Fairview Rd (55-65 dBA); light tree movement with breeze
	-	-	-	-	-	No evening attended measurement due to safety of site access at night.
	-	-	-	-	-	No night attended measurement due to safety of site access at night.
Gas & Pipeline 4	17/06/08	17:45pm	26	40	41	Birds, insects and cow noise dominant noise sources. Distance traffic just audible (trucks ~ 35 dBA).
	17/06/08	6:15pm	19	34	34	Insect, bird and cow noise all dominant though not loud; distant traffic on Carnarvon Hwy audible (truck ~ 35-40 dBA, car ~25-32 dBA)
	-	-	-	-	-	No night attended measurement due to safety of site access at night.
Gas & Pipeline 5	17/06/08	3:15pm	21	30	32	Insects and birds dominant; light tree movement in breeze; 4WD drove by on dirt road (45-47 dBA over 15 seconds)
	-	-	-	-	-	No evening attended measurement due to safety of site access at night.
	-	-	-	-	-	No night attended measurement due to safety of site access at night.

Monitoring Location	Date	Time (end of 15 min period)	Measured Noise Level (dBA)			Comments
			LA90	LAeq	LA10	
Gas & Pipeline 6	18/06/08	12:45pm	19	32	34	Bird and cow noise dominant; light tree movement in breeze; traffic pass-by on local road (40-45 dBA over ~20 seconds).
	18/06/08	9:30pm	25	28	30	Insects dominant (3.15kHz dominant); distant cow and frog noise.
	-	-	-	-	-	No night attended measurement due to safety of site access at night.
Gas & Pipeline 7	18/06/08	3:45pm	28	35	36	Insect and bird noise dominant; occasional car pass-by on local road (32-35 dBA); distant construction noise (road works ~500m) – just audible.
	18/06/08	6:15pm	64	66	67	Insects loud and dominant (3.15kHz dominant); occasional car pass-by on local road (didn't raise levels above insects).
	18/06/08	11:00pm	32	39	32	Insects dominant noise source; distant rail/industry noise to NE (coal mine) – low frequency noise.
Gas & Pipeline 8	19/06/08	12:45pm	26	32	35	Insects and birds dominant noise source; light tree movement in breeze; distant creaking of tin roof on house and shed in sun.
	19/06/08	9:30pm	31	36	35	Insects dominant noise source; distant mechanical noise (pump); truck passing by on Mt Alma Rd (up to 45 dBA for ~30-45 sec)
	26/06/08	2:15am	17	21	23	Very quiet at this location; occasional frog noise; distant train movement just audible.
Gas & Pipeline 9	15/07/08	10:45am	28	36	39	Birds dominant, light tree movement. Passing 4WDs audible (~38-42 dBA), 5 pass-bys in 15min block. Distant construction noise from booster site.
	-	-	-	-	-	No evening attended measurement due to safety of site access at night.
	-	-	-	-	-	No night attended measurement due to safety of site access at night.

Note: Daytime (7.00 am to 6.00 pm), evening (6.00 pm to 10.00 pm) and night-time (10.00 pm to 7.00 am)

The attended measurements and observations summarised in **Table 8,** show that insect noise frequently dominates the ambient noise environment at the majority of monitoring locations and time periods. Where possible, the measured noise levels have been corrected to remove the influence of insects on background and ambient noise levels. Industrial noise was observed at locations Plant 1, 3, 4 and 6 and Gas and Pipeline 7. Road traffic noise was observed at locations Plant 3 – 4, and Gas and Pipeline 9. Birds, frogs and other fauna noise were frequently observed at all locations. Gas and Pipeline locations 2 – 6 and 8 were noted as being extremely quiet during the evening and night-time periods.

5.4 Near Field Measurements

During a site visit carried out in July 2008, attended measurements of Fairview Compressor Site 2 (Compressor Site 2) and Completions Drill Rig No. 5 (Completions Drill Rig) were undertaken to determine sound power levels (SWL) for this equipment. The SWL would be used in Heggies' models to predict noise levels at various set-back distances to allow assessment of noise impacts against the relevant noise guidelines and assist in locating this equipment so as to minimise noise impacts.

Measurements of a completions drill rig were undertaken to represent the most noise intensive operation involved in the construction phase of the CSG field (as advised by URS/Santos).

5.4.1 Compressor Site 2

Short-term attended measurements were conducted at seven (7) locations surrounding the compressor site to determine a SWL (SWL is calculated based on measured sound pressure level at a known distance from a noise source). The measurement locations ranged from approximately 20m to 95m from the compressors and were all taken outside of the compound for safety purposes. The noise levels measured at Compressor Site 2 were noted as continuous.

During this site visit, it was noted that Compressor Site 2 comprised of four (4) large compressors, two (2) mid size compressors and three (3) small-sized compressors.

Table 9 summarises the calculated SWL and octave band spectrum for Compressor Site 2.

Table 9 Compressor Site 2 - Sound Power Level and Octave Band Spectrum

		Sound Power Level (dBA) Octave Band Centre Frequency (Hz)								
	dBA	**31.5**	**63**	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**
Compressor Site 2	123	91	105	111	114	116	114	117	114	102

The measured noise levels have been assumed to be representative of a typical compressor site and the noise assessment of operational compressors (**Section 7.6.3**) is based on the sound power levels shown above.

5.4.2 Completions Drill Rig

Short-term attended measurements were conducted at six (6) locations surrounding the Completions Drill Rig to predict a SWL. The measurement locations ranged from approximately 10m to 20m from the drill rig and were all taken outside of the 10m exclusion zone for safety purposes. The noise levels measured from the completions drill rig were noted as continuous.

Plant items noted during site measurements of the Completions Drill Rig included a carrier well head, mud pump, generators (three in total) and booster compressor.

Table 10 summarises the calculated SWL for the Completion Drill Rig and octave band spectrum.

Table 10 Completions Drill Rig – Sound Power Level and Octave Band Spectrum

		Sound Power Level (dBA) Octave Band Centre Frequency (Hz)								
	dBA	**31.5**	**63**	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**
Completions Drill Rig	116	75	104	100	102	110	111	110	104	99

6 IMPACT ASSESSMENT CRITERIA

6.1 Community Values Relating to Noise and Vibration

The Queensland Environmental Protection (Noise) Policy 1997 defines the values to be protected as the qualities of the acoustic environment that are conducive to:

- The wellbeing of the community or a part of the community, including its social and economic amenity; or
- The wellbeing of an individual, including the individual's opportunity to have sleep, relaxation, and conversation without unreasonable interference from intrusive noise.

Sleep

A person's ability to sleep is perhaps the most important value that can be impacted by noise and/or vibration. Noise and vibration effects on sleep are generally referred to as sleep disturbance.

Recreation

Recreation is an important aspect of a healthy lifestyle. Recreation may include time spent both indoors and outdoors. In terms of acoustic function, recreation may involve communication with others in verbal conversation or simple enjoyment of an outdoor or indoor soundscape.

Education and Work

The needs for education and work in relation to the acoustic environment relate to the need to be able to communicate effectively either face-to-face or by telephone, and the ability to think or focus on auditory information without undue intrusion from other sources of noise.

6.2 Construction

6.2.1 Noise

For construction work occurring during normal daytime hours, provided all mechanical powered plant is fitted with appropriate mufflers, specific noise limits are generally not warranted. In this regard, it may be noted that the Queensland Environmental Protection (Noise) Policy 1997 [EPP(Noise)] does not include construction noise limits (other than those which apply to blasting). Noise impacts are usually minimised by limiting the hours of operation and, in particular circumstances, scheduling the noisiest activities to occur at times when they would generate least disruption.

In accordance with the Environmental Protection Regulation (1997), where construction noise may affect adjacent residential premises or other residential accommodation (including hotels, motels, serviced units or backpacker accommodation), it is recommended to limit the hours of operation to:

- Monday to Saturday - 6.30 am to 6.30 pm

For construction works extending outside normal working hours, particular noise limits should be applied or permission granted by the potentially affected sensitive receptors.

The most important amenity issue for surrounding residents during the evening/night-time period is sleep preservation. The World Health Organisation (WHO) recommends for quality sleep, maximum noise levels should not exceed 45 dBA. This guideline is recommended for construction work outside the recommended hours listed above.

Based on a conservative building façade noise reduction of 5 dBA through an open window, the following external criterion is recommended for sleep disturbance, assessable at four metres from the building facade:

- LAmax (external) - 50 dBA

6.2.2 Vibration

When dealing with construction vibration, the effects in buildings can be divided into the following main categories:

- Human comfort.
- Structural damage.
- Safe vibration levels for common services.
- Effects of vibration on building contents.

Human Comfort

A discussed in **Section 4.2**, human tactile perception of random motion, as distinct from human comfort considerations, was investigated by Diekmann and subsequently updated in German Standard *DIN 4150 Part 2-1975*. On this basis, the resulting degrees of perception for humans are suggested by the continuous vibration level categories given in **Table 11**.

Table 11 Vibration Levels and Human Perception of Motion

Approximate Vibration Level	Degree of Perception
0.10 mm/s	Not felt
0.15 mm/s	Threshold of perception
0.35 mm/s	Barely noticeable
1 mm/s	Noticeable
2.2 mm/s	Easily noticeable
6 mm/s	Strongly noticeable
14 mm/s	Very strongly noticeable

Note: These approximate vibration levels (in floors of building) are for vibration having frequency content in the range of 8 Hz to 80 Hz.

Table 11 suggests that people will just be able to feel continuous floor vibration at levels of about 0.15 mm/s and that the motion becomes “noticeable” at a level of approximately 1 mm/s.

Guidance in relation to assessing the potential human disturbance from ground-borne vibration inside buildings and structures is contained in British Standard BS 6472-1992 *“Evaluation of Human Exposure to Vibration in Buildings (1 Hz to 80 Hz)”.*

Satisfactory magnitudes of peak vertical vibration velocity (ie below which the probability of “adverse comment” is low) from BS 6472 are shown in **Table 12** (for generally sinusoidal vibration).

Table 12 Satisfactory Level or Peak Vertical Vibration Velocity (8 Hz to 80 Hz)

Type of Space Occupancy	Time of Day	Satisfactory Peak Vibration Levels in mm/s Over the Frequency Range 8 Hz to 80 Hz			
		Continuous Vibration		Impulsive Vibration with up to 3 Occurrences per Day	
		Vertical	Horizontal	Vertical	Horizontal
Critical working areas (eg some hospital operating theatres, some precision laboratories, etc)	Day Night	0.14 0.14	0.4 0.4	0.14 0.14	0.4 0.4
Residential	Day Night	0.3 to 0.6 0.2	0.8 to 1.6 0.6	8.4 to 12.6 2.8	24 to 36 8
Offices	Day Night	0.6 0.6	1.6 1.6	18 18	51 51
Workshops	Day Night	1.2 1.2	3.2 3.2	18 18	51 51

Table 12 indicates that continuous floor vibration levels above which "adverse comment" in residences and offices may arise during daytime range from approximately 0.3 mm/s to 0.6 mm/s.

Structural Damage

In terms of relevant vibration damage criteria, *British Standard 7385: Part 2-1993 Evaluation and measurement for vibration in buildings Part 2* is a definitive standard against which the likelihood of building damage from ground vibration can be assessed.

Although there is a lack of reliable data on the threshold of vibration-induced damage in buildings both in countries where national standards already exist and in the UK, BS 7385: Part 2 has been developed from an extensive review of UK data, relevant national and international documents and other published data. The standard sets guide values for building vibration based on the lowest vibration levels above which damage has been credibly demonstrated. These levels are judged to give a minimum risk of vibration-induced damage, where minimal risk for a named effect is usually taken as a 95% probability of no effect.

Sources of vibration which are considered in the standard include blasting, demolition, piling, ground treatments (ie compaction), construction equipment, tunnelling, road and rail traffic and industrial machinery.

As the strain imposed on a building at foundation level is proportional to the peak particle velocity but is inversely proportional to the propagation velocity of the shear or compression waves in the ground, this quantity (ie peak particle velocity) has been found to be the best single descriptor for correlating with case history data on the occurrence of vibration-induced damage.

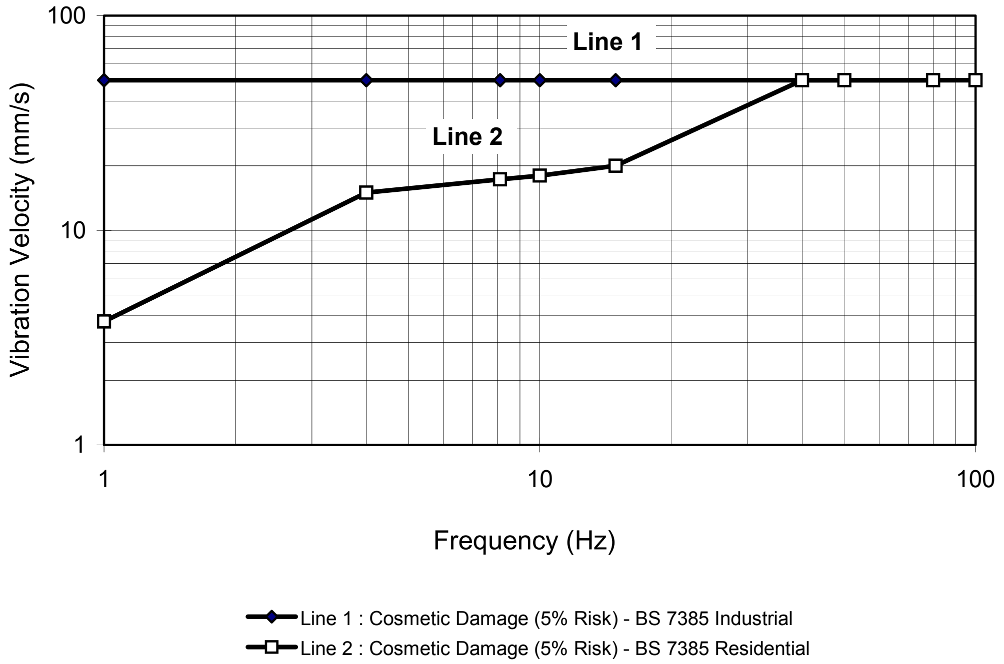
The guide values from this standard for transient vibration judged to result in a minimal risk of cosmetic damage to residential buildings and industrial buildings are presented numerically in **Table 13** and graphically in **Figure 2**.

Table 13 BS 7385 – Transient Vibration Guide Values for Cosmetic Damage

Line	Type of Building	Peak Component Particle Velocity in Frequency Range of Predominant Pulse	
		4 Hz to 15 Hz	15 Hz and above
1	Reinforced or framed structures Industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	

Line	Type of Building	Peak Component Particle Velocity in Frequency Range of Predominant Pulse	
		4 Hz to 15 Hz	**15 Hz and above**
2	Non-reinforced or light framed structures Residential or light commercial type buildings	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above

Figure 2 Graph of Transient Vibration Guide Values for Cosmetic Damage



In the lower frequency region where strains associated with a given vibration velocity magnitude are higher, the guide values for the building types corresponding to Line 2 are reduced. Below a frequency of 4 Hz where a high displacement is associated with the relatively low peak component particle velocity value, a maximum displacement of 0.6 mm (zero to peak) is recommended. This displacement is equivalent to a vibration velocity of 3.7 mm/s at 1 Hz.

Fatigue considerations are also addressed in the standard and it is concluded that unless calculation indicates that the magnitude and number of low reversals is significant (in respect of the fatigue life of building materials) then the guide values in **Table 13** should not be reduced for fatigue considerations.

Nevertheless, the standard states that the guide values in **Table 13** relate predominantly to transient vibration which does not give rise to resonant responses in structures, and to low-rise buildings. Where the dynamic loading caused by continuous vibration is such to give rise to dynamic magnification due to resonance, especially at the lower frequencies where lower guide values apply, then the guide values in **Table 13** may need to be reduced by up to 50%.

It is noteworthy that additional to the guide values nominated in **Table 13**, the Standard states that:

> *"Some data suggests that the probability of damage tends towards zero at 12.5 mm/s peak component particle velocity. This is not inconsistent with an extensive review of the case history information available in the UK."*

Also that:

> *"A building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive."*

Safe Vibration Levels for Common Services

Vibration due to the construction process has the potential to effect services such as buried pipes, electrical and telecommunication cables.

German Standard DIN 4150-3 1999 *"Structural Vibration – Part 3: Effects of vibration on structures"* provides guidance on safe vibration levels for buried pipe work. The levels assume "current technology" as special considerations must be applied for systems associated with older structures such as might occur in the vicinity of Heritage Listed buildings. **Table 14** details the DIN 4150-3 limits for short-term vibration. The levels apply at the wall of the pipe. For long-term vibration the guideline levels presented in **Table 14** should be halved.

Table 14 DIN 4150 Part 3 – Damage to Buried Pipes – Guidelines for Short-term Vibration

Pipe Material	Peak Wall Vibration Velocity
Steel (including welded pipes)	100 mm/s
Clay, concrete, reinforced concrete, prestressed concrete, metal with or without flange (other than steel)	80 mm/s
Masonry, plastic	50 mm/s

Note: For gas and water supply pipes within 2 m of buildings, the levels given in **Table 14** should be applied. Consideration must also be given to pipe junctions with the building structure as potential significant changes in mechanical loads on the pipe must be considered.

Recommended vibration criteria for electrical cables and telecommunication services such as fibre optic cables range from between 50 mm/s and 100 mm/s.

It is noted however that although the cables may sustain these vibration levels, the services they are connected to, such as transformers and switch blocks, may not. It is recommended that should such equipment be encountered during the construction process an individual vibration assessment should be carried out.

Effects of Vibration on Building Contents

Over the frequency range typical of vibration in buildings from construction and excavation activities, industrial vibration, road and rail traffic (approximately 8 Hz to possibly 100 Hz), the threshold for visible movement of susceptible building contents (ie plants, hanging pictures, blinds, etc) is approximately 0.5 mm/s and audible rattling of loose objects (ie crockery) generally does not occur until levels of about 0.9 mm/s are reached.

For delicately balanced objects, rattling may sometimes occur at lower vibration levels. Window rattling may also be excited acoustically (ie by sound pressure waves, which may be thought of as vibration in the air).

In any premises, day-to-day activities (eg, footfalls, doors closing, etc) will cause levels of vibration in floors and walls that exceed 1 mm/s (sometimes by quite considerable margins), and therefore visible movement and rattling are often observed. In most instances however, such movement is considered normal, and vibration levels of even much greater magnitude do not result in damage to the objects or building contents.

Potentially vibration-susceptible building contents include sensitive instrumentation, computers and other electronic equipment, although such items are not usually kept in residences (apart from personal computers which are considerably more robust). Typical maximum floor vibration levels for satisfactory operation of such sensitive items are:

- 0.5 mm/s to 2 mm/s — Precision balances; Some optical microscopes
- 1 mm/s to 5 mm/s — Large computer disk drives; Sensitive electronic instrumentation

Very short duration vibration events, for example vibration from infrequent impulsive vibration, could be permitted to cause somewhat higher levels, depending on vibration frequency content and on the specific susceptibility of particular objects and their location.

The actual levels of vibration induced by a source outside a building are a function of the particular ground conditions, the foundation/footing interaction, location of the receiver within the building and the nature of the building and its floor.

6.2.3 Blasting

The EPP (Noise) Environment Protection Amendment Regulation (No 2) 1999 contains the following blast emissions (airblast and vibration) criteria:

"61 Noise from blasting is not unlawful environmental nuisance for an affected building if:

- *The airblast overpressure is no more than 115 dB Linear Peak for 4 out of 5 consecutive blasts: and*

The ground vibration is:

- *For vibrations of more than 35 Hz – no more than 25 mm/s ground vibration, peak particle velocity; or*
- *For vibrations of no more than 35 Hz – no more than 10 mm/s ground vibration, peak particle velocity."*

The subject Regulation does not nominate times of blasting. However, the Queensland EPA's document entitled *Ecoaccess Guideline: Noise and Vibration from Blasting* contains both blast emissions criteria and times of blasting.

The relevant section is as follows:

Noise Criteria

Blasting activities must be carried out in such a manner that if blasting noise should propagate to a noise-sensitive place, then

1. The airblast overpressure must not be more than 115 dB(linear) peak for nine out of any 10 consecutive blast initiated, regardless of interval between blasts, and
2. The airblast overpressure must not exceed 120 dB(linear) peak for any blast.

Vibration Criteria

Blasting operations must be carried out in such a manner that if ground vibration should propagate to a noise-sensitive place, then

1. The ground borne vibration must not exceed a peak particle velocity of 5mm per second for nine out of any 10 consecutive blast initiated, regardless of interval between blasts, and

2. The ground borne vibration must not exceed a peak particle velocity of 10mm per second for any blast.

Times of Blasting

"Blasting should generally only be permitted during the hours of 9 am to 3 pm, Monday to Friday, and from 9 am to 1 pm on Saturdays. Blasting should not generally take place on Sundays or public holidays.

Blasting outside these recommended times should be approved only where:

1. *blasting during the preferred times is clearly impracticable (in such situations blasts should be limited in number and stricter airblast overpressure and ground vibration limits should apply); or*

2. *There is no likelihood of persons in a noise-sensitive place being affected because of the remote location of the blast site."*

The Guideline further states (under the heading of "Weather Effects") that:

"When a temperature inversion or a heavy low cloud cover is present, values of airblast overpressure will be higher than normal in surrounding areas. Accordingly, blasting should be avoided if predicted values of airblast overpressure in noise-sensitive places exceed acceptable levels. If this is not practicable, blasting should be scheduled to minimise noise annoyance. An appropriate period is generally between 11 am and 1 pm. Similarly, blasting should be avoided at times when strong winds are blowing from the blasting site towards noise sensitive places."

6.2.4 Construction Noise Criteria Summary

A summary of criteria applicable at residential receptors and associated with the construction phase of the project is shown in **Table 15** below.

Table 15 Construction Criteria

Construction Noise		**Vibration**			**Blasting [1]**	
Monday to Saturday (6:30am to 6:30pm)	**Monday to Saturday (6:30pm to 6:30am); Sundays and Public Holidays**	**Structural Damage (mm/s)**	**Human Comfort (mm/s)**		**Airblast (dB Linear Peak)**	**Vibration (mm/s PPV)**
			Day	Night		
No limit	50 dBA LAmax	12.5	0.3 – 0.6[2]	0.2[2]	115	> 35 Hz - 25
						< 35 Hz - 10

Note 1: Blasting should generally only be permitted during the hours of 9 am to 3 pm, Monday to Friday, and 9 am to 1 pm on Saturdays

2: Continuous vibration

6.3 Operational Noise

Operational noise levels emitted by the GLNG project at its ultimate capacity will be assessable in accordance with the Queensland's Environmental Protection Agency's (EPA) *Ecoaccess Guideline: Planning for Noise Control* (the Guideline). This assessment process takes into account four factors:

- Control and prevention of background creep;
- Determination of planning noise levels;
- Containment of variable and short term noise emissions by setting specific (intrusive) noise levels; and
- Sleep disturbance.

6.3.1 Background Noise Creep

The Guideline provides recommended RBLs in order to prevent background noise levels from progressively increasing over time with the establishment of new developments. This gradual increase in overall sound levels through the incremental effect of many potentially minor noise sources is known as 'background creep'.

Table 16 contains background noise levels for various land uses, as shown in Table 1 of the Guideline*.*

Table 16 Recommended Outdoor Background Noise Planning Levels (RBL)

Receiver Land Use	Land Use Type	Receiver Dominant Land Use (Description of Neighbourhood) [1]	RBL (dBA) Time Period Day	Evening	Night
Purely residential	R1	Very rural	35	30	25
	R2	Rural residential, church, hospital	40	35	30
Residential area on a busy road or near an industrial / commercial area	R3	Residential, church, hospital, school	45	40	35
Industrial Area	R4	Residential, church, hospital, school	50	45	40
Passive recreation area	R5	Picnic grounds, bush walks, public gardens	35	35	35

Note 1: The dominant land use is defined by a radius of 200m from the receiver location under consideration.
2: The RBL is defined as the rating background level (minLA90(1hour)).

Where existing noise levels in an area approach the recommended RBL, the criteria must be adjusted to prevent background creep. The recommended adjustments are shown in **Table 17**.

Table 17 Adjustments to Recommended RBL to Prevent Background Creep

Existing Background Level at Residential Receiver	Recommended RBL ($L_{A90(1hour)}$)
> (Recommended RBL)	Background – 10 dBA
= (Recommended RBL)	(Recommended RBL) – 10 dBA
(Recommended RBL) – 1 dBA	(Recommended RBL) – 9 dBA
(Recommended RBL) – 2 dBA	(Recommended RBL) – 5 dBA
(Recommended RBL) – 3 dBA	(Recommended RBL) – 3 dBA
(Recommended RBL) – 4 dBA	(Recommended RBL) – 2 dBA
(Recommended RBL) – 5 dBA	(Recommended RBL) – 2 dBA
< (Recommended RBL) – 5 dBA	Background + 5 dBA

The Guideline notes that it may not be possible to maintain background levels in very rural areas below 25 dBA as development occurs. In such cases, a threshold background level of 25 dBA is to be used.

6.3.2 Determination of Planning Noise Levels

Maximum Planning Noise Levels (PNLs) for various noise area categories are also recommended within the Guideline. These PNLs are also applicable to the corresponding daytime, evening and night-time periods. **Table 18** contains estimated maximum hourly values of PNLs for different areas containing residences, as shown in Table 3 of the Guideline.

Table 18 Recommended Maximum Values of Planning Noise Levels (PNL)

Noise Area Category	Description of Neighbour	Max hourly sound pressure level, $L_{Aeq(1hour)}$ (PNL) – All Days (dBA)		
		Day	**Evening**	**Night**
Z1	Very rural, purely residential. < 40 vehicles an hour	40	35	30
Z2	Negligible transportation. < 80 vehicles an hour	50	55	40
Z3	Low-density transportation. < 200 vehicles an hour	55	50	45
Z4	Medium density transportation (< 600 vehicles an hour) or some commerce or industry	60	55	50

Note 1: Time periods are:
- Day: 7am to 6pm
- Evening: 6pm to 10pm
- Night: 10pm to 7am

Where existing noise levels in an area approach the maximum PNL, the noise level from any new source must be controlled to preserve the amenity of the area. To achieve this, the Guideline recommends modifications be made to the maximum PNL depending on the existing noise levels. These modifications are summarised in **Table 19**.

Table 19 Modifications to Recommended Maximum PNL to Preserve Amenity

Existing Noise Level (dBA)	PNL for New Sources (dBA)
≥ PNL + 2	Where existing noise levels are likely to decrease: PNL – 10
	Where existing noise levels are unlikely to decrease: Existing Level - 10
PNL + 1	PNL – 9
PNL	PNL – 8
PNL – 1	PNL – 6
PNL – 2	PNL – 4
PNL – 3	PNL – 3
PNL – 4	PNL – 2
PNL – 5	PNL – 2
PNL – 6	PNL – 1
< PNL – 6	PNL

6.3.3 Containment of Short-Term Emissions – Specific (Intrusive) Noise Level

The specific (or intrusive) noise level (SNL) $L_{Aeq(1hour)}$ is determined as follows:

SNL $L_{Aeq(1hour)}$ = RBL + 3 (adjusted for tonality of impulsiveness)

The SNL is determined from the existing RBL (obtained from ambient attended and unattended noise monitoring).

In very rural areas (where minimum L_{A90} is lower than 25 dBA) it may be possible for the (L_{Aeq}) SNL to be calculated to a lower noise level than the recommended background creep level (L_{A90}) due to the 25 dBA threshold nominated for background creep in the Guideline. It is considered to be appropriate to set the SNL (L_{Aeq} level) higher than the background creep level (min L_{A90}), therefore background creep + 3dBA has been adopted for the SNL in these instances.

6.3.4 Sleep Disturbance

The Guideline recommends that in order to achieve a good night of sleep, internal noise levels should not exceed an L_{Amax} of 45 dBA more than 10 to 15 times per night.

Based on a conservative attenuation of 5 dBA through a façade with open windows, the recommended external sleep disturbance criterion (assessable four metres from the facade and during the night-time period only) is an $L_{Amax(external)}$ of 50 dBA.

6.3.5 Low Frequency Noise Criteria

Low frequency noise spans the frequency range from approximately 20 Hz to 200 Hz. Low frequency noise from the operational LNG facility and compressor stations will be assessable in accordance with the EPA's *EcoAccess Guideline: Assessment of Low Frequency Noise*. The intent of these criteria is to accurately assess annoyance and discomfort to persons at noise sensitive places.

The EcoAccess's low frequency noise assessment procedure involves the following:

- Initial Screening
  - Sound pressure levels inside residences should not exceed 50 dB(Linear).
  - If the difference between the overall L_{LINeq}[1] value and the overall L_{Aeq} value is greater than 15 dB a 1/3rd octave band analysis should be performed.
- Audibility Assessment
  - Determine if $L_{LINeq} – L_{Aeq} > 15$ dB.
  - If it does, 1/3rd octave band data should be compared to the median hearing threshold (see Table 1 of the *EcoAccess Guideline: Assessment of Low Frequency Noise*).
- Annoyance due to Tonal Noise
  - If the sound pressure in a particular 1/3rd octave band is 5 dB or more above the levels in the two neighbouring bands, the noise is said to be tonal.
  - The acceptable criteria for tonal noise, limit values for exceedance of the threshold table values by the equivalent level of the tone/s are as follows:

Frequency band **Period**	**8 Hz to 63 Hz**	**80 Hz**	**100 Hz**	**> 100 Hz and < 200 Hz**
Day	5 dB	10 dB	15 dB	17 dB
Night	0 Db	5 dB	10 dB	12 dB

- Annoyance due to Non-tonal Noise
  - The A-weighted 1/3rd octave band data for indoors is summed to yield the A-weighted noise level in the frequency range 10 Hz to 160 Hz. The resulting level is called $L_{pA,LF}$.
  - The acceptable criteria for non-tonal noise, limit values of the $L_{pA,LF}$ are as follows:

Type of space	**$L_{pA,LF}$ (dBA)**
Dwelling, evening and night	20
Dwelling, day	25
Classroom, office etc	30
Rooms within commercial enterprises	35

The criteria above are for indoor noise levels, assuming a conservative attenuation of 3 dB in the low frequency range through a façade with open windows, the outdoor noise limits should be raised by 3 dB compared to the above.

6.3.6 Operational Noise Criteria Summary

An example of the methodology used to calculate the relevant operational noise criteria (in accordance with the Guideline) is shown in **Table 20** for assessment location Plant 1.

[1] L_{LINeq} is defined in the *EcoAccess Guideline: Assessment of Low Frequency Noise* as '*the value of the unweighted sound pressure level of a continuous steady sound that within a specified time interval, T, has the same mean-square sound pressure as a sound under consideration whose level varies with time'* (time interval is 10 minutes).

Table 20 Noise Criterion as per EcoAccess Noise Guideline 'Planning for Noise Control' – Plant 1

Description (EcoAccess Reference)	Day	Evening	Night
	7.00am to 6.00pm	6.00 pm to 10.00 pm	10.00 pm to 7.00 am
Measured RBL (L_{A90})	41	41	41
Recommended RBL (L_{A90}) (Table 16)	45	40	35
Difference (Table 17)	45 - 41 = 4	40 - 41 = -1	35 – 41 = -6
Adjustments to Background Level (Table 17)	Recommended - 2	Measured - 10	Measured – 10
Background Creep Criterion (L_{A90})	**43 dBA**	**31 dBA**	**31 dBA**
Existing $L_{Aeq(1hour)}$	61 dBA	58 dBA	54 dBA
PNL Cat Z4 (Table 18)	60 dBA	55 dBA	50 dBA
Difference (Table 19)	60 - 61 = -1	55 - 58 = -3	50 - 54 = -4
Adjustment to PNL	-9	-10	-10
Maximum PNL $L_{Aeq(1hour)}$ (Table 19)	60 - 9 = **PNL 51**	58 - 10 = **PNL 48**	54 - 10 = **PNL 44**
Specific Noise Level (SNL) (Equation 1)	41 + 3 = 44 **44 dBA $L_{Aeq(1hour)}$**	41 + 3 = 44 **44 dBA $L_{Aeq(1hour)}$**	41 + 3 = 44 **44 dBA $L_{Aeq(1hour)}$**

The relevant operational noise criteria for the Project have been calculated for residences surrounding the Project area. This is shown in **Table 21**.

The noise criteria associated with the operational phase of the project at each assessment location are summarised in **Table 21**. These assessment locations are representative of the nearest potentially affected receptors to noise emissions from the project. The location of the assessment locations are shown in **Appendix B**.

Table 21 Project Operational Noise Criteria

Noise Assessment Location	Background Noise Creep Criteria	Design Criteria[1]	Sleep disturbance[2]	Low Frequency Criteria[2]
	$L_{A90(1hour)}$ (dBA)	$L_{Aeq(1hour)}$ (dBA)	L_{Amax} (dBA)	$L_{pA,LF}$ (dBA)
Day				
Plant 1	43	44	N/A	28
Plant 2	38	36	N/A	28
Plant 3	42	45	N/A	28
Plant 4	43	44	N/A	28
Plant 5	33	34	N/A	28
Plant 6	35	48	N/A	28
Plant 7 [3]	40	53	N/A	28
Gas & Pipeline 1	37	40	N/A	28
Gas & Pipeline 2	28	28	N/A	28
Gas & Pipeline 3	29	28	N/A	28
Gas & Pipeline 4	32	30	N/A	28
Gas & Pipeline 5	26	28	N/A	28
Gas & Pipeline 6	26	28	N/A	28
Gas & Pipeline 7	34	32	N/A	28

Noise Assessment Location	Background Noise Creep Criteria	Design Criteria[1]	Sleep disturbance[2]	Low Frequency Criteria[2]
	LA90(1hour) (dBA)	LAeq(1hour) (dBA)	LAmax (dBA)	LpA,LF (dBA)
Gas & Pipeline 8	34	32	N/A	28
Gas & Pipeline 9	33	33	N/A	28
Evening				
Plant 1	31	44	N/A	23
Plant 2	32	35	N/A	23
Plant 3	32	45	N/A	23
Plant 4	30	43	N/A	23
Plant 5	25	34	N/A	23
Plant 6	32	45	N/A	23
Plant 7 [3]	35	48	N/A	23
Gas & Pipeline 1	25	37	N/A	23
Gas & Pipeline 2	25	28	N/A	23
Gas & Pipeline 3	25	28	N/A	23
Gas & Pipeline 4	25	28	N/A	23
Gas & Pipeline 5	25	28	N/A	23
Gas & Pipeline 6	25	28	N/A	23
Gas & Pipeline 7	27	30	N/A	23
Gas & Pipeline 8	26	28	N/A	23
Gas & Pipeline 9	25	32	N/A	23
Night				
Plant 1	31	44	50	23
Plant 2	25	34	50	23
Plant 3	27	40	50	23
Plant 4	27	40	50	23
Plant 5	25	36	50	23
Plant 6	28	41	50	23
Plant 7 [3]	30	43	50	23
Gas & Pipeline 1	25	31	50	23
Gas & Pipeline 2	25	28	50	23
Gas & Pipeline 3	25	28	50	23
Gas & Pipeline 4	25	28	50	23
Gas & Pipeline 5	25	28	50	23
Gas & Pipeline 6	25	28	50	23
Gas & Pipeline 7	25	30	50	23
Gas & Pipeline 8	25	28	50	23
Gas & Pipeline 9	25	32	50	23

Note 1: Design criterion is the most stringent of the PNL and SNL as per Sections **6.3.2** and **6.3.3**.

2: Sleep disturbance and low frequency criteria have been adjusted to represent outdoor levels.

3: Noise criteria are based on typical background noise levels for an "Industrial Area' as shown in Queensland's Environmental Protection Agency's (EPA) *Ecoaccess Guideline: Planning for Noise Control* 'Recommended Outdoor Planning Noise Levels' **Table 16**.

6.4 Road Traffic Noise Criteria

Road traffic noise criteria applicable to the project are contained in two documents, Queensland's *Environmental Protection (Noise) Policy 1997*[2] and *Road Traffic Noise Management: Code of Practice (Queensland Main Roads, January 2000)*.[3]

The EPP[Noise] is applicable to all public roads whilst the Code of Practice is only applicable to the state-controlled road network.

Unless it is specifically stated, it may be assumed that all road traffic noise levels quoted in this report apply to a position one metre in front of the most exposed facade of a noise sensitive building and therefore include the appropriate facade correction (+2.5 dBA).

Environmental Protection (Noise) Policy 1997

For noise from activities described as "beneficial assets" (particularly roads, railways and airports), the EPP[Noise] specifies "planning levels" for noise sensitive locations (eg residences, educational and health care facilities) which "may be used as a guide'' when assessing the noise levels from an activity.

The planning levels for a Public Road are:

- For a State-controlled road - 68 dBA $L_{A10(18hour)}$;
- For all other public roads - 63 dBA $L_{A10(18hour)}$;
- 60 dBA, assessed as the highest 1 hour equivalent continuous A-weighted sound pressure level between 10 pm and 6 am (60 dBA $L_{Aeq(1hour)}$); and
- 80 dBA assessed as a single event maximum sound pressure level (80 dBA L_{Amax}).

Main Roads – Road Traffic Noise Management: Code of Practice

The Main Roads document *Road Traffic Noise Management: Code of Practice,* provides details for the assessment of road traffic noise from state-controlled roads. Different criteria and priorities apply depending on the road type (new or existing, access/non-access controlled roads) and to receiver/land usage type (residential, educational and health, or parks and other recreational facilities).

For this project, the proposed road connecting the bridge to Landing Road would be regarded as a new road.

For existing residential sites adjacent to a new road, the Code of Practice noise objective is 63 dBA $L_{A10(18hour)}$ within a 10 year post-construction period.

For existing residential sites adjacent to and existing or upgraded road, the Code of Practice noise objective is 68 dBA $L_{A10(18hour)}$ within a 10 year post-construction period.

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2 *Referred to within this report as EPP[Noise]*

3 *Referred to within this report as Code of Practice*

Incremental Change in Road Traffic Noise Levels

Where the LNG Project is adding vehicles to an existing or upgraded road it is appropriate to consider the incremental change in noise levels due to the changes in traffic volume.

A change of up to 3 dBA in the level of a dynamic noise, such as passing vehicles is difficult for most people to detect, whilst a 3 dBA to 5 dBA change corresponds to a small but noticeable change in loudness. A 10 dBA change corresponds to an approximate doubling or halving in loudness.

It is acknowledged that people will probably notice increased traffic based on visual clues and perception of vehicle pass-by frequency before they will objectively notice an increase in the average noise level.

For assessment purposes it is common to set the threshold of significance in relation to changes in the noise emission level from roads at 2 dBA.

Summary of Road Traffic Noise Criteria

The road traffic noise criteria for the project are summarised in **Table 22**.

Table 22 Summary of Road Traffic Noise Criteria

Road Type		Criteria
State	Existing Road	68 dB $L_{A10(18hour)}$ and ≤ 2 dBA change in existing $L_{A10(18hour)}$
	New Road	63 dB $L_{A10(18hour)}$
Other public road	Existing Road	63 dB $L_{A10(18hour)}$ and ≤ 2 dBA change in existing $L_{A10(18hour)}$
	New Road	63 dB $L_{A10(18hour)}$

6.5 Rail Traffic Noise Criteria

Rail traffic noise criteria applicable to the project are:

- 87 dBA L_{Amax}
- 65 dBA $L_{Aeq\ (24hours)}$

These are in accordance with the noise planning levels stipulated in both QR's Code of Practice for Railway Noise Management ("the Code") and EPP(Noise) 1997. The Code was first endorsed for use by the Minister for the Environment in 1999. Following the required review, the Minister for Sustainability, Climate Change and Innovation re-endorsed the use of Version 2 of the Code in December 2007.

Unless it is specifically stated, it may be assumed that all rail traffic noise levels quoted in this report apply to a position one metre in front of the most exposed facade of a noise sensitive building and therefore include the appropriate facade correction (+3 dBA) for rail noise.

7 MODELLING METHODOLOGY

7.1 SoundPLAN

In order to calculate the noise emission levels at the various noise sensitive receiver locations from construction and operational plant and equipment associated with the project, a SoundPLAN (Version 6.4) environmental computer model was developed. SoundPLAN is a software package which enables compilation of a sophisticated computer model comprising a digitised ground map (containing ground contours), the location and acoustic sound power levels of potentially critical noise sources on site and the location of receivers for assessment purposes.

The computer model can generate noise emission levels taking into account such factors as the source sound power levels and locations, distance attenuation, ground absorption, air absorption and shielding attenuation, as well as meteorological conditions, including wind effects.

7.1.1 LNG Facility

URS supplied ground topography for the Gladstone area in 3-D electronic format. This information was incorporated into the LNG facility noise model. LNG facility layout designs and respective jetty designs have been supplied by URS as 2D drawings.

Gladstone harbour and surrounding rivers/estuaries have been modelled as a reflective (hard) surface; all other areas of the model have been modelled as absorptive (soft) surfaces.

Noise level predictions have been undertaken at numerous sensitive receivers (approximately 50) in the surrounding community of Gladstone, these have been grouped based on their location within regards to the ambient noise monitoring (each group is referred to as an assessment location). Each of these prediction locations within each group are assessed against the same construction/operational criteria based on the results of the monitoring. Only the prediction location within each group with the highest predicted noise level is reported. All receivers have been positioned 1.5 m above ground and a minimum of 4 m from the nearest building facade (ie free field).

7.1.2 Gas Transmission Pipeline and CSG Field

Due to the large spatial area of the gas transmission pipeline alignment and CSG fields study area, predictions have been carried out at various off-set distances from construction and operational activities conducted in these areas to determine the distances at which the appropriate noise criteria would be achieved. Noise predictions for activities associated with the proposed gas transmission pipeline and CSG field are based on the assumption that there is flat, soft ground between the noise source and the receiver. A discussion on the effects of meteorological conditions, topography and vegetation on noise propagation is included in **Section 8.3.1**.

7.2 CONCAWE

All noise predictions for this project have been carried out utilising the CONCAWE prediction methodology within SoundPLAN, with the exception of road traffic noise predictions (which have been carried out using the CoRTN prediction method).

The CONCAWE prediction method is specially designed for large facilities and incorporates the influence of wind effects and the stability of the atmosphere.

The statistical accuracy of environmental noise predictions using CONCAWE was investigated by Marsh (Applied Acoustics 15 - 1982). Marsh concluded that CONCAWE was accurate to ±2 dBA in any one octave band between 63 Hz and 4 kHz and ± 1 dBA overall.

Noise levels have been calculated for both neutral and "worst case" weather conditions where appropriate. The "worst case" weather conditions used to assess the effect of adverse meteorological conditions on noise propagation is shown in **Table 23** below. These parameters are considered typical of neutral and "worst case" weather in regards to noise propagation.

Table 23 Weather Conditions – Neutral and "Worst Case"

Parameter	Neutral Weather	"Worst Case" Weather
Temperature	10°C	10°C
Humidity	70%	90%
Pasquill Stability Category	D	F
Wind Speed	0 m/s	2 m/s (source to receiver)

7.3 CoRTN Road Traffic Noise Prediction Method

The Calculation of Road Traffic Noise (CoRTN) 1988 prediction technique was utilised to calculate the road traffic noise levels from the project (and the change in road traffic noise levels).

These calculations account for traffic volumes, composition, vehicle speed and road surface. CoRTN is the recommended road traffic noise prediction technique in Main Roads Code of Practice.

The assessment methodology for transportation contributable from the LNG facility, gas transmission pipeline and CSG fields has been performed by calculating how traffic changes would alter the $L_{A10(18hour)}$ level of noise emission from roadways using the CoRTN prediction algorithms. The $L_{A10(18hour)}$ parameter is the average of the hourly L_{A10} traffic noise level between the hours of 6 am and midnight.

Road traffic noise impacts associated with the construction and operational phases of the project are discussed in **Section 8.3**

7.4 Nordic Rail Traffic Noise Prediction Method

The Nordic Rail Traffic Noise Prediction Method (Kilde 130) dates from 1984 and is commonly utilised for QR rail noise assessments. It calculates noise emission noise level based on the number of trains, speed, and length and predicts the $L_{Aeq(24hour)}$ and L_{Amax} parameters as required by the QR Code of Practice.

The assessment methodology for rail traffic noise associated with the construction phase of the gas transmission pipeline has been performed by calculating how rail traffic changes would alter the L_{Amax} and $L_{Aeq(24hour)}$ level of noise emission from the Moura Rail line using the Nordic Rail Traffic Noise Prediction Method (Kilde 130) prediction algorithms.

Rail traffic noise impacts associated with the construction phase of the project are discussed in **Section 8.4**.

7.5 Construction Noise and Vibration

The assessment methodology for determining noise and vibration impacts associated with the construction phase of the Project is discussed in the following sections (**Sections 7.5.1** to **7.5.3**). Assessments of the following construction noise and vibration sources are discussed:

- LNG Facility
  - General facility construction.
  - Pile driving and jetty construction.

    - Dredging.
    - Bridge construction.
    - Gas transmission pipeline crossing at The Narrows (adjacent to the proposed bridge).
- Gas Transmission Pipeline
    - Gas transmission pipeline construction.
    - Rail Laydown Areas.
    - Blasting.
- CSG Fields
    - Gas well construction (including drilling).
    - Compressor site construction.

Blasting is only potentially required during the construction phase of the gas transmission pipeline.

Road traffic noise impacts associated with the construction phase of the project are discussed in **Section 8.3**

7.5.1 LNG Facility

Construction Noise

Significant construction noise sources typically include blasting (if required), pile driving, rock breaking and drilling and mobile equipment (air compressors, cranes and service trucks).

A list of the proposed construction equipment to be used and their associated L_{Amax} sound power level (sourced from Heggies' database) is presented in **Table 24**.

Table 24 LNG Facility Construction Equipment Sound Power Levels (SWL)

Item	Maximum SWL (dBA)
14g Grader	110
150t Crane	111
Asphalt delivery truck	103
Asphalt Paver	114
Backhoe	107
Barge with 250t Crane	113
Bobcat	106
Bored Piling Rig	118
Compressor (approx 600 CFM)	105
Concrete batch plant	111
Concrete pump and vibrator	112
Concrete truck	103
D8 Dozer	118
Directional Drilling Rig	115
Dredge – Large Cutter Suction (CSD)	121
Dredge – Large Trailer Suction Hopper (TSHD)	115
Dredge Pump	118
Excavator – 30t	110

Item	Maximum SWL (dBA)
Excavator – 50t	117
Front end loader (FEL)	110
Generator	107
Haul Truck	113
Haul Truck (80t)	117
High pressure blow-out noise (testing of pipelines)	147
Pile Driver	130
Pump	100
Rock Breaker	120
Roller – Vibratory	110
Scraper – Cat 621G	120
Water cart	107
Weld Rig	103

While noise from diesel-powered mobile plant (ie dozers and excavators etc) will generally form a major part of the emission over the construction phase of the project, the highest noise levels are expected to occur where construction requires the use of pile driving, rock drilling or rock breaking equipment. Also in the finishing stages of the LNG facility, there will be high pressure testing of the pipelines that will cause blow-out noise similar to that of flare noise. These processes are associated with the highest construction noise impacts.

Predicted construction noise levels will inevitably depend upon the number of plant items and equipment operating at any one time and on their precise location relative to the receiver(s). Therefore a receiver will experience a range of values representing "minimum" and "maximum" construction noise emissions depending upon:

- The location of the particular construction activity (ie if the plant item of interest were as close as possible to or further away from the receiver of interest); and
- The likelihood of the various items of equipment operating simultaneously.

General LNG Facility Construction, Pile Driving and Jetty Construction

Six (6) representative construction noise modelling scenarios have been assessed for general LNG facility construction, pile driving and jetty construction activities based upon information provided by URS. These construction scenarios are described in **Table 25** and are considered to best reflect the proposed methodologies for construction of the proposed LNG facility including the facility and jetty.

Table 25 LNG Facility General, Pile Driving and Jetty Construction Scenarios and Typical Plant Items

Stage	Description	Typical Plant Items
Clear and grade	Clearing of vegetation and topsoil; levelling ground around the site	Dozers Scrapers Excavators Haul trucks Compacters

Stage	Description	Typical Plant Items
Concrete pad, asphalt paving and foundations	Concrete batch-plant; pouring concrete and asphalt surface;	Concrete batch plant Concrete trucks and pumps Asphalt pavers Rollers
Erecting of process trains and decking	Building the deck and installing process train equipment.	Crane Generators Welding rig Trucks Erecting steel frame
Construction of storage tank	Building the foundation and storage tanks and installing LNG storage equipment	Crane Concrete trucks and pumps Welding rig
Piling and Jetty	Pile driving and building the jetty	Piling rig Barge and crane
High Pressure Testing of Pipelines	Pressurising pipelines and releasing high pressure air-jet	High pressure jet noise

Dredging

Marine dredging is commonly conducted in coastal waters to deepen channels and harbours, reclaim land, and mine seabed resources. Dredges can be strong sources of continuous noise with both broadband and tonal characteristics. The highest levels usually occur during loading. Reported source levels for dredging operations range from 160 dB to 180dB @ 1 m with the peak noise intensity between 50Hz and 500Hz (Greene and Moore, 1995). Received levels of dredging noise can exceed ambient levels out to considerable distances.

The LNG facility will require a channel to be dredged allowing LNG ships to access the loading jetty from the existing Targinie Channel. It is assumed this channel will be dredged using Trailer Suction Hopper Dredges (TSHD).

Swing basins have also been proposed adjacent to the loading jetty to allow the LNG ships to be moved into place by tug-boats. It is assumed that the swing basin will be dredged using Cutter Suction Dredges (CSD).

It is also assumed that dredge spoils will be transported or pumped to a land reclamation area to be used for future land development. Heggies has undertaken a noise assessment of the proposed dredge disposal site at Laird Point. The findings of this report show compliance with all applicable noise criteria. For further details, see Heggies letter report (20-2014 URS Dredging Disposal 20090123 L1-R1) dated 28 January 2009.

A dredged trench is the proposed method for the gas transmission pipeline crossing at The Narrows. This trench will be in a similar location to the bridge. Both the TSHD and CSD have been assessed for the gas transmission pipeline crossing and are discussed below.

Sound power levels for TSHD, CSD and dredge pumps are shown in **Table 24**.

Bridge Construction

At the time of reporting, the bridge construction and alignment was still in the preliminary design phase. The following bridge construction assessment is based on previous work Heggies has undertaken. The construction scenarios and plant items shown in **Table 26** are expected to be typical of bridge construction works implemented at the Narrows.

Table 26 Bridge Construction Scenarios and Typical Plant Items

Stage	Description	Typical Plant Items
Clear and grade	Clearing of vegetation and topsoil at the approaches to the bridge; levelling ground around the site	Excavators Dozers Haul trucks Grader Rock Breaker Water Truck Vibratory Roller
Piling Works	Piling of pillars to form foundation of new bridge	Impact Piling Rig Barge & 150t Crane Excavator
Finishing Works	Construction of the bridge excluding piling	Concrete Truck Excavator Water Truck Crane Compressor
Asphalt Surfacing	Surfacing works on the bridge and approaching roads	Generator Asphalt Paver Asphalt Delivery Truck Bobcat

Estimated sound power levels for those plant items listed in **Table 26** are as specified in **Table 24**.

Gas Transmission Pipeline Crossing (The Narrows)

As stated previously, it has been proposed that the gas transmission pipeline will cross The Narrows via a dredged trench. The gas transmission pipeline will then be lowered into the trench and held in place via rocks and other material. The construction scenarios and plant items expected for these activities are shown in **Table 27**.

Table 27 Gas Transmission Pipeline Crossing Construction Scenarios and Typical Plant Items

Stage	Description	Typical Plant Items
Dredging of the pipeline trench	A trench is to be dredged for the pipeline	CSD or TSHD Dredge Pump
Joining and lowering pipeline	Joining pipeline lengths and lowering into dredged trench	Barge & crane Weld rig Generators
Covering trench	Covering the trench to protect pipeline	Barge & crane

Estimated sound power levels for those plant items listed in **Table 27** are as specified in **Table 24**.

Construction Vibration

The following potential sources of ground vibration have been identified for the construction phase of the LNG facility:

Pile Driving

Based on the current proposed construction methodology, it is anticipated that the primary source of potential ground vibration is likely to be from pile driving associated with jetty bridge construction. The typical levels of ground vibration from pile driving range from 1 mm/s to 3 mm/s at distances of 25 m to 50 m, depending on the ground conditions and the energy of the driving hammer. Recent measured vibration levels (September 2006) from pile driving at the RG Tanna Coal Terminal Berth 4 expansion for a 14 tonne hammer driving a 1200 mm pile of 600 mm wall thickness showed that vibration levels at a distance of 380 m from the piling site were not measurable (only ambient vibration levels were measured, at less than 0.1 mm/s Peak Particle Velocity).

Truck Traffic

Heavy trucks passing over normal (smooth) road surfaces generate relatively low vibration levels, typically ranging from 0.01 mm/s to 0.2 mm/s at the footings of buildings located 10 m to 20 m from a roadway. Very large surface irregularities can cause levels up to 5 to 10 times higher.

7.5.2 Gas Transmission Pipeline

Construction Noise

Construction equipment to be used during the gas transmission pipeline construction phase (see **Table 28**) and the relevant construction staging scenarios (see **Table 29**) are discussed in the following sections. Construction sound power levels and relevant construction staging scenarios have been used to predict the acoustic footprint of gas transmission pipeline construction activities along the proposed alignment.

Predicted construction noise levels will inevitably depend upon the number of plant items and equipment operating at any one time and on their precise location relative to the receiver(s). Therefore a receiver will experience a range of values representing “minimum” and “maximum” construction noise emissions depending upon:

- The location of the particular construction activity (ie if the plant item of interest were as close as possible to or further away from the receiver of interest); and
- The likelihood of the various items of equipment operating simultaneously.

Due to the large spatial area which the gas transmission pipeline will cover, the noise assessment methodology has been based on predicting noise levels at various off-set distances, assuming propagation over flat, soft ground (ie open grassland) to a typical receiver. The predicted construction noise levels are correct for “neutral” meteorological conditions.

Construction Equipment Noise Sources

The sound power levels shown in **Table 28** are maximum noise emission levels of plant that would be used for gas transmission pipeline construction.

Table 28 Gas Transmission Pipeline Construction Equipment Sound Power Levels (SWL)

Plant Item	LAmax Sound Power Level (dBA)
14G Grader	110
4WD	102
Air Drill	118
Backhoe	108
Boring machine	111
Compressor (approx 600 CFM)	105
Concrete truck	112
D8 Bulldozer	118
Dump truck (approx 15 tonne)	108
Excavator – 30t	110
Front end loader (FEL)	110
Generator	104
Grit Blaster	111
Hand Tools	98
Haul Truck	113
Mulcher	113
Ozzie Padder	118
Pump	100
Reversing Alarm	110
Sideboom tractor	110
Tractor	110
Trencher – Chain	118
Trencher – Wheel	118
Weld Rig	103

Gas Transmission Pipeline Construction Staging and Typical Plant Items

Construction works for the gas transmission pipeline would be carried out in accordance with the requirements of *AS 2885 Pipelines – Gas and Liquid Petroleum* and the Australian Pipeline Industry Association *Code of the Environmental Practice (2005)*. **Table 29** below summarises the proposed construction staging and typical plant items for gas transmission pipeline construction works.

Table 29 Gas Transmission Pipeline Construction Staging and Typical Plant Items

Stage	Description	Typical Plant Items
Survey and Fencing	Erecting construction fences and gates	Trucks
		Tractors
		4WD

Stage	Description	Typical Plant Items
Clear and grade	Graders, bulldozers and rakes are utilised for clearing. Top soil and vegetation are stockpiled for later reuse.	Grader
		Dozer
		Front End Loader (FEL)
		Mulcher
		Trucks
		4WD
Blasting - preparation	In areas with large amounts of rock, blasting may be required.	Drill rigs
		4WD
Blasting	Blasting of Rock	-
Trenching, Stringing and lowering in	Trenches for the pipeline are dug. Steel pipe is laid end to end in the prepared trenches. If required, pipe sections are bent to match changes in the alignment of the pipeline. Side booms are utilised to lower the pipe into the trench.	Excavator
		Chain or wheel trencher
		Sideboom (on tractors/dozers)
		generator/electric pump
		4WD
Welding and joint coating	Pipe sections are welded together.	Sideboom (on tractors/dozers)
		Weld rig
		4WD
		Grit/sand blasting
X-raying and pressure testing	The welds are inspected using x-ray detectors and pressure testing is undertaken.	Excavator
		Weld rig
		4WD
		Air compressors
Padding and backfilling	Padding machines are used to sift the excavated material. The fine material is used to pad beneath the pipe and to fill the trench.	Padders
		Trucks
		Excavator
		4WD
		FEL
		Dozers
		Graders
Tie-ins, push sections and road crossings	These activities are required where tie to existing infrastructure is required or the route crosses existing infrastructure such as a road.	Dozer
		Excavator
		Weld rig
		4WD
		Boring machine or HDD
Restoration and rehabilitation	This phase may include contouring and revegetation of the work area.	4WD
		Excavator
		Dozer
		FEL
		Grader
		Truck

Rail Laydown Areas

The railway traffic and activities associated with the laydown / storage areas of the pipe joints for the gas transmission pipeline are planned to only operate during daytime. There is however risk that operations will be carried out on Sundays or Public holidays, therefore the construction noise criteria outside "normal" working hours as per **Section 6.2.1** may be applicable.

A list of typical noise sources for rail yard and laydown areas are presented in **Table 30**.

Table 30 Summary of Typical Maximum Sound Power Levels for Pipe Laydown Areas next to the Railway

Equipment	Typical LAmax Sound Power Level (dBA)
Crane truck	105
Forklift	100
Loco Idling	99

Blasting

Blasting will be required to form the trench in areas of igneous rock which is not separable by mechanical methods (such as with a chain/wheel trencher or an excavator).

Whilst Heggies has not been provided with details of the blast parameters and design, it is assumed drill and blast techniques incorporating confined blasting will be employed. Further more, Heggies has assumed typical blast parameters in order to conduct an assessment of typical blasting impacts. These blast parameters will be required to be reviewed to enable a further detailed assessment once a blast design is confirmed. The typical parameters assumed for this assessment are presented in **Table 31**.

Table 31 Typical Blast Design Parameters

Parameter	Free-Face
Bench height	4.2 m
Stemming (using 20 mm aggregate)	2.7 m
Blasthole diameter	102 mm
Blasthole spacing	3.0 m
Burden	3.0 m
Maximum Instantaneous Charge (MIC)	10, 25 and 50 kg

7.5.3 CSG Fields

Construction Noise

Construction equipment to be used during the CSG fields construction phase (eg for construction of gas wells and compressor sites, see **Table 32**) and the relevant construction staging scenarios (see **Table 33**) are discussed in the following sections. The construction sound power levels and relevant construction staging scenarios have been used to predict the acoustic footprint of construction activities throughout the CSG fields.

Predicted construction noise levels will inevitably depend upon the number of plant items and equipment operating at any one time and on their precise location relative to the receiver(s). Therefore a receiver will experience a range of values representing "minimum" and "maximum" construction noise emissions depending upon:

- The location of the particular construction activity (ie if the plant item of interest were as close as possible to or further away from the receiver of interest); and

- The likelihood of the various items of equipment operating simultaneously.

Due to the large spatial area which the CSG fields will cover, the noise assessment methodology has been based on predicting noise levels at various off-set distances, assuming propagation over flat, soft ground (ie open grassland) to a typical receiver. The predicted noise levels are correct for "neutral" meteorological conditions.

Construction Equipment Noise Sources

The sound power levels shown in **Table 32** are maximum noise emission levels of plant that would be used for construction activities in the CSG fields.

Table 32 CSG Fields Construction Equipment Sound Power Levels (SWL)

Plant Item	LAmax Sound Power Level (dBA)
4WD	102
D8 Dozer	118
Compactor (vibratory roller)	110
Completion Drill Rig[1]	116
Compressor (approx 600 CFM)	105
Concrete truck	112
Crane (mobile)	103
Drill Rig (Exploratory)	110
Excavator – 30t	110
Generator	104
Hand Tools	98
Haul Truck	113
Weld Rig	103

Note 1: Completion drill rig is based on measurements as per **Section 5.4.2** and comprises of a drill rig, generators, booster pumps and mud pump.

CSG Fields Construction Staging and Plant Items

Representative construction scenarios for gas wells and compressor sites have been assessed based upon information provided by URS. These construction scenarios are described in **Table 33** and **Table 34** (gas wells and compressor sites respectively) and are considered to be representative of the proposed construction staging for the gas wells and compressor sites.

Table 33 Gas Well Construction Staging and Typical Plant Items

Stage	Description	Typical Plant Items
Clear and grade	Clearing of vegetation and topsoil; levelling ground around the site and construction of earthen/flare pit; erecting fence.	Dozers Excavators 4WD (fencing)
Setup of temporary facilities	Transporting and erecting of temporary facilities.	Trucks (Drilling support vehicles) 4WD
Cellar and surface conductor pipe	Pouring concrete; pipe connections.	Concrete trucks and pumps Hand tools
Drilling	Initial well drilling.	Drill rig Generators

Stage	Description	Typical Plant Items
Casings and completions rig	Inserting steel pipe casings, back filling with concrete (between pipe and earth); completion of well.	Drill rig (completions rig) Generators Booster pumps
Wellhead valves	Installing wellhead valves (Christmas tree).	Drilling rig Hand tools

Table 34 Compressor Site Construction Staging and Typical Plant Items

Stage	Description	Typical Plant Items
Clear and grade	Clearing of vegetation and topsoil; levelling ground around the site	Dozers Excavators
Concrete pad and foundations	Pouring concrete pad for compressors and site facilities	Haul trucks Compactors
Set up of facilities	Erecting site office, fences	Crane (mobile) Weld Rig Hand tools
Construction of compressors and coolers	Installing compressors and coolers.	Weld Rig Hand tools

7.6 Operational Noise and Vibration

The methodologies for assessing noise and vibration impacts associated with the operational phase of the Project are discussed in the following sections (**Sections 7.6.1** to **7.5.4**). Assessment of the following operational noise and vibration sources are discussed:

- LNG Facility
  - Operational Noise Emission – Optimized Cascade (OCP) Design.
  - Operational Noise Emission – C3MR Design.
  - Operational Noise Emission – Flares.
  - Operational Noise Emission – Shipping (LNG Ship Movements).
- Gas Transmission Pipeline
  - Operational Noise Emission – Mainline valves.
- CSG Fields
  - Operational Noise Emission – Gas wells and compressor sites.

All operational noise emissions have been assessed against the applicable background noise creep noise guideline (as they are continuous steady state noise sources), with the exception of noise from ship movements and mainline valves which have been assessed against the sort term intrusive noise criteria (as they are more transient noise sources).

Road traffic noise impacts associated with the operational phase of the project are discussed in **Section 8.3**

7.6.1 LNG Facility

Two competitive LNG liquefaction process designs have been proposed for the GLNG project, including:

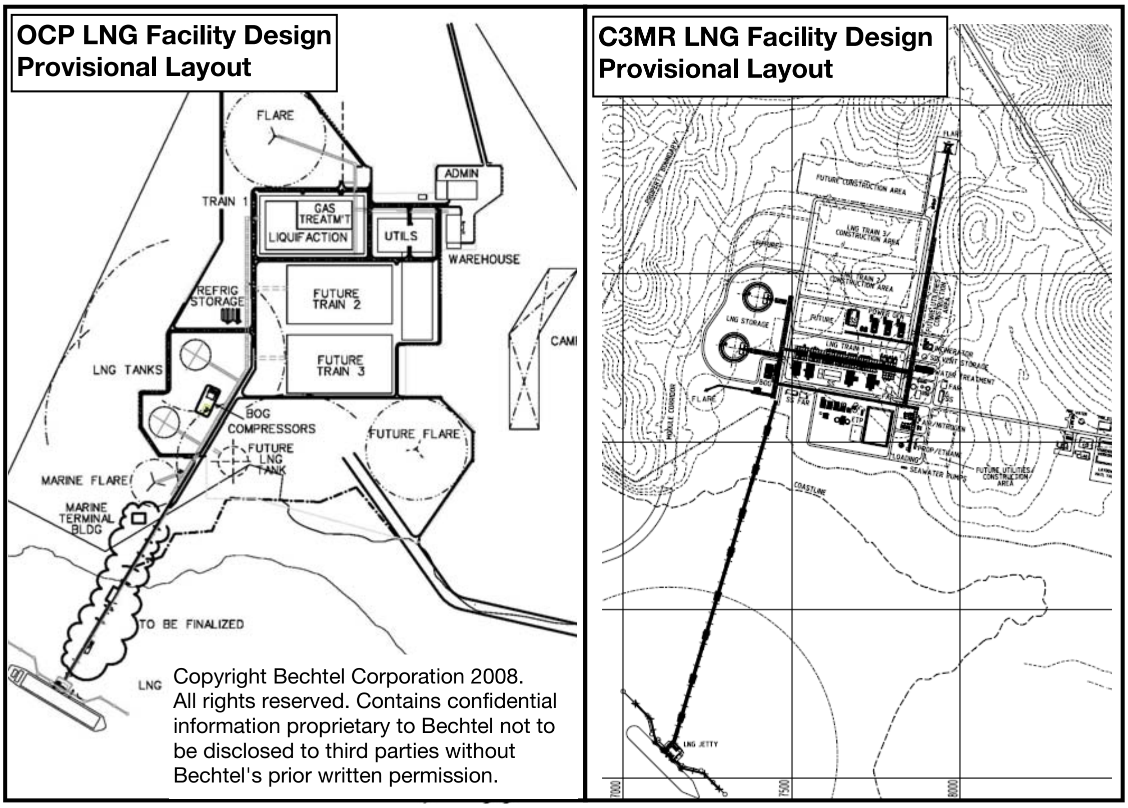
- Optimized Cascade LNG Process – refer throughout as OCP.

- Propane Pre-cooled Mixed Refrigerant process - refer throughout as C3MR.

These two (2) LNG liquefaction processes are previously described in **Section 2.1**.

Noise level emissions from the Gladstone LNG facility have been estimated based upon data provided by URS and Santos. Where necessary this data was supplemented with data obtained through other sources (ie literature searches, manufacturers data and Heggies noise source database). The following sections present the major noise sources associated with the operation of the respective process plants for both the OCP and C3MR designs. The two (2) LNG facility design layouts are shown in **Figure 3**.

Figure 3 OCP and C3MR LNG Facility Design Layouts



Note: Figures for presentation only.

It is noted that the LNG facility site will be cleared and graded to a level of RL16.5m AHD.

The LGN facility designs assessed in this report are based on the design layout shown in the following drawings:

- OCP – *'Santos GLNG - Overall Site Plan'* Drawing No. 1603-50-5001-PDF, Rev B, dated 26 June 2008.
- C3MR – *'Santos – Gladstone LNG Pre-FEED Study – Overall Site Plan'* Drawing No. 3591-8230-01-0002, Rev 01, dated 27 June 2008.

It is noted that the design layout of the LNG facility has since changed from the time of this assessment, however, it is not expected to significantly impact the results of this report.

OCP LNG Facility Design

URS and Santos have provided a list of the major noise sources associated with their LNG facility design, including source heights and sound power levels presented in Pre-FEED Studies (2008). The major noise sources (per process train) for the OCP LNG facility design and used in the noise modelling for the OCP LNG facility are specified in **Table 35** below. It is noted that the fully operational OCP LNG facility will include three (3) process trains. **Table 36** summarises the sound power levels in octave bands for the major groups of noise generating plant**.**

Table 35 Major Noise Sources (per Process Train), OCP LNG Facility

Equipment	SWL for Group of Sources (dBA)
Coolers	119
Combustion Turbines	118
Compressors	113
Piping	130
Misc. Equipment	117
Gas Turbine Generators	119
Total SWL	**131**

Table 36 Sound Power Levels in Octave Bands for the Major Noise Sources (per Process Train), OCP LNG Facility

Equipment Group	dBA	Sound Power Level (dBA) Octave Band Centre Frequency (Hz)								
		31.5	63	125	250	500	1k	2k	4k	8k
Coolers	119	83	98	108	111	114	114	107	103	97
Combustion Turbines	118	94	109	111	111	114	106	106	101	98
Compressors	113	75	81	93	101	107	107	108	104	95
Piping	130	101	111	117	120	123	123	122	122	120
Misc. Equipment	117	67	81	92	102	107	113	112	107	99
Gas Turbine Generators	119	81	87	99	107	113	113	114	110	101

The sound power levels defined in **Table 36** were included in the SoundPLAN noise model developed for the OCP LNG facility designs. The octave band information in **Table 36** has been determined from the following sources:

- **Coolers** – The coolers are assumed to be dominated by the air-cooled heat exchangers at the top of the deck. Octave band data obtained for a Hudson fin-fan with a fan diameter 4.3 m has been used and adjusted (raised) to achieve the overall sound power level for all fans whilst maintaining the appropriate spectral shape (octave band relation).
- **Combustion turbine** – the combustion turbine exhaust is assumed to have similar spectral content to that of the Solar Taurus 60. Octave band data has been obtained for a silenced combustion exhaust from Solar Turbines Incorporated. The octave band values have been adjusted (raised) to achieve the overall sound power level for all six turbines whilst maintaining the appropriate spectral shape.
- **Compressor –** It is not clear which types of compressors are to be used, the LM 2500+ is mentioned however no octave band data is available. It has been assumed that the spectral content of the compressors (without extra acoustic enclosures) is similar to the Solar Taurus 60. The octave band data for the Solar Taurus 60 has been adjusted (raised) to achieve the overall sound power level for all compressors whilst maintaining the appropriate spectral shape.

- **Piping** – The octave band data used for the piping within each process train has been obtained from measurement data presented by URS (2002). An alternative (with extra acoustic treatment for compressor noise in the piping) is also nominated to enable a 15 dBA reduction in the total sound power radiating from the piping.
- **Miscellaneous equipment** – The miscellaneous equipment is dominated by noise from pumps, especially the Lean Solvent Charge Pump. The octave band data for pumps presented in Bies and Hansen (1996) has been used in this assessment.
- **Gas turbine generators** – The Solar Taurus 60 gas turbine generators are proposed to be used for the OCP LNG facility. The octave band data for the Solar Taurus 60 has been adjusted (raised) to achieve the overall sound power level for the five gas turbine generators whilst maintaining the appropriate spectral shape.

Other major noise sources, not associated with the process trains, are defined in **Table 37** for the OCP LNG facility design.

Table 37 Major Noise Sources not Associated with the Process Trains, OCP LNG Facility

Equipment	SWL for Group of Source (dBA)
Compressors	117
Water Pumps	106
Ship Loading	101

Table 38 summarises the sound power levels in octave bands for the major groups of noise generating plant identified in **Table 37** for the OCP LNG facility design.

Table 38 Sound Power Levels in Octave Bands for the Groups of Major Noise Sources not Associated with the Process Train, OCP LNG Facility

Equipment Group	dBA	Sound Power Level (dBA) Octave Band Centre Frequency (Hz)								
		31.5	63	125	250	500	1k	2k	4k	8k
Compressor	117	79	85	96	105	111	110	111	107	98
Pumps	106	56	70	81	91	96	102	101	96	88
Ship Loading	101	-	84	92	95	96	95	90	81	69

The sound power levels defined in **Table 38** were included in the SoundPLAN noise model developed for the OCP LNG facility designs. The octave band information in **Table 38** has been determined from the following sources:

- **Compressor** – It has been assumed that the spectral content of the compressor (without extra acoustic enclosure) is similar to that of the combustion turbines (with acoustic enclosure). The octave band data for the Solar Taurus 60 has been adjusted (raised) to achieve the overall sound power level for the compressors whilst maintaining the appropriate spectral shape.
- **Pumps** – The octave band data for pumps has been obtained from Bies and Hansen (1996).
- **Ship Loading** – Only auxiliary power generation is assumed during ship loading. The sound power level and octave band information has been gathered from Heggies' noise source database.

Both the OCP and C3MR LNG facility designs include a high pressure flare used to burn emergency hydrocarbon releases resulting from process upsets within the LNG facility or resulting from the unlikely event of emptying the gas transmission pipeline. Flares noise is regarded as an intermittent noise source. The methodology for the assessment of flare noise is discussed in the section following the description of the C3MR LNG facility design.

C3MR LNG Facility Design

URS and Santos has provided a list of the major noise generating equipment associated with the operational phase of the C3MR LNG facility (Foster Wheeler 2008). The major items of noise generating plant and equipment are:

- Air cooled exchangers
- Flare
- Pumps
- Compressors
- Generators

Incinerators and heaters have not been included in the above list of major noise generating plant and equipment as they are not expected to contribute significantly to the overall noise emission from the LNG facility.

URS and Santos has provided a list of major noise sources and their associated sound pressure levels for the C3MR LNG facility (refer Table 7 of Foster Wheeler 2008). Where noise data was not available in a suitable format for the C3MR LNG facility design, this information is supplemented with the equivalent noise source data supplied for the OCP LNG facility for noise modelling/prediction purposes.

The major noise sources (per process train) for the C3MR LNG facility design as provided by URS and Santos, and used in the noise modelling for the C3MR LNG facility are specified in **Table 39** below. It is noted that the fully operational C3MR LNG facility will include three (3) process trains. **Table 40** summarises the sound power levels in octave bands for the major groups of noise generating plant**.**

Table 39 Major Noise Sources per Process Train, C3MR LNG Facility

Equipment	SWL for Group of Sources (dBA)
Air cooled exchangers	116
Pumps	117
Combustion Turbines Exhausts	114
Compressors [1]	114
Generators [1]	116
Piping [2]	130
Total	**130**

Note 1: Noise data received by GE for acoustically enclosed Frame 5D.
2: Noise levels from piping have been assumed the same as the OCP LNG facility design.

Table 40 Sound Power Levels in Octave Bands for the Groups of Major Noise Sources per Process Train, C3MR LNG Facility

Equipment Group	dBA	Sound Power Level (dBA) Octave Band Centre Frequency (Hz)								
		31.5	63	125	250	500	1k	2k	4k	8k
Air cooled exchangers	116	80	95	105	109	111	111	104	100	94
Pumps	117	67	81	92	102	107	113	112	107	99
Combustion Turbines	114	90	105	107	107	110	102	102	97	94
Compressors	114	76	82	94	102	108	108	109	105	96
Generators	116	78	84	96	104	110	110	111	107	98
Piping	130	101	111	117	120	123	123	122	122	120

The sound power levels defined in **Table 40** were included in the SoundPLAN noise model developed for the C3MR LNG facility design. The octave band information in **Table 40** has been determined from the following sources:

- **Air-cooled exchangers –** For the air-cooled exchangers, octave band data has been obtained for a Hudson fin-fan. The C3MR LNG facility refers to the Hudson Product Corporation, with a fan diameter 4.3 m. The octave band values have been adjusted (raised) to achieve the overall sound power level for all fans whilst maintaining the appropriate spectral shape.
- **Pumps –** The octave band data for pumps has been obtained from Bies and Hansen (1996).
- **Combustion Turbines and Compressors –** For the turbines and compressors overall sound power levels were obtained for a GE Frame 5D. Octave band data for the GE Fame 5D was not available and therefore the same spectral content as for the Solar Taurus 60 combustion turbine has been used in the noise model.
- **Generators –** Overall sound power levels for generators were obtained for a GE Frame 5D. Octave band data for the GE Fame 5D was not available, therefore the same spectral content as for the Solar Taurus 60 combustion turbine has been used in the noise model.
- **Piping –** The sound power level and spectral content for piping has been obtained from the OCP LNG facility design as no data was supplied for the C3MR LNG facility for this noise source.

Other major noise sources, not associated with the process trains, are described in **Table 41**. **Table 42** summarises the sound power levels in octave bands for the groups of major noise sources not associated with the process trains as specified in **Table 41.**

Table 41 Major Noise Sources not Associated with the Process Train, C3MR LNG Facility

Equipment	SWL for Group of Source (dBA)
Compressors [1]	117
Water Pumps	106
Ship Loading	101

Note 1: Assumed same sound power level as given for the OCP LNG facility design.

Table 42 Sound Power Levels in Octave Bands for the Groups of Major Noise Sources not Associated with the Process Train, C3MR LNG Facility

Equipment Group	dBA	Sound Power Level (dBA) Octave Band Centre Frequency (Hz)								
		31.5	63	125	250	500	1k	2k	4k	8k
Compressor	117	79	85	96	105	111	110	111	107	98
Water Pumps	106	56	70	81	91	96	102	101	96	88
Ship Loading	101	-	84	92	95	96	95	90	81	69

The sound power levels defined in **Table 42** were included in the SoundPLAN noise model developed for the C3MR LNG facility design. The octave band information in **Table 42** has been determined from the following sources:

- **Compressor** – It has been assumed that the spectral content of the compressors (without extra acoustic enclosures) are similar to that of the combustion turbines (with acoustic enclosure). The octave band data for the Solar Taurus 60 combustion turbine has been adjusted (raised) to achieve the overall sound power level for the compressor whilst maintaining the appropriate spectral shape.
- **Pumps** – The octave band data for pumps has been obtained from Bies and Hansen (1996).
- **Ship Loading** – Only auxiliary power generation is assumed during ship loading. The sound power level and octave band information has been obtained from Heggies' noise source database.

LNG Facility Flare Noise

An accurate assessment of noise emission associated with LNG facility flare events requires sound power level and source height data. Foster Wheeler (2008) has provided sound pressure level data for a flare event as shown in **Table 43**.

Table 43 Sound Pressure Levels for the Flare Stack

Equipment	Total Qty	Sources height (m)	Sound Pressure Level (dB)
Flare Stack	1	80	100

The distance at which the sound pressure level was measured for the flare event in **Table 43** is not specified by Foster Wheeler (2008). However, if the stack height is 80 m and it is assumed that the measurement was performed on the ground and 90 m away from the bottom of the stack then the measurement distance to the top of the flare stack is 120 m.

A measured sound pressure level of 100 dB at 120 m from a flare stack burning a gas stream with heat release of 5x109 BTU/h (1465 million W) is presented in Baukal (2001). This is consistent with the noise emission data supplied by Foster Wheeler (2008) (for the assumption made regarding measurement distance). Baukal (2001) also gives measured octave band data for flare noise emission as presented in **Table 44**. The sound power level calculated from the data above and presented in **Table 44** has been used to assess the noise associated with an unmitigated flare event.

Table 44 Elevated Flare Maximum Sound Power Level

Equipment Group	dBA	Sound Power Level (dBA) Octave Band Centre Frequency (Hz)								
		31.5	**63**	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**
Elevated Flares	147	109	121	129	127	133	135	136	144	143

Shipping Noise (LNG Ship Movements)

The LNG tankers will enter and exit Port Curtis along the main shipping channel to and from the loading berth. The turnaround time for vessels is estimated to be 22 to 24 hours, of which ship loading will take approximately 14 hours. Four tugs have been assumed for the assistance during berthing and departure.

Initially, it is proposed that there will be approximately 40 to 50 ships per annum (when one process train is operational) although this is expected to increase to approximately 120 to 150 ships per annum when the LNG facility is at full capacity.

Sound power levels for the LNG tanker and four tugs during berthing and departure has been obtained from Heggies noise source database. The sound power levels in **Table 45** have been used to predict the $L_{Aeq(1hour)}$ at the applicable assessment locations in the vicinity of the main shipping channel.

Table 45 Sound Power Levels in Octave Bands for Ship Movement

Equipment Group	dBA	Sound Power Level (dBA) Octave Band Centre Frequency (Hz)							
		63	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**
LNG Tanker	111	121	118	113	109	105	99	90	80
Tugs (four in total)	117	127	124	119	115	111	105	96	86

7.6.2 Gas Transmission Pipeline

The normal operation of a gas transmission pipeline is silent along the right of way and will not generally involve significant noise impact. Once the gas transmission pipeline has been constructed and commissioned, there should not be any requirement for movement of large plant or equipment on the gas transmission pipeline corridor (except in an emergency) and noise levels along the easement will return to pre-existing levels.

Scraper stations and mainline valves (emergency blow out valves) will be located approximately every 75 km along the gas transmission pipeline. Heggies has been advised that there is no significant noise emission associated with the operation of the scraper stations and these are not considered further in this report.

In an emergency situation and during planned maintenance, high pressure gas venting will occur at the mainline valves. According to information provided by Santos, the typical sound power level from these blow-out events will be approximately 120 dBA. Sound power level and octave band data for mainline valves (typical high pressure blow-out noise) is shown in **Table 46**.

Table 46 Mainline Valves - Sound Power Level

Source	dBA	Sound Power Level (dBA) Octave Band Centre Frequency (Hz)								
		31.5	63	125	250	500	1k	2k	4k	8k
Mainline valves	120	82	94	102	100	106	108	109	116	116

7.6.3 CSG Fields

Major operational noise sources associated with the CSG Field study area consist of compressor stations and operational well heads.

The sound power level for a typical compressor site has been calculated from attended noise measurements obtained at the Compressor Site 2 (see **Section 5.4.1**). The sound power level (123 dBA) presented in **Table 9** has been used to predict the noise emission from a Compressor Site at various off-set distances.

The operation well heads will be fitted with a small gas pump for pumping up the gas into the gathering network. The operational well head gas pump has been assumed to be of the order of 30 kW and running at 1000 RPM to 1500 RPM. Octave band data for pumps has been obtained from Bies and Hansen (1996). **Table 47** presents the sound power level used to assess the noise emission from the operational well head gas pump.

Table 47 Operational Well Head Gas Pump - Sound Power Level

Source	dBA	Sound Power Level (dBA) Octave Band Centre Frequency (Hz)								
		31.5	63	125	250	500	1k	2k	4k	8k
Operational well head	90	40	55	66	75	81	87	85	81	73

7.7 Cumulative Noise Impacts

It is noted that there is the potential for development of other LNG facilities and industrial developments within the Gladstone Region (including on Curtis Island). A discussion of the cumulative noise impacts from the proposed Santos LNG facility and any other proposed industry (including any other proposed LNG facilities) is included below.

The cumulative noise impacts are inherently assessed through the background creep (L_{A90}) and the planning noise level (PNL) (L_{Aeq}) criteria (see **Section 6.3**) contained in the EPA's Planning for Noise Control guideline. Both criteria take into account the existing ambient noise level in an area from all existing industry and other noise sources such as road and railway traffic. Any other proposed industrial developments (including any other proposed LNG facilities) would be required to achieve the same noise criteria which are applicable for the Santos Project.

The (EPA's Planning for Noise Control) assessment methodology is based on the existing ambient noise monitoring (undertaken at the surrounding communities to the proposed LNG project) and comparison to recommended ambient noise levels. The cumulative effect of the existing industry and other noise sources, together with the noise emission from the proposed Santos LNG project, is assessed to not exceed the recommended ambient noise levels. If the existing noise level is already above the recommended noise levels, the associated noise levels of the proposed LNG project are set between 8 and 10 dBA below the existing ambient noise level so as the cumulative effects of existing and proposed industry should not increase above existing noise levels.

As discussed above, any other proposed industrial developments (including any other proposed LNG facilities) would be required to achieve the same noise criteria which are applicable for the Santos Project. Therefore, the cumulative effect of noise emission from the Santos LNG Project and any other proposed industrial developments (including any other proposed LNG facilities) should not exceed existing background noise levels within the region if the operational (background creep) noise criteria for these proposed industrial developments are set at levels similar to those set for the Santos LNG Project.

8 RESULTS AND ASSESSMENT

Noise level emissions associated with construction and operational phases of the LNG facility have been predicted at the assessment locations in the Gladstone region as shown in **Figure 4**. The sound pressure levels have also been predicted for selected locations at the property boundary of the LNG facility as shown in **Figure 5**. For the gas transmission pipeline and CSG fields, the assessment is based on a generic approach with noise levels predicted at various off-set distances from construction or operational noise sources. All predictions are based on methodology and noise sources specified in **Section 7**.

Figure 4 Assessment Locations in the Gladstone Area

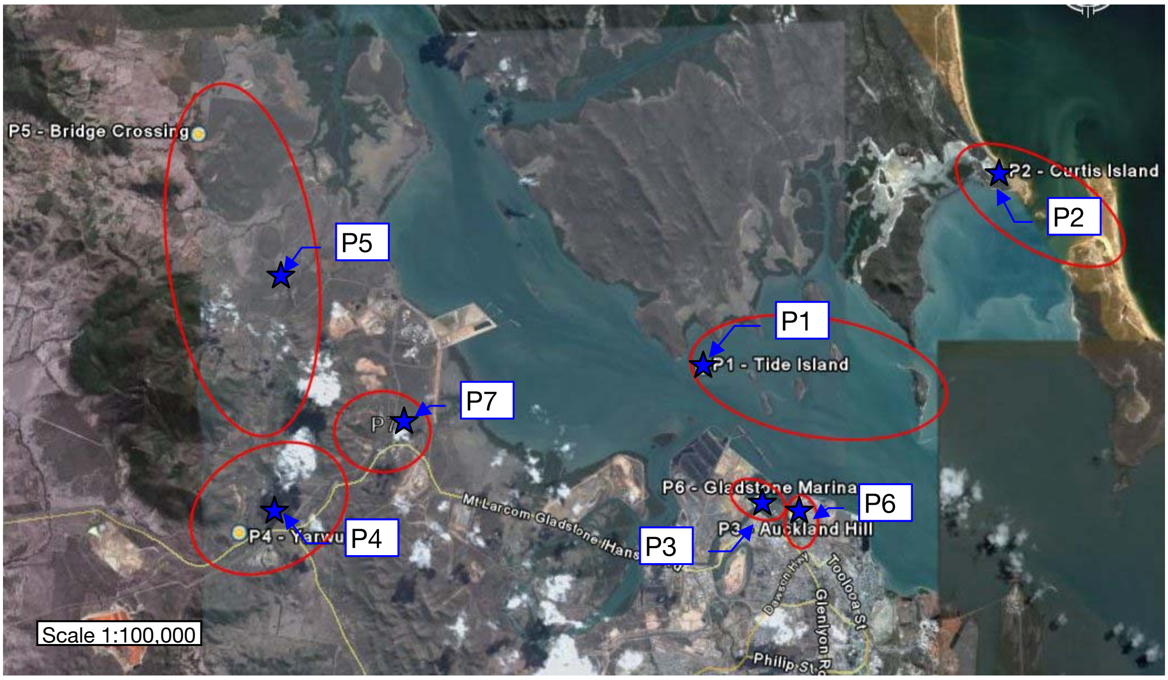
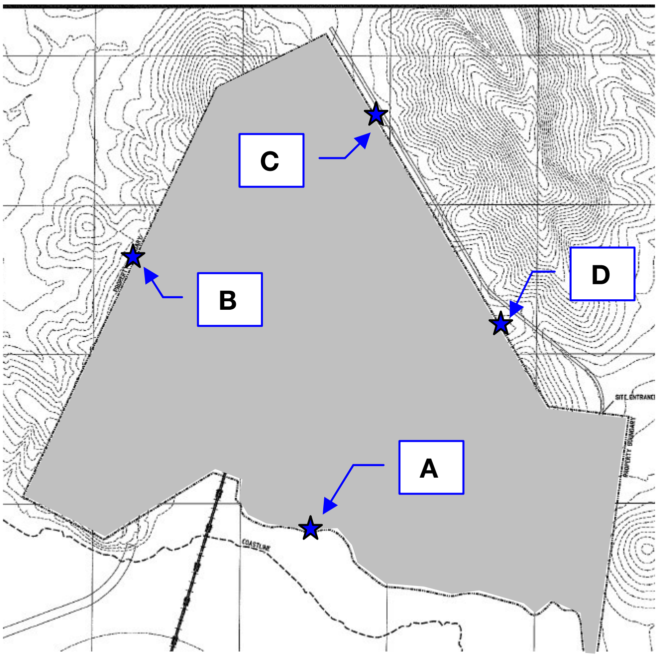


Figure 5 Locations for Predicted Sound Pressure Levels along the Gladstone LNG Facility Property Boundary



8.1 Construction Noise and Vibration

The predicted construction noise and vibration emissions from the project are presented in the following sections (**Sections 8.1.1** to **8.1.3**). The predicted noise and vibration levels are assessed against the relevant criteria for the LNG facility, gas transmission pipeline and CSG fields.

8.1.1 LNG Facility

Construction Noise

The following potential sources of construction noise emissions associated with the LNG facility construction works form the basis of the noise assessment:

On-Site Construction Activities

Noise level emissions associated with the construction phase of the LNG facility have been predicted for the assessment locations in the Gladstone region (see **Figure 4**) and at locations along the property boundary of the LNG facility (see **Figure 5**). The predictions are based on methodology and noise sources specified in **Section 7.5.1**. The predicted noise levels for six (6) different construction scenarios are presented in **Table 48** together with the relevant evening and night-time noise criteria (night-time sleep disturbance L_{Amax} 50 dBA).

Table 48 Predicted Sound Pressure Levels from Construction Noise – LNG Facility

Assess-ment Locations	Construction Noise Criteria (dBA) Monday to Saturday (6:30pm to 6:30am); Sundays and Public Holidays	Predicted Sound Pressure Levels (dBA)					
		Clear and Grade	Concrete Pad and Foundations	Erecting Process Trains and Decking	Building of storage tank	Piling and Jetty	High Pressure Testing of pipelines
P1	50	28	24	20	18	40	43
P2	50	< 10	< 10	< 10	< 10	17	21
P3	50	19	17	12	11	31	32
P4	50	< 10	< 10	< 10	< 10	17	21
P5	50	13	< 10	< 10	< 10	21	25
P6	50	17	13	< 10	< 10	30	30
P7	50	22	19	13	14	32	35
Boundary A	-	56	51	48	47	57	79
Boundary B	-	63	56	51	46	48	72
Boundary C	-	50	46	45	34	42	62
Boundary D	-	50	48	45	36	46	66

The construction noise associated with the LNG facility is predicted to meet the 50 dBA L_{Amax} noise criteria at all assessment locations. There are no construction noise criteria applicable to daytime construction works (except on Sundays and Public Holidays).

Dredging

Based on the proposed use of a TSHD for the dredging of the main channel and a CSD for the dredging of the swing basin (both include a dredge pump), **Table 49** shows the predicted noise levels at the assessment locations surrounding the LNG facility.

Table 49 Predicted Noise Levels from Dredging

Assessment Location	Construction Noise Criteria (dBA) Monday to Saturday (6:30pm to 6:30am); Sundays and Public Holidays	Predicted Sound Pressure Levels (dBA)	
		Channel Dredging (TSHD)	Swing Basin (CSD)
P1	50	47	33
P2	50	12	< 10
P3	50	24	20
P4	50	< 10	< 10
P5	50	< 10	< 10
P6	50	23	20
P7	50	17	21

The construction noise associated with dredging is predicted to meet the noise criteria at all assessment locations.

Bridge Construction and Gas Transmission Pipeline Crossing

Table 50 shows predicted noise levels at assessment locations surrounding the LNG facility area for the construction of the proposed bridge, based on the construction scenarios and typical plant items in **Table 26** (**Section 7.5.1**), and associated sound power levels in **Table 24.**

Table 50 Predicted Noise Levels from Bridge Construction

Assessment Location	Construction Noise Criteria (dBA) Monday to Saturday (6:30pm to 6:30am); Sundays and Public Holidays	Predicted Sound Pressure Levels dBA			
		Clear and Grade	Piling Works	Finishing Works	Asphalt Surfacing
P1	50	10	25	11	< 10
P2	50	< 10	12	< 10	< 10
P3	50	< 10	23	< 10	< 10
P4	50	< 10	19	< 10	< 10
P5	50	13	29	12	10
P6	50	< 10	22	< 10	< 10
P7	50	14	30	15	13

Table 51 shows predicted noise levels at assessment locations surrounding the LNG facility for construction activities associated with the gas transmission pipeline crossing based on the construction scenarios and typical plant items in **Table 27** (**Section 7.5.1**).

Table 51 Predicted Noise Levels from Gas Transmission Pipeline Crossing

Assessment Location	Construction Noise Criteria (dBA) Monday to Saturday (6:30pm to 6:30am); Sundays and Public Holidays	Predicted Sound Pressure Levels dBA			
		Dredging Trench - CSD	Dredging Trench - TSHD	Joining and Lowering Pipe	Covering Trench
P1	50	18	18	< 10	< 10
P2	50	< 10	< 10	< 10	< 10
P3	50	18	18	< 10	< 10
P4	50	11	11	< 10	< 10
P5	50	22	22	11	< 10
P6	50	16	15	< 10	< 10
P7	50	23	22	11	10

Construction noise emissions associated with both the bridge construction and gas transmission pipeline crossing are predicted to meet the noise criteria at all assessment locations.

Construction Vibration

The following potential sources of ground vibration associated with LNG facility construction works form the basis of the vibration assessment:

Pile Driving

Based on the current proposed construction methodology, it is anticipated that the primary source of potential ground vibration is likely to be from pile driving associated with jetty bridge construction. The typical levels of ground vibration from pile driving range from 1 mm/s to 3 mm/s at distances of 25 m to 50 m, depending on the ground conditions and the energy of the driving hammer. Recent measured vibration levels (September 2006) from pile driving at the RG Tanna Coal Terminal Berth 4 expansion for a 14 tonne hammer driving a 1200 mm pile of 600 mm wall thickness showed that vibration levels at a distance of 380 m from the piling site were not measurable (only ambient vibration levels were measured, at less than 0.1 mm/s Peak Particle Velocity).

The above data in combination with vibration criteria outlined in **Section 6.2.2** was used to develop “Safe Working Distances” for the pile driving activities. Safe working distances for pile driving equipment are listed in **Table 52** for both “cosmetic” damage and human comfort. The human comfort safe working distances correspond to a *“Low Probability of Adverse Comment”* response.

Table 52 Safe Working Distances for Vibration Intensive Plant Items

Item	“Safe” Working Distance	
	Cosmetic Damage (BS7385)	Human Comfort (BS6472)
Impact Pile Driver	20 m to 40 m	80 m to 120 m
Vibratory Pile Driver	5 m to 15 m	20 m to 50 m
Pile Boring (<800 mm)	2 m (nominal)	N/A

The safe working distances given in **Table 52** are indicative and will vary depending upon the particular item of plant and local geotechnical conditions (eg presence of elevated water table). Furthermore, it is noted that the safe working distances for “cosmetic” damage apply to damage of typical buildings and do not address heavy industrial buildings.

Based on the significant separation distances between the bridge and jetty structures and the nearest buildings, vibration emissions from pile driving would be in compliance with the relevant vibration criteria. The recommended safe working distances shown in **Table 52** should be adhered to for all pile driving activities carried out on the project.

Truck Traffic

Heavy trucks passing over normal (smooth) road surfaces generate relatively low vibration levels, typically ranging from 0.01 mm/s to 0.2 mm/s at the footings of buildings located 10 m to 20 m from a roadway. Very large surface irregularities can cause levels up to 5 to 10 times higher.

Based on the data above, vibration levels from truck traffic utilising the roads on site are expected to be significantly below both "building damage" and "human comfort" criteria. In fact it is expected that any vibration from truck movements would be imperceptible (ie less than 0.15 mm/s).

8.1.2 Gas Transmission Pipeline

Construction Noise

In order to assess the noise impacts associated with various gas transmission pipeline construction activities, calculations were carried out in order to determine:

- Noise emission levels at various distances from construction activities.
- Buffer distances from construction activities at which the nominated noise emission levels (and noise criteria) are predicted.

The noise emissions in **Table 53** and **Table 54** assume propagation over flat, soft ground (ie open grassland) to a typical receiver and are correct for "neutral" meteorological conditions.

The influence of meteorological (wind effects and temperature inversion) and topographical effects on calculated noise levels in **Table 53** and **Table 54** are discussed in **Section 8.3.1**.

It is noted that the predictions in **Table 53** and **Table 54** are based on the expected summation of noise sources at the receiver for the noisiest activities. Depending on the scenario, the level may result from the noisiest operation, or be from multiple sources.

Table 53 Predicted Noise Levels at Various Offset Distances - Gas Transmission Pipeline

Stage	Activity	Predicted L_{Amax} Noise Level at Buffer Distance (dBA)						
		50m	100m	250m	500m	1,000m	2,000m	5,000m
Stage 1	Survey and fencing	68	60	47	38	30	21	6
Stage 2	Clear and grade	76	68	57	49	40	31	16
Stage 3	Blasting (preparation)	71	63	52	42	33	23	7
Stage 4	Trenching, stringing and lowering step	77	69	56	47	39	31	15
Stage 5	Welding and joint coating	71	62	50	42	34	26	10
Stage 6	X-ray and pressure test	69	62	50	41	32	23	8
Stage 7	Padding and Backfilling	73	65	54	46	38	29	13
Stage 8	Tie-ins, push sections and road crossings	71	64	54	45	37	28	13
Stage 9	Restoration and rehabilitation	76	68	57	50	42	33	18

Table 54 Buffer Distances to Meet Construction Noise Criteria (LAmax 50 dBA) – Gas Transmission Pipeline

Stage	Activity	Distance from Noise Source (m)
Stage 1	Survey and fencing	225
Stage 2	Clear and grade	475
Stage 3	Blasting (preparation)	300
Stage 4	Trenching, stringing and lowering step	425
Stage 5	Welding and joint coating	250
Stage 6	X-ray and pressure test	250
Stage 7	Padding and backfilling	375
Stage 8	Tie-ins, push sections and road crossings	375
Stage 9	Restoration and rehabilitation	500

The predicted noise level emissions in **Table 53** and **Table 54** show that the most significant noise generating stages of the gas transmission pipeline construction works are:

- Stage 2 – Clear and grade; and
- Stage 9 – Restoration and rehabilitation.

Rail Laydown Area

Based on the noise sources associated with rail laydown areas stated in **Table 30,** an off-set buffer distance was predicted at which compliance with the 50 dBA LAmax sleep disturbance noise criteria is achieved (see **Table 55**).

Table 55 Off-set Distances from Laydown Areas to Achieve the Noise Criteria

Process	Relevant Sleep Disturbance Criterion (dBA)	Off-set Buffer Distance (m)
Unloading pipe joints at Laydown / Storage Areas	50	400

If rail laydown areas are required to be located closer than 400 m to sensitive receptors, mitigation measures may be required and should be determined in consultation with the affected residents.

Construction Vibration - Truck Traffic

Heavy trucks passing over normal (smooth) road surfaces generate relatively low vibration levels, typically ranging from 0.01 mm/s to 0.2 mm/s at the footings of buildings located 10 m to 20 m from a roadway. Very large surface irregularities can cause levels up to 5 to 10 times higher.

Based on the data above, vibration levels from truck traffic utilising the roads on site are expected to be significantly below both “building damage” and “human comfort” criteria. In fact it is expected that any vibration from truck movements would be imperceptible (ie less than 0.15 mm/s).

Blasting – Noise and Vibration

By adopting the nominated typical blast design (see **Table 31**), the level of blast emissions can be predicted using the formula given in the AS 2187-2, 2006 and ICI Explosives Blasting Guide, applicable to blasting in average rock. Also given in the Guide is a formula in relation to the prediction of airblast emissions. Both methods of blast emission estimation are considered conservative.

The relevant formulae are as follows:

$$PVS = 1140 (R/Q^{0.5})^{-1.6}$$
$$dB = 164.2 - 24(\log_{10} R - 0.33 \log_{10} Q)$$

Where,

PVS = Peak Vector Sum ground vibration level (mm/s)
dB = Peak airblast level (dB Linear)
R = Distance between charge and receiver (m)
Q = Charge mass per delay (kg)

The relationship between distance and the peak vector sum (PVS) ground vibration and peak airblast from the blasting are presented in **Figure 6** to **Figure 11** respectively for MIC of 10 kg, 25 kg and 50 kg. The PVS is the vector sum of peak particle velocity (PPV) in all three directions (horizontal, transversal and vertical).

Figure 6 Peak Vector Sum Ground Vibration for an MIC of 10 kg

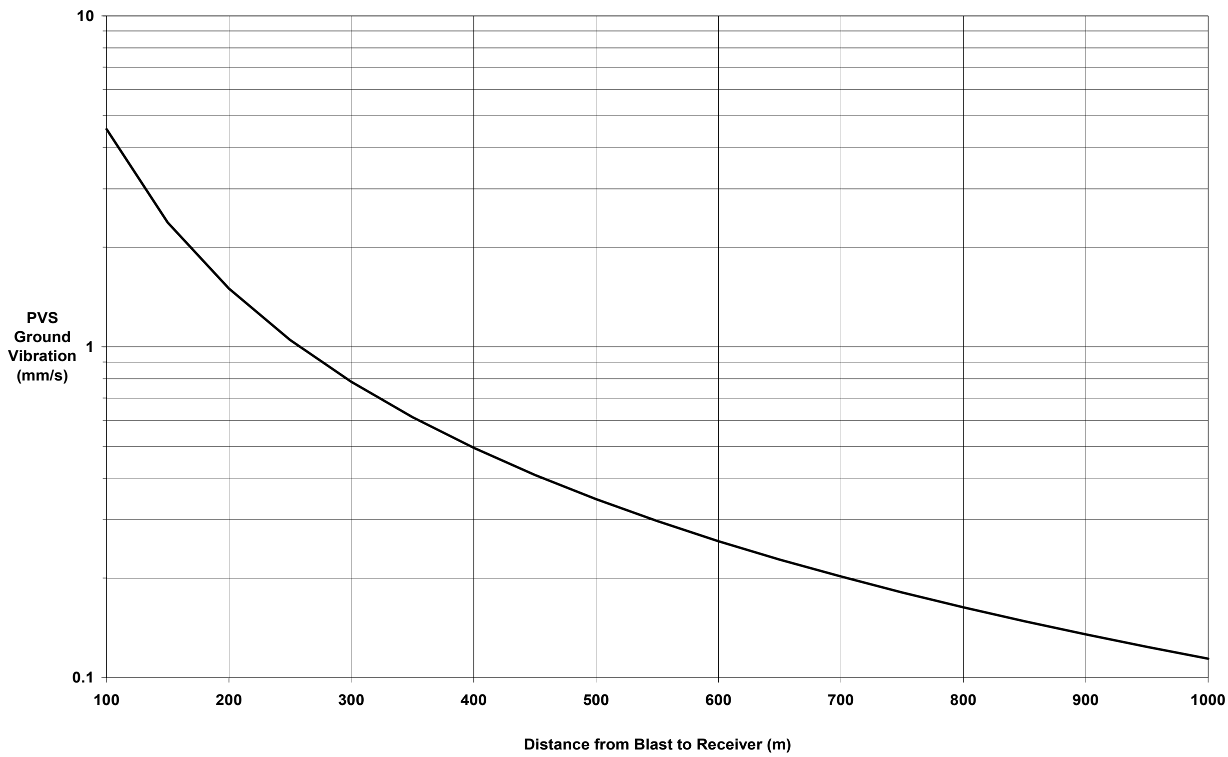


Figure 7 Peak Airblast for an MIC of 10kg

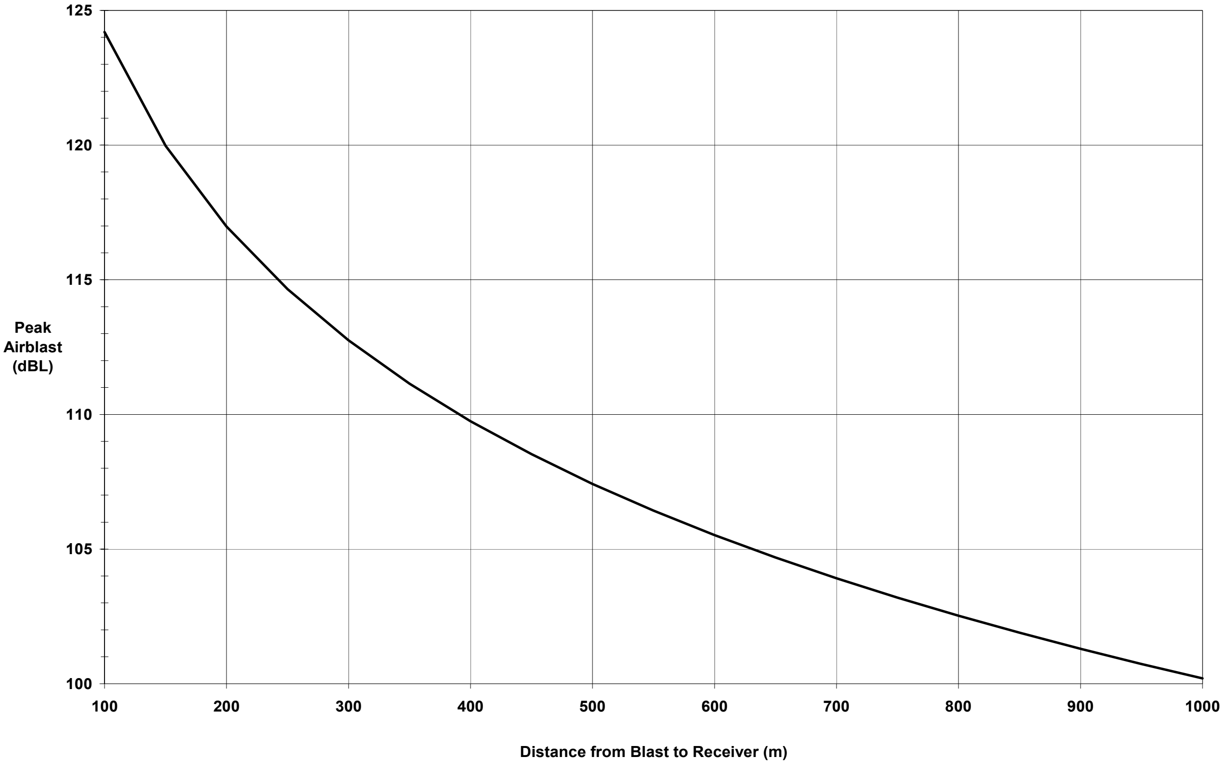


Figure 8 Peak Vector Sum Ground Vibration for an MIC of 25 kg

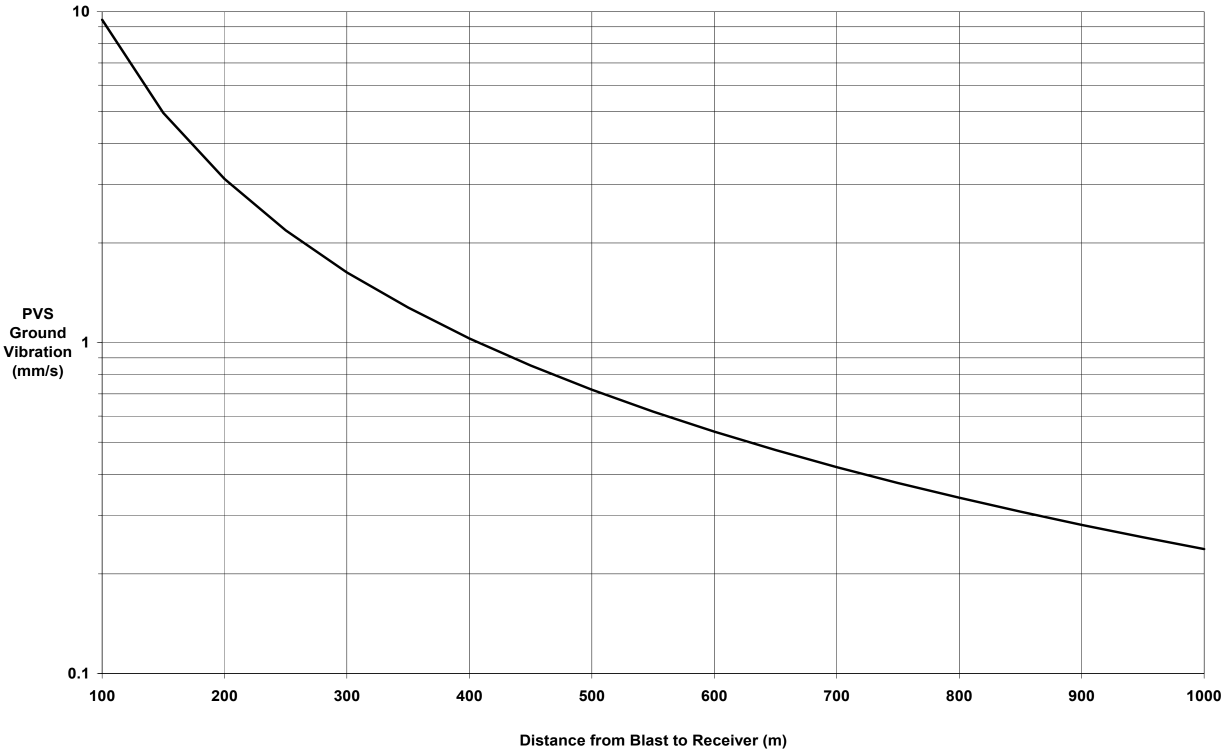


Figure 9 Peak Airblast for an MIC of 25kg

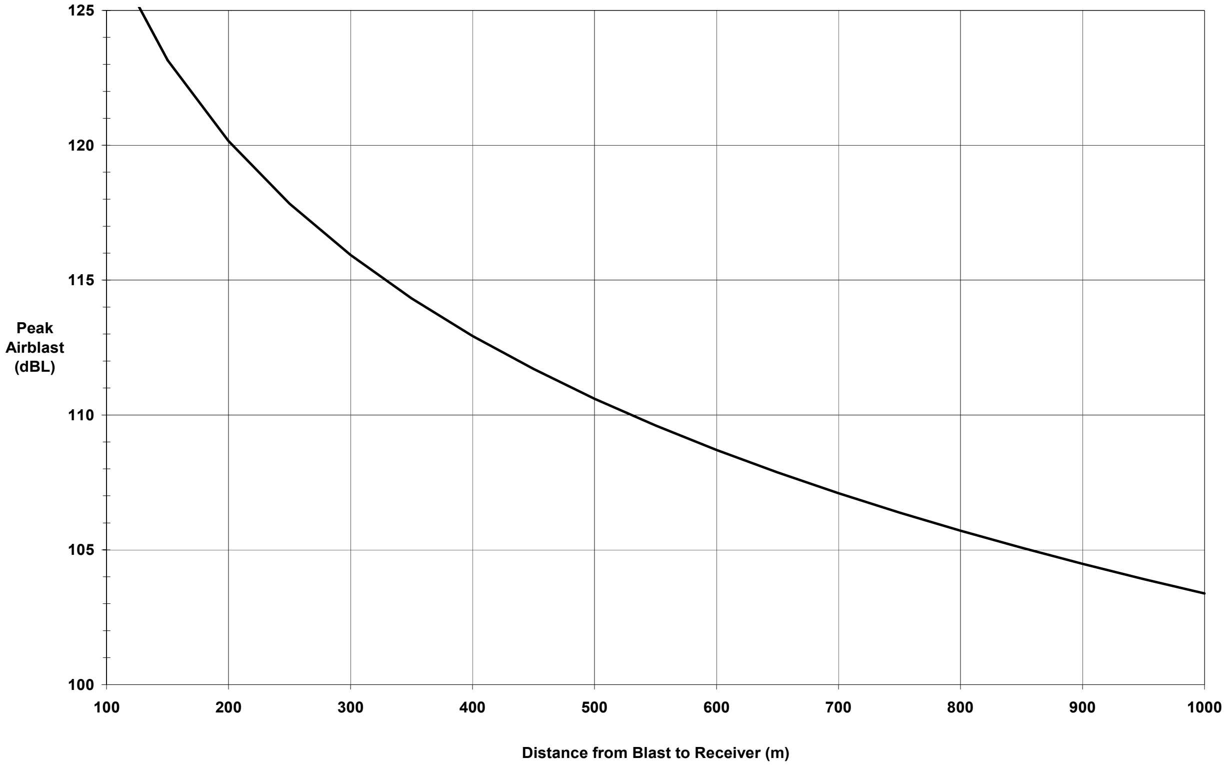


Figure 10 Peak Vector Sum Ground Vibration for an MIC of 50 kg

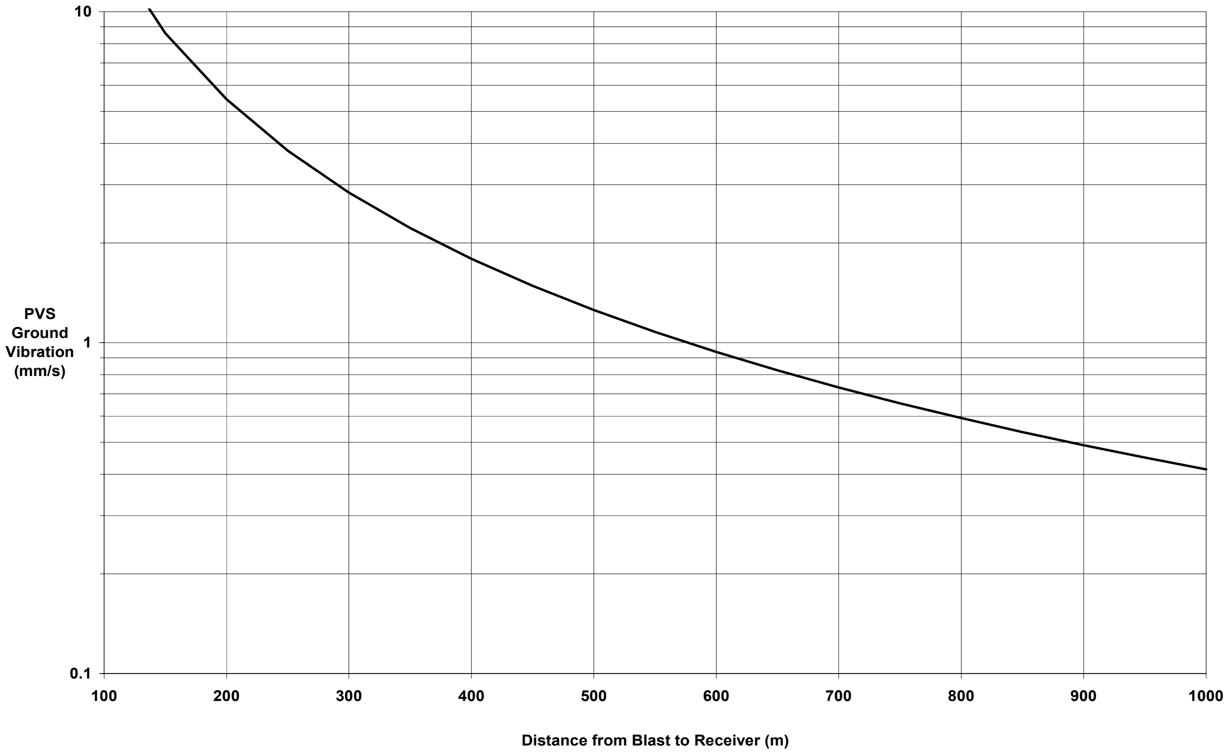


Figure 11 Peak Airblast for an MIC of 50kg

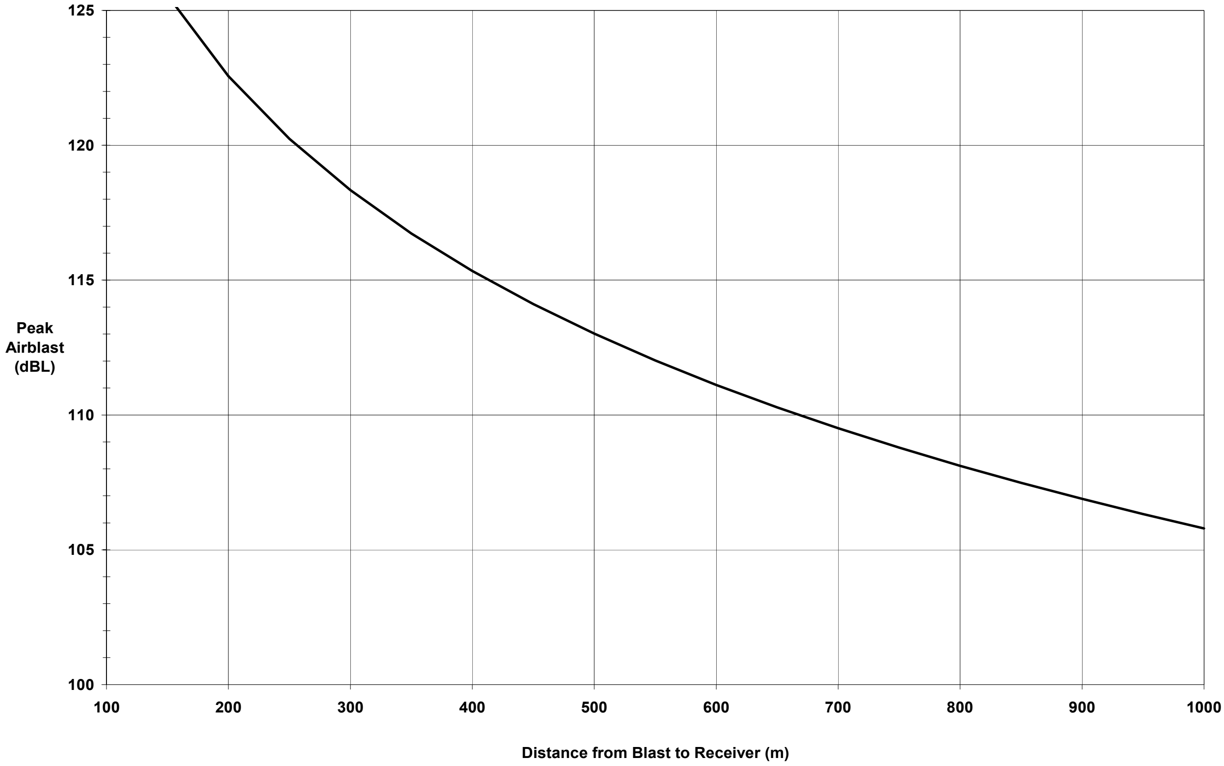


Figure 6 to **Figure 11** are used to determine the predicted level of blast emissions at appropriate distances to the blast site. Offset distances required to meet the airblast criterion of 115 dB Linear peak (maximum of 120 dB Linear peak) and PVS ground vibration criterion of 5 mm/s (maximum of 10 mm/s) are summarised in **Table 56**.

Table 56 Offset Distances to Comply with Airblast and PVS Ground Vibration Criterion

MIC	Offset Distances (m)			
	Airblast		PVS Ground Vibration	
	115 dB Linear peak	120 dB Linear peak	5 mm/s	10 mm/s
10 kg	250	160	<100	<100
25 kg	330	210	150	<100
50 kg	420	260	220	130

Table 56 shows that for a blast with a 50 kg MIC the airblast criteria (115 dB Linear peak) is predicted to be exceeded at distances within 420 m of the blast, whilst the PVS ground vibration criteria (5 mm/s) is predicted to be exceeded at 220 m from the blast location.

Following identification of the potentially affected residences in the vicinity of the blast sites, the assessment of potential impacts of the typical blast designs can be reviewed.

8.1.3 CSG Fields

Construction Noise

In order to assess the noise impacts associated with various CSG fields construction activities, calculations were carried out in order to determine:

- Noise emission levels at various distances from construction activities; and
- Buffer distances from construction activities at which the nominated noise emission levels are predicted.

The noise emissions in **Table 57** to **Table 60** assume propagation over flat, soft ground (ie open grassland) to a typical receiver and are correct for "neutral" meteorological conditions.

The influence of meteorological (wind effects and temperature inversion) and topographical effects on calculated noise levels in **Table 57** to **Table 60** are discussed in **Section 8.3.1**.

It is noted that the predictions in **Table 57** to **Table 60** are based on the expected summation of noise sources at the receiver for the noisiest activity. Depending on the scenario, the level may result from the noisiest operation, or be from multiple sources.

Gas Wells

Predicted noise levels at various offset distances are shown in **Table 57** for the likely gas well construction scenarios (see **Table 33**) and associated sound power levels (see **Table 32**). Similarly, the predicted offset distances at which the L_{Amax} 50 dBA sleep disturbance noise criteria is expected to be met are shown in **Table 58** for each construction stage.

Table 57 Predicted Noise Levels at Various Offset Distances – Gas Wells

Stage	Activity	Predicted Noise Level at Buffer Distance (dBA)						
		50m	100m	250m	500m	1,000m	2,000m	5,000m
Stage 1	Clear and grade	76	68	57	47	39	29	15
Stage 2	Setup of temporary facilities	68	61	48	37	26	16	0
Stage 3	Cellar and surface conductor pipe	66	59	47	37	28	18	4
Stage 4	Drilling	70	63	51	42	33	24	9
Stage 5	Casings and completions rig	74	66	55	46	37	27	12
Stage 6	Wellhead valves	69	62	51	42	33	23	8

Table 58 Buffer Distances to Meet Construction Noise Levels (L_{Amax} 50 dBA) – Gas Wells

Stage	Activity	Predicted Noise Level (m) – 50 dBA
Stage 1	Clear and grade	425
Stage 2	Setup of temporary facilities	225
Stage 3	Cellar and surface conductor pipe	225
Stage 4	Drilling	275
Stage 5	Casings and completions rig	400
Stage 6	Wellhead valves	275

Although it is seen in **Table 57** and **Table 58** that Stage 1 (clear and grade) is noted as the most significant noise generating stage, it is expected that these works would only occur during day-light hours and should be relatively short in duration (ie less than one (1) week).

Stage 5 (Casings and completions rig) is a 24 hour process which may last longer than a week. Therefore it is recommended that where possible gas wells are located no nearer than 400m from sensitive receptors (where possible) to allow the LAmax 50 dBA sleep disturbance noise criteria to be met.

If gas wells are required to be installed closer than 400m, mitigation measures may be required and should be determined in consultation with the affected residents.

Compressor Sites

Predicted noise levels at various offset distances are shown in **Table 59** for the likely compressor site construction scenarios (see **Table 34**) and associated sound power levels (see **Table 32**). Similarly, the predicted offset distances at which the LAmax 50 dBA evening and night-time sleep disturbance noise criteria is expected to be met are shown in **Table 60** for each construction stage.

Table 59 Predicted Noise Levels at Various Offset Distances – Compressor Sites

Stage	Activity	Predicted Noise Level at Buffer Distance (dBA)						
		50m	100m	250m	500m	1,000m	2,000m	5,000m
Stage 1	Clear and grade	76	68	57	47	39	29	15
Stage 2	Concrete pad and foundations	68	61	49	40	31	21	5
Stage 3	Set up of facilities	69	62	50	41	32	22	6
Stage 4	Construction of compressors and coolers	69	62	50	41	32	22	6

Table 60 Buffer Distances to Meet Construction Noise Levels (LAmax 50 dBA) – Compressor Sites

Stage	Activity	Predicted Noise Level (m) – 50 dBA
Stage 1	Clear and grade	425
Stage 2	Concrete pad and foundations	250
Stage 3	Set up of facilities	250
Stage 4	Construction of compressors and coolers	250

The predicted noise level emissions in **Table 59** and **Table 60** show that the most significant noise generating stage of the compressor site construction is from Stage 1 (clear and grade). However, it is expected that these works would only occur during day light hours and should be relatively short in duration (ie less than one (1) week).

If construction activities associated with compressor sites are required to be carried out during the evening and night time periods, it is recommended that where possible, these activities are located no closer than 250m from sensitive receptors (where possible) to allow the LAmax 50 dBA sleep disturbance noise criteria to be met.

8.2 Operational Noise and Vibration

The predicted operational noise emissions from the project are presented and assessed in the following sections (**Sections 8.2.1** to **8.2.3**). The predicted noise levels in **Section 8.2** do not include attenuation from any noise mitigation measures. Assessment of the following operational noise sources is discussed:

- LNG Facility
  - OCP and C3MR LNG facility designs.
  - Flare noise.

- Shipping noise.
- Gas Transmission Pipeline
    - Mainline valves.
- CSG Fields
    - Gas wells and compressor sites.

There is no major vibration sources that can induce ground vibration over long distances (outside LNG facility property boundary) associated with the operation of the LNG facility, gas transmission pipeline or CSG fields. Vibration emission from the operational phase of the LNG facility, gas transmission pipeline and CSG fields is not considered further in this report.

8.2.1 LNG Facility

Operational Noise

Sound pressure levels for the operational noise generated by the LNG facility have been predicted for the assessment locations in the Gladstone area (see **Figure 4**) and at locations along the property boundary of the LNG facility (see **Figure 5**). The predictions are based on the methodology and noise sources described in **Section 7.6.1**.

OCP and C3MR LNG Facility Designs

Predicted noise levels based on the LNG facility design and associated noise source data for the OCP and C3MR LNG facilities are presented in **Table 61** and **Table 62** respectively as well as the initial LNG facility operation (1 process train) and ultimate LNG facility configuration (3 process trains). The predicted noise levels do not include noise mitigation measures. Predictions have been carried out for both neutral and 'worst case' weather conditions. The operational noise levels from the LNG facility are assessed against the Guideline's background creep criterion (see **Section 6.3.1**). The planning noise levels for the different assessment locations have been determined and are included in **Table 61** and **Table 62**. The difference between the predicted noise level and the planning noise level are shown within brackets in **Table 61** and **Table 62**.

Table 61 Predicted Noise Levels -OCP LNG Facility Design, No Mitigation

Assessment Locations (Distance from LNG Facility)	Background Creep Noise Criteria (dBA)	Predicted Sound Pressure Levels (dBA)			
		1 Process Train		3 Process Train	
		Neutral Weather	Worst Case Weather	Neutral Weather	Worst Case Weather
P1 (3.4 km)	31	33 (+2)	38 (+7)	39 (+8)	44 (+13)
P2 (10 km)	25	13 (-12)	17 (-8)	22 (-3)	26 (+1)
P3 (7.9 km)	27	26 (-1)	31 (+4)	31(+4)	36 (+9)
P4 (12.4 km)	27	17 (-10)	20 (-7)	21 (-6)	25 (-2)
P5 (10.5 km)	25	20 (-5)	24 (-1)	25 (0)	30 (+5)
P6 (7.2 km)	28	23 (-5)	28 (0)	28 (0)	33 (+5)
P7 (7.0 km)	30	29 (-1)	33 (+3)	34 (+4)	39 (+9)
Boundary A	-	57	59	66	67
Boundary B	-	71	72	74	74
Boundary C	-	60	62	62	64
Boundary D	-	56	59	61	64

Table 62 Predicted Noise Levels - C3MR LNG Facility Design, No Mitigation

Assessment Locations (Distance from LNG Facility)	Background Creep Noise Criteria (dBA)	Predicted Sound Pressure Levels (dBA)			
		1 Process Train		3 Process Train	
		Neutral Weather	Worst Case Weather	Neutral Weather	Worst Case Weather
P1 (3.4 km)	31	35 (+4)	40 (+9)	39 (+8)	44 (+13)
P2 (10 km)	25	18 (-7)	22 (-3)	22 (-3)	26 (+1)
P3 (7.9 km)	27	27 (0)	31 (+4)	31 (+4)	36 (+9)
P4 (12.4 km)	27	16 (-11)	20 (-7)	20 (-7)	24 (-3)
P5 (10.5 km)	25	20 (-5)	24 (-1)	24 (-1)	28 (+3)
P6 (7.2 km)	28	24 (-4)	29 (+1)	28 (0)	33 (+5)
P7 (7.0 km)	30	29 (-1)	34 (+4)	33 (+3)	38 (+8)
Boundary A	-	70	70	71	72
Boundary B	-	59	61	65	67
Boundary C	-	52	55	60	63
Boundary D	-	58	60	65	66

The predicted noise levels in **Table 61** and **Table 62** indicate that noise mitigation measures are required for both the OCP and C3MR LNG facility designs in order to meet the background creep noise criterion at the assessment locations. These noise mitigation measures are discussed in **Section 9.2.1**.

Low Frequency Noise Prediction

The predicted low frequency noise emission from the OCP and C3MR LNG facility designs has been carried out in accordance with the methodology described in the EPA's EcoAccess Guideline: *Assessment of Low Frequency Noise*. The predicted low frequency noise levels for the OCP and C3MR LNG facility designs are shown in **Table 63** and **Table 64**.

Table 63 OCP LNG Facility Design – Low Frequency Assessment

Assessment Locations	Low Frequency Criteria[1] $L_{pA,LF}$ (dBA)	Predicted Low Frequency Sound Pressure Levels $L_{pA,LF}$ (dBA)			
		1 Process Train		3 Process Train	
		Neutral Weather	Worst Case Weather	Neutral Weather	Worst Case Weather
P1 (3.4 km)	23	28 (+5)	31 (+8)	33 (+10)	36 (+13)
P2 (10 km)	23	12	16	21	25 (+2)
P3 (7.9 km)	23	24 (+1)	28 (+5)	29 (+6)	33 (+10)
P4 (12.4 km)	23	16	19	21	24 (+1)
P5 (10.5 km)	23	19	22	24 (+1)	28 (+5)
P6 (7.2 km)	23	19	22	24 (+1)	27 (+4)
P7 (7.0 km)	23	26 (+3)	29 (+6)	31 (+8)	35 (+12)

Note 1: Low frequency criteria raised 3 dB to represent outdoor levels

Table 64 C3MR LNG Facility Design – Low Frequency Assessment

Assessment Locations	Low Frequency Criteria[1] $L_{pA,LF}$ (dBA)	Predicted Low Frequency Sound Pressure Levels $L_{pA,LF}$ (dBA)			
		1 Process Train		3 Process Train	
		Neutral Weather	Worst Case Weather	Neutral Weather	Worst Case Weather
P1 (3.4 km)	23	28 (+5)	32 (+9)	32 (+9)	36 (+13)
P2 (10 km)	23	16	20	21	25 (+2)
P3 (7.9 km)	23	24 (+1)	28 (+5)	28 (+5)	32 (+9)
P4 (12.4 km)	23	15	19	19	23
P5 (10.5 km)	23	18	22	23	26 (+3)
P6 (7.2 km)	23	19	22	23	27 (+4)
P7 (7.0 km)	23	25 (+2)	29 (+6)	30 (+7)	33 (+10)

Note 1: Low frequency criteria raised 3 dB to represent outdoor levels

The predicted noise levels in **Table 63** and **Table 64** indicate that noise mitigation measures are required for both the OCP and C3MR LNG facility designs in order to meet the low frequency noise criteria at the assessment locations. These noise mitigation measures are discussed in **Section 9.2.1**.

It is noted that limited frequency spectra data was available for plant items associated with the OCP and C3MR LNG facility design. Therefore, it is recommended that more detailed frequency spectra data be obtained during the detailed design phase of the project in order to undertake a more detailed assessment of low frequency noise impacts.

LNG Facility Flare Noise

Operational noise levels generated during a flare event are assumed to be both intermittent and short-term. It is therefore assessed against the Guideline's design criteria (most stringent of the PNL and SNL) $L_{Aeq(1hour)}$ for short term intrusive noise (see **Section 6.3.3**). The predicted noise levels during a flare event are presented in **Table 65**, along with the applicable short term intrusive noise criteria at the assessment locations.

Table 65 Predicted Sound Pressure Levels from a Flare Event

Assessment Locations	Design Criteria (dBA)	Predicted Sound Pressure Levels (dBA)	
		OCP	C3MR
P1 (3.4 km)	44	46 (+2)	48 (+4)
P2 (10 km)	34	18 (-16)	30 (-4)
P3 (7.9 km)	40	37 (-3)	38 (-2)
P4 (12.4 km)	40	27 (-13)	27 (-13)
P5 (10.5 km)	34	31 (-3)	31 (-3)
P6 (7.2 km)	41	33 (-8)	34 (-7)
P7 (7.0 km)	43	38 (-5)	38 (-5)
Boundary A	-	67	69
Boundary B	-	74	71
Boundary C	-	82	78
Boundary D	-	71	77

As noted in **Table 65**, the applicable short-term intrusive noise criteria are exceeded at P1 (Tide Island) by 2 dBA and 4 dBA respectively for the OCP and C3MR LNG facility layouts respectively. For the C3MR LNG facility layout, the flare is located more to the south-east of the LNG facility site (closer to Tide Island) and has been determined as the reason for the higher predicted noise level when compared to the OCP LNG facility design. The predicted flare noise levels do not include any noise mitigation measures (see **Figure 3** for the locations of flares).

Shipping Noise – LNG Ship Movements

Noise levels associated with LNG ship movements have been predicted at the assessment locations shown in **Figure 4**. The predictions are based on the methodology and noise sources specified in **Section 7.6.1**. The predicted noise levels for the LNG ship movements are presented in **Table 66**.

LNG shipping noise emissions are assessed against the Guideline's design criteria (most stringent of the PNL and SNL) $L_{Aeq(1hour)}$ for short term intrusive noise (see **Section 6.3.3**). The applicable short-term intrusive noise criteria are shown in **Table 66** along with the predicted noise levels for neutral and "worst case" weather conditions.

Table 66 Predicted Sound Pressure Levels from LNG Ship Movements

Assessment Locations	Design Criteria (dBA)	Predicted Sound Pressure Levels dBA	
		Neutral Weather	"Worst Case" Weather
P1 (3.4 km)	44	44	49
P2 (10 km)	34	19	23
P3 (7.9 km)	40	34	40
P4 (12.4 km)	40	8	12
P5 (10.5 km)	34	11	15
P6 (7.2 km)	41	34	40
P7 (7.0 km)	43	22	27

Table 66 shows that the applicable short-term intrusive noise criteria are met at all assessment locations, with the exception of Tide Island (P1) under "worst case" weather conditions.

The noise levels are predicted to exceed the applicable short-term intrusive noise criteria by 5 dBA at Tide Island (P1) for “worst case” weather conditions. At full capacity, two (2) LNG ships per week will pass Tide Island on route to the loading jetty. It has been advised that large ships would never enter the main shipping channel simultaneously.

Based on shipping data on Gladstone Port Authority’s webpage, it has been estimated that approximately 800 ships annually use the Targinie Channel to access either RG Tanner Coal loading berths or Fisherman’s Landing loading berths. At full capacity, the maximum annual volume of LNG ships has been stated as approximately 150.

The $L_{Aeq(1hour)}$ noise level emission from large ship movements is not expected to increase at P1 (Tide Island) as there are already large ships passing Tide Island to access RG Tanna and Fisherman’s Landing loading berths and the frequency of additional large ships passing Tide Island (ie 2 additional ships per week) is not expected to affect the $L_{Aeq(1hour)}$ noise level at this assessment location.

Shipping Noise – Barging / Ferrying

A ‘No Bridge Option’ has been proposed for the LNG Project. Barging/ferrying of all personnel and equipment/materials from Gladstone (Auckland Point) to the LNG facility is proposed under this Option for the construction and operational phase for the life-time of the LNG Project (unless alternate options are proposed or made available in the future).

Due to the high volume of marine traffic already present on the waters of Gladstone Harbour, the addition of GLNG barges/ferries is expected to have negligible noise impacts on surrounding sensitive receptors (Tide Island).

8.2.2 Gas Transmission Pipeline

Operational noise levels generated during the operation of mainline valves (mainline valve blowout events) are assumed to be intermittent and short-term. This noise source has therefore been assessed against the Guideline’s design criteria (most stringent of the PNL and SNL) $L_{Aeq(1hour)}$ for short term intrusive noise (see **Section 6.3.3**). The sound power level for the mainline valve (valve blowout events) is shown in **Table 46** in **Section 7.6.2**. The predicted noise levels from the operation of mainline valve assume propagation over flat, soft ground (ie open grassland) to a typical receiver and are correct for “neutral” meteorological conditions. The predicted noise level and the corresponding off-set buffer distance at which the short-term intrusive noise criterion of 28 dBA is expected to be met for mainline valve noise are shown in **Table 67**.

Table 67 Off-set Distance from Mainline Blowout Events to Achieve Noise Criteria

Process	Design Criteria (dBA)	Off-set Buffer Distance (m)
Mainline Valve (blowout events)	28	1,500

Table 67 shows that without any mitigation measures, the applicable noise criteria would be achieved at a distance of approximately 1,500 m from the mainline valve.

8.2.3 CGS Field

The operational noise levels associated with the gas wells and compressor sites are assessed against the Guideline’s background creep criterion (see **Section 6.3.1**). Sound power levels for the operational noise of gas wells and compressor sites have been described in **Section 7.6.3**. The predicted noise levels from the operation of the gas wells and compressor sites assume propagation over flat, soft ground (ie open grassland) to a typical receiver and are correct for “neutral” meteorological conditions. The predicted noise level and the corresponding off-set buffer distance at which the background creep noise criterion of 25 dBA is expected to be met for compressor sites and gas wells are shown in **Table 68**.

Table 68 Off-set Distances from CSG Field Noise Sources to Achieve the Noise Criteria

Process	Relevant Background Creep Criterion (dBA)	Off-set Buffer Distance (m)
Compressor Site	25	3,400
Gas Wells	25	300

Low frequency noise has been assessed for compressor site operations in accordance with the methodology described in **Section 6.3.5**. The noise emission levels from a compressor site has low frequency characteristics (L_{LINeq} - L_{Aeq} = 19 dB). The relevant low frequency noise criteria (23 dBA $L_{pA,LF}$) is predicted to be achieved at an off-set distance of approximately 2,500 m from the compressor site.

Operational noise from the gas well pump does not display low frequency noise characteristics.

8.3 Transportation – Road Traffic Noise

8.3.1 Vehicle Movements

Table 69 shows the expected peak workforce number for the LNG facility, gas transmission pipeline and CSG fields for both construction and operational phases of the project.

Table 69 LNG Facility, Gas Transmission Pipeline and CSG Field Workforce Numbers for Construction and Operational Phases

Area	Expected Peak Workforce Number	
	Construction Phase	Operational Phase
LNG Facility	3,080	120
Gas Transmission Pipeline	1500	4
CSG Fields	~370	~290

For the road traffic noise assessment, it has been assumed that:

- **LNG Facility** – each worker would travel in individual vehicles except during the construction of the LNG facility. It is proposed to construct accommodation on Curtis Island near the LNG facility to house workers during the construction phase. It is likely that these workers will be ferried to and from the construction site (from Gladstone) and stay at the workers accommodation working a shift roster. As a result, the road traffic noise impacts associated with construction of the LNG facility would be negligible and therefore has not been assessed in this report. Expected workforce daily traffic movements for the operational phase of the LNG facility includes provision for delivery vehicles, other contracts and visitors (assume 60 movements per day).
- **Gas Transmission Pipeline** – all personnel are transported by 4WD bus (20 person capacity) during the construction phase, while each worker would travel in individual vehicles during the operational phase.
- **CSG Fields** – all personnel are transported by 4WD bus (20 person capacity) during both construction and operational phases.

It has also been assumed that workers will contribute 2 vehicle movements per day (1 vehicle movement for each direction of travel). This would result in an approximate number of daily vehicle movements as shown in **Table 70**.

Table 70 LNG Facility, Gas Transmission Pipeline and CSG Field Vehicle Trip Numbers for Construction and Operational Phases Based on Workforce

Area	Expected Workforce Daily Traffic Movement	
	Construction Phase	Operational Phase
LNG Facility	-	300
Gas Transmission Pipeline	150	8
CSG Fields	40	29

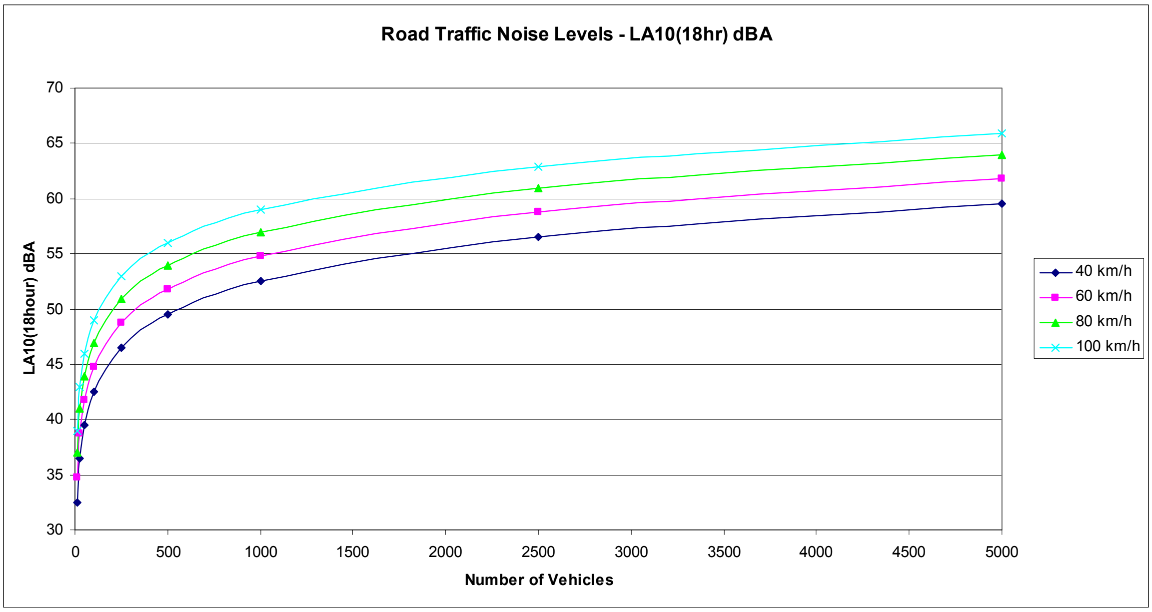
Construction of the gas transmission pipeline would require approximately 67 truck loads of pipe joints to be transported per day from ships at Auckland Point in Gladstone. The pipe joints are delivered to the designated pipeline laydown areas at the beginning of the construction program (2010 – 2011) for a period of approximately 6 month.

8.3.2 Predicted Road Traffic Noise Levels

In order to assess the likely compliance with the road traffic noise criterion it is necessary to estimate the overall $L_{A10(18hour)}$ road traffic noise level from vehicles (associated with the LNG Project) travelling on new roads.

Figure 12 shows the predicted $L_{A10(18hour)}$ road traffic noise level at a distance of 25 m from the road edge for a range of traffic volumes and speeds.

Figure 12 Relationship Between Road Traffic Noise Level, Traffic Volume and Vehicle Speed



Note: Road traffic noise levels are predicted at an off-set distance from the road pavement edge of 25m

Figure 12 shows that a new road with a speed limit of 80 km/hr could therefore carry up to 2,500 light vehicles per day and meet the $L_{A10(18hour)}$ road traffic noise criterion of 63 dBA at a distance of 25 metre from the road edge.

It should be noted that noise levels will decrease with distance from a roadway at a rate of approximately 3 dBA per doubling of distance (e.g. a noise level of 55 dBA at 25 m from a roadway would be expected to reduce to 52 dBA at 50 m).

New Roads – LNG Facility

There is an option to construct a new road including a bridge to join the LNG facility to Gladstone. At the time of writing, the alignment of this road was not confirmed, although it is likely to deviate from Landings Rd (between Yarwun and Gladstone) and track north to meet the bridge crossing at The Narrows.

It is expected that there will be approximately 300 vehicle movements (associated with this project) per day on this road when the LNG facility is at full capacity (i.e. 3 process trains). This figure is based on 120 employees travelling to and from the LNG facility each day (as per **Table 70**) as well as delivery vehicles and other contractors and visitors travelling to and from the facility.

It is also assumed that the likely traffic speed along this road would be 70 – 80 km/hr with a dense graded asphalt (DGA) road surface, with the majority of vehicles travelling between 6am and 12 midnight.

The predicted $L_{A10(18hour)}$ noise level at a distance of 25m from the pavement edge for road traffic associated with the operational phase of the LNG facility is 57 dBA (assumes 10% heavy vehicle movements). This predicted level is significantly lower than the applicable 63 dBA $L_{A10(18hour)}$ road traffic noise criterion for new roads, therefore no noise mitigation measures are required.

New Roads – CSG Fields

It is likely that new roads would be required throughout the CSG fields to service the gas wells and compressor sites. **Figure 12** shows the relationship between predicted $L_{A10(18hour)}$ traffic noise levels, traffic volumes and vehicle speeds. It is noted that the road traffic noise predictions in **Figure 12** are based on a DGA road surface (0 dBA correction). It is expected that new roads in the CSG Field areas would be either dirt roads or a chip seal road surface. In these instances the predicted road traffic noise levels would be typically 5-7 dBA higher than for a DGA road surface.

The predicted $L_{A10(18hour)}$ noise level at a distance of 25m from the pavement edge for road traffic associated with the operational phase of the CSG fields is 57 - 59 dBA (assumes 100% heavy vehicle movements and dirt/chip-seal road surface). This predicted level is significantly lower than the applicable 63 dBA $L_{A10(18hour)}$ road traffic noise criterion for new roads, therefore no noise mitigation measures are required.

New Roads – Gas Transmission Pipeline

Road traffic noise impact from the operational phase of the gas transmission pipeline is expected to be insignificant due to the low number of daily traffic movements (8 vehicles/day).

8.3.3 Predicted Incremental Change in Road Traffic Noise Levels

In order to assess the likely change in $L_{A10(18hour)}$ road traffic noise levels due to the additional vehicle movements associated with the construction and operational phases of the LNG Project the existing traffic volumes on the subject road are required.

Data relating to the existing roads to be used for road transportation associated with the LNG Project and the associated traffic volumes on those roads was not available at the time of reporting. Therefore it is appropriate to consider the resultant change in $L_{A10(18hour)}$ road traffic noise levels as a function of the percentage increase in traffic volume (as a result of the project) on the subject road.

Assuming that the proportion of heavy vehicles, traffic speed and road surface remain constant, the relationship between increases in traffic volume on a roadway and the resulting increase in $L_{A10(18hour)}$ traffic noise emission can be developed and is summarised in **Table 71.**

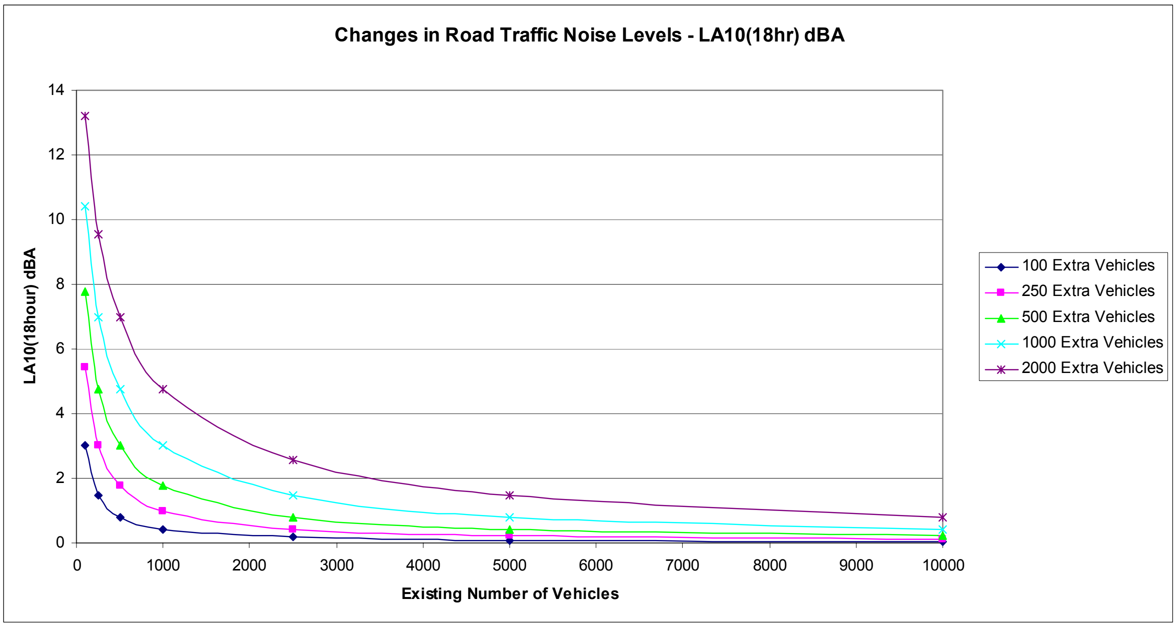
Table 71 Relationship Between Traffic Volumes Changes and LA10(18hour) Noise Emissions

Increase/Decrease in AADT Traffic	Resultant Change in LA10(18hour) Noise Emission
10%	0.4 dBA
25%	1.0 dBA
50%	1.8 dBA
75%	2.4 dBA
100%	3.0 dBA

It can be seen from **Table 71** that a doubling of traffic on a given roadway will result in a 3 dBA increase in the LA10(18hour) emission from the roadway.

Figure 13 shows the relationship between existing traffic volumes and the increase in vehicle movements in terms the LA10(18hour) noise level. This change assumes that the number of heavy vehicles, traffic speed and road surface remains constant.

Figure 13 Change in Road Traffic Noise Levels with Additional Traffic



Similar to **Table 71**, **Table 72** shows the relationship between changes to percentage of heavy vehicle movements and LA10(18hour) noise emissions. This change assumes that the traffic volumes, traffic speed and road surface remains constant.

Table 72 Relationship Between Changes to Percentage Heavy Vehicle Movements and LA10(18hour) Noise Emissions

	Change to Noise Emission (dBA) vs Future %HV			
Existing %HV	**5%**	**10%**	**20%**	**30%**
5%	-	0.9	2.3	3.4
10%	-0.9	-	1.4	2.5
20%	-2.3	-1.4	-	1.1
30%	-3.4	-2.5	-1.1	-

Existing Roads

Based on the workforce-generated traffic volumes in **Table 70**, an increase of greater than 2 dBA from road traffic associated with the LNG Project may occur for roads with existing traffic volumes less than those stated in **Table 73**.

Table 73 Minimum Existing Daily Traffic Counts Resulting in a Cumulative Effect of Less Than 2 dBA Due to Additional LNG Project Road Traffic

Area	Contribution from LNG Project		Minimum Existing Daily Traffic Counts to Achieve <2 dBA Increase	
	Expected Workforce Daily Traffic Counts	**%HV**	**Existing Daily Traffic Counts**	**%HV** [1]
LNG Facility - Operations	300	10% [2]	425	15%
Gas Transmission Pipeline - Construction	150	100%	950	15%
CSG Fields – Construction	40	100%	250	15%
CSG Fields – Operations	29	100%	180	15%

Note 1: Assume 15% heavy vehicles for a typical rural highway.
2: Percentage of heavy vehicles for the operational phase of the LNG facility is assumed to include provisions for delivery vehicles and contractors.

If existing traffic volumes per day are higher than those nominated above, the incremental increase in road traffic noise levels will be less than 2 dBA.

Road traffic noise impact from the operational phase of the gas transmission pipeline is expected to be insignificant due to the low number of daily traffic movements (8 vehicles/day).

It should be noted that incremental changes in road traffic noise levels of greater than +2 dBA would only occur for roads where the existing traffic volumes are low. Therefore the overall noise emissions from road traffic would be minimal and no noise mitigation required.

Heavy Vehicles

It should be noted that as the number of heavy vehicles generated by the project are relatively low (ie less that 150 per day). Any incremental increase in noise levels due to an increase in percent heavy vehicles is also expected to be low. The incremental increase in road traffic noise due to an increase in percent of heavy vehicles would only be significant when the existing traffic volume on that road is also low. In these instances, as a result of the low existing traffic volume, the overall noise level emission would be low

The number of heavy vehicles transporting the pipe joints for the gas transmission pipeline construction is expected to consist of approximately 134 truck movements per day. If the existing road traffic volume on these roads is greater than 850 vehicles per day with 15% heavy vehicles, the incremental increase in road traffic noise due to the project would be less than 2 dBA. This increase would be negligible to the human ear.

8.4 Transportation – Rail Traffic Noise

The project is investigating an option to transport the pipe joints, required to construct the gas transmission pipeline, via the QR Moura rail line. This option would eliminate the need for truck traffic associated with the delivery of the pipe joints for the gas transmission pipeline (approximately 67 trucks loads per day).

8.4.1 Rail Movements

Rail noise levels for existing rail traffic and including the proposed additional rail traffic during the construction of the gas transmission pipeline have been predicted at distances of 25m, 50m, 100m and 200m to residential receivers. The parameters used to predict the existing and future rail noise levels are summarised in **Table 74**.

Table 74 Train Movements on the Moura Rail Line

Section of the Moura Rail Line	Parameter	Existing Trains	Project additional Trains
Inside Gladstone down to Auckland Pt	Number of train movements per day (average)	4	2
	Notch setting of train	Notch 4	Notch 4
	Speed of train	30 – 50 km/h	30 – 50 km/h
	Number of wagons	70	50
	Number and type of locomotives	4 Diesel electric	4 Diesel-Electric
Between Moura and Gladstone	Number of train movements per day (average)	26	2
	Notch setting of train	Notch 4	Notch 4
	Speed of train	80 km/h	80 km/h
	Number of wagons	70	50
	Number and type of locomotives	4 Diesel electric	4 Diesel-Electric

Rail traffic noise emission levels were predicted by reference to the general rolling stock emissions used by QR and represented by two noise sources:

- Diesel-Electric locomotives (sources at 4 metre above rail).
- Freight consists (sources at 0.5 metre above rail).

As there is to be no change to the type of locomotive and rolling stock, it would be expected that there will be no change in the L_{Amax} noise level at any of the nearby receptors due to the addition of any proposed rail traffic associated with the gas transmission pipeline construction.

The predicted maximum noise levels at 25 m from the rail line between Moura and Gladstone and inside Gladstone are shown in **Table 75**. It should be noted that the predicted noise levels in **Table 75**, **Table 76** and **Table 77** assume propagation over flat, soft ground and don't take into account elevated noise levels due to rail curves, bridge crossings, turnouts, mechanical joints, braking or squeal noise.

Table 75 Predicted Rail Noise Levels at 25 m from the Rail Line

Noise Parameter	Predicted Noise Level (dBA)			Criterion Noise Level (dBA)
	Train at 30 km/h (Notch 4)	Train at 50 km/h (Notch 4)	Train at 80 km/h (Notch 4)	
Moura to Gladstone	--	--	85	87
Inside Gladstone down to Auckland Pt	85	85	--	87

The predicted rail noise levels in **Table 75** indicate that the L_{Amax} noise criterion of 87 dBA is expected to be achieved at residences not closer than 25 metre from the rail corridor.

Based on the information in **Table 74**, rail noise levels were predicted for various off-set buffer distances to residences adjacent to the rail corridor. The predicted existing $L_{Aeq(24hour)}$ noise level and cumulative $L_{Aeq(24hour)}$ noise levels due to the LNG construction phase are shown in **Table 76** and **Table 77**.

Table 76 Predicted $L_{Aeq(24hour)}$ Noise Levels – Rail Operations Moura to Gladstone (80 km/h)

Distance to Receiver (m)	Existing Trains (26 trains per day) $L_{Aeq(24 hour)}$ (dBA)	Including GLNG Trains (28 trains per day) $L_{Aeq(24 hour)}$ (dBA)	Limit $L_{Aeq(24 hour)}$ (dBA)
25	60	61 (+0.2)	**65**
50	57	57 (+0.3)	**65**
100	53	54 (+0.3)	**65**
200	50	50 (+0.2)	**65**

Table 77 Predicted $L_{Aeq(24hour)}$ Noise Levels – Rail Operations Gladstone to Auckland Point (30 – 50 km/h)

Distance to Receiver (m)	Existing Trains (4 trains per day) $L_{Aeq(24 hour)}$ (dBA)		Including GLNG Trains (6 trains per day) $L_{Aeq(24 hour)}$ (dBA)		Limit $L_{Aeq(24 hour)}$ (dBA)
	30 km/h	50 km/h	30 km/h	50 km/h	
25	46	49	47	51	**65**
50	42	45	44	47	**65**
100	39	42	40	44	**65**
200	35	39	37	40	**65**

Table 76 and **Table 77** show the cumulative effect to the $L_{Aeq(24hour)}$ noise level from the additional rail movements associated with the LNG Project is less than 0.5 dBA for the Moura rail line (outside Gladstone) and approximately 1.5 dBA increase on the rail section down to Auckland Point.

A change of up to 3 dBA in the level of a sound is difficult for most people to detect. The cumulative effects of the additional rail movements are considered to be negligible. Therefore no noise attenuation measures are proposed to attenuate noise from rail traffic.

It should also be noted that all rail traffic associated with the project would only operate during daytime hours and the additional trains associated with the LNG Project would only be required during the beginning of the construction phase when the pipes for gas transmission pipeline is delivered, approximately 6 months.

8.5 Discussion of Factors Affecting Noise Propagation

The predicted noise levels in **Sections 8.1.2, 8.1.3, 8.2.2** and **8.2.3** for the gas transmission pipeline and CSG field study areas are based on either or both of the following assumptions:

- Neutral weather conditions.
- Propagation over flat, soft ground (ie open grassland) to a typical receiver

The following sections (**Sections 8.5.1** to **8.5.3**) discuss potential changes to predicted noise levels based on the following:

- Meteorological effects.
- Topographical effects.

- Vegetation attenuation.

8.5.1 Meteorological Effects

As stated previously, all construction predictions are based on neutral weather conditions, which include the following meteorological parameters:

- 10°C.
- 70% humidity.
- Pasquill stability category D.
- 0 m/s wind speed.

The "worst case" weather conditions used to assess the effect of adverse meteorological conditions on noise propagation from the operational activities associated with the project are:

- 10°C.
- 90% humidity.
- Pasquill stability category F (to simulate temperature inversion conditions).
- 2 m/s wind speed (source to receiver).

The resulting change in predicted levels due to adverse meteorological conditions is summarised in the **Table 78**.

Table 78 Predicted Increase in Noise Levels due to "Worst Case" Weather Conditions

	Increase in Predicted Noise Level at Offset Distance (dBA)						
	50m	100m	250m	500m	1,000m	2,000m	5,000m
Change due to adverse weather	0	1	2	4	5	6	7

Note: Predicted increase is based on propagation over flat, soft ground (ie open grassland) to a typical receiver.

Appendix D of NSW's '*Industrial Noise Policy'* (INP) provides guidance on estimating the increase in noise levels due to temperature inversion conditions. The increase in noise levels was estimated using similar modelling parameters as those nominated above for "worst case" weather conditions. The increase in noise levels (nominated in NSW INP) due to temperature inversion conditions is estimated to be between 1 dBA and 6.5 dBA depending on the distance from the noise source and the change in temperature (increase for temperature inversions) with respect to height above ground. The increase in noise level due to temperature inversion conditions, nominated in the NSW INP (1 dBA to 6.5 dBA) is consistent with the predicted increase in noise levels from the "worst case" weather conditions assumed (0 dBA to 7 dBA) as shown in **Table 78**.

Table 78 shows that there is negligible change to the predicted noise level for activities carried out less than 250m from a sensitive property. Those sensitive properties located at 500m or more from operational works may experience a noticeable change in noise levels as a result of adverse weather conditions.

8.5.2 Topographical Effects

Local topography can dramatically effect the propagation of noise, especially if the construction works are conducted through areas with steep terrain (ie Fairview and Acadia Valley). The extent of change in noise levels due to topographical effects would be dependant on the level of shielding provided (which would be very much site specific). The actual degree of noise attenuation due to topographical shielding is a function of the frequency spectrum of the noise and the length of the diffracted noise path compared to the direct noise path.

Noise attenuation due to topographical shielding typically ranges from 5 dBA if line-of-sight between the noise source and receiver location is just obscured, and up to approximately 15 dBA where the topography provides optimal blocking of the sound transmission path.

It is noted that during “worst case” weather conditions, noise attenuation due to topographical shielding would be less than that expected during “neutral” weather conditions.

8.5.3 Vegetation Attenuation

Dense forest increases the amount of sound absorption along the noise propagation path. The increased sound absorption of typical forest vegetation is estimated to be between 0.05 to 0.1 dBA per metre of propagation distance.

9 MITIGATION MEASURES

9.1 Construction

9.1.1 Construction Noise

It is recommended that where possible construction activities be carried out during the daytime when ambient noise levels are higher and there are no applicable noise criteria.

Section 8.1.1 shows that the applicable noise criteria would be complied with for construction noise emission from the LNG facility during all time periods. **Section 8.1.2** and **8.1.3** show the off-set buffer distances at which the applicable (evening and night time) construction noise criteria is expected to be met for noise from gas transmission pipeline and CSG field construction activities respectively. Noise mitigation measures may be required for gas transmission pipeline and CSG field construction works that are carried out during the evening and night time noise and within the recommended off-set distances specified in **Section 8.1.2** and **8.1.3**.

Noise mitigation strategies should be considered and implemented during work performed during the evening and night-time periods (6.30pm to 6.30am) or on Sundays/Public holidays.

AS 2436-1981 "*Guide to Noise Control on Construction, Maintenance and Demolition Sites"* sets out numerous practical recommendations to assist in mitigating construction noise emissions. Noise control strategies that should be considered for construction activities carried out on Gladstone LNG Project are listed below.

<u>Source Noise Control Strategies</u>

- Quietest plant and equipment that can economically undertake the work should be selected, wherever possible.
- Regular maintenance of equipment in order to keep it in good working order.

<u>Work Practice Control Strategies</u>

- Construction work to occur, wherever possible, within the daytime period.
- Where practicable, avoid the coincidence of plant and equipment working simultaneously close together.
- Operators of construction equipment to be made aware of the potential noise problems and of techniques to minimise noise emission through a continuous process of operator education.

<u>Community Liaison Strategies</u>

- Utilise existing community consultation framework to provide access to information for the community and maintain positive relations with residents.

For the gas transmission pipeline construction, there are some places where sensitive residents are located closer to the proposed gas transmission pipeline then set-back distance of 500 metres at which the 50 dBA L_{Amax} noise criteria is predicted to be met. For these sections, work during evening and night-time or Sundays/Public holidays should be avoided where possible. Where construction noise levels exceed the recommended criteria or in the event of complaints, an investigation of construction noise may be required.

Blasting should generally be permitted during the hours of 9 am to 3 pm (Monday to Friday) and 9 am to 1 pm on Saturdays. This is in accordance with the EPA's *Ecoaccess Guideline: Noise and Vibration from Blasting*.

The following details elaborate further on the strategies outlined above and should be examined and implemented in critical areas wherever practical.

Work Practice Controls

- Reversing alarms within construction areas cannot be avoided for safety reasons. Consideration should therefore be given to sourcing so-called “quiet” white-noise alarms whose annoying character diminishes quickly with distance and self-adjusting alarms which adjust emission levels relative to the local background noise level.
- Large rocks are to be placed in dump trucks not dropped.
- Horn signals should be kept at a low volume, where feasible.
- For transportation of pipes for the gas transmission pipeline in railway wagons special care need to be considered to avoid metal against metal banging noise during rail operations. This can be avoided by lining the railway wagons with a rubber mat and in a similar way isolate between the pipes.

Source Noise Controls

- Mobile plant and other diesel powered equipment to be fitted with residential class mufflers.
- Minimise the usage of truck exhaust brakes.
- Where possible, use silenced air compressors.

Community Liaison Controls

- Construction site personnel are to be made aware of all community attitudes and complaints.
- Residents are to be made aware of the times and duration that they will be affected. Making residents aware of likely future occurrence of noise significantly reduces annoyance and allows people to make arrangements accordingly.
- Implement as part of the broader community involvement plan, a well-planned, focussed community awareness programme inviting representative groups of the community to a short, concentrated noise and vibration briefing prior to commencement of works near or within their community.
- Provision of a complaints phone number.
- A nominated person is to receive, log, track and respond to complaints within an appropriate timeframe and to record what actions were taken.

The above strategies are fully detailed in the Environmental Management Plans.

9.1.2 Construction Vibration

Based on the predicted vibration levels in **Section 8.1**, no mitigation measures are required to reduce vibration levels at residences in the communities surrounding the LNG facility.

Vibration impact from construction activities associated with the gas transmission pipeline and CSG fields is expected to be minimal, with the possible exception of blasting.

Section 8.1.2 shows the predicted vibration levels from blasting based on generic blast design parameters. The relevant PVS ground vibration criteria of 5mm/s is predicted to be exceeded for a 50kg MIC blast at a distance of 220m from the blast. It has not yet been determined where blasting would be carried out on the project.

Therefore, it is recommended that all blasts are monitored at the closest/potentially most affected residence in order to establish compliance with the nominated criteria in order to optimise future blast designs, based on actual site conditions. In this way, site laws can be developed to assist with the blast designs in order to ensure compliance with the criteria are met at all nearby residences

Community consultation controls such as those nominated in **Section 9.1.1** should be adhered to for blasting activities.

9.2 Operational Noise and Vibration

9.2.1 LNG Facility

The predicted noise levels for the two alternate LNG facility designs (OCP and C3MR) at full capacity (three process trains) exceed the Guideline's background creep criteria at the majority of assessment locations (refer to **Table 61** and **Table 62** in **Section 8.2.1**). The following section describes the proposed noise mitigations measures to reduce the predicted noise levels from the LNG facility to below the Guideline's background creep criterion. All mitigation measures and associate noise reductions are based on the LNG facility operating at full capacity (three process trains).

It should be noted that the below mitigation measures are only examples of potential noise reduction options. Detailed cost-effective mitigation measures should be explored during the detailed design phase of this project.

OCP LNG Facility Design

Mitigation Scenario 1

Piping located close to the compressors has been identified as the dominant noise source. The initial mitigation measure proposed (Mitigation Scenario 1) includes reducing the pipeline noise by 20 dBA. This should be achievable by choosing appropriately designed silencers on both the intake and outlet pipes for the compressors as well as applying appropriate acoustic lagging on the piping. The predicted noise levels for Mitigation Scenario 1 are presented in **Table 79.**

As noted in **Table 79**, the predicted noise levels for Mitigation Scenario 1 still exceed the applicable background creep noise criteria at three (3) sensitive locations when modelled under 'worst case' weather conditions.

Mitigation Scenario 2

Mitigation Scenario 2 recommends reducing the predicted noise levels to meet the background creep criteria at all assessment locations except Tide Island (P1). To achieve the necessary noise reductions for Mitigation Scenario 2 the following noise mitigation measures are proposed:

- **Combustion turbines** – Improve silencers to reduce the exhaust noise from the combustion turbine exhausts by 6 dBA.
- **Air-cooled exchangers** –Noise emissions from the air-cooled heat exchangers is required to be reduced by 6 dBA. Pre-FEED Studies (2008) has stated sound pressure levels of 86 dBA at 1 metre from the fans. Data from Hudson Product Corporation suggests that a sound pressure level of 80 dBA at 1 m is achievable without specific noise control applied to the fan drivers.
- Vibration isolation is needed for all equipment, pipelines and fans connected to any frame work that can transmit structure borne vibration and re-radiate sound.

Mitigation Scenario 3

Mitigation Scenario 3 recommends further mitigation measures so as background creep criteria are met at all assessment locations, including Tide Island (P1). To achieve the necessary noise reductions for Mitigation Scenario 3, the following noise mitigation measures are proposed:

- **Combustion turbines** – Improved silencers to reduce the exhaust noise from the combustion turbine exhausts by 10 dBA.
- **Air-cooled exchangers** – Noise emissions from the air-cooled heat exchangers to be reduced by 8 dBA to a total sound power level of 111 dBA. This will required specific noise control to be applied to both fans and drivers.
- **Generators** – Improved silencers and an acoustic enclosure to reduce the total sound power level by 10 dBA.
- **Compressors** – Acoustic enclosures to reduce the total sound power level from the compressors by 6 dBA.
- **Misc. Equipment** – The total sound power level from the major noise generating pumps (ie the lean solvent charge pumps) to be reduced by 6 dBA.
- **Boil off Gas Compressor** – An acoustic enclosure and silencer on the intake and outlet would be required to reduce the total sound power level by 10 dBA.
- Vibration isolation is needed for all equipment, pipelines and fans connected to any frame work that can transmit structure borne vibration and re-radiate sound.

Significant noise mitigation measures are required to achieve the noise reductions necessary for compliance with the applicable noise criteria at all assessment locations (including P1, Tide Island) for the OCP LNG facility design. This is reflected in the noise mitigation requirements specified for Mitigation Scenario 3. Significantly less noise mitigation is required to achieve compliance with the applicable noise criteria at all assessment locations except P1 (Tide Island) as can be seen for Mitigation Scenario 2.

The predicted noise levels with the recommended mitigation measures and associated noise reductions are shown in **Table 79** Noise level predictions have been carried out for 'worst case" weather conditions for all mitigation scenarios. The low frequency assessment is presented in **Table 80**.

Table 79 OCP LNG Facility Design with 3 Process Trains – Mitigated

Assessment Locations	Predicted Sound Pressure Levels (dBA)						
	Background Creep Criteria (dBA)	Mitigation Scenario 1		Mitigation Scenario 2		Mitigation Scenario 3	
		Neutral Weather	"Worst Case" Weather	Neutral Weather	"Worst Case" Weather	Neutral Weather	"Worst Case" Weather
P1 (3.4 km)	31	34 (+3)	39 (+5)	31 (0)	37 (+6)	26 (-5)	31 (0)
P2 (10 km)	25	18 (-7)	21 (-4)	13 (-12)	17 (-8)	9 (-16)	13 (-12)
P3 (7.9 km)	27	26 (-1)	31 (+4)	22 (-5)	27 (0)	18 (-9)	23 (-4)
P4 (12.4 km)	27	16 (-11)	20 (-7)	12 (-15)	16 (-11)	8 (-19)	12 (-15)
P5 (10.5 km)	25	20 (-5)	25 (0)	16 (-9)	20 (-5)	12 (-13)	17 (-8)
P6 (7.2 km)	28	23 (-5)	28 (0)	20 (-8)	25 (-3)	15 (-3)	20 (-8)
P7 (7.0 km)	30	29 (-1)	33 (+3)	25 (-5)	30 (0)	21 (-9)	25 (-5)
Boundary A	-	62	63	59	61	53	55
Boundary B	-	67	68	64	65	60	60
Boundary C	-	58	59	55	57	50	52
Boundary D	-	57	59	55	57	49	51

Table 80 OCP LNG Facility Design with 3 Process Trains - Mitigated Low Frequency Assessment – "Worst Case" Weather

Assessment Locations	Predicted Low Frequency Sound Pressure Levels $L_{pA,LF}$ (dBA)			
	Low Frequency Criteria[1] $L_{pA,LF}$ (dBA)	Mitigation Scenario 1	Mitigation Scenario 2	Mitigation Scenario 3
P1 (3.4 km)	23	32	27	24
P2 (10 km)	23	20	15	12
P3 (7.9 km)	23	28	23	19
P4 (12.4 km)	23	19	14	11
P5 (10.5 km)	23	23	18	15
P6 (7.2 km)	23	23	18	14
P7 (7.0 km)	23	30	25	21

Note 1: Low frequency criteria raised 3 dB to represent outdoor levels

The low frequency noise predictions (as shown in **Table 80**) show that there are significant low frequency components in the overall noise levels predicted at receiver locations in the Gladstone region. The low frequency criterion is exceeded by 1 dBA at Tide Island for Mitigation Scenario 3.

As noted in **Section 7.6.1**, many assumptions were made regarding the frequency spectra (octave band data) for many of the major plant items due to a lack of data at the time of reporting. It is therefore recommended that the low frequency noise assessment component of this report be more closely assessed during the detailed design phase of this project when more accurate octave data would be available.

However, based on the initial assessment of low frequency noise, it is expected that compliance with the applicable noise criteria is able to be achieved with the incorporation of appropriate noise mitigation measures to the LNG facility. The details of such noise mitigation measures would be determined during the detailed design phase, when more detailed information relating to plant items is available.

C3MR LNG Facility Design

Mitigation Scenario 1

Similar to the OCP LNG facility design, piping located close to the compressors has been identified as the dominant noise source for the C3MR LNG facility design. The initial mitigation measure (Mitigation Scenario 1) recommends reducing the pipeline noise by 20 dBA. This should be achievable by choosing appropriately designed silencers on both the intake and outlet pipes for the compressors as well as applying appropriate acoustic lagging on the pipelines. The predicted noise levels for Mitigation Scenario 1 are presented in **Table 81.**

As noted in **Table 81**, the predicted noise levels for Mitigation Scenario 1 meet the background creep criteria at all assessment locations except Tide Island (P1) when modelled under 'worst case' weather conditions.

Mitigation Scenario 2

Mitigation Scenario 2 has the same noise controls as Mitigation Scenario 1 as the objective of reducing the predicted noise levels to meet the background creep criteria at all assessment locations except Tide Island (P1) is already achieved (for Mitigation Scenario 1). Therefore for the C3MR LNG facility design no mitigation measures additional to those nominated for Mitigation Scenario 1 are required to achieve this objective. This results in the same predicted noise levels for Mitigation Scenario 1 and 2.

Mitigation Scenario 3

Mitigation Scenario 3 recommends further mitigation measures so as background creep criteria are met at Tide Island (P1). To achieve the necessary noise reductions for Mitigation Scenario 3, the following noise mitigation measures are proposed:

- **Combustion turbines** – Improved silencers to reduce the exhaust noise from the combustion turbine exhausts by 8 dBA.
- **Air-cooled exchangers** – Noise emission from the air-cooled heat exchangers is required to be reduced by 7 dBA to a total sound power level of 109 dBA. This will required specific noise control to be applied to both fans and drivers.
- **Generators** – Improved silencers and an acoustic enclosure to reduce the total sound power level by 8 dBA.
- **Compressors** – Acoustic enclosures to reduce the total sound power level from the compressors by 6 dBA.
- **Pumps** – The total sound power level from the major noise generating pumps (ie the lean solvent charge pumps) need to be reduced by 8 dBA.
- **Boil off Gas Compressor** – An acoustic enclosure and silencer on the intake and outlet would be required to reduce the total sound power level by 10 dBA.
- Vibration isolation is needed for all equipment, pipelines and fans connected to any frame work that can transmit structure borne vibration and re-radiate sound.

Significant noise mitigation measures are required to achieve the noise reductions necessary for compliance with the applicable noise criteria at all assessment locations (including P1, Tide Island) for the C3MR LNG facility design. This is reflected in the noise mitigation requirements specified for Mitigation Scenario 3. Significantly less noise mitigation is required to achieve compliance with the applicable noise criteria at all assessment locations except P1 (Tide Island) as can be seen for Mitigation Scenario 1 and 2.

The predicted noise levels with the recommended mitigation measures and associated noise reductions are shown in **Table 81**. Noise level predictions have been carried out for 'worst case" weather conditions for all mitigation scenarios. The low frequency assessment is presented in **Table 82**.

Table 81 C3MR LNG Facility Design with 3 Process Trains – Mitigated

Assessment Locations	Predicted Sound Pressure Levels dBA				
	Background Creep Criteria (dBA)	Mitigation Scenario 1 and 2		Mitigation Scenario 3	
		Neutral Weather	Worst Case Weather	Neutral Weather	Worst Case Weather
P1 (3.4 km)	31	32 (-1)	38 (+5)	26 (-5)	31 (0)
P2 (10 km)	25	12 (-13)	16 (-9)	9 (-16)	13 (-12)
P3 (7.9 km)	27	22 (-5)	27 (0)	18 (-9)	22 (-5)
P4 (12.4 km)	27	10 (-17)	14 (-13)	7 (-20)	11 (-16)
P5 (10.5 km)	25	15 (-11)	19 (-7)	11 (-13)	15 (-10)
P6 (7.2 km)	28	20 (-8)	25 (-3)	15 (-13)	20 (-8)
P7 (7.0 km)	30	24 (-6)	29 (-1)	19 (-11)	24 (-6)
Boundary A	-	64	64	57	58
Boundary B	-	59	60	52	53
Boundary C	-	55	56	48	50
Boundary D	-	59	61	53	54

Table 82 C3MR LNG Facility Design with 3 Process Trains - Mitigated Low Frequency Assessment – "Worst Case" Weather

Assessment Locations	Predicted Low Frequency Sound Pressure Levels $L_{pA,LF}$ (dBA)		
	Low Frequency Criteria[1] $L_{pA,LF}$ (dBA)	Mitigation Scenario 1 and 2	Mitigation Scenario 3
P1 (3.4 km)	23	25	23
P2 (10 km)	23	14	11
P3 (7.9 km)	23	22	19
P4 (12.4 km)	23	13	10
P5 (10.5 km)	23	16	13
P6 (7.2 km)	23	16	14
P7 (7.0 km)	23	23	20

Note 1: Low frequency criteria raised 3 dB to represent outdoor levels

The low frequency noise predictions (as shown in **Table 82**) show that there are significant low frequency components in the overall noise levels predicted at receiver locations in the Gladstone region. The low frequency criterion is complied with at all assessment locations for Mitigation Scenario 3.

As noted in **Section 7.6.1**, many assumptions were made regarding the frequency spectra (octave band data) for many of the major plant items due to a lack of data at the time of reporting. It is therefore recommended that the low frequency noise assessment component of this report be more closely assessed during the detailed design phase of this project when more accurate octave data would be available.

The predicted low frequency noise levels in **Table 82** show that compliance with the applicable noise criteria is able to be achieved with the appropriate noise mitigation measures. The details of such noise mitigation measures would be determined during the detailed design phase, when more detailed information relating to plant items is available.

Shipping Movements

No noise mitigation measures would be required for noise emission from ship movements associated with the LNG facility.

LNG Facility Flare

The applicable short-term intrusive noise criteria is met at all assessment locations for flare noise with the exception of P1 (Tide Island) where the noise criteria is exceeded by up to 4 dBA (depending on the LNG facility design). Noise mitigation is required to achieve compliance with the noise criteria at P1 (Tide Island) during flare events. The overall sound power level from the flare is required to be reduced to 143 dBA (or a sound pressure level of 96 dBA at 120 m) in order to achieve compliance with the noise criteria. The 4 dBA noise level reduction may be achieved using various mitigation techniques including (but not limited to) lagging of piping, muffling the gas stream jets (or via water injection) and incorporating design measures such as appropriate diameter flare ports.

9.2.2 CSG Fields

The achievable noise reductions from mitigation measures incorporated at compressor sites were supplied by URS (URS 2008 [2]) as shown in **Table 83**.

Table 83 Noise Reduction from Mitigation Measures - Compressor Sites, CSG Fields

	Noise Reduction (dB) - Octave Band centre frequency (Hz)							
Mitigation	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**
Hospital grade exhaust silencer (assumed to be standard)	25	45	45	25	25	25	25	25
Secondary absorptive exhaust silencer	10	15	20	30	30	20	15	10
Absorptive splitter attenuator – 50% free area, 1.2m long	2	6	11	20	23	19	12	10
100 mm thick mineral wool insulated panel with steel facing (inner perforated)	15 (3)	20 (11)	25 (13)	30 (20)	30 (28)	35 (35)	45 (40)	45 (42)

Source: URS (2008 [2])

Note: Numbers in brackets refer to measured reductions (in octave bands) from previous work Heggies has undertaken. These measurements were based on a 130mm thick mineral wool insulated panel with steel facing, double skin construction.

In addition to the hospital grade exhaust silencer (assumed to be standard), the following additional noise mitigation measures were also incorporated into the prediction of noise emissions from compressor sites:

- Additional secondary absorptive exhaust silencer fitted to the gas engine exhaust
- Absorptive splitter attenuator installed on the gas engine air inlet

- The engines and compressors have been fully enclosed in either separate buildings or a single building enclosing all engines/compressors. The building walls and roof have a double skin construction consisting of an outer metal sheet, 100 mm thick mineral wool and an inner perforated metal sheet. The engine/compressor building is likely to require auxiliary ventilation, which has not been included in the prediction.

Based on the noise mitigation measures and associated noise reductions described in **Table 83**, predicted noise levels and the associated off-set buffer distances at which the background creep and low frequency criteria are expected to be met have been calculated for the operation of a compressor site. The predicted off-set buffer distances are shown in **Table 84**.

Table 84 Set Back Distances to Achieve the Noise Criteria – With Additional Mitigation

Process	Background Creep Criteria (dBA)	Low Frequency $L_{pA,LF}$ Criteria (dBA)	Set Back Distance (m)
Compressor Site	25	-	1000
Compressor Site	-	23	750

The predicted off-set buffer distances in **Table 84** assume flat, soft terrain and no dense vegetation or forest. With dense forest of approximately 400 metres between sources and receiver the sound propagation could potentially be reduced by up to 10 dBA reducing the required off-set buffer distance required between compressor sites and noise sensitive residences to approximately 500 metres.

The off-set buffer distances shown in **Table 84** are based on a sound power level (refer to **Table 9**) for a compressor site (including 4 large compressors, 2 mid size compressors and 3 small-sized compressors) and the supplied noise reduction data for the mitigation measured described above (refer to **Table 83**). It is recommended that this data be reviewed in order to confirm noise emissions from individual plant items during the detail design phase of this Project to confirm the accuracy of the predicted off-set distances.

10 DISCUSSION AND CONCLUSION

Heggies has undertaken a terrestrial noise and vibration impact assessment for the construction and operational phases of the proposed Gladstone LNG Project (incorporating the LNG facility, the gas transmission pipeline and CSG fields).

Long-term unattended noise measurements were conducted within the communities surrounding Roma, Injune, Banana, Biloela, Yarwun and Gladstone in order to determine the existing noise environment (see **Section 5.3**) and the applicable noise criteria (see **Section 6**).

The noise and vibration assessment has found that compliance with the applicable noise criteria is able to be achieved with the appropriate noise mitigation measures (see **Section 9**) and allowing for the appropriate off-set buffer distances between construction and operational plant items and noise sensitive receivers.

A summary of the assessment of noise and vibration predictions against the applicable noise criteria and the recommended noise mitigation measures is provided below.

10.1 Construction Noise and Vibration

The relevant construction noise and vibration criteria are detailed in **Section 6.2**.

Based on the predicted vibration levels in **Section 8.1**, no mitigation measures are required to reduce vibration levels at residences in the communities surrounding the LNG facility.

Vibration impact from construction activities associated with the gas transmission pipeline and CSG fields is expected to be minimal, with the possible exception of blasting.

The relevant PVS ground vibration criteria of 5mm/s is predicted to be exceeded for a 50kg MIC blast at a distance of 220m from the blast. It has not yet been determined where blasting would be carried out on the project. Therefore a vibration monitoring program is recommended for blasting activities near sensitive receptors or structures in order to assist with the blast designs in order to ensure compliance with the criteria are met at all nearby residences.

The construction noise modelling scenarios (as described in **Section 7.5**) were assessed against the applicable noise criteria. The results were as follows:

- **LNG Facility –** The construction noise and vibration associated with the LNG facility (including clear and grade, construction scenarios for erecting the LNG facility, pile driving for the jetty, truck traffic, dredging, bridge and gas transmission pipeline crossing) is predicted to meet the noise criteria at all assessment locations in the Gladstone area.
- **Gas Transmission Pipeline –** The predicted off-set buffer distance at which the applicable construction noise criteria (50 dBA L_{Amax} sleep disturbance) is expected to be met for noise associated with gas transmission pipeline construction works is 500 m. The predicted off-set buffer distance at which the applicable construction noise criteria (50 dBA L_{Amax} sleep disturbance) is expected to be met for noise associated with rail laydown areas is 400 m. Based on a blast with a 50 kg MIC the airblast criteria (115 dBL) is predicted to be exceeded at distances within 420 m of the blast
- **Gas Wells –** The predicted off-set buffer distance at which the applicable construction noise criteria (50 dBA L_{Amax} sleep disturbance) is expected to be met for noise associated with gas well construction works is 425 m.
- **Compressor Site –** The predicted off-set buffer distance at which the applicable construction noise criteria (50 dBA L_{Amax} sleep disturbance) is expected to be met for noise associated with compressor site construction works is 425 m.

10.2 Operational Noise and Vibration

There are no major vibration sources associated with the operational phase of the project likely to generate vibrations at the sensitive receivers.

Operational noise criteria have been developed in accordance with Ecoaccess Guideline based upon the measured existing noise levels as outlined in **Section 6.3**. Operational noise modelling scenarios (as described in **Section 7.6**) were assessed against these criteria. A summary of the noise modelling results are described below for the scenario without any noise mitigation measures.

- **OCP LNG Facility 1 Process Train –**
  - Neutral weather conditions - the noise criteria is exceeded at one (1) receiver by 2 dBA.
  - "Worst case" weather conditions - the noise criteria are exceeded at three (3) receivers by 3 dBA to 7 dBA.
- **OCP LNG Facility 3 Process Train –**
  - Neutral weather conditions - the noise criteria is exceeded at three (3) receivers by 4 dBA to 8 dBA.
  - "Worst case" weather conditions, the noise criteria is exceeded at six (6) receivers by 1 dBA to 13 dBA.
- **C3MR LNG Facility 1 Process Train –**
  - Neutral weather conditions - the noise criteria is exceeded at one (1) receiver by 4 dBA.
  - "Worst case" weather conditions - the noise criteria is exceeded at four (4) receivers by 1 dBA to 9 dBA.
- **C3MR LNG Facility 3 Process Train –**
  - Neutral weather conditions - the noise criteria is exceeded at three (3) receivers by 4 dBA to 8 dBA.
  - "Worst case" weather conditions - the above criteria is exceeded at six (6) receivers by 1 dBA to 13 dBA.
- **Gas Transmission Pipeline –** The predicted off-set buffer distance at which the applicable operational noise criteria is expected to be met for noise associated with the operation of the mainline valves is 1,500 m for the scenario without any noise mitigation measures.
- **Gas Wells –** The predicted off-set buffer distance at which the applicable operational noise criteria is expected to be met for noise associated with the operation of the gas wells is 300 m for the scenario without any noise mitigation measures.
- **Compressor Site –** The predicted off-set buffer distance at which the applicable operational noise criteria is expected to be met for noise associated with the operation of the compressor sites is 3,400 m for the scenario without any noise mitigation measures.

Low Frequency Noise

Where applicable, operational noise levels have been assessed against the low frequency noise criteria. Operational noise associated with the LNG facility operating with three (3) Process Trains is predicted to exceed the low frequency noise criteria for both LNG facility designs (OCP and C3MR) at the receivers for which there is an exceedance of the overall noise criteria (for 3 process trains as described above). The level of exceedance of the low frequency noise criteria is similar to the exceedance of the overall noise criteria.

For the CSG fields, low frequency noise from the compressor station has been assessed. The low frequency noise criterion is achieved at a shorter buffer distance from the compressor station than the distance at which the overall noise criteria will be achieved.

No assessment of low frequency noise was undertaken for the gas transmission pipeline, as the noise profile of the mainline valve blowout events was considered to be all mid to high frequency noise (ie greater than 200 Hz).

10.3 Transportation – Road Traffic

The road traffic noise assessment carried out for project related vehicle movements (see **Section 8.3**) revealed that impacts from road traffic noise are predicted to be minimal. Therefore no noise mitigation measures are proposed to attenuate noise from road traffic.

It is recommended however that more detailed modelling be undertaken for new roads associated with the project during the detailed design phase to confirm noise impacts when the final road designs and forecasted traffic data (ie AADT traffic counts, posted speed limits, percentage of commercial vehicles) is known.

10.4 Transportation – Rail Traffic

The rail traffic noise assessment carried out for LNG Project (see **Section 8.4**) revealed that impacts from rail traffic noise are predicted to be minimal.

The predicted rail noise levels indicate that the 87 dBA L_{Amax} noise criteria for rail noise will be achieved for residences not closer than 25 metre from the rail corridor. The cumulative effect to the $L_{Aeq(24hour)}$ noise level from the additional rail movements associated with the LNG Project is less than 0.5 dBA for the Moura rail line (outside Gladstone) and approximately 1.5 dBA increase on the rail section down to Auckland Point. The 65 dBA $L_{Aeq(24hour)}$ noise criteria for rail noise will be achieved for residences not closer than 25 metre from the rail corridor. Therefore no noise mitigation measures are proposed to attenuate noise from rail traffic due to relevant noise criterion being achieve.

It should also be noted that all rail traffic associated with the project would only operate during daytime hours and the additional trains associated with the LNG Project would only be required during the beginning of the construction phase when the pipes for gas transmission pipeline is delivered, approximately 6 months.

10.5 Mitigation Measures

Additional noise mitigation measures beyond the implementation of "best practice" techniques will generally not be required to attenuate construction noise and vibration from the project. The exception is for noise and vibration from blasting, where further investigation is required to determine the predicted impact from this activity.

Appropriate off-set buffer distances to limit the likelihood of construction noise and vibration impact are nominated for the relevant construction activities carried out during the evening and night time periods, these distances should be adhered to where reasonable and feasible. The noise mitigation strategies described in **Section 9.1** should be considered and implemented during work performed during the evening and night-time periods (6.30pm to 6.30am) and on Sundays/Public Holidays.

It should be noted that the below presented mitigation measures for the operational phase are only examples of potential noise reduction options. Detailed cost-effective mitigation measures should be explored during the detailed design phase of this project.

LNG Facility 3 Process Train – Extensive mitigation measures will be required for both the OCP and C3MR LNG facility designs (3 process trains) if background creep criteria are to be met at all assessment locations in the Gladstone region (including Tide Island). Details of the proposed noise mitigation measures for the LNG facility are provided in **Section 9.2.1**. The following noise mitigation scenarios have been considered to reduce noise emissions from the proposed LNG facility:

- **Mitigation Scenario 1** – reducing the noise emission from piping located close to the compressors by 20 dBA. This should be achievable by choosing appropriately designed silencers on both the intake and outlet pipes for the compressors as well as applying appropriate acoustic lagging on the piping.
- **Mitigation Scenario 2** – reducing the predicted noise levels to meet the background creep criteria at all assessment locations except Tide Island (P1). Reductions in noise emissions are required on the combustions turbines and air-cooled exchangers. These additional mitigation measure (to those proposed for Mitigation Scenario 1) are only required for the OCP LNG facility design.
- **Mitigation Scenario 3** - reducing the predicted noise levels to meet the background creep criteria at all assessment locations, including Tide Island (P1). Reductions in noise emissions are required on the following LNG facility items:
  - Piping noise
  - Combustion turbines.
  - Air-cooled exchangers.
  - Generators.
  - Compressors.
  - Pumps (lean solvent charge pump).
  - Boil off gas compressor.

Compressor Site – Extensive noise mitigation measures are required in order to reduce the off-set buffer distance, at which the applicable background creep noise criteria would be met, to approximately 1,000 m. These noise mitigation measures are discussed in **Section 9.2.2** and include a “compressor building” for the compressor packages. It is noted that the calculation of required off-set buffer distances assumes noise propagation over flat, soft terrain and no dense vegetation or forest. If there was dense vegetation and/or local hilly terrain located between the compressor site and the receiver this off-set buffer distance could be reduced.

LNG Facility Flare Noise – A 4 dBA or more noise reduction is required to achieve the applicable short-term intrusive noise criteria at all assessment locations for flare noise. The overall sound power level from the flare is required to be reduced to 143 dBA (or a sound pressure level of 96 dBA at 120 m) in order to achieve compliance with the noise criteria. The 4 dBA noise level reduction may be achieved using various mitigation techniques including (but not limited to) lagging of piping, muffling the gas stream jets (or via water injection) and incorporating design measures such as appropriate diameter flare ports.

Gas Transmission Pipeline – Mitigation is required for mainline valves if the location of the valves is within 1,500m of a sensitive property. Due to the low number of mainline required, it is assumed that these valves can be located in areas which are greater than 1,500m from sensitive properties and therefore mitigation should not be required. This should be reviewed and assessed accordingly during the detailed design phase. If required, additional noise mitigation measures such as barriers/partial enclosure or pipeline lagging may be incorporated into the mainline valve design. This should be reviewed and assessed accordingly during the detailed design phase.

Gas Wells – Mitigation is required for the gas wells if the location of the valves is within 300m of a sensitive property. Should a gas well be located within the 300m off-set distance referred to above, noise mitigation measures such as an enclosure or partial enclosure may be incorporated. This should be reviewed and assessed accordingly during the detailed design phase.

Low Frequency Noise

The low frequency noise predictions (as shown in **Table 80** and **Table 82**) show that there are significant low frequency components in the overall noise levels predicted at receiver locations in the Gladstone region.

As noted in **Section 7.6.1**, many assumptions were made regarding the frequency spectra (octave band data) for many of the major plant items due to a lack of data at the time of reporting. It is therefore recommended that the low frequency noise assessment component of this report be more closely assessed during the detailed design phase of this project when more accurate octave data would be available.

However, based on the initial assessment of low frequency noise, it is expected that compliance with the applicable noise criteria is able to be achieved with the incorporation of appropriate noise mitigation measures to the LNG facility. The details of such noise mitigation measures would be determined during the detailed design phase, when more detailed information relating to plant items is available.

For the CSG fields, low frequency noise from the compressor station has been assessed. The low frequency noise criterion is achieved at a shorter buffer distance from the compressor station than the distance at which the overall noise criteria will be achieved. For this reason, standard mitigation measures required to achieve the overall operational noise criteria are considered to be sufficient to allow the low frequency noise criterion to be achieved.

No assessment of low frequency noise was undertaken for the gas transmission pipeline, as the noise profile of the mainline valve blowout events was considered to be all mid to high frequency noise (ie greater than 200 Hz).

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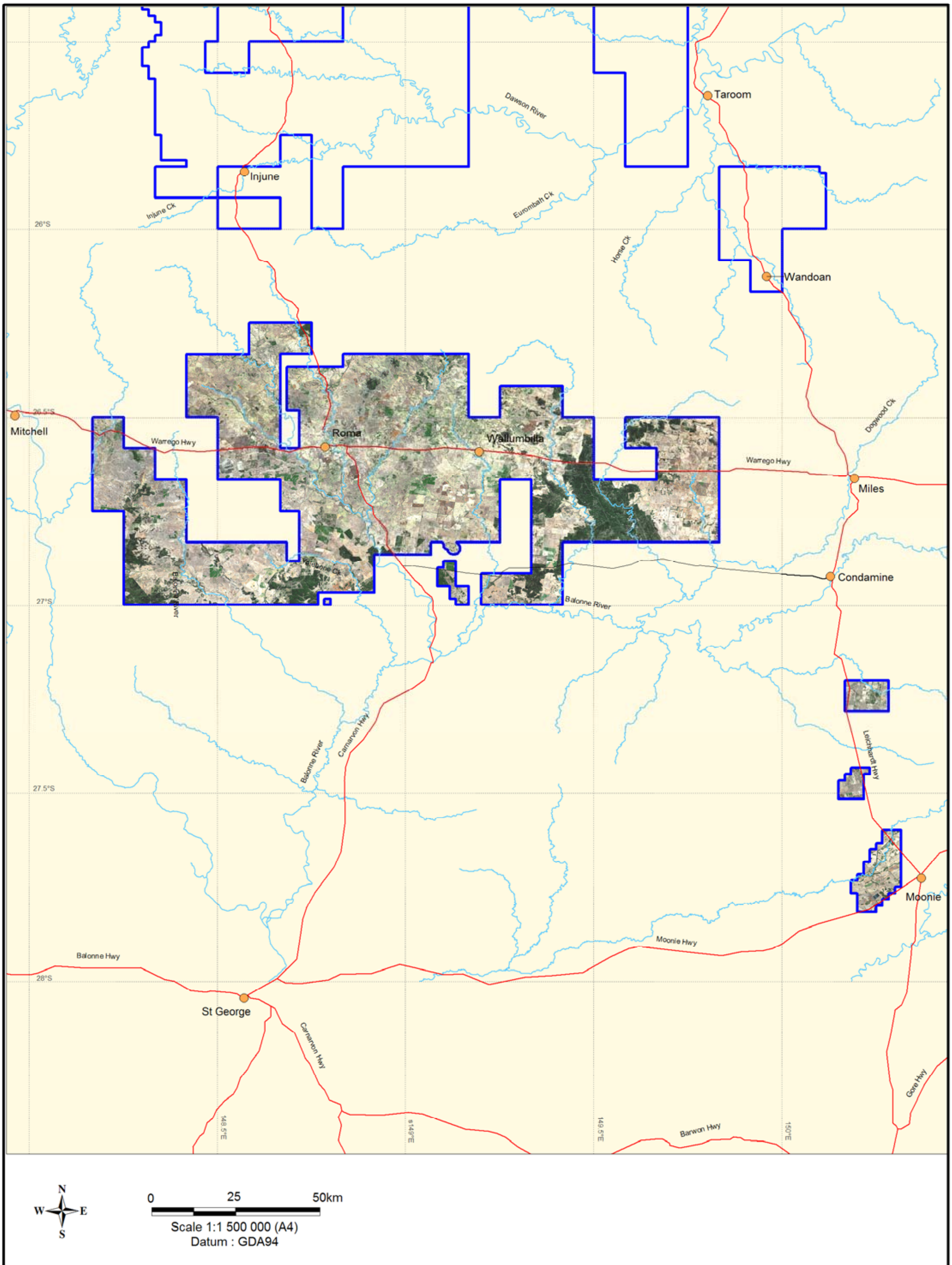
URS, (2008 [2]), Acoustic Report – Wallumbilla Compressor Station Noise Assessment (Reference: 42167587.00200)

SITE PLANS FOR THE CSG FIELDS AND THE PIPELINE ALIGNMENT



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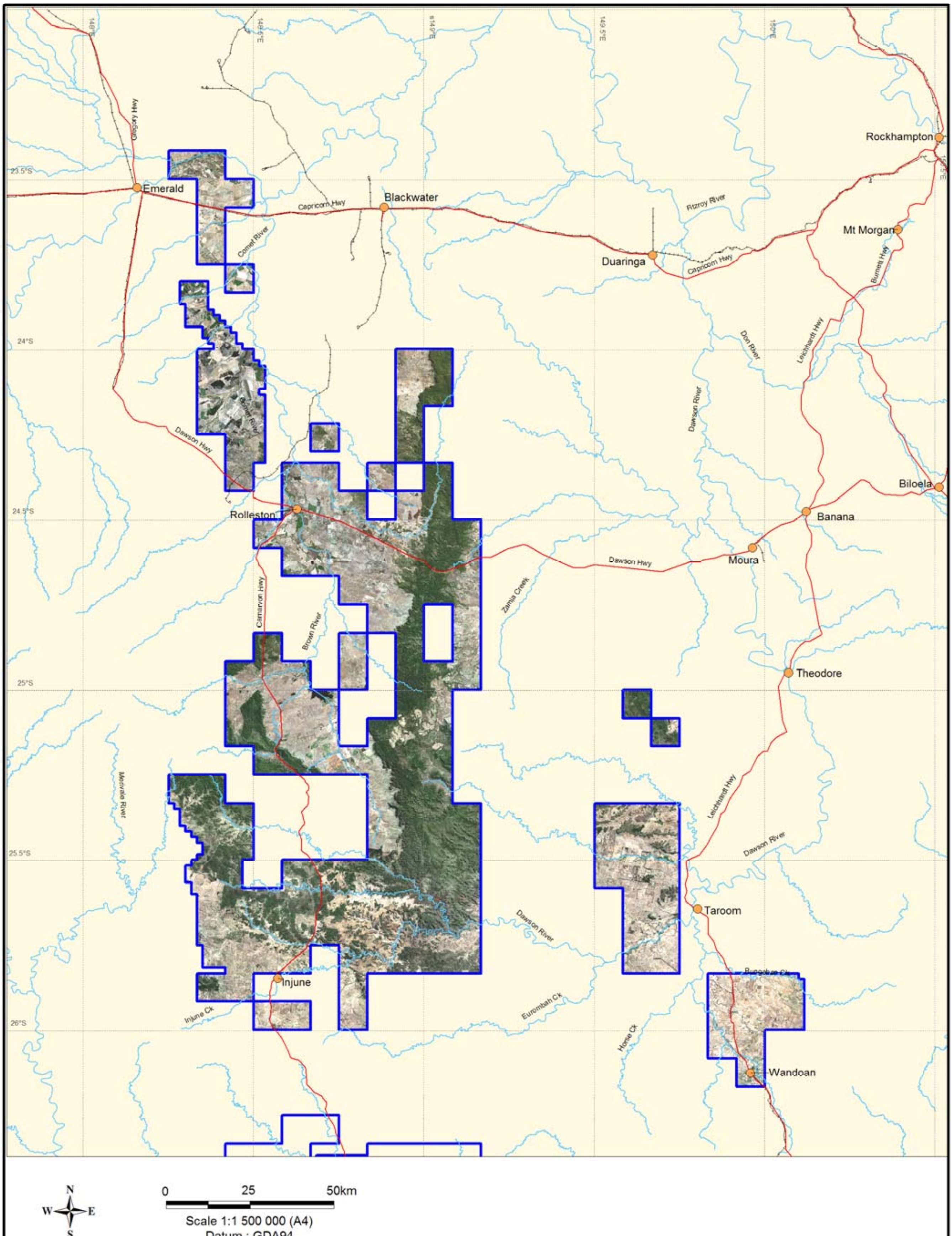
Client	Project	Title
URS / HEGGIES	GLADSTONE LNG PROJECT NOISE AND VIBRATION INVESTIGATION	CSG FIELDS (SOUTHERN SECTION)
	Drawn: LL/GC · Approved: MC · Date: 26-01-2009	Figure: 1 · Rev:A
	Job No: **4262 6220** · File No: 42626220-g-502.wor	A4



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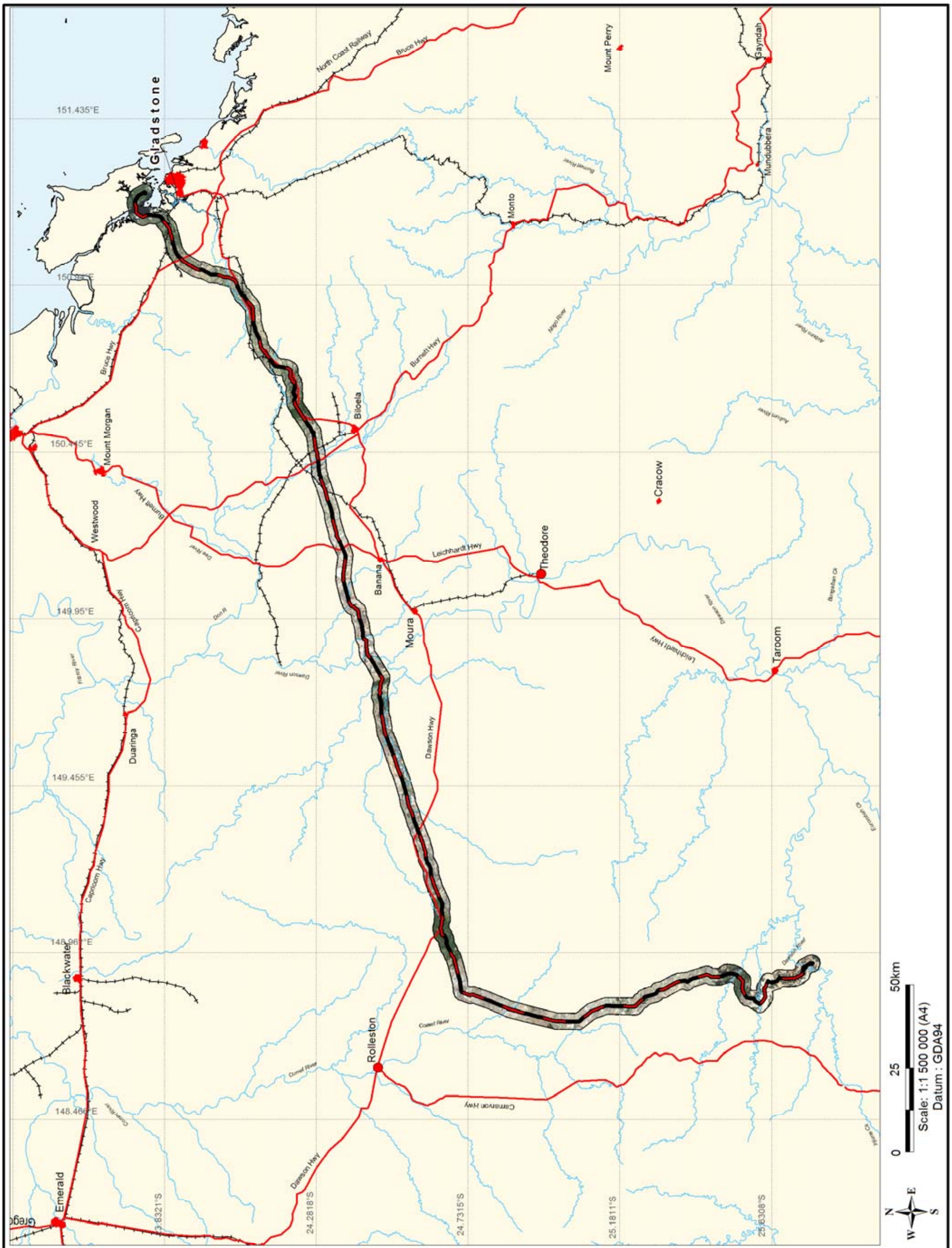
	Drawn: LL/GC; Approved: MC; Date: 26-01-2009	Figure: 2 — Rev:A
	Job No: **4262 6220**; File No: 42626220-g-503.wor	A4



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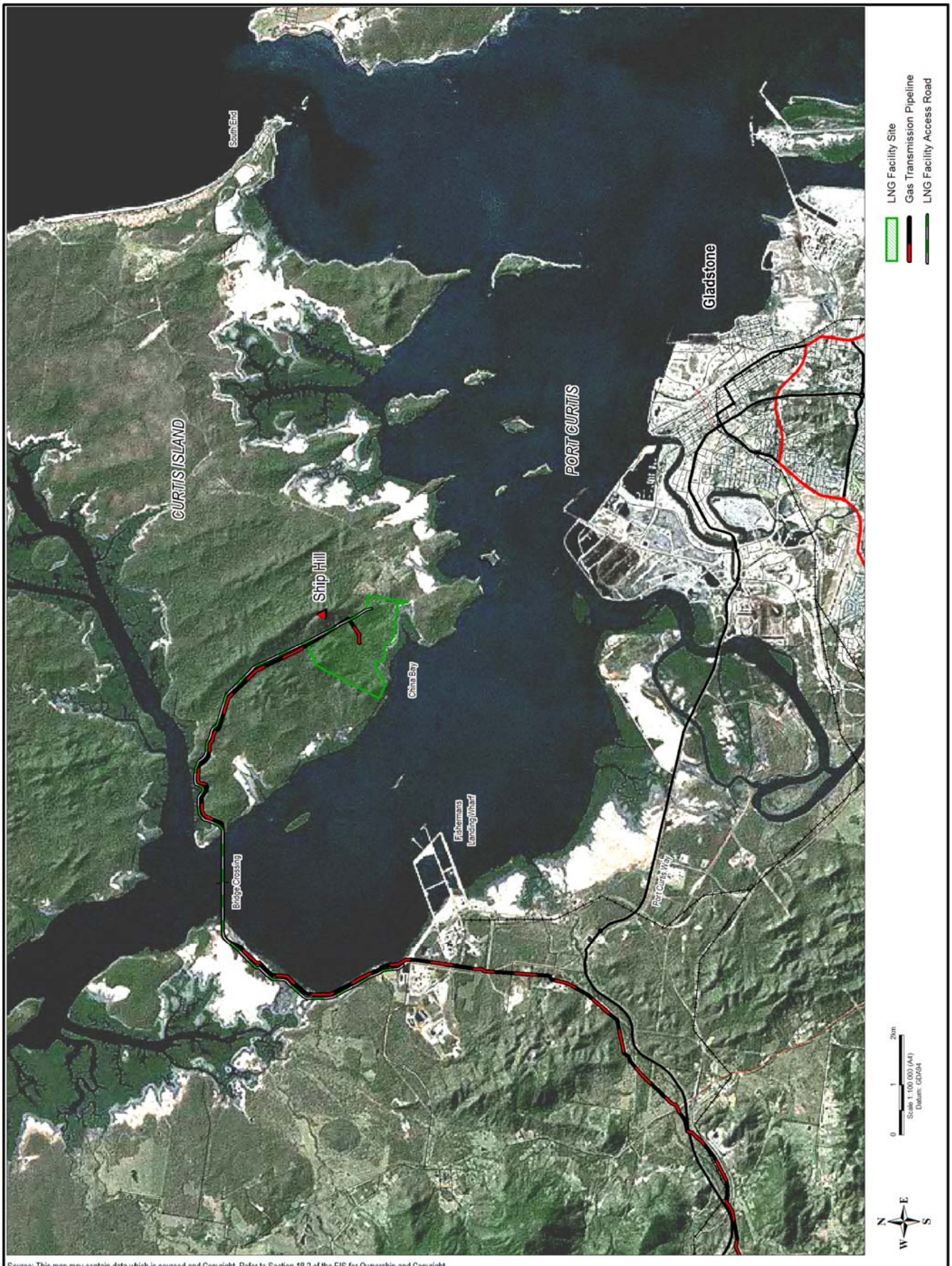
URS	GLADSTONE LNG PROJECT NOISE AND VIBRATION INVESTIGATION	GAS TRANSMISSION PIPELINE CORRIDOR	
HEGGIES	Drawn: LL/GC · Approved: MC · Date: 26-01-2009	Figure: 3	Rev: A
	Job No: **4262 6220** · File No: 42626220-g-504.wor		A4



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Client	Project	Title
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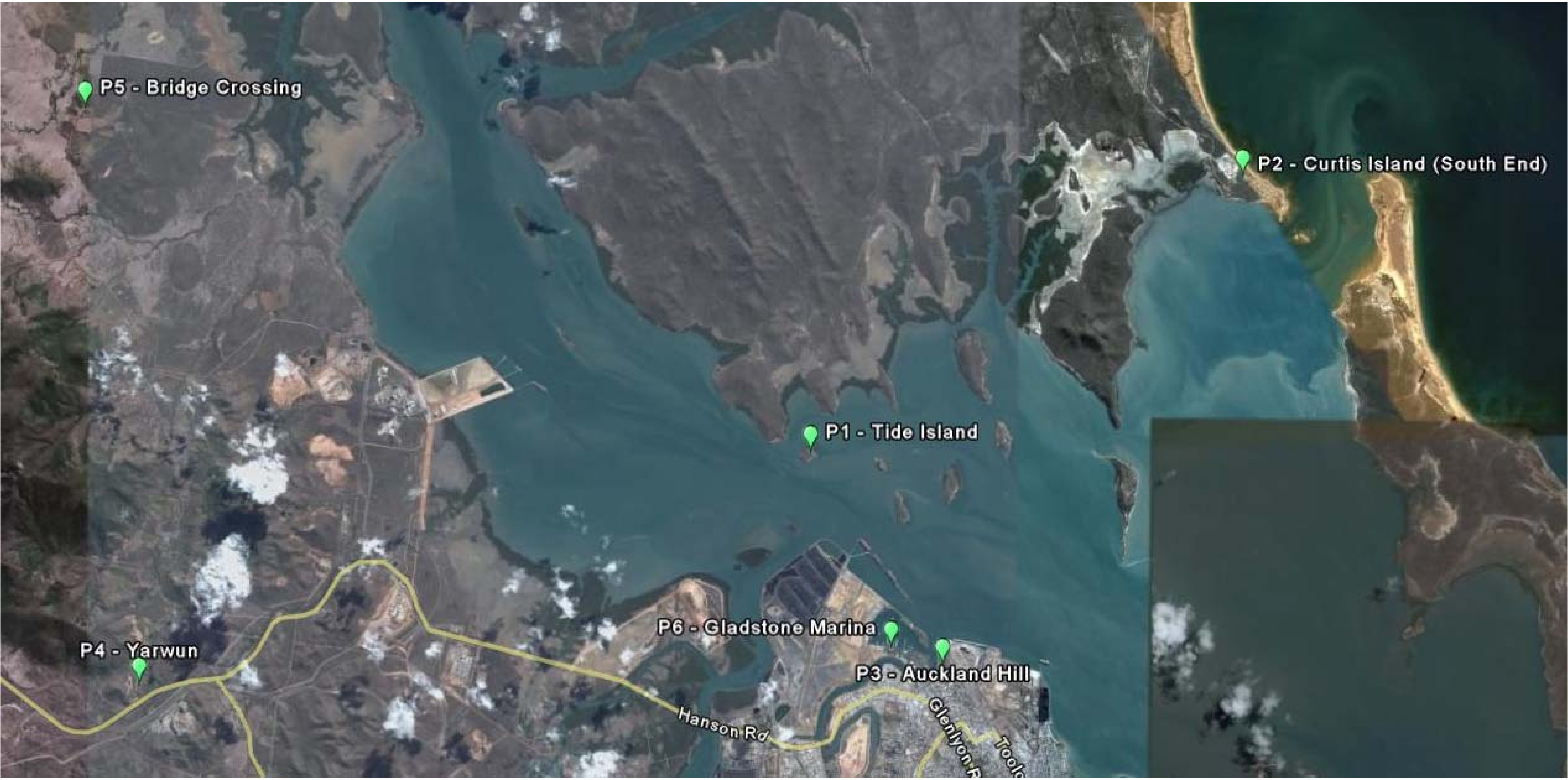
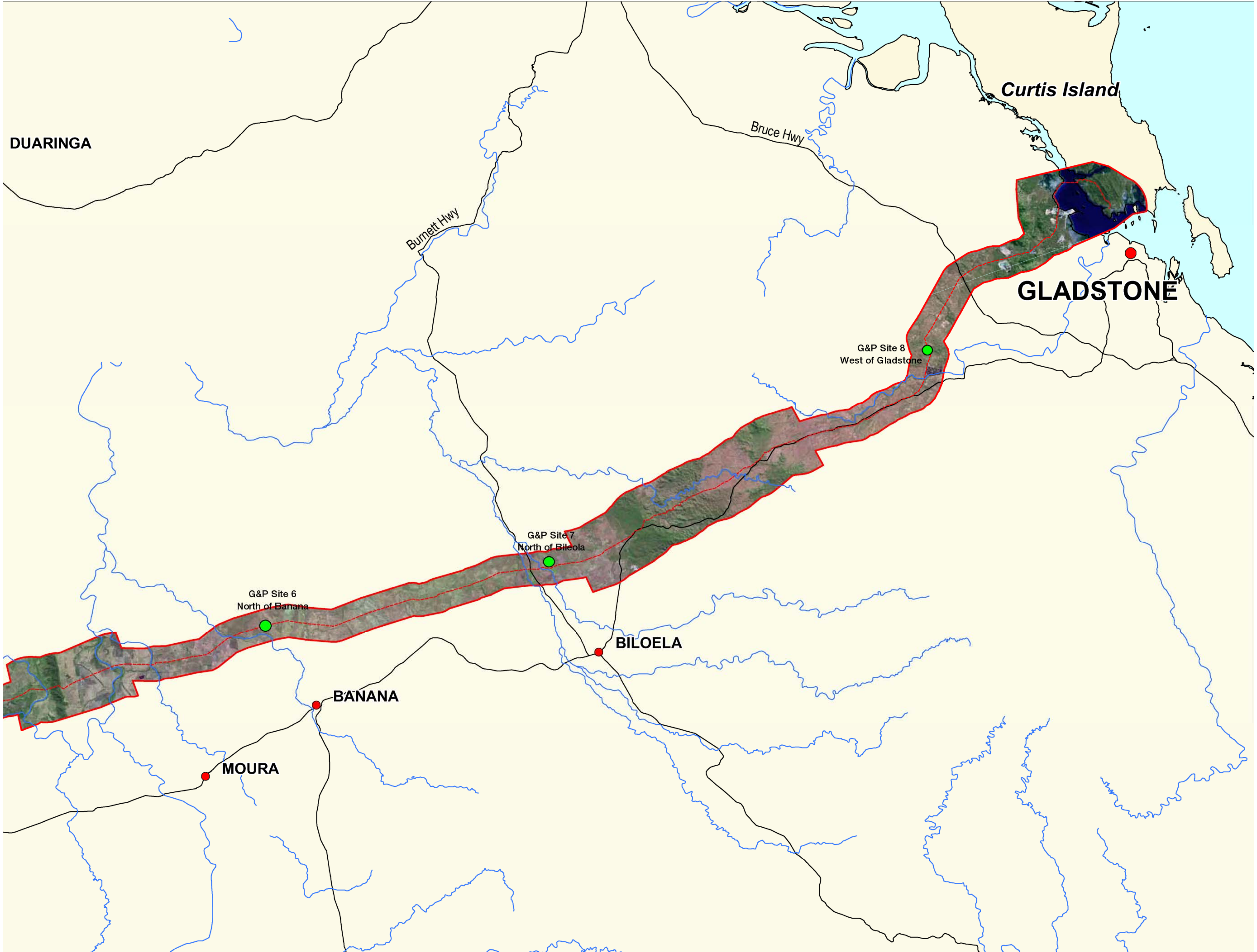
HEGGIES	Drawn: LL/GC · Approved: MC · Date: 26-01-2009 Job No: **4262 6220** · File No: 42626220-g-505.wor	Figure: **4** · Rev: A · A4

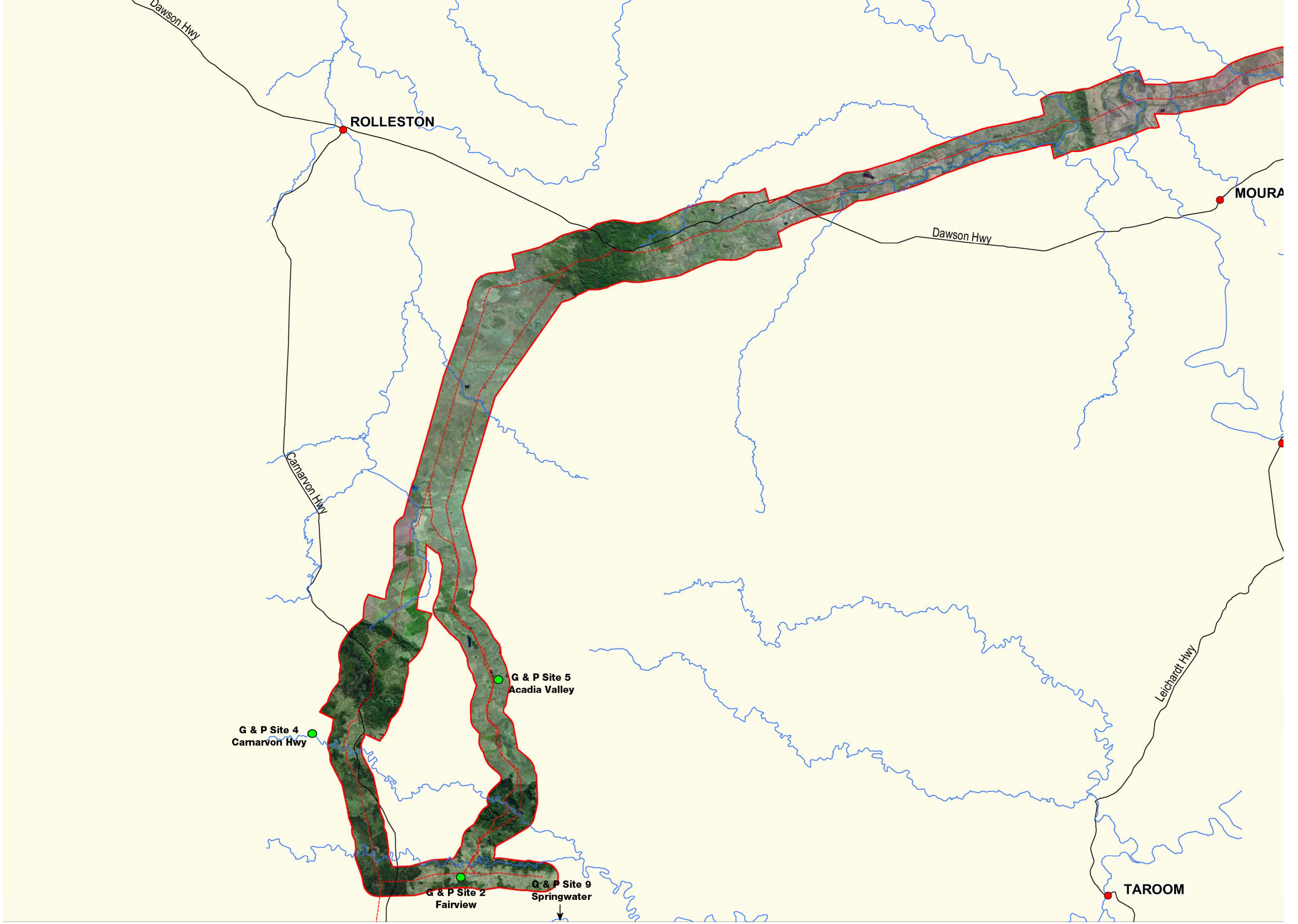
AMBIENT NOISE MONITORING LOCATIONS

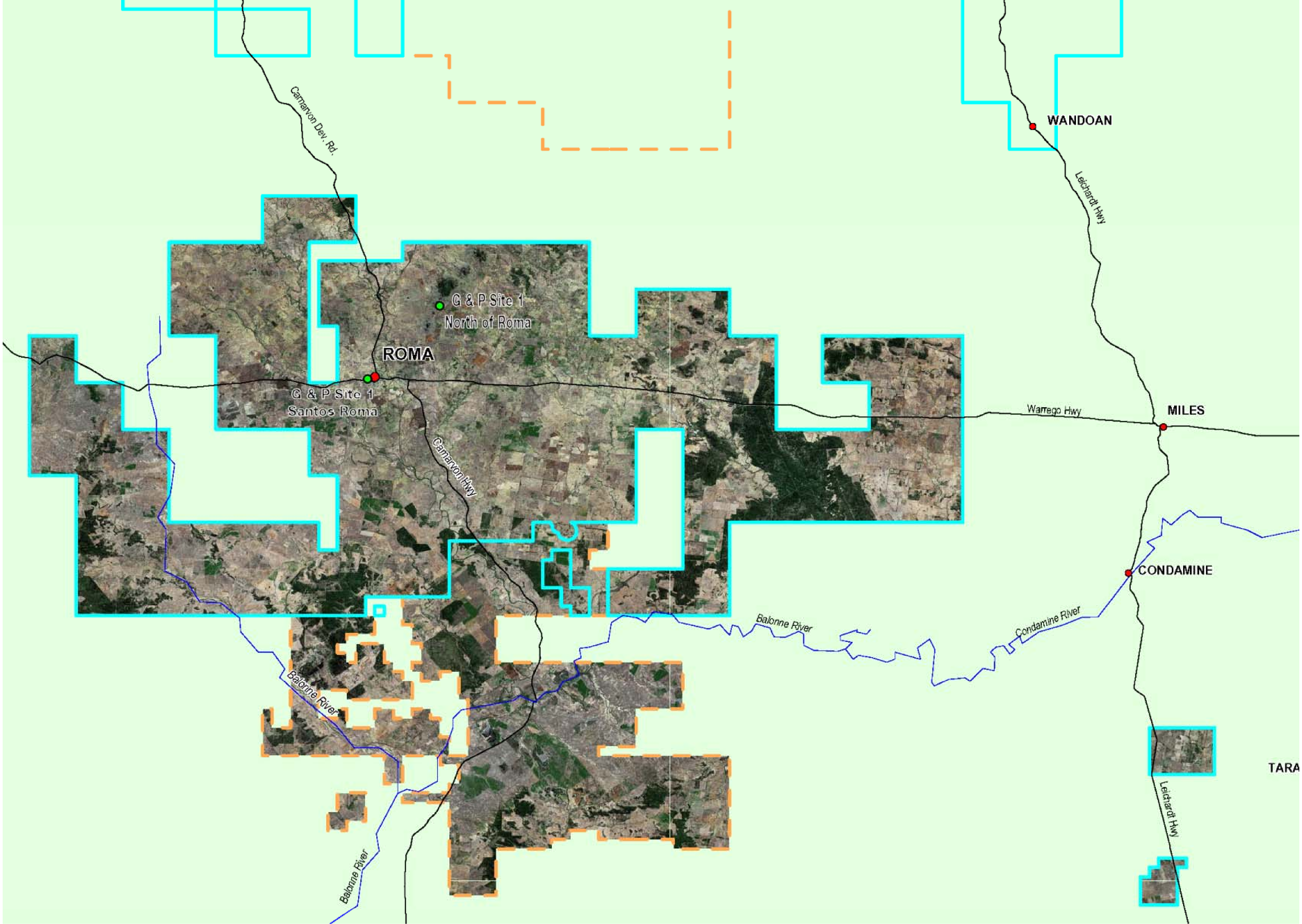


P5 - Bridge Crossing
P2 - Curtis Island (South End)
P1 - Tide Island
P6 - Gladstone Marina
P4 - Yarwun
P3 - Auckland Hill
Hanson Rd



Curtis Island
Bruce Hwy
DUARINGA
Burnett Hwy
GLADSTONE
G&P Site 8
West of Gladstone
G&P Site 7
North of Bileola
G&P Site 6
North of Banana
BILOELA
BANANA
MOURA

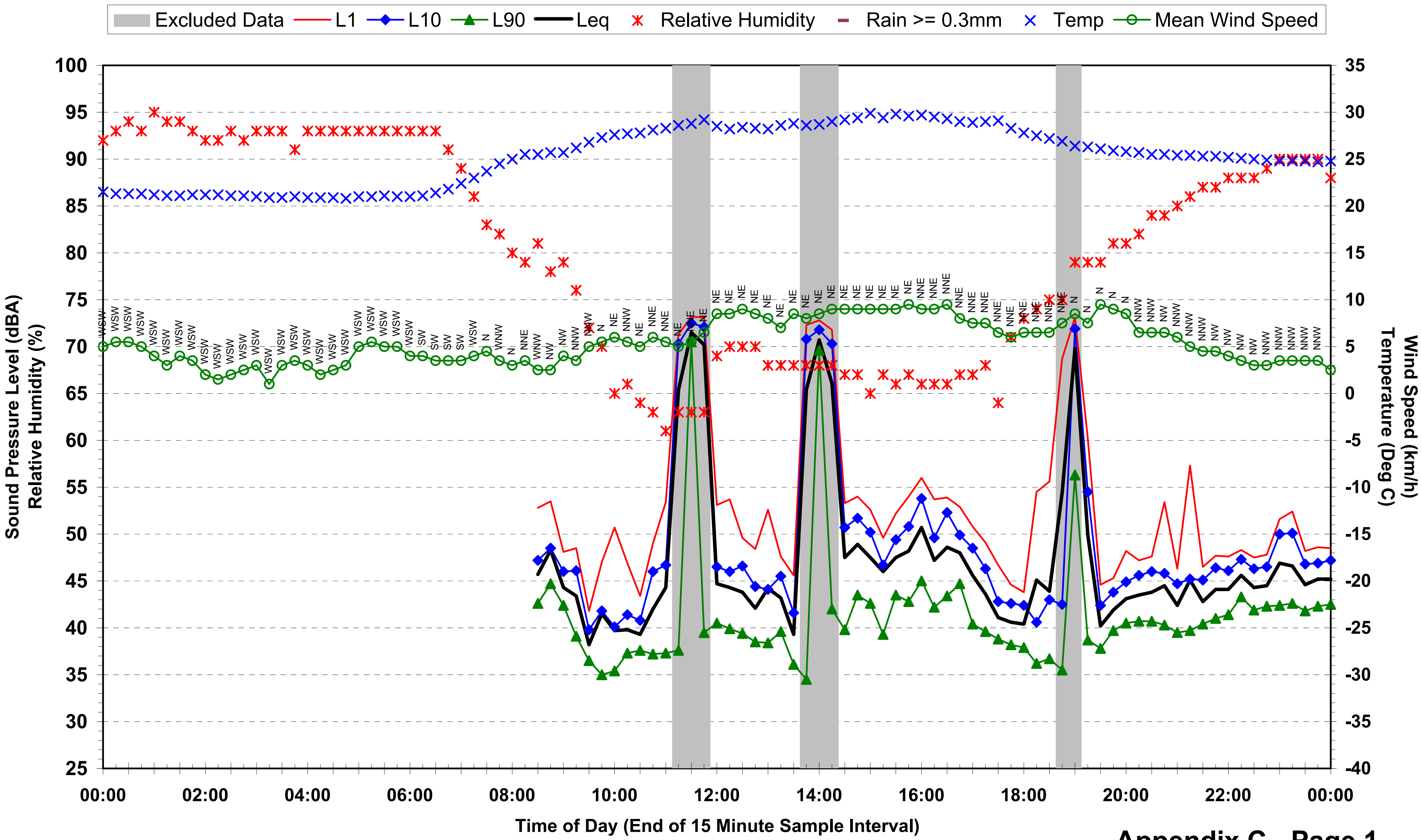

Dawson Hwy
ROLLESTON
MOURA
Dawson Hwy
Carnarvon Hwy
G & P Site 5
Acadia Valley
G & P Site 4
Carnarvon Hwy
Leichardt Hwy
G & P Site 2
Fairview
G & P Site 9
Springwater
TAROOM



Carnarvon Dev. Rd.
WANDOAN
Leichardt Hwy
G & P Site 1
North of Roma
ROMA
G & P Site 1
Santos Roma
Carnarvon Hwy
Warrego Hwy
MILES
CONDAMINE
Balonne River
Condamine River
Balonne River
TARA
Leichardt Hwy
Balonne River

UNATTENDED NOISE MONITORING – STATISTICAL NOISE PLOTS

Statistical Ambient Noise Levels
20-2014 - Plant 1 - Tide Island - Thursday 21 February 2008



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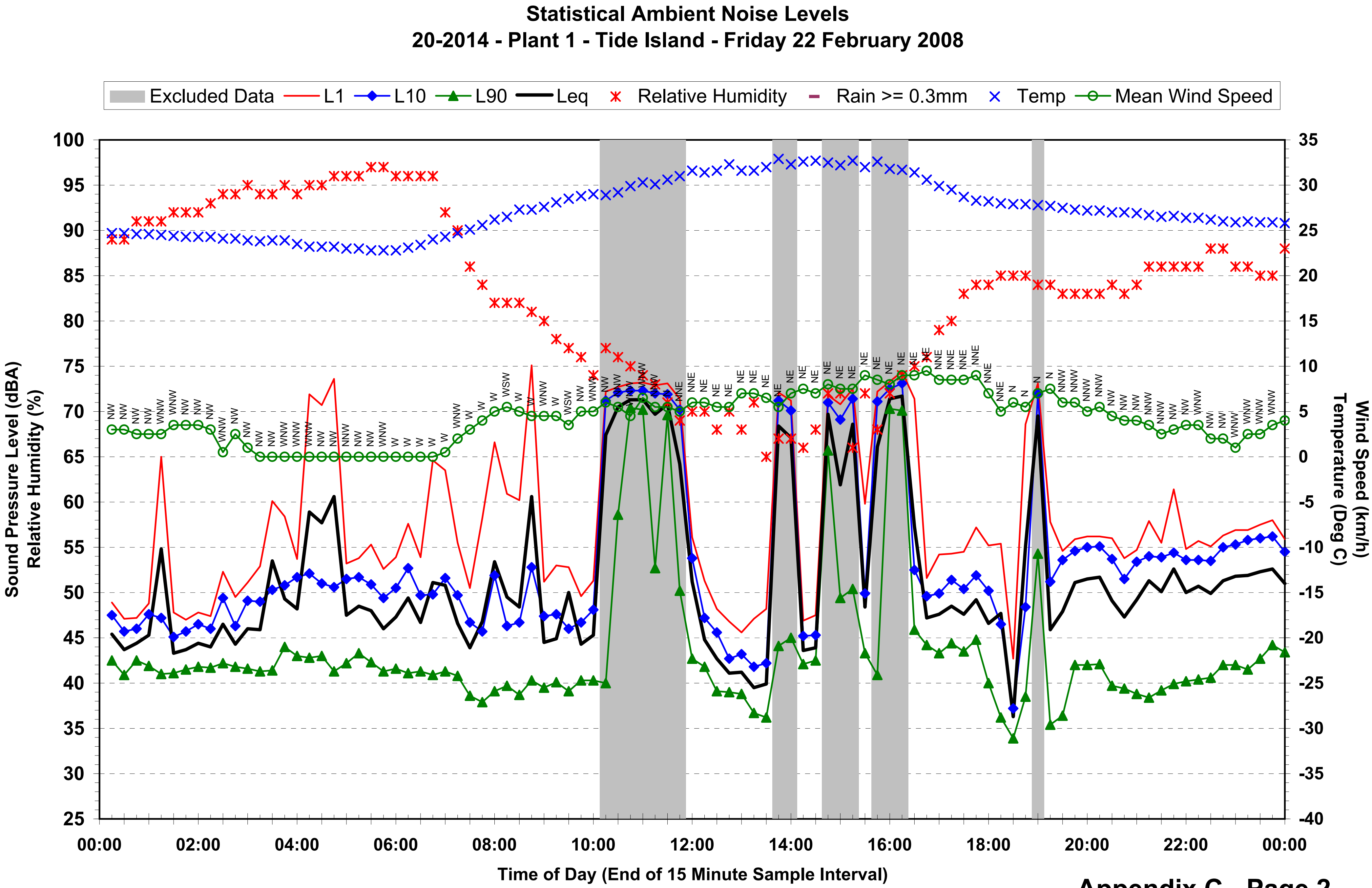
Ambient Conditions
RHA Report 20-2014



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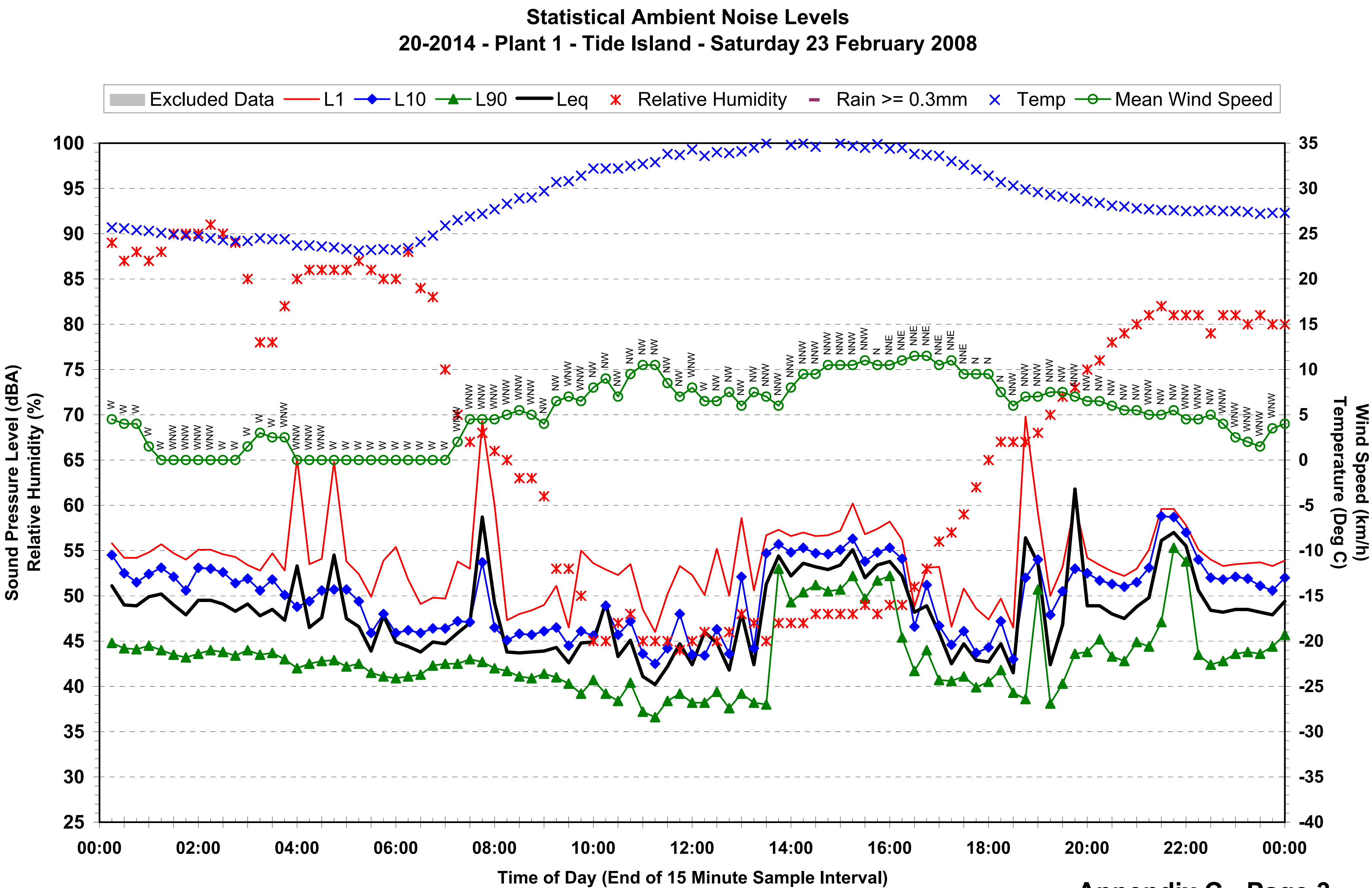
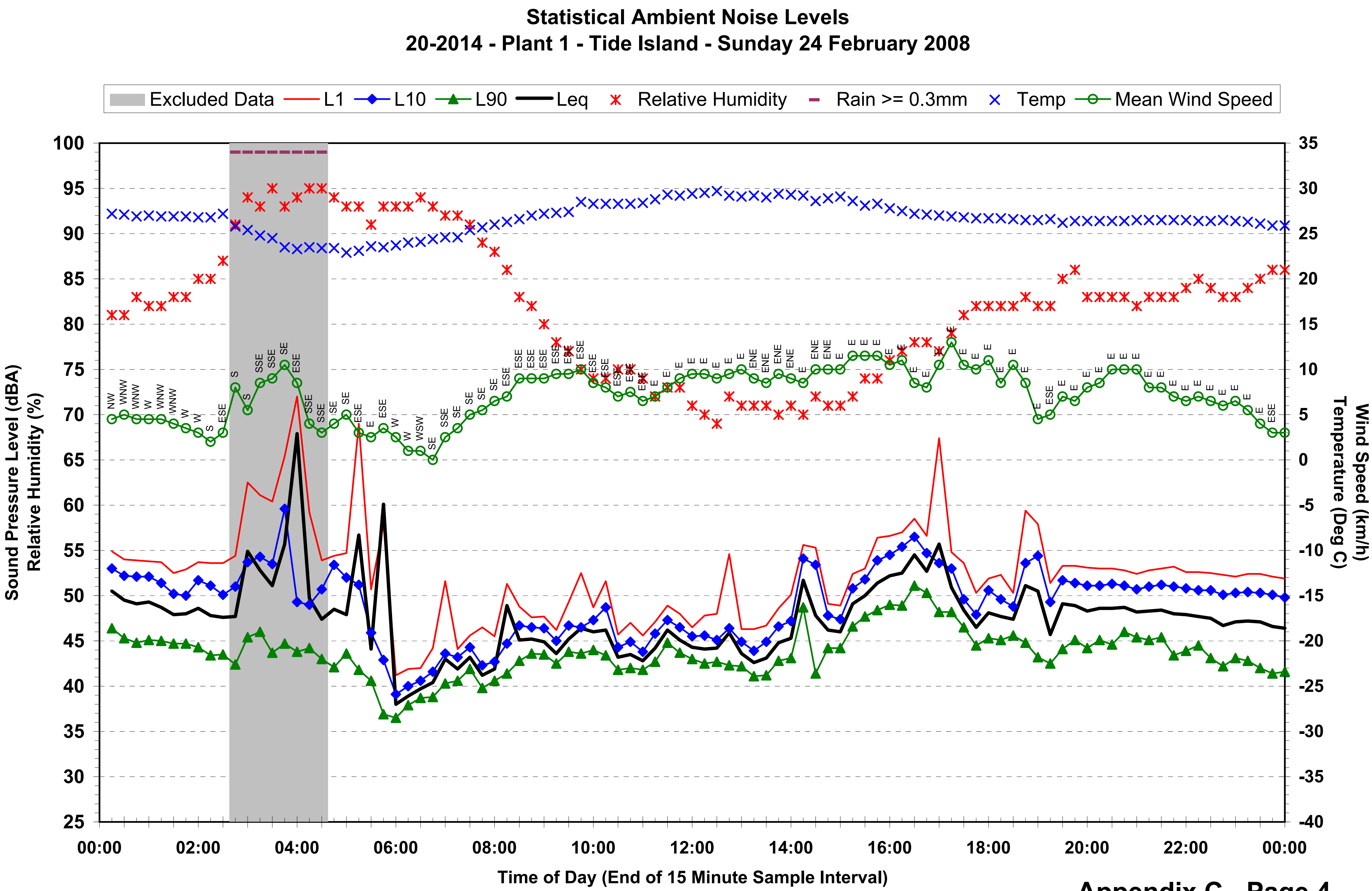
Ambient Conditions

RHA Report 20-2014

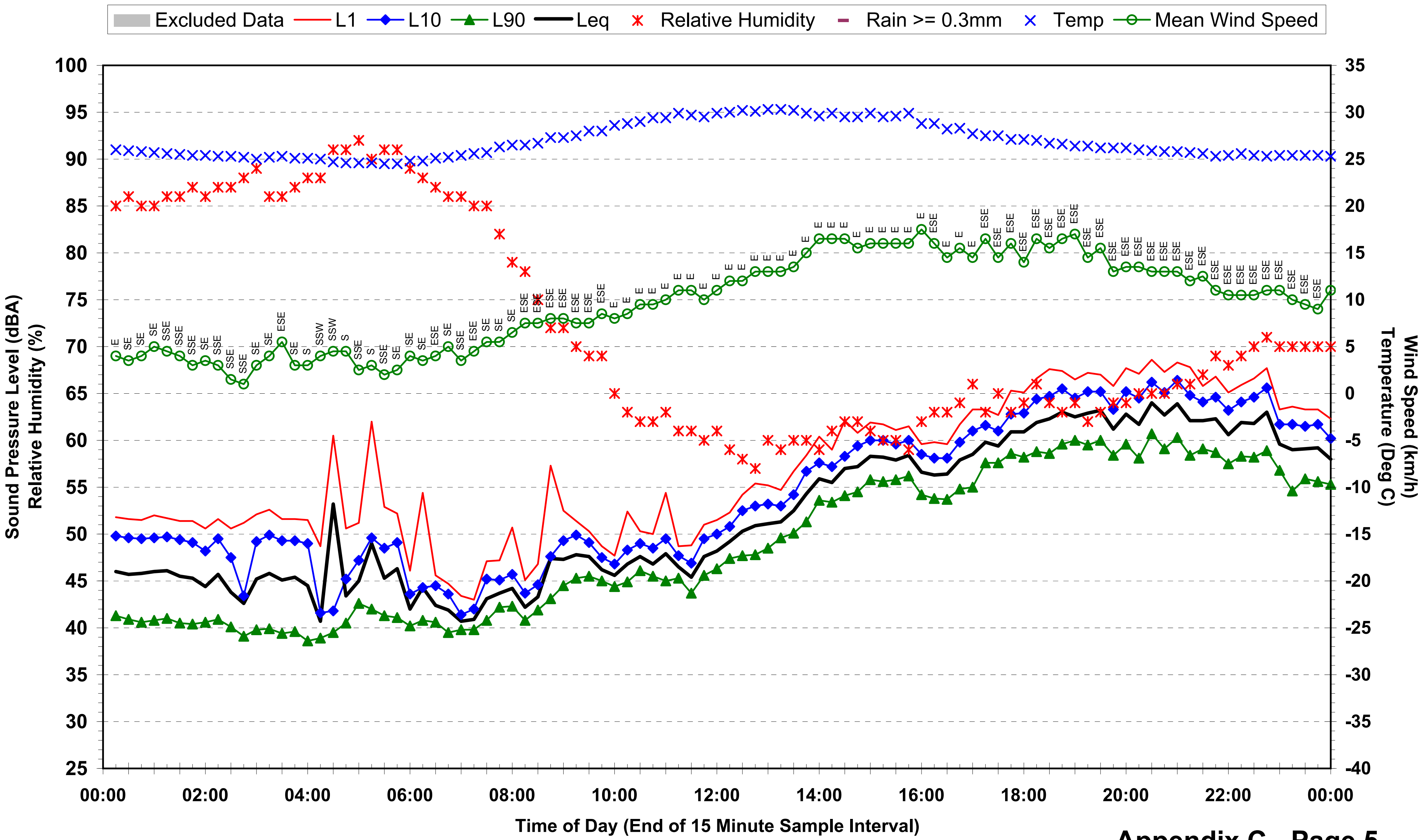


Statistical Ambient Noise Levels
20-2014 - Plant 1 - Tide Island - Saturday 23 February 2008
Excluded Data
L1
L10
L90
Leq
Relative Humidity
Rain >= 0.3mm
Temp
Mean Wind Speed
Sound Pressure Level (dBA)
Relative Humidity (%)
Wind Speed (km/h)
Temperature (Deg C)
Time of Day (End of 15 Minute Sample Interval)



Statistical Ambient Noise Levels
20-2014 - Plant 1 - Tide Island - Sunday 24 February 2008
Excluded Data
L1
L10
L90
Leq
Relative Humidity
Rain >= 0.3mm
Temp
Mean Wind Speed
Sound Pressure Level (dBA)
Relative Humidity (%)
Wind Speed (km/h)
Temperature (Deg C)
Time of Day (End of 15 Minute Sample Interval)

Statistical Ambient Noise Levels
20-2014 - Plant 1 - Tide Island - Monday 25 February 2008



Statistical Ambient Noise Levels
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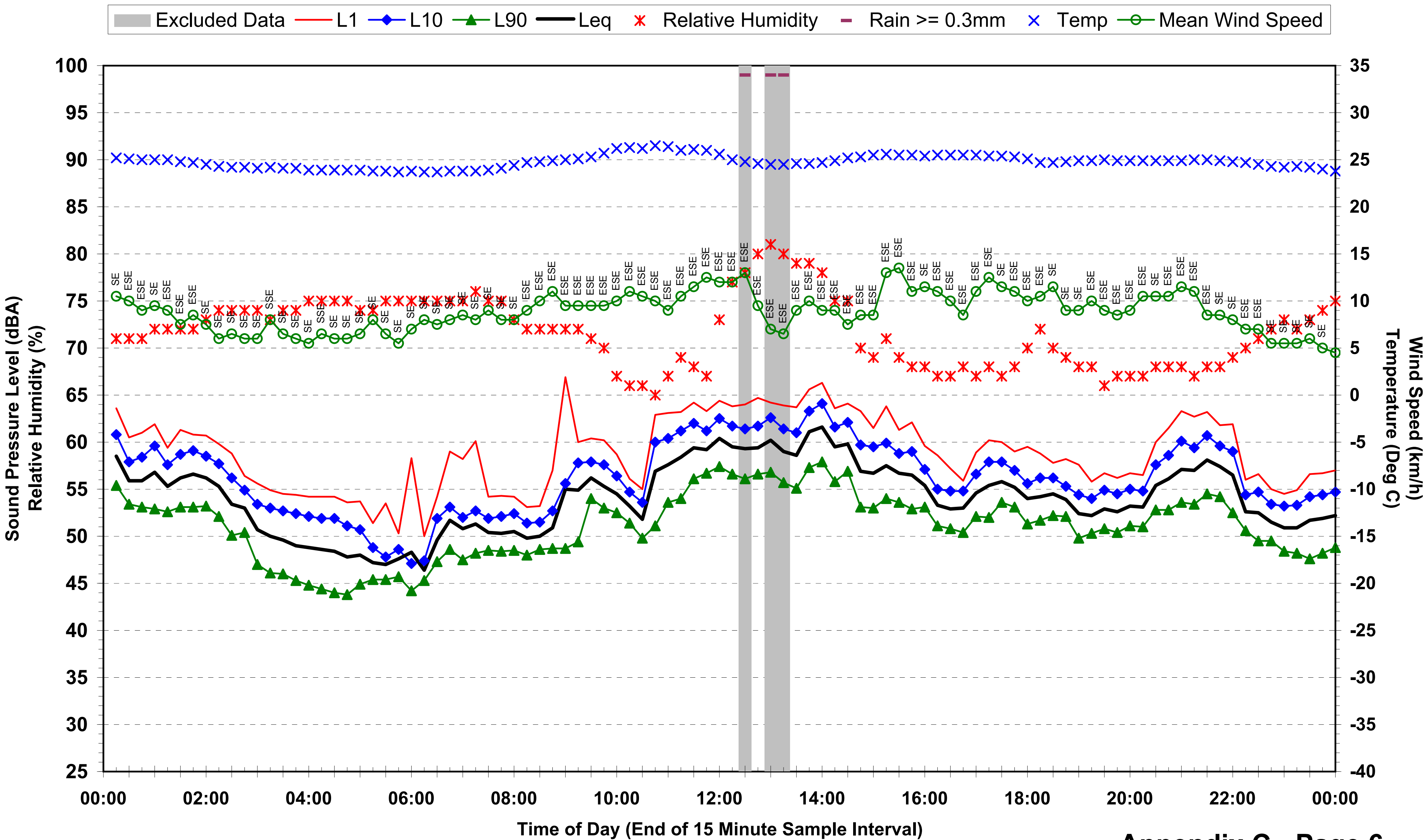

Statistical Ambient Noise Levels
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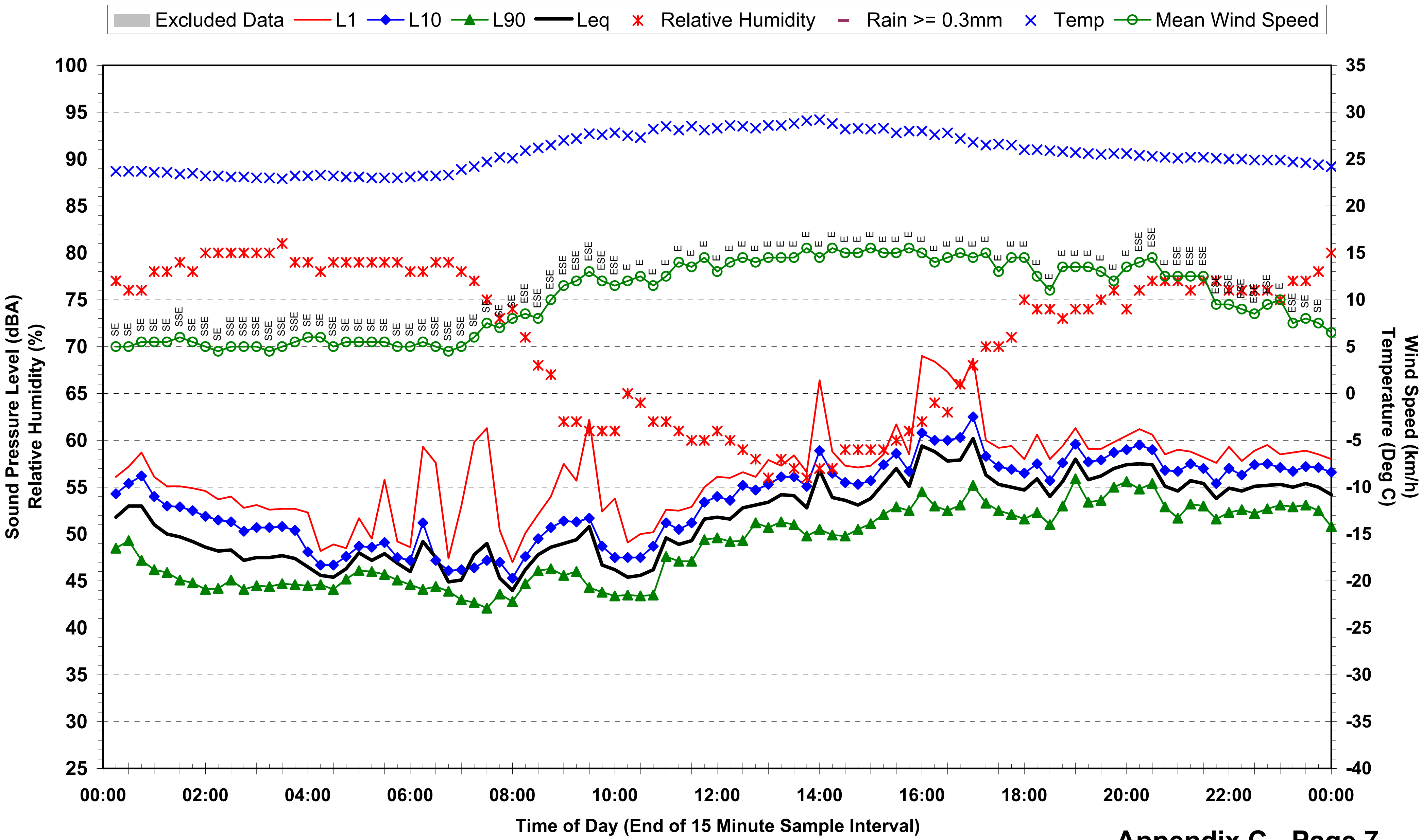

Statistical Ambient Noise Levels
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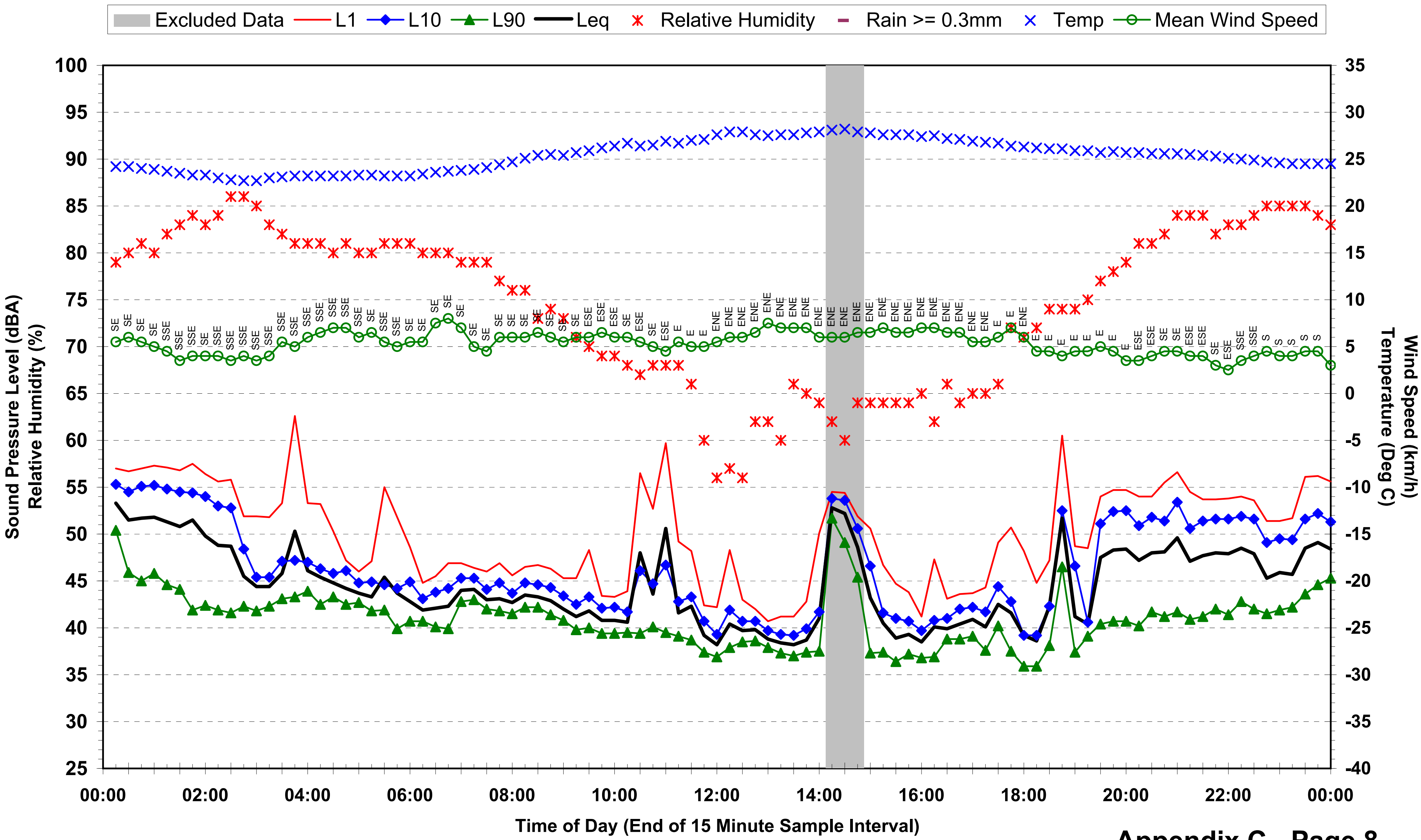

Statistical Ambient Noise Levels
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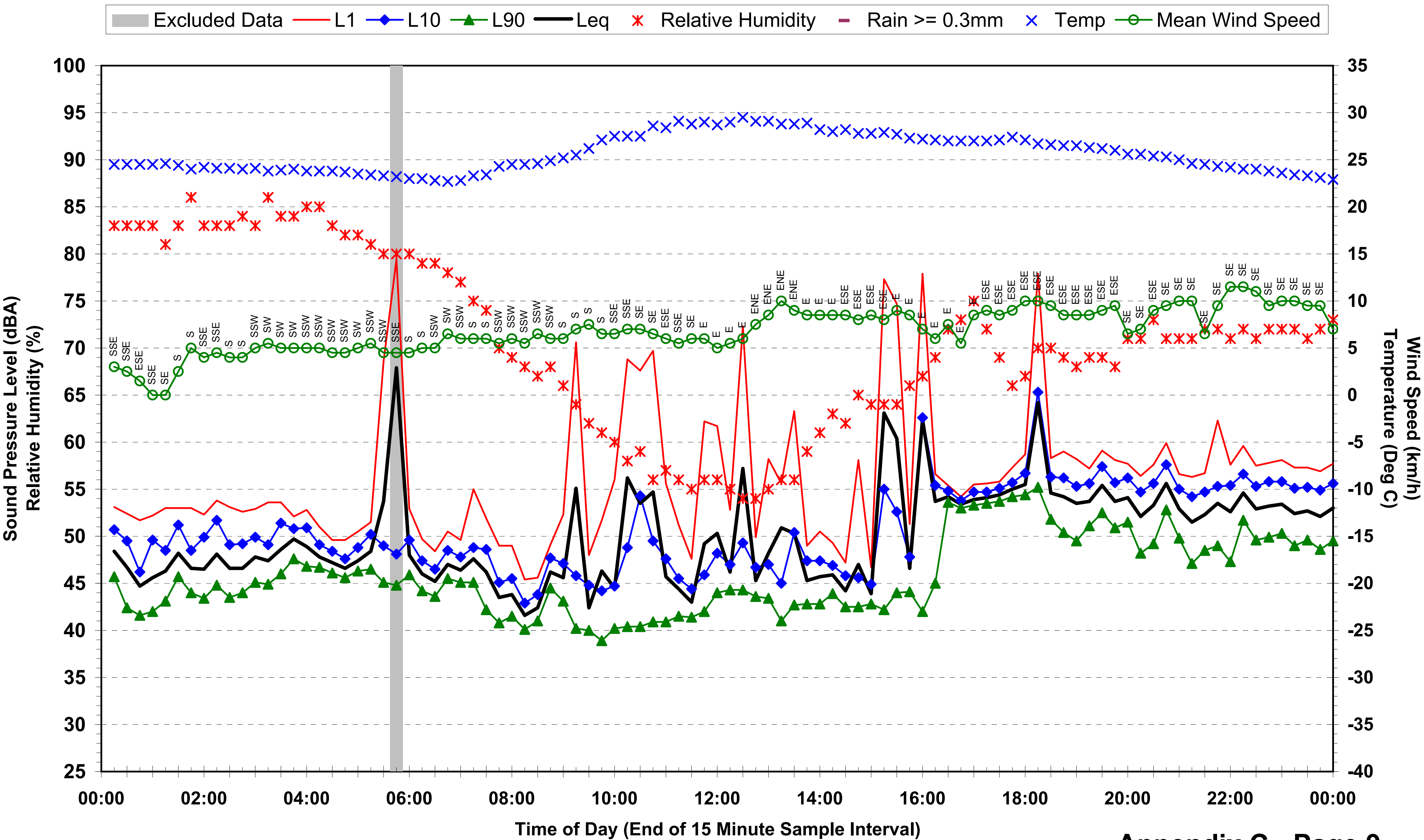
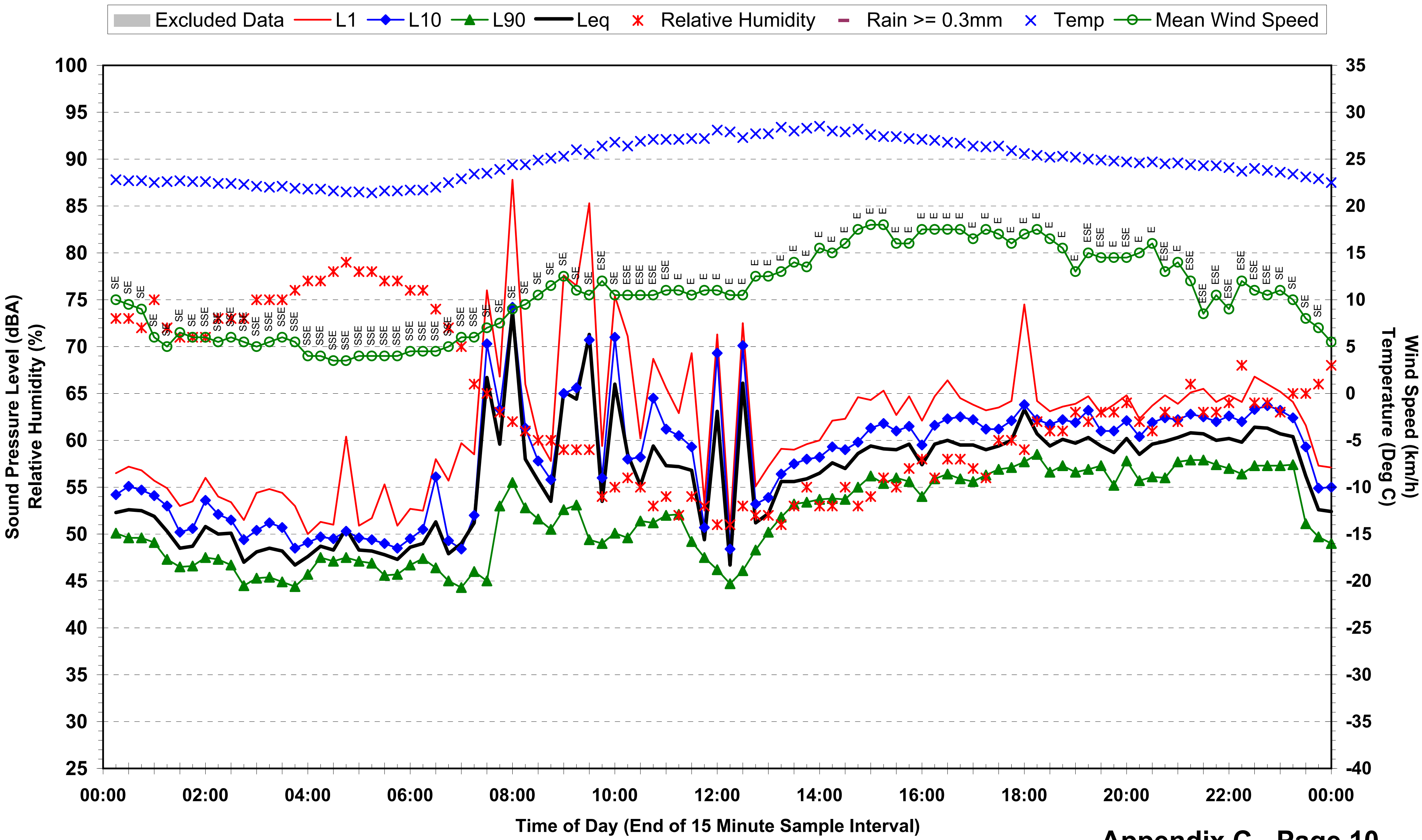
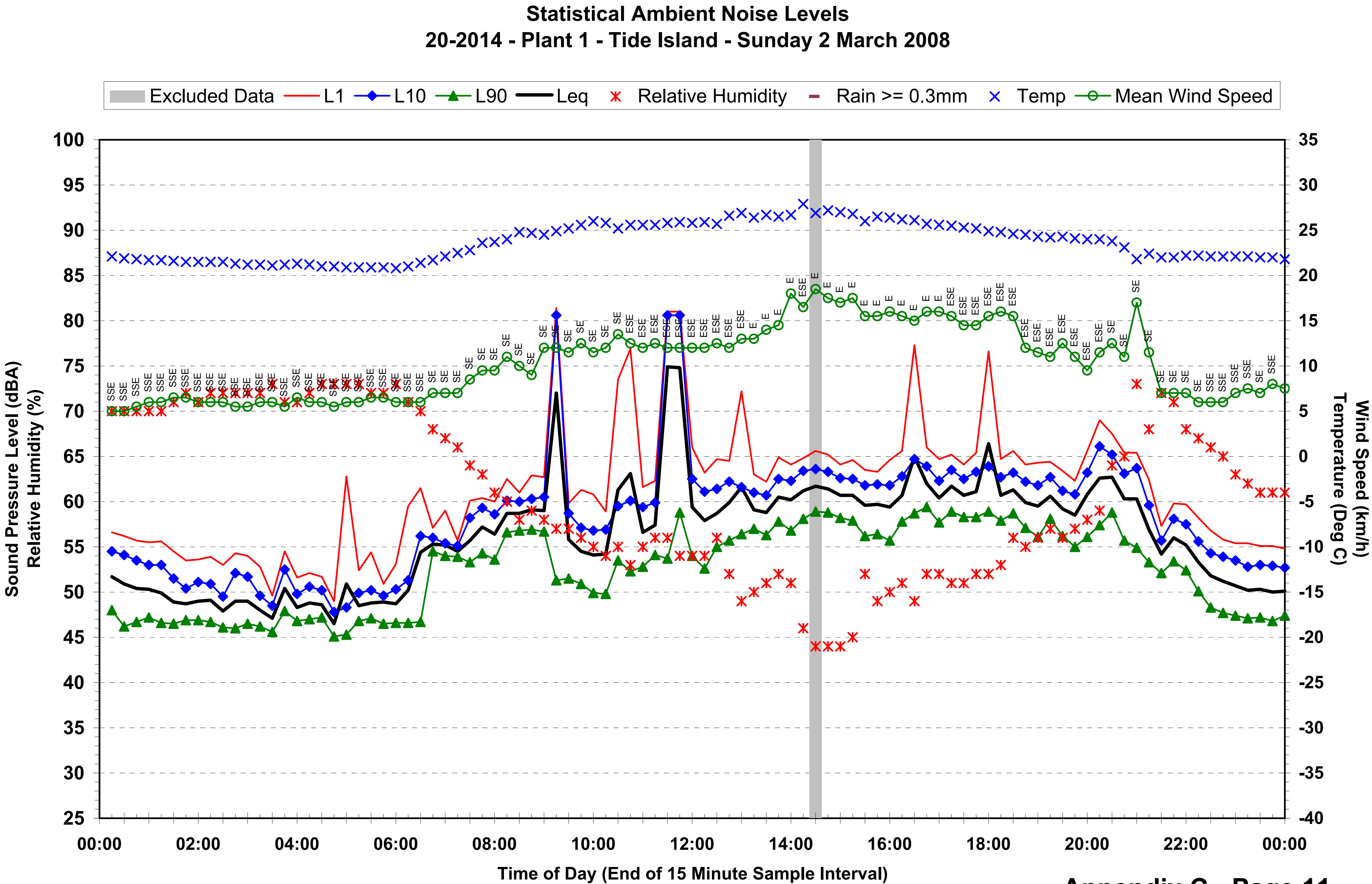


Statistical Ambient Noise Levels
20-2014 - Plant 1 - Tide Island - Saturday 1 March 2008





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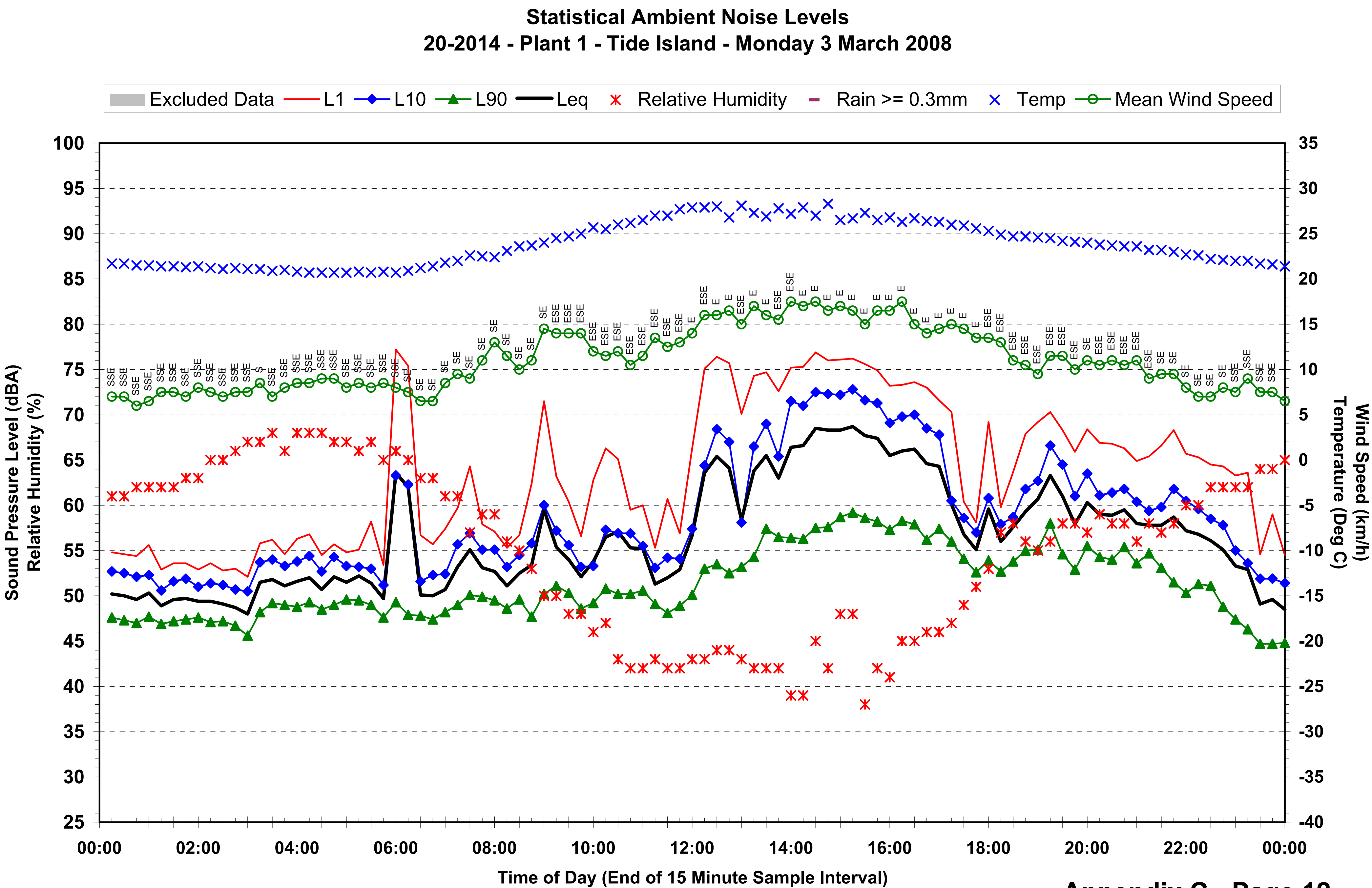
Ambient Conditions

RHA Report 20-2014



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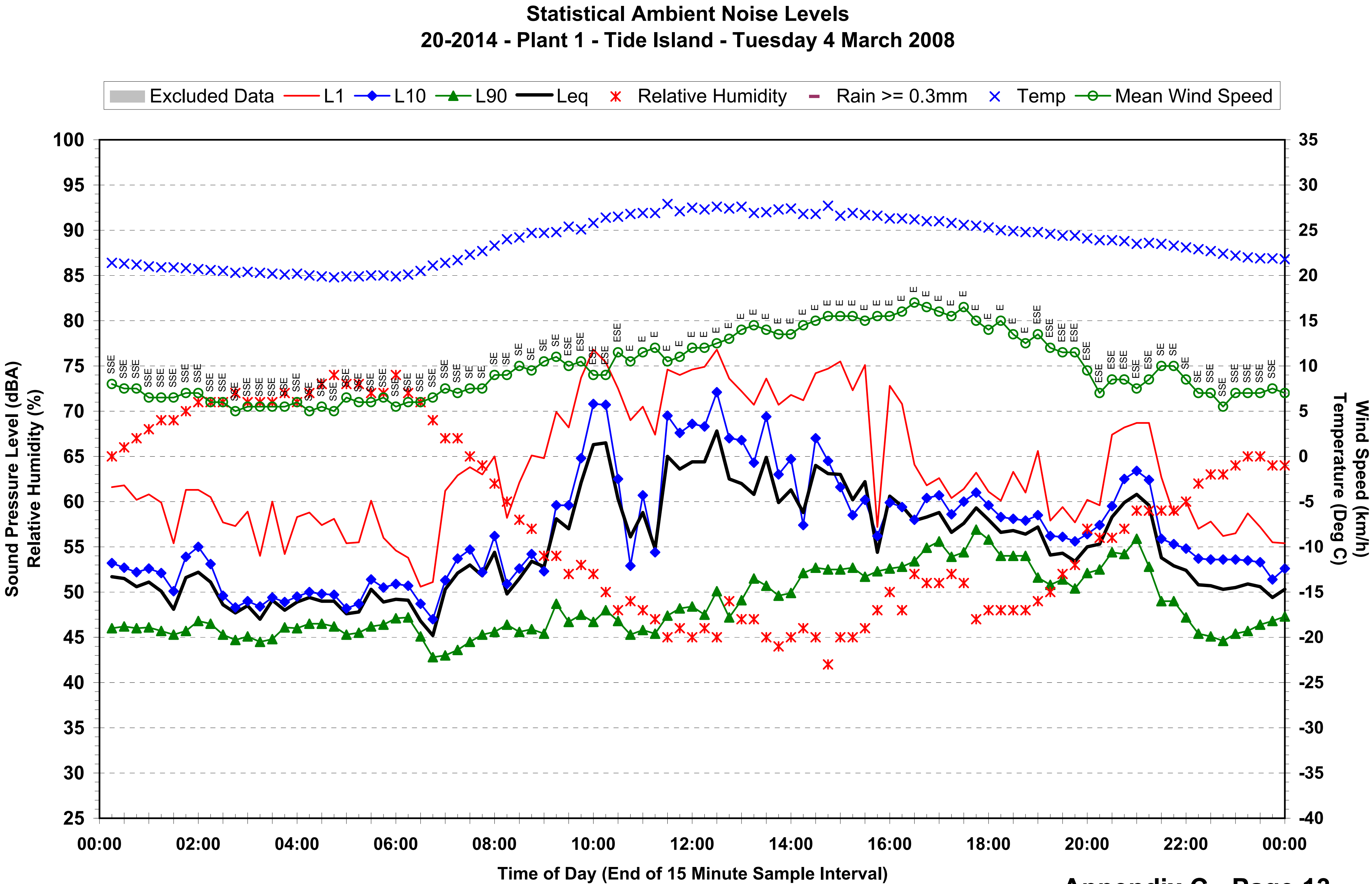
Ambient Conditions
RHA Report 20-2014



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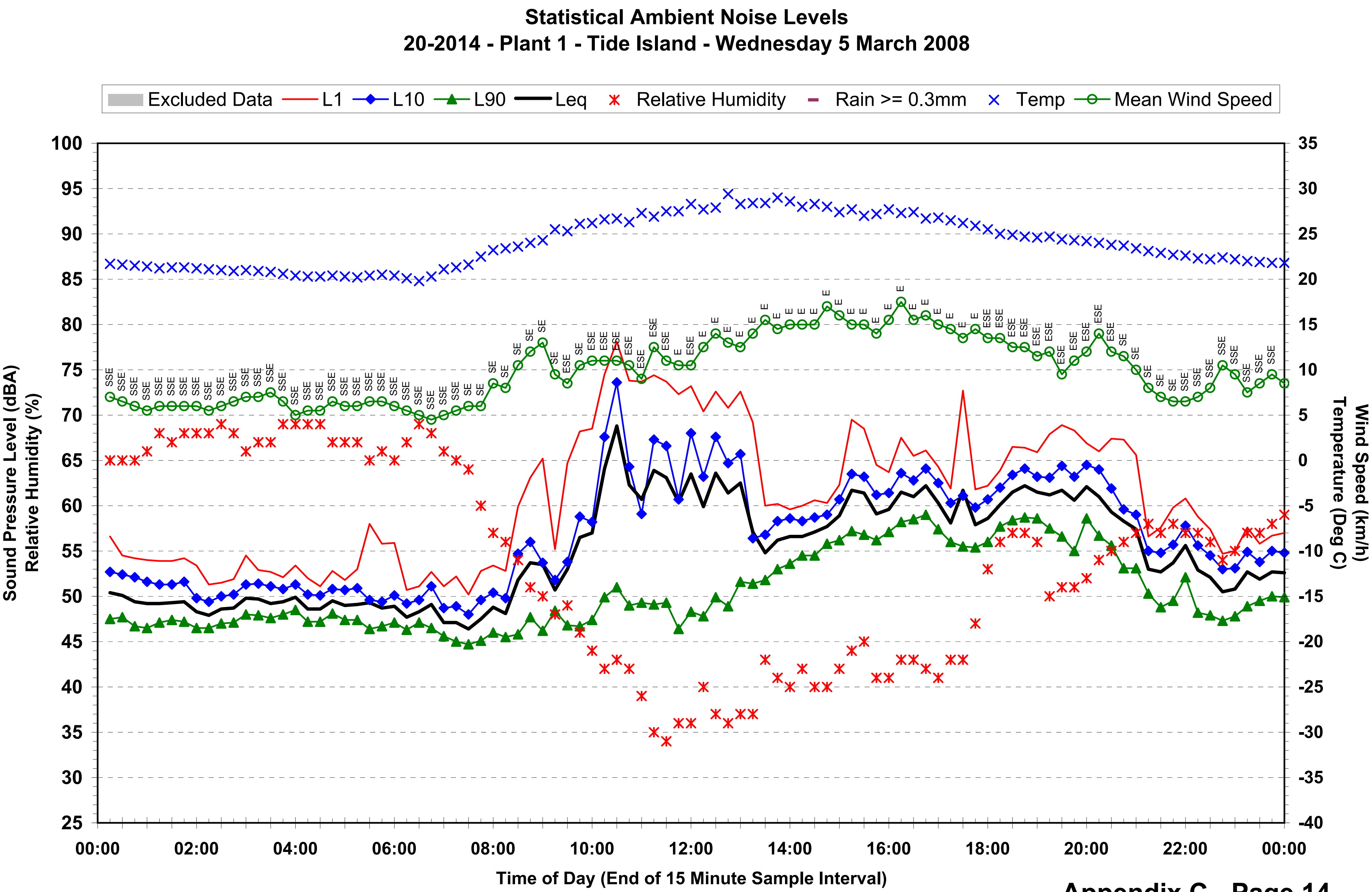
Ambient Conditions

RHA Report 20-2014



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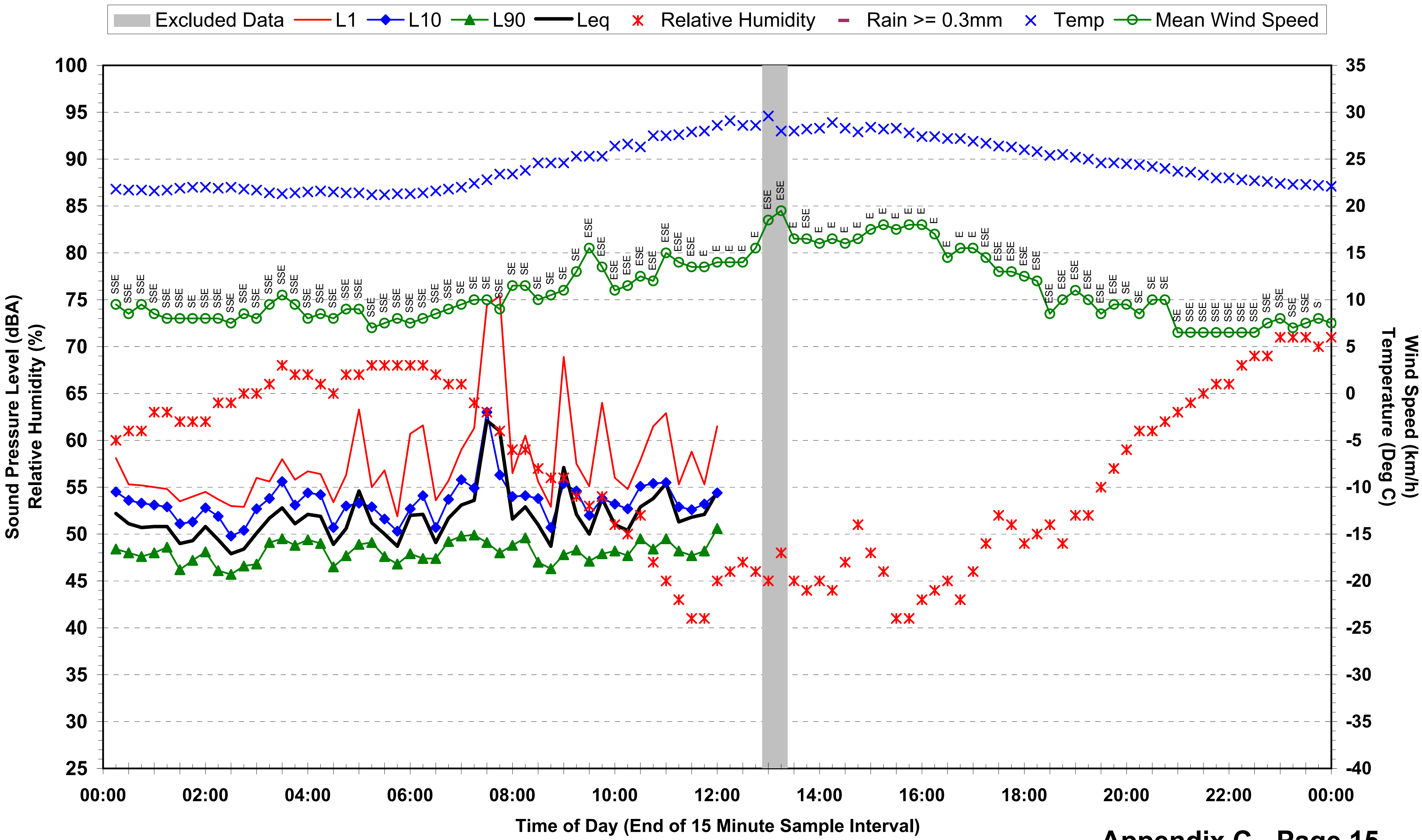
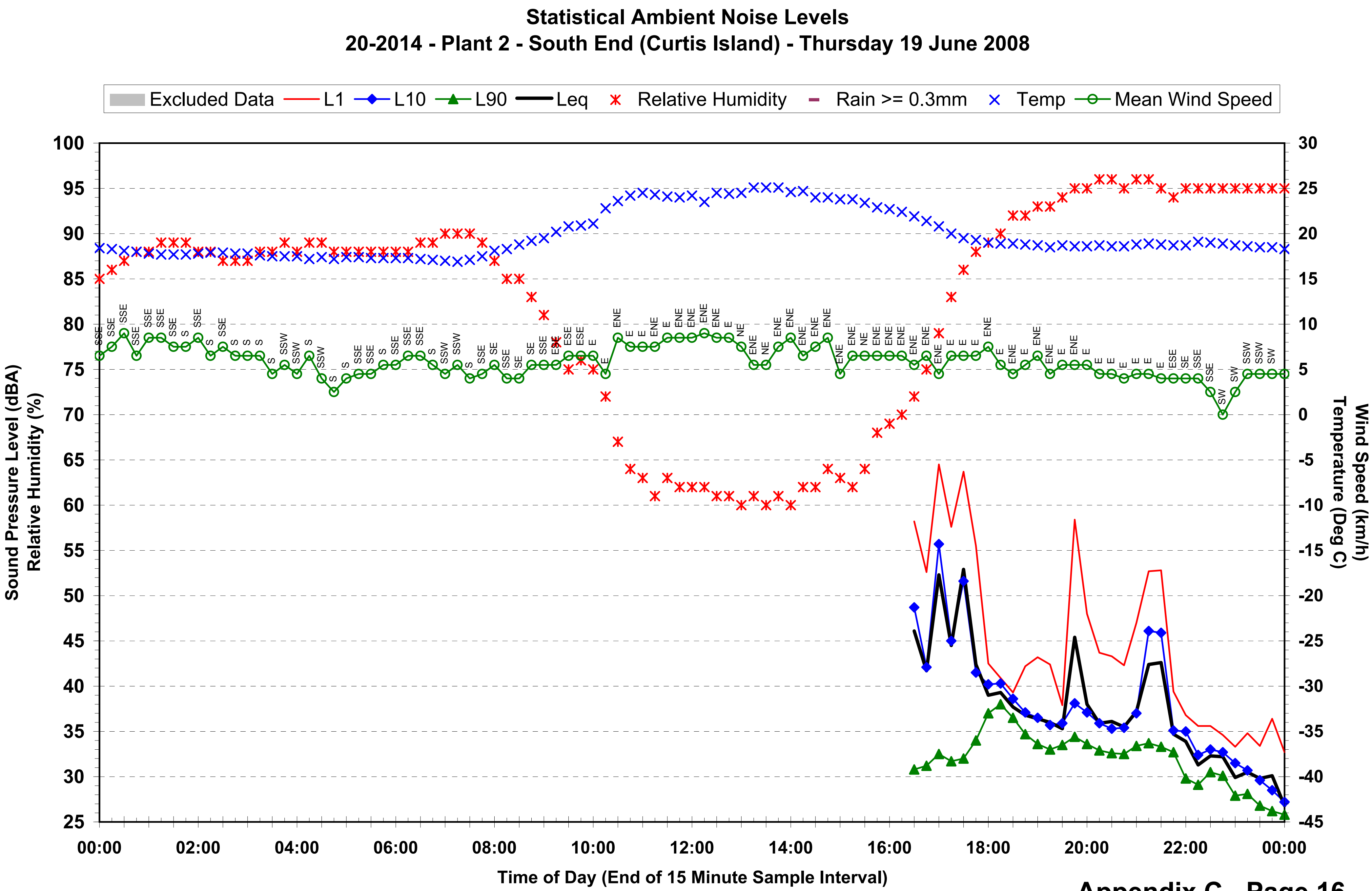
Ambient Conditions

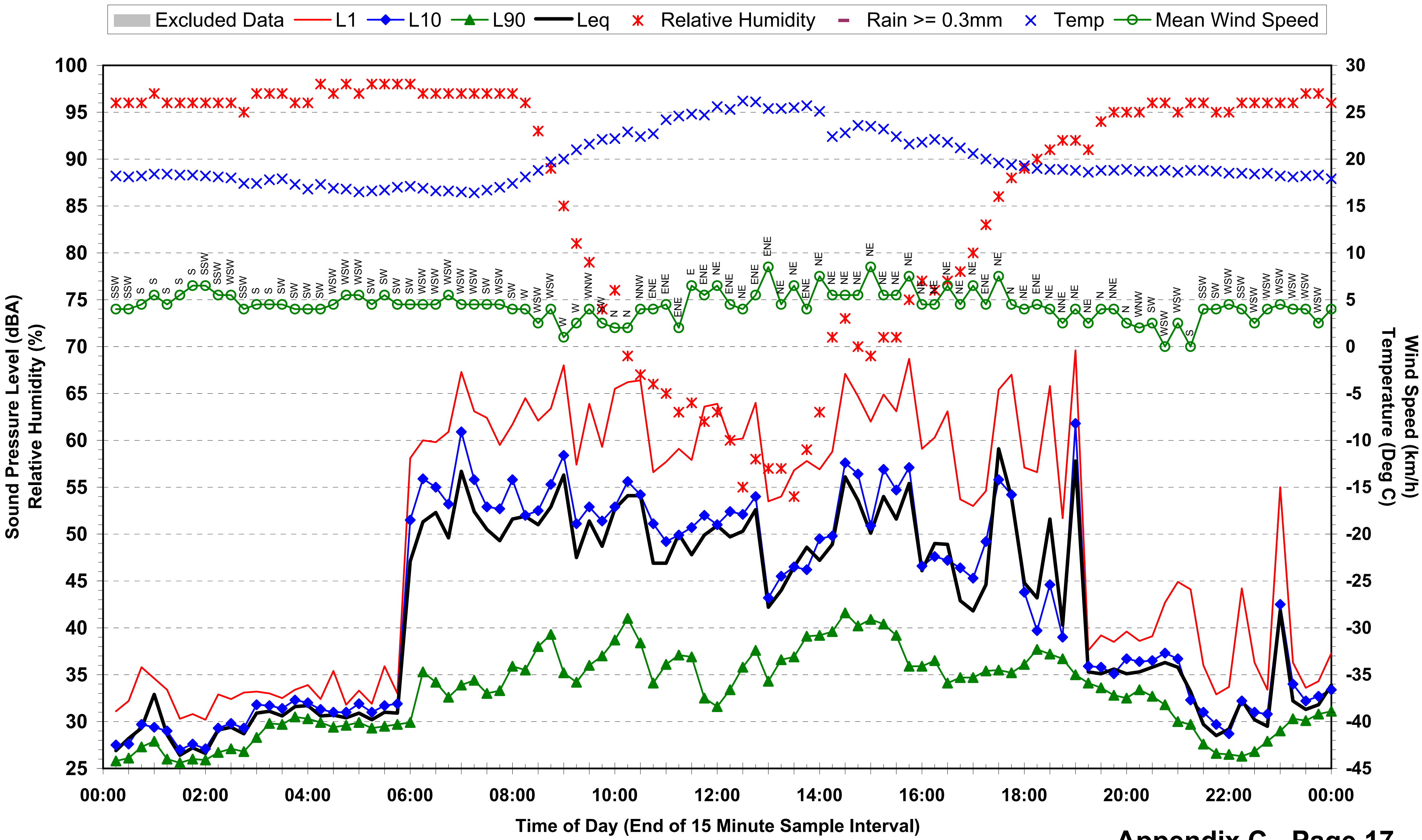
RHA Report 20-2014

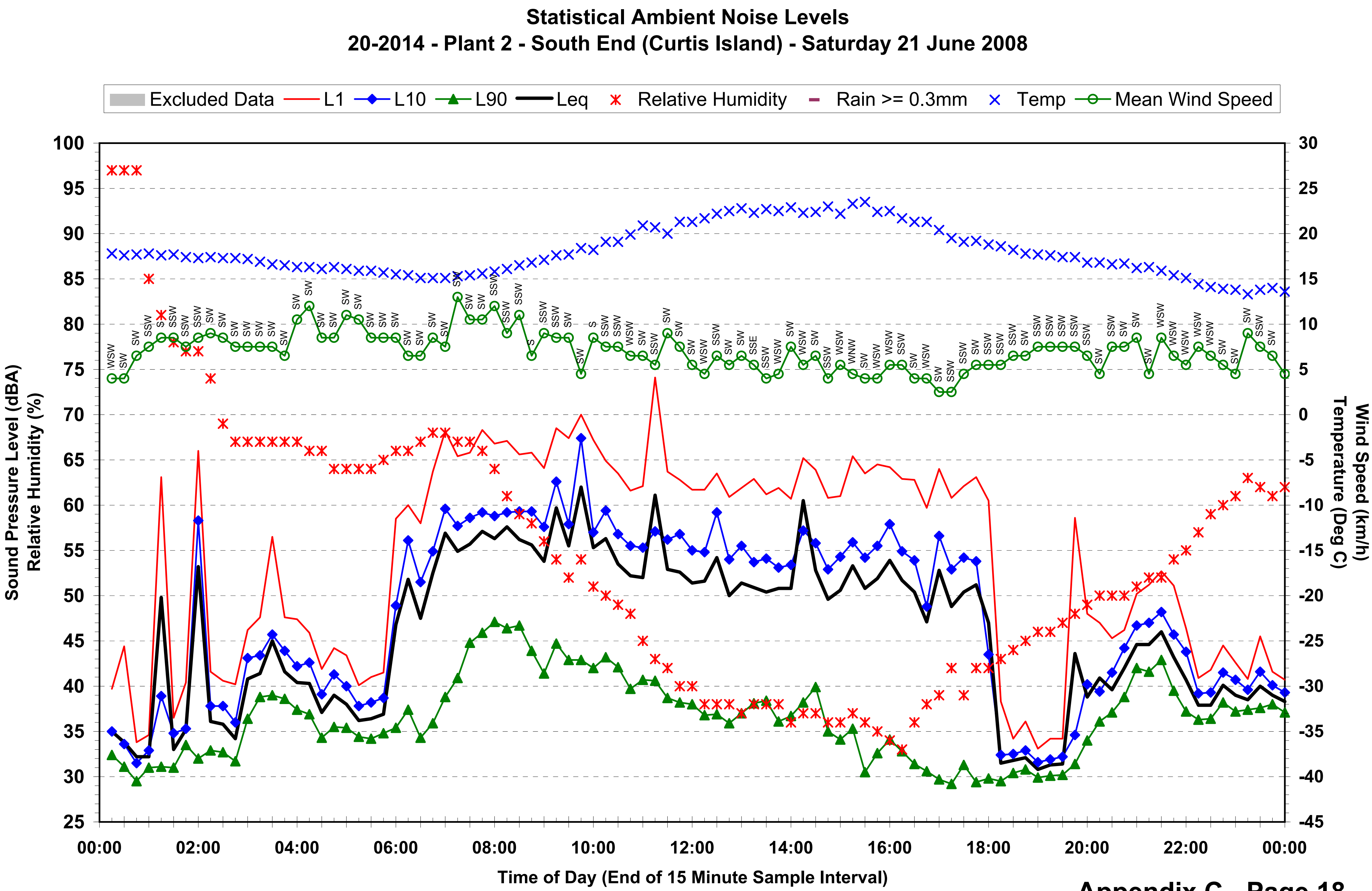
Statistical Ambient Noise Levels
20-2014 - Plant 1 - Tide Island - Thursday 6 March 2008




Statistical Ambient Noise Levels
20-2014 - Plant 2 - South End (Curtis Island) - Thursday 19 June 2008
Excluded Data
L1
L10
L90
Leq
Relative Humidity
Rain >= 0.3mm
Temp
Mean Wind Speed
Sound Pressure Level (dBA)
Relative Humidity (%)
Wind Speed (km/h)
Temperature (Deg C)
Time of Day (End of 15 Minute Sample Interval)
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
30
25
20
15
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
00:00
02:00
04:00
06:00
08:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
00:00

Statistical Ambient Noise Levels
20-2014 - Plant 2 - South End (Curtis Island) - Friday 20 June 2008





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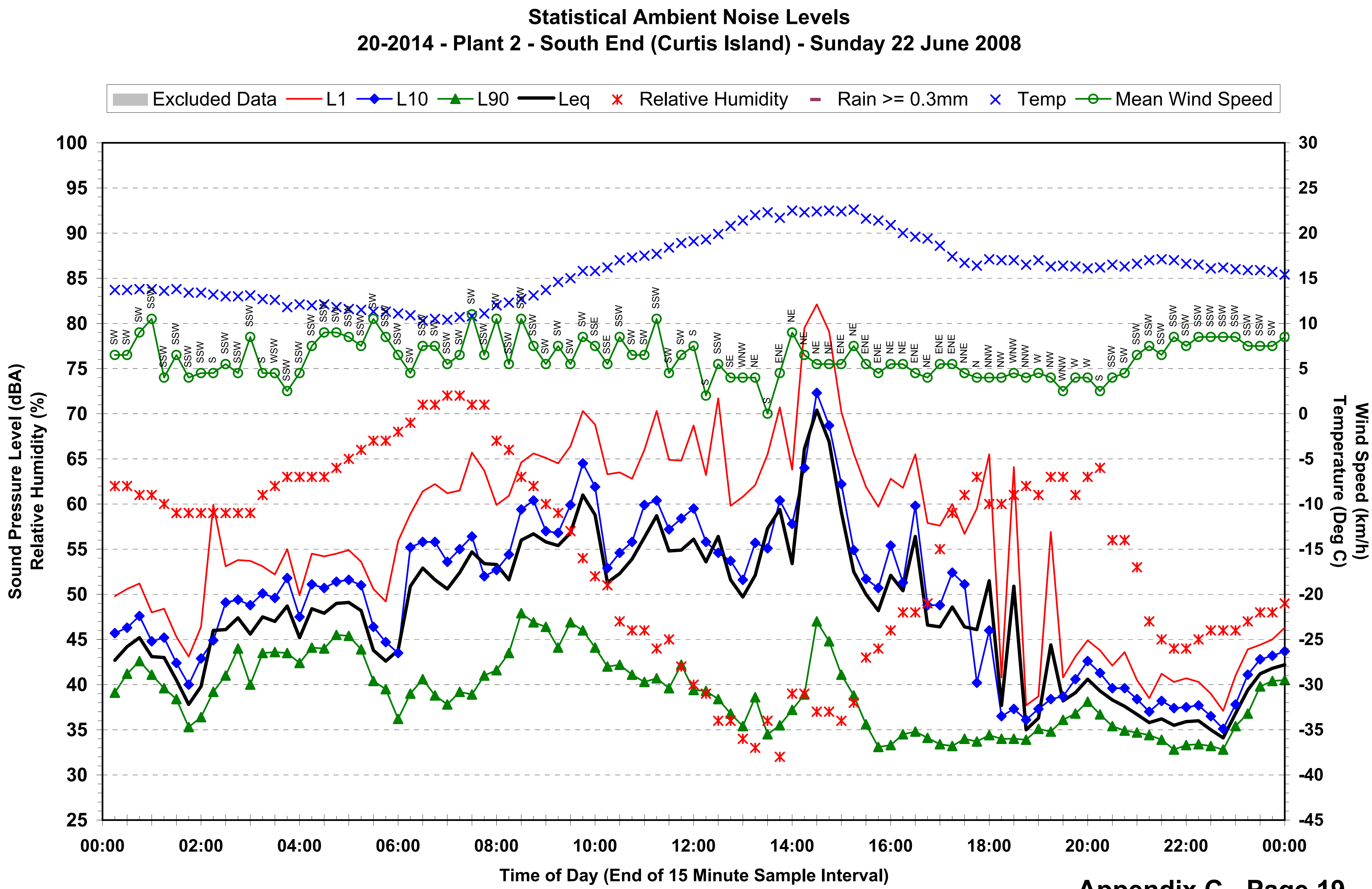

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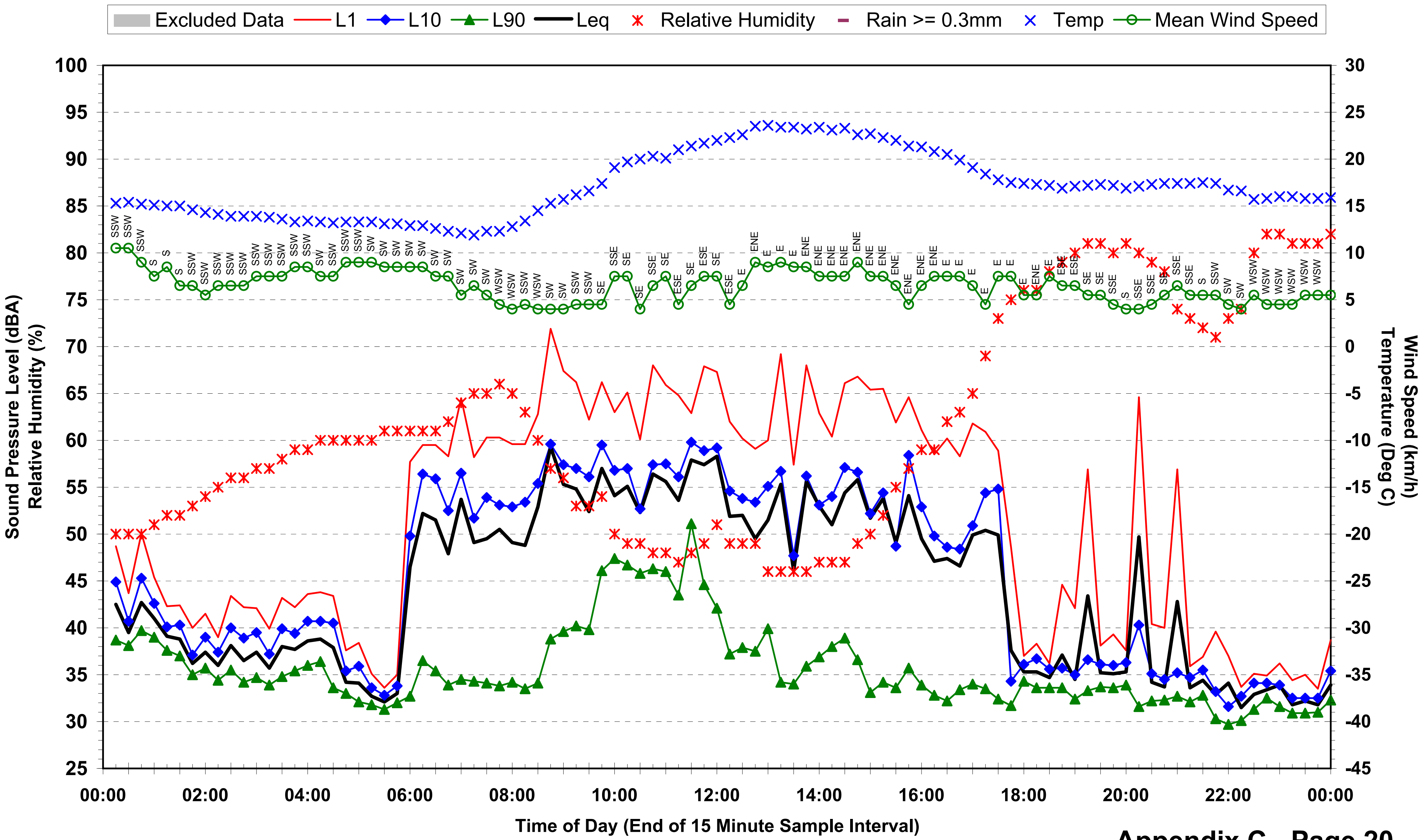
Ambient Conditions

RHA Report 20-2014

Statistical Ambient Noise Levels
20-2014 - Plant 2 - South End (Curtis Island) - Monday 23 June 2008



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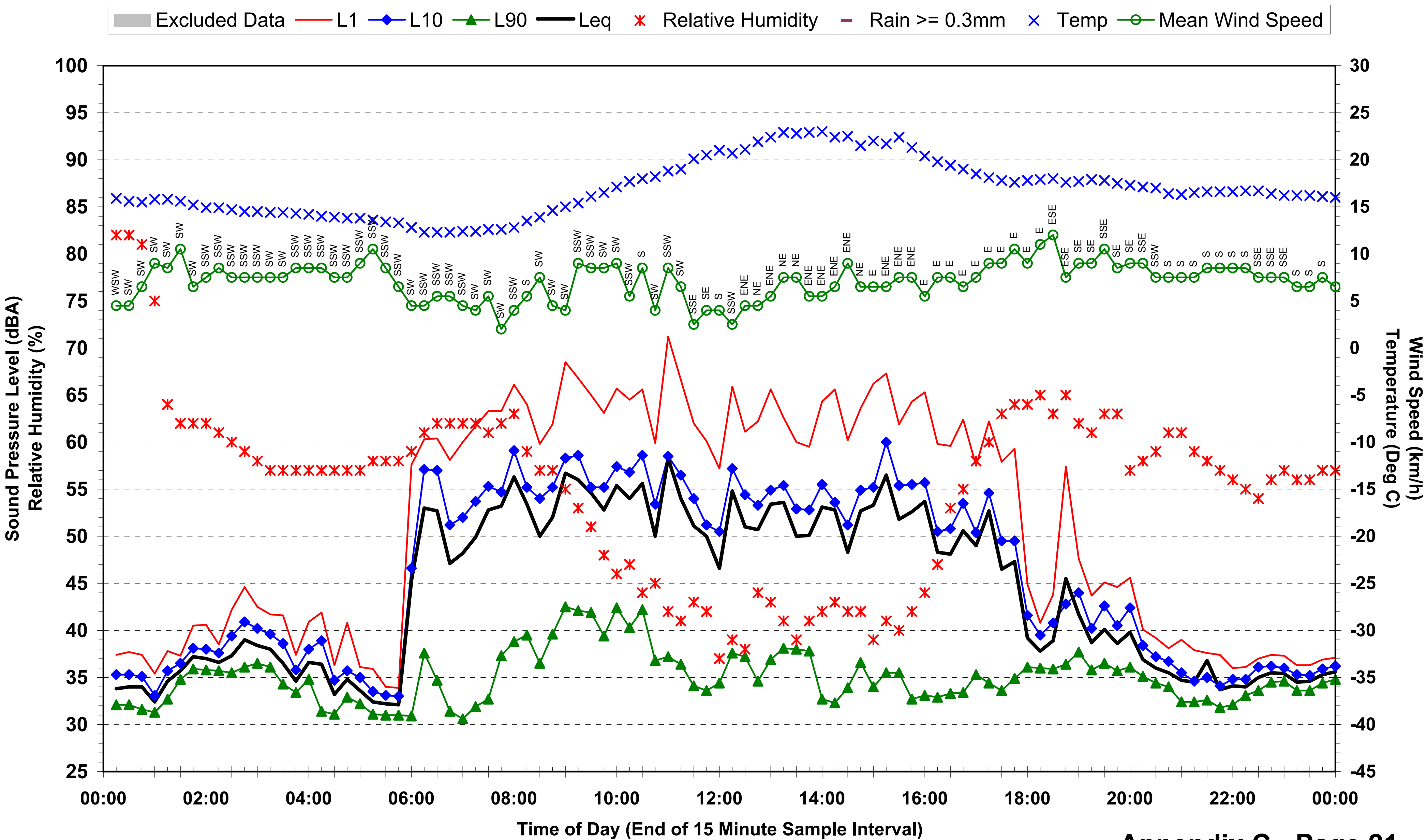
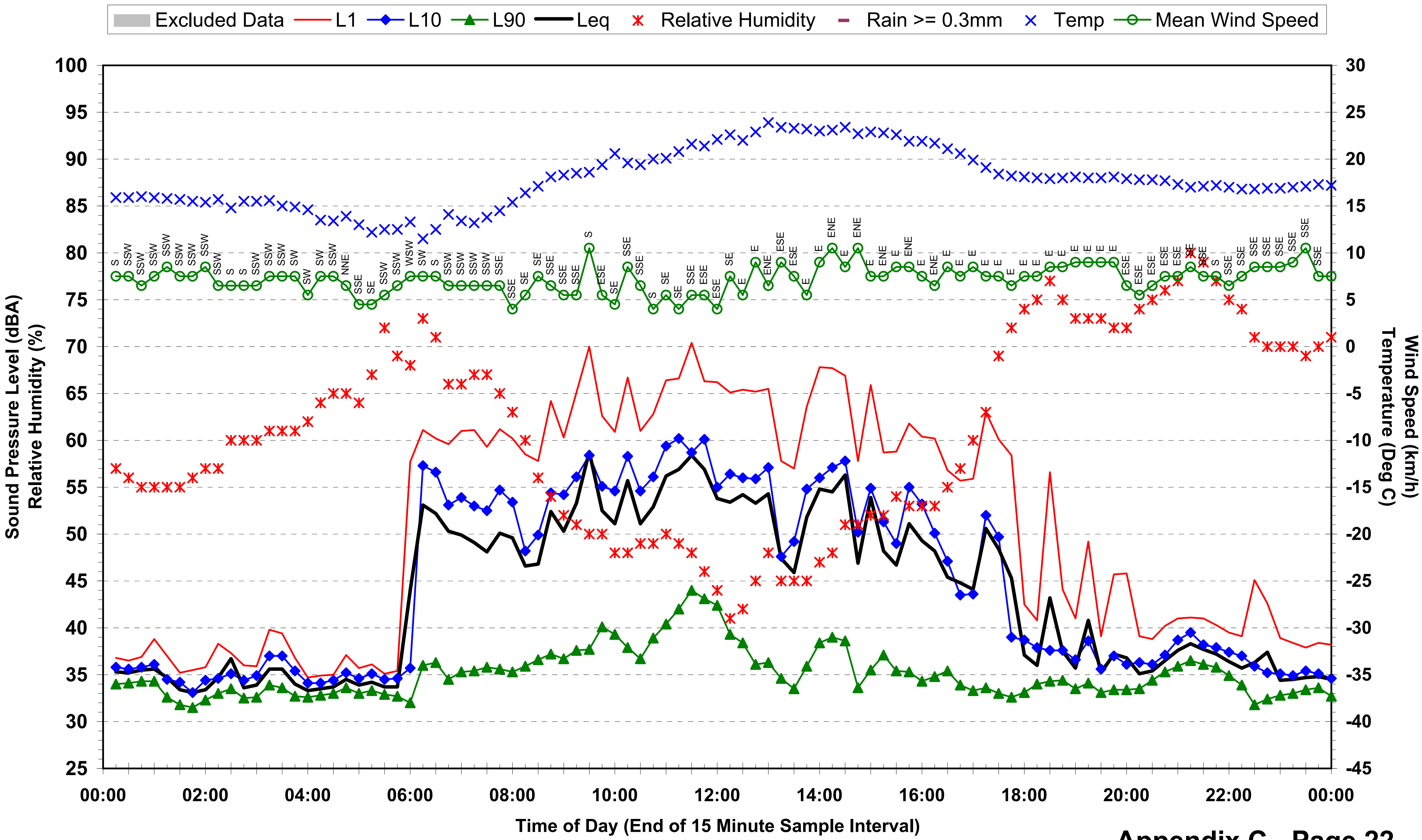
Ambient Conditions
RHA Report 20-2014

Statistical Ambient Noise Levels
20-2014 - Plant 2 - South End (Curtis Island) - Tuesday 24 June 2008



Statistical Ambient Noise Levels
20-2014 - Plant 2 - South End (Curtis Island) - Wednesday 25 June 2008



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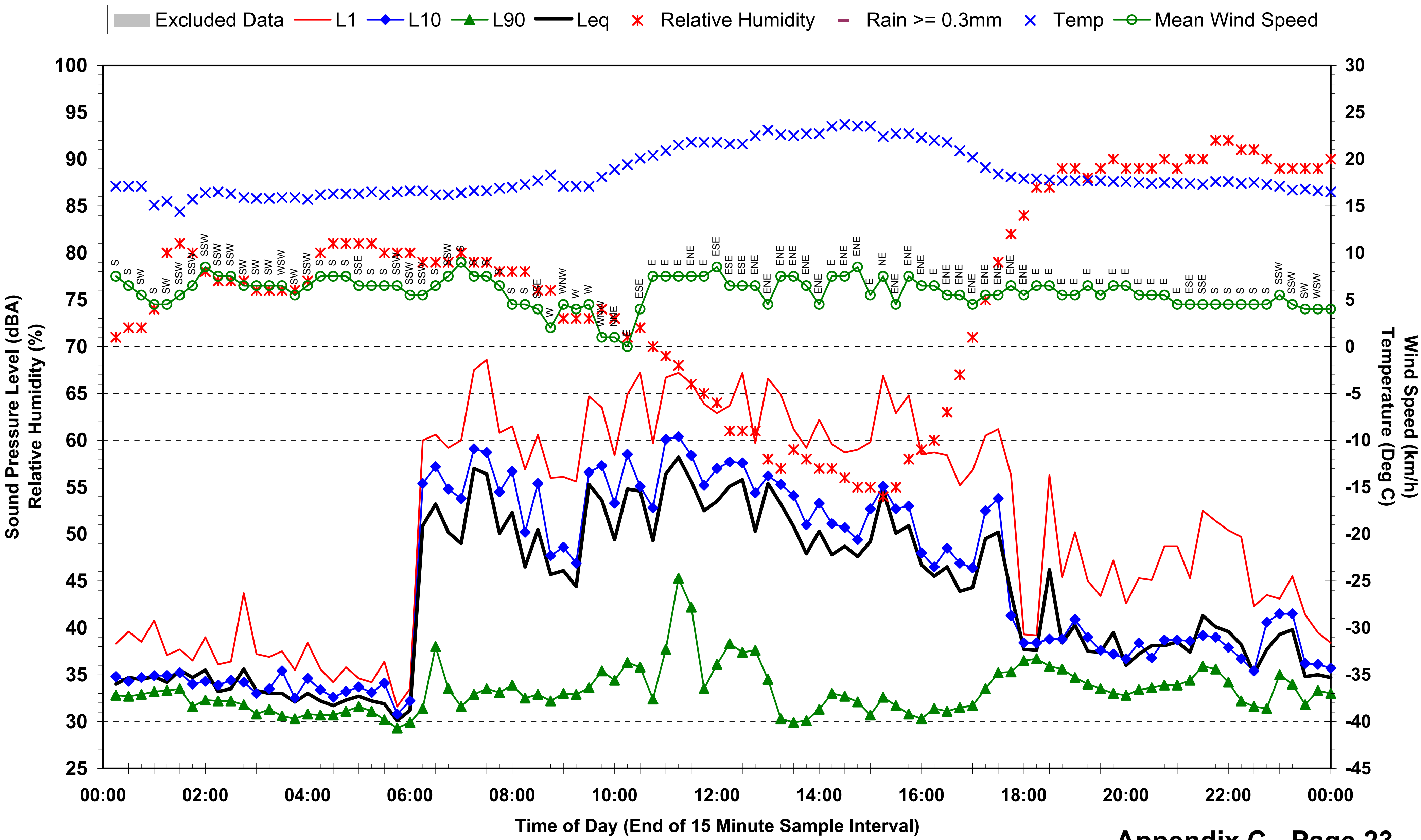
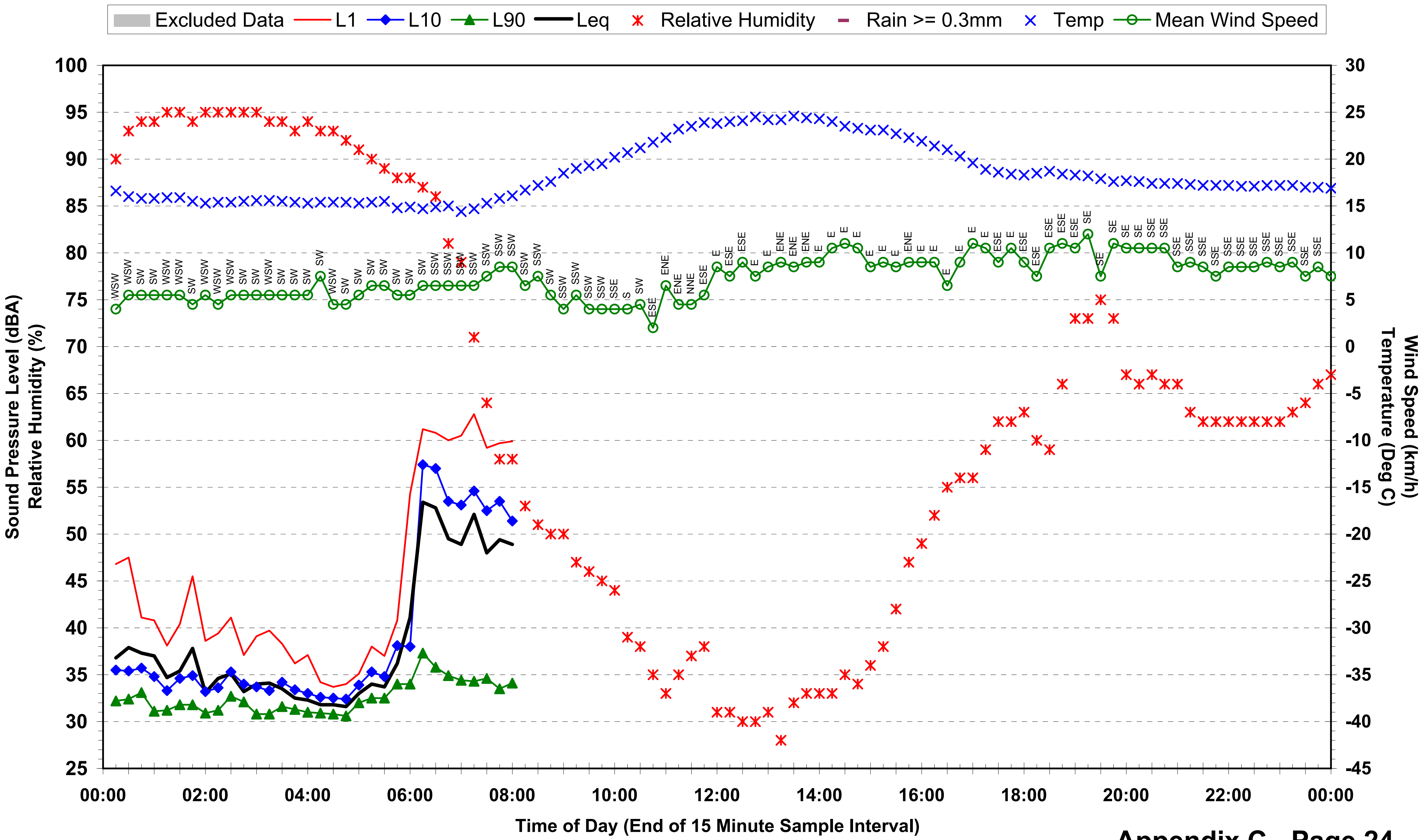
Ambient Conditions

RHA Report 20-2014

Statistical Ambient Noise Levels
20-2014 - Plant 2 - South End (Curtis Island) - Thursday 26 June 2008



Statistical Ambient Noise Levels
20-2014 - Plant 2 - South End (Curtis Island) - Friday 27 June 2008



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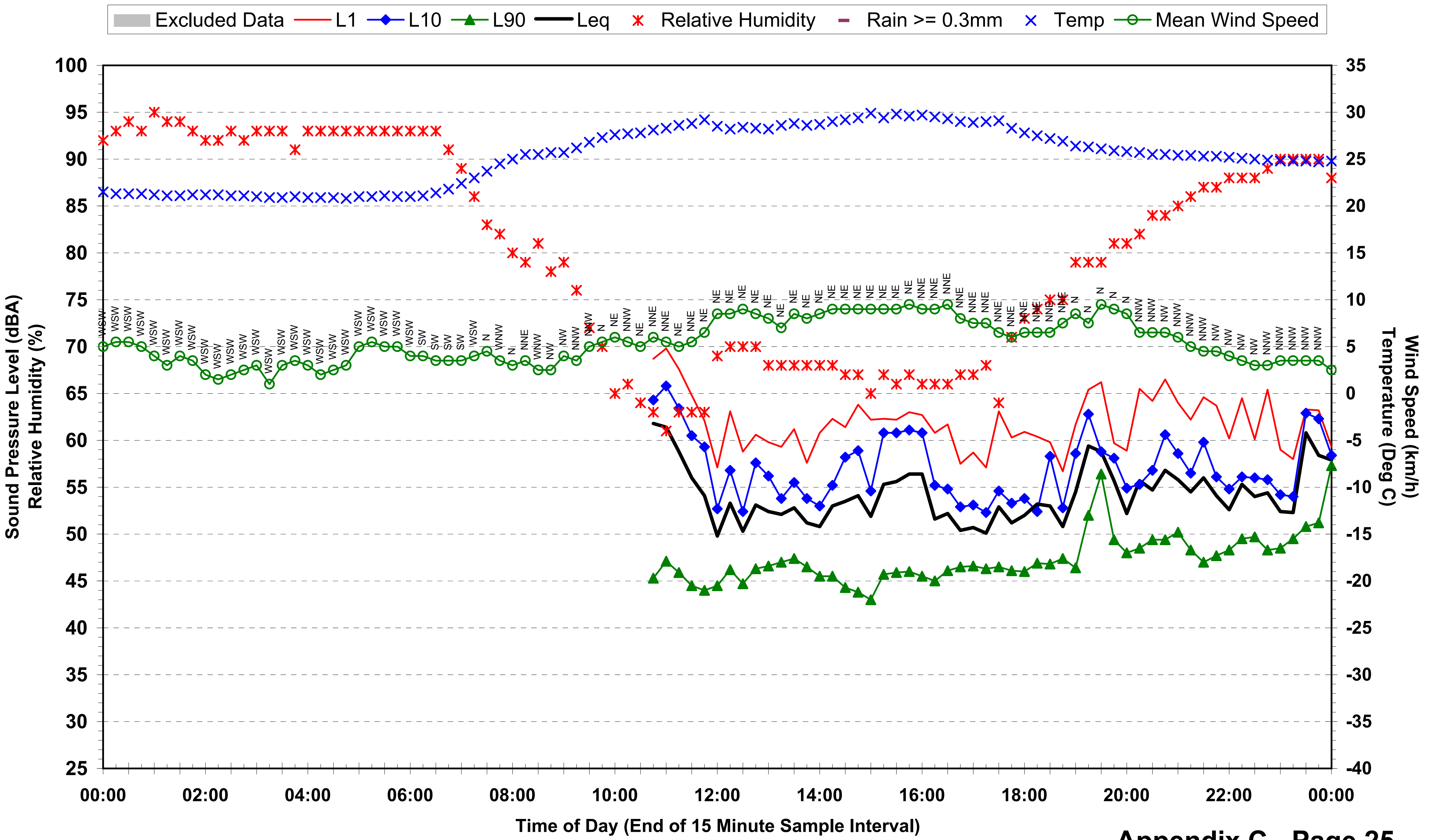
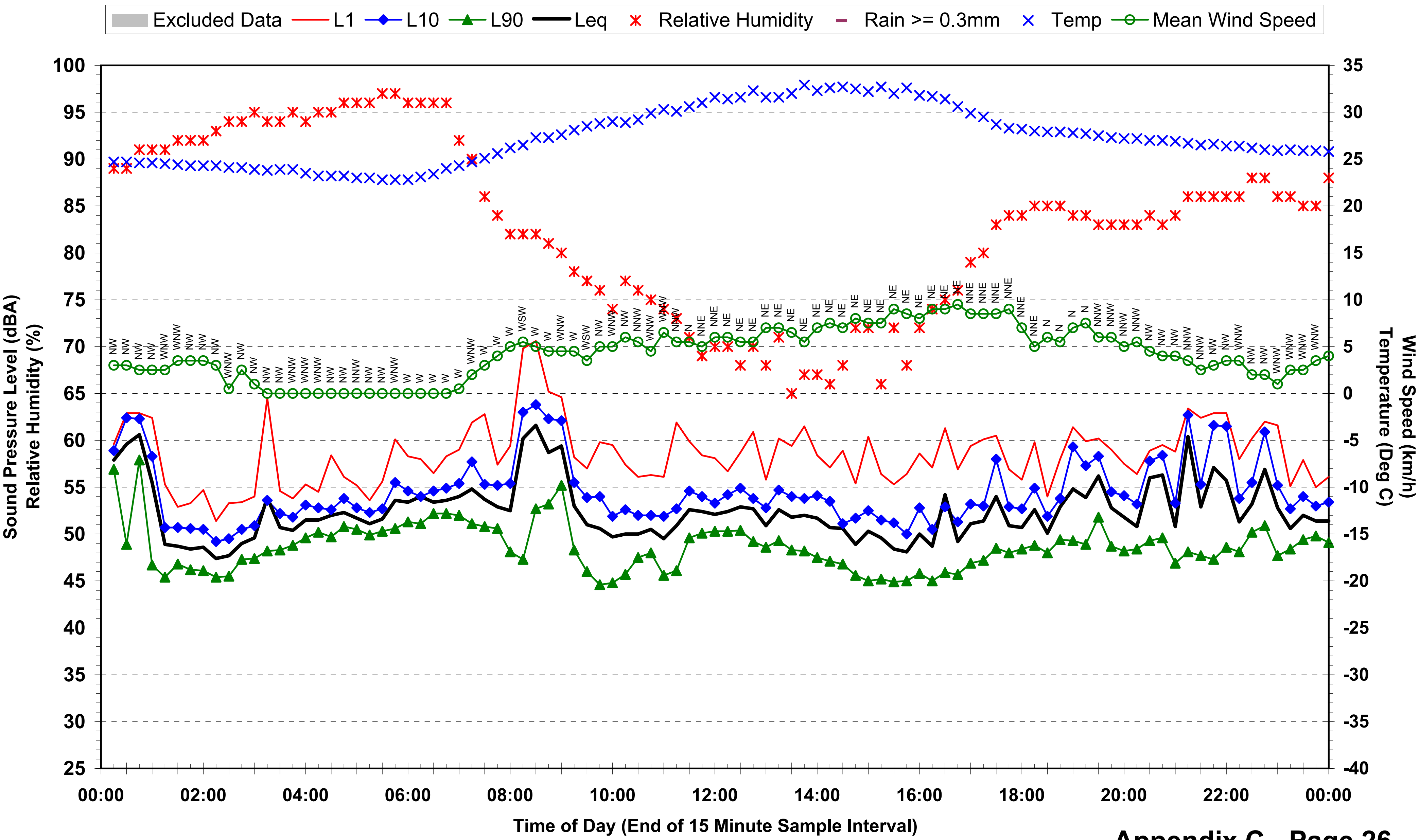
Ambient Conditions

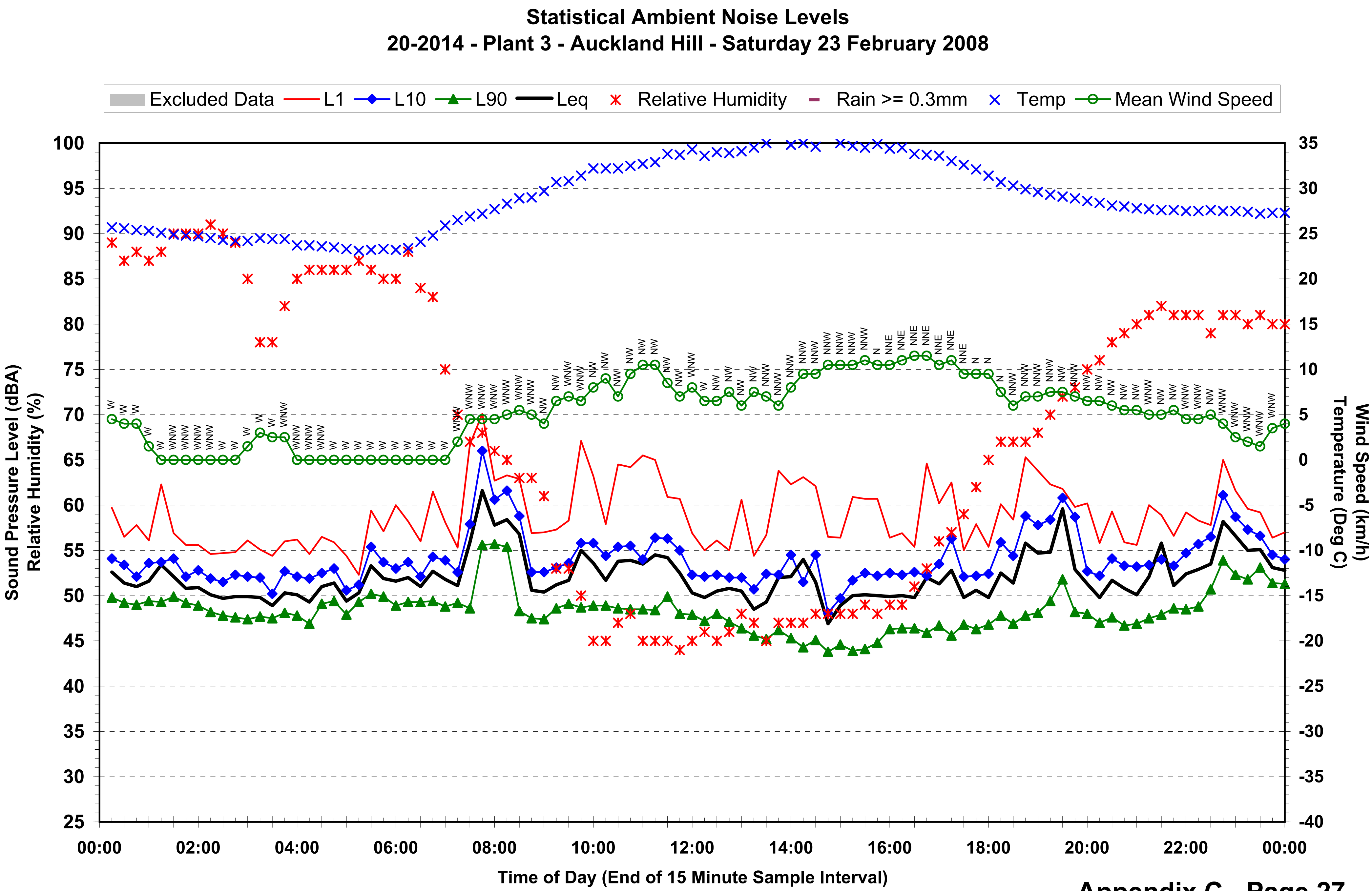
RHA Report 20-2014

Statistical Ambient Noise Levels
20-2014 - Plant 3 - Auckland Hill - Thursday 21 February 2008



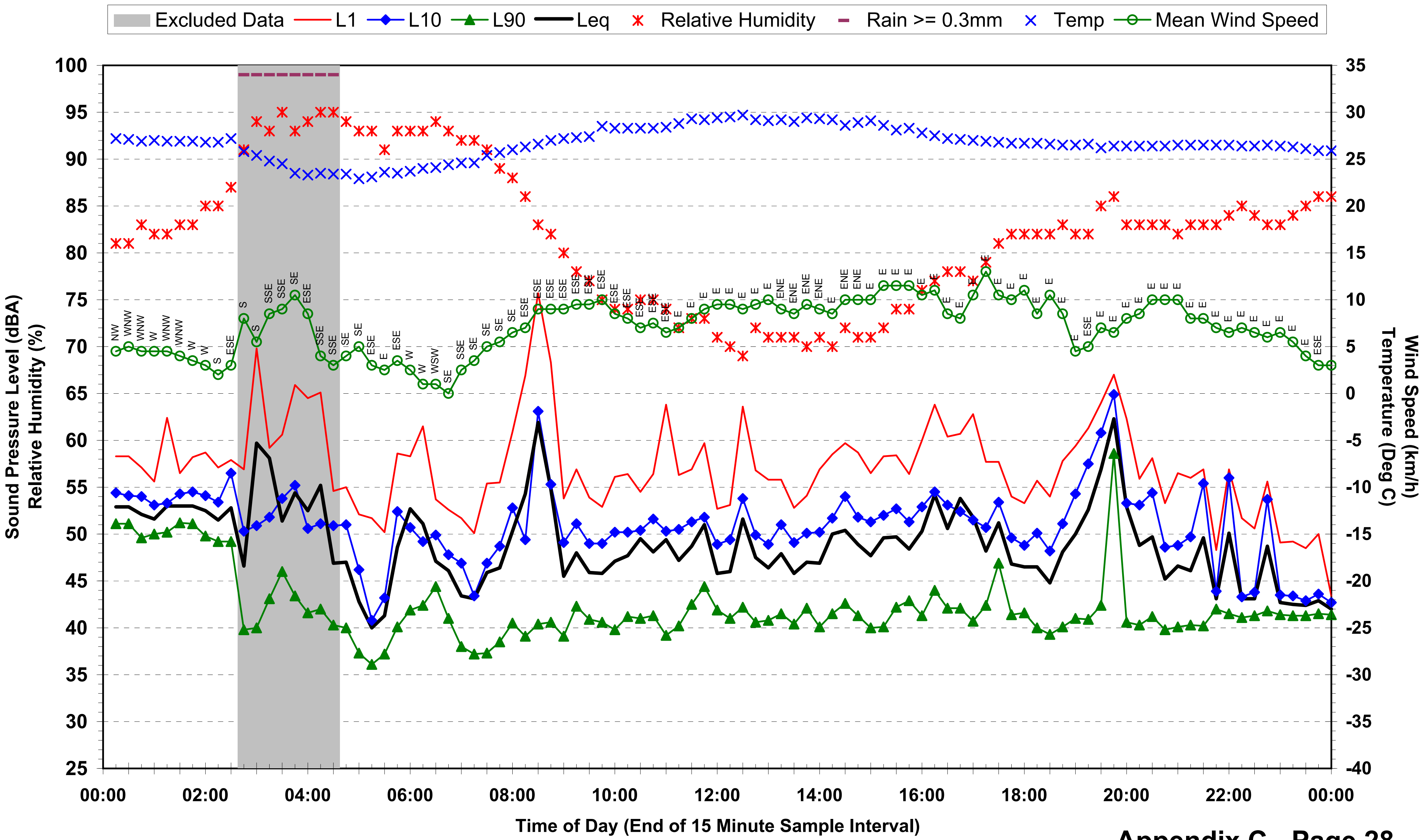
Statistical Ambient Noise Levels
20-2014 - Plant 3 - Auckland Hill - Friday 22 February 2008

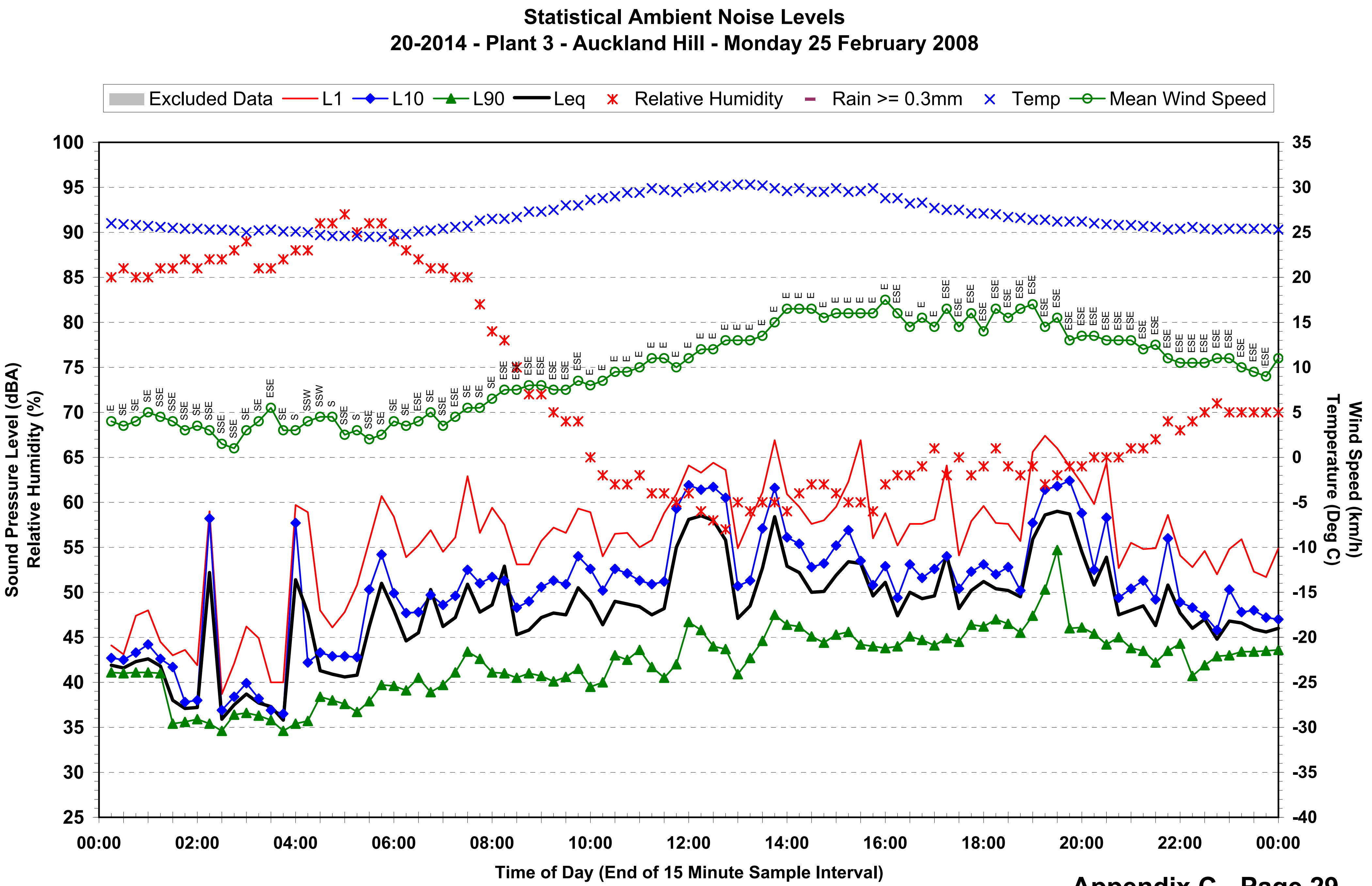




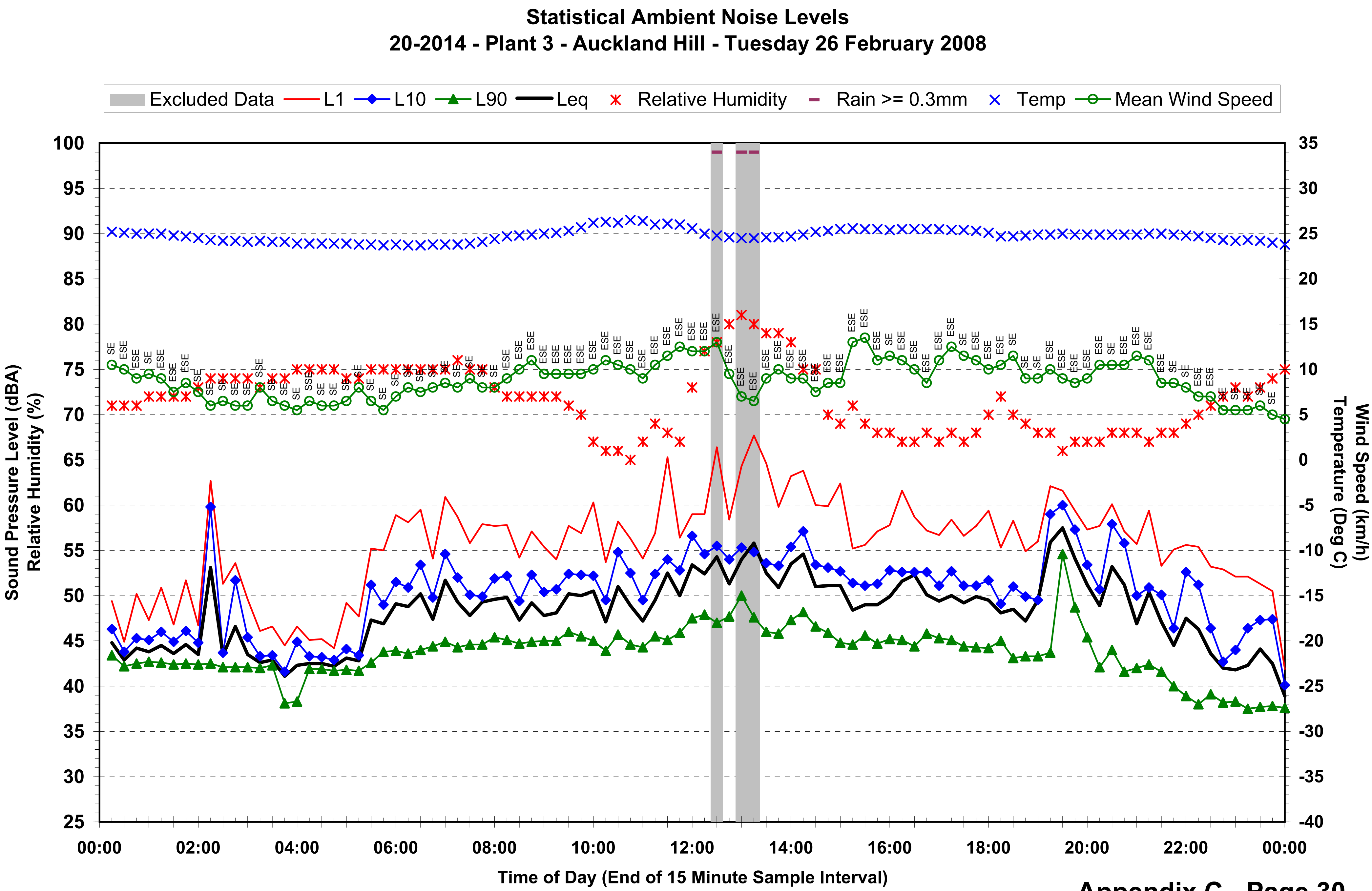
Statistical Ambient Noise Levels
20-2014 - Plant 3 - Auckland Hill - Saturday 23 February 2008
Excluded Data
L1
L10
L90
Leq
Relative Humidity
Rain >= 0.3mm
Temp
Mean Wind Speed
Sound Pressure Level (dBA)
Relative Humidity (%)
Wind Speed (km/h)
Temperature (Deg C)
Time of Day (End of 15 Minute Sample Interval)

Statistical Ambient Noise Levels
20-2014 - Plant 3 - Auckland Hill - Sunday 24 February 2008

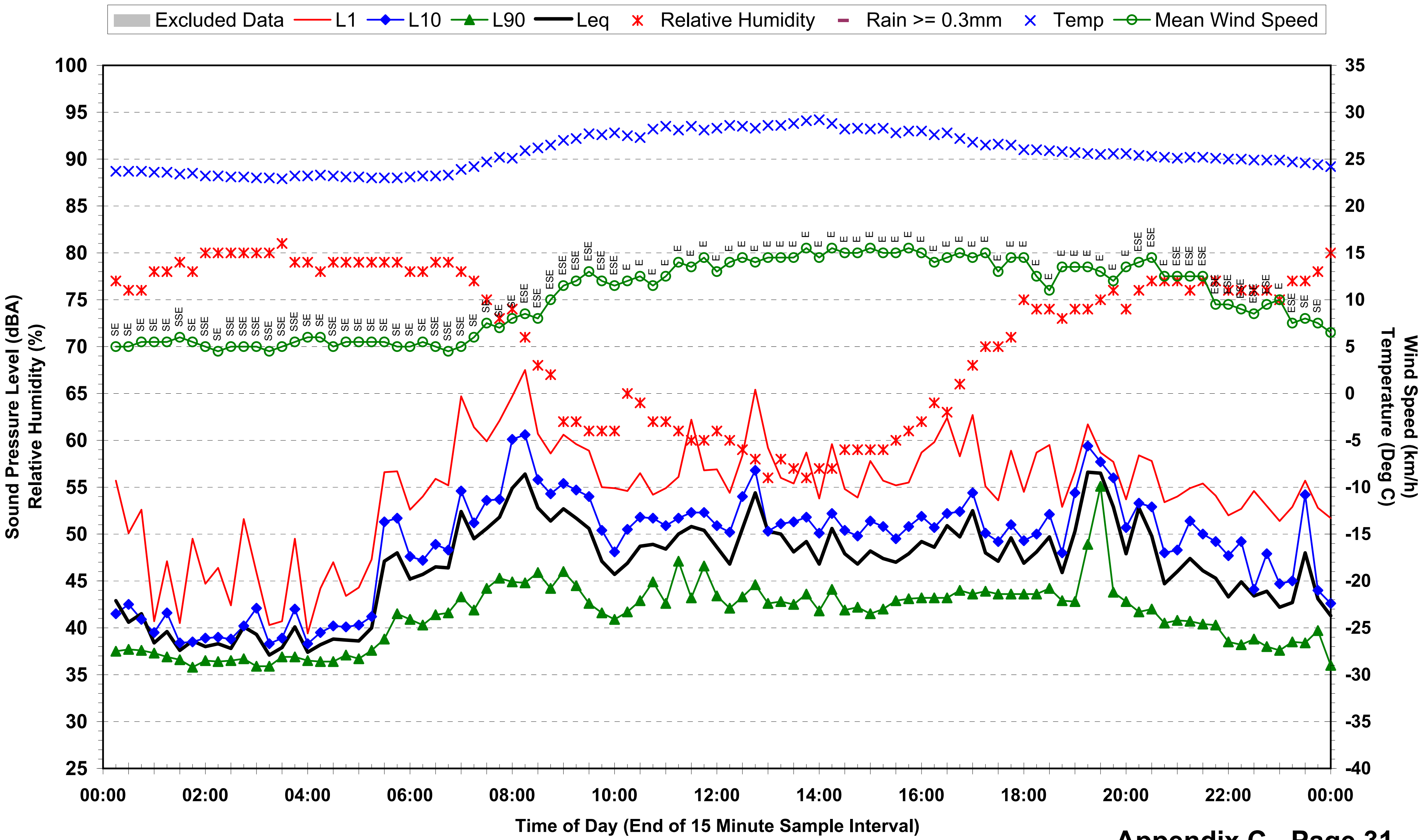




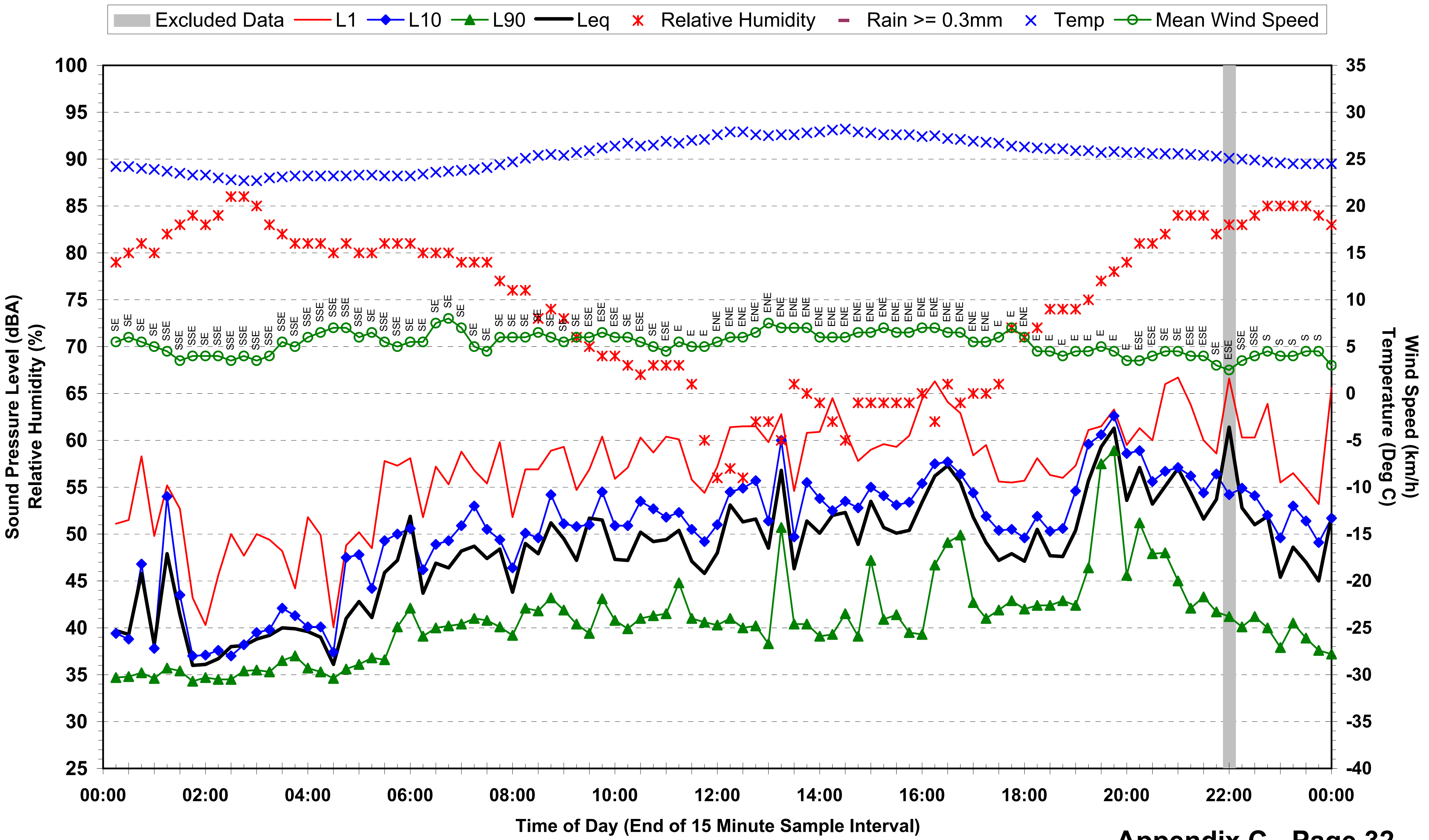
Statistical Ambient Noise Levels
20-2014 - Plant 3 - Auckland Hill - Monday 25 February 2008
Excluded Data
L1
L10
L90
Leq
Relative Humidity
Rain >= 0.3mm
Temp
Mean Wind Speed
Sound Pressure Level (dBA)
Relative Humidity (%)
Wind Speed (km/h)
Temperature (Deg C)
Time of Day (End of 15 Minute Sample Interval)


Statistical Ambient Noise Levels
20-2014 - Plant 3 - Auckland Hill - Tuesday 26 February 2008
Excluded Data
L1
L10
L90
Leq
Relative Humidity
Rain >= 0.3mm
Temp
Mean Wind Speed
Sound Pressure Level (dBA)
Relative Humidity (%)
Wind Speed (km/h)
Temperature (Deg C)
Time of Day (End of 15 Minute Sample Interval)

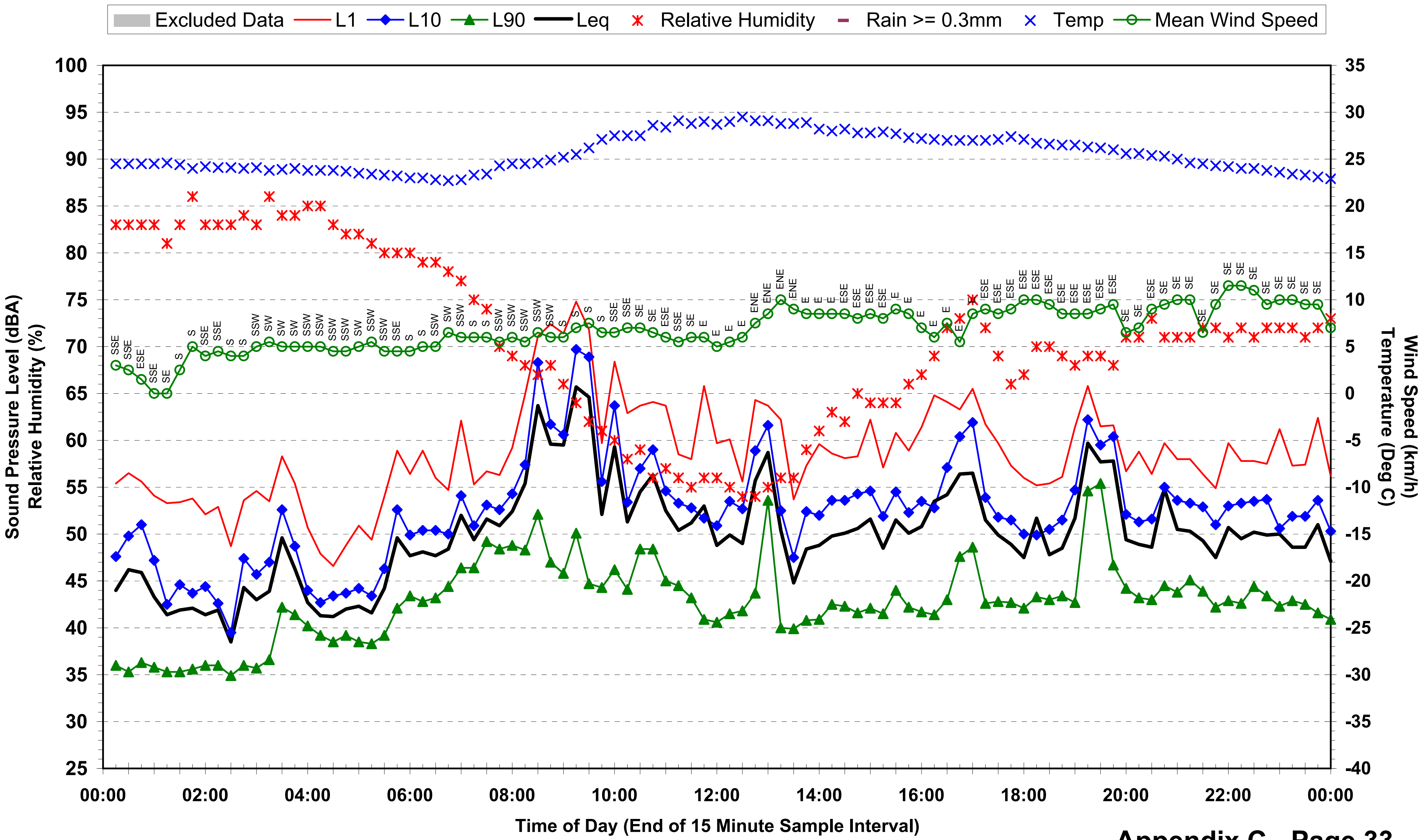
Statistical Ambient Noise Levels
20-2014 - Plant 3 - Auckland Hill - Wednesday 27 February 2008

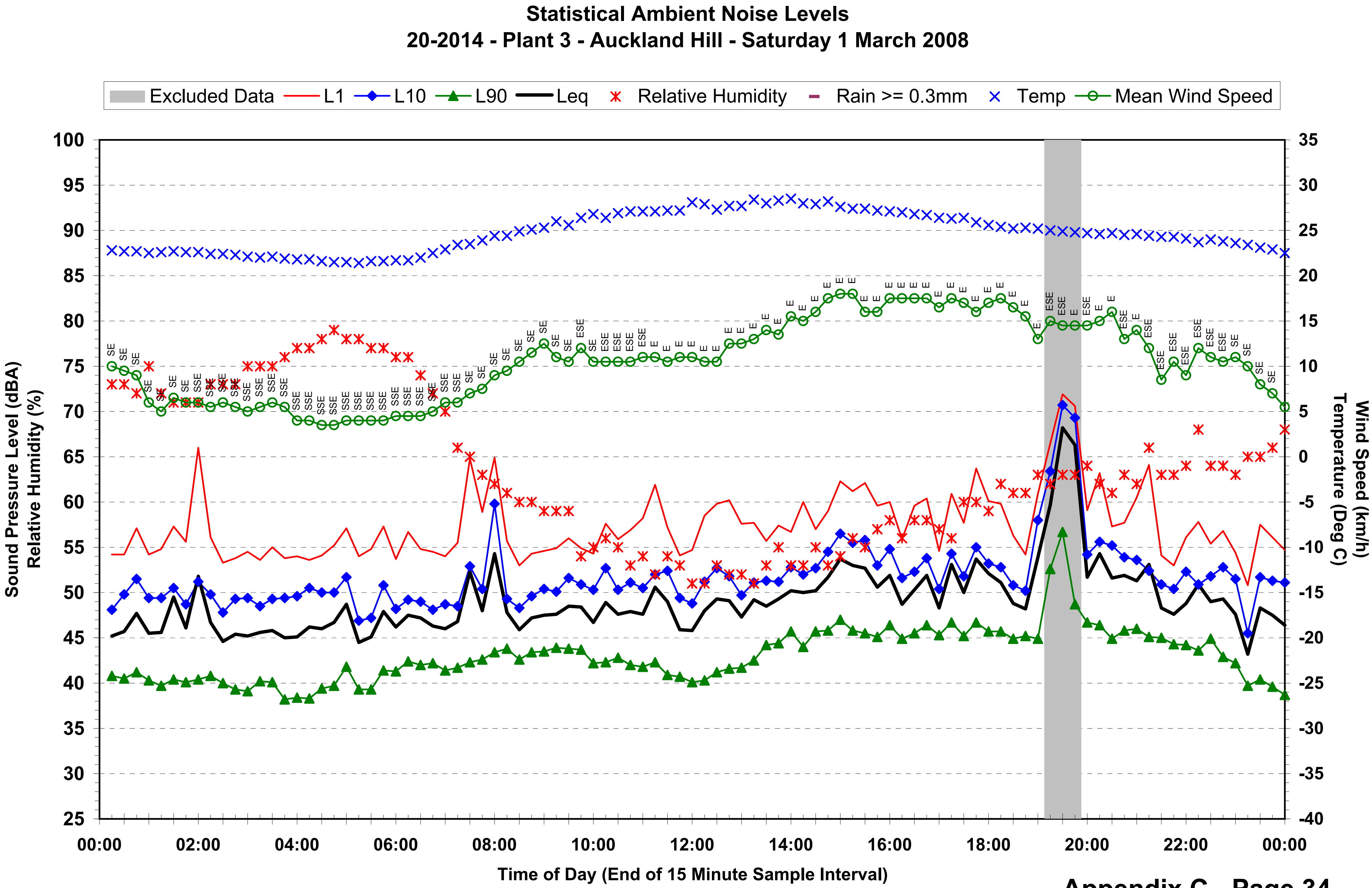


Statistical Ambient Noise Levels
20-2014 - Plant 3 - Auckland Hill - Thursday 28 February 2008



Statistical Ambient Noise Levels
20-2014 - Plant 3 - Auckland Hill - Friday 29 February 2008





Statistical Ambient Noise Levels
20-2014 - Plant 3 - Auckland Hill - Saturday 1 March 2008
Excluded Data
L1
L10
L90
Leq
Relative Humidity
Rain >= 0.3mm
Temp
Mean Wind Speed
Sound Pressure Level (dBA)
Relative Humidity (%)
Wind Speed (km/h)
Temperature (Deg C)
Time of Day (End of 15 Minute Sample Interval)
00:00
02:00
04:00
06:00
08:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
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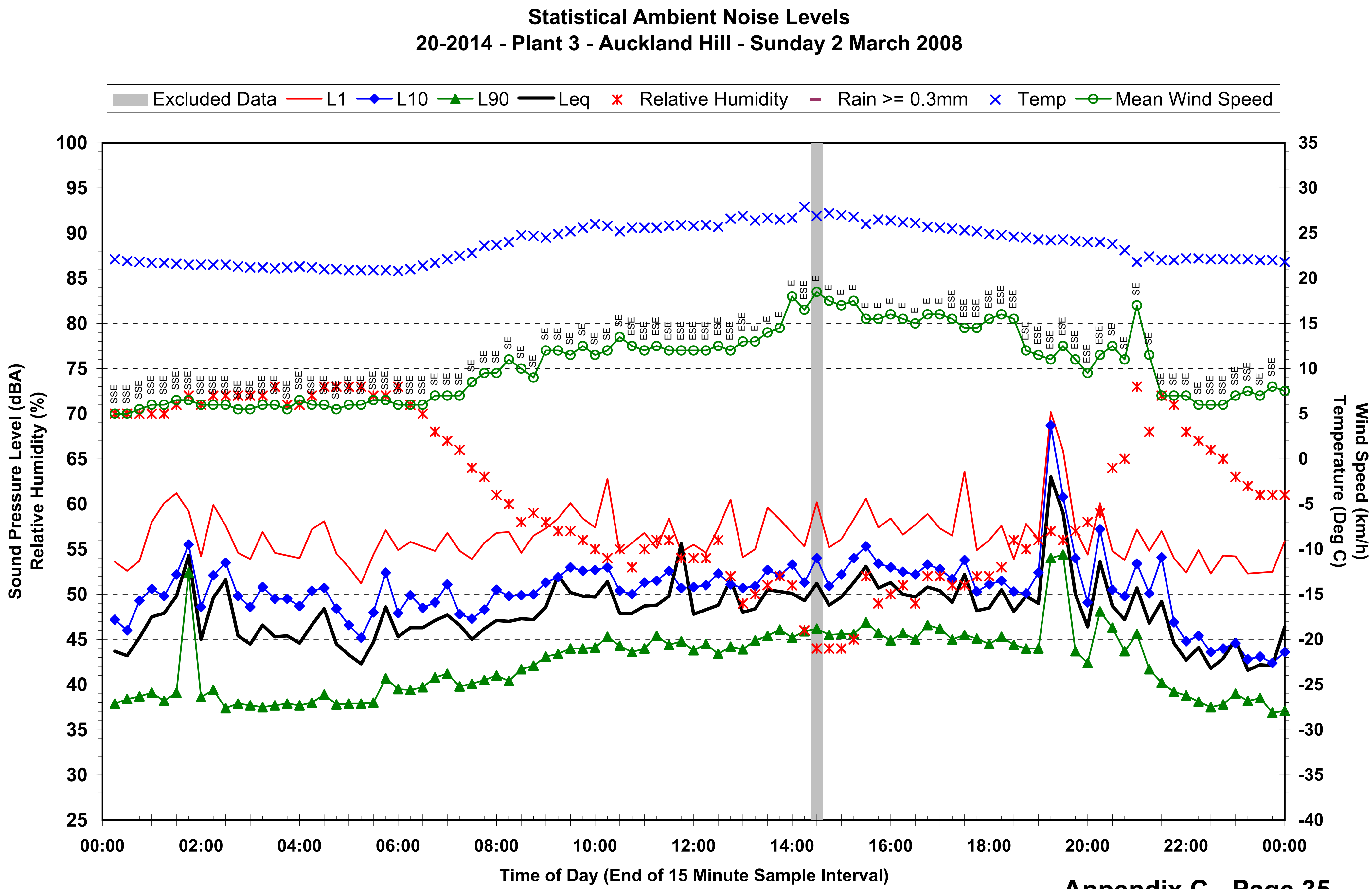

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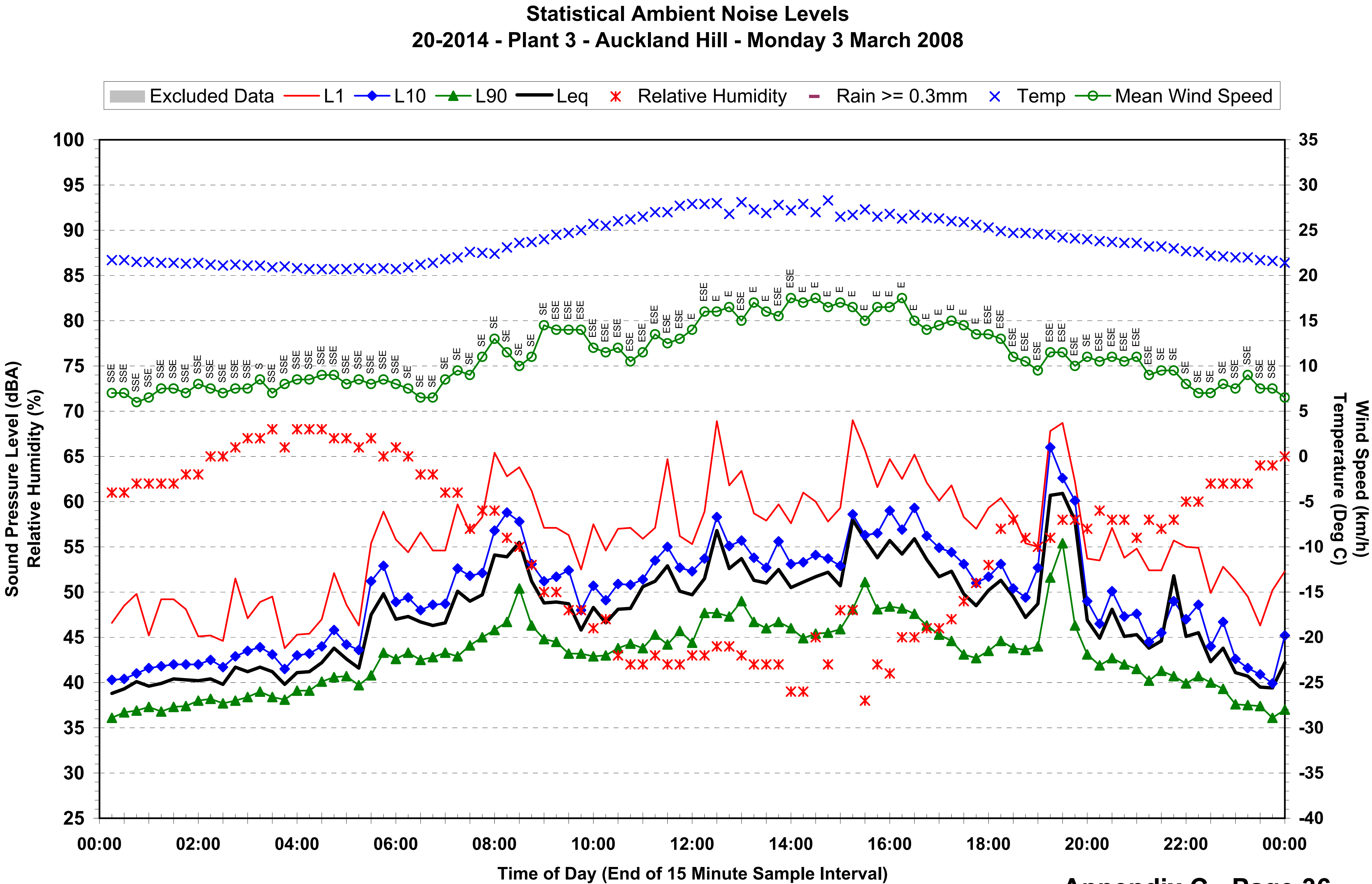
Ambient Conditions

RHA Report 20-2014



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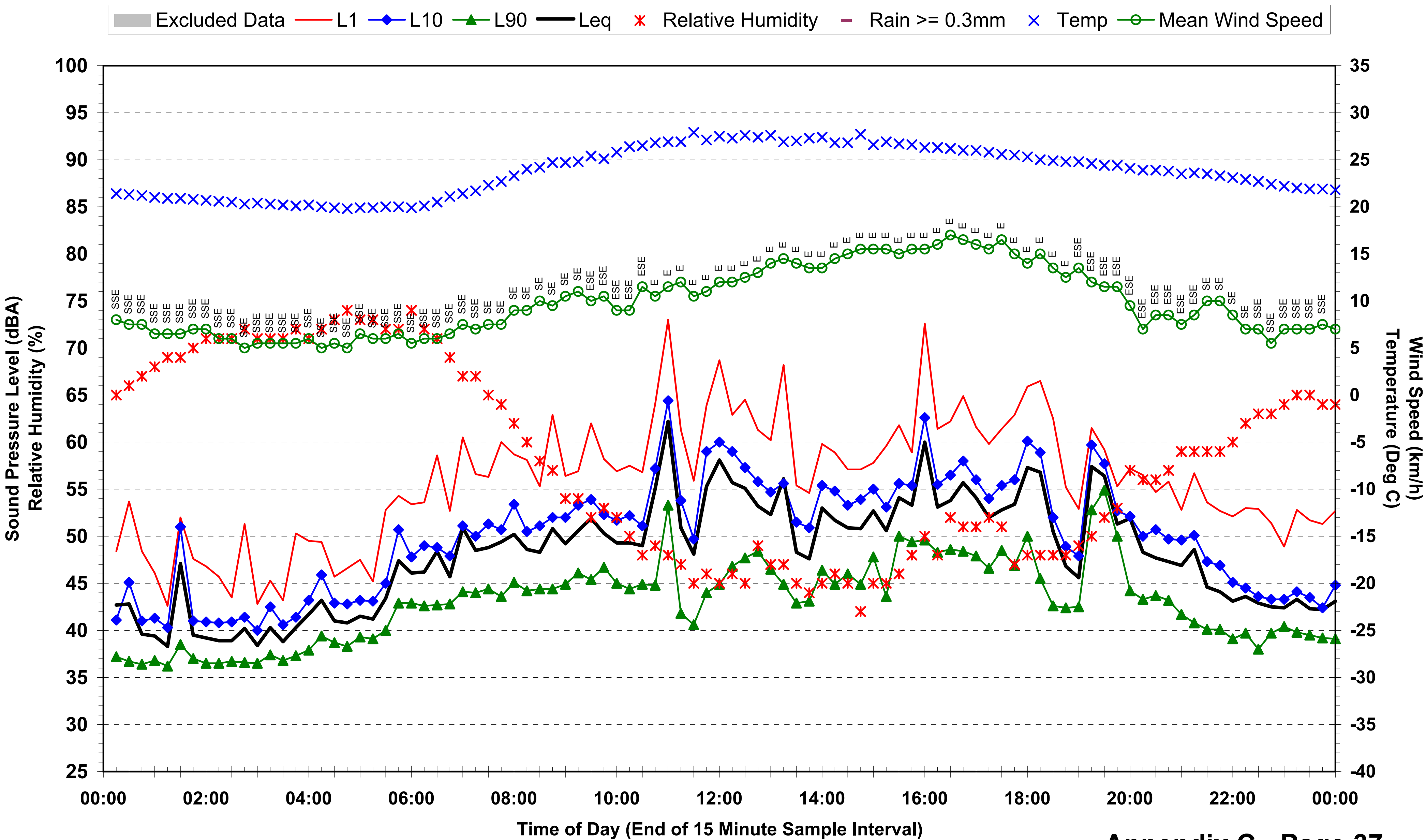
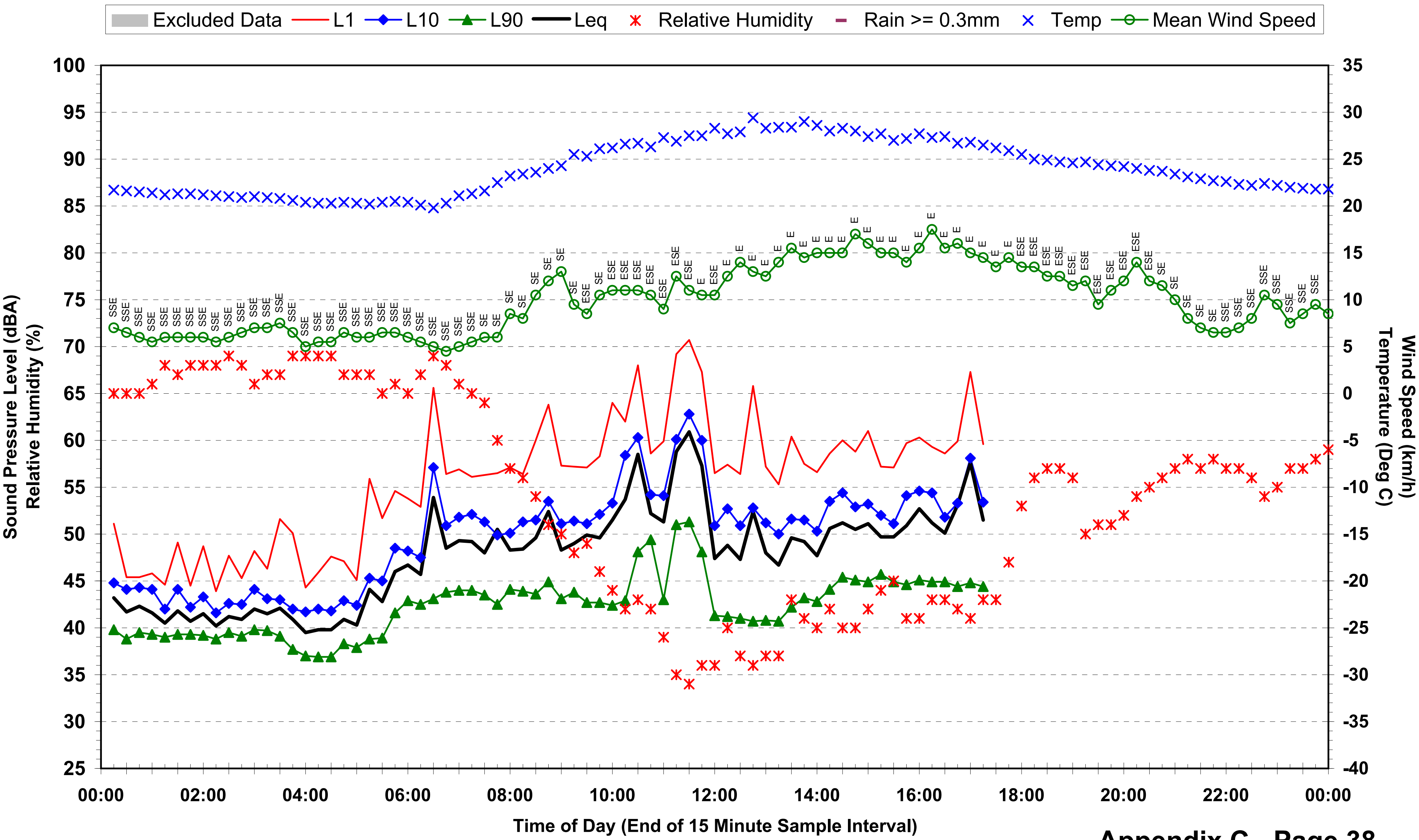
Ambient Conditions

RHA Report 20-2014

Statistical Ambient Noise Levels
20-2014 - Plant 3 - Auckland Hill - Tuesday 4 March 2008



Statistical Ambient Noise Levels
20-2014 - Plant 3 - Auckland Hill - Wednesday 5 March 2008



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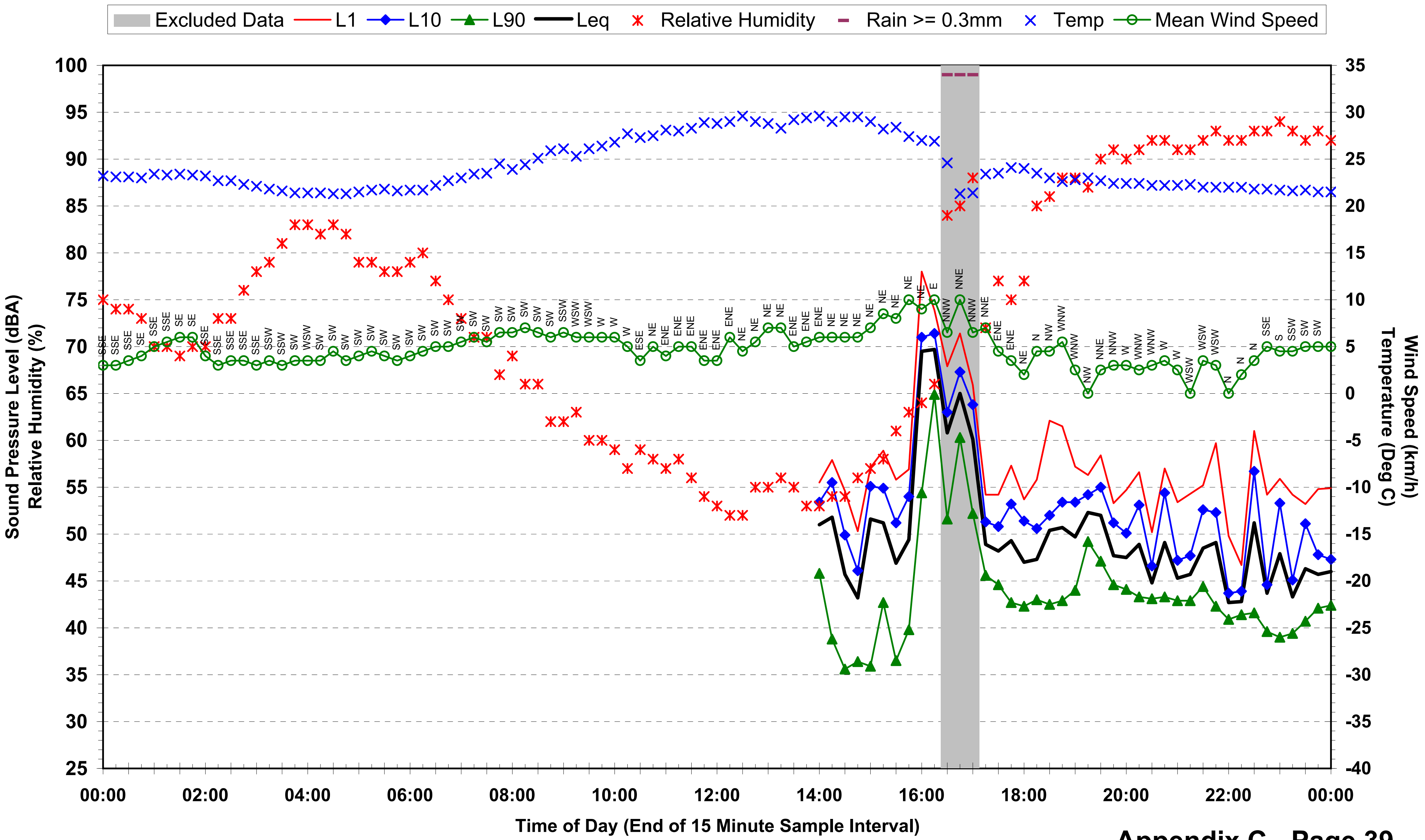
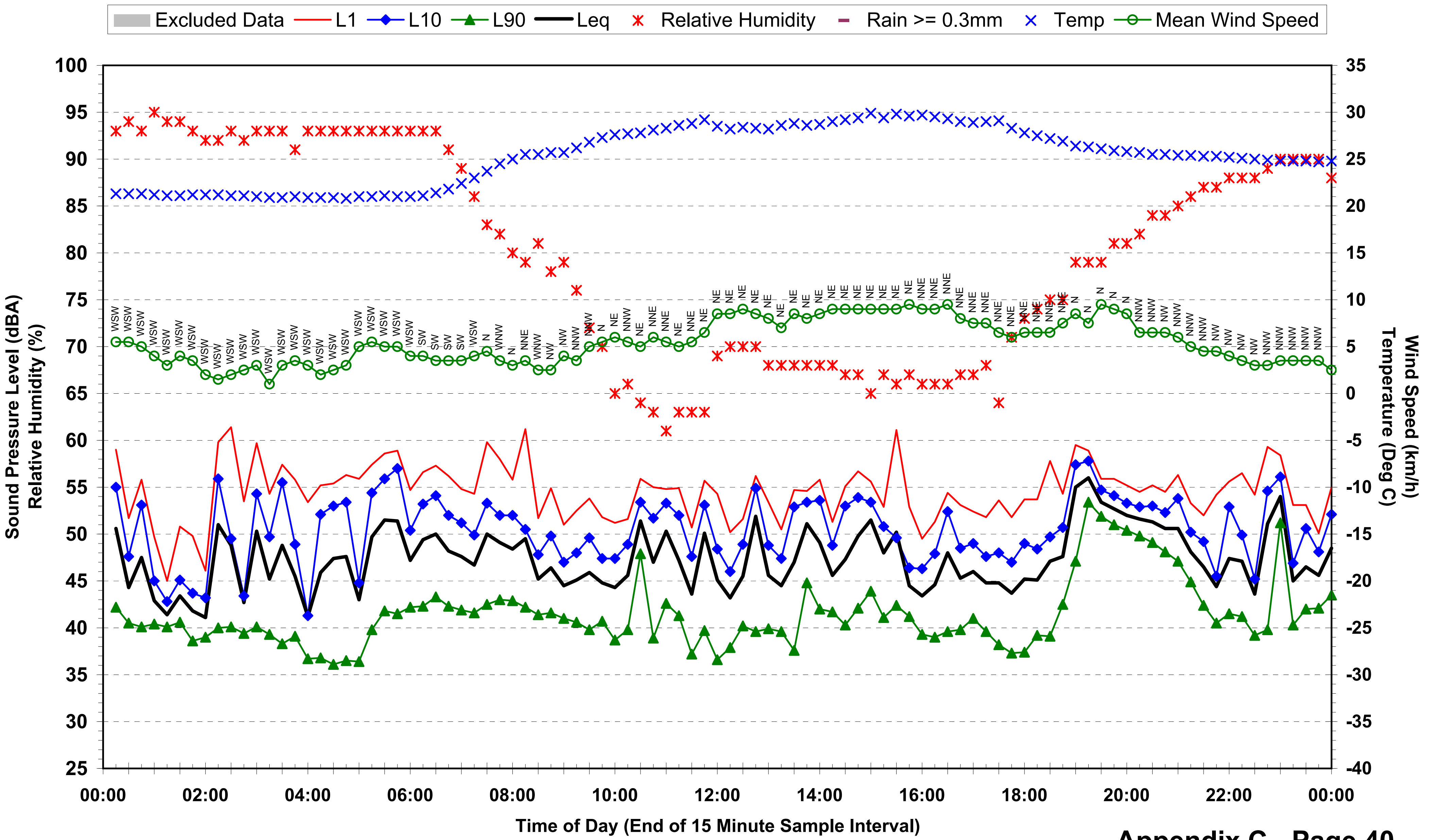
Ambient Conditions

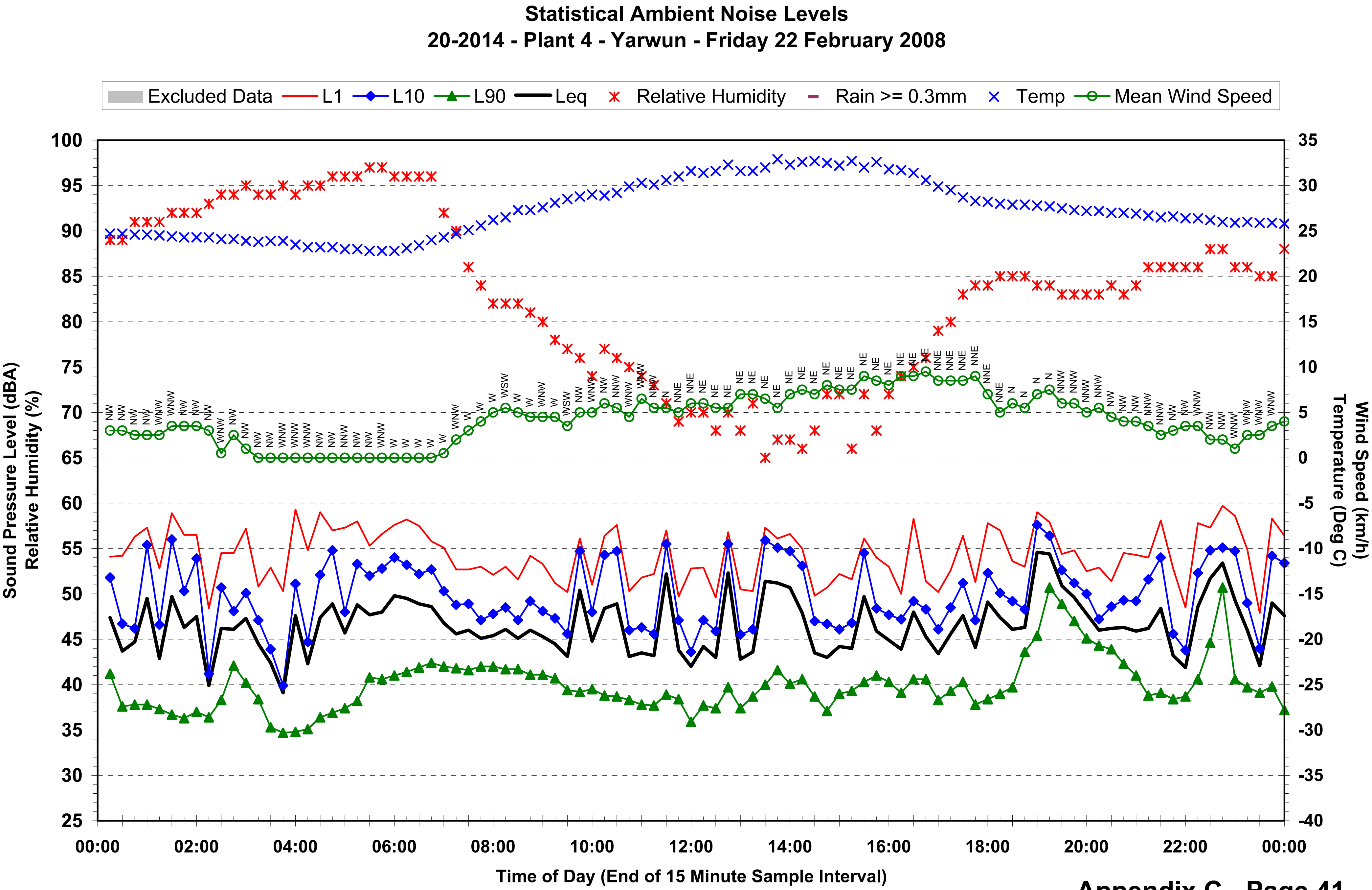
RHA Report 20-2014

Statistical Ambient Noise Levels
20-2014 - Plant 4 - Yarwun - Wednesday 20 February 2008

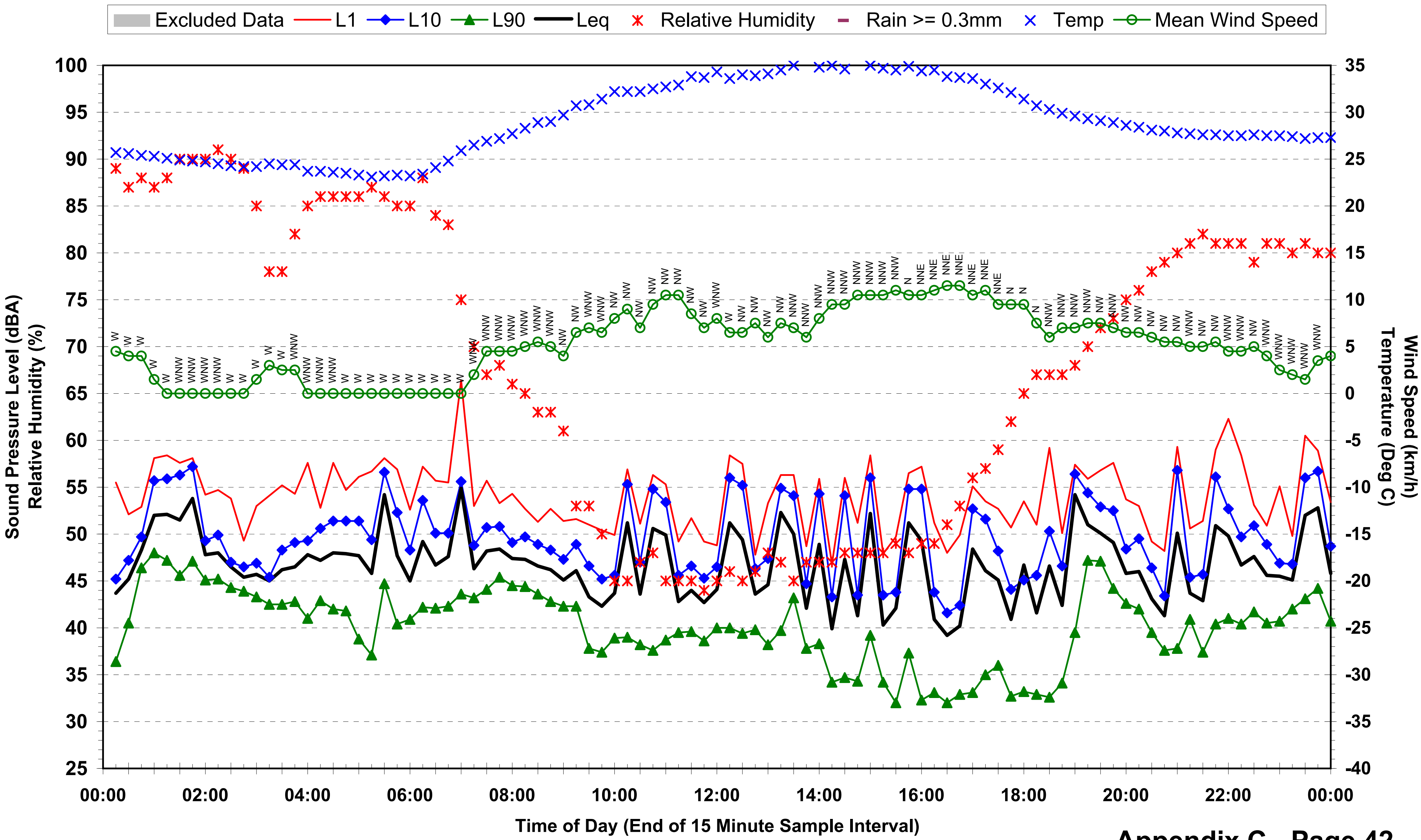


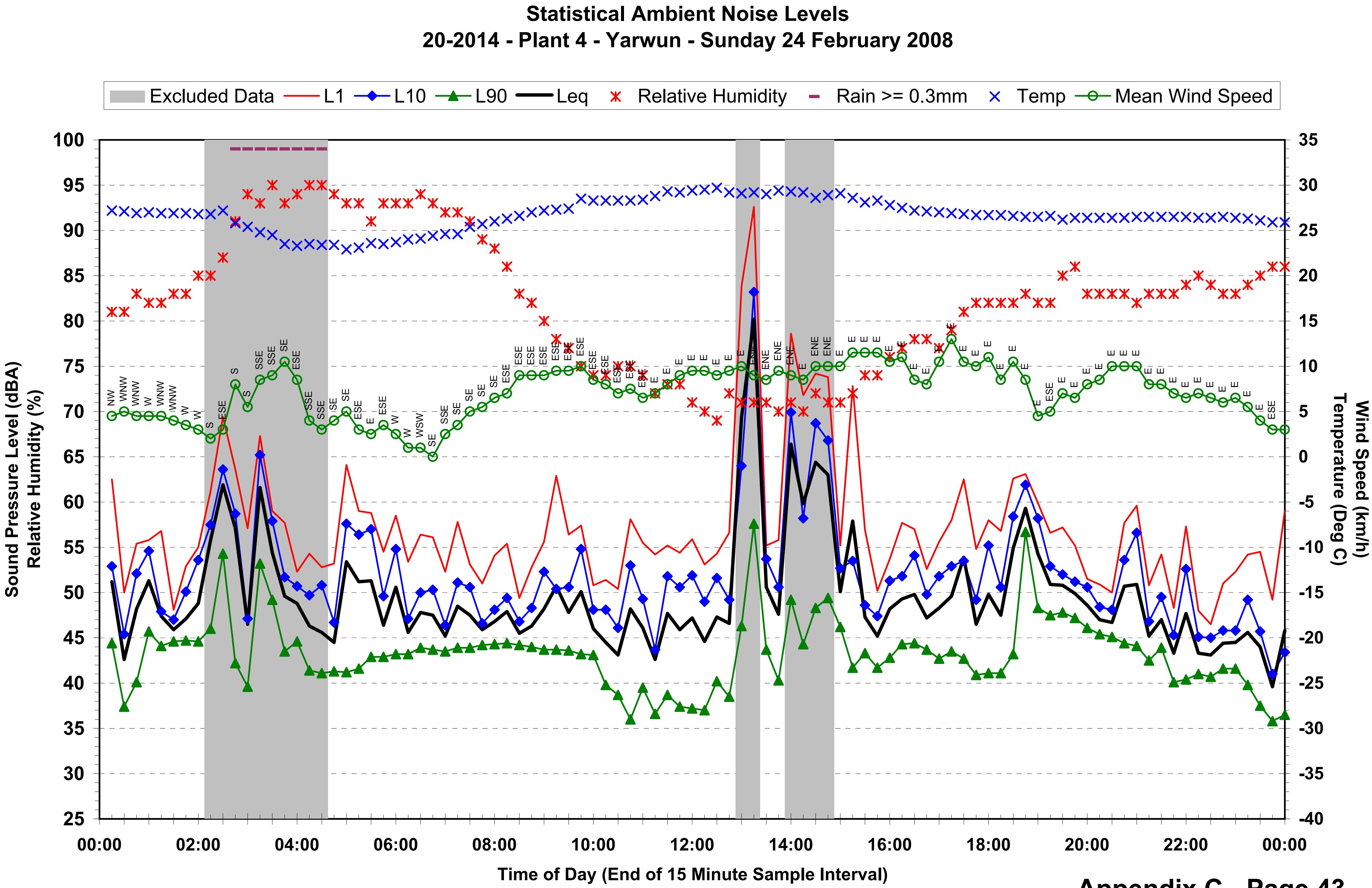
Statistical Ambient Noise Levels
20-2014 - Plant 4 - Yarwun - Thursday 21 February 2008




Statistical Ambient Noise Levels
20-2014 - Plant 4 - Yarwun - Friday 22 February 2008
Excluded Data
L1
L10
L90
Leq
Relative Humidity
Rain >= 0.3mm
Temp
Mean Wind Speed
Sound Pressure Level (dBA)
Relative Humidity (%)
Wind Speed (km/h)
Temperature (Deg C)
Time of Day (End of 15 Minute Sample Interval)

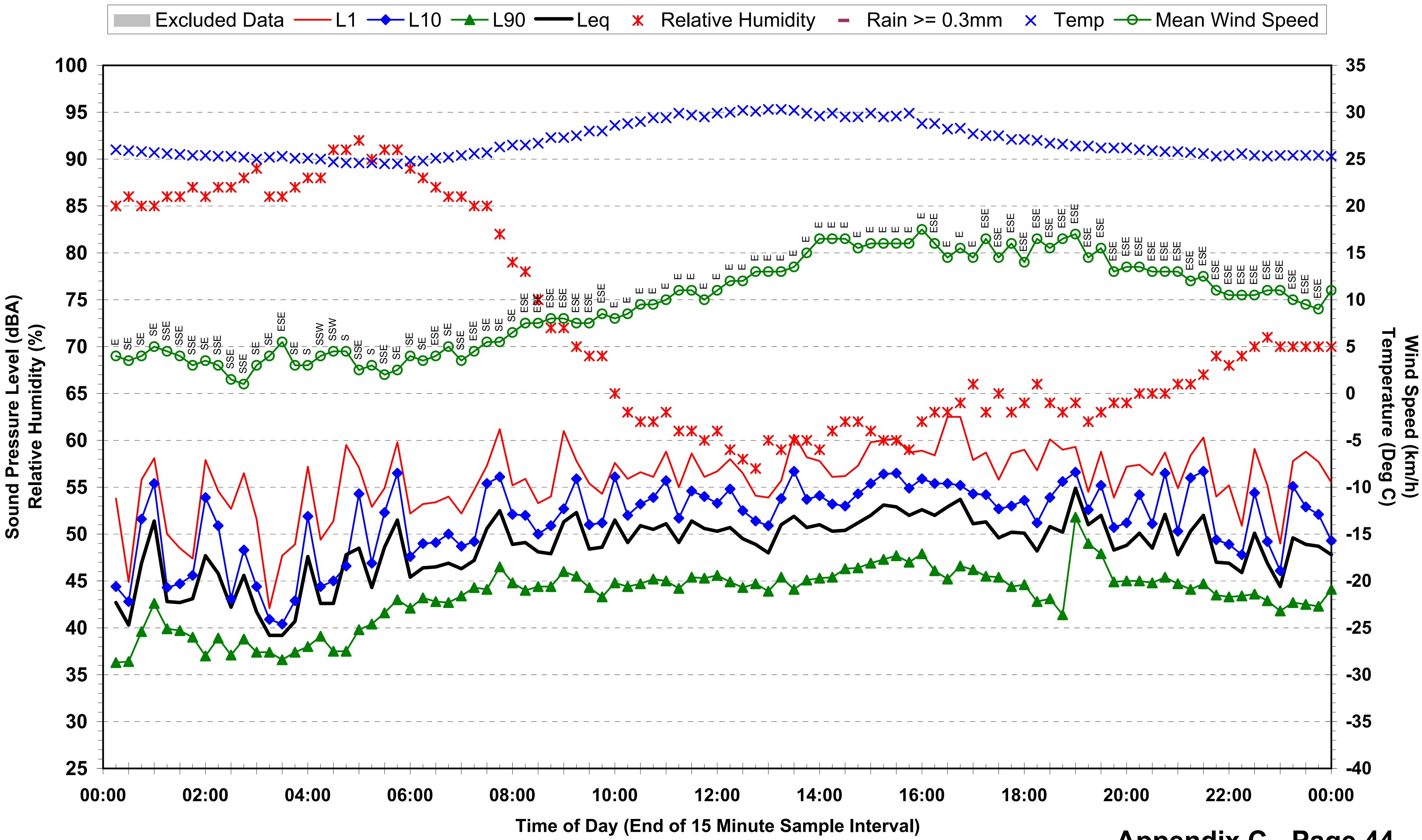
Statistical Ambient Noise Levels
20-2014 - Plant 4 - Yarwun - Saturday 23 February 2008



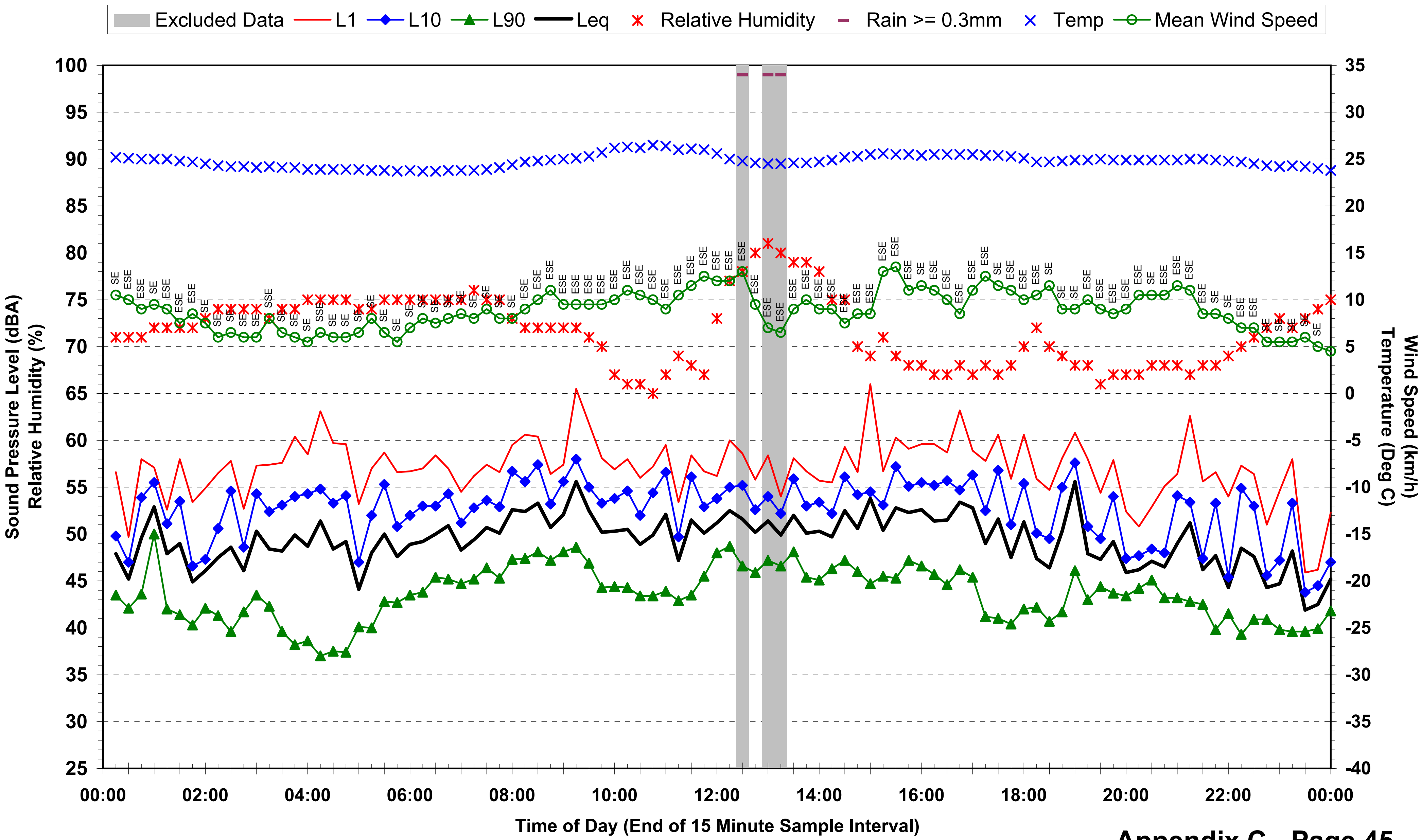


Statistical Ambient Noise Levels
20-2014 - Plant 4 - Yarwun - Sunday 24 February 2008
Excluded Data
L1
L10
L90
Leq
Relative Humidity
Rain >= 0.3mm
Temp
Mean Wind Speed
Sound Pressure Level (dBA)
Relative Humidity (%)
Wind Speed (km/h)
Temperature (Deg C)
Time of Day (End of 15 Minute Sample Interval)

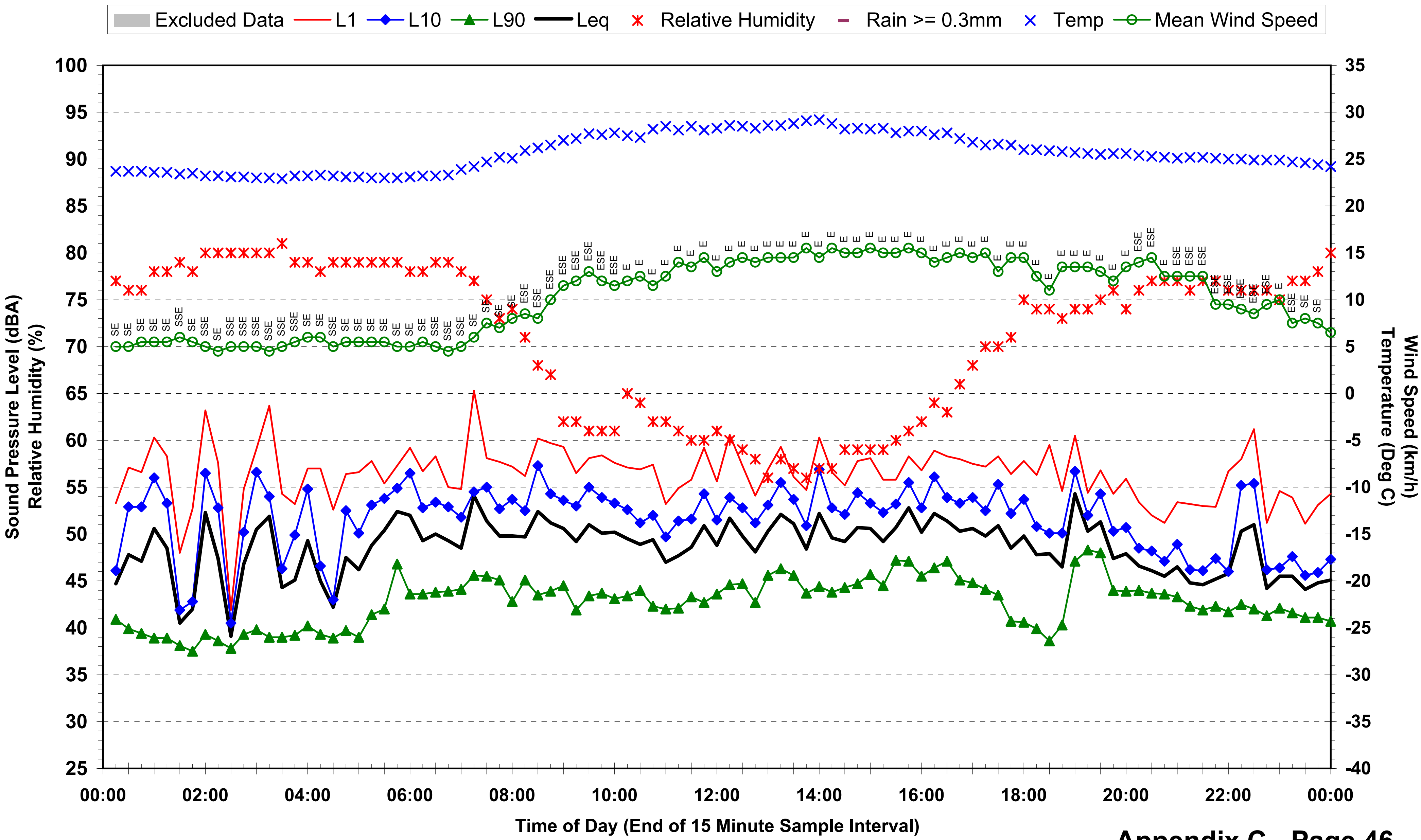
Statistical Ambient Noise Levels
20-2014 - Plant 4 - Yarwun - Monday 25 February 2008



Statistical Ambient Noise Levels
20-2014 - Plant 4 - Yarwun - Tuesday 26 February 2008



Statistical Ambient Noise Levels
20-2014 - Plant 4 - Yarwun - Wednesday 27 February 2008



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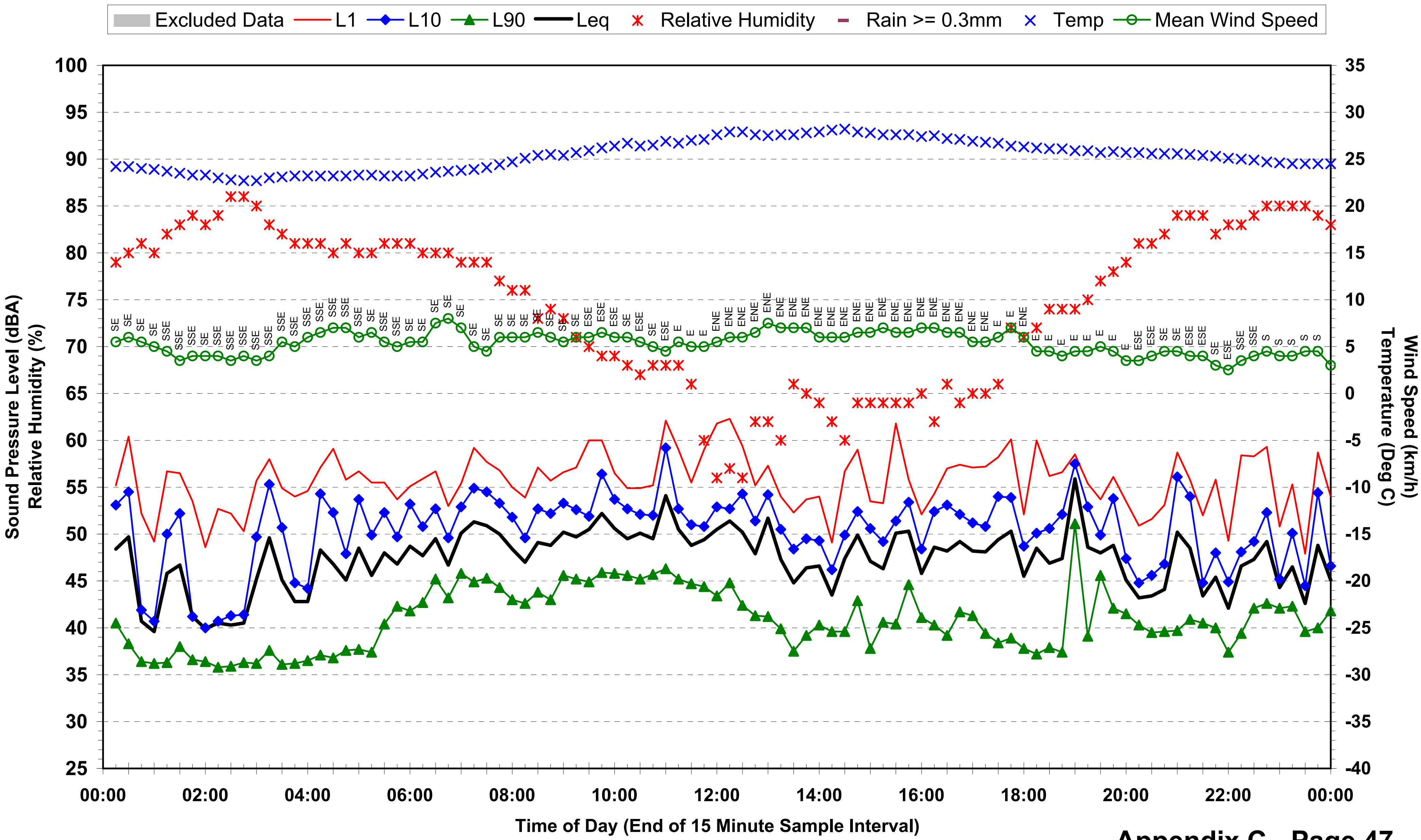
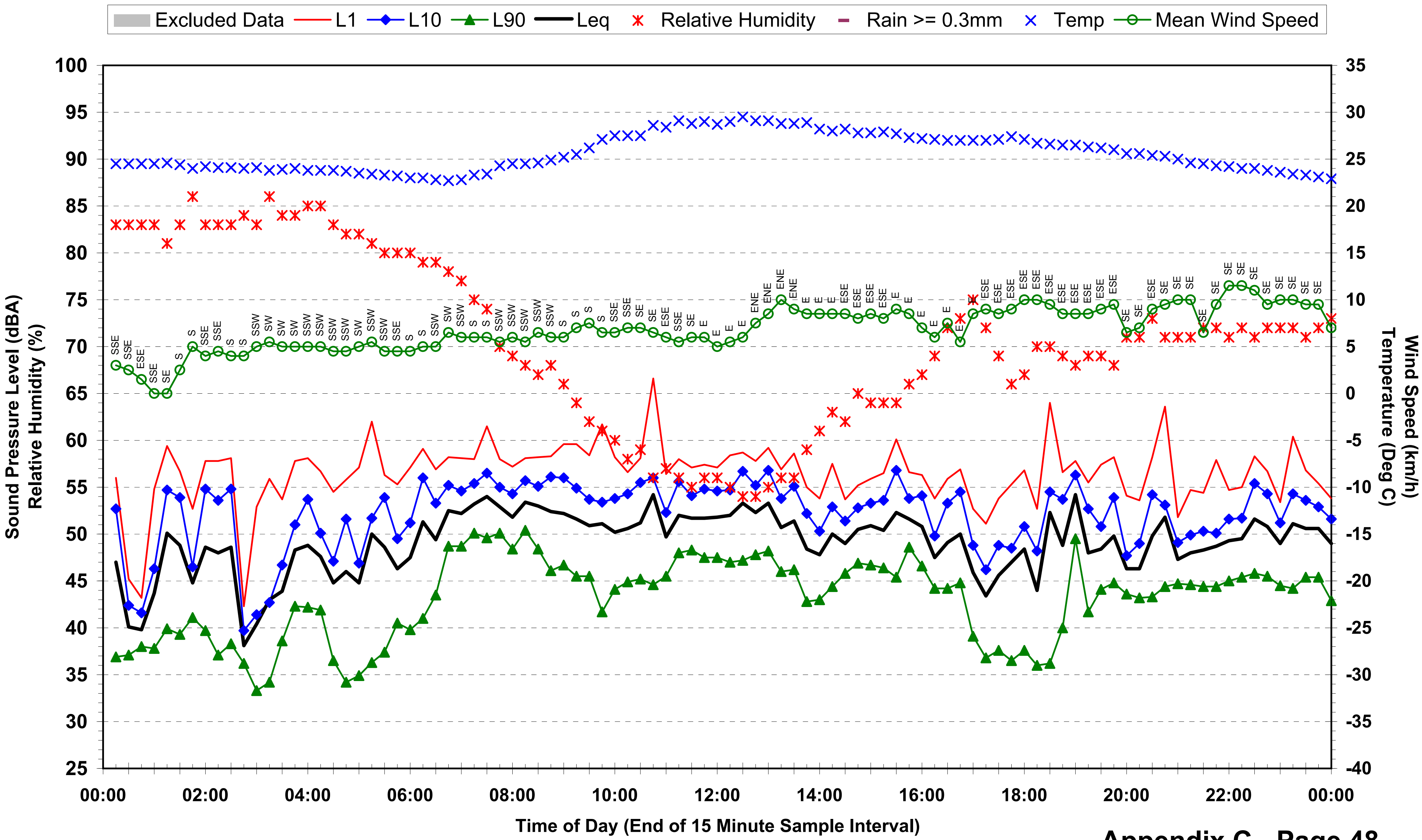
Ambient Conditions
RHA Report 20-2014

Statistical Ambient Noise Levels
20-2014 - Plant 4 - Yarwun - Thursday 28 February 2008



Statistical Ambient Noise Levels
20-2014 - Plant 4 - Yarwun - Friday 29 February 2008



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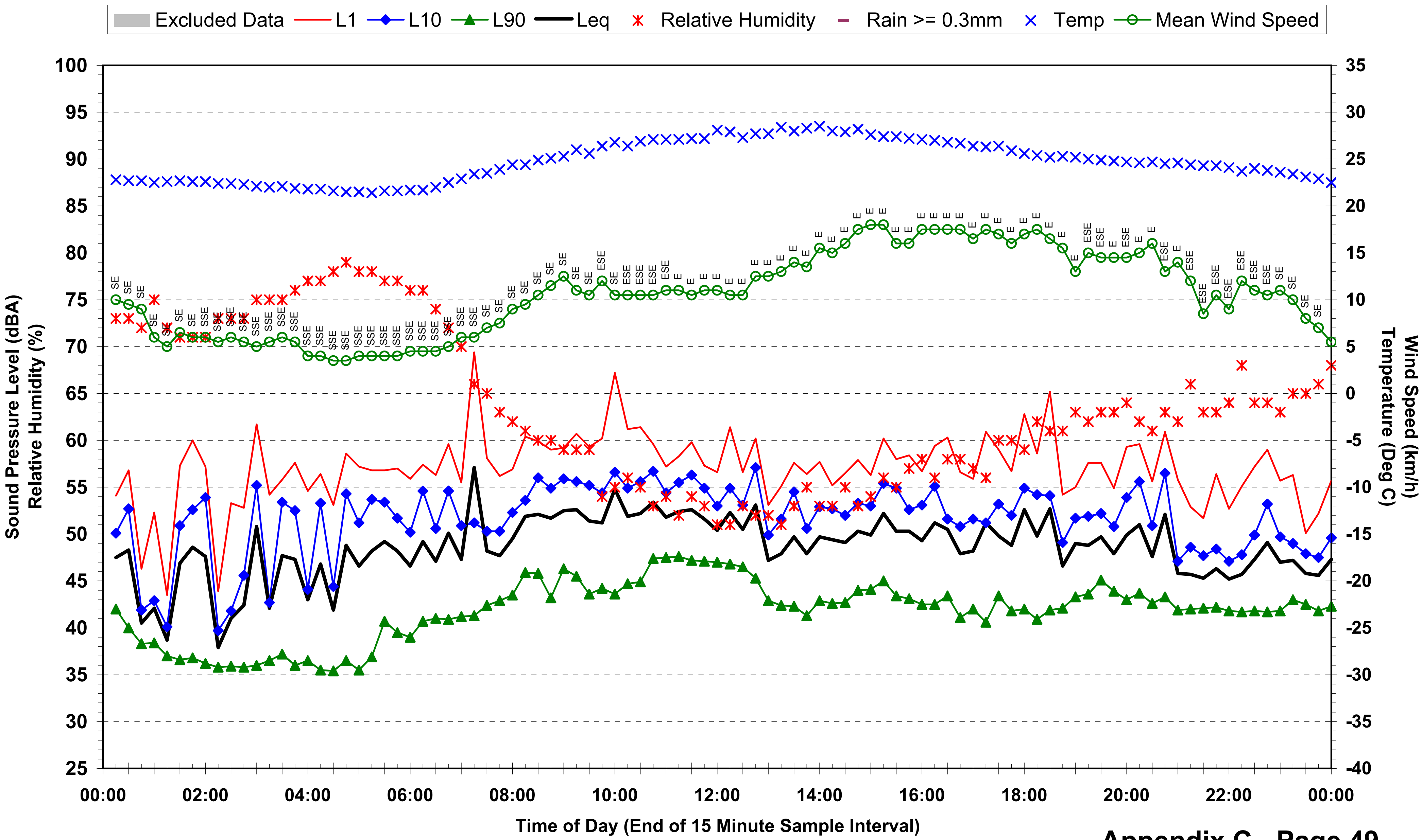
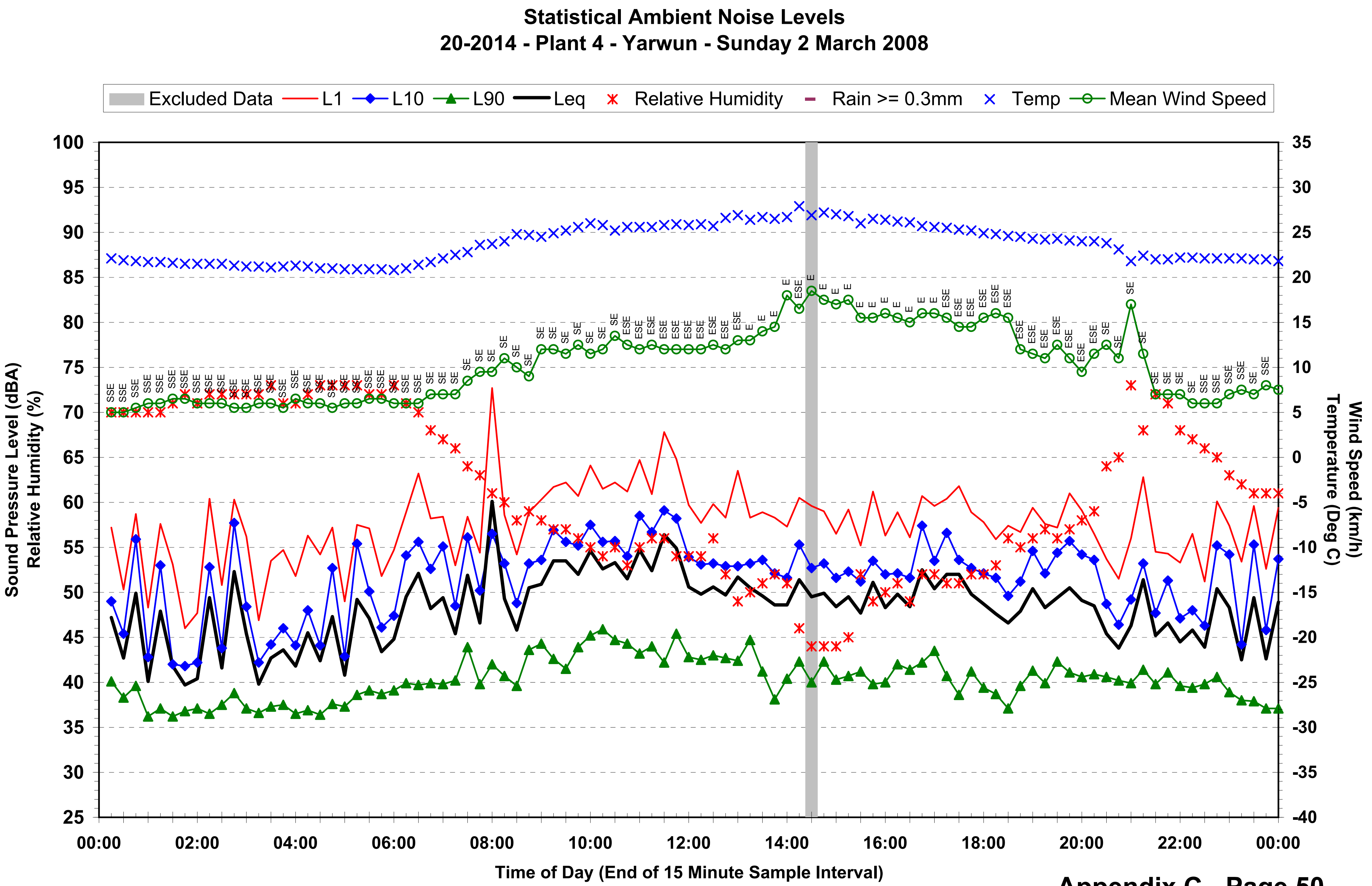
Ambient Conditions

RHA Report 20-2014

Statistical Ambient Noise Levels
20-2014 - Plant 4 - Yarwun - Saturday 1 March 2008





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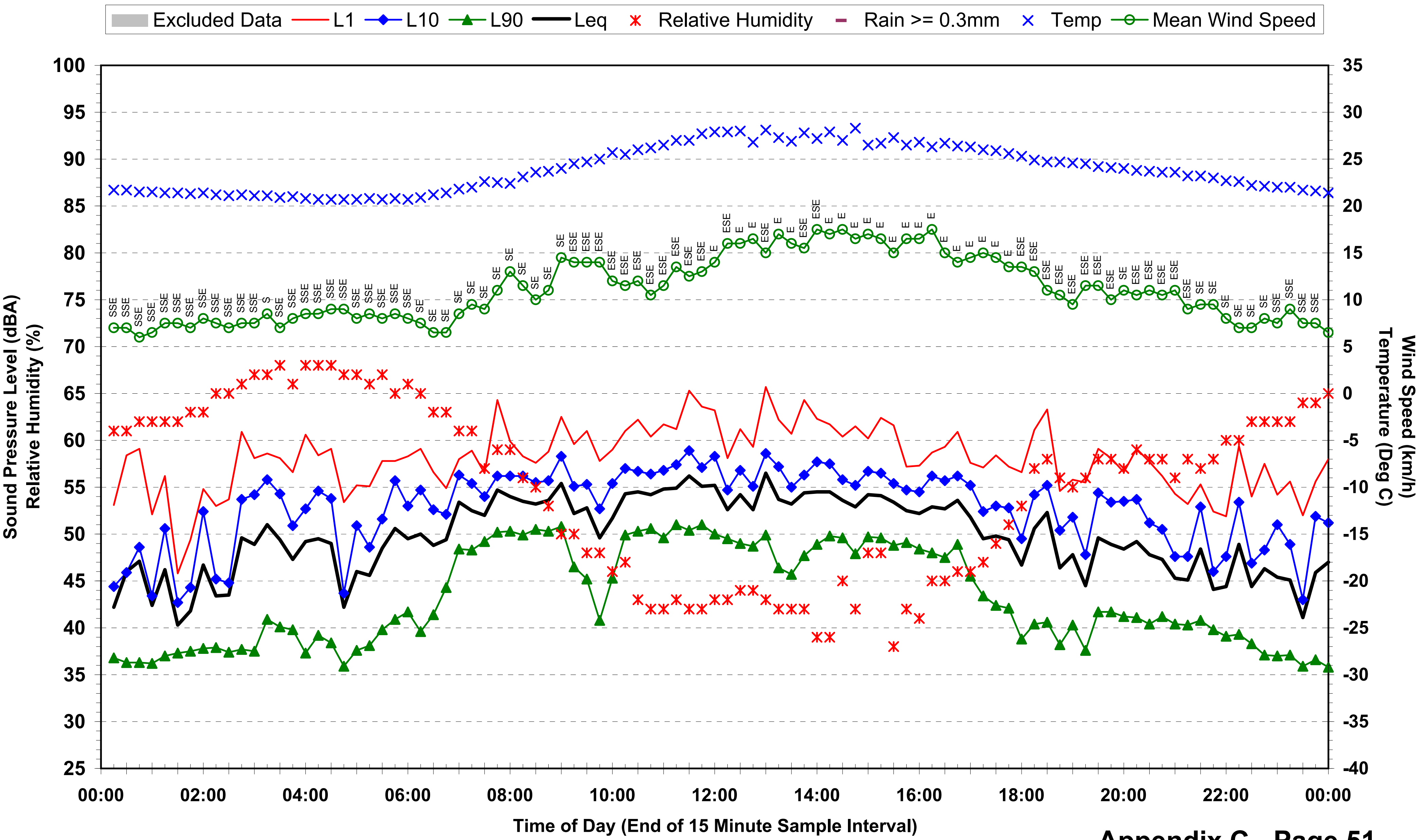
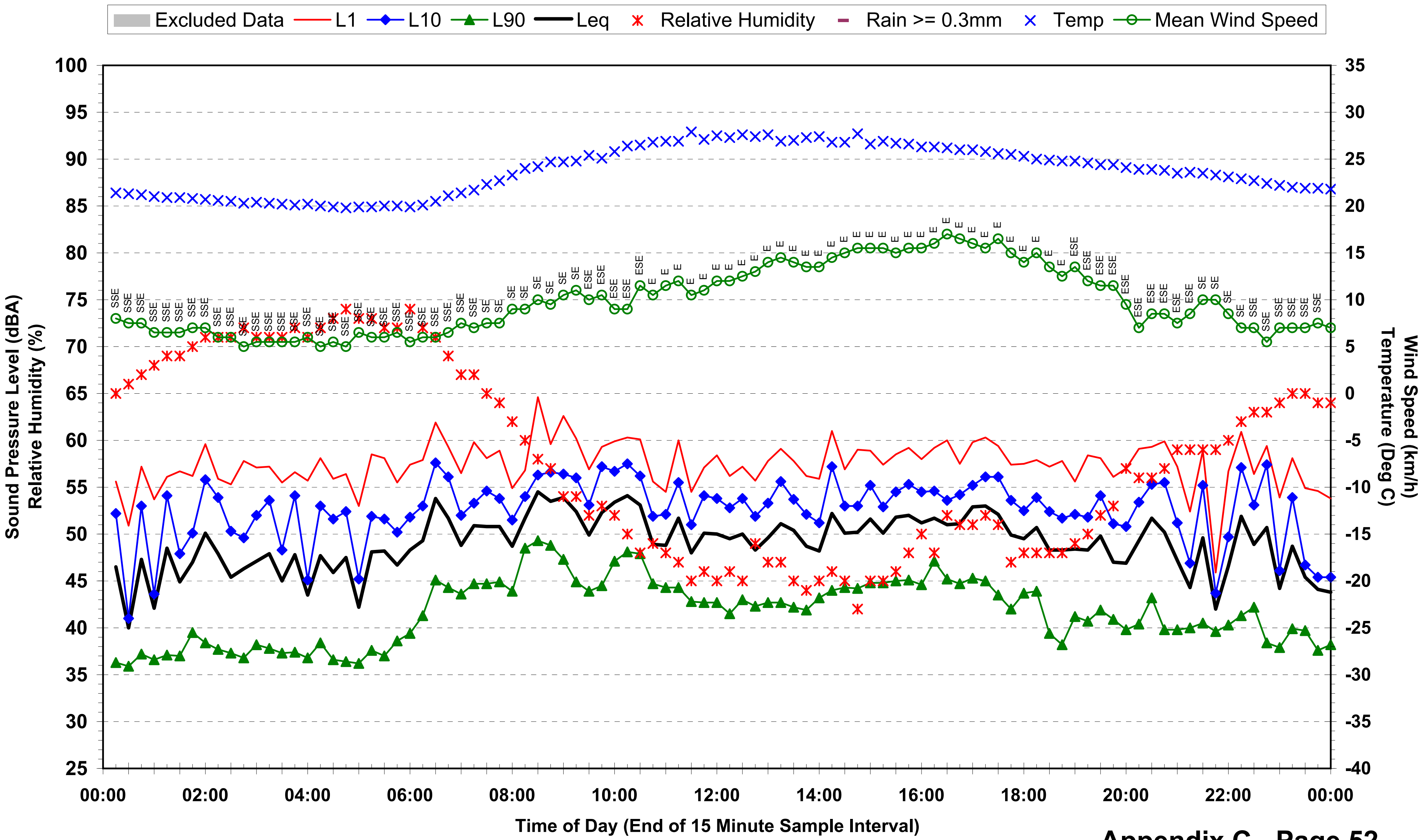
Ambient Conditions

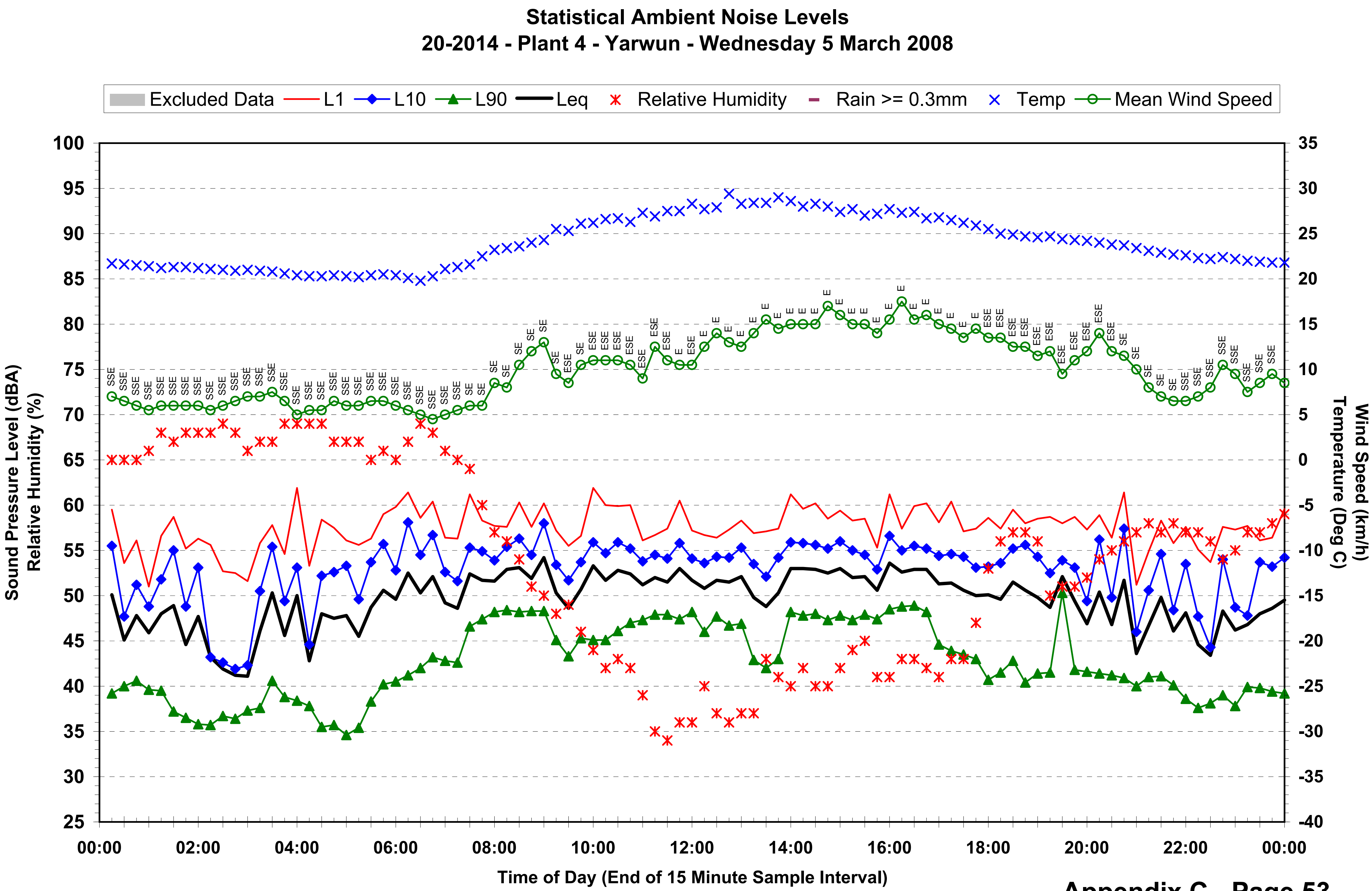
RHA Report 20-2014

Statistical Ambient Noise Levels
20-2014 - Plant 4 - Yarwun - Monday 3 March 2008

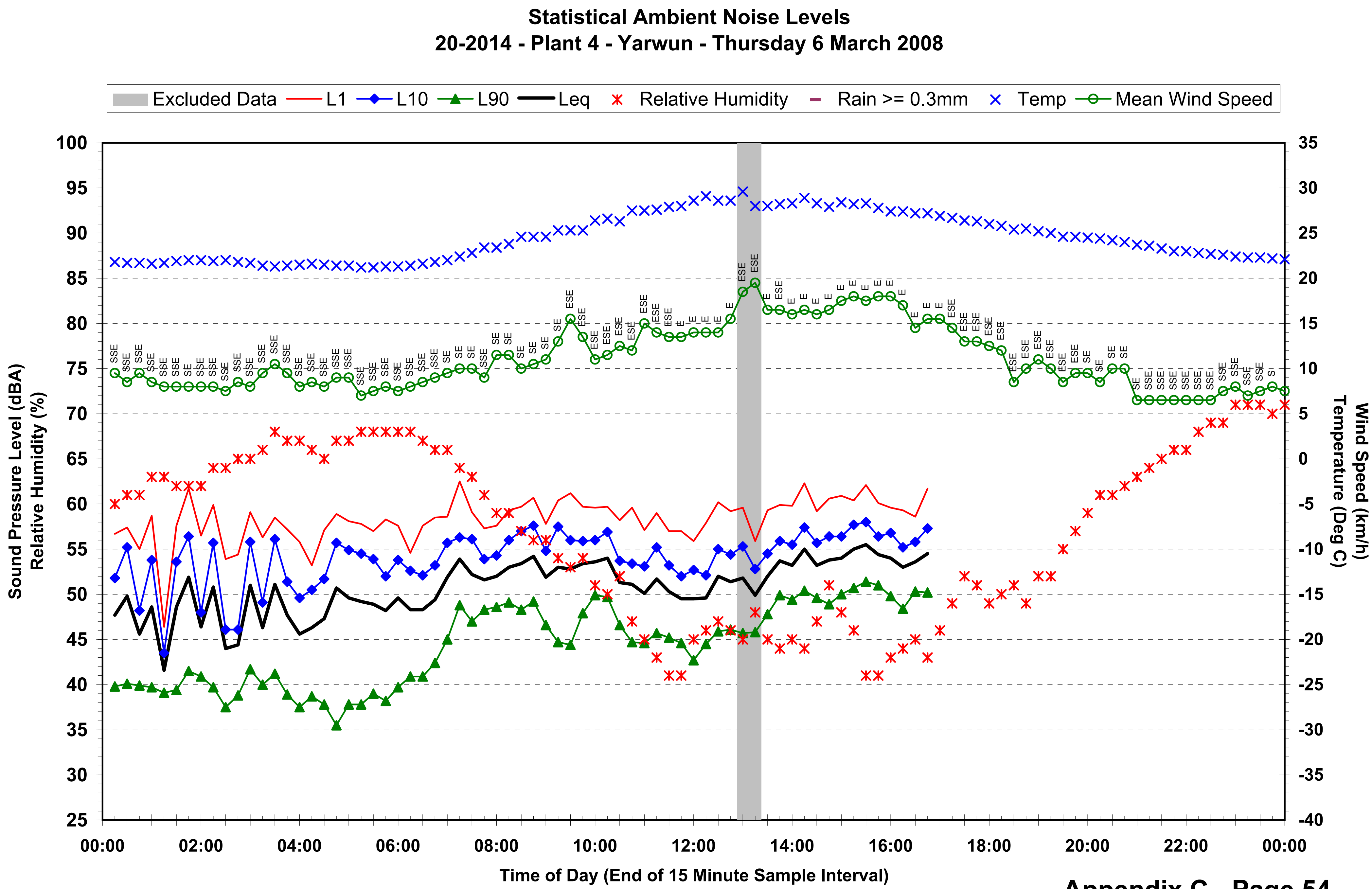


Statistical Ambient Noise Levels
20-2014 - Plant 4 - Yarwun - Tuesday 4 March 2008

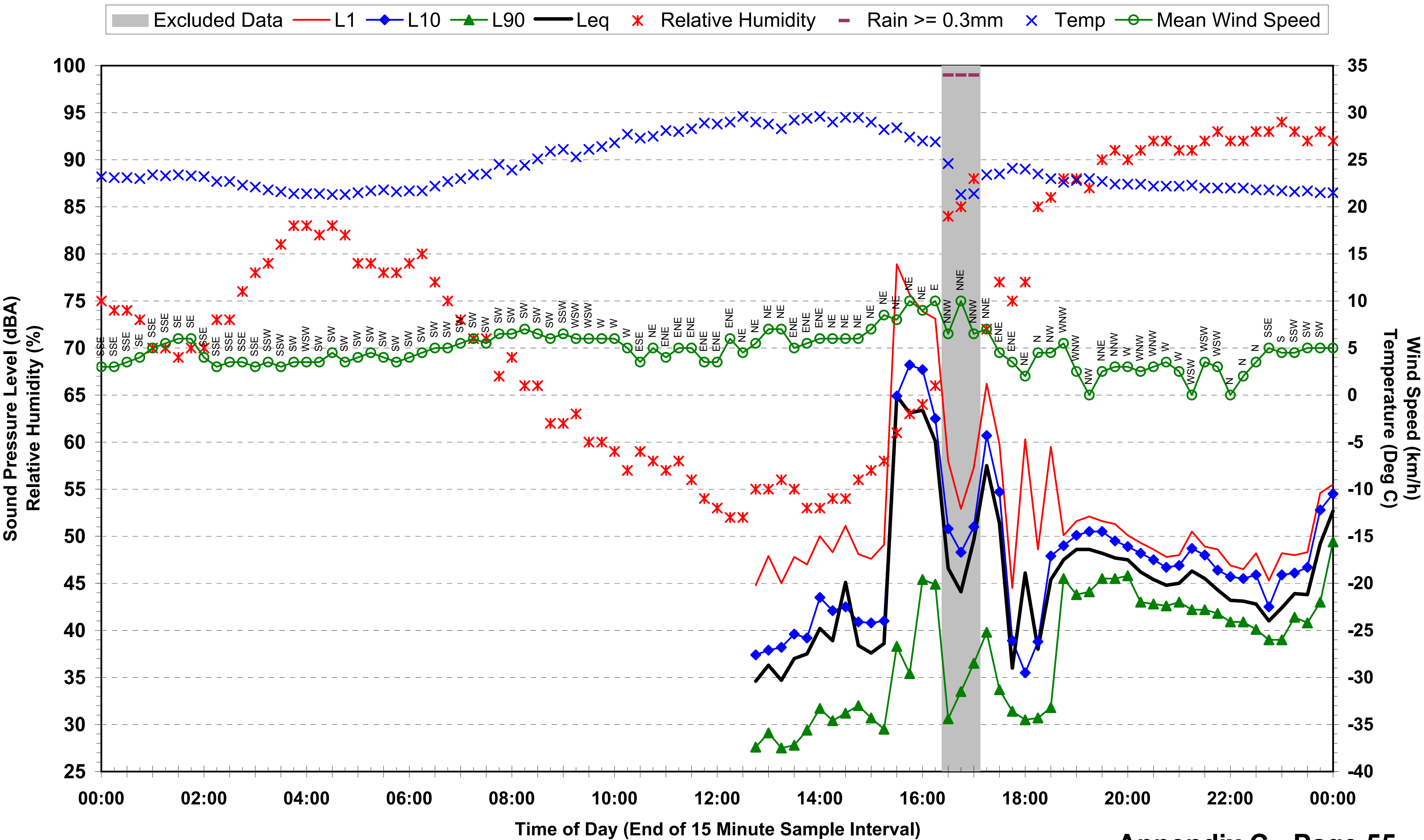




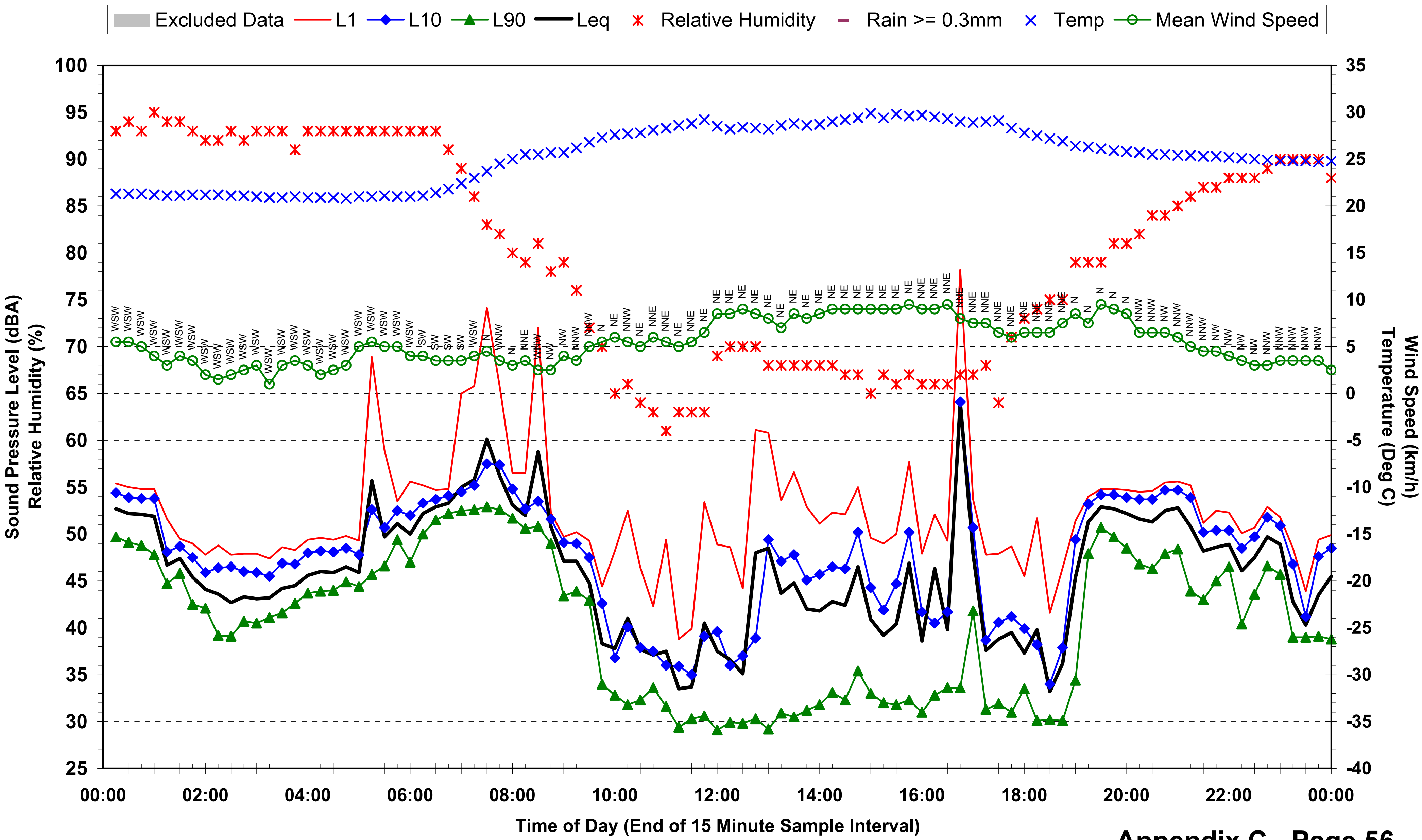
Statistical Ambient Noise Levels
20-2014 - Plant 4 - Yarwun - Wednesday 5 March 2008
Excluded Data
L1
L10
L90
Leq
Relative Humidity
Rain >= 0.3mm
Temp
Mean Wind Speed
Sound Pressure Level (dBA)
Relative Humidity (%)
Wind Speed (km/h)
Temperature (Deg C)
Time of Day (End of 15 Minute Sample Interval)


Statistical Ambient Noise Levels
20-2014 - Plant 4 - Yarwun - Thursday 6 March 2008
Excluded Data
L1
L10
L90
Leq
Relative Humidity
Rain >= 0.3mm
Temp
Mean Wind Speed
Sound Pressure Level (dBA)
Relative Humidity (%)
Wind Speed (km/h)
Temperature (Deg C)
Time of Day (End of 15 Minute Sample Interval)

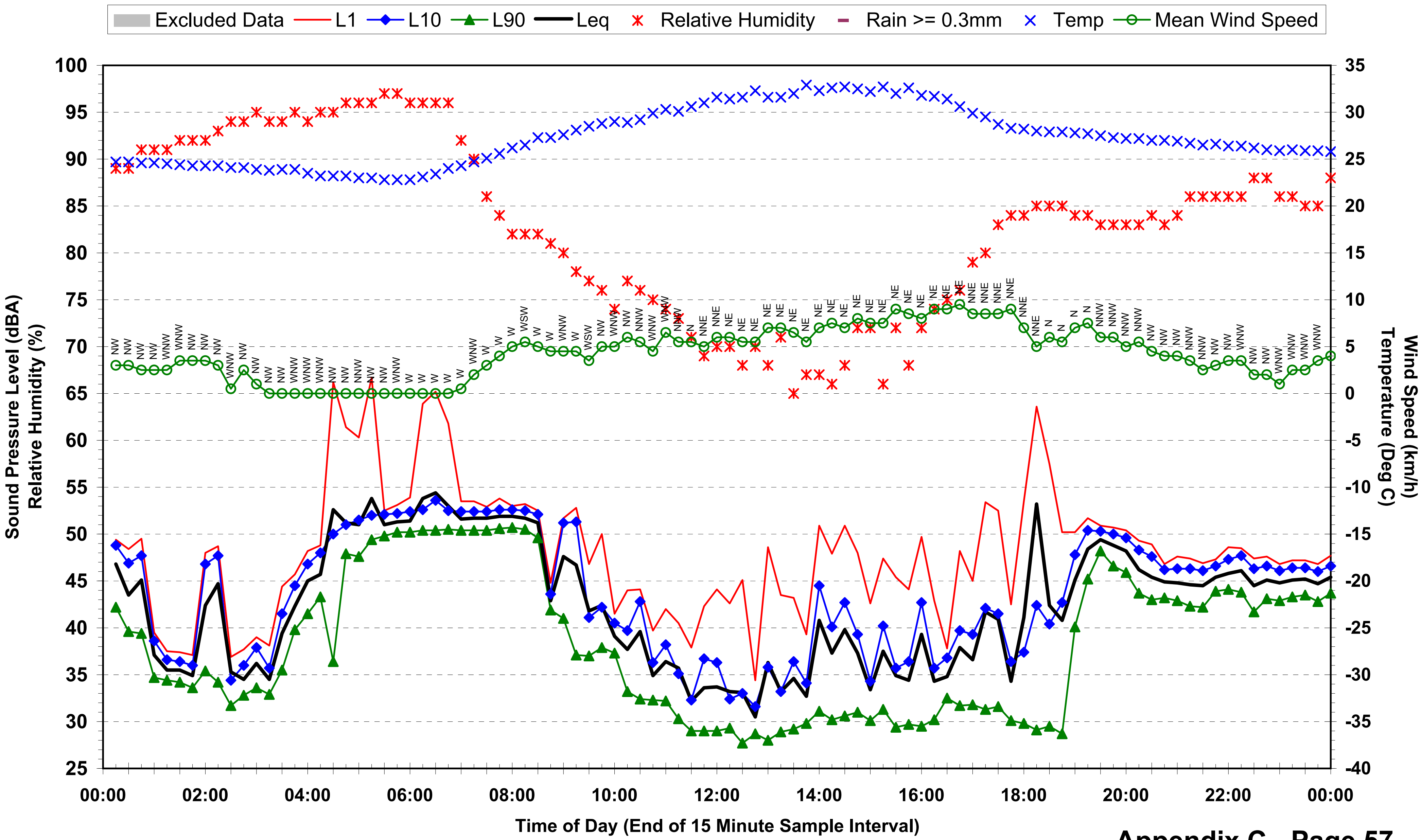
Statistical Ambient Noise Levels
20-2014 - Plant 5 - Near Bridge Crossing - Wednesday 20 February 2008



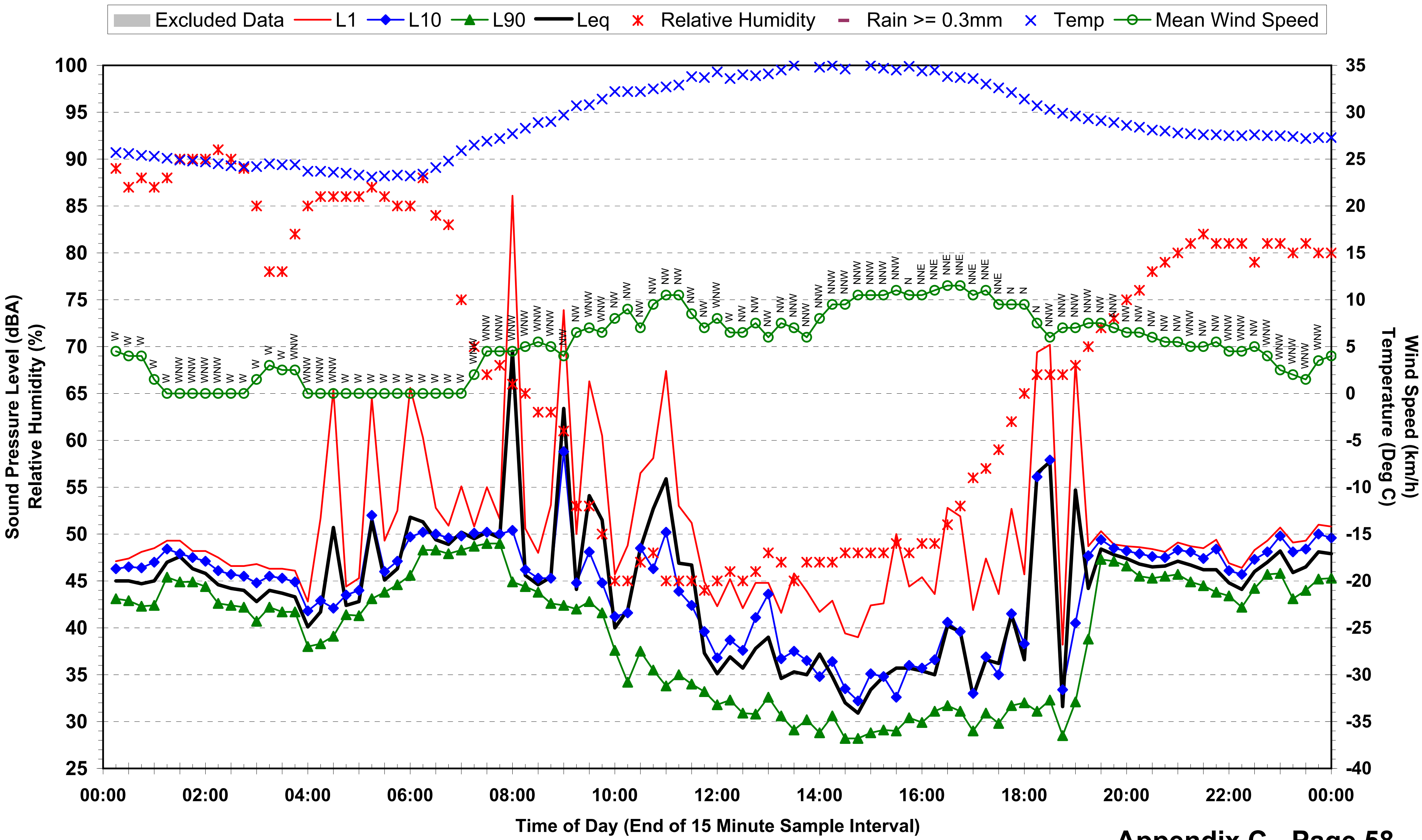
Statistical Ambient Noise Levels
20-2014 - Plant 5 - Near Bridge Crossing - Thursday 21 February 2008

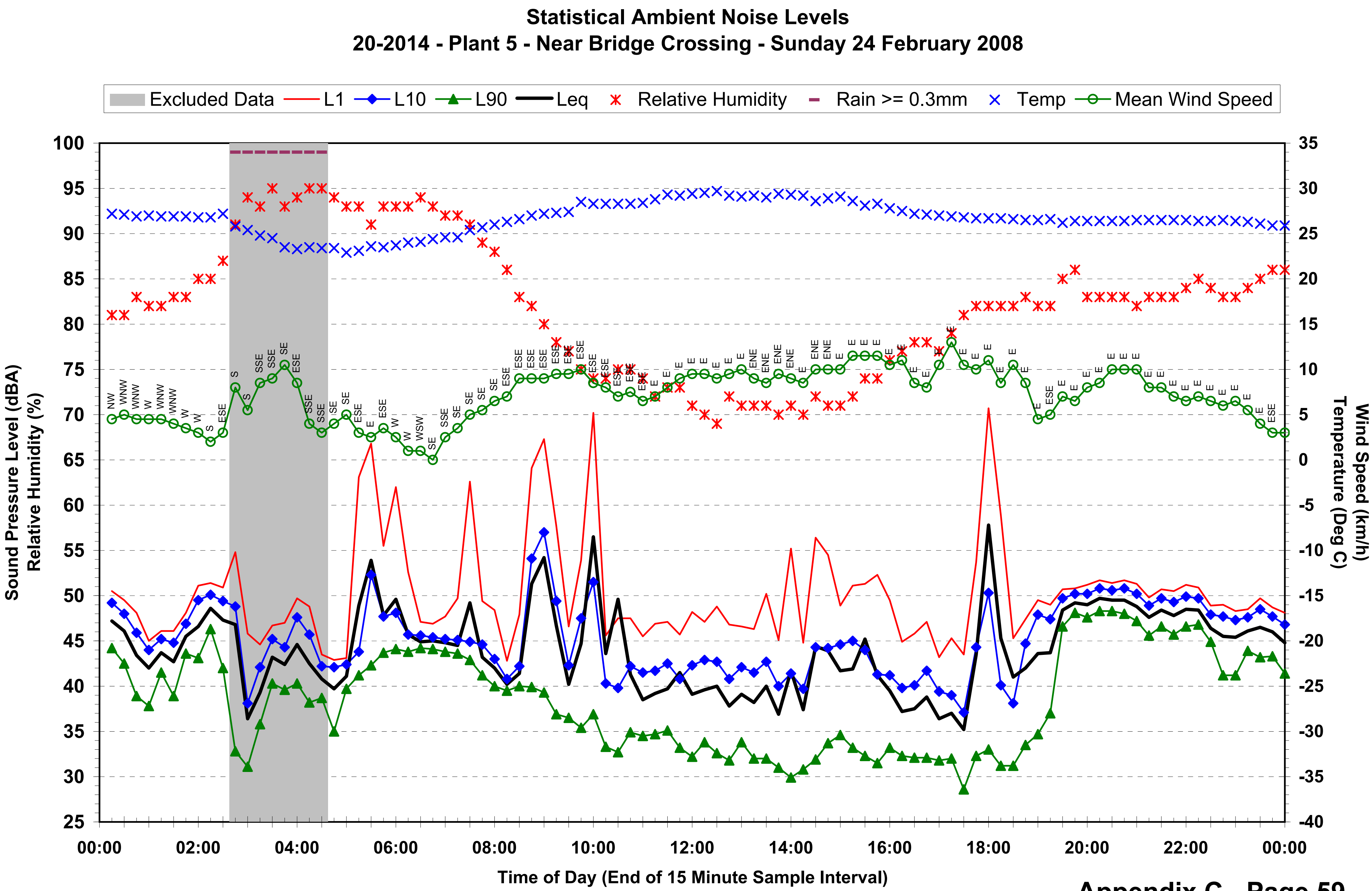


Statistical Ambient Noise Levels
20-2014 - Plant 5 - Near Bridge Crossing - Friday 22 February 2008



Statistical Ambient Noise Levels
20-2014 - Plant 5 - Near Bridge Crossing - Saturday 23 February 2008





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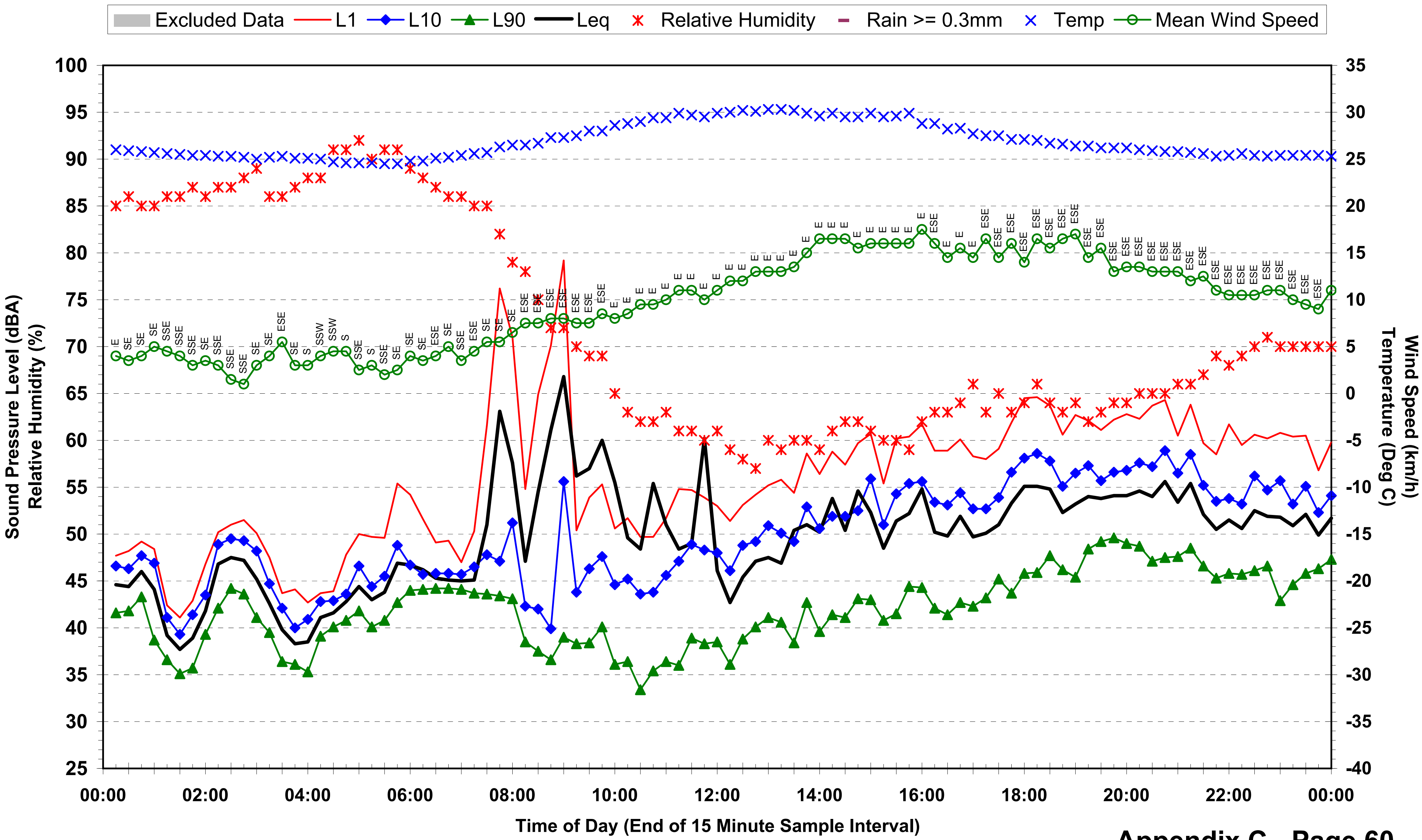
Ambient Conditions

RHA Report 20-2014

Statistical Ambient Noise Levels
20-2014 - Plant 5 - Near Bridge Crossing - Monday 25 February 2008



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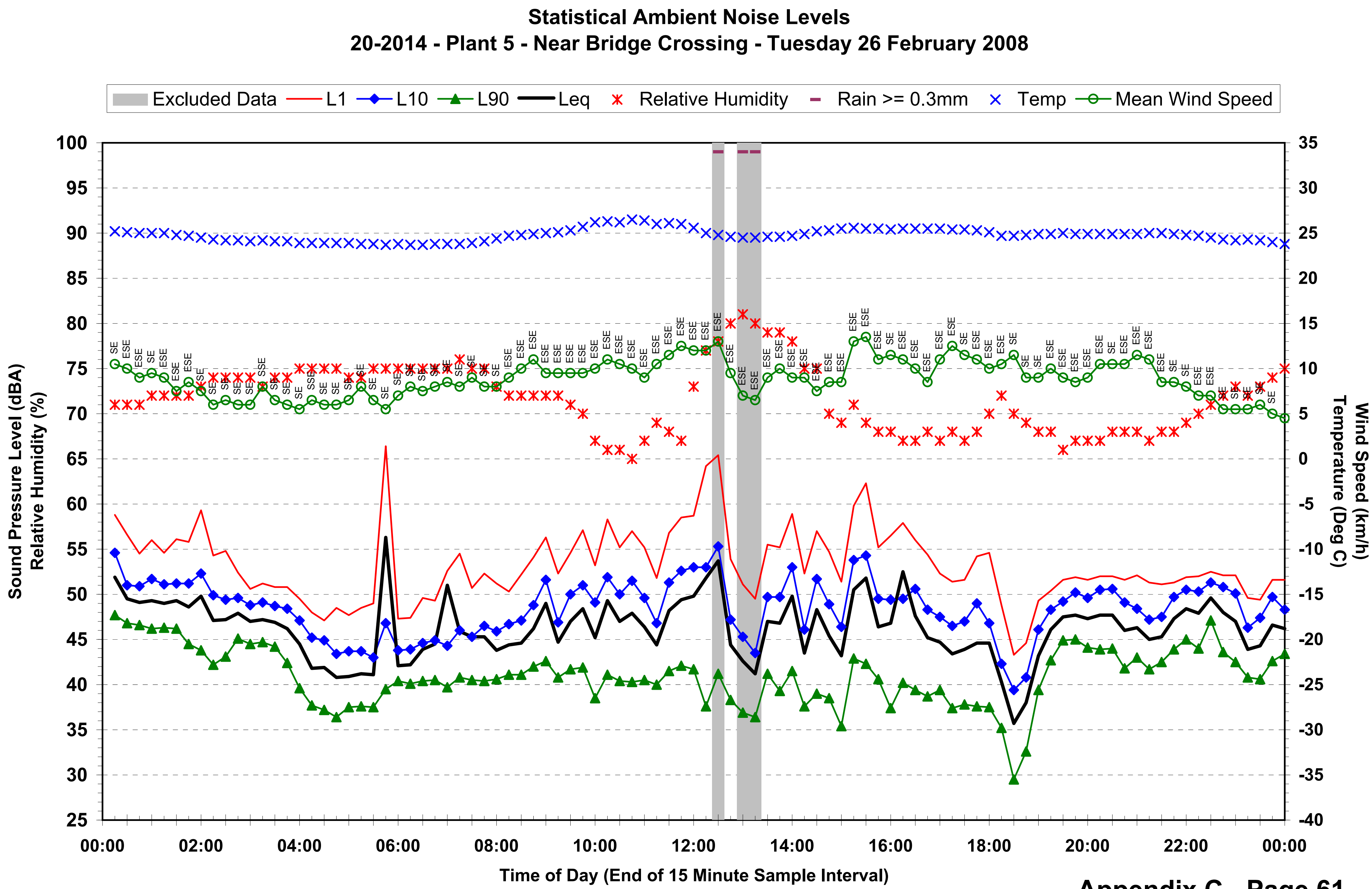
Ambient Conditions

RHA Report 20-2014


Statistical Ambient Noise Levels
20-2014 - Plant 5 - Near Bridge Crossing - Tuesday 26 February 2008
Excluded Data
L1
L10
L90
Leq
Relative Humidity
Rain >= 0.3mm
Temp
Mean Wind Speed
Sound Pressure Level (dBA)
Relative Humidity (%)
Wind Speed (km/h)
Temperature (Deg C)
100
95
90
85
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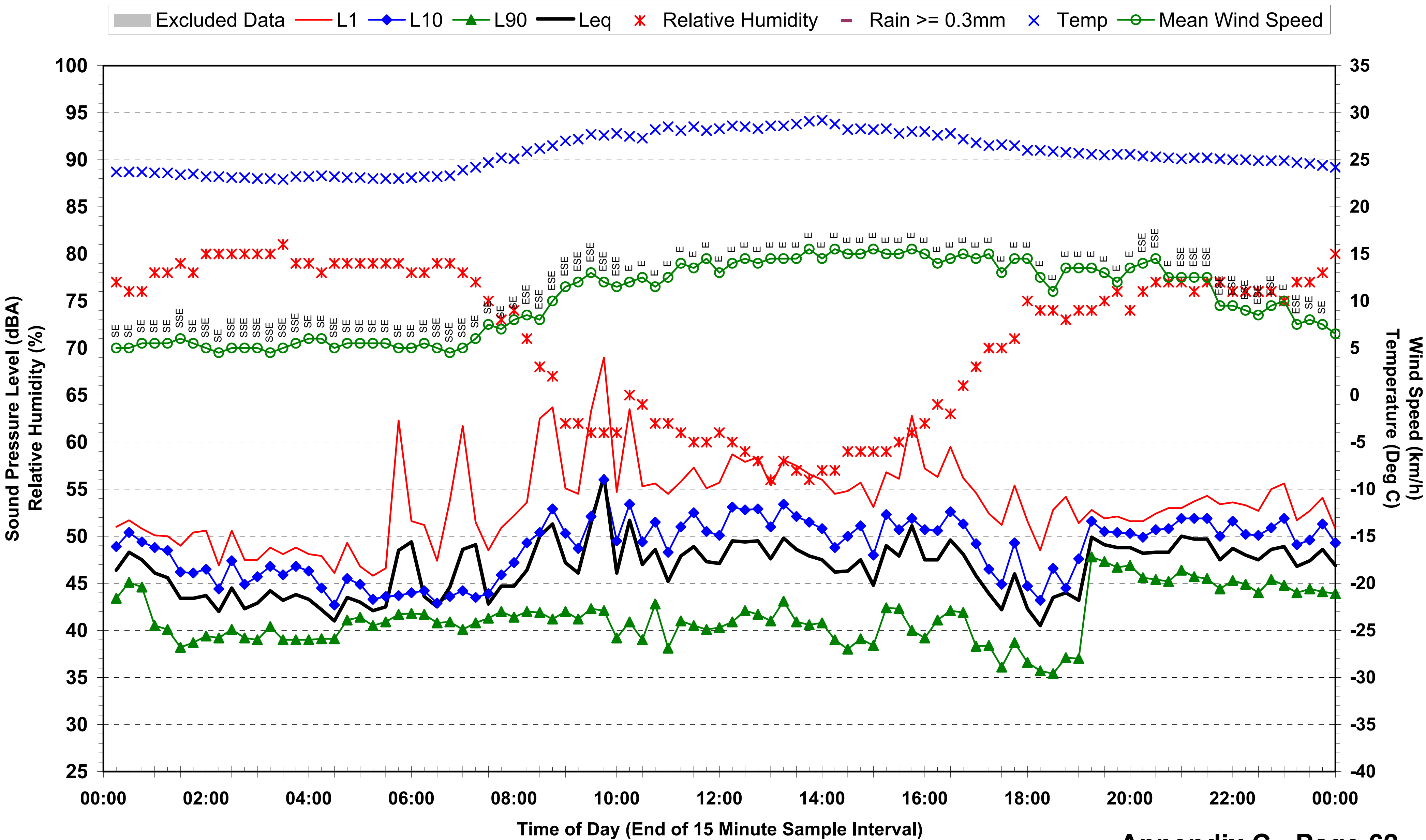
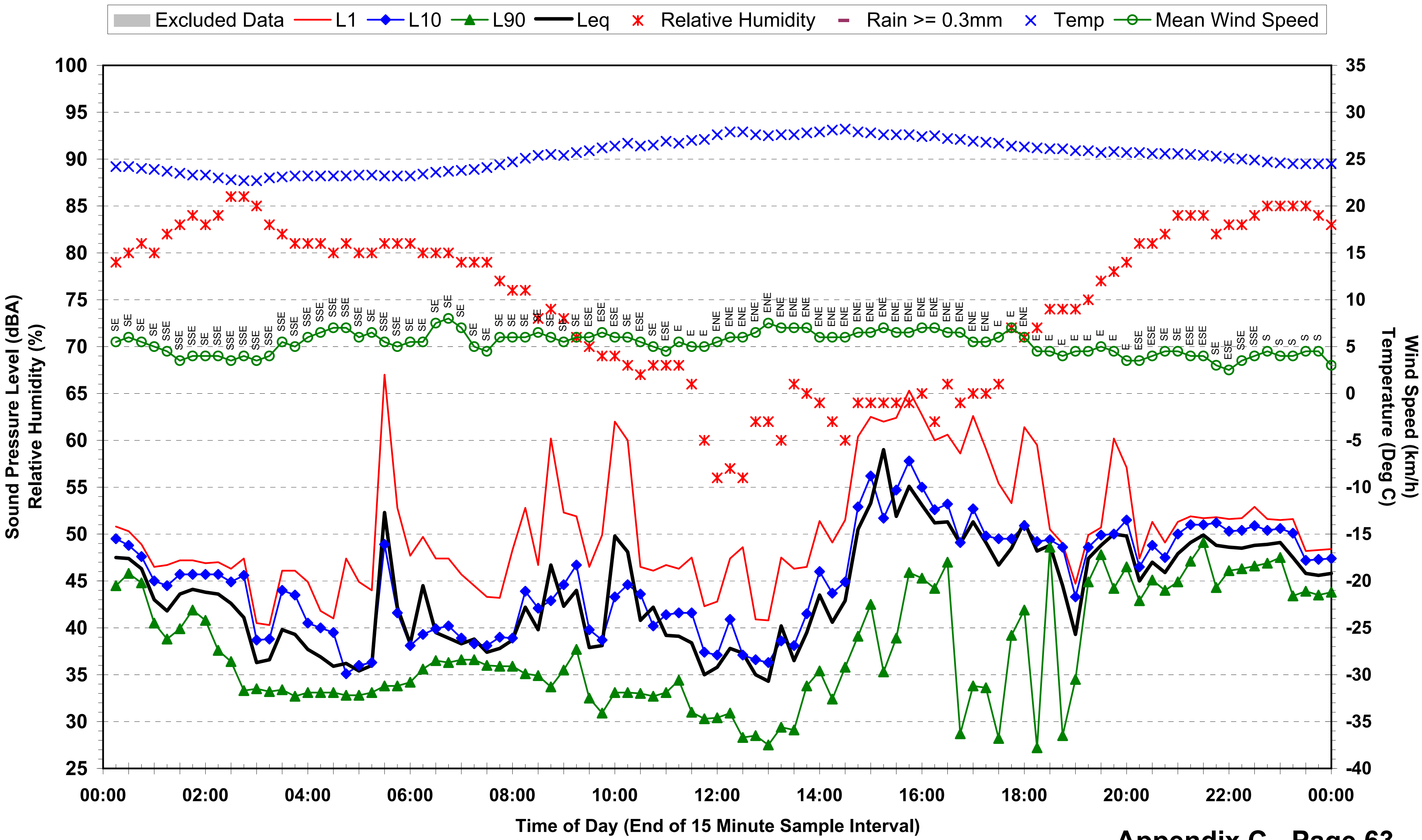
16:00
18:00
20:00
22:00
00:00
Time of Day (End of 15 Minute Sample Interval)

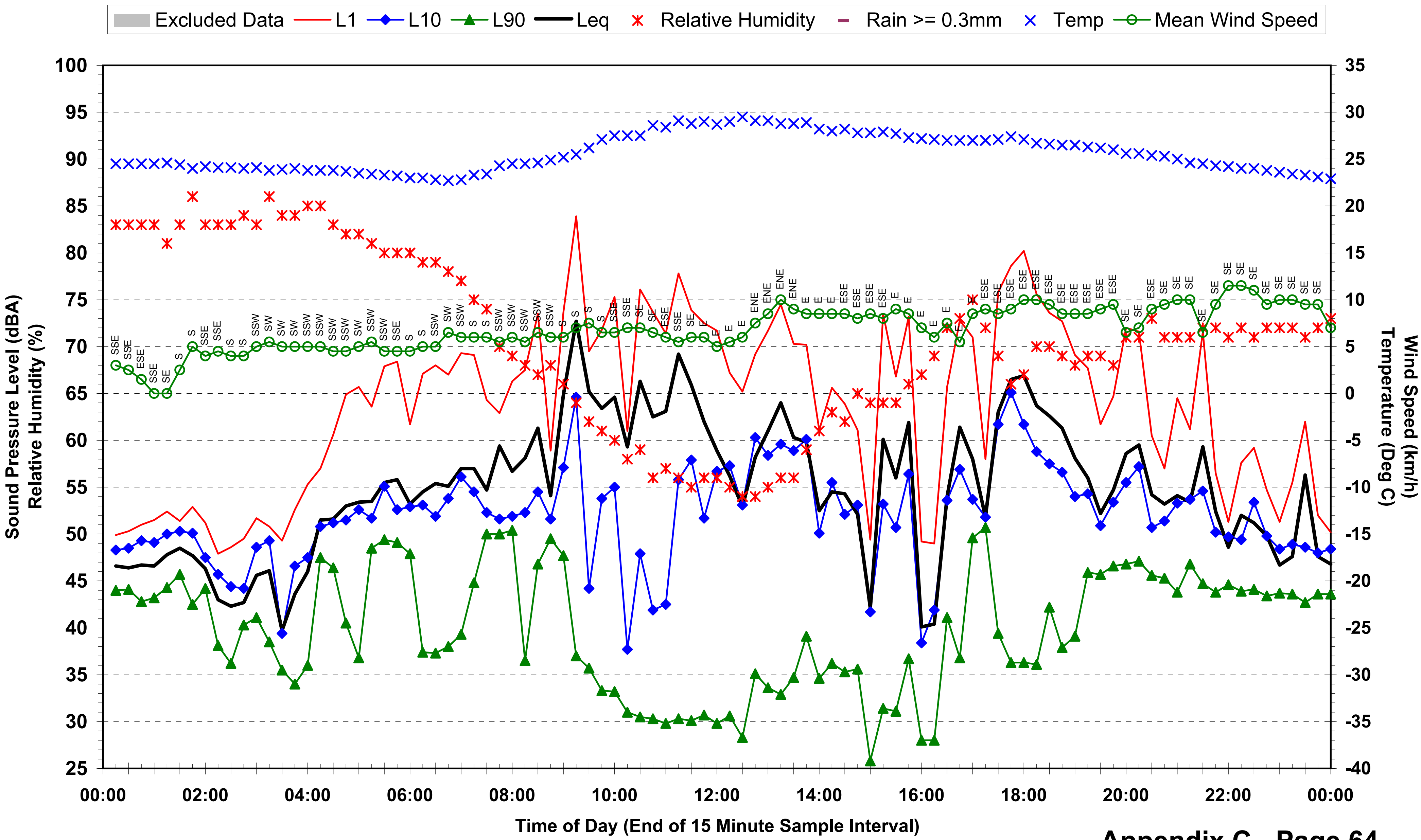
Statistical Ambient Noise Levels
20-2014 - Plant 5 - Near Bridge Crossing - Wednesday 27 February 2008



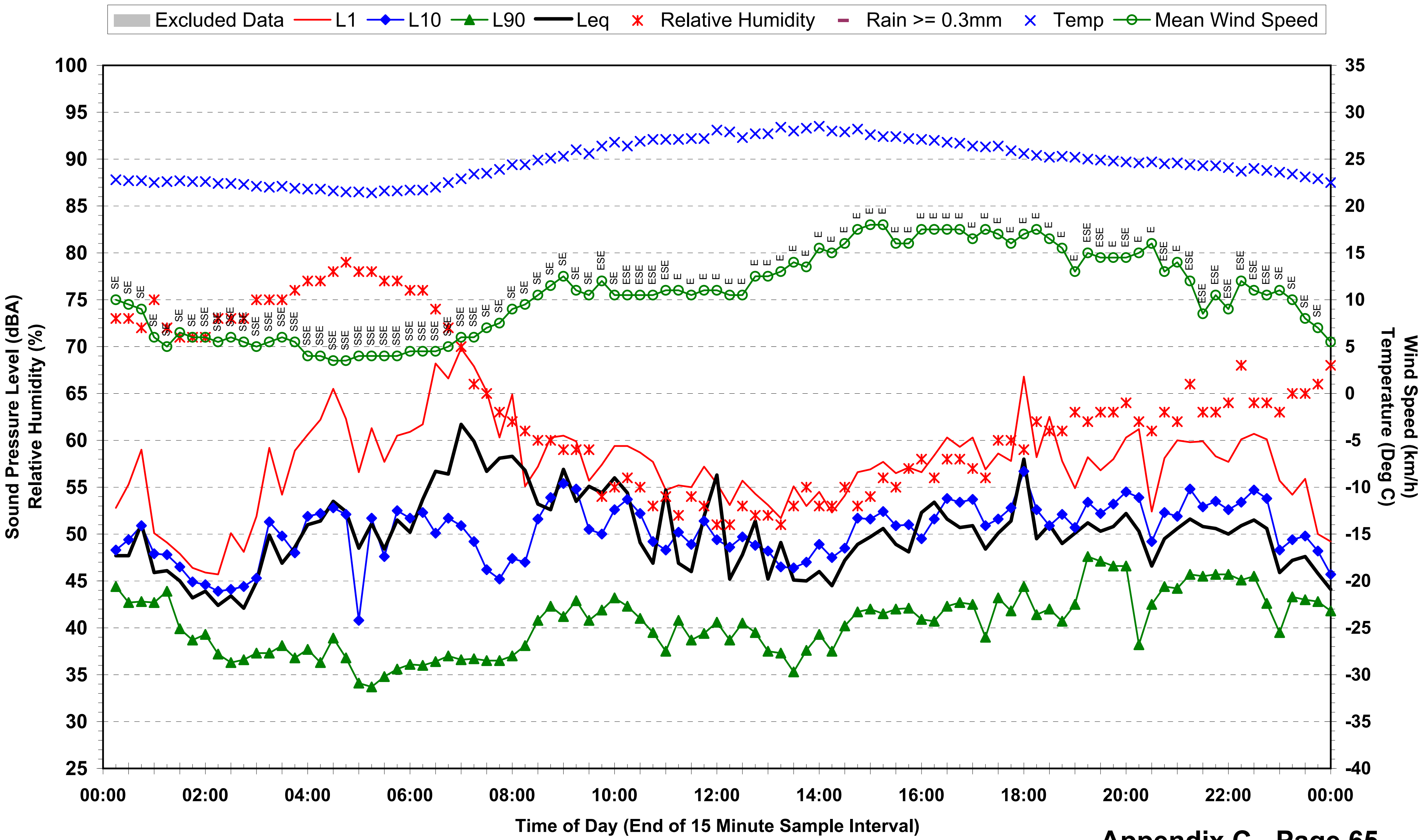
Statistical Ambient Noise Levels
20-2014 - Plant 5 - Near Bridge Crossing - Thursday 28 February 2008



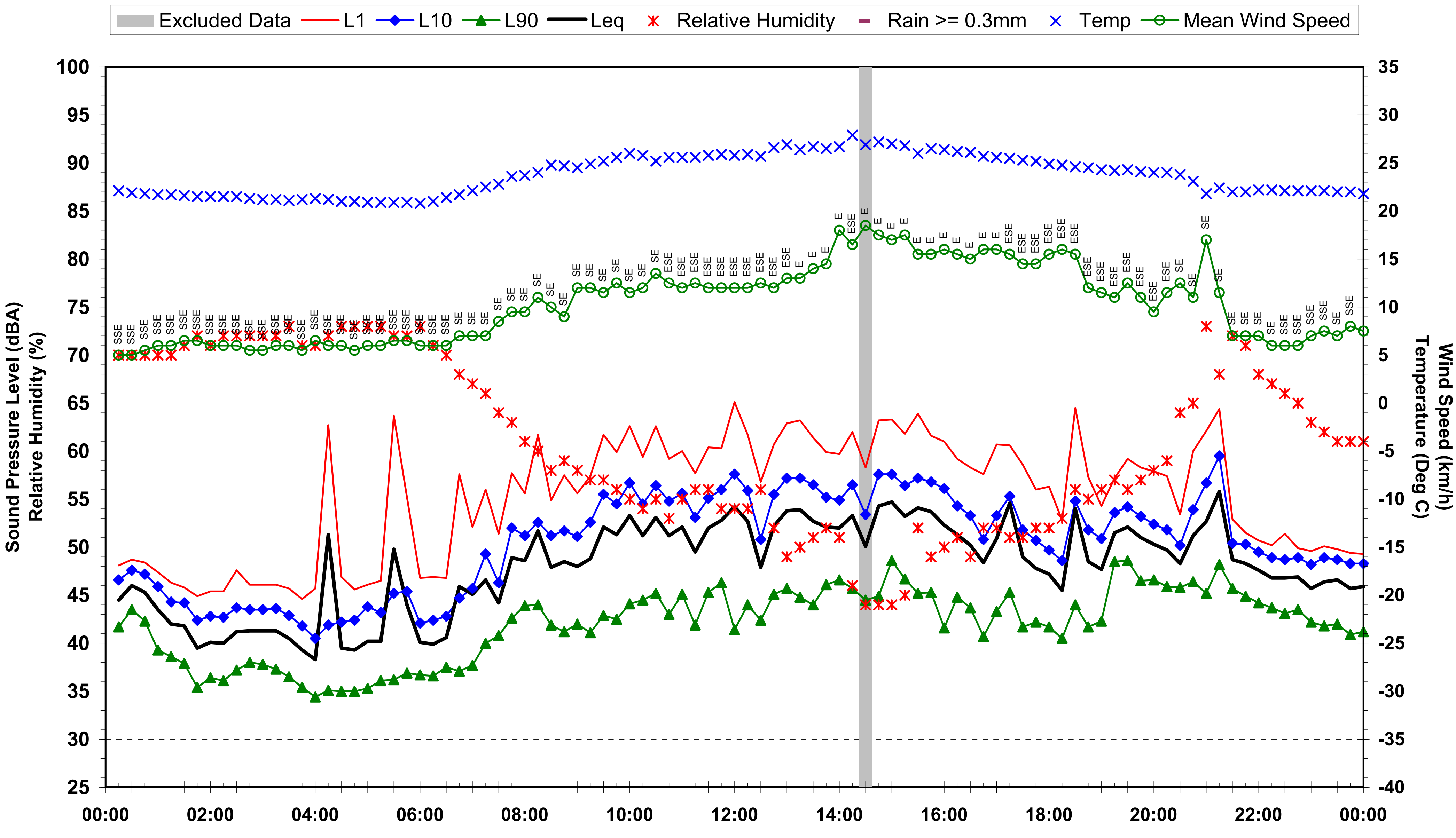
Statistical Ambient Noise Levels
20-2014 - Plant 5 - Near Bridge Crossing - Friday 29 February 2008

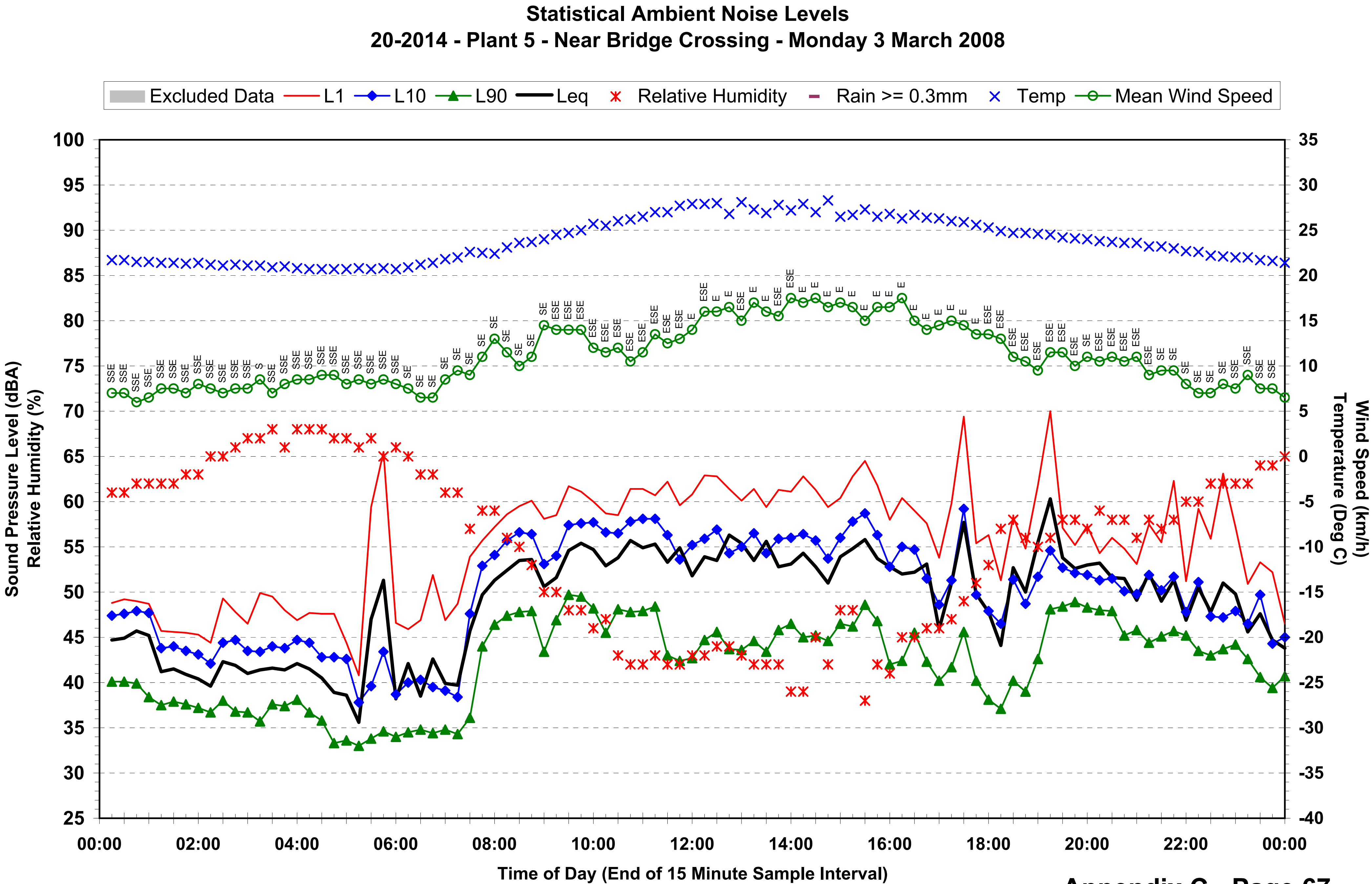


Statistical Ambient Noise Levels
20-2014 - Plant 5 - Near Bridge Crossing - Saturday 1 March 2008

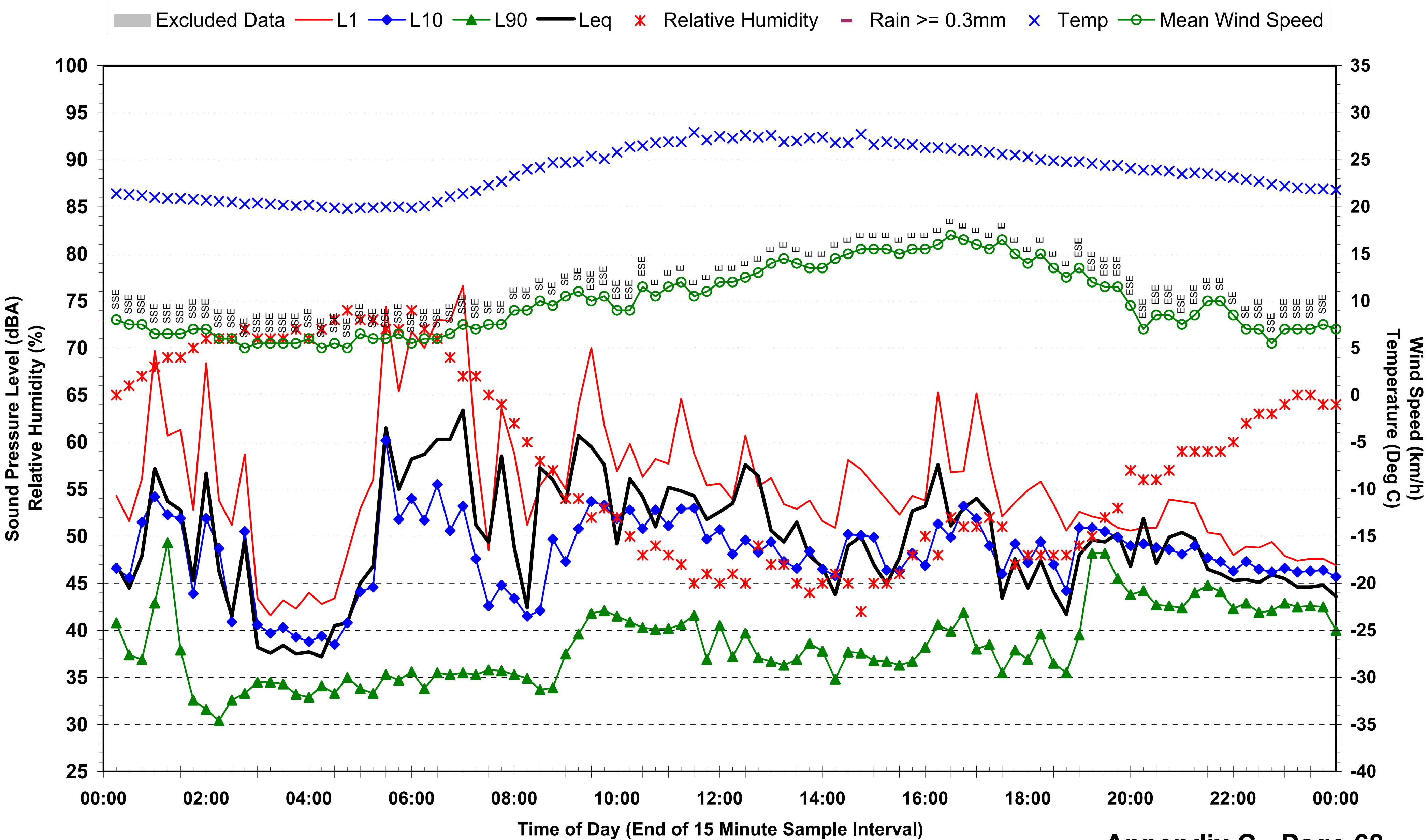


Statistical Ambient Noise Levels
20-2014 - Plant 5 - Near Bridge Crossing - Sunday 2 March 2008

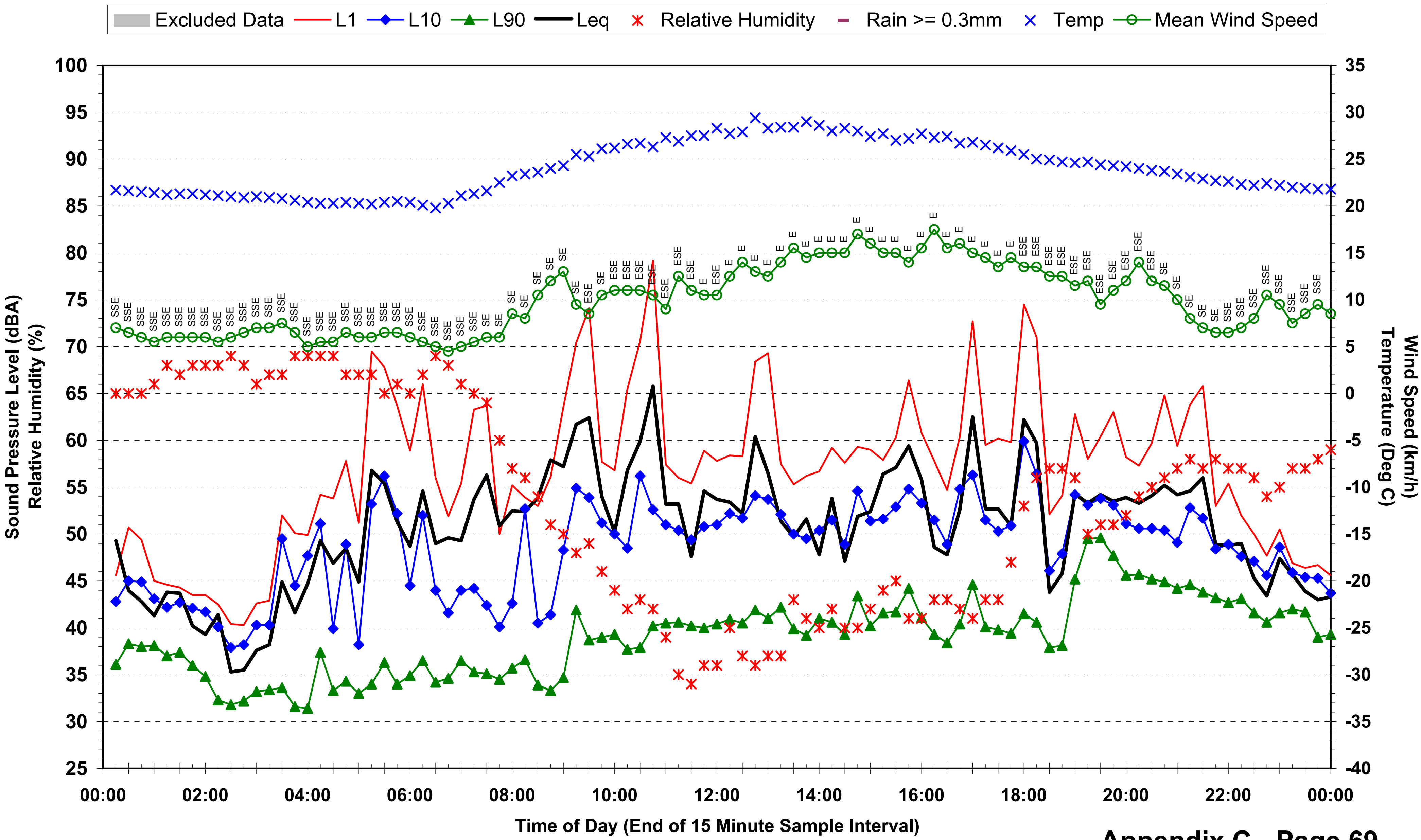



Statistical Ambient Noise Levels
20-2014 - Plant 5 - Near Bridge Crossing - Monday 3 March 2008
Excluded Data
L1
L10
L90
Leq
Relative Humidity
Rain >= 0.3mm
Temp
Mean Wind Speed
Sound Pressure Level (dBA)
Relative Humidity (%)
Wind Speed (km/h)
Temperature (Deg C)
Time of Day (End of 15 Minute Sample Interval)
00:00
02:00
04:00
06:00
08:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
00:00

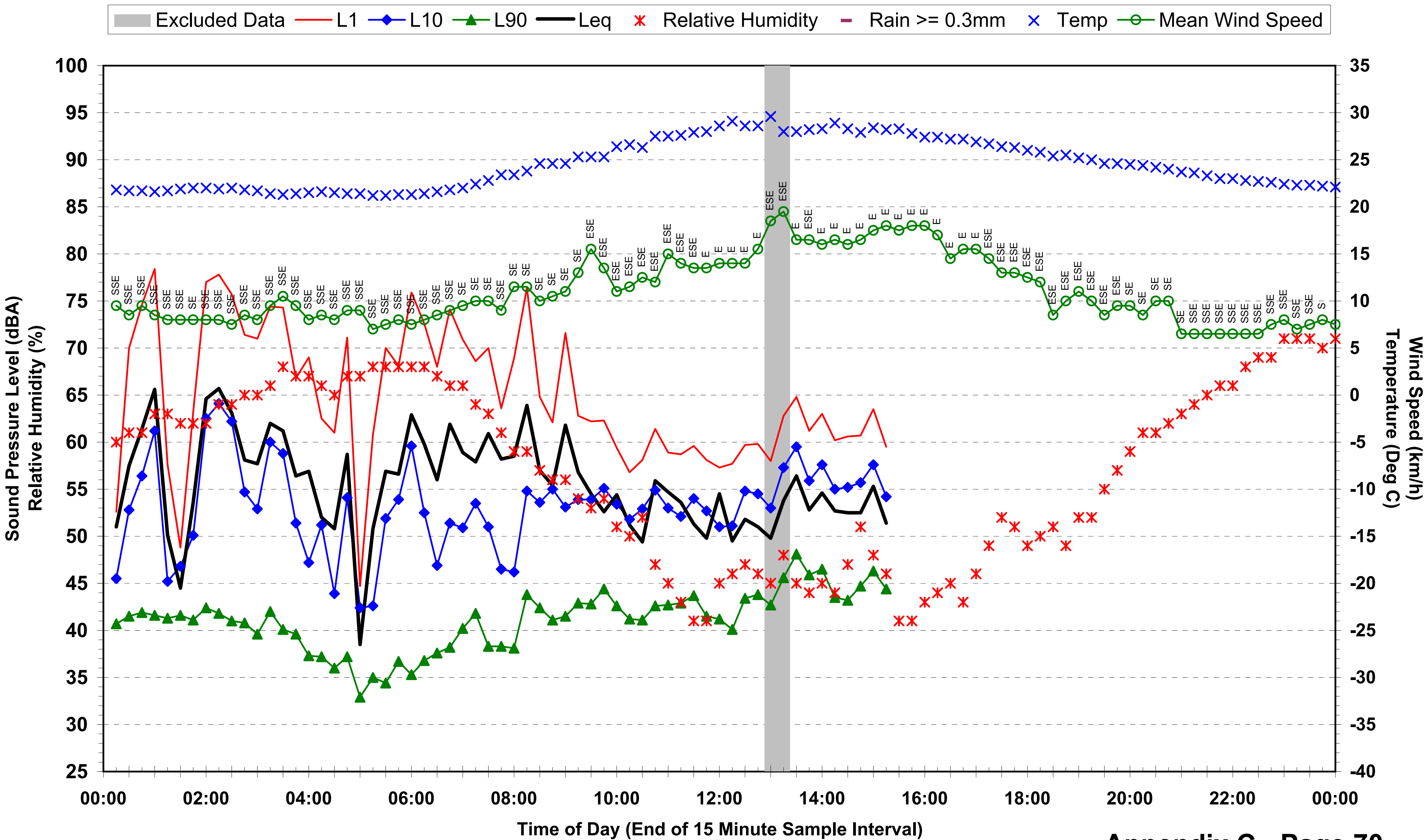
Statistical Ambient Noise Levels
20-2014 - Plant 5 - Near Bridge Crossing - Tuesday 4 March 2008



Statistical Ambient Noise Levels
20-2014 - Plant 5 - Near Bridge Crossing - Wednesday 5 March 2008



Statistical Ambient Noise Levels
20-2014 - Plant 5 - Near Bridge Crossing - Thursday 6 March 2008



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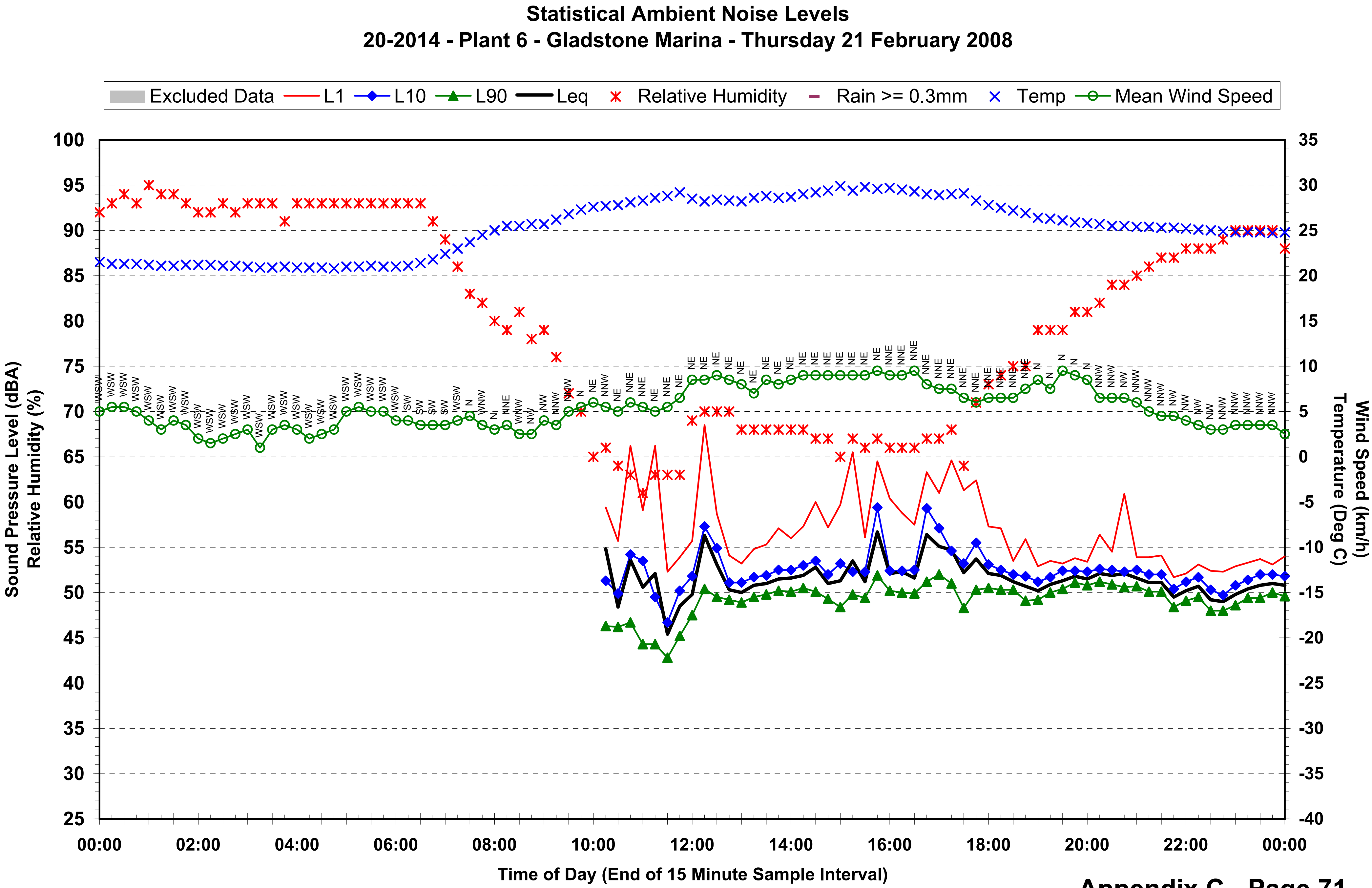
Ambient Conditions

RHA Report 20-2014



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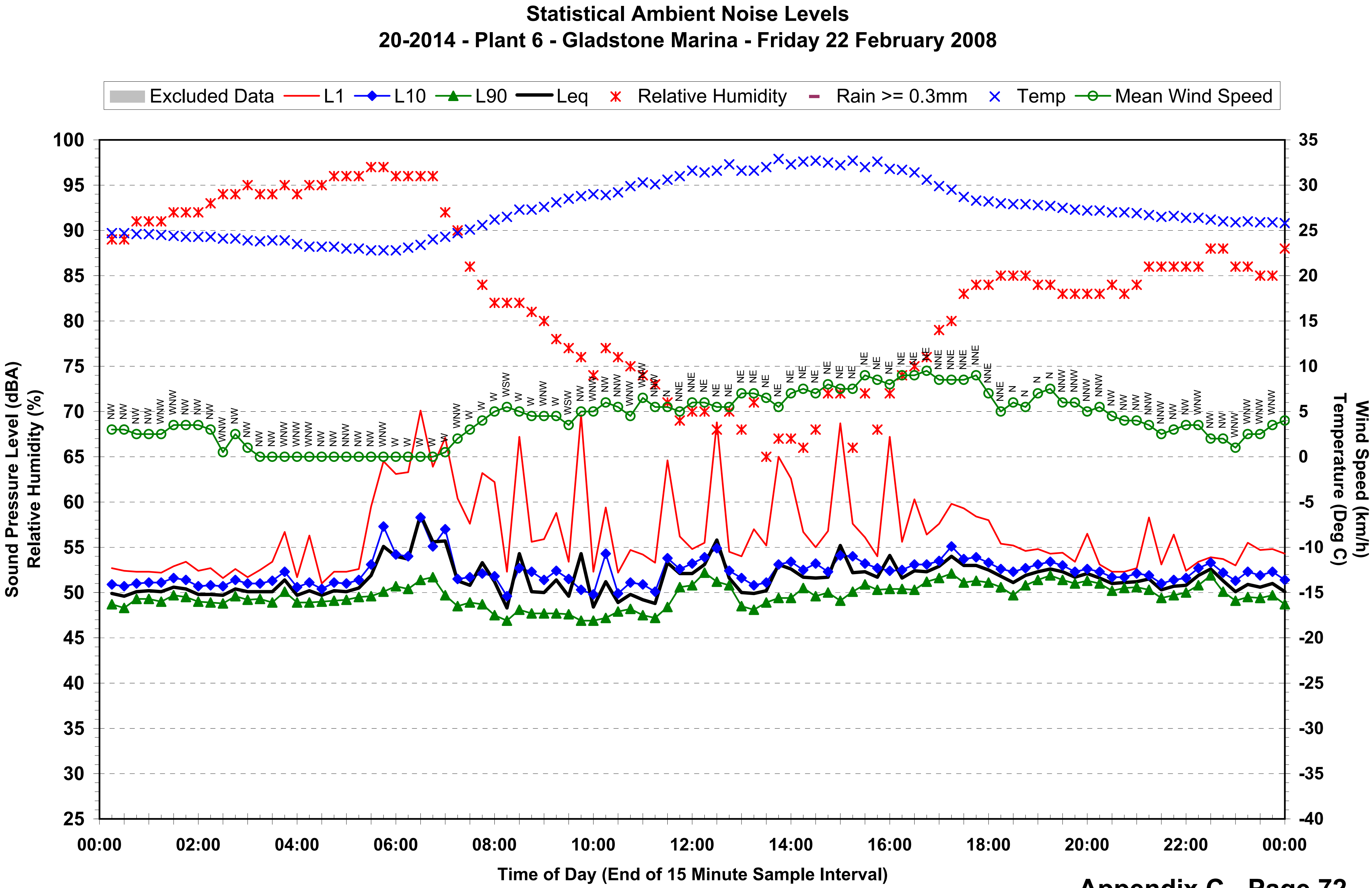
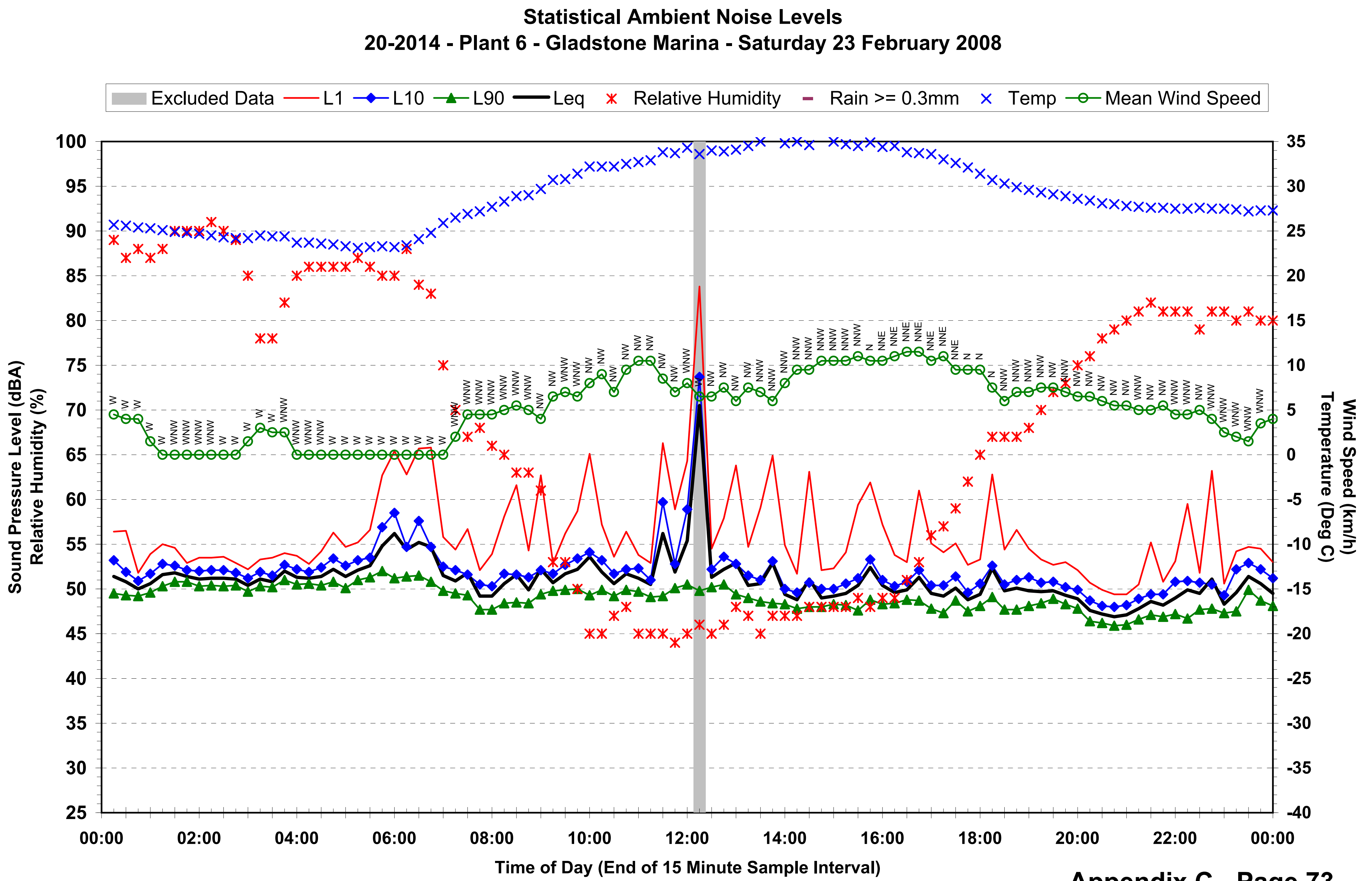
Ambient Conditions

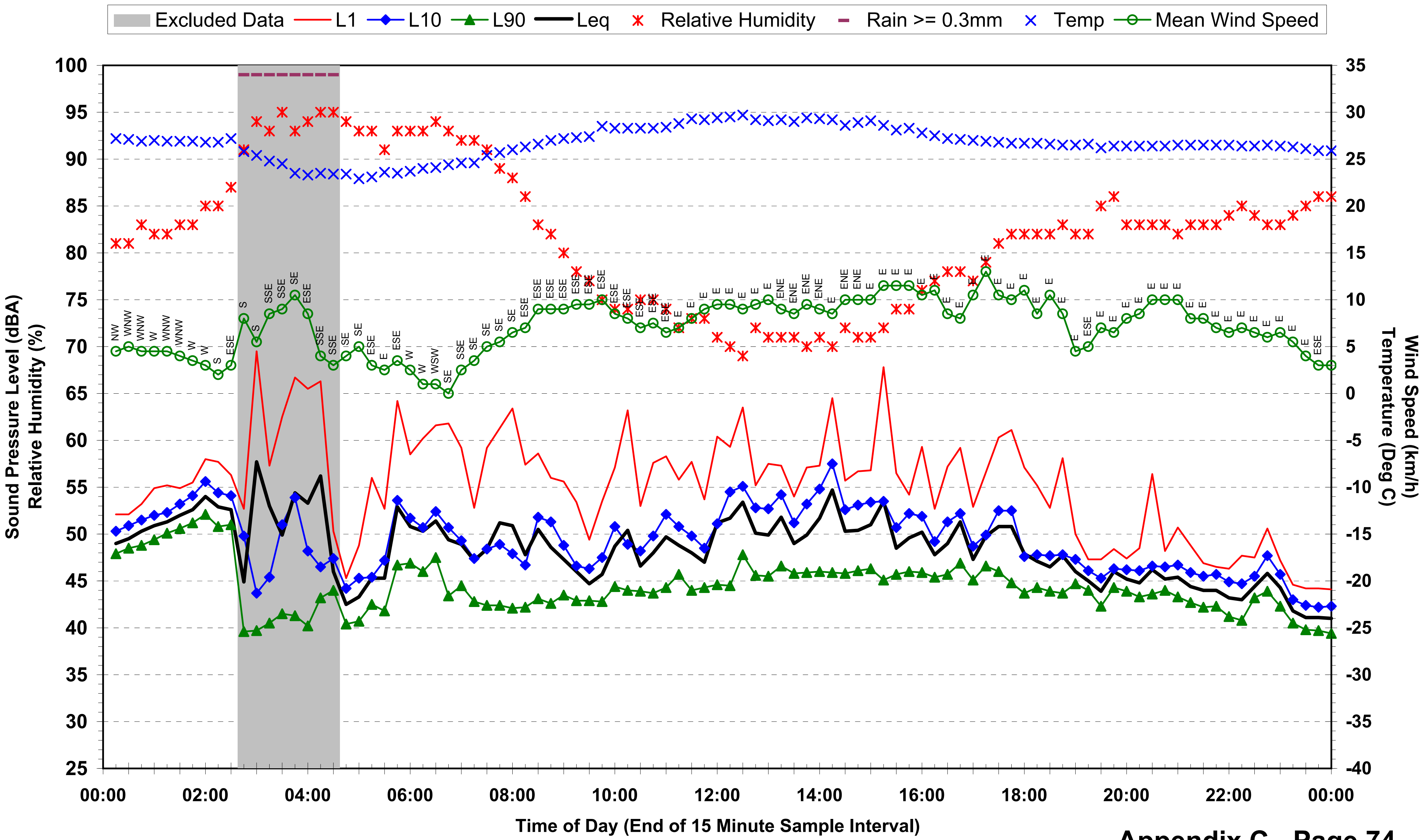
RHA Report 20-2014

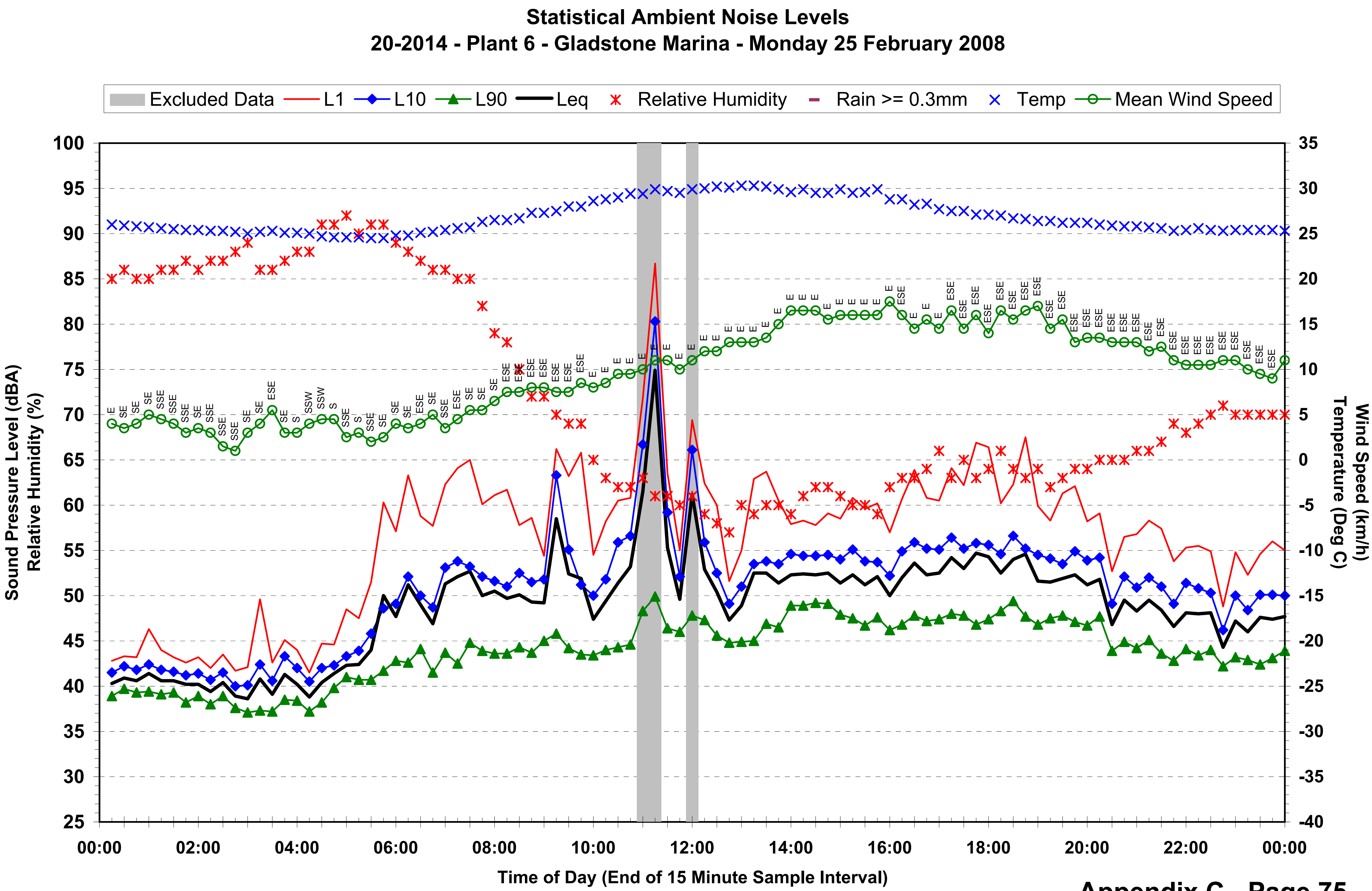


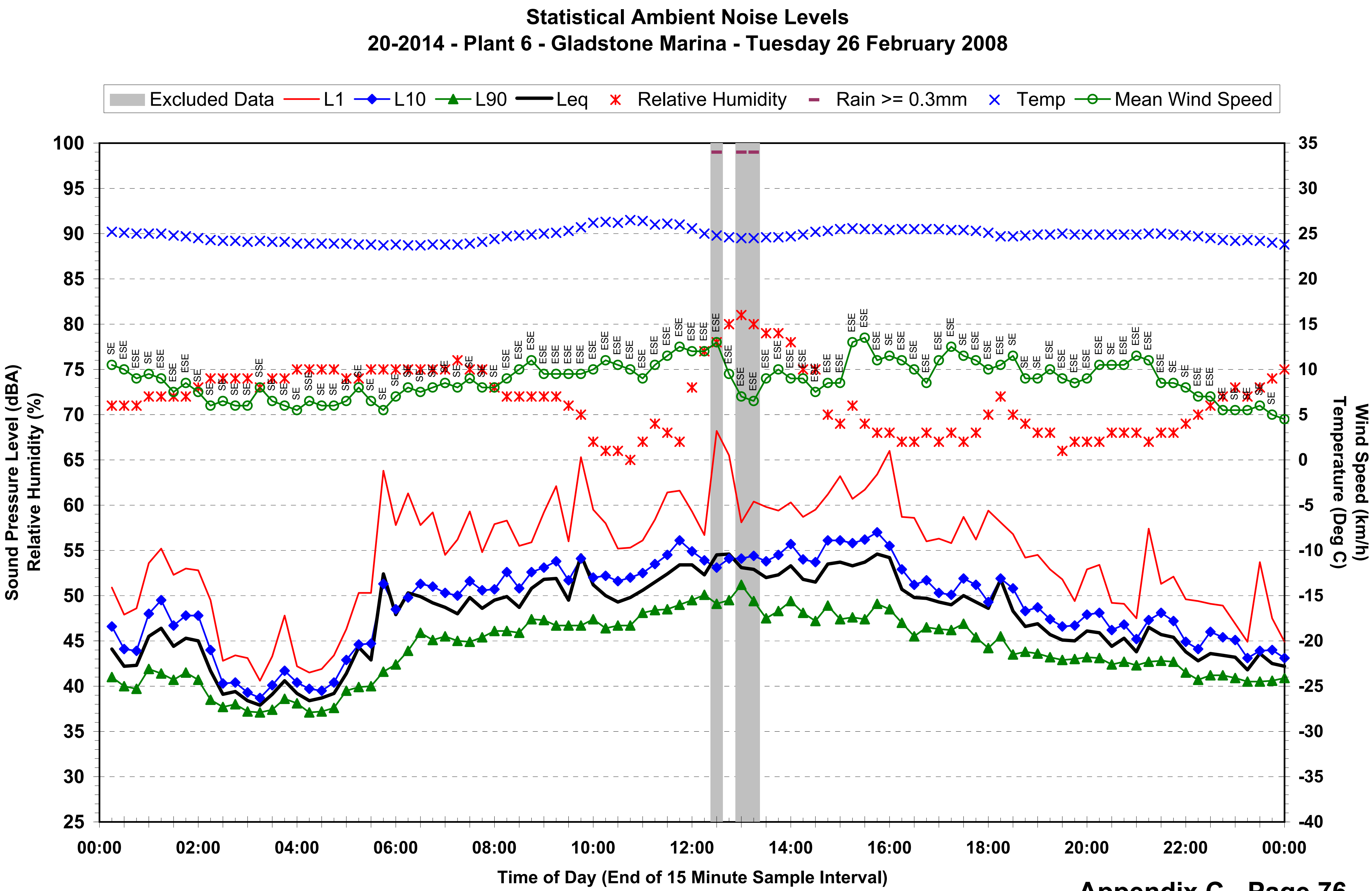
Statistical Ambient Noise Levels
20-2014 - Plant 6 - Gladstone Marina - Friday 22 February 2008
Excluded Data
L1
L10
L90
Leq
Relative Humidity
Rain >= 0.3mm
Temp
Mean Wind Speed
Sound Pressure Level (dBA)
Relative Humidity (%)
Wind Speed (km/h)
Temperature (Deg C)
Time of Day (End of 15 Minute Sample Interval)


Statistical Ambient Noise Levels
20-2014 - Plant 6 - Gladstone Marina - Saturday 23 February 2008
Excluded Data
L1
L10
L90
Leq
Relative Humidity
Rain >= 0.3mm
Temp
Mean Wind Speed
Sound Pressure Level (dBA)
Relative Humidity (%)
Wind Speed (km/h)
Temperature (Deg C)
Time of Day (End of 15 Minute Sample Interval)

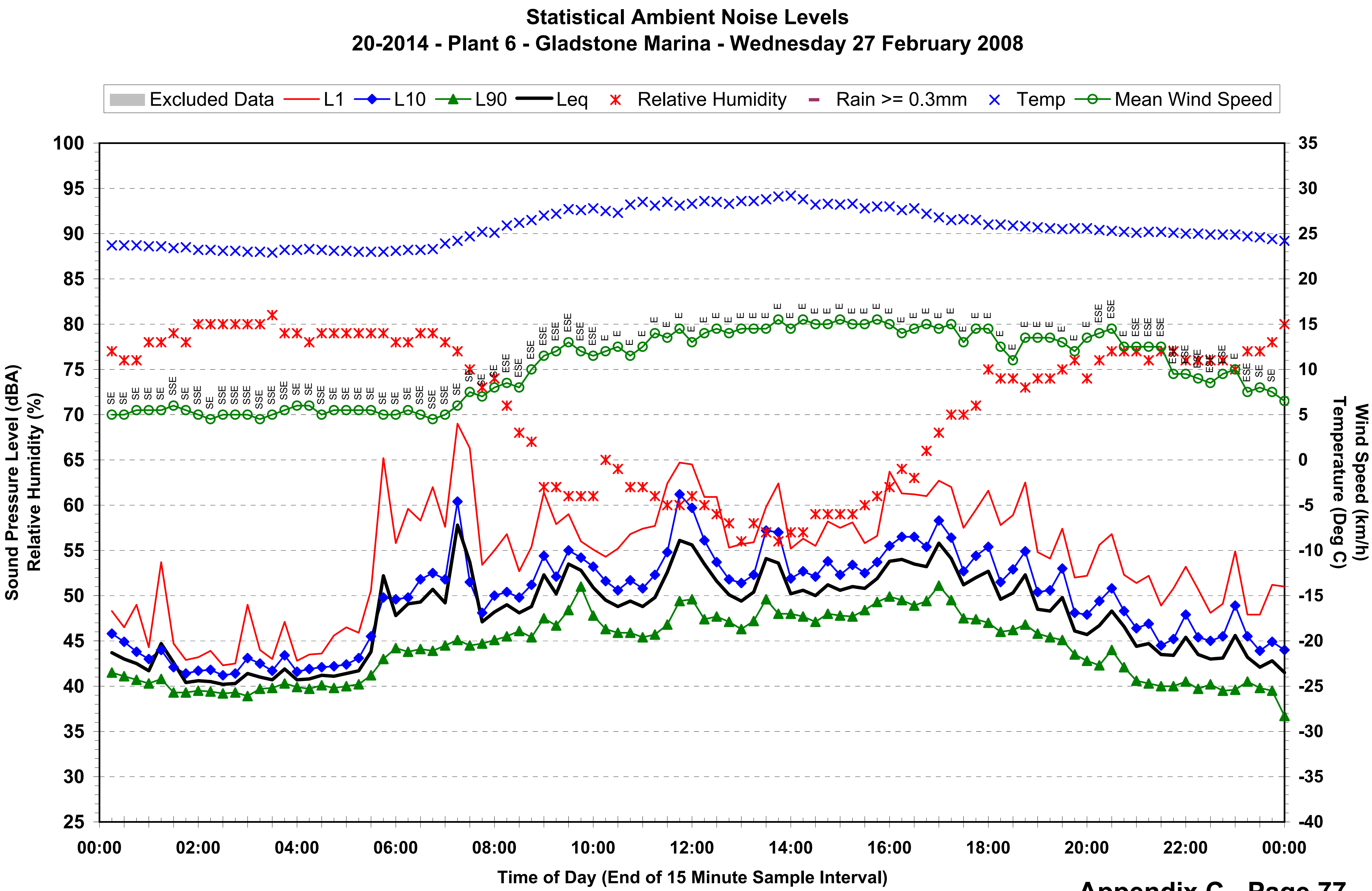
Statistical Ambient Noise Levels
20-2014 - Plant 6 - Gladstone Marina - Sunday 24 February 2008




Statistical Ambient Noise Levels
20-2014 - Plant 6 - Gladstone Marina - Monday 25 February 2008
Excluded Data
L1
L10
L90
Leq
Relative Humidity
Rain >= 0.3mm
Temp
Mean Wind Speed
Sound Pressure Level (dBA)
Relative Humidity (%)
Wind Speed (km/h)
Temperature (Deg C)
Time of Day (End of 15 Minute Sample Interval)

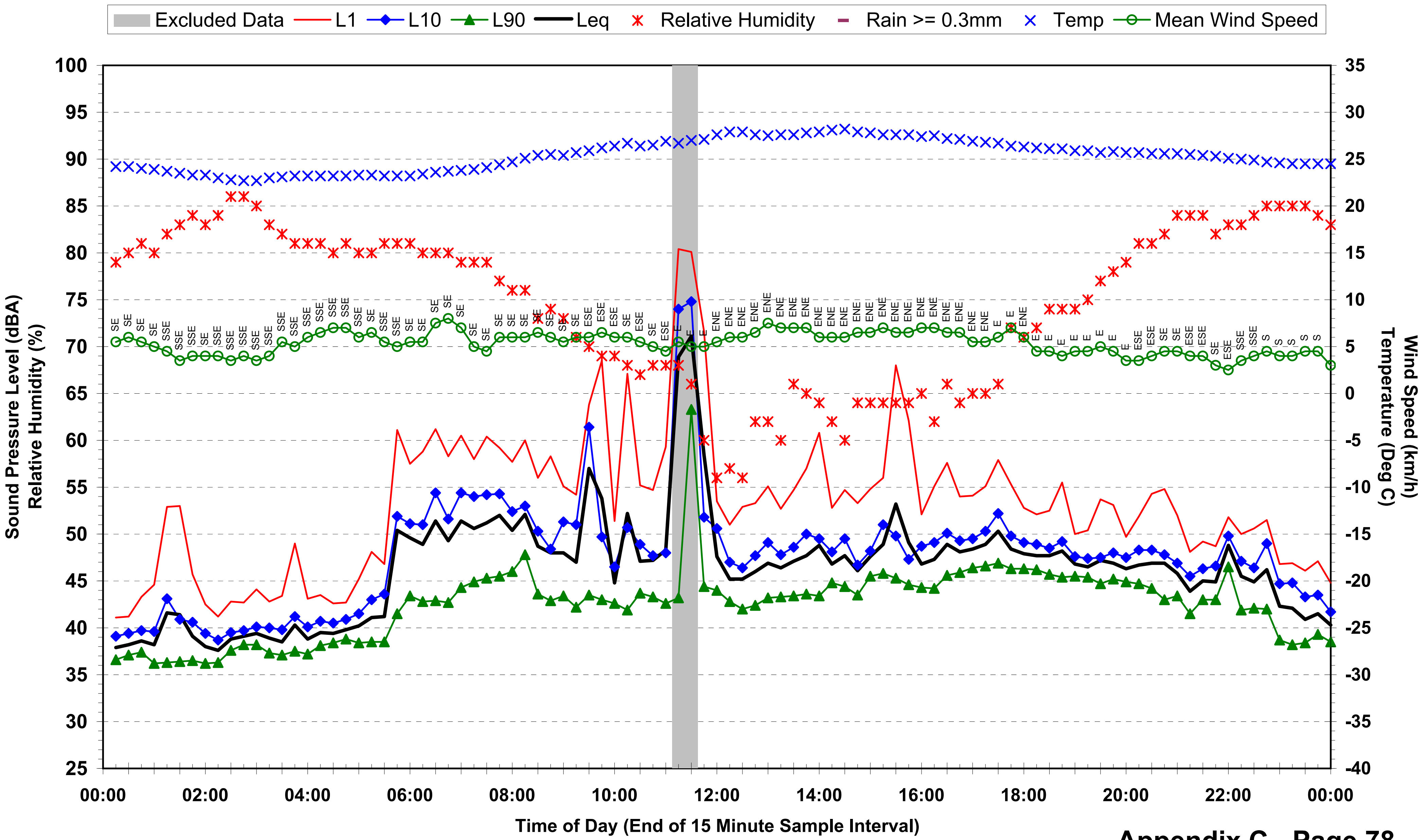


Statistical Ambient Noise Levels
20-2014 - Plant 6 - Gladstone Marina - Tuesday 26 February 2008
Excluded Data
L1
L10
L90
Leq
Relative Humidity
Rain >= 0.3mm
Temp
Mean Wind Speed
Sound Pressure Level (dBA)
Relative Humidity (%)
Wind Speed (km/h)
Temperature (Deg C)
Time of Day (End of 15 Minute Sample Interval)

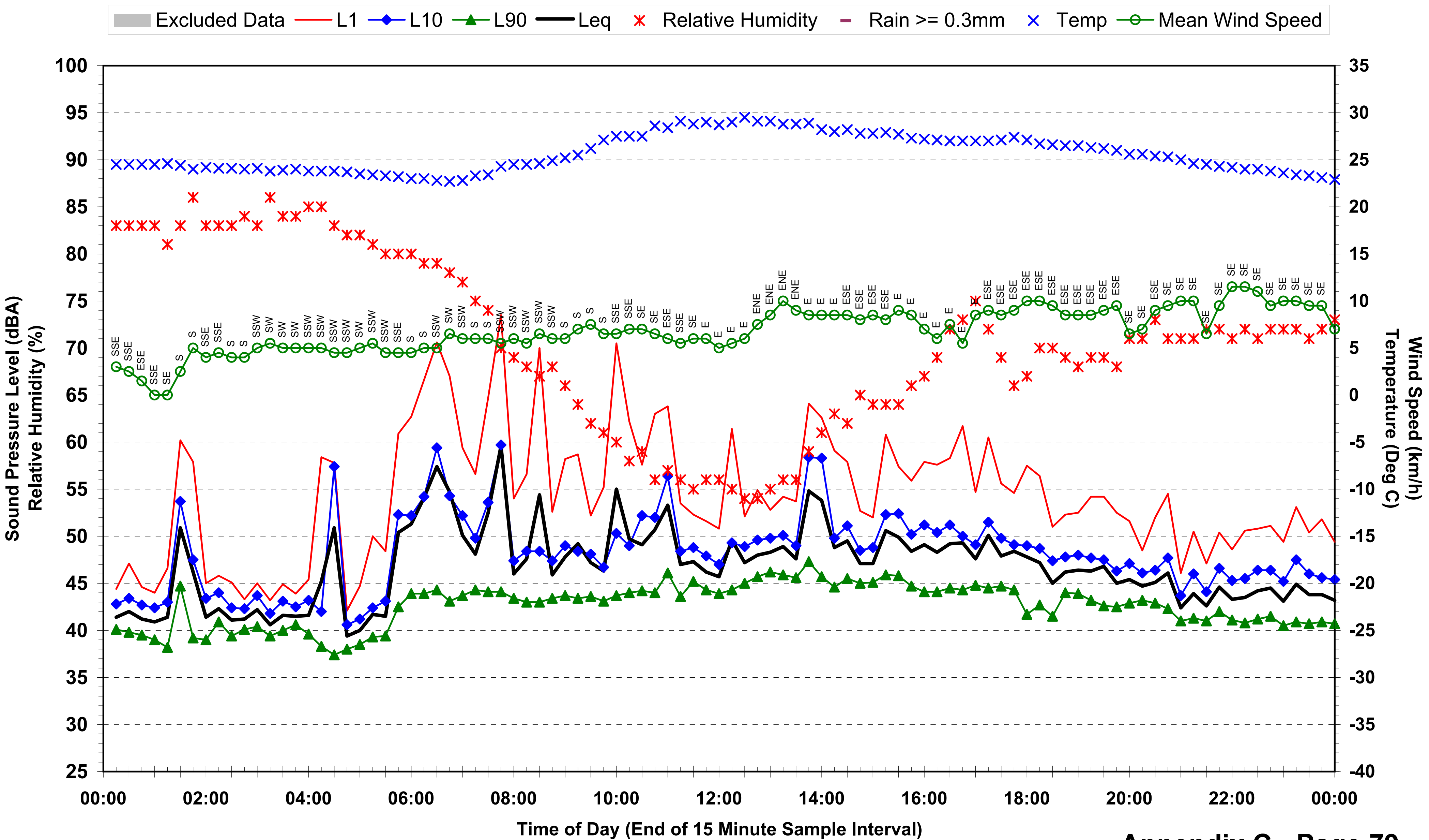


Statistical Ambient Noise Levels
20-2014 - Plant 6 - Gladstone Marina - Wednesday 27 February 2008
Excluded Data
L1
L10
L90
Leq
Relative Humidity
Rain >= 0.3mm
Temp
Mean Wind Speed
Sound Pressure Level (dBA)
Relative Humidity (%)
Wind Speed (km/h)
Temperature (Deg C)
Time of Day (End of 15 Minute Sample Interval)
00:00
02:00
04:00
06:00
08:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
00:00

Statistical Ambient Noise Levels
20-2014 - Plant 6 - Gladstone Marina - Thursday 28 February 2008



Statistical Ambient Noise Levels
20-2014 - Plant 6 - Gladstone Marina - Friday 29 February 2008



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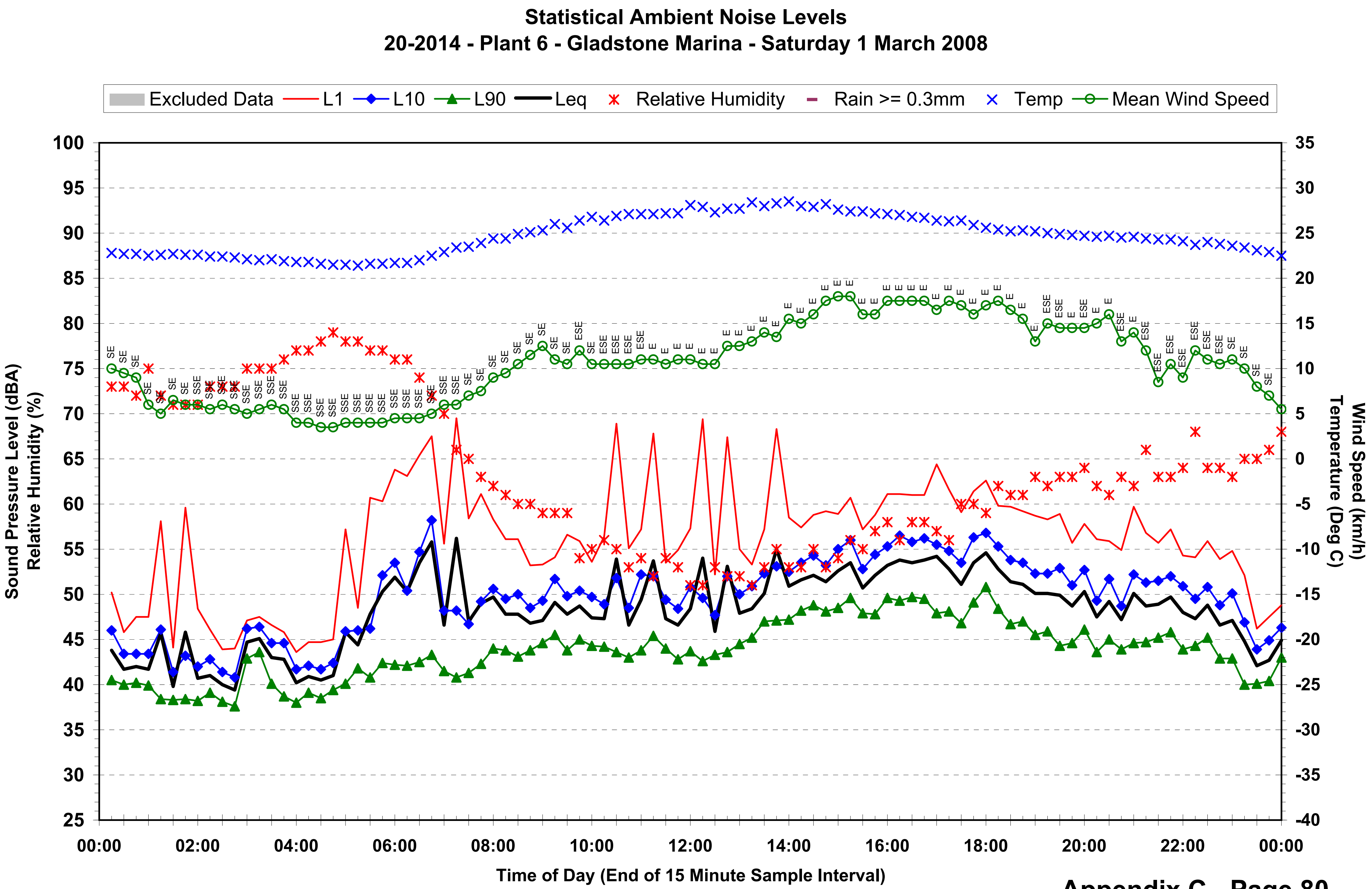
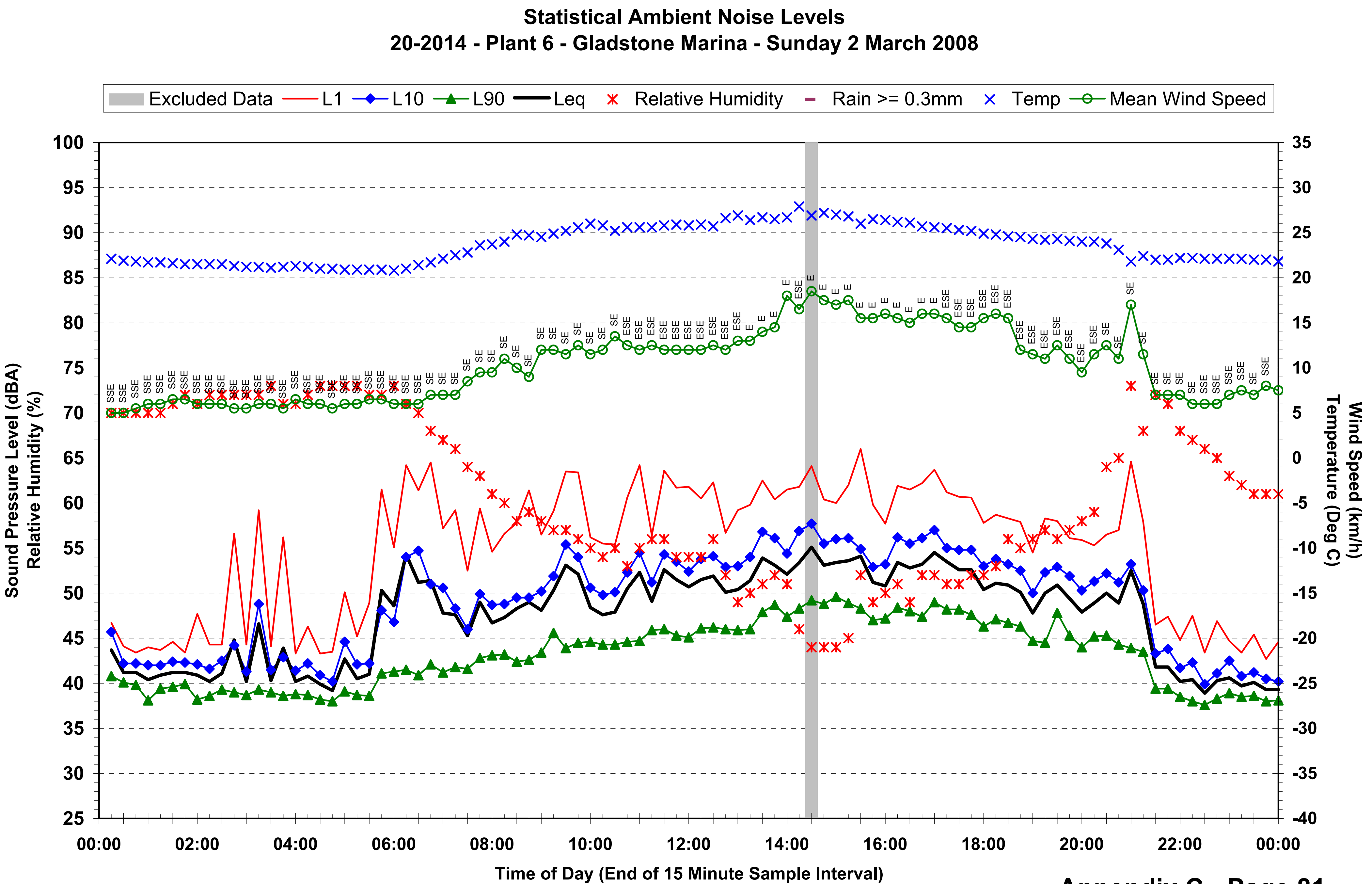
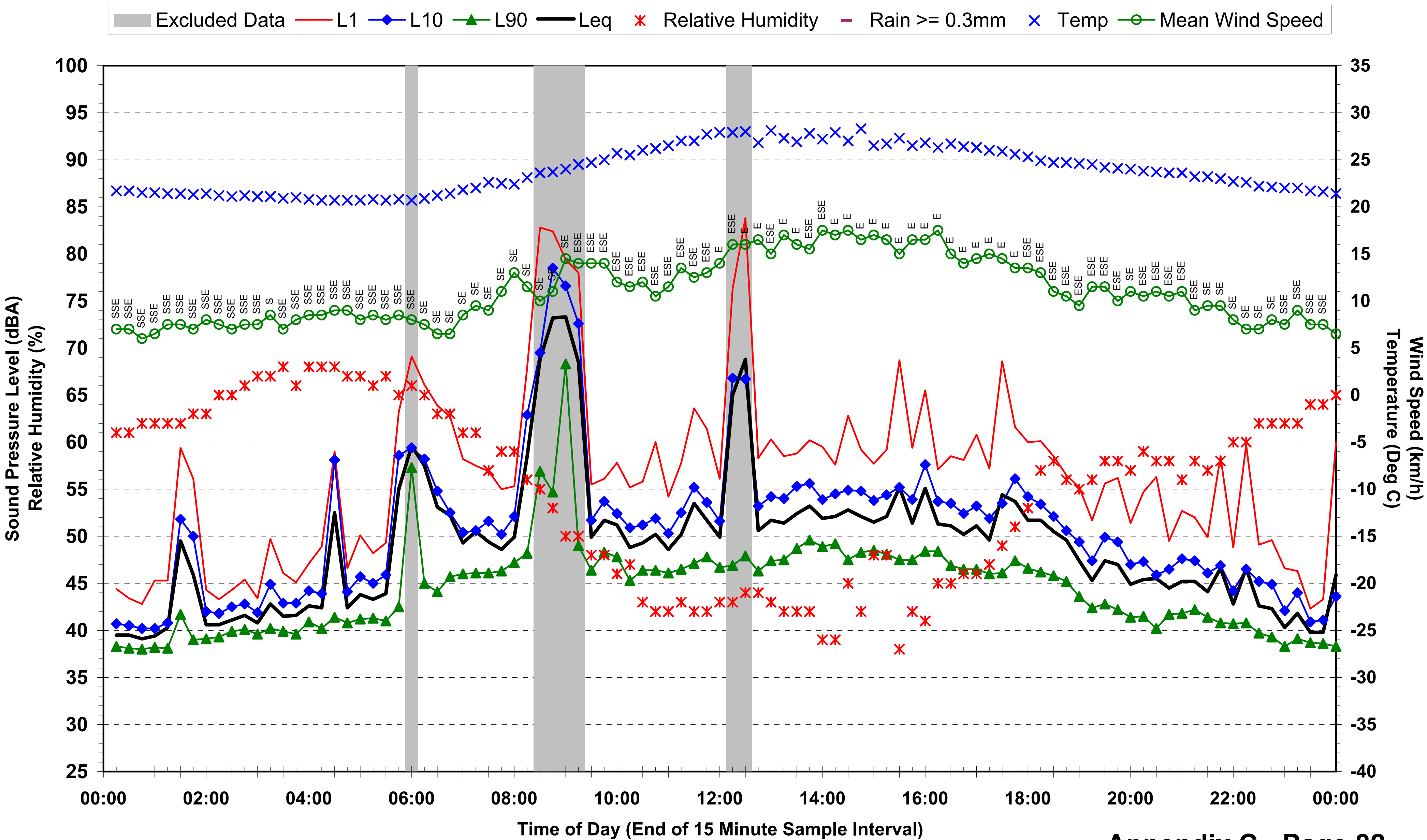
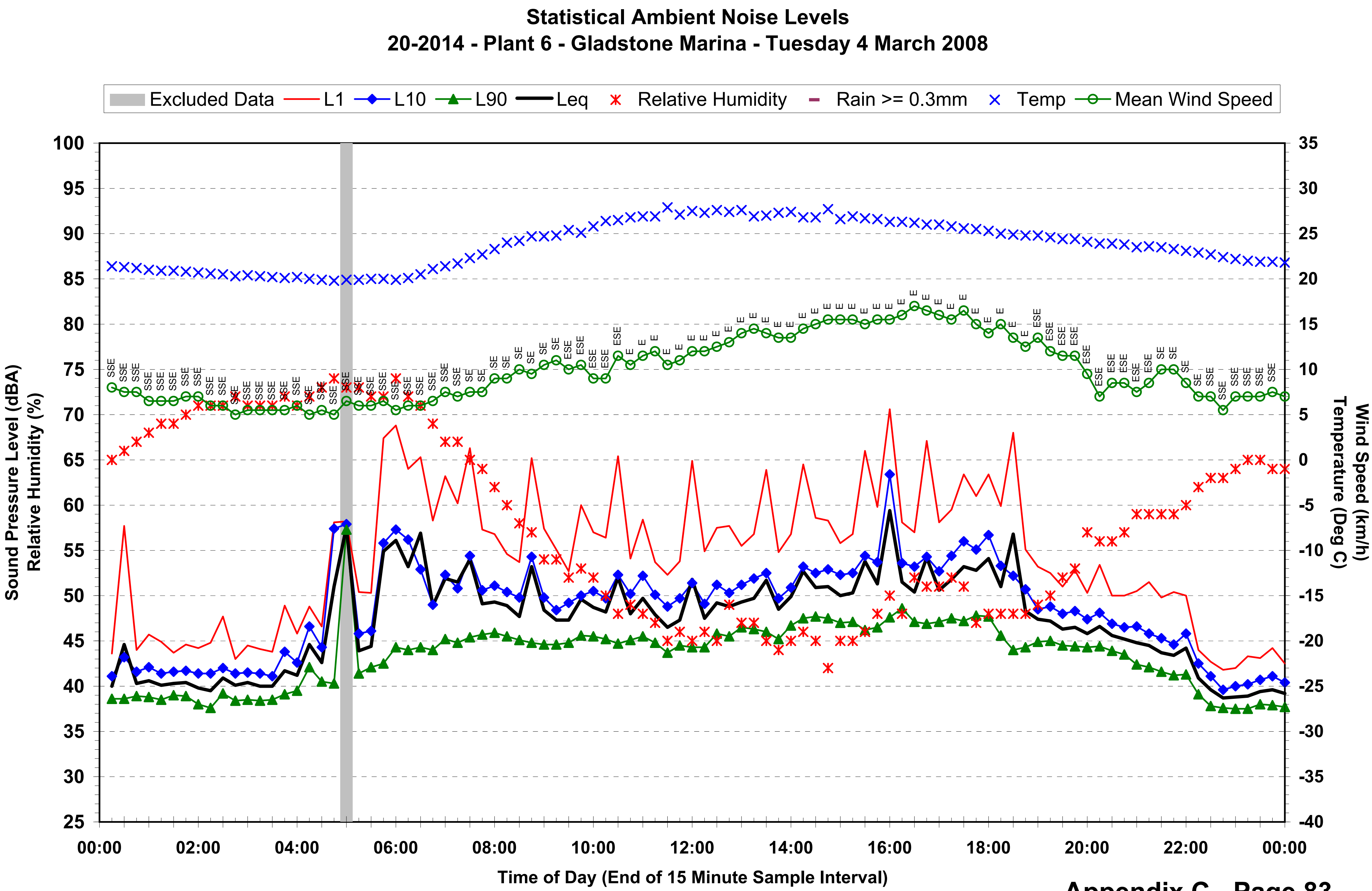


Statistical Ambient Noise Levels
20-2014 - Plant 6 - Gladstone Marina - Saturday 1 March 2008
Excluded Data
L1
L10
L90
Leq
Relative Humidity
Rain >= 0.3mm
Temp
Mean Wind Speed
Sound Pressure Level (dBA)
Relative Humidity (%)
Wind Speed (km/h)
Temperature (Deg C)
Time of Day (End of 15 Minute Sample Interval)


Statistical Ambient Noise Levels
20-2014 - Plant 6 - Gladstone Marina - Sunday 2 March 2008
Excluded Data
L1
L10
L90
Leq
Relative Humidity
Rain >= 0.3mm
Temp
Mean Wind Speed
Sound Pressure Level (dBA)
Relative Humidity (%)
Wind Speed (km/h)
Temperature (Deg C)
Time of Day (End of 15 Minute Sample Interval)
00:00
02:00
04:00
06:00
08:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
00:00

Statistical Ambient Noise Levels
20-2014 - Plant 6 - Gladstone Marina - Monday 3 March 2008





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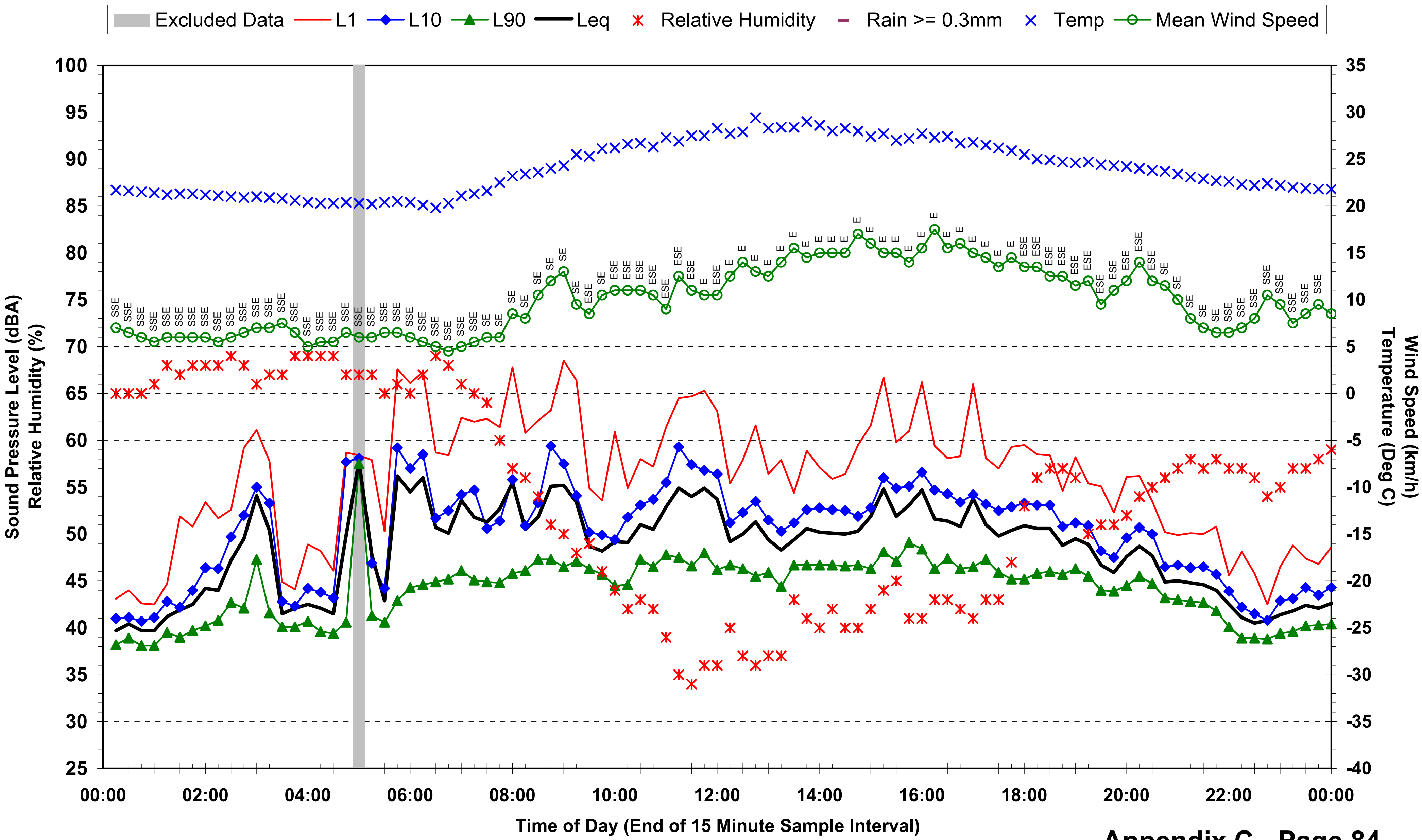
Ambient Conditions

RHA Report 20-2014

Statistical Ambient Noise Levels
20-2014 - Plant 6 - Gladstone Marina - Wednesday 5 March 2008



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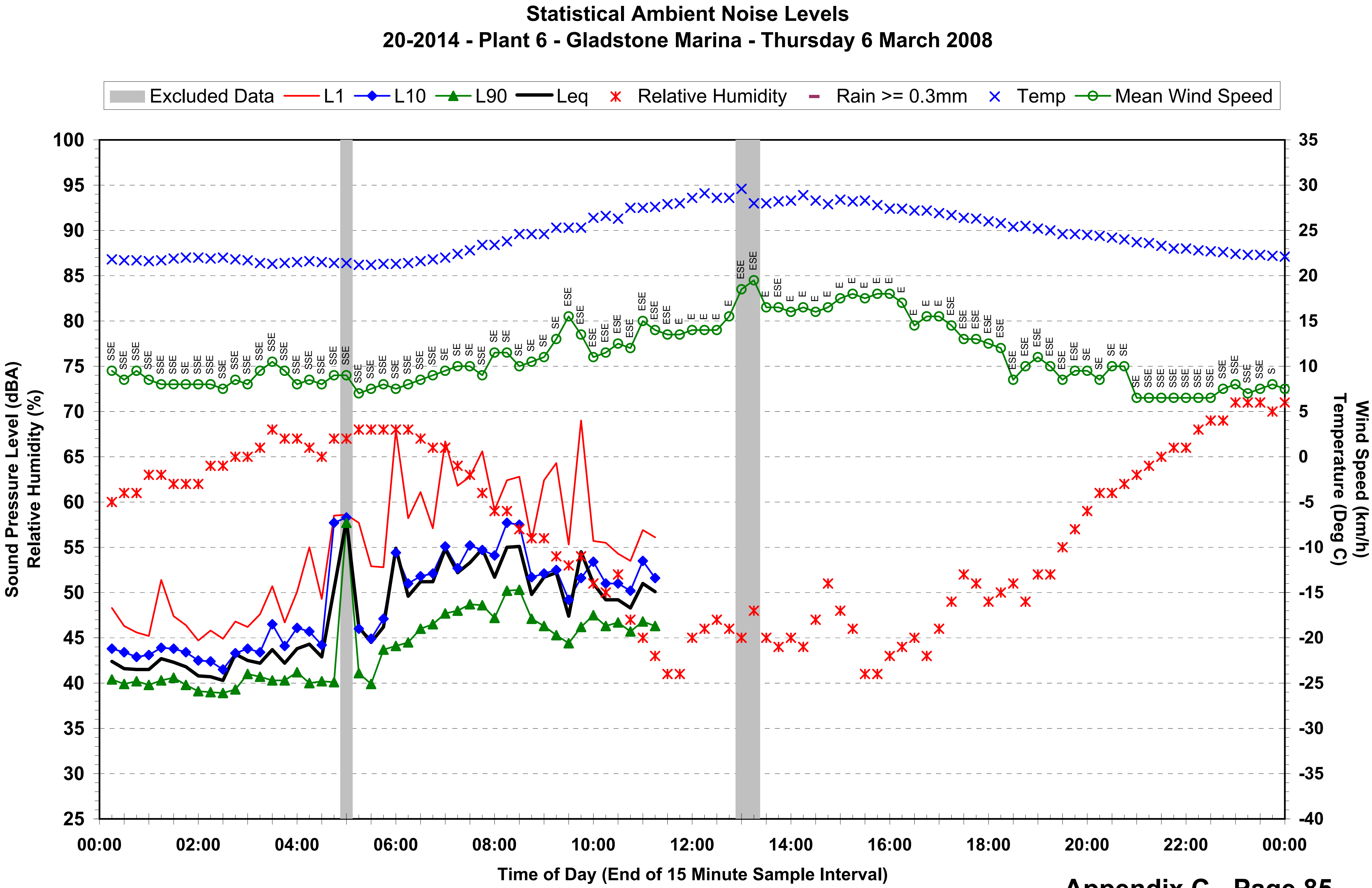

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Ambient Conditions

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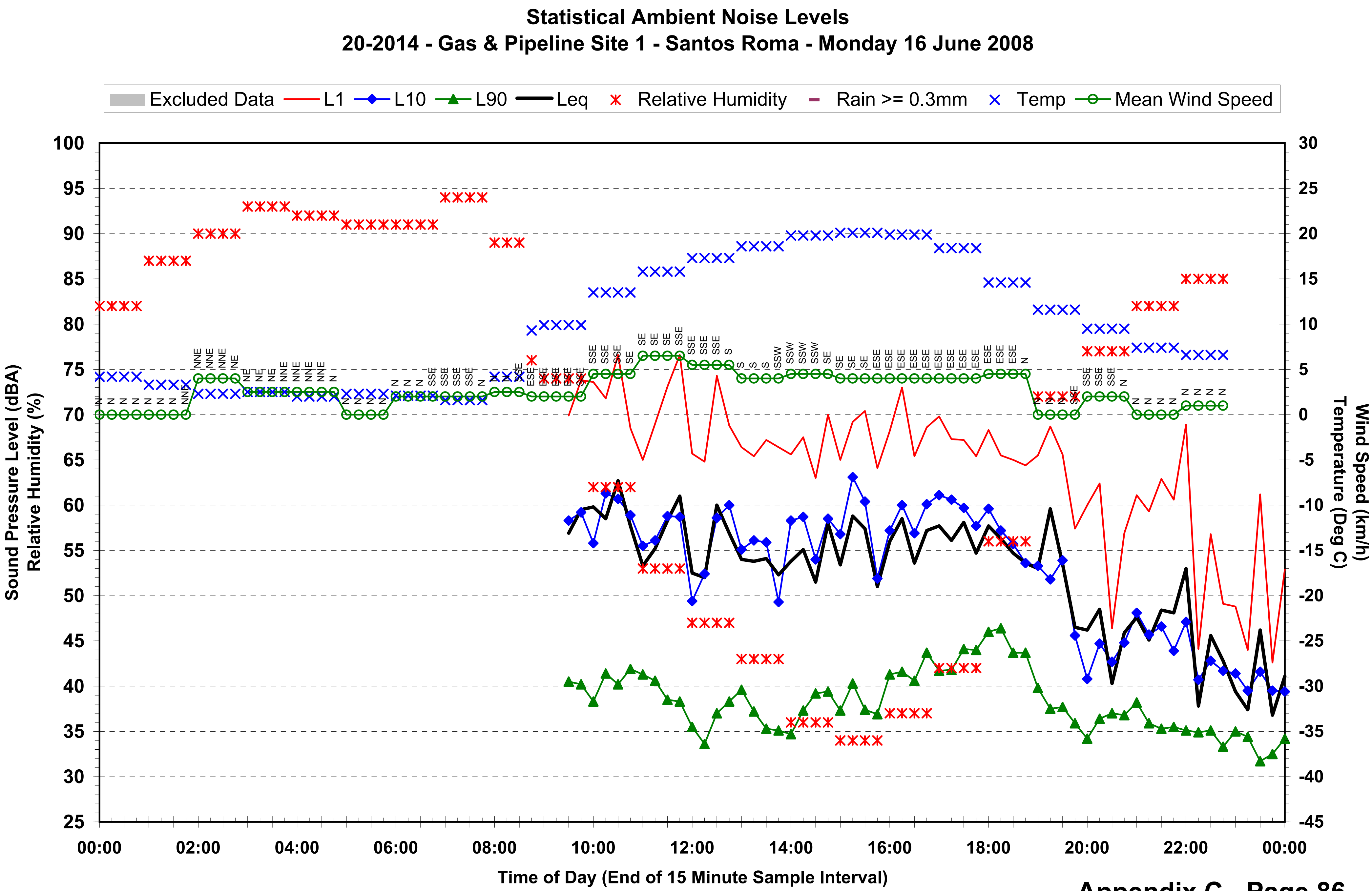

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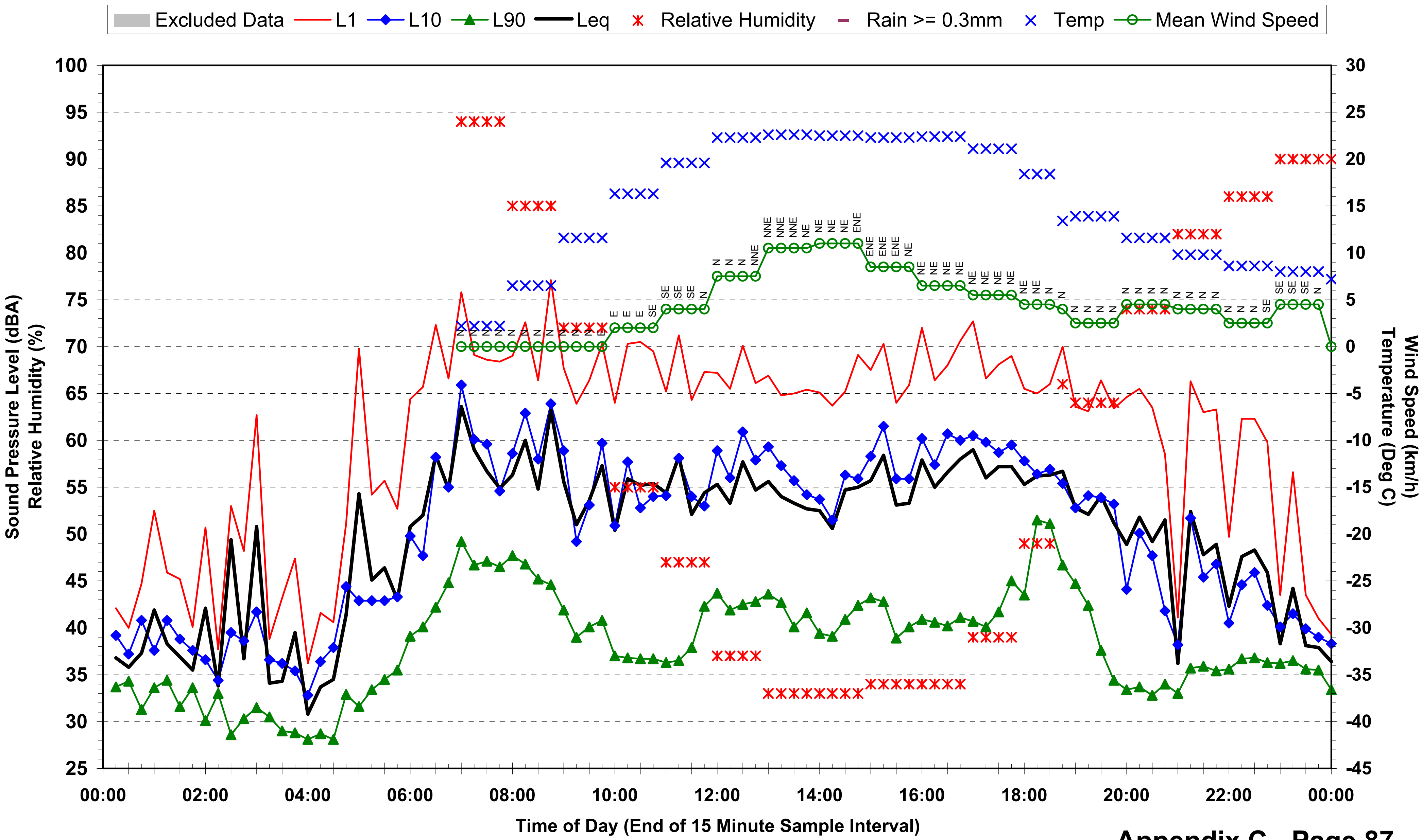
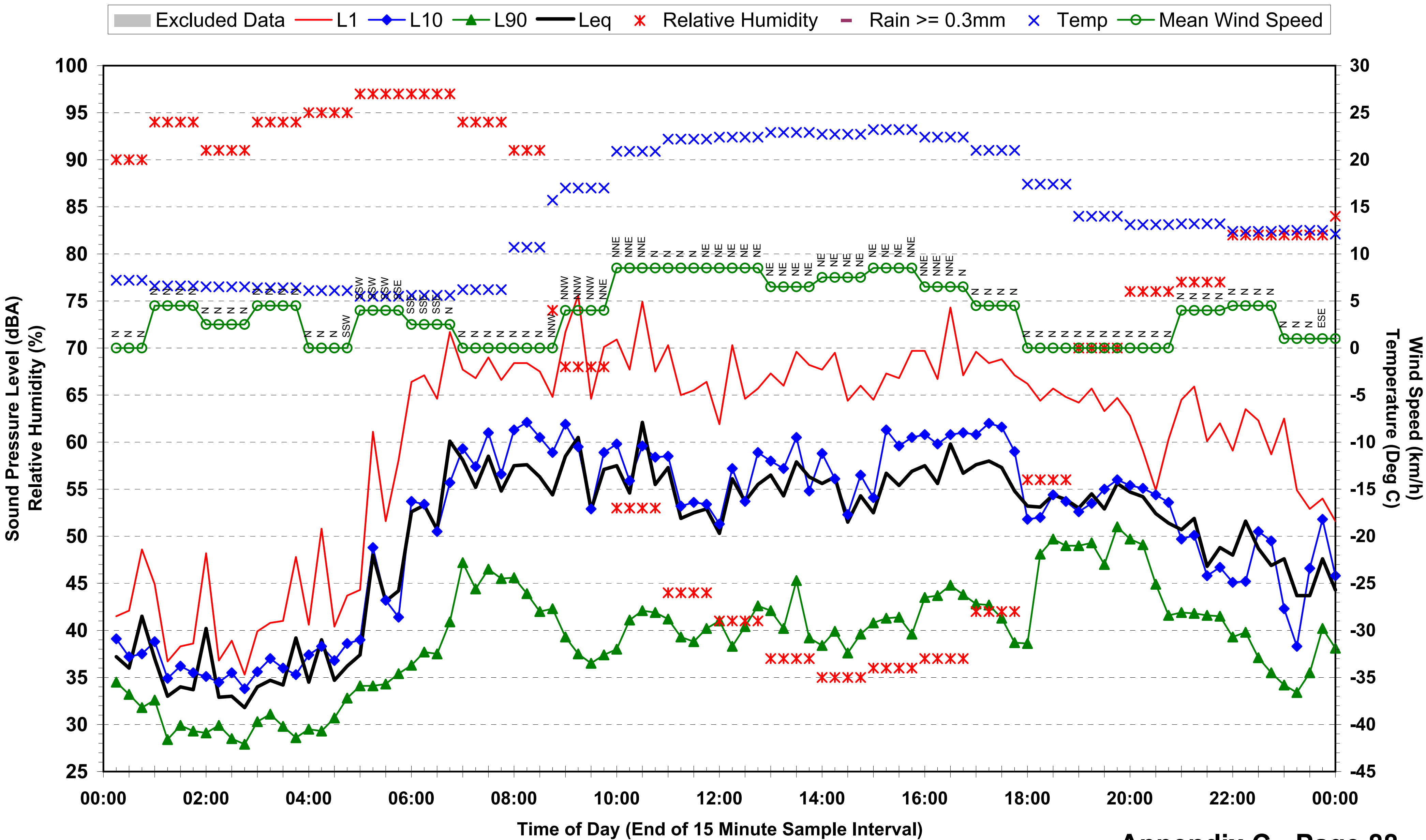
Ambient Conditions

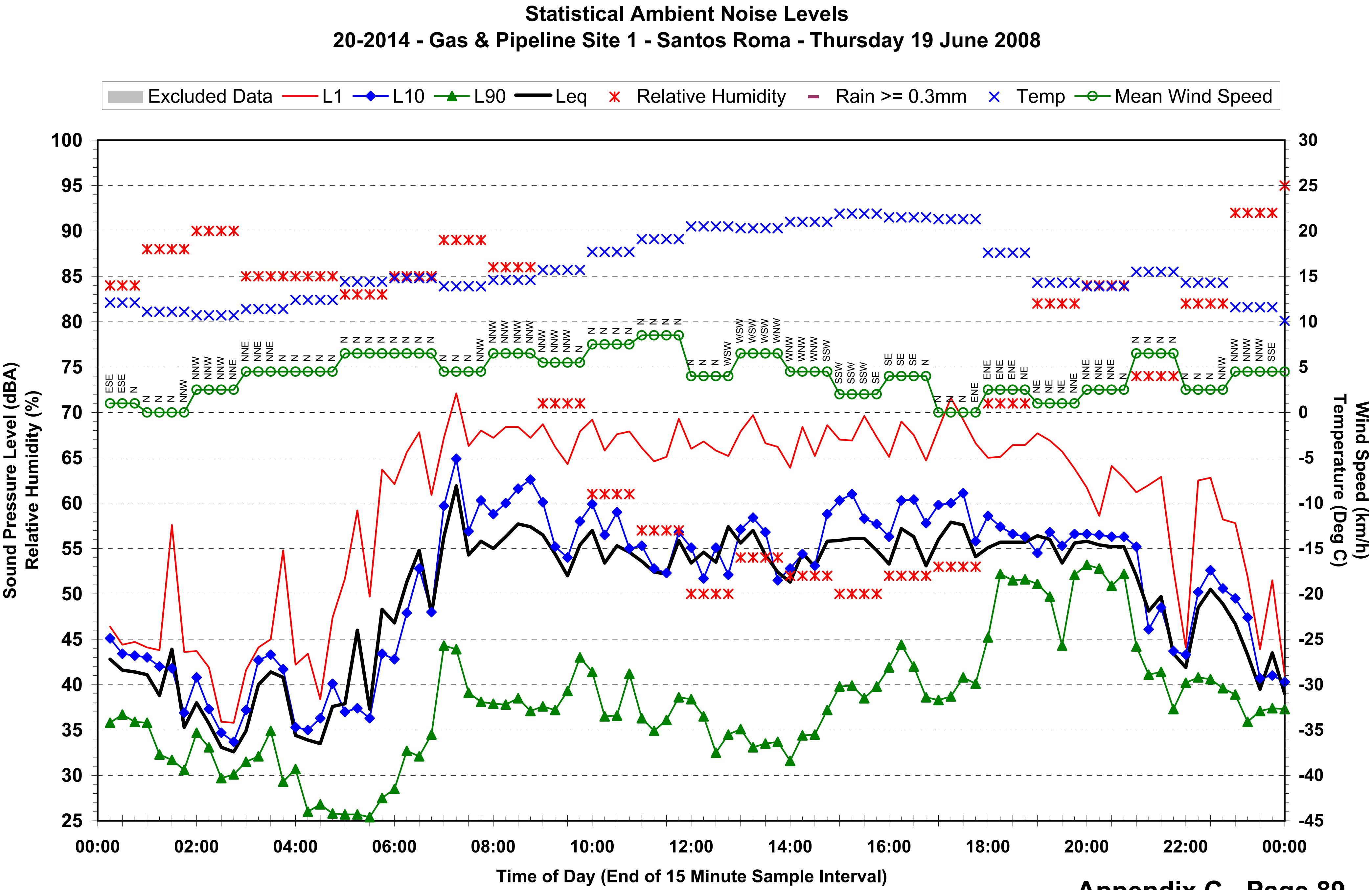
RHA Report 20-2014

Statistical Ambient Noise Levels
20-2014 - Gas & Pipeline Site 1 - Santos Roma - Tuesday 17 June 2008



Statistical Ambient Noise Levels
20-2014 - Gas & Pipeline Site 1 - Santos Roma - Wednesday 18 June 2008





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Ambient Conditions

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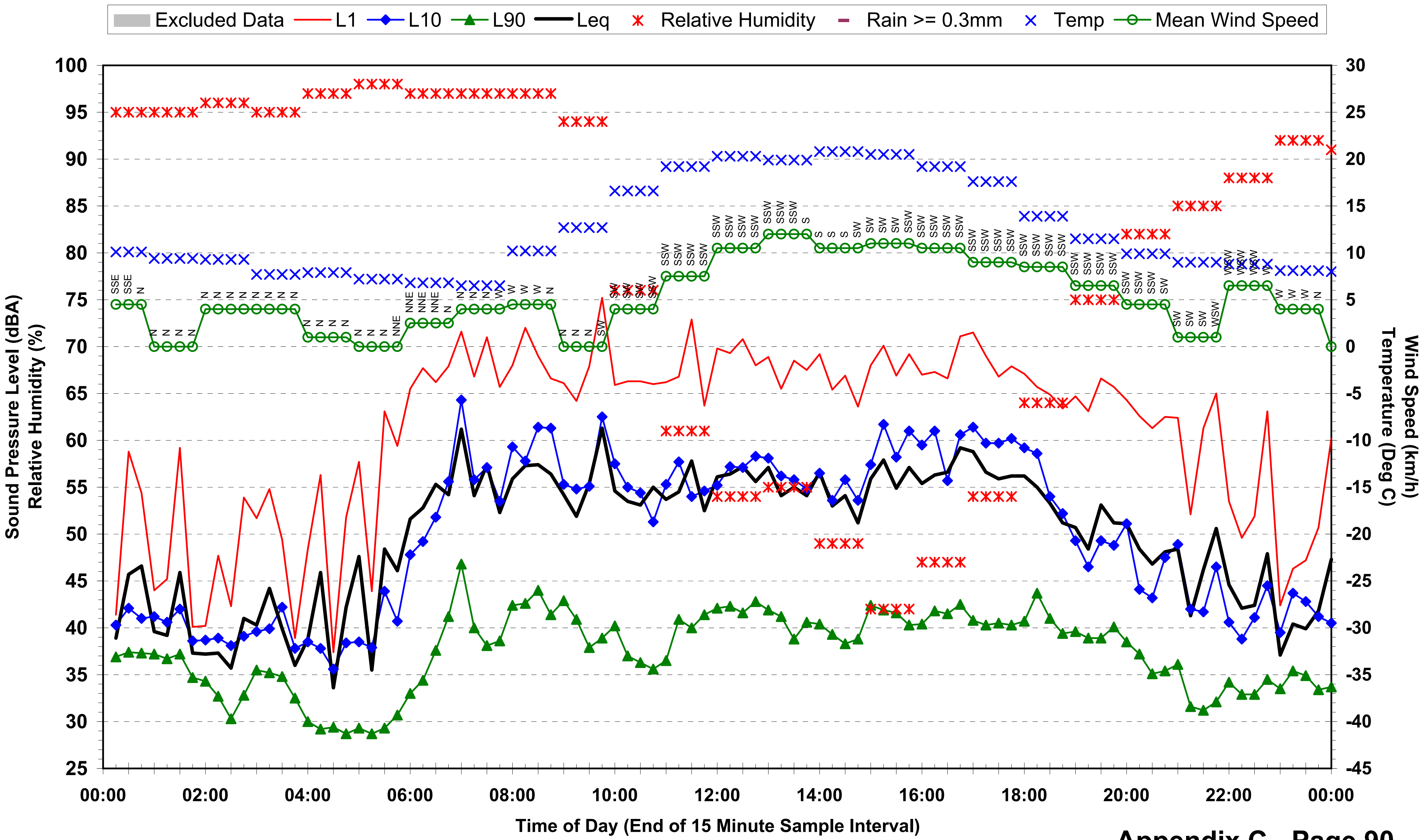
Statistical Ambient Noise Levels
20-2014 - Gas & Pipeline Site 1 - Santos Roma - Friday 20 June 2008



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Ambient Conditions

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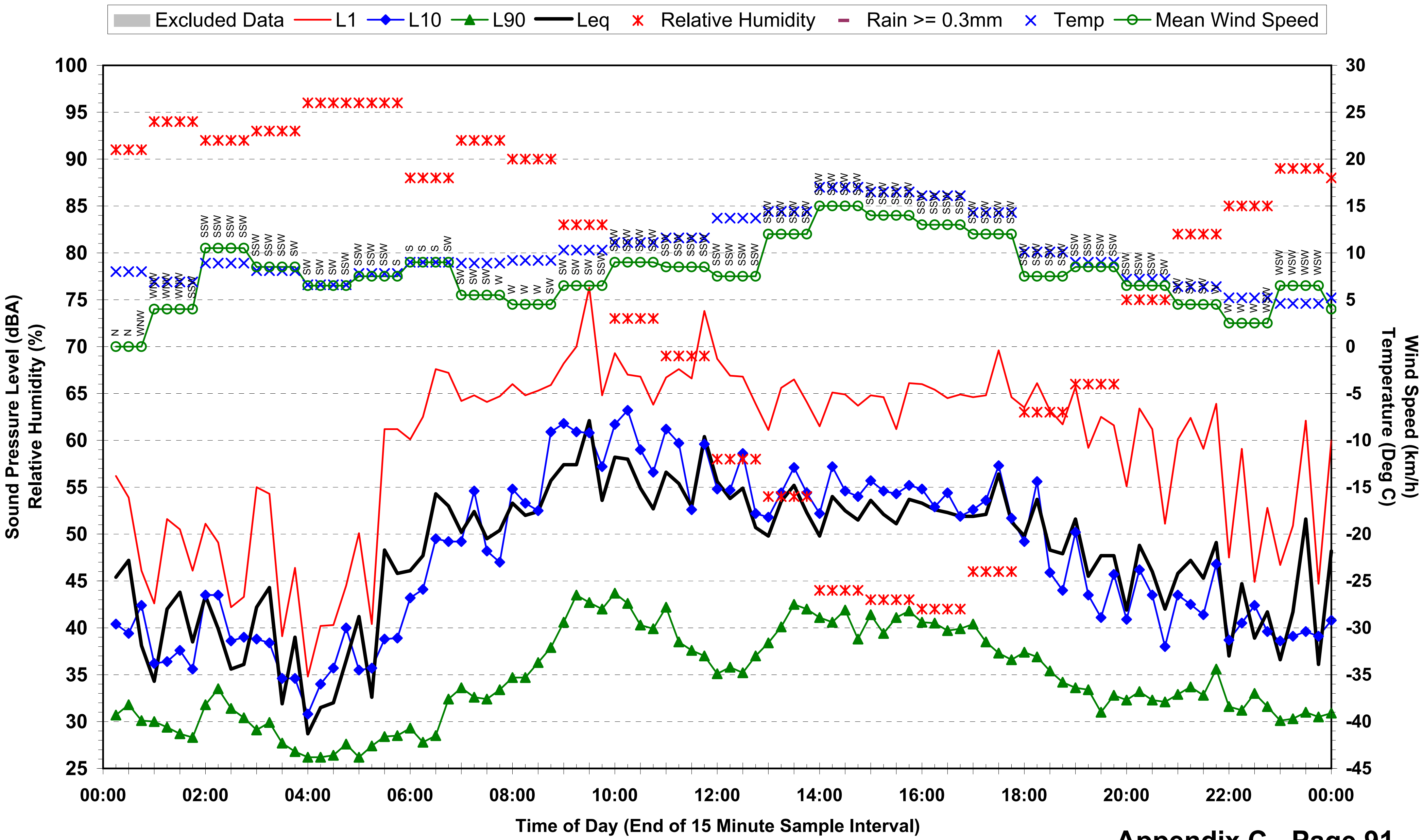
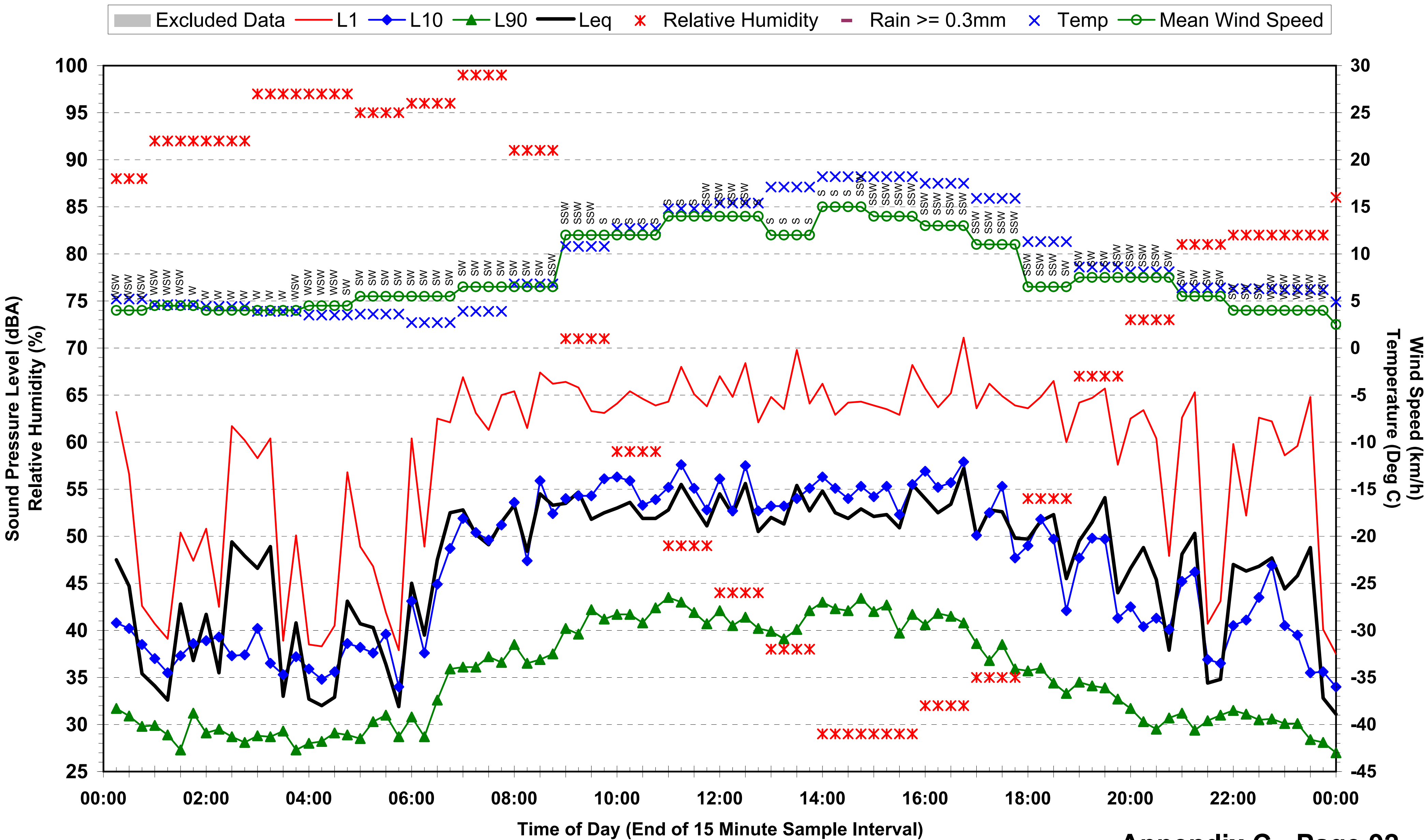
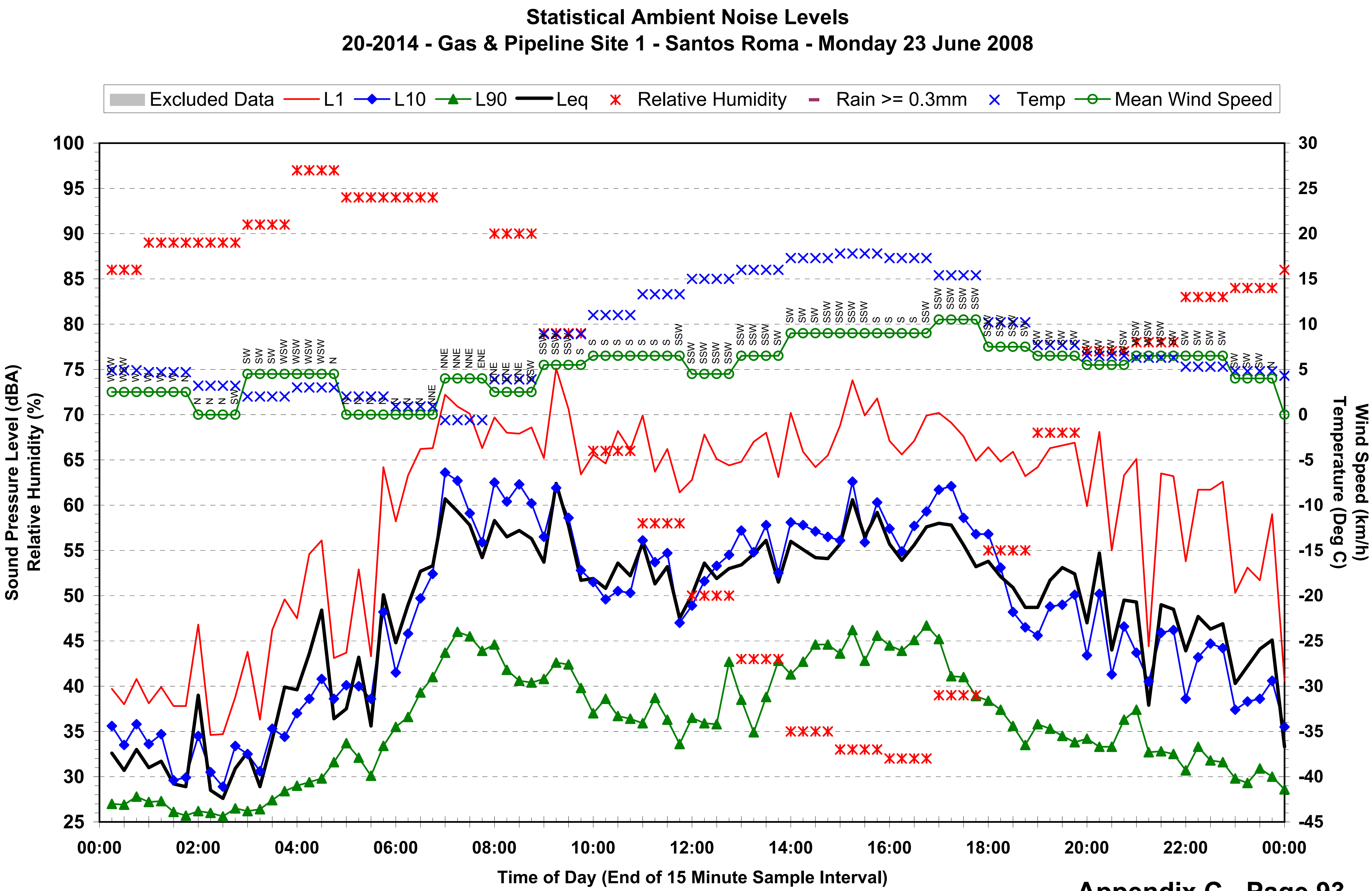
Statistical Ambient Noise Levels
20-2014 - Gas & Pipeline Site 1 - Santos Roma - Saturday 21 June 2008



Statistical Ambient Noise Levels
20-2014 - Gas & Pipeline Site 1 - Santos Roma - Sunday 22 June 2008



Ambient Conditions
RHA Report 20-2014



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Ambient Conditions

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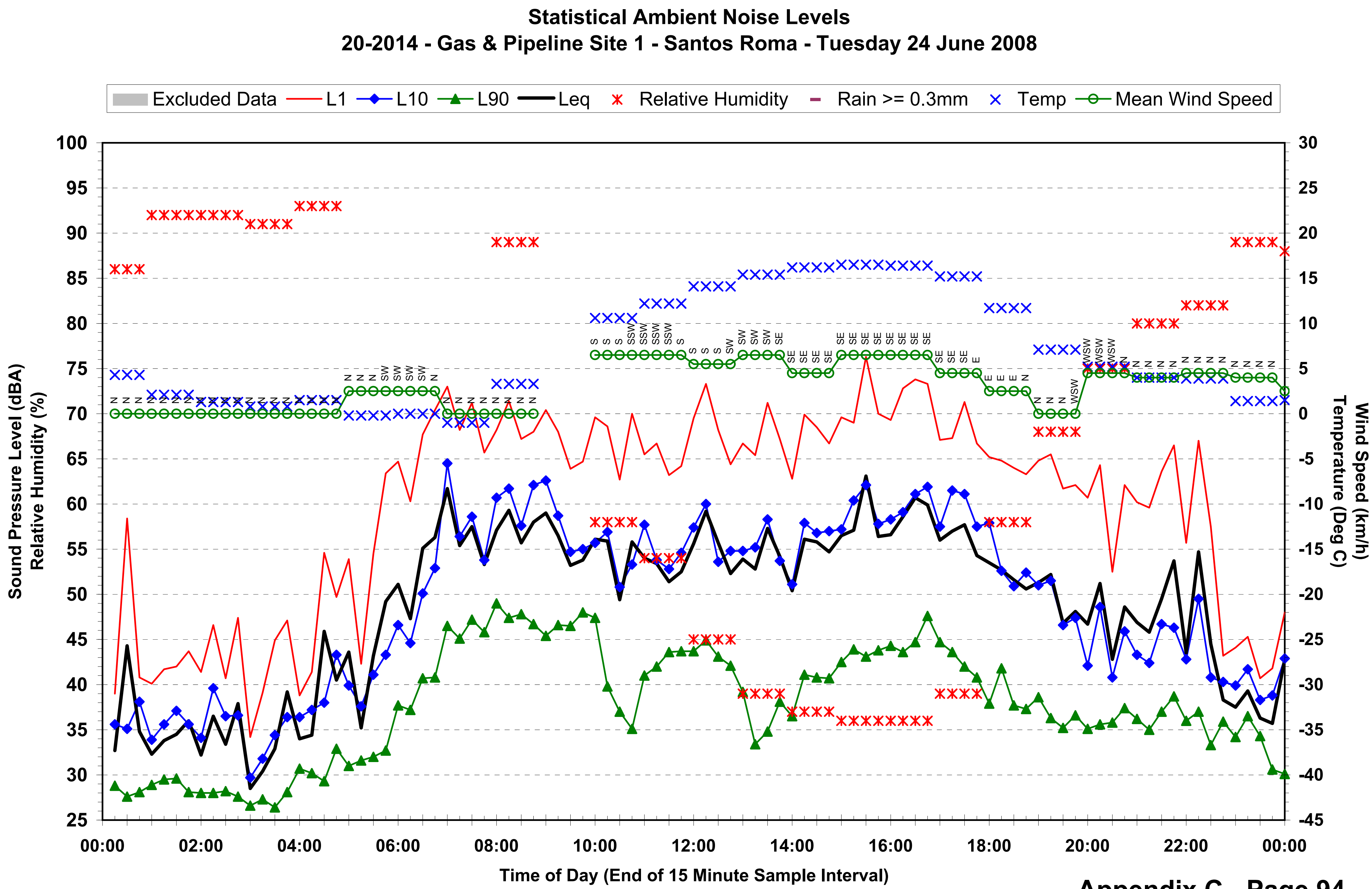

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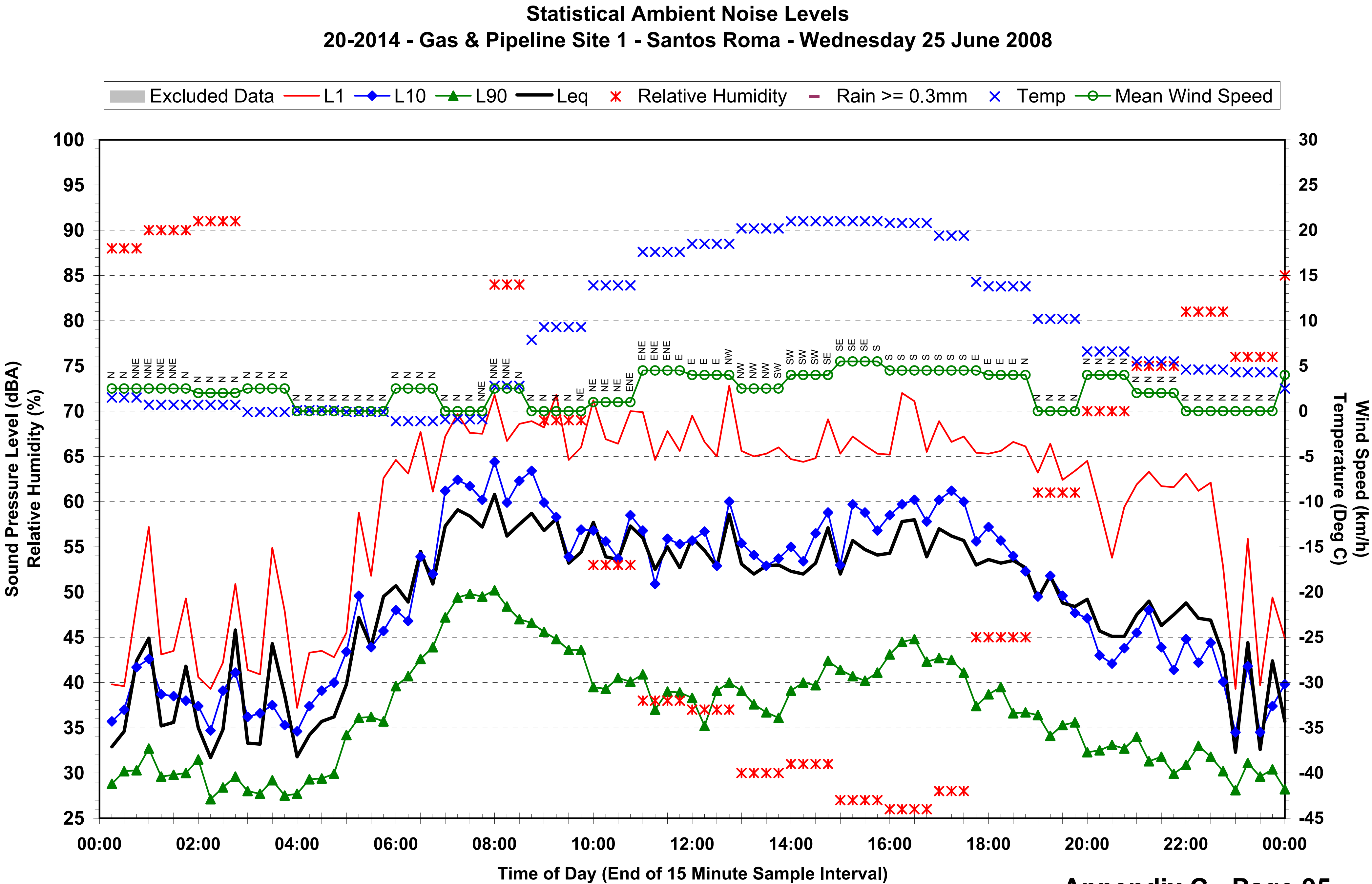

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Ambient Conditions

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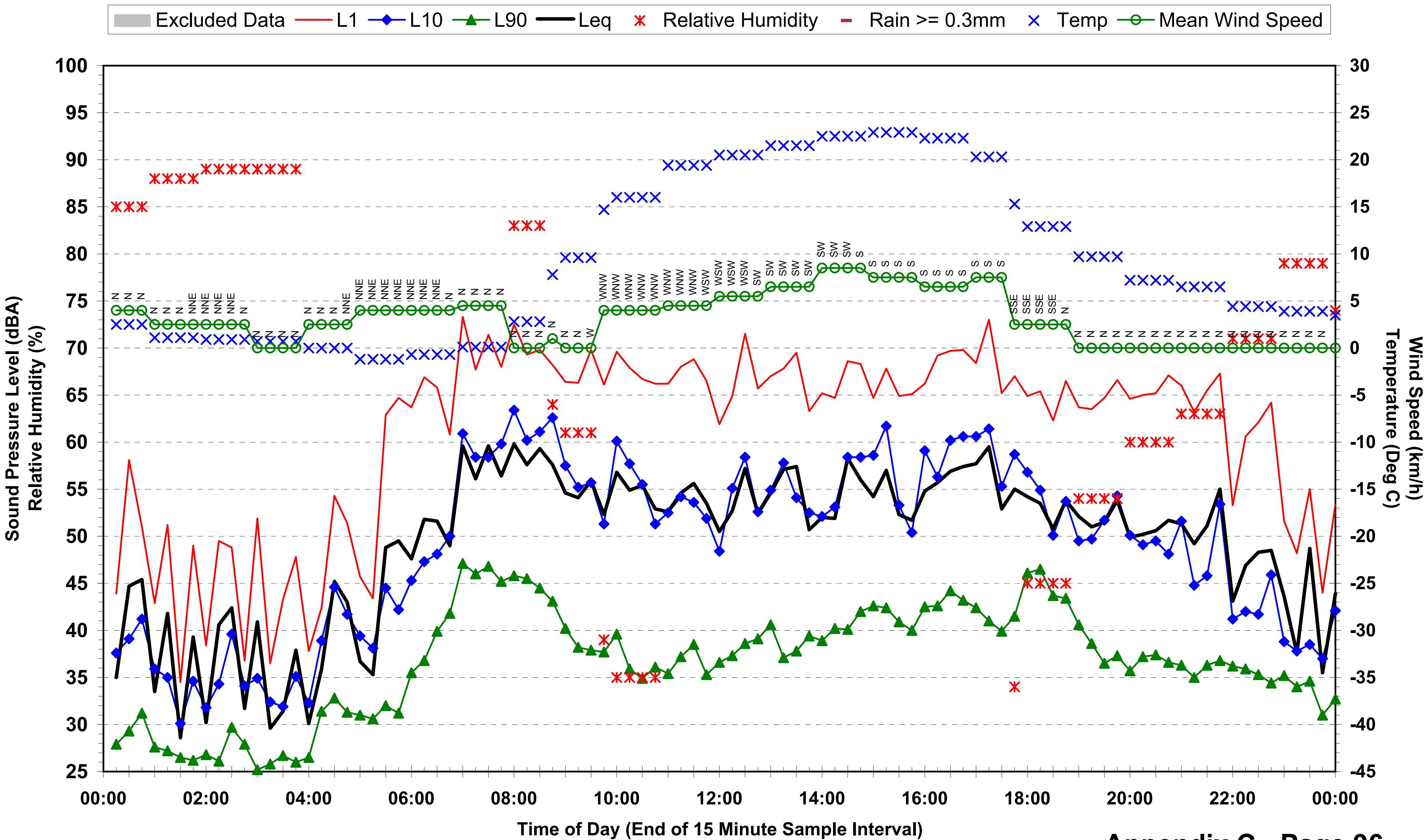
Statistical Ambient Noise Levels
20-2014 - Gas & Pipeline Site 1 - Santos Roma - Thursday 26 June 2008



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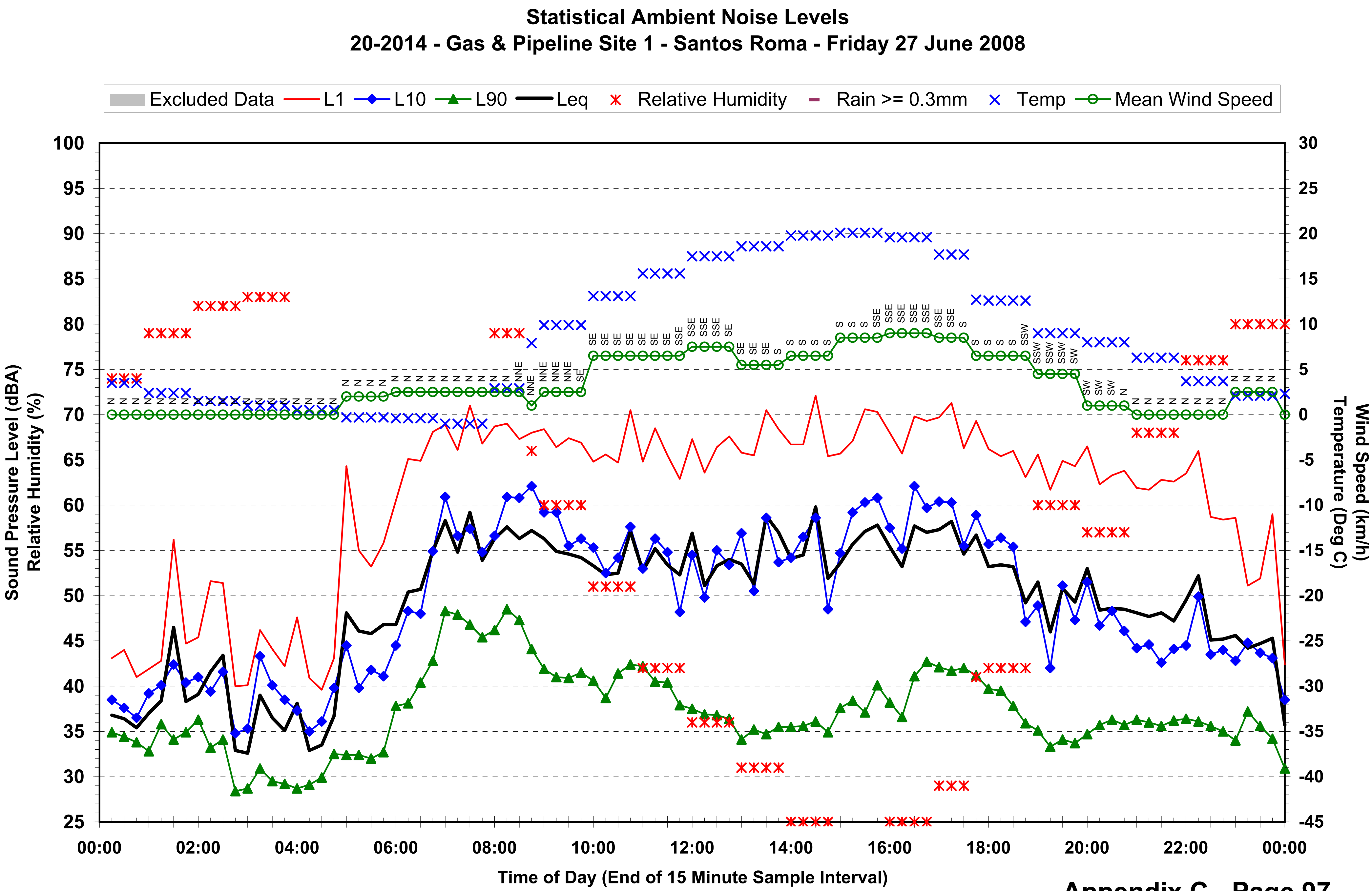

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Ambient Conditions

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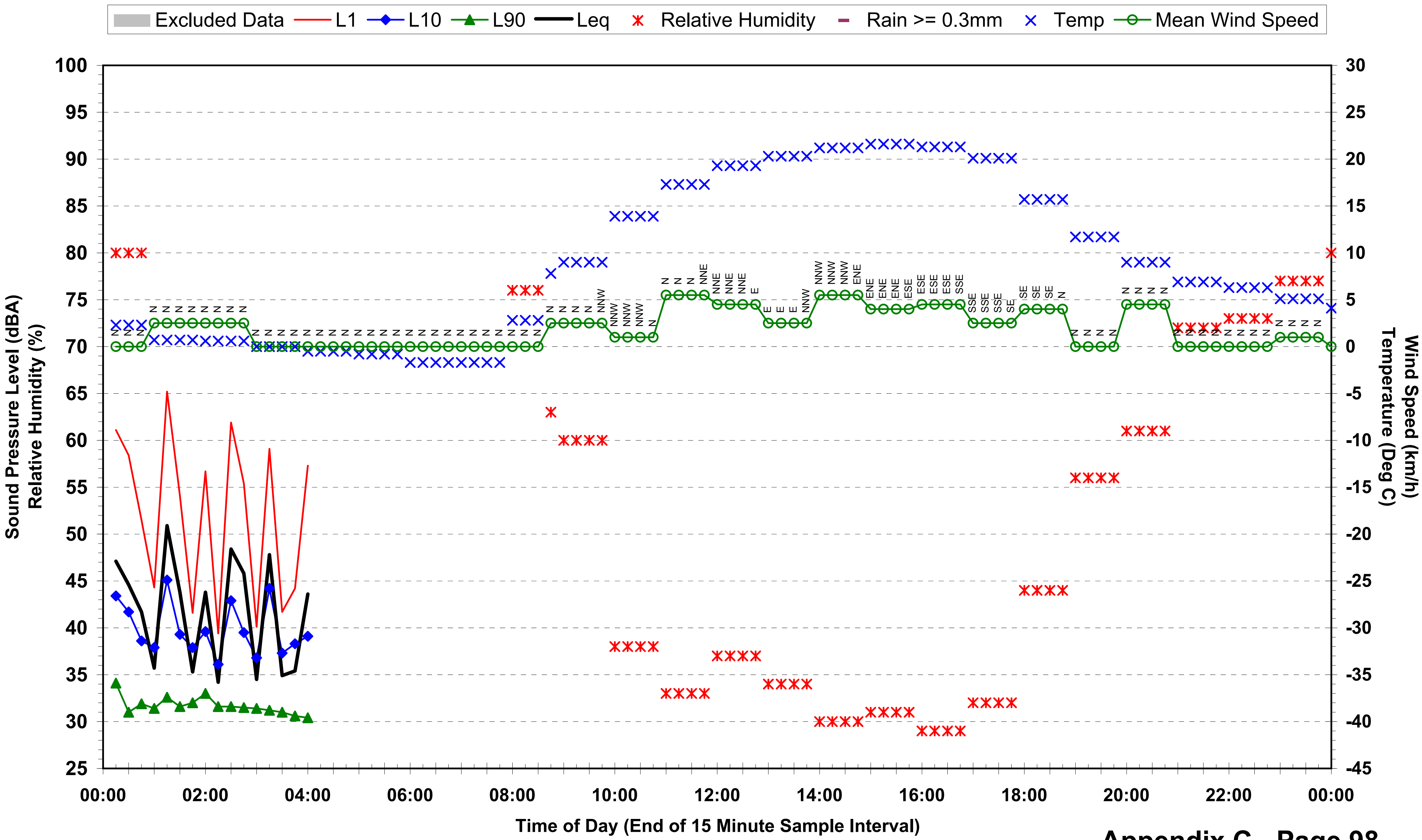
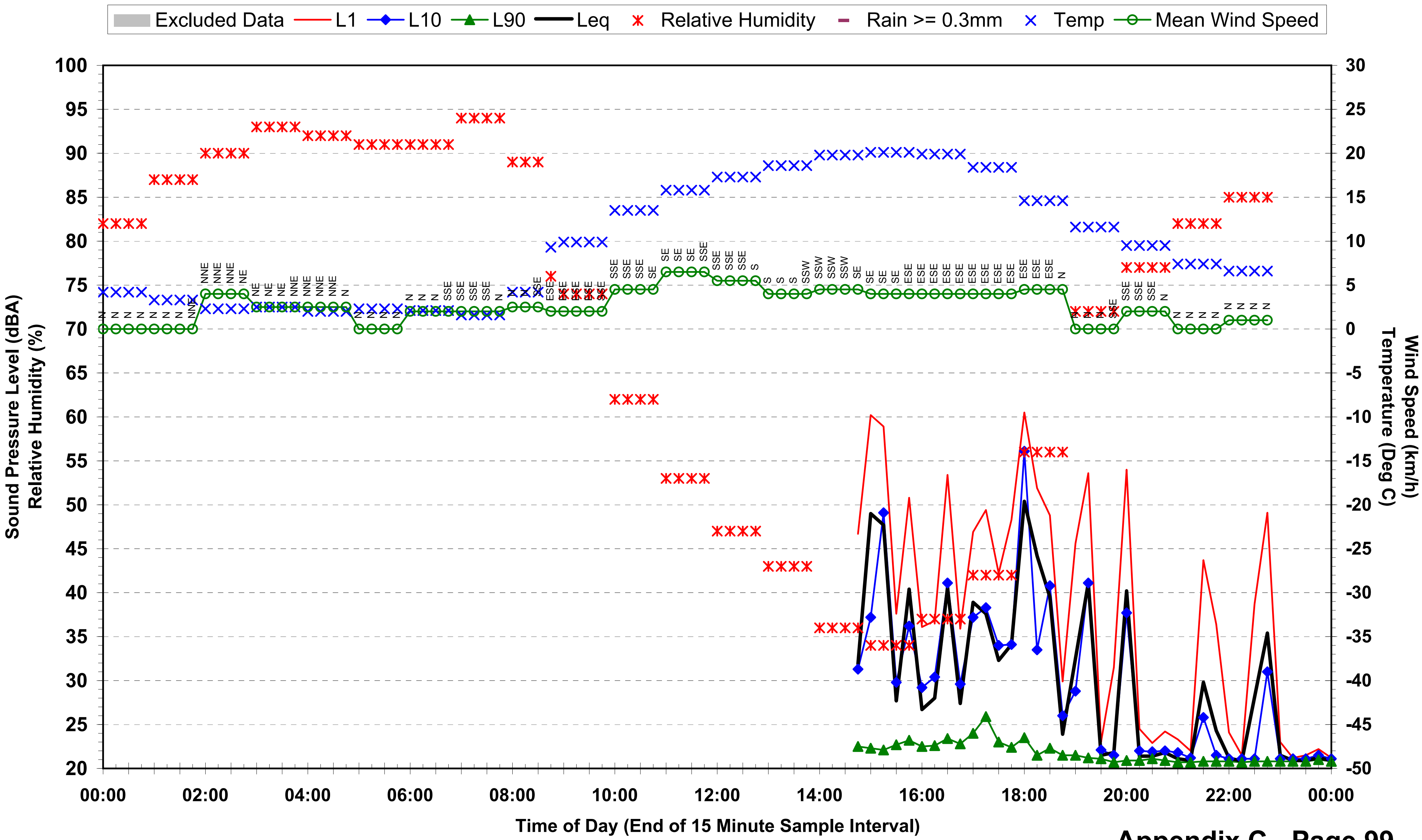
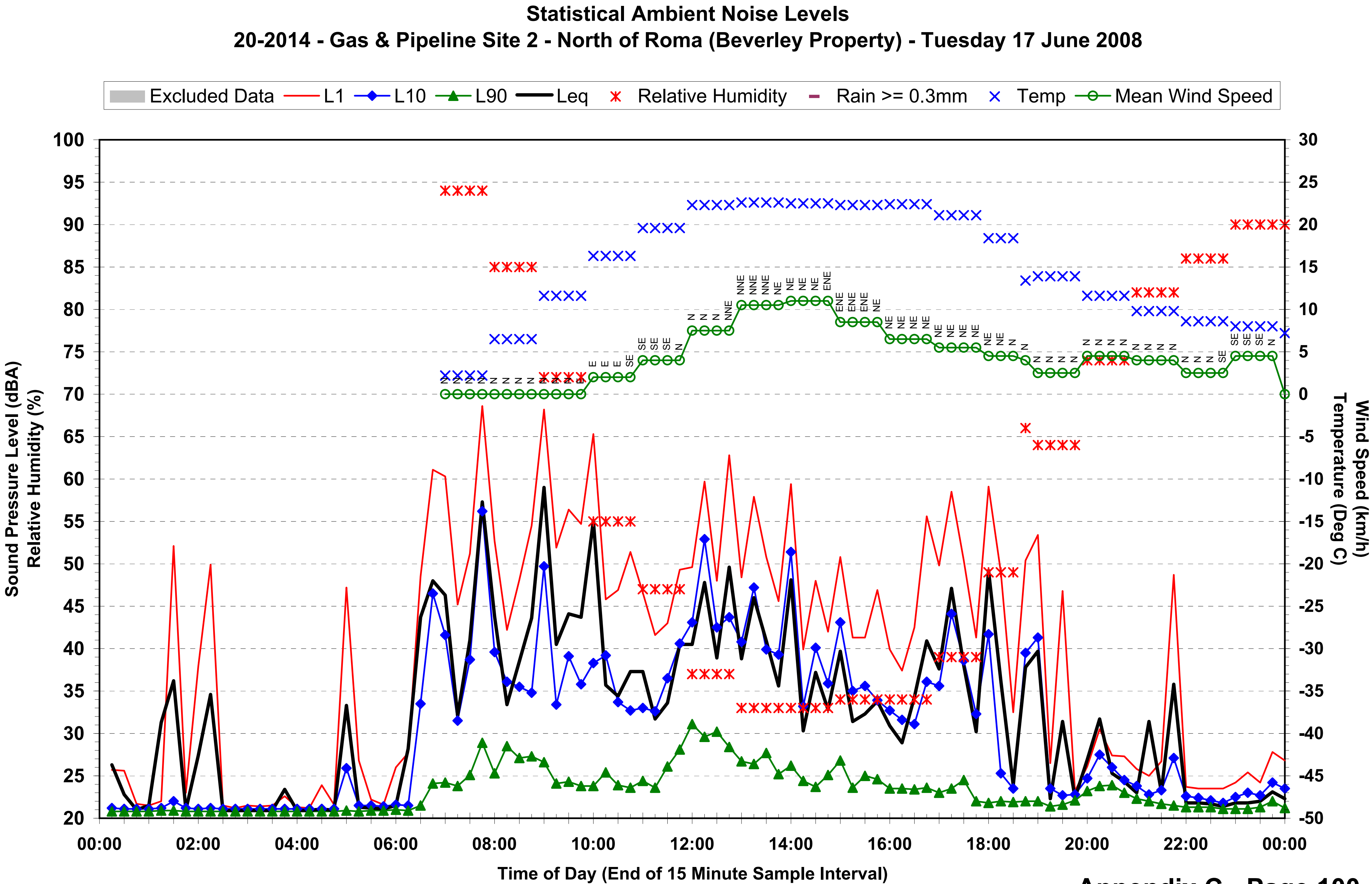
Statistical Ambient Noise Levels
20-2014 - Gas & Pipeline Site 1 - Santos Roma - Saturday 28 June 2008

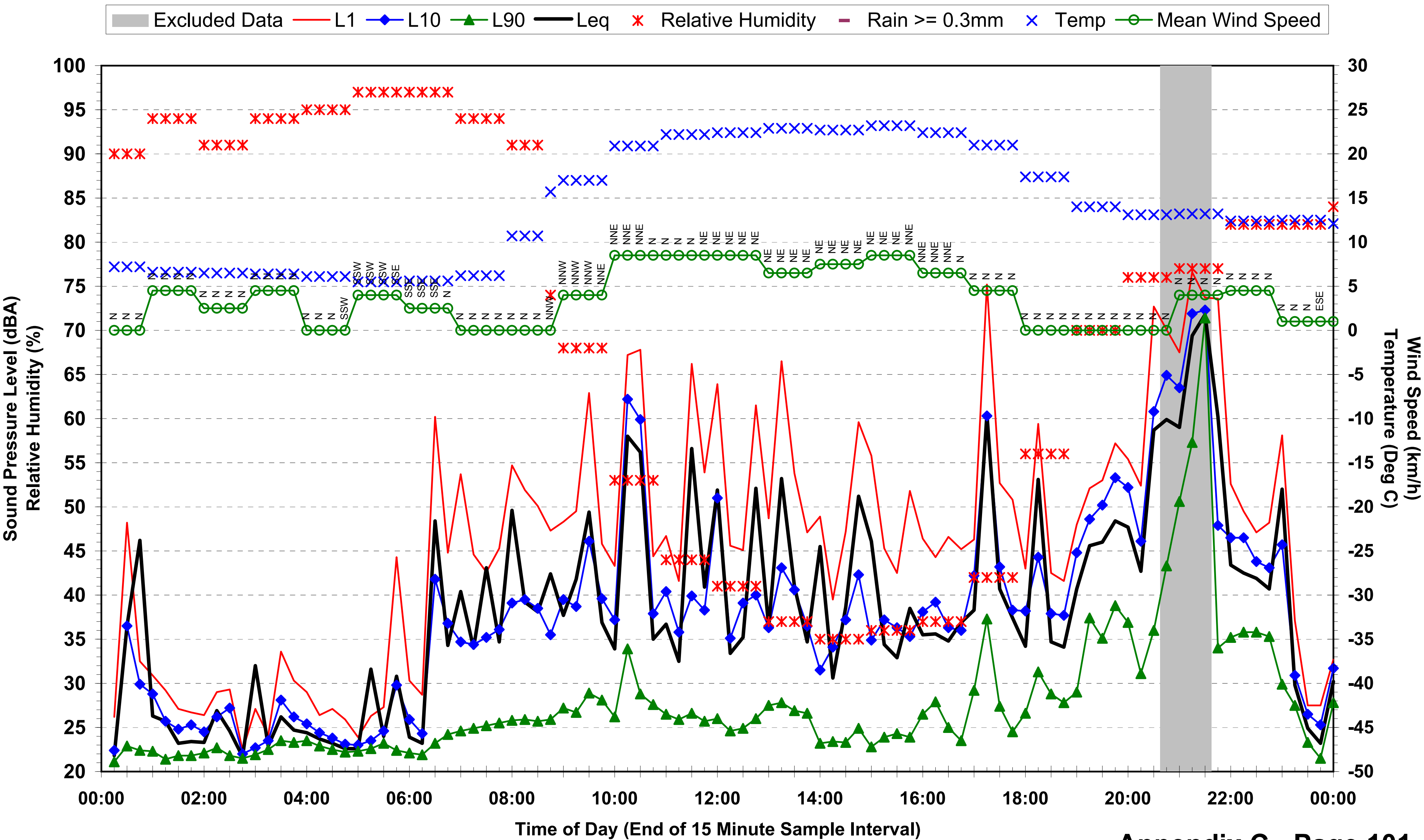


Statistical Ambient Noise Levels
20-2014 - Gas & Pipeline Site 2 - North of Roma (Beverley Property) - Monday 16 June 2008

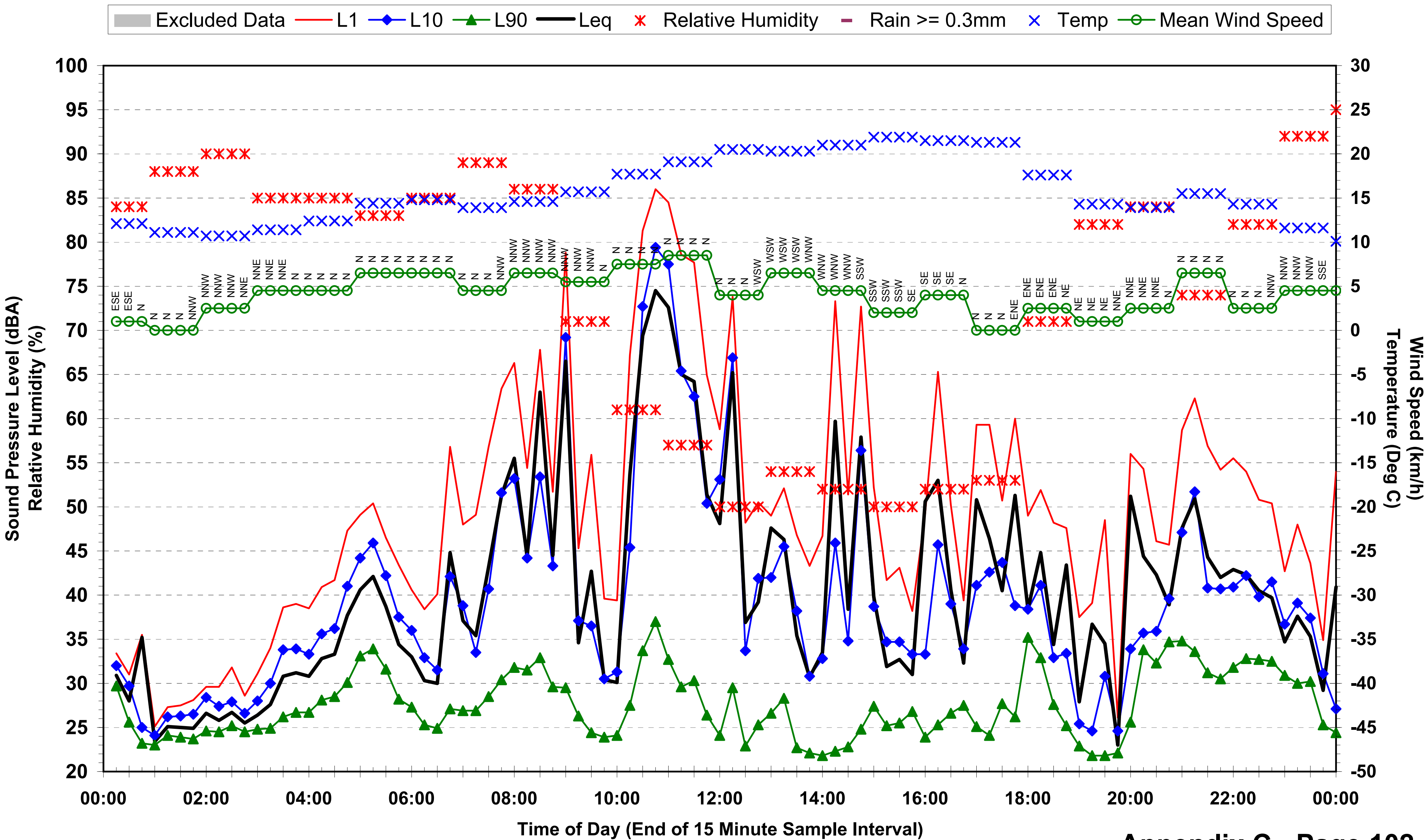



Statistical Ambient Noise Levels
20-2014 - Gas & Pipeline Site 2 - North of Roma (Beverley Property) - Tuesday 17 June 2008
Excluded Data
L1
L10
L90
Leq
Relative Humidity
Rain >= 0.3mm
Temp
Mean Wind Speed
Sound Pressure Level (dBA)
Relative Humidity (%)
Wind Speed (km/h)
Temperature (Deg C)
Time of Day (End of 15 Minute Sample Interval)

Statistical Ambient Noise Levels
20-2014 - Gas & Pipeline Site 2 - North of Roma (Beverley Property) - Wednesday 18 June 2008

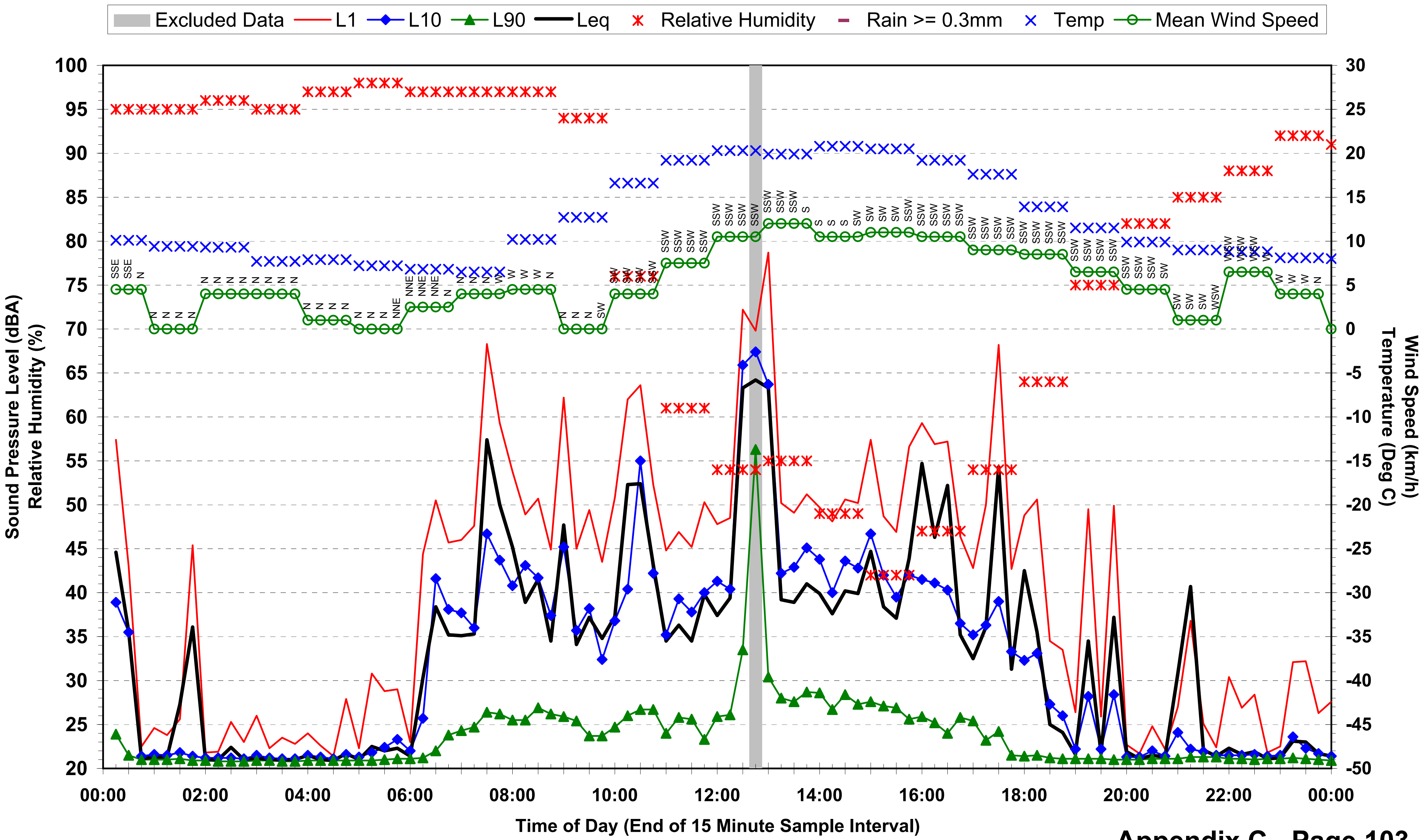


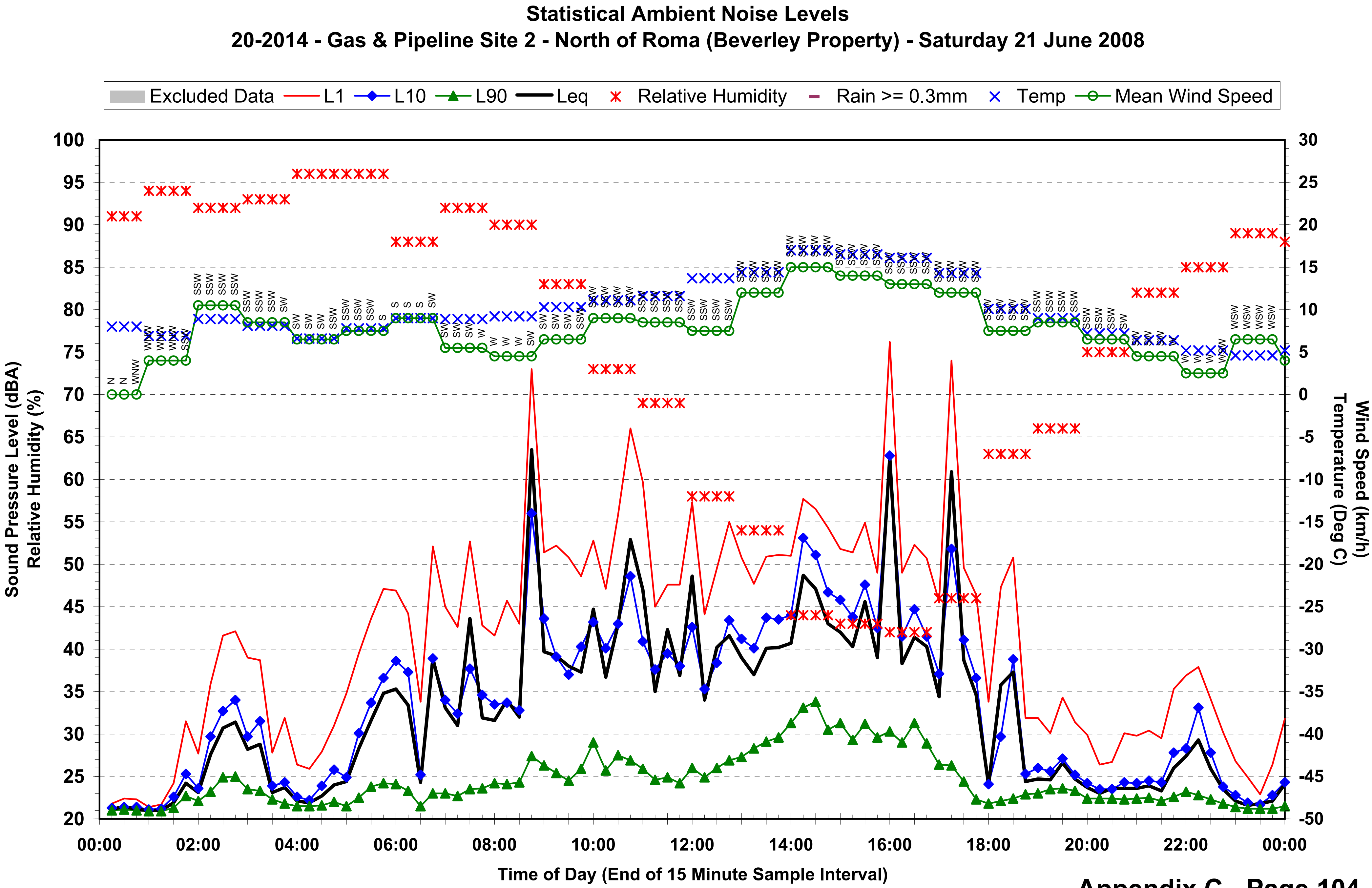
Statistical Ambient Noise Levels
20-2014 - Gas & Pipeline Site 2 - North of Roma (Beverley Property) - Thursday 19 June 2008



Statistical Ambient Noise Levels

20-2014 - Gas & Pipeline Site 2 - North of Roma (Beverley Property) - Friday 20 June 2008





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Ambient Conditions

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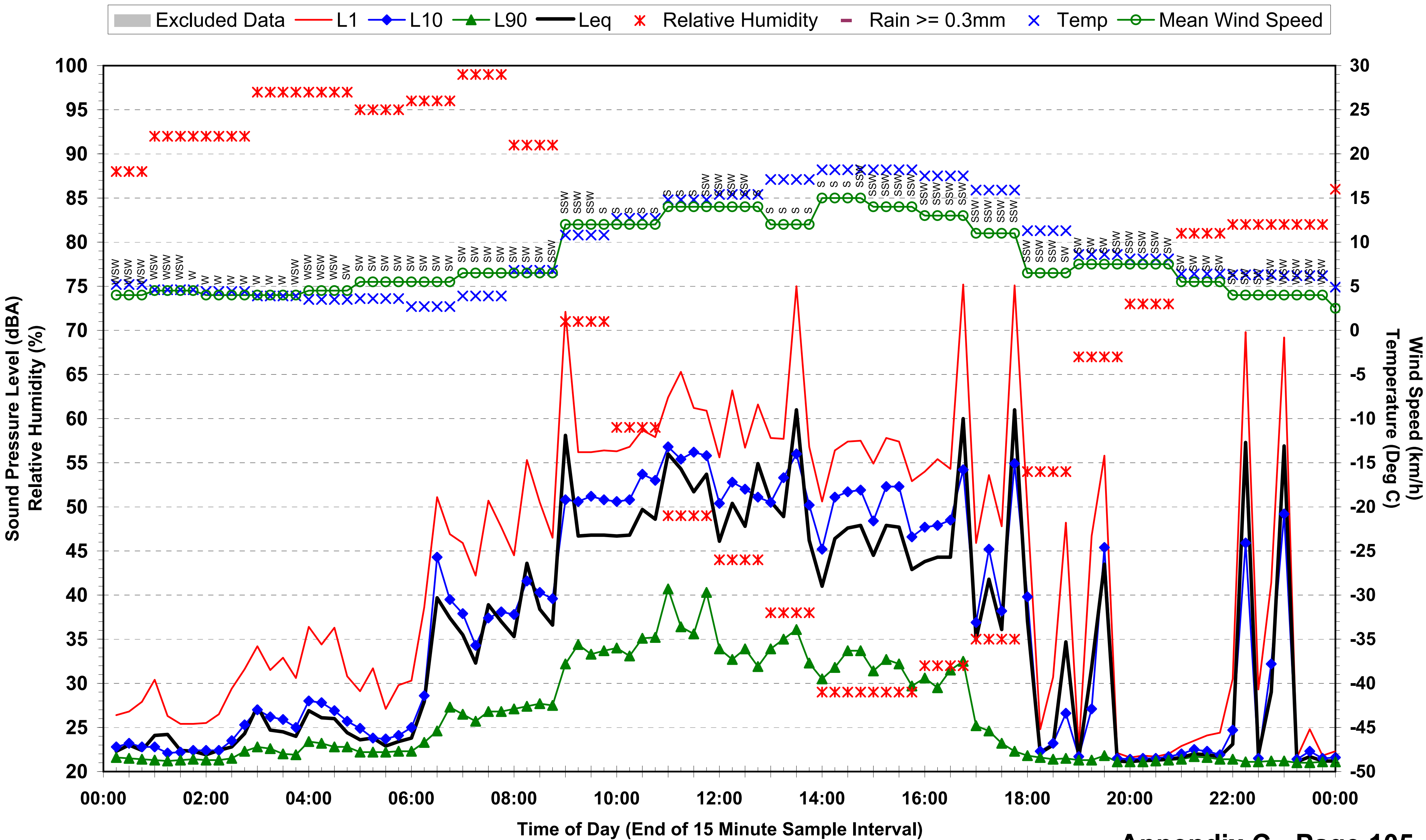
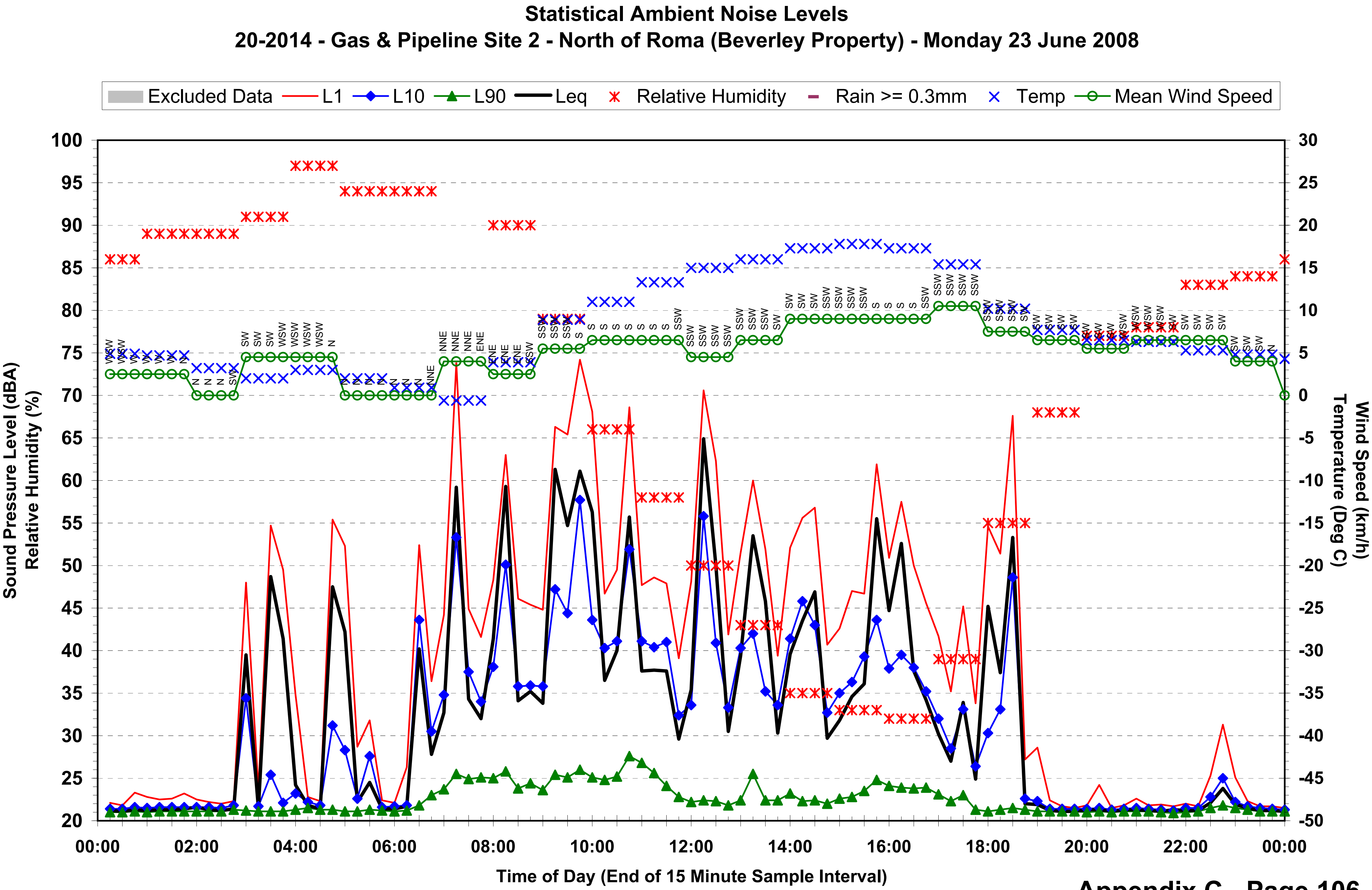
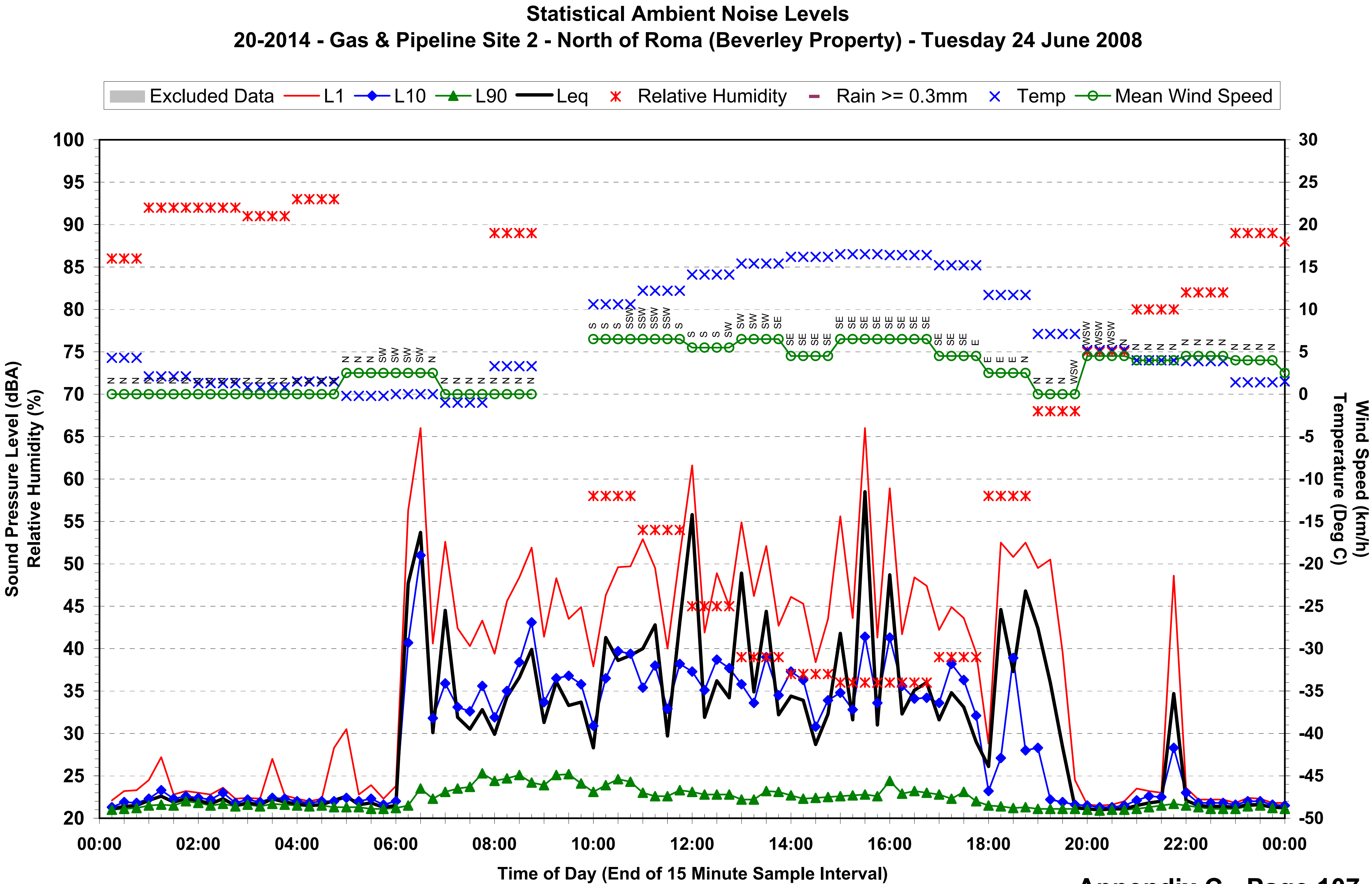
Statistical Ambient Noise Levels
20-2014 - Gas & Pipeline Site 2 - North of Roma (Beverley Property) - Sunday 22 June 2008




Statistical Ambient Noise Levels
20-2014 - Gas & Pipeline Site 2 - North of Roma (Beverley Property) - Monday 23 June 2008
Excluded Data
L1
L10
L90
Leq
Relative Humidity
Rain >= 0.3mm
Temp
Mean Wind Speed
Sound Pressure Level (dBA)
Relative Humidity (%)
Wind Speed (km/h)
Temperature (Deg C)
Time of Day (End of 15 Minute Sample Interval)



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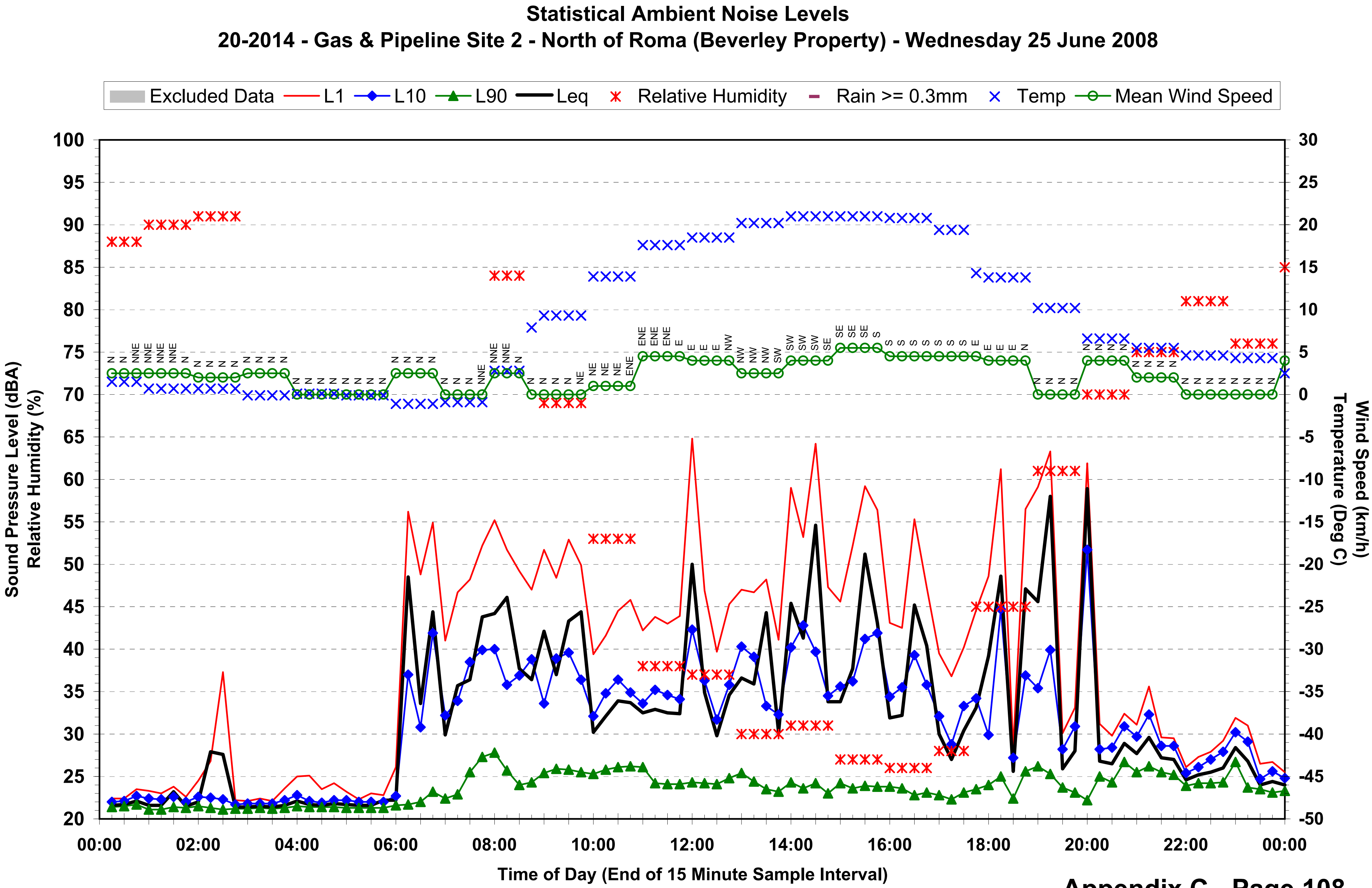

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Ambient Conditions

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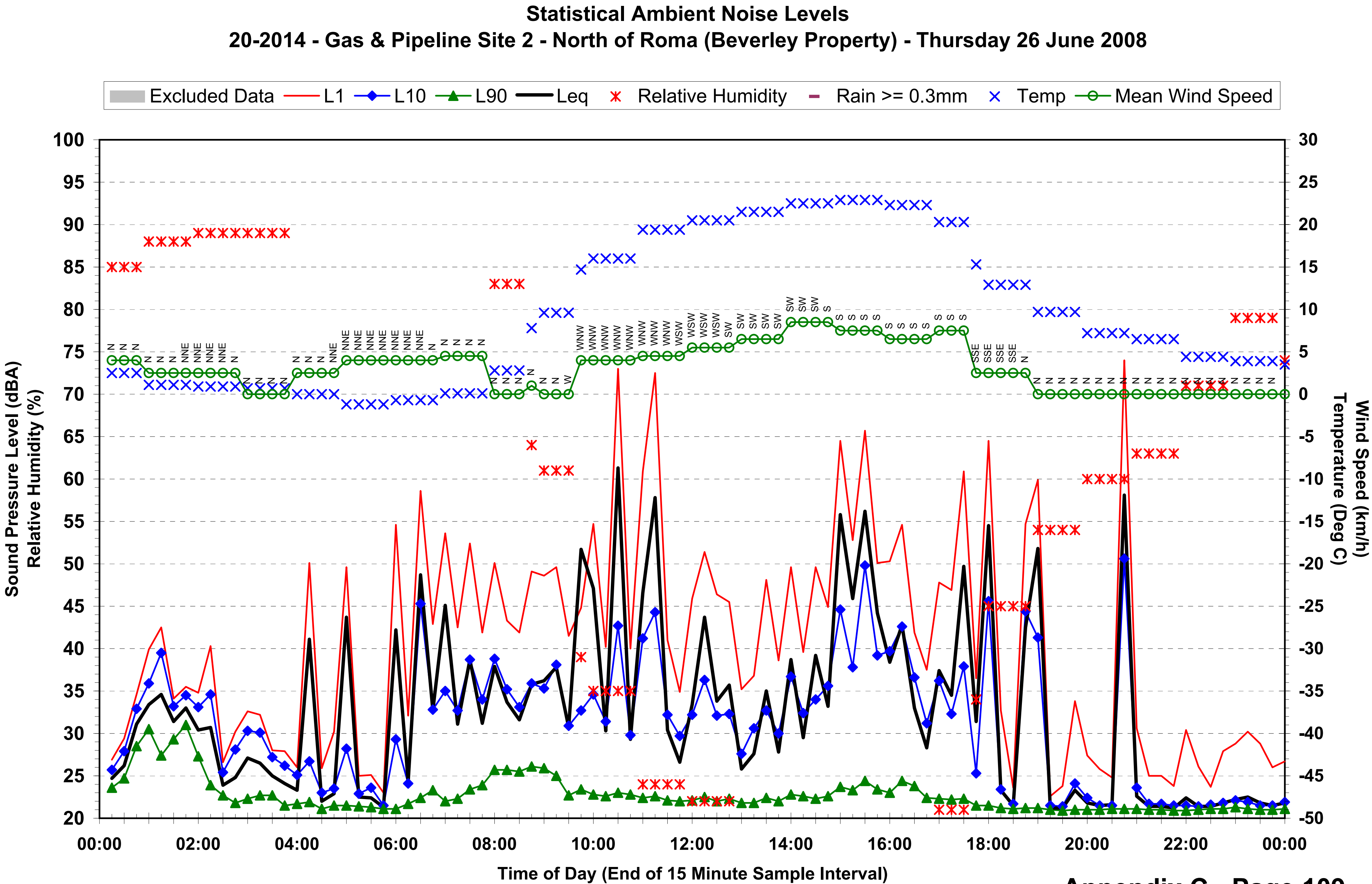
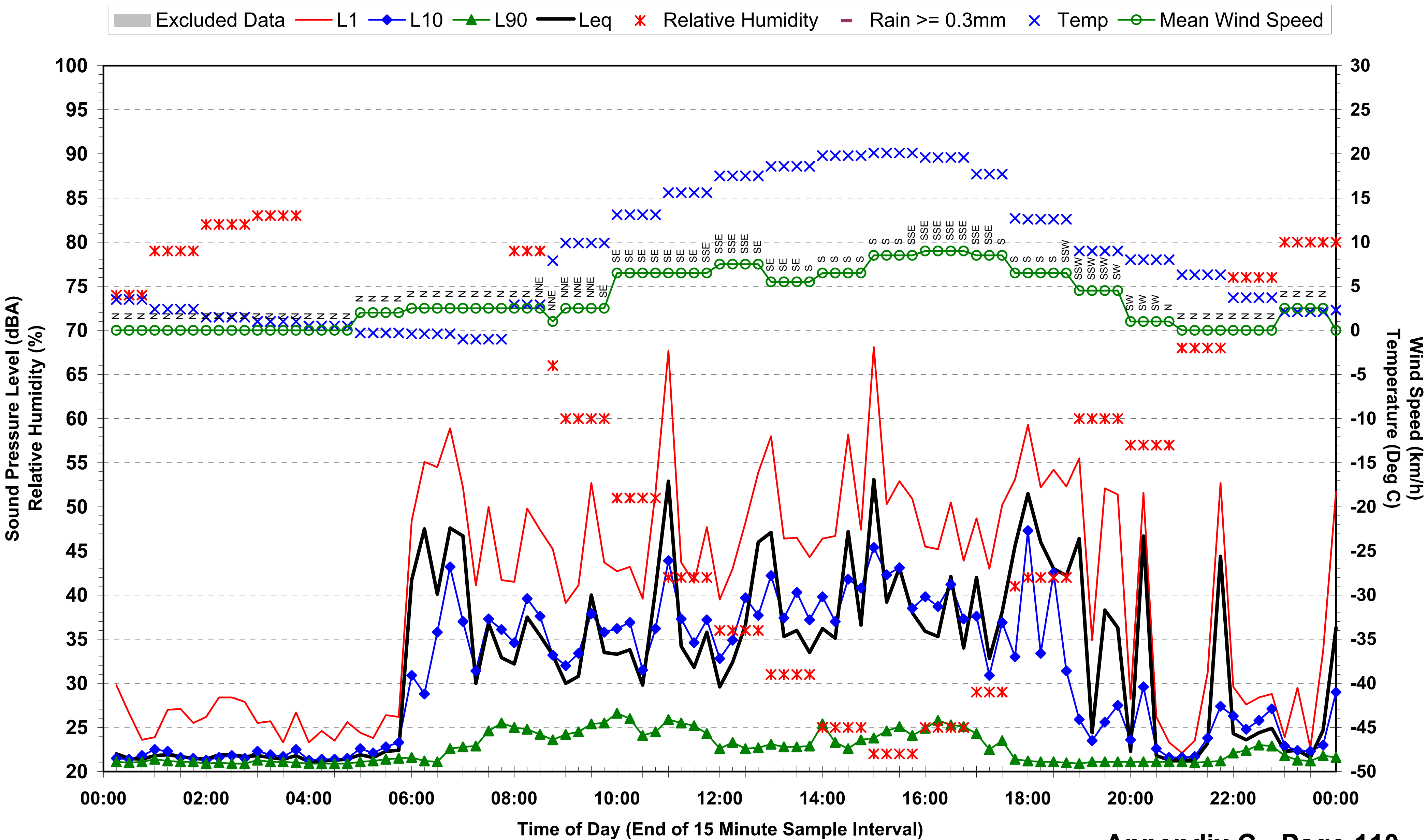
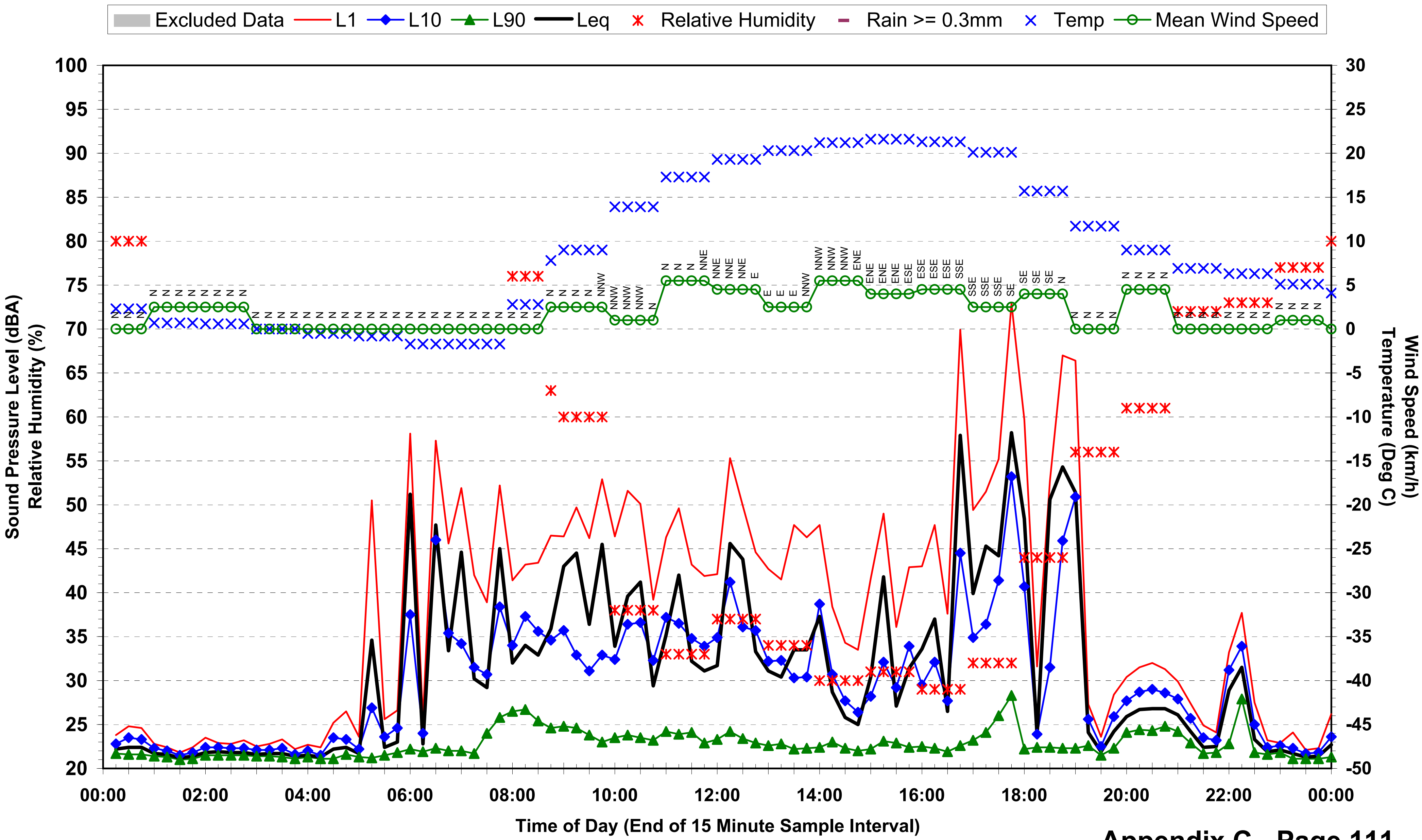

Statistical Ambient Noise Levels
20-2014 - Gas & Pipeline Site 2 - North of Roma (Beverley Property) - Thursday 26 June 2008
Excluded Data
L1
L10
L90
Leq
Relative Humidity
Rain >= 0.3mm
Temp
Mean Wind Speed
Sound Pressure Level (dBA)
Relative Humidity (%)
Wind Speed (km/h)
Temperature (Deg C)
Time of Day (End of 15 Minute Sample Interval)
00:00
02:00
04:00
06:00
08:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
00:00

Statistical Ambient Noise Levels

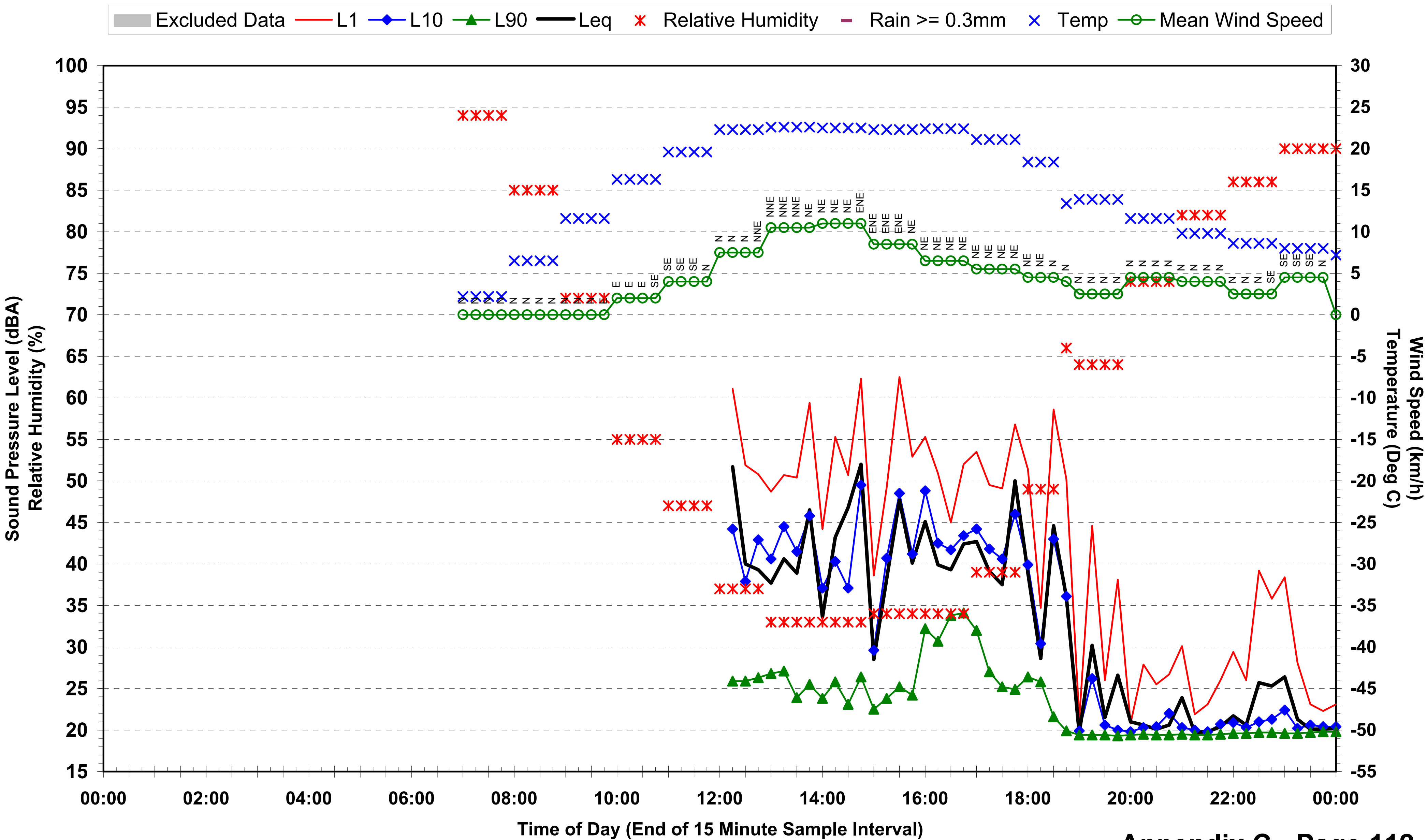
20-2014 - Gas & Pipeline Site 2 - North of Roma (Beverley Property) - Friday 27 June 2008



Statistical Ambient Noise Levels
20-2014 - Gas & Pipeline Site 2 - North of Roma (Beverley Property) - Saturday 28 June 2008



Statistical Ambient Noise Levels
20-2014 - Gas & Pipeline Site 3 - Fairview Rd - Tuesday 17 June 2008



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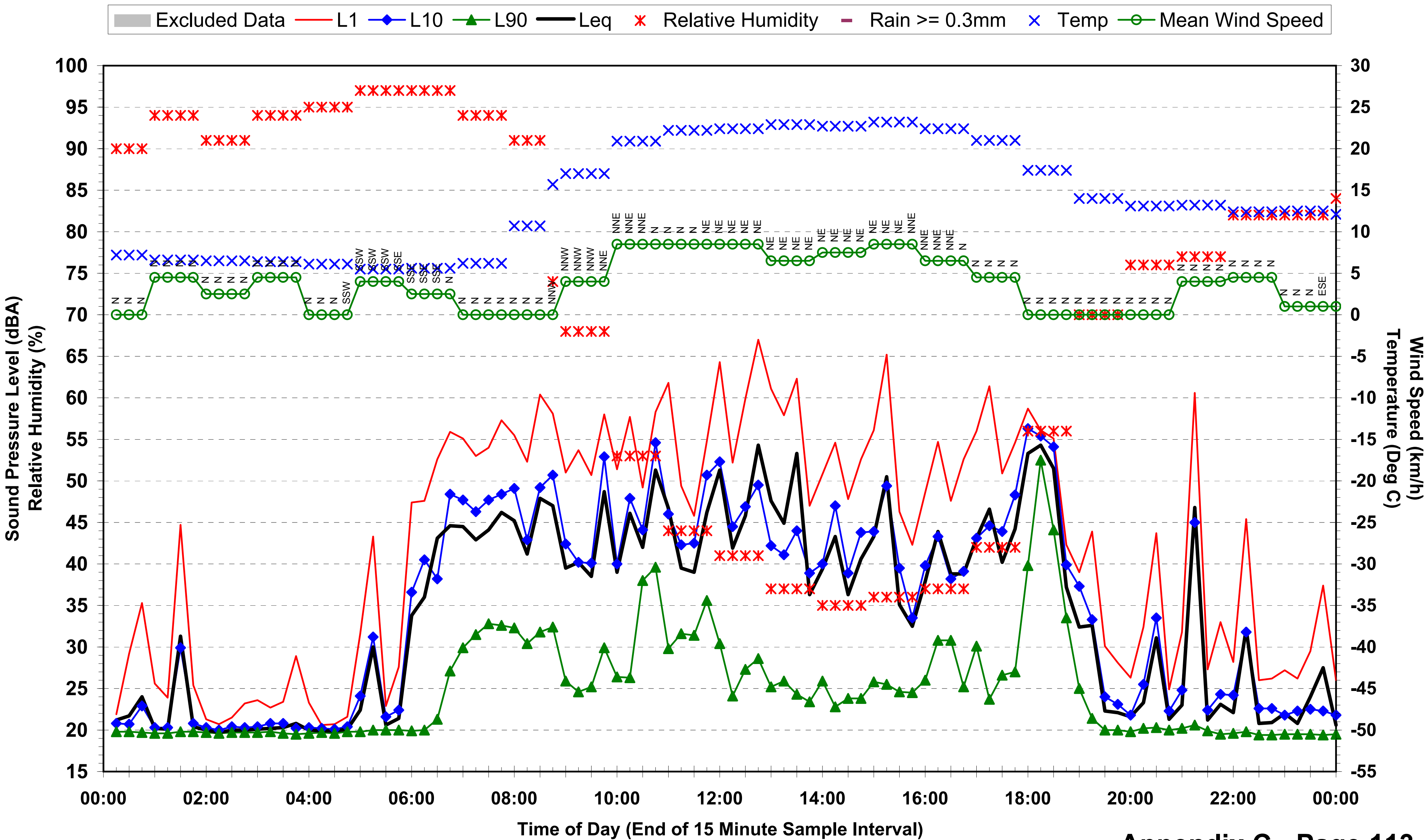
Statistical Ambient Noise Levels
20-2014 - Gas & Pipeline Site 3 - Fairview Rd - Wednesday 18 June 2008



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Ambient Conditions

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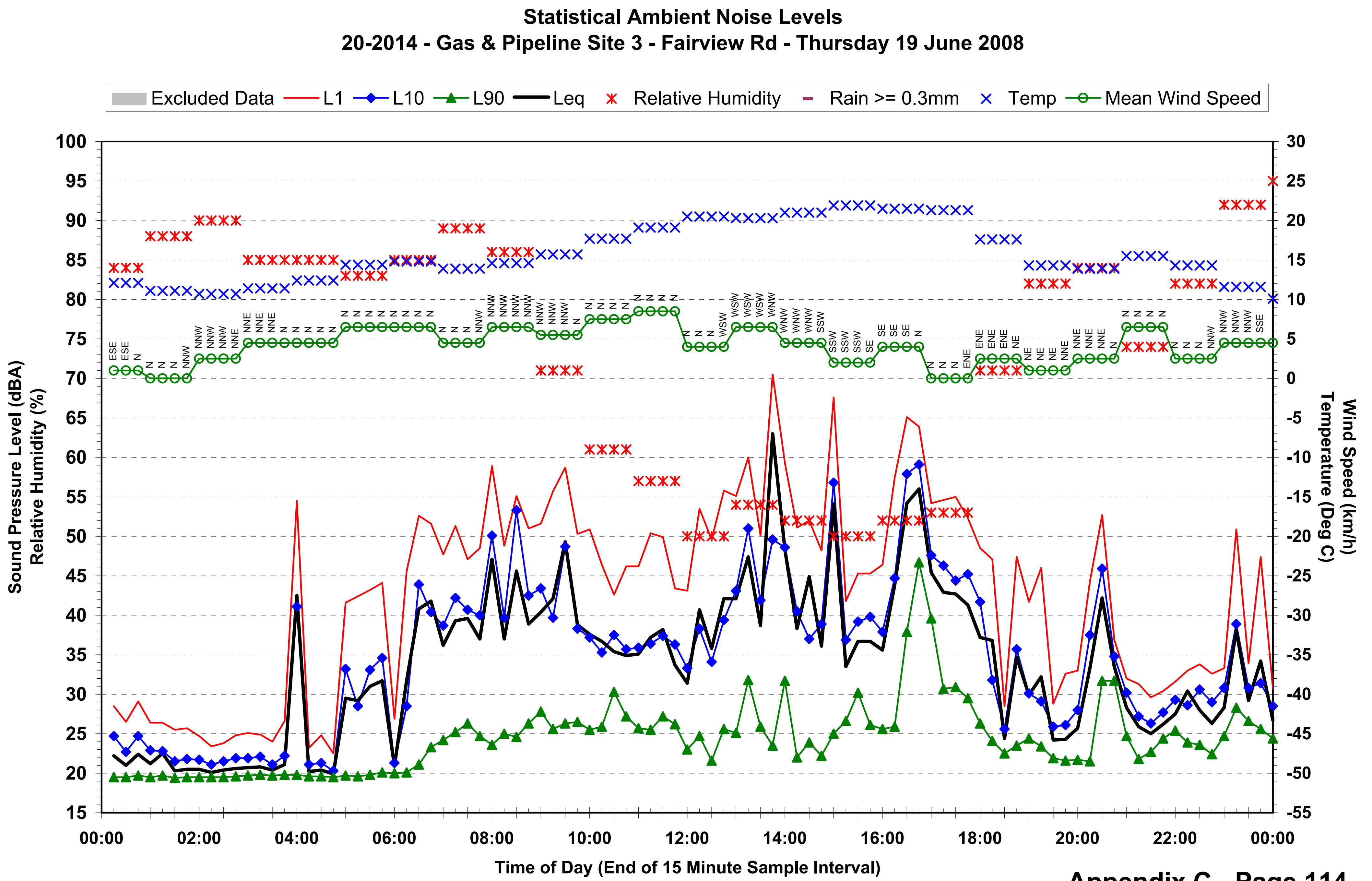
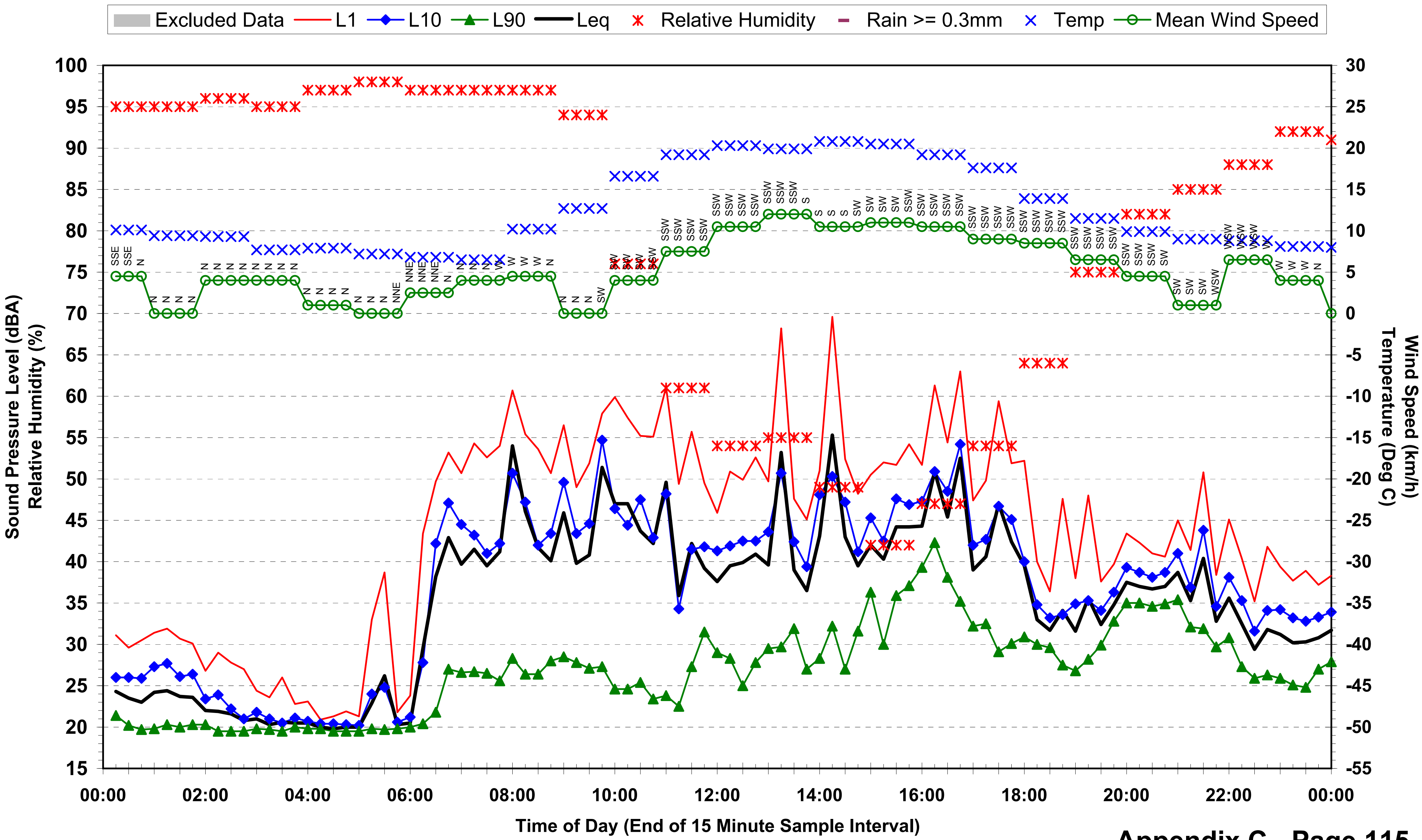
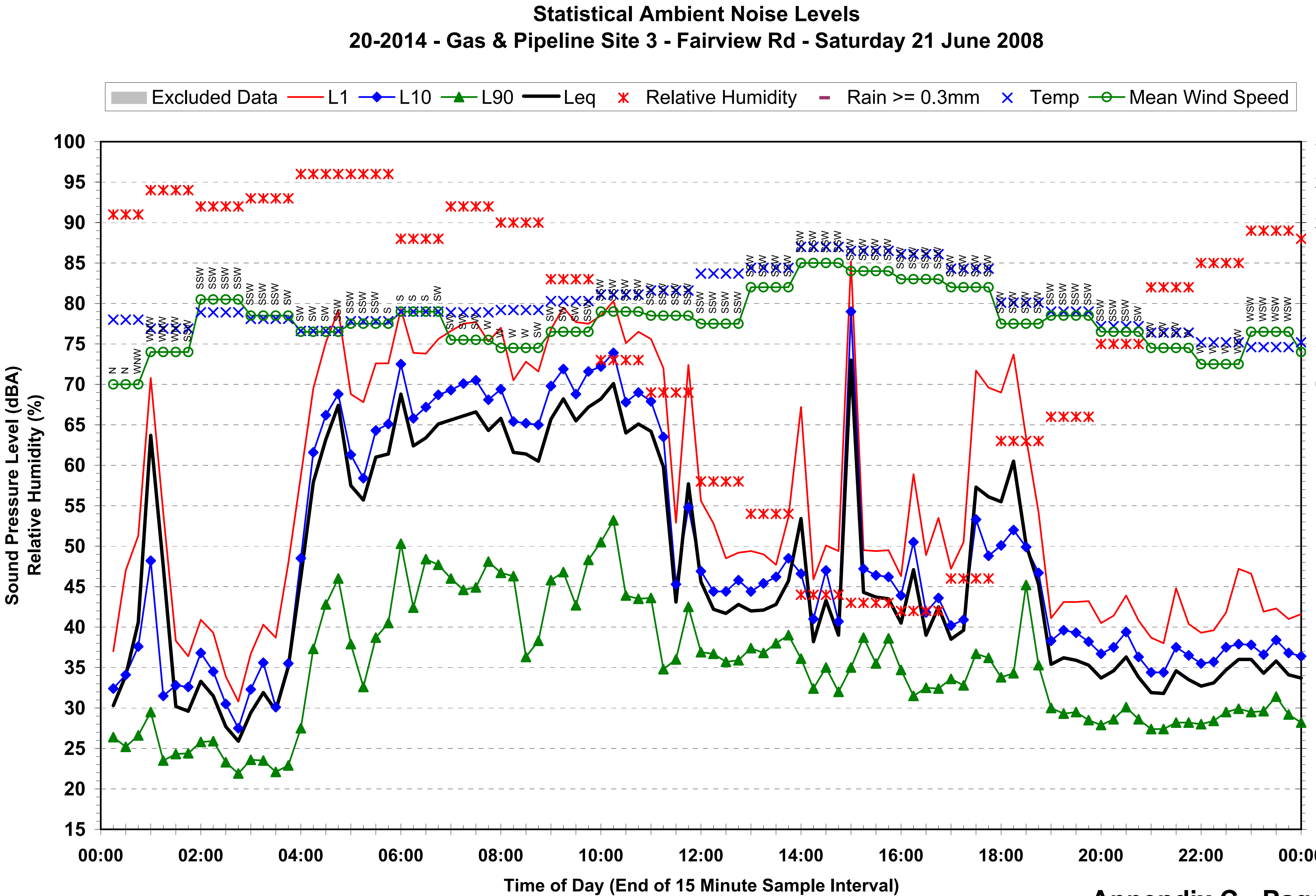

Statistical Ambient Noise Levels
20-2014 - Gas & Pipeline Site 3 - Fairview Rd - Thursday 19 June 2008
Excluded Data
L1
L10
L90
Leq
Relative Humidity
Rain >= 0.3mm
Temp
Mean Wind Speed
Sound Pressure Level (dBA)
Relative Humidity (%)
Wind Speed (km/h)
Temperature (Deg C)
Time of Day (End of 15 Minute Sample Interval)

Statistical Ambient Noise Levels
20-2014 - Gas & Pipeline Site 3 - Fairview Rd - Friday 20 June 2008





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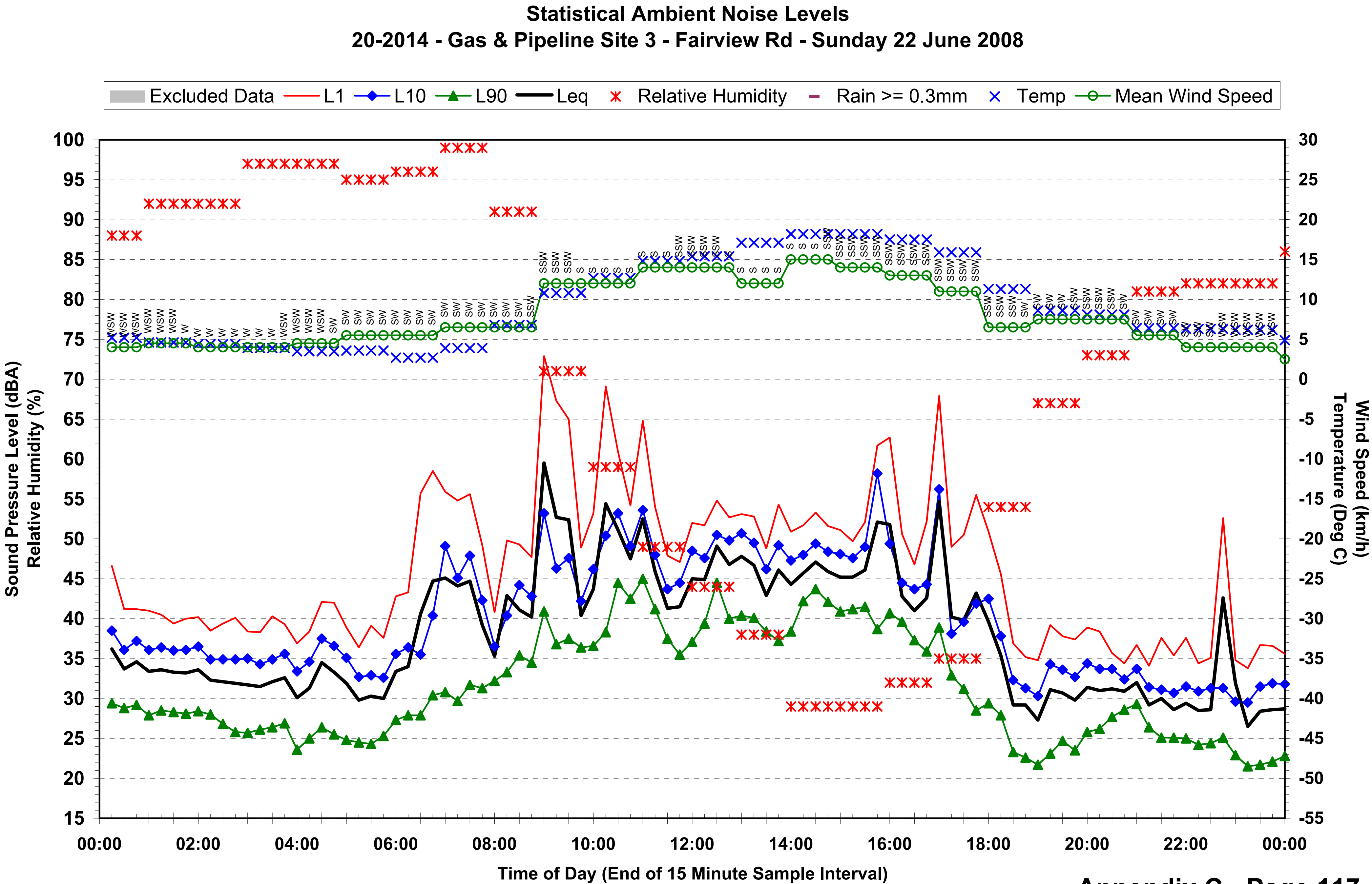
Ambient Conditions
RHA Report 20-2014



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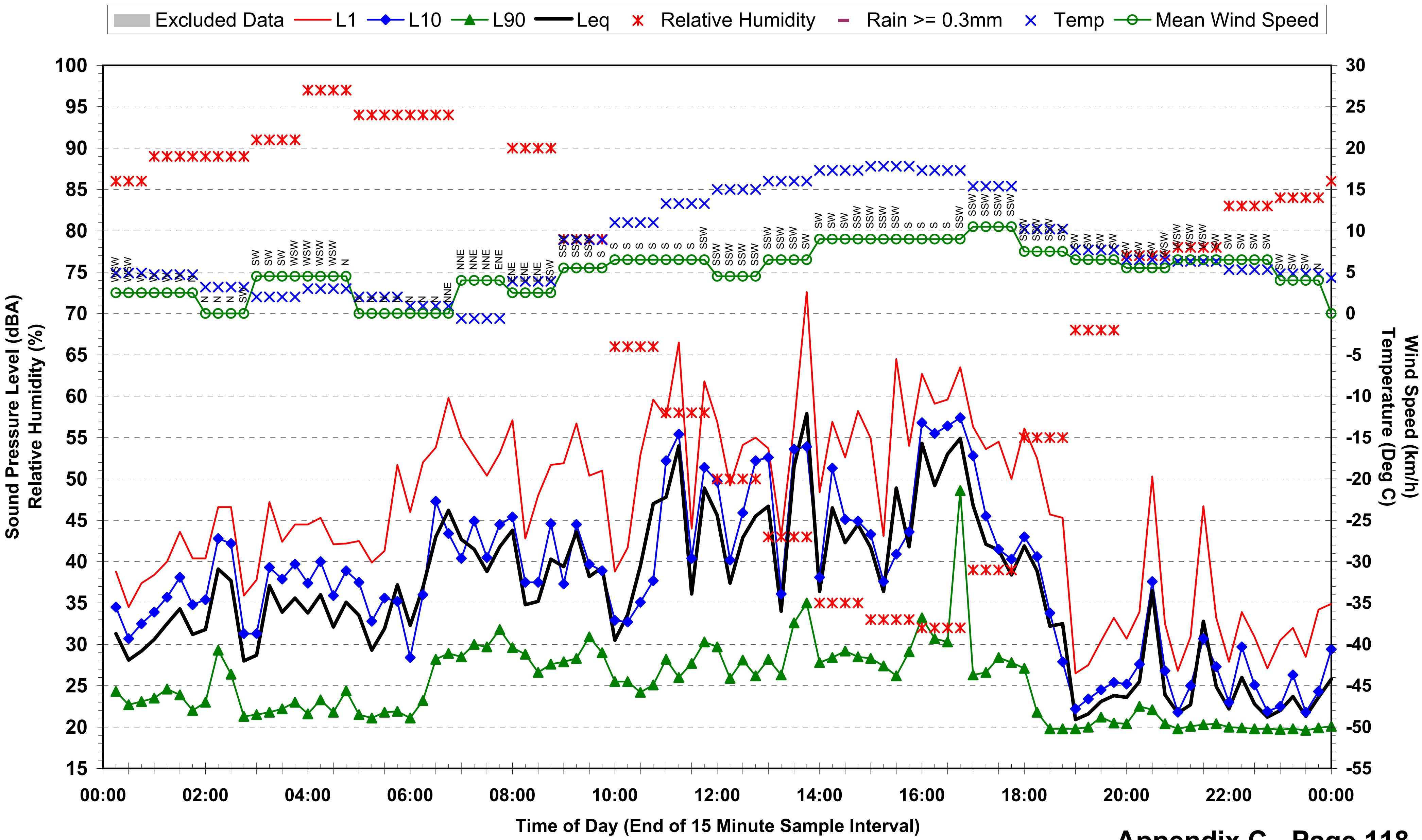
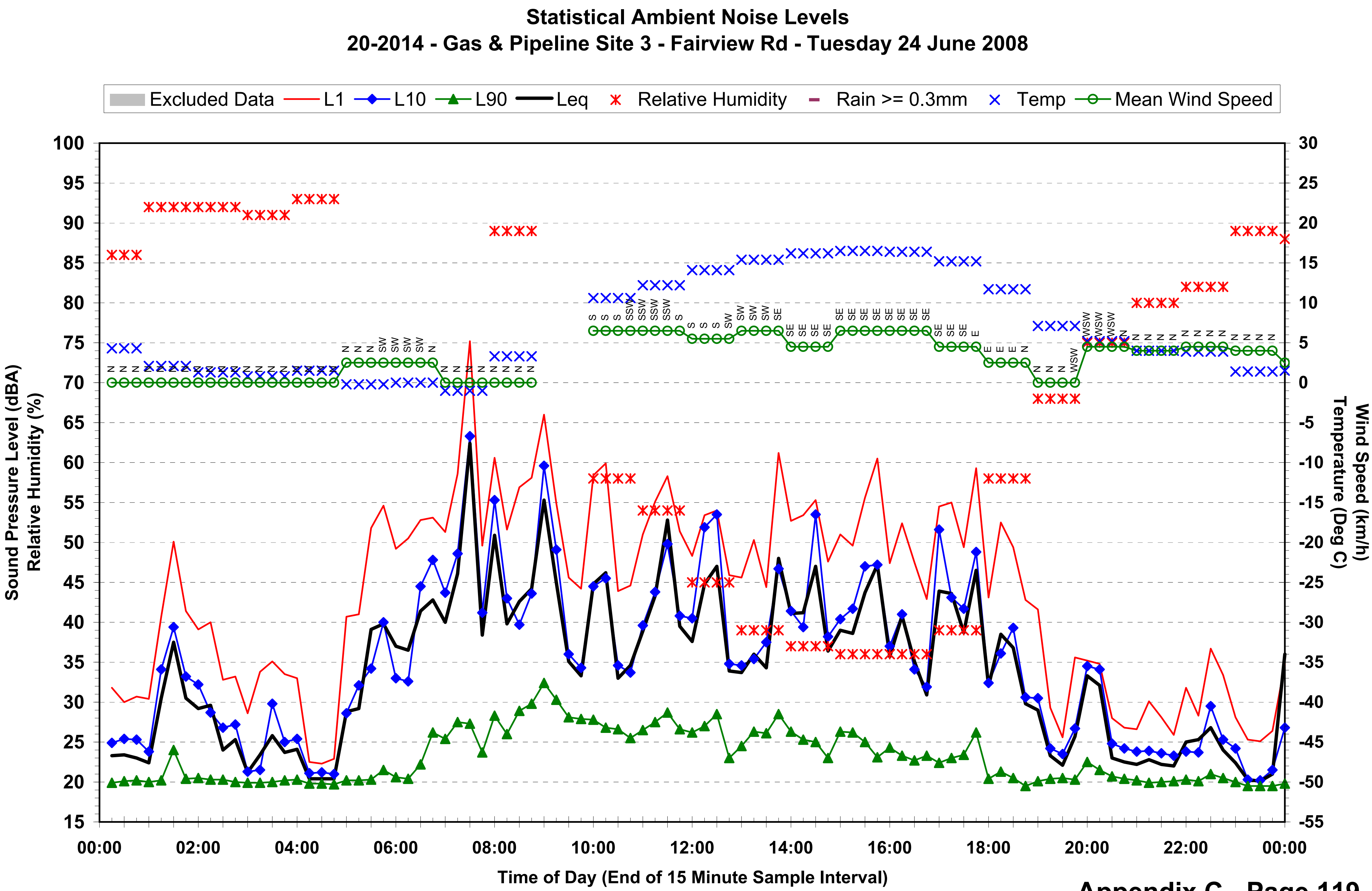
Ambient Conditions

RHA Report 20-2014

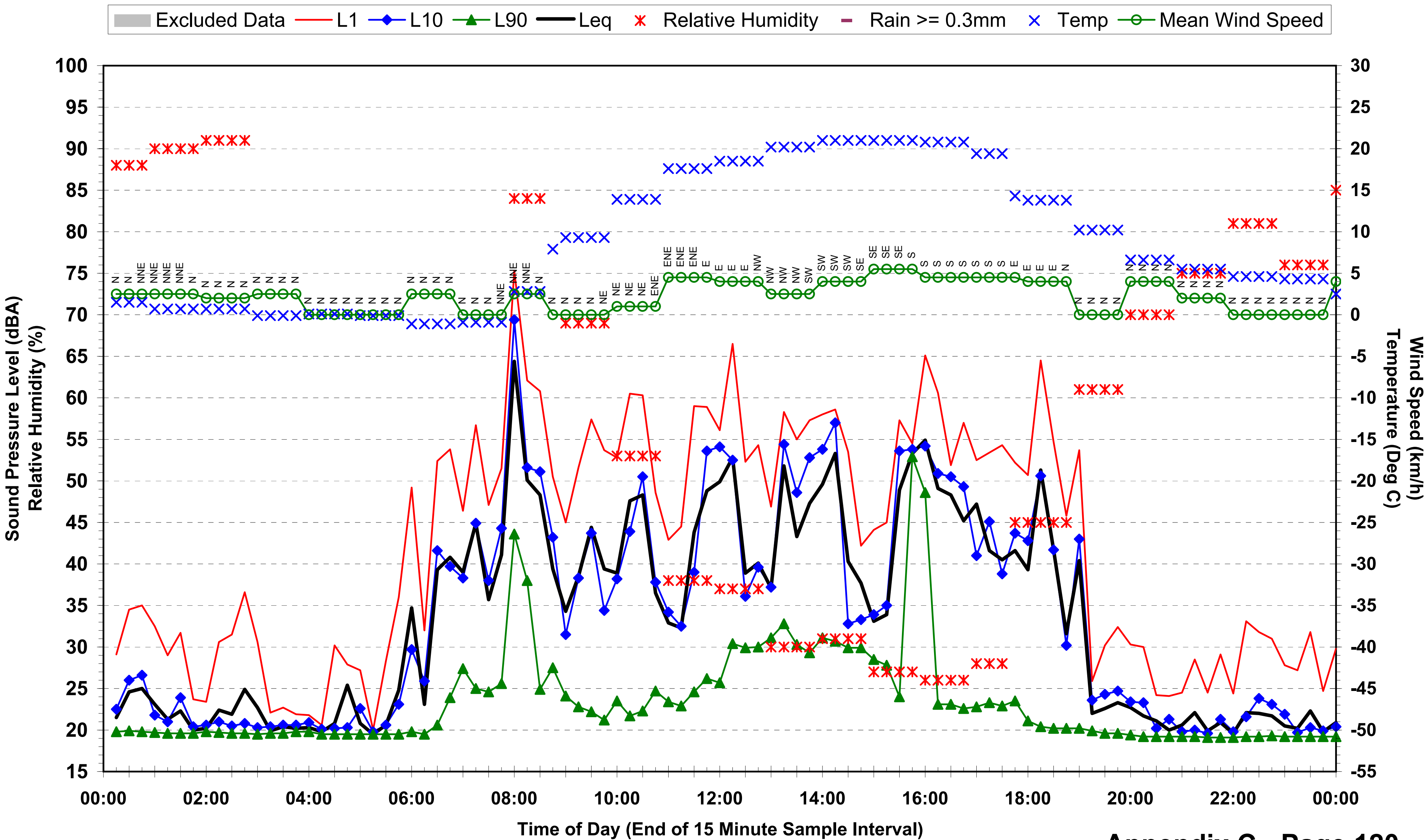
Statistical Ambient Noise Levels
20-2014 - Gas & Pipeline Site 3 - Fairview Rd - Monday 23 June 2008

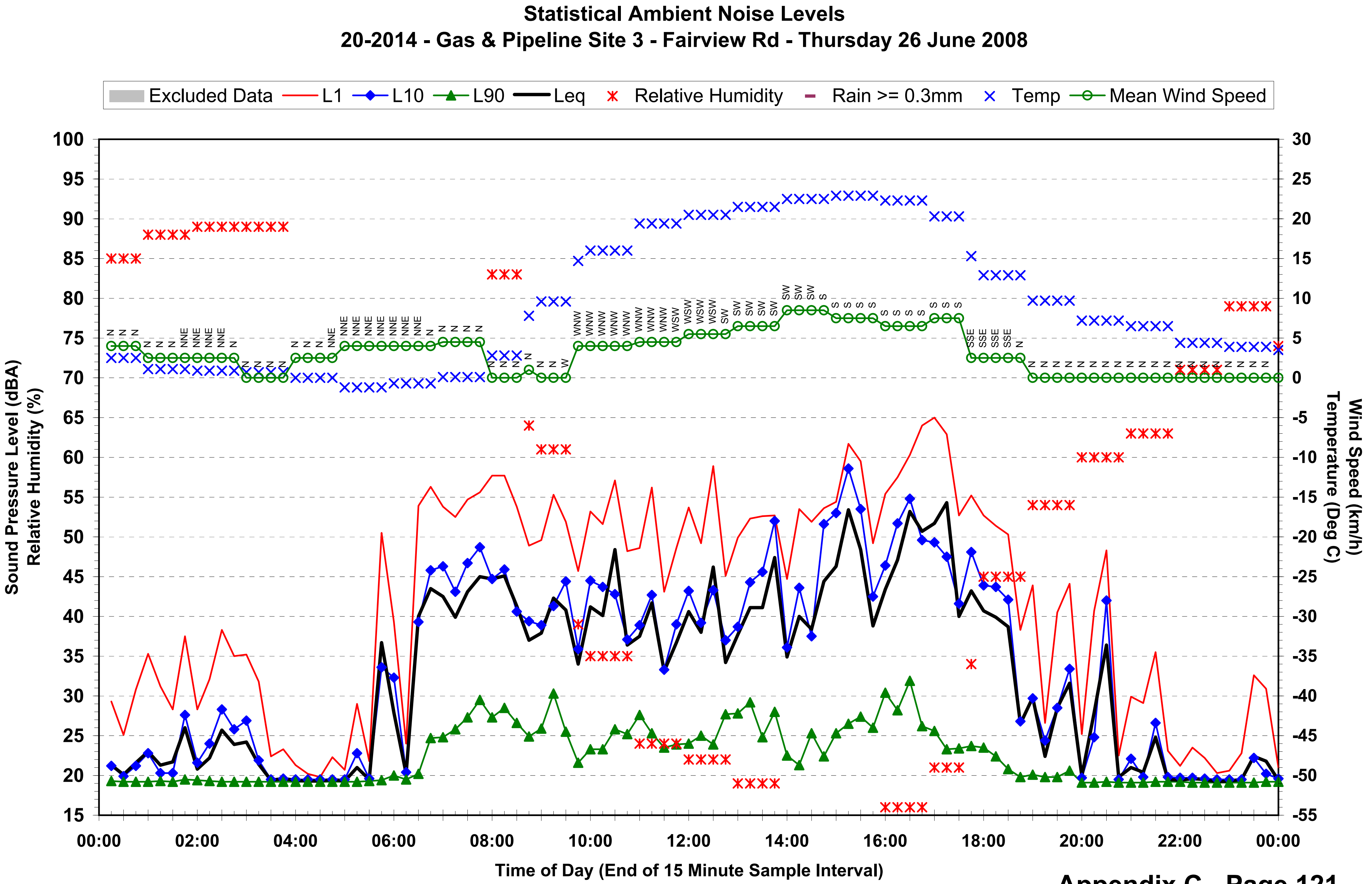




Ambient Conditions
RHA Report 20-2014

Statistical Ambient Noise Levels
20-2014 - Gas & Pipeline Site 3 - Fairview Rd - Wednesday 25 June 2008





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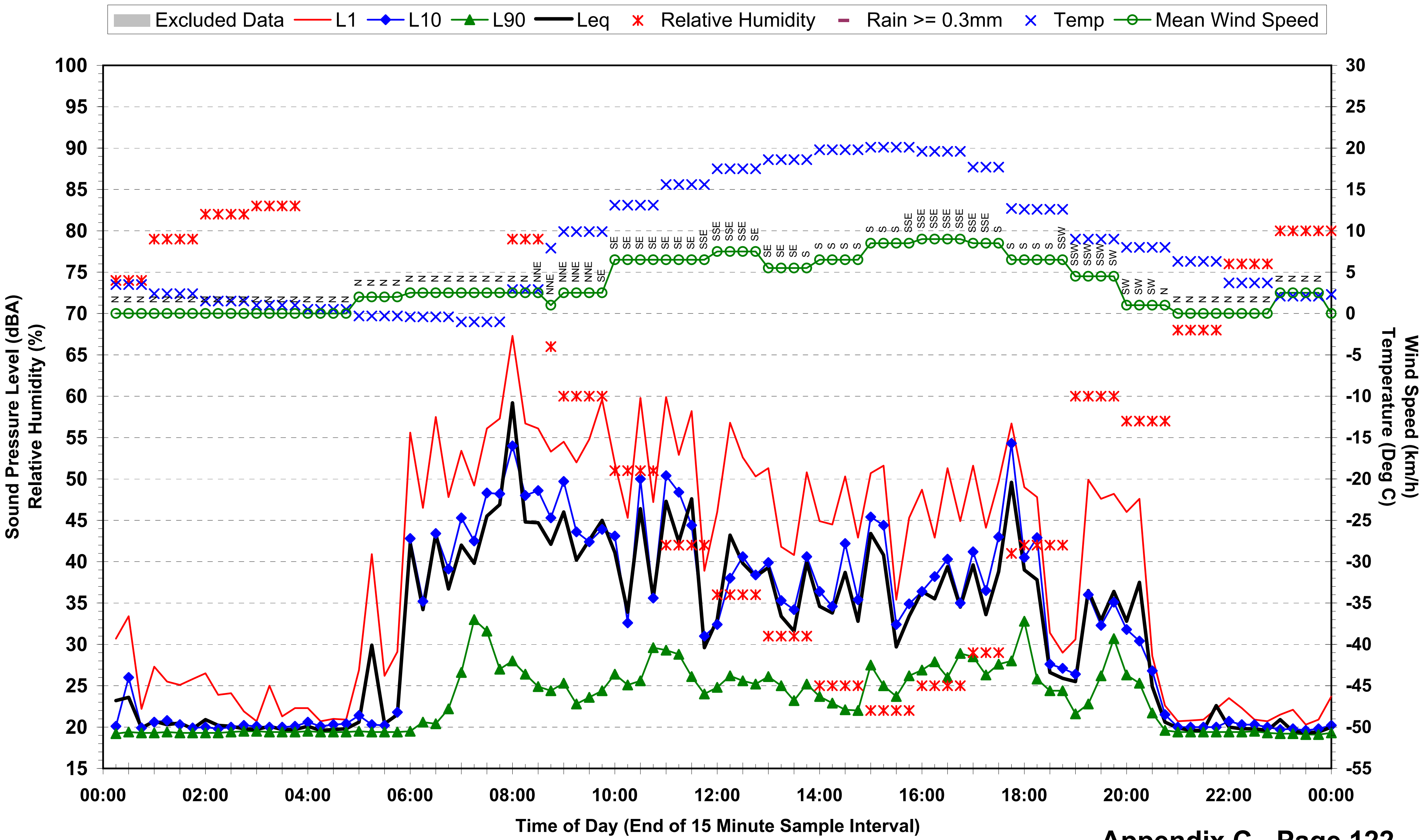
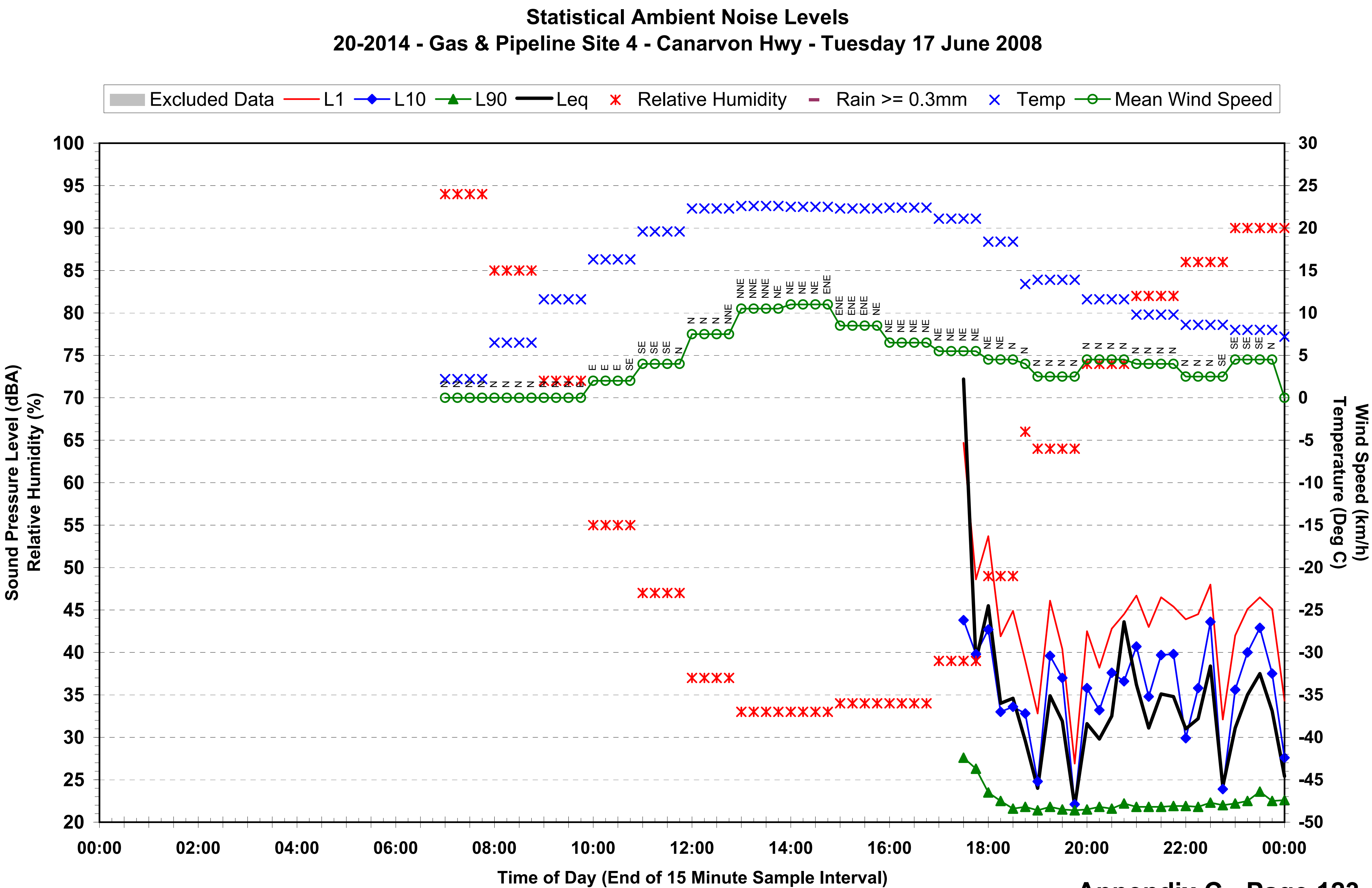
Ambient Conditions

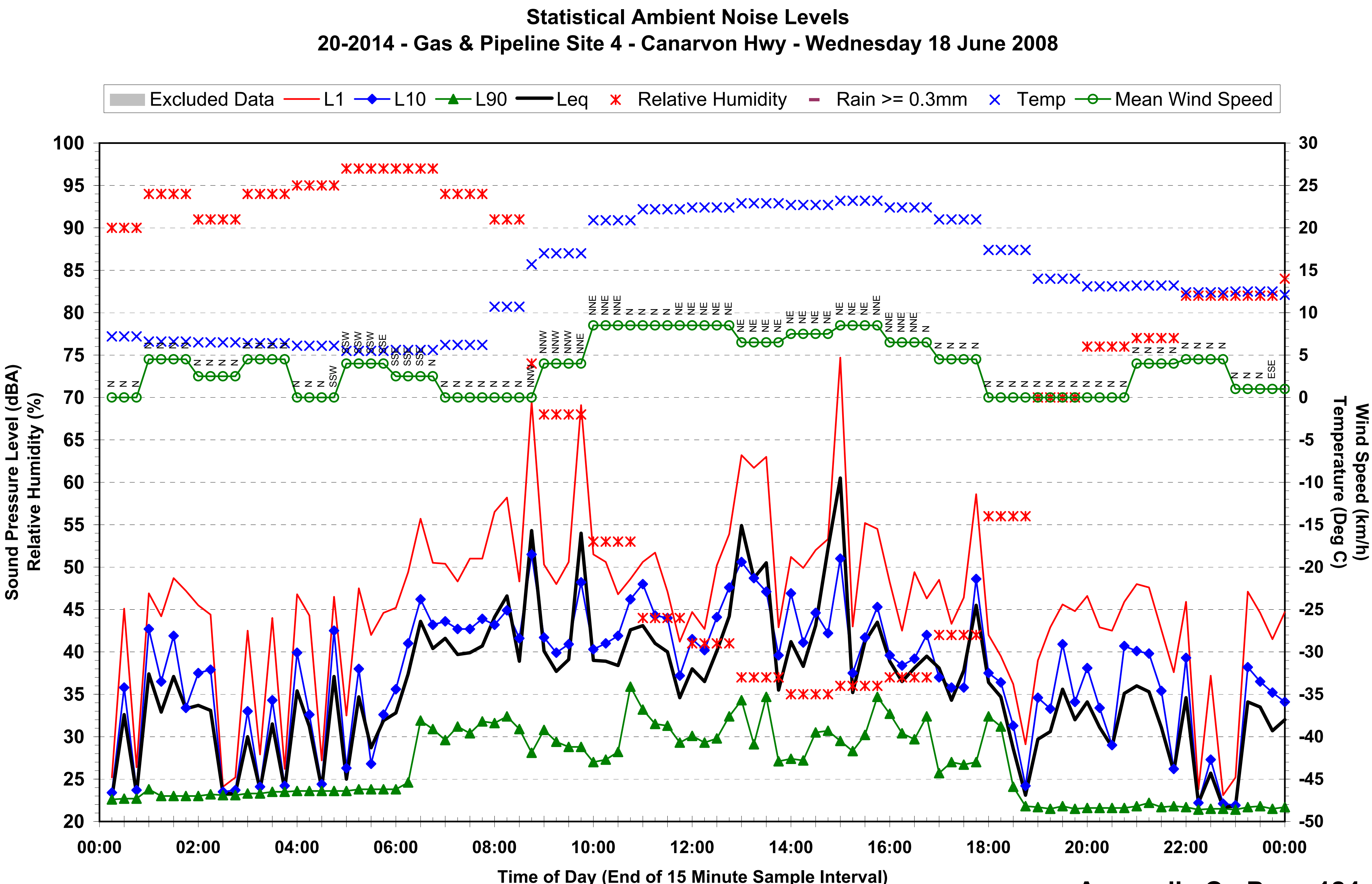
RHA Report 20-2014

Statistical Ambient Noise Levels
20-2014 - Gas & Pipeline Site 3 - Fairview Rd - Friday 27 June 2008





Statistical Ambient Noise Levels
20-2014 - Gas & Pipeline Site 4 - Canarvon Hwy - Tuesday 17 June 2008
Excluded Data
L1
L10
L90
Leq
Relative Humidity
Rain >= 0.3mm
Temp
Mean Wind Speed
Sound Pressure Level (dBA)
Relative Humidity (%)
Wind Speed (km/h)
Temperature (Deg C)
Time of Day (End of 15 Minute Sample Interval)



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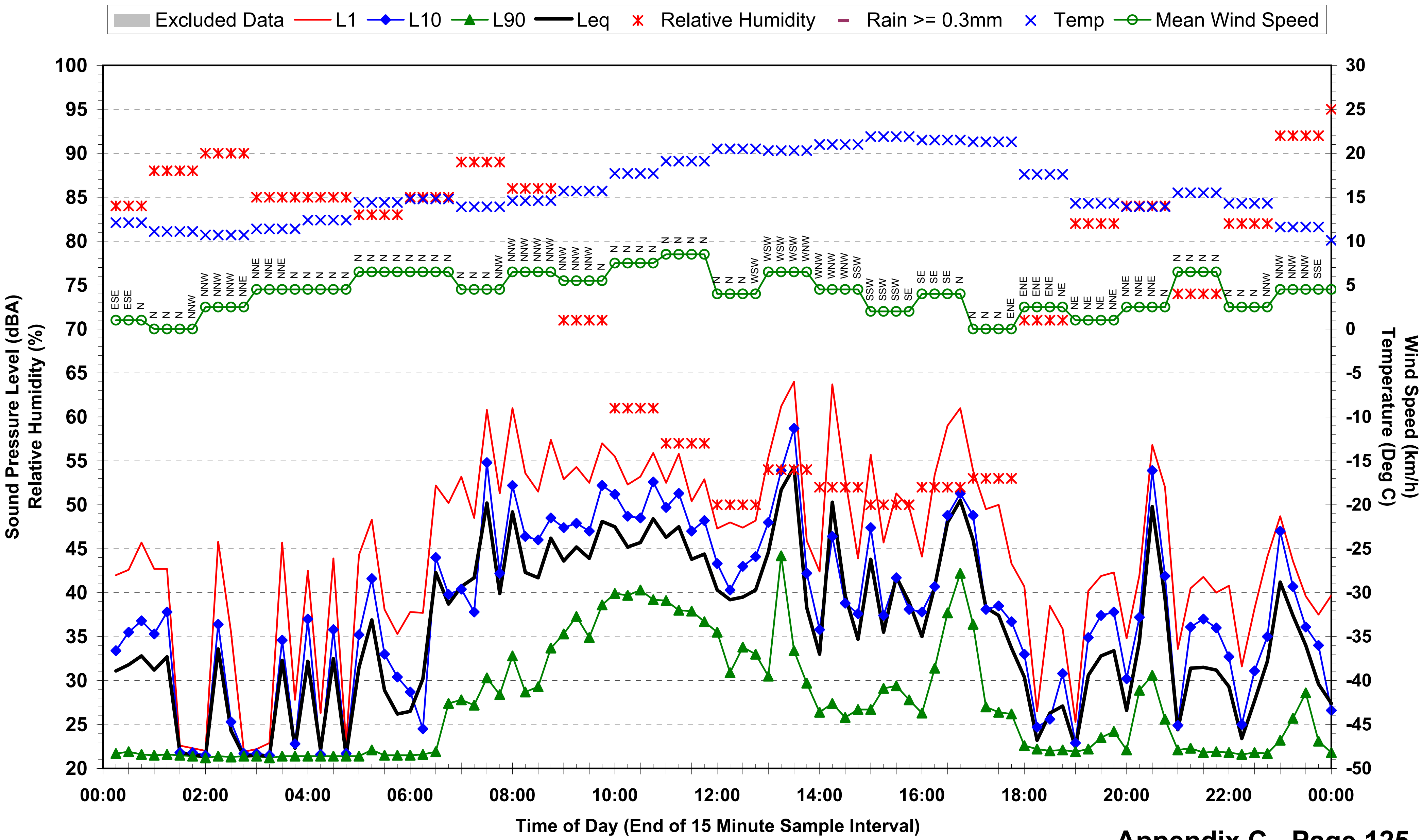
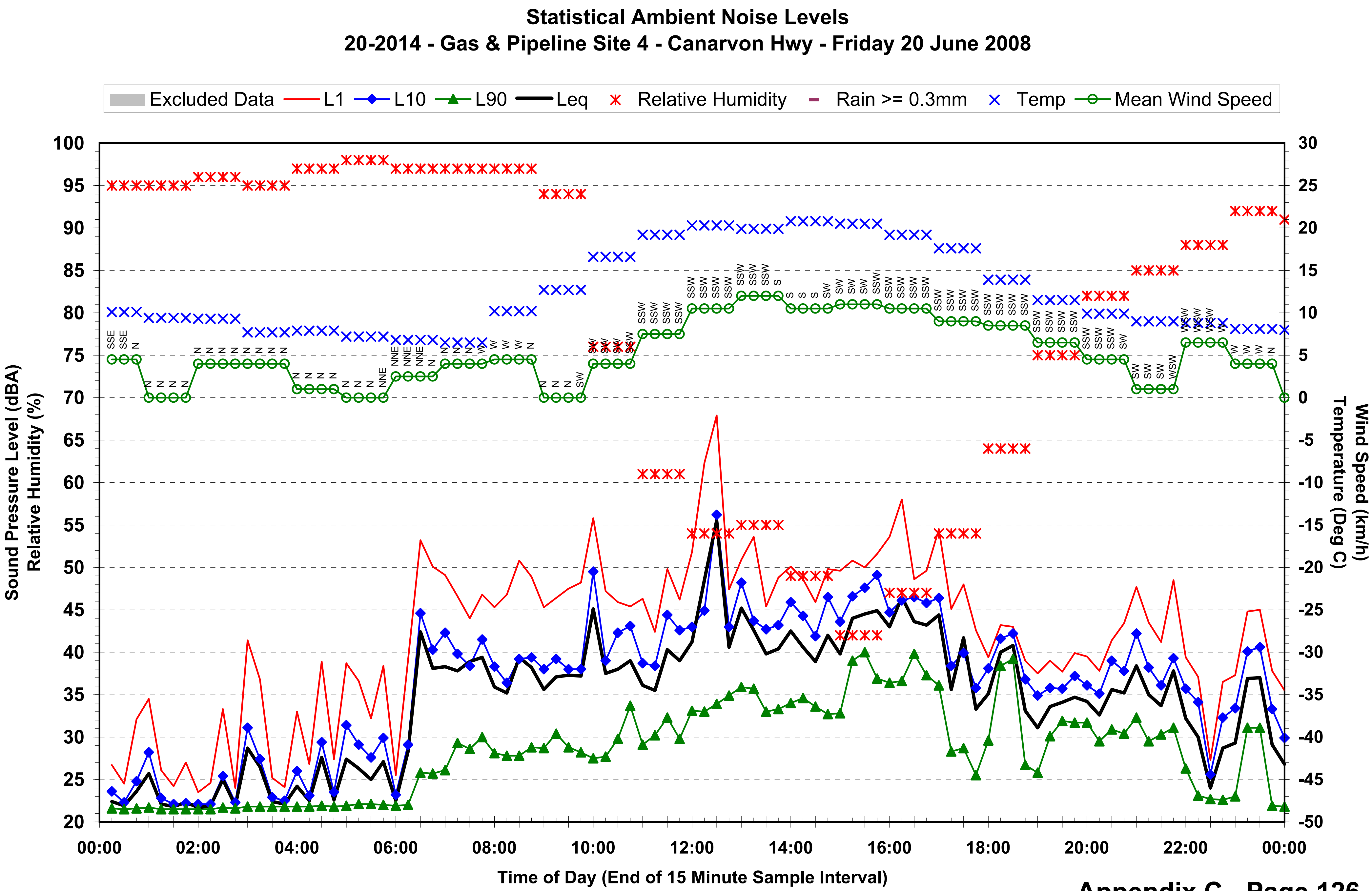
Ambient Conditions
RHA Report 20-2014

Statistical Ambient Noise Levels
20-2014 - Gas & Pipeline Site 4 - Canarvon Hwy - Thursday 19 June 2008





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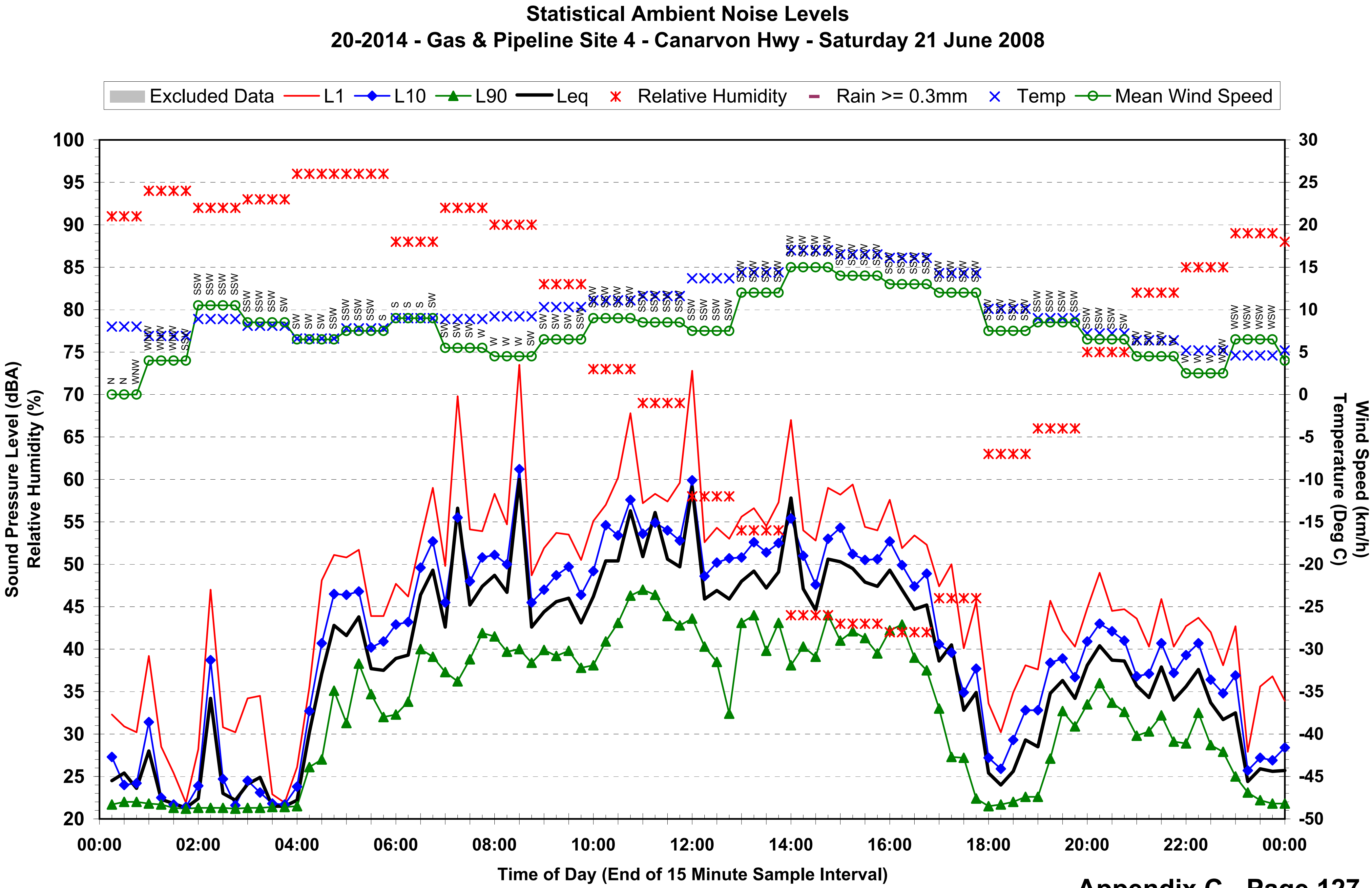
Ambient Conditions
RHA Report 20-2014



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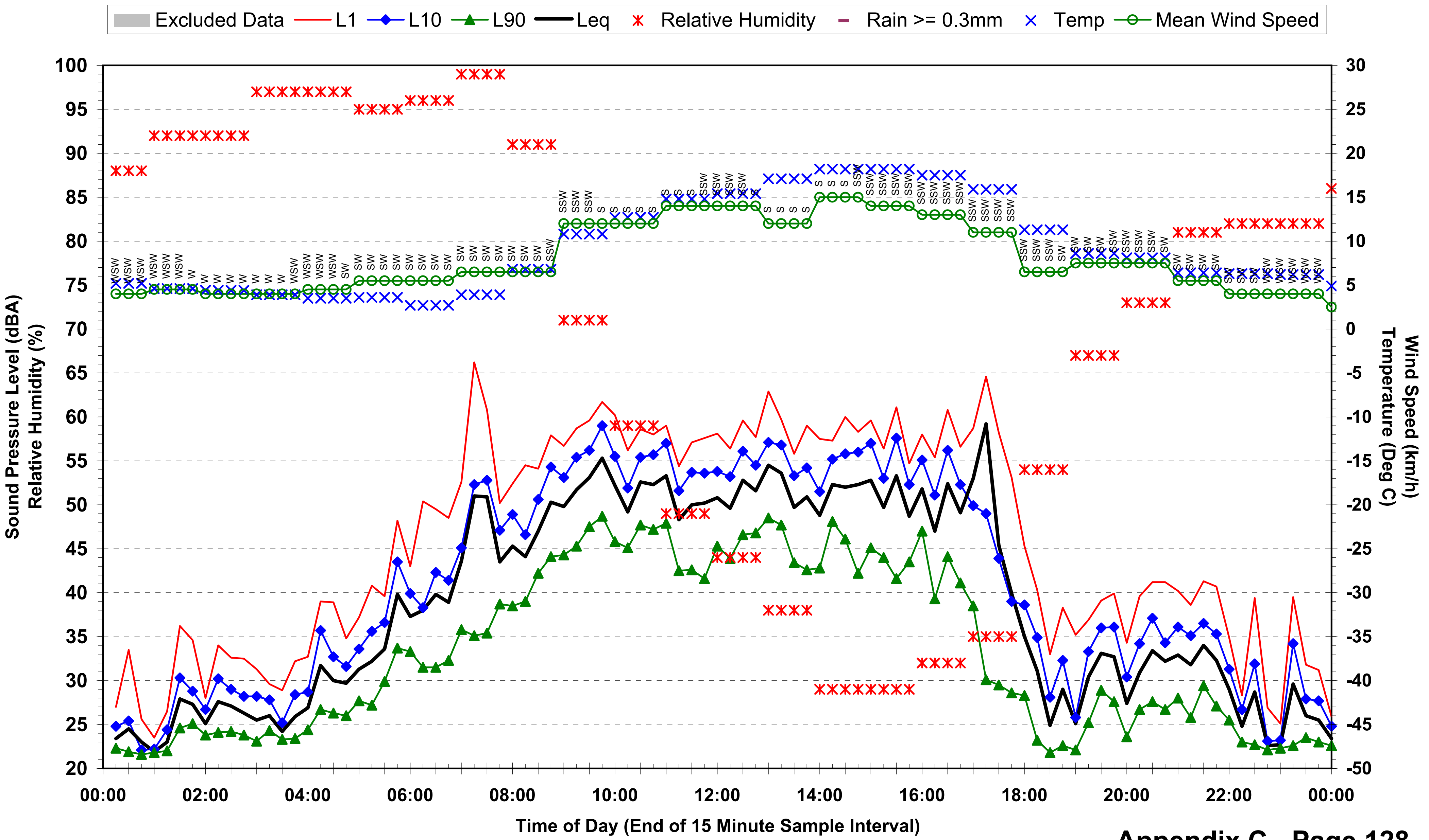
Ambient Conditions

RHA Report 20-2014

Statistical Ambient Noise Levels
20-2014 - Gas & Pipeline Site 4 - Canarvon Hwy - Sunday 22 June 2008



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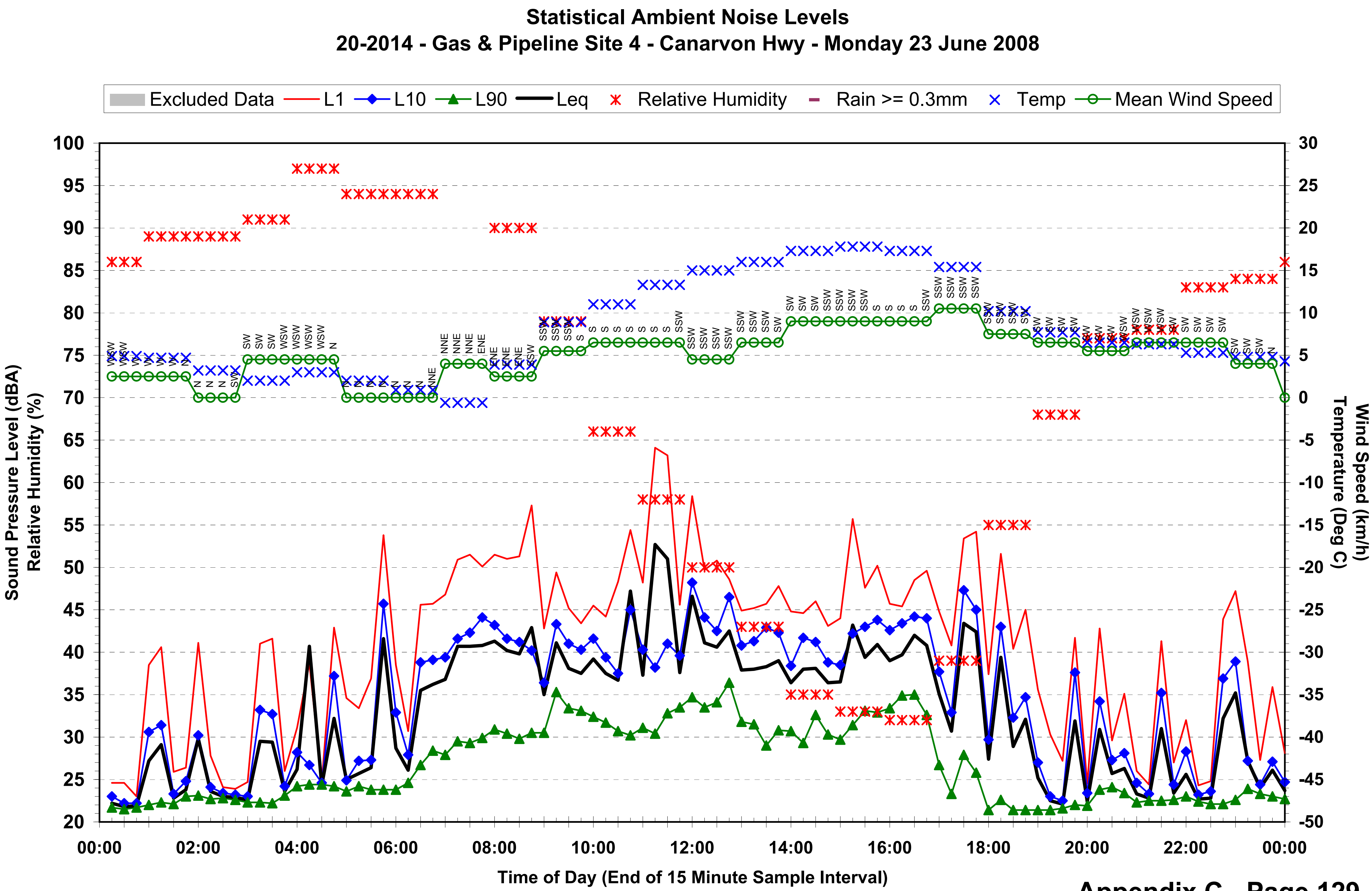
Ambient Conditions

RHA Report 20-2014



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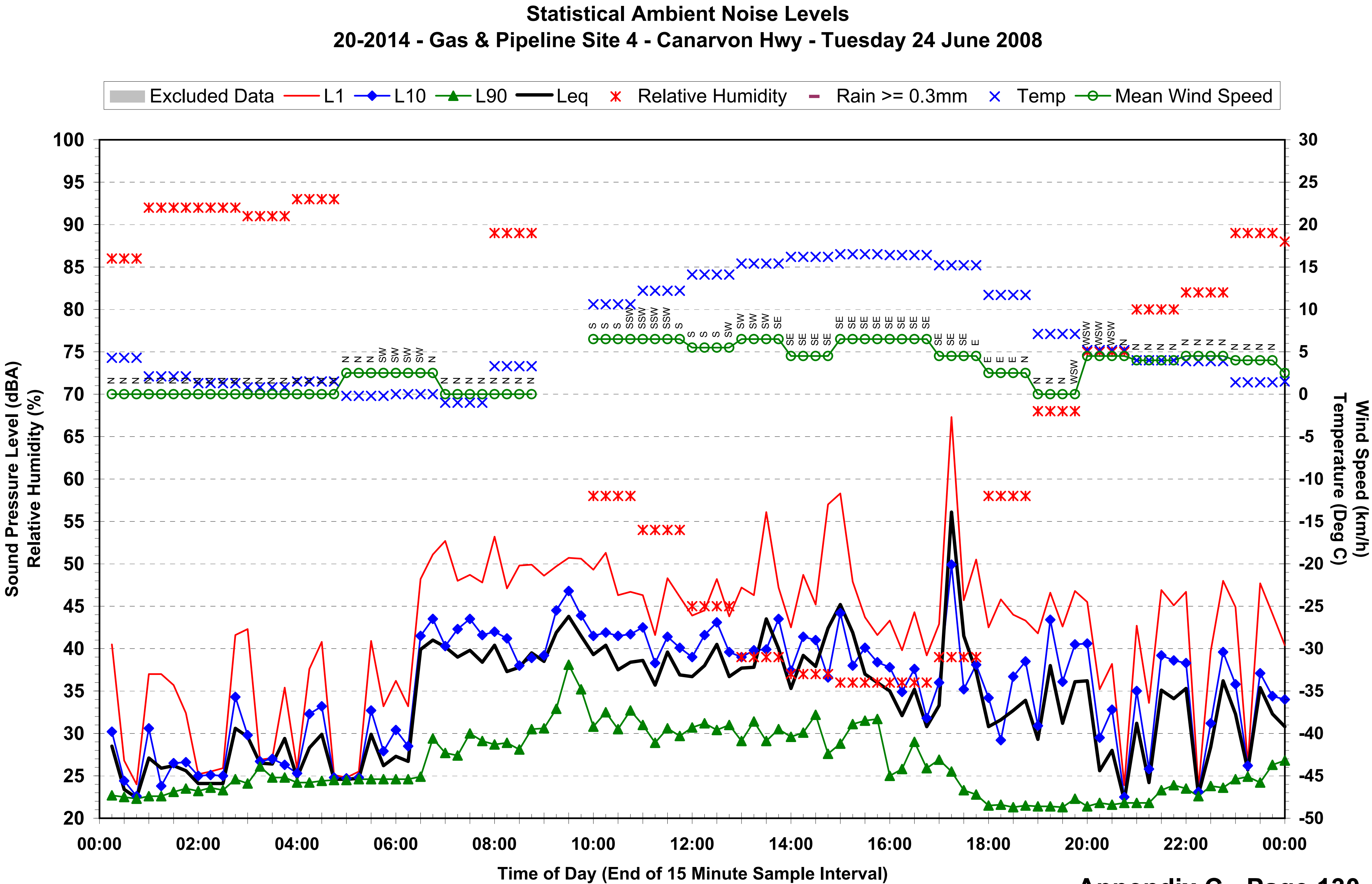
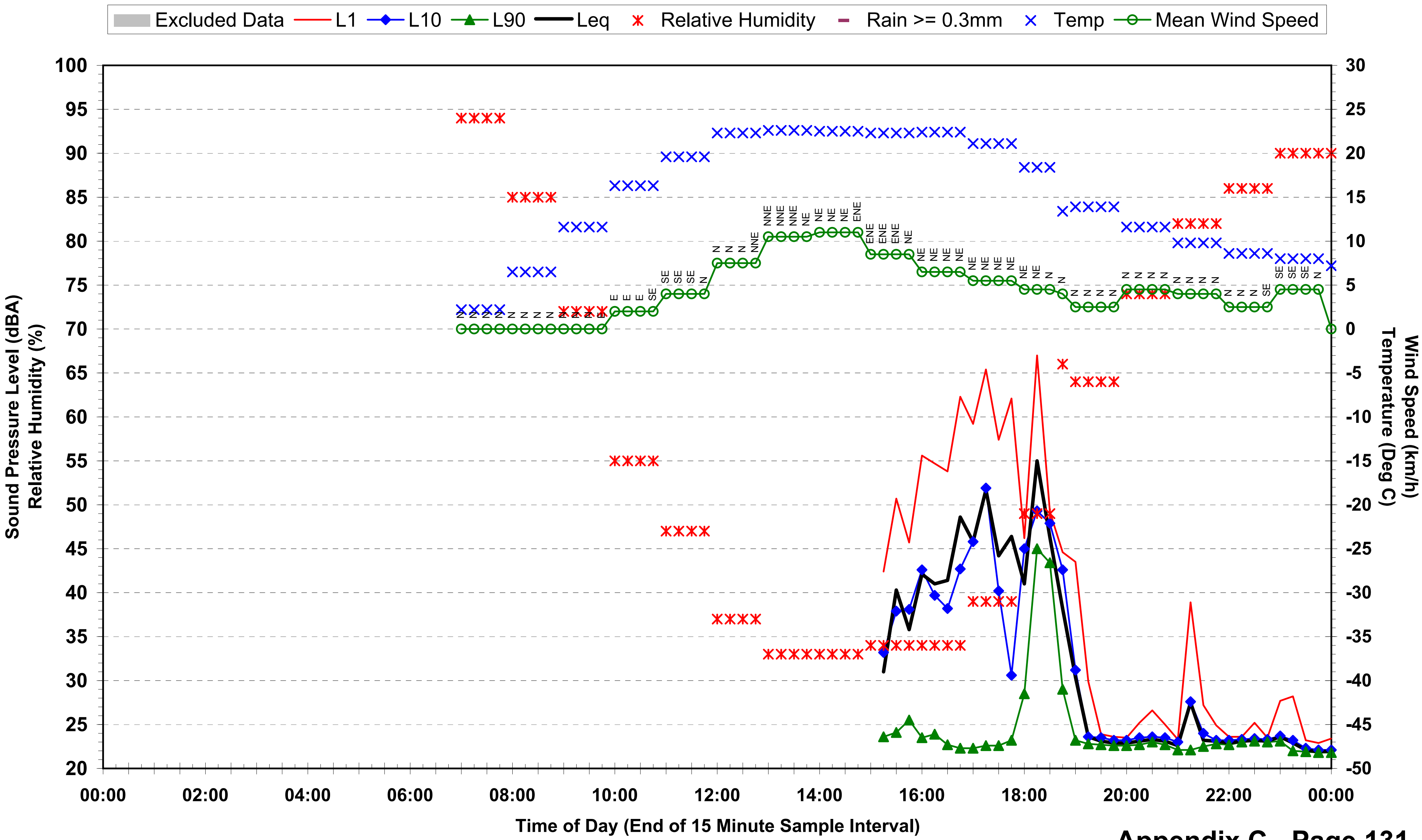
Ambient Conditions

RHA Report 20-2014

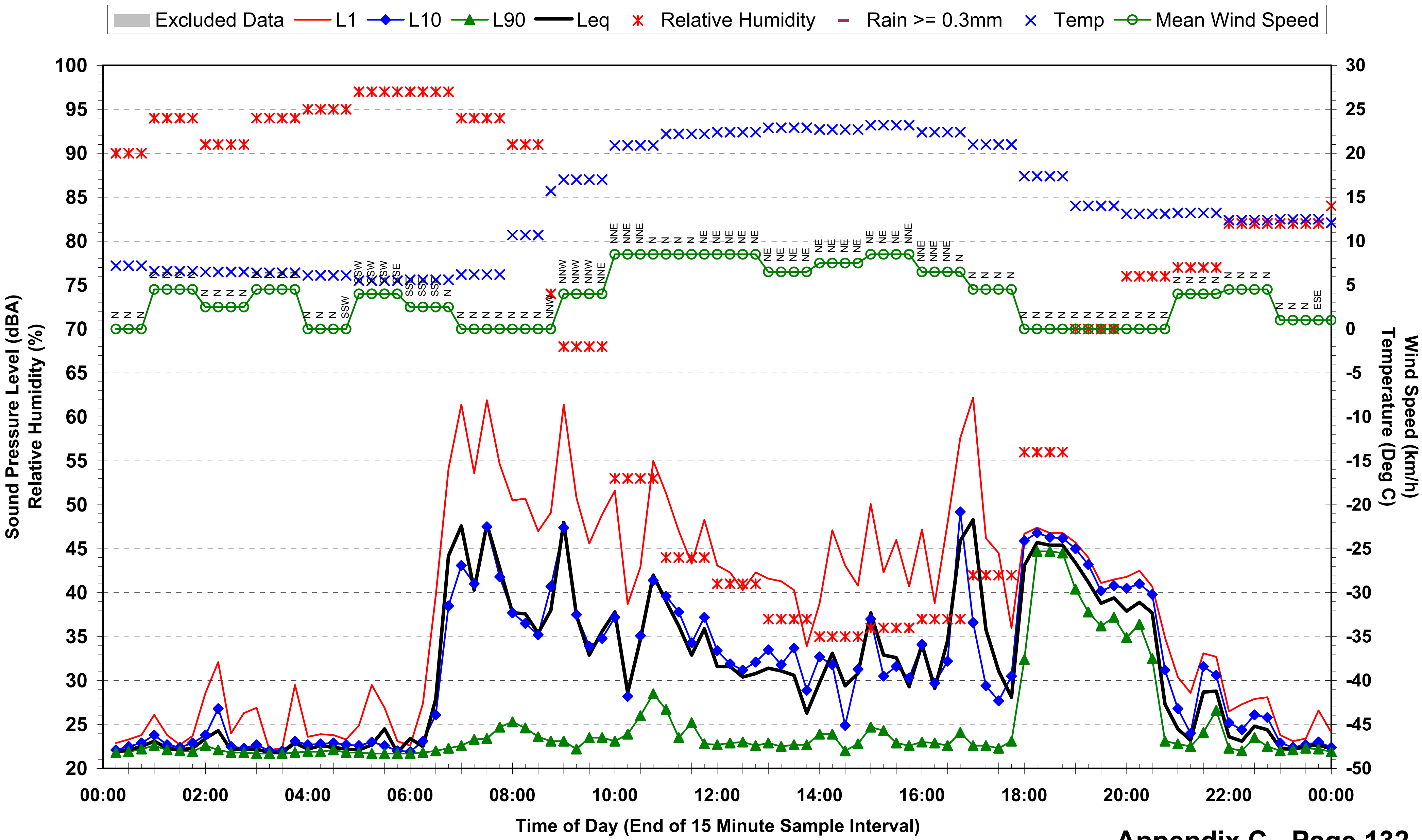


Ambient Conditions
RHA Report 20-2014

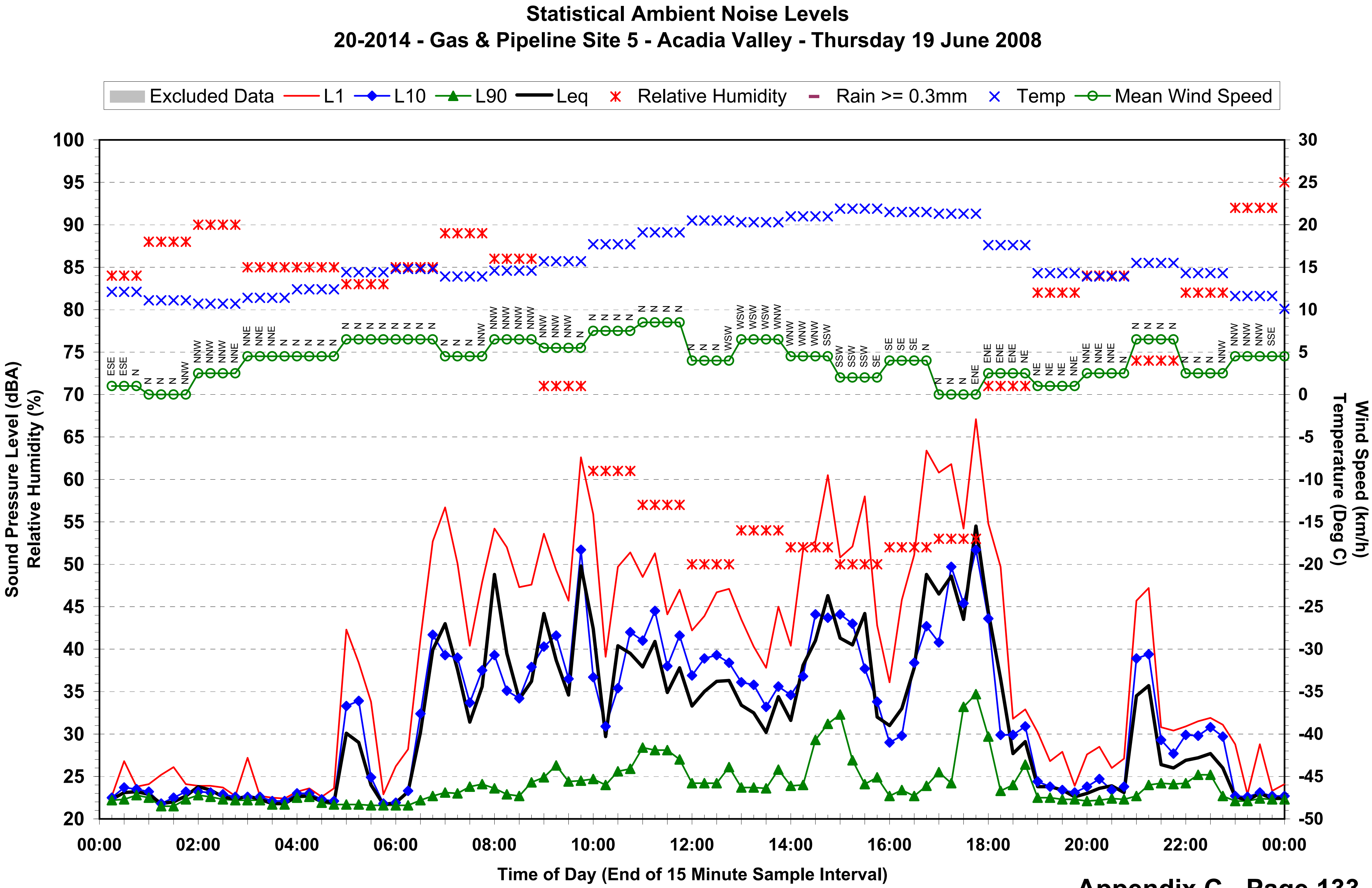
Statistical Ambient Noise Levels
20-2014 - Gas & Pipeline Site 5 - Acadia Valley - Tuesday 17 June 2008



Statistical Ambient Noise Levels
20-2014 - Gas & Pipeline Site 5 - Acadia Valley - Wednesday 18 June 2008



Ambient Conditions
RHA Report 20-2014



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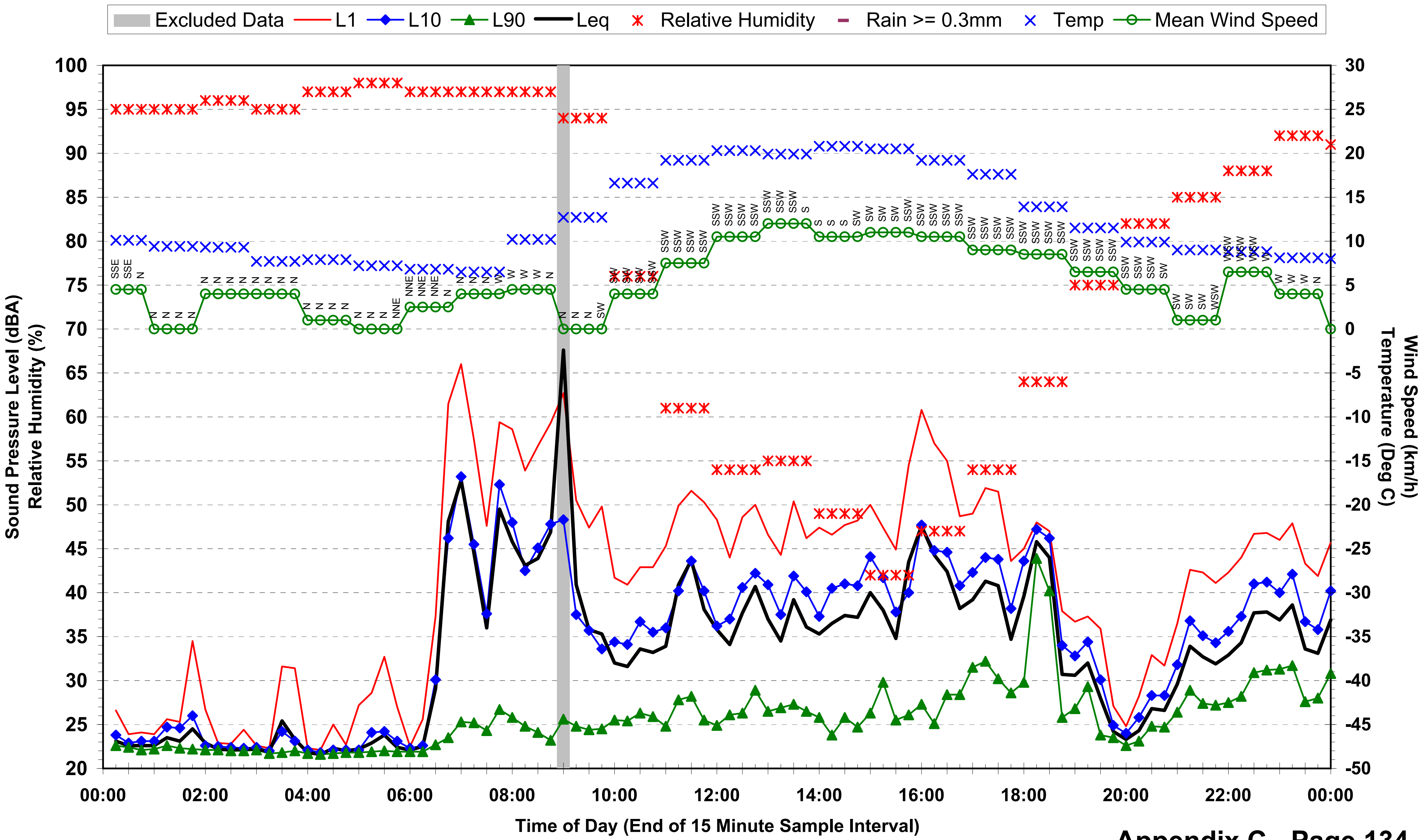
Ambient Conditions

RHA Report 20-2014

Statistical Ambient Noise Levels
20-2014 - Gas & Pipeline Site 5 - Acadia Valley - Friday 20 June 2008



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Ambient Conditions

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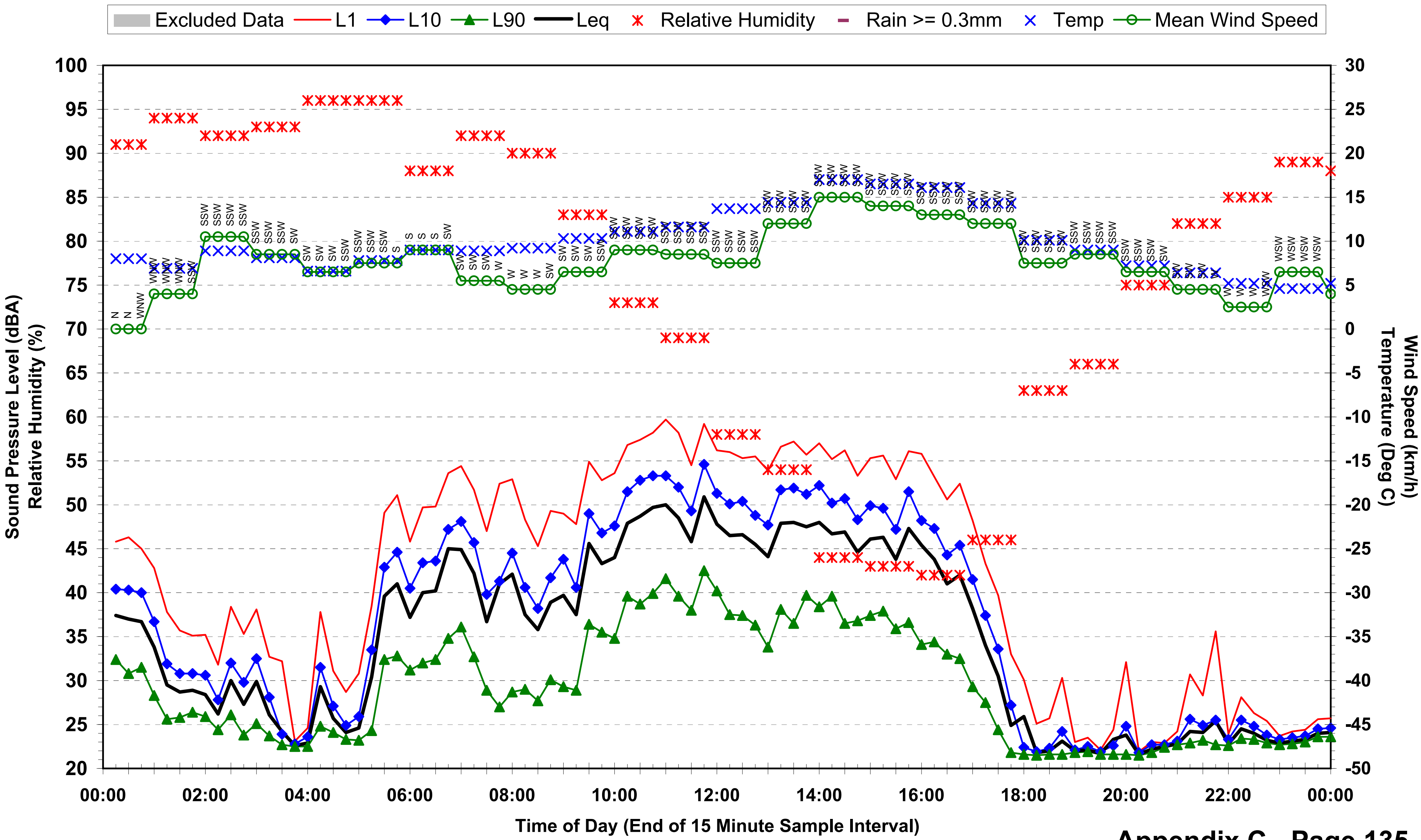
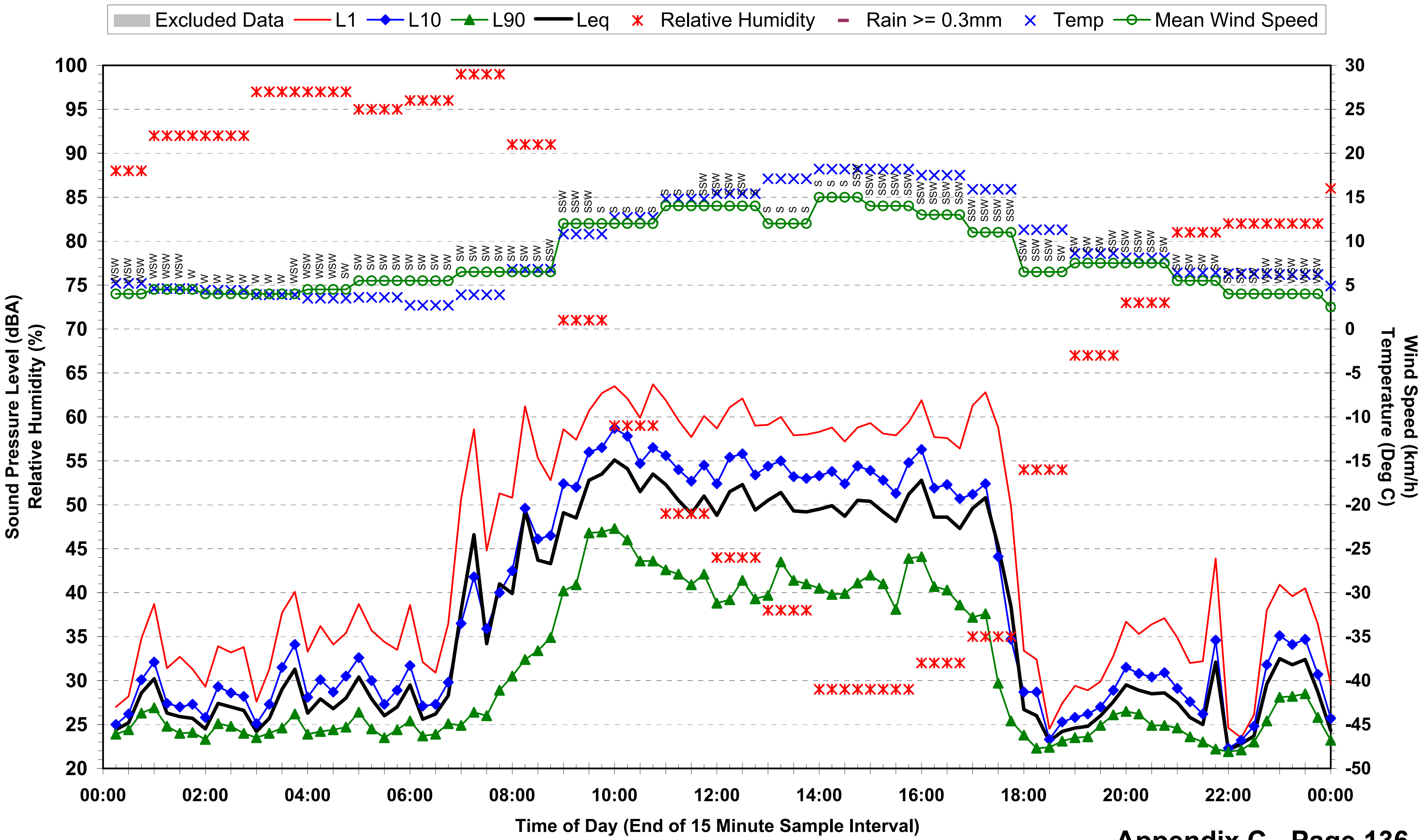
Statistical Ambient Noise Levels

20-2014 - Gas & Pipeline Site 5 - Acadia Valley - Saturday 21 June 2008



Statistical Ambient Noise Levels
20-2014 - Gas & Pipeline Site 5 - Acadia Valley - Sunday 22 June 2008



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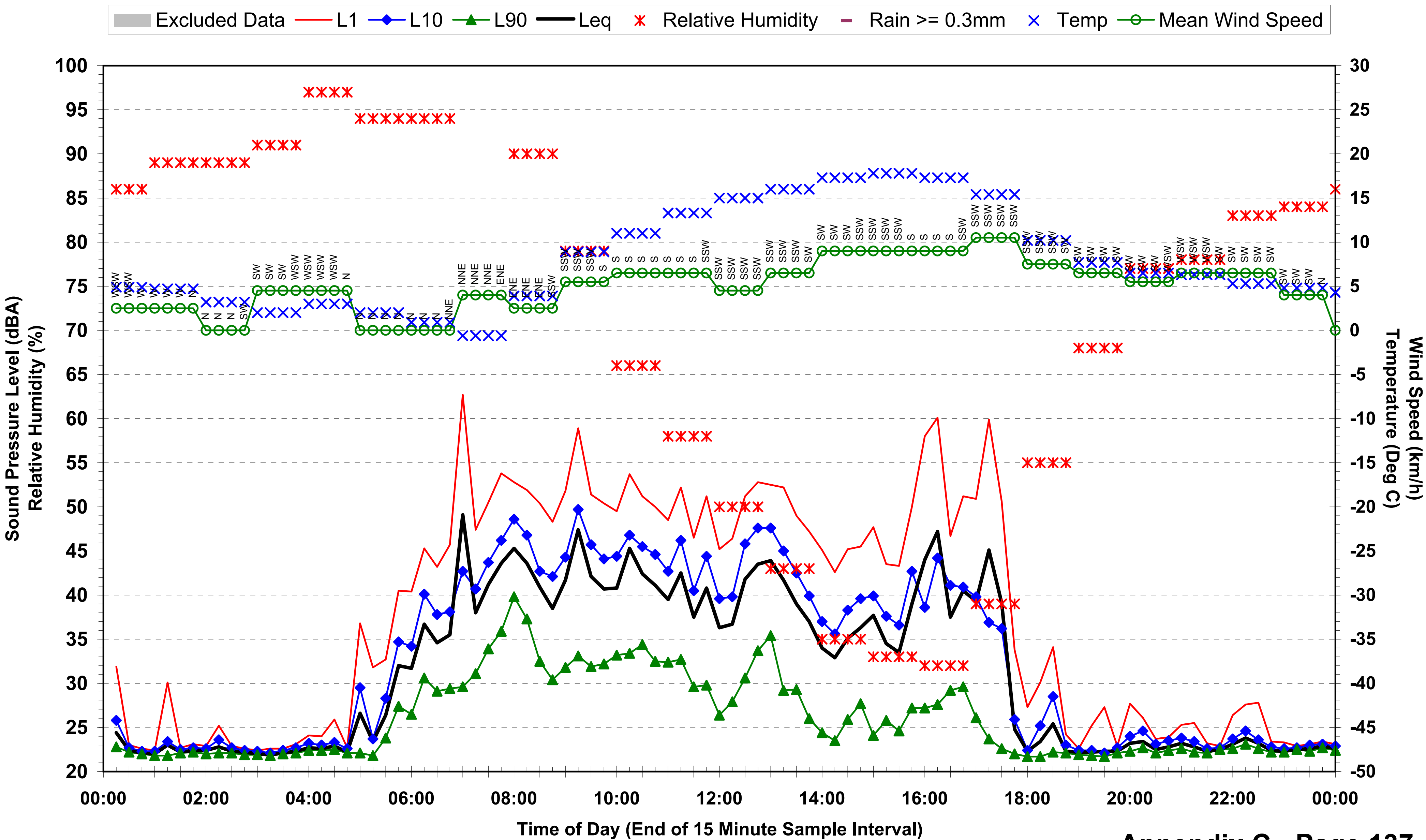
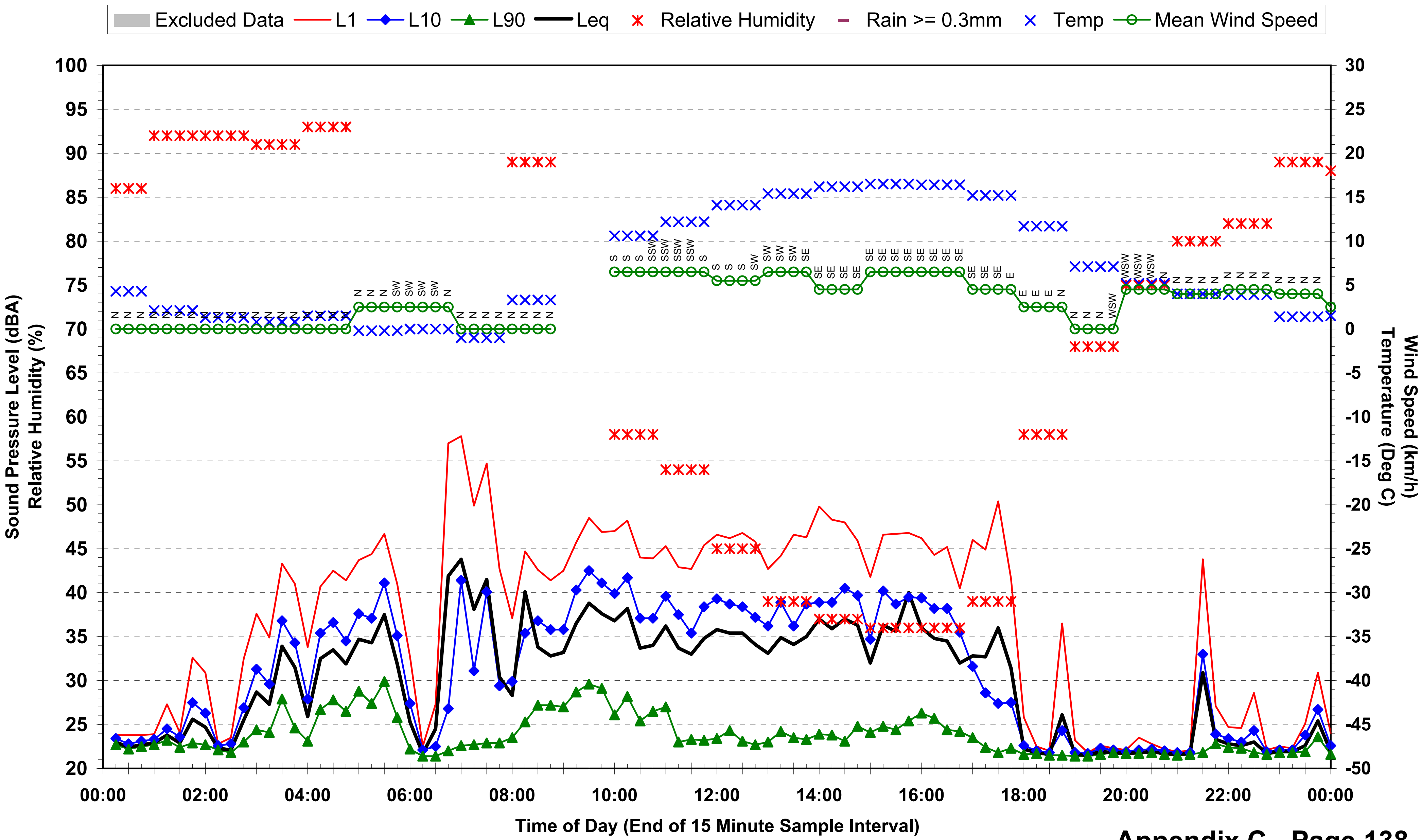
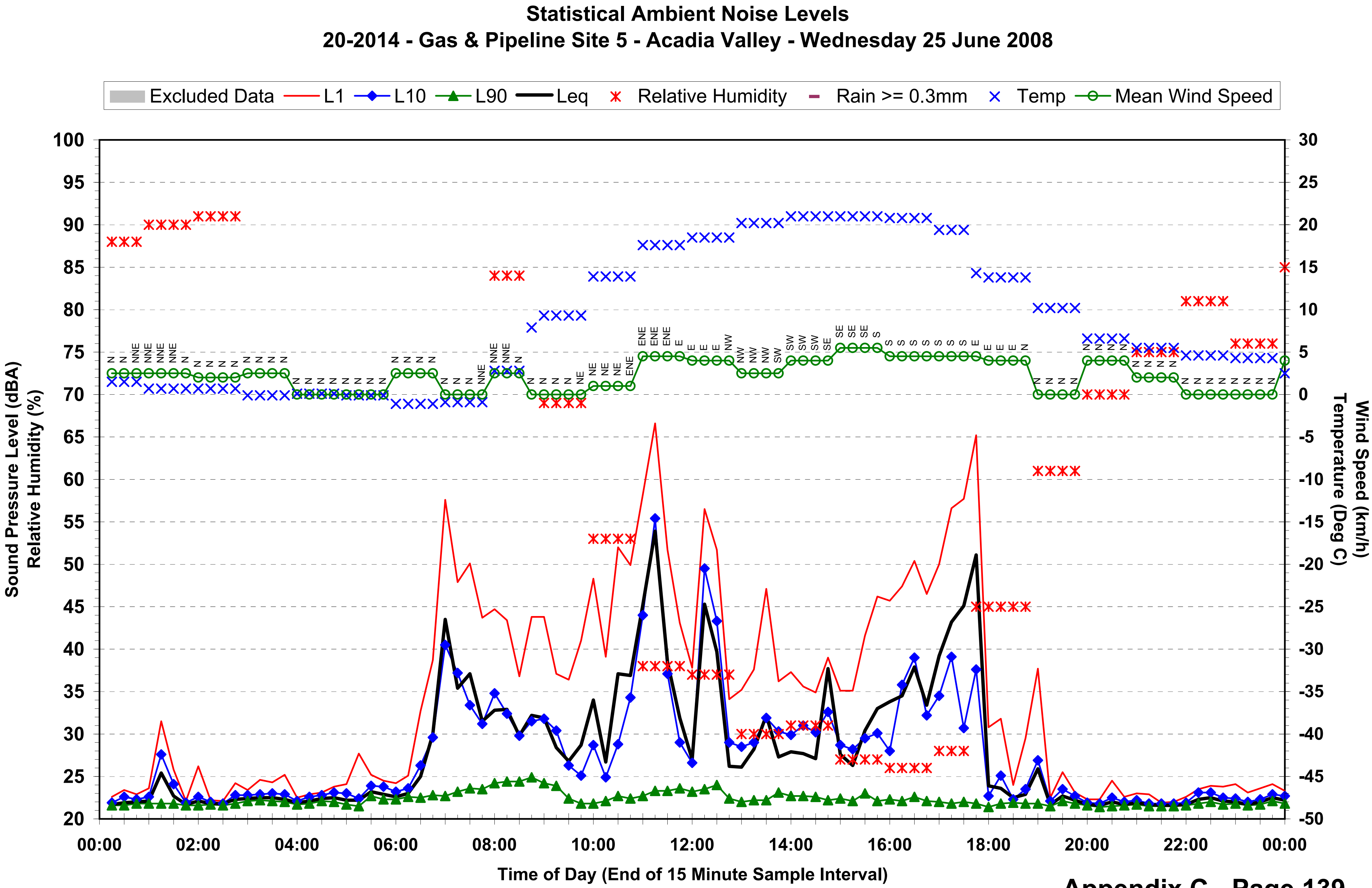
Ambient Conditions
RHA Report 20-2014

Statistical Ambient Noise Levels
20-2014 - Gas & Pipeline Site 5 - Acadia Valley - Monday 23 June 2008



Statistical Ambient Noise Levels
20-2014 - Gas & Pipeline Site 5 - Acadia Valley - Tuesday 24 June 2008





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Ambient Conditions
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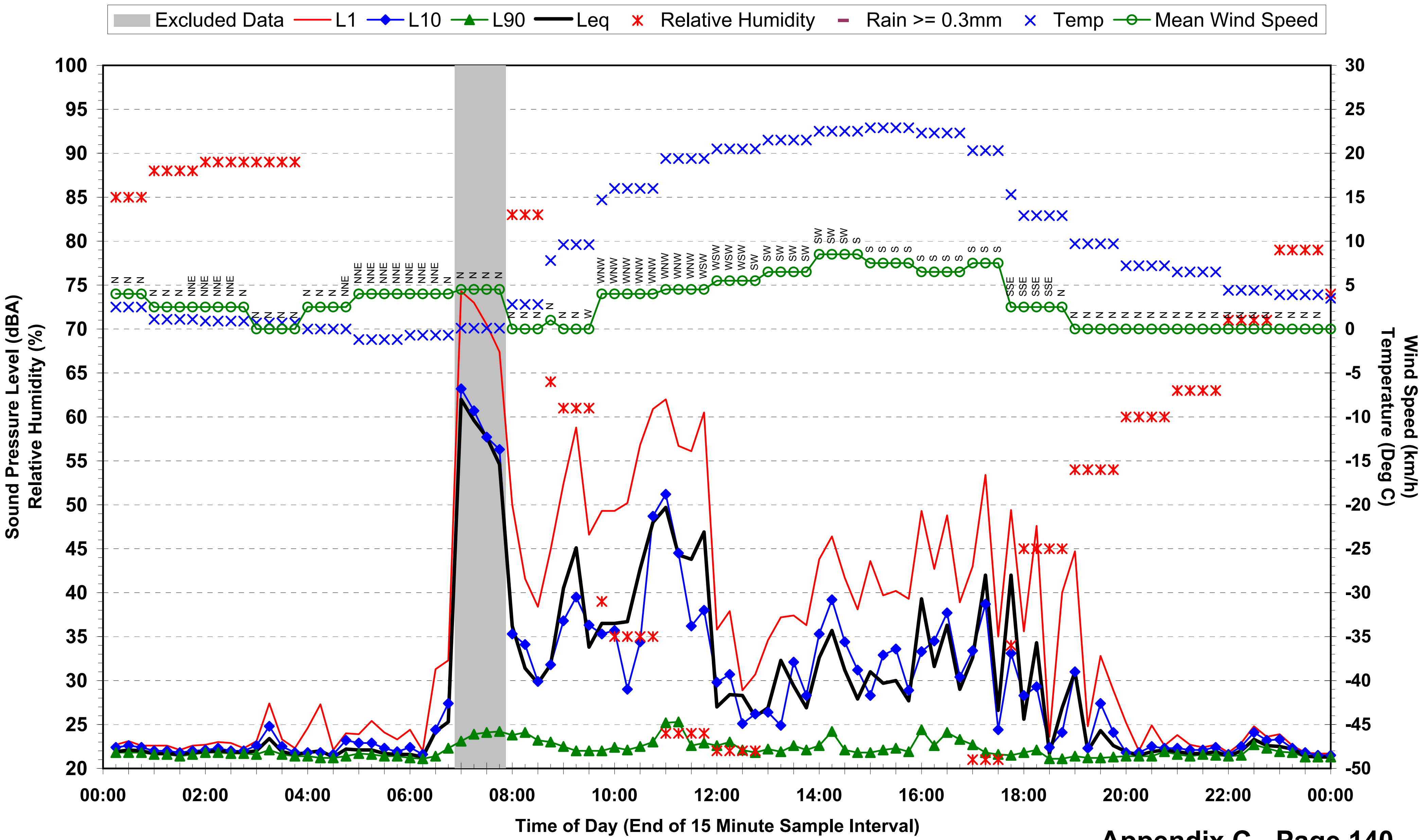
Statistical Ambient Noise Levels

20-2014 - Gas & Pipeline Site 5 - Acadia Valley - Thursday 26 June 2008



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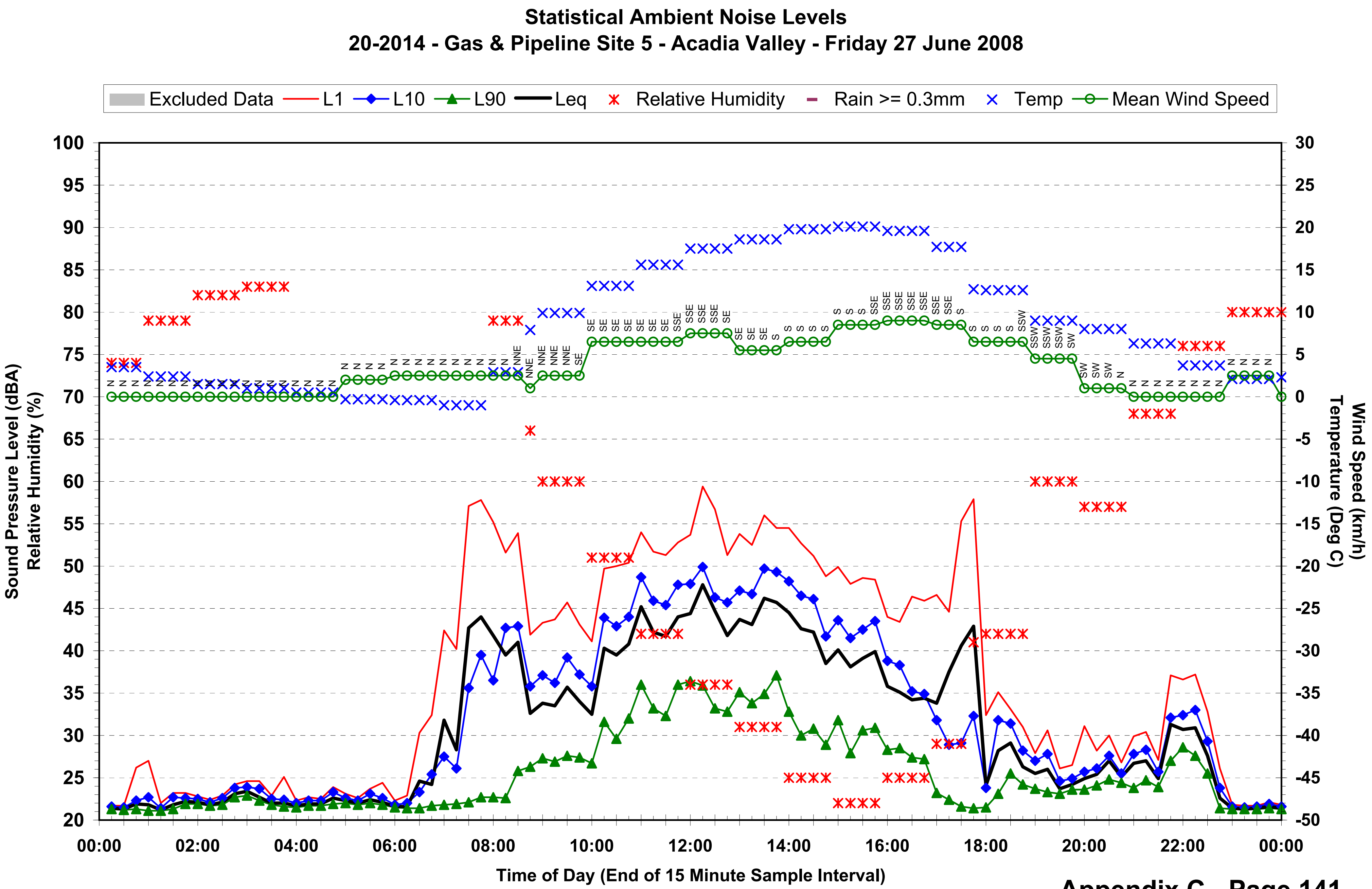
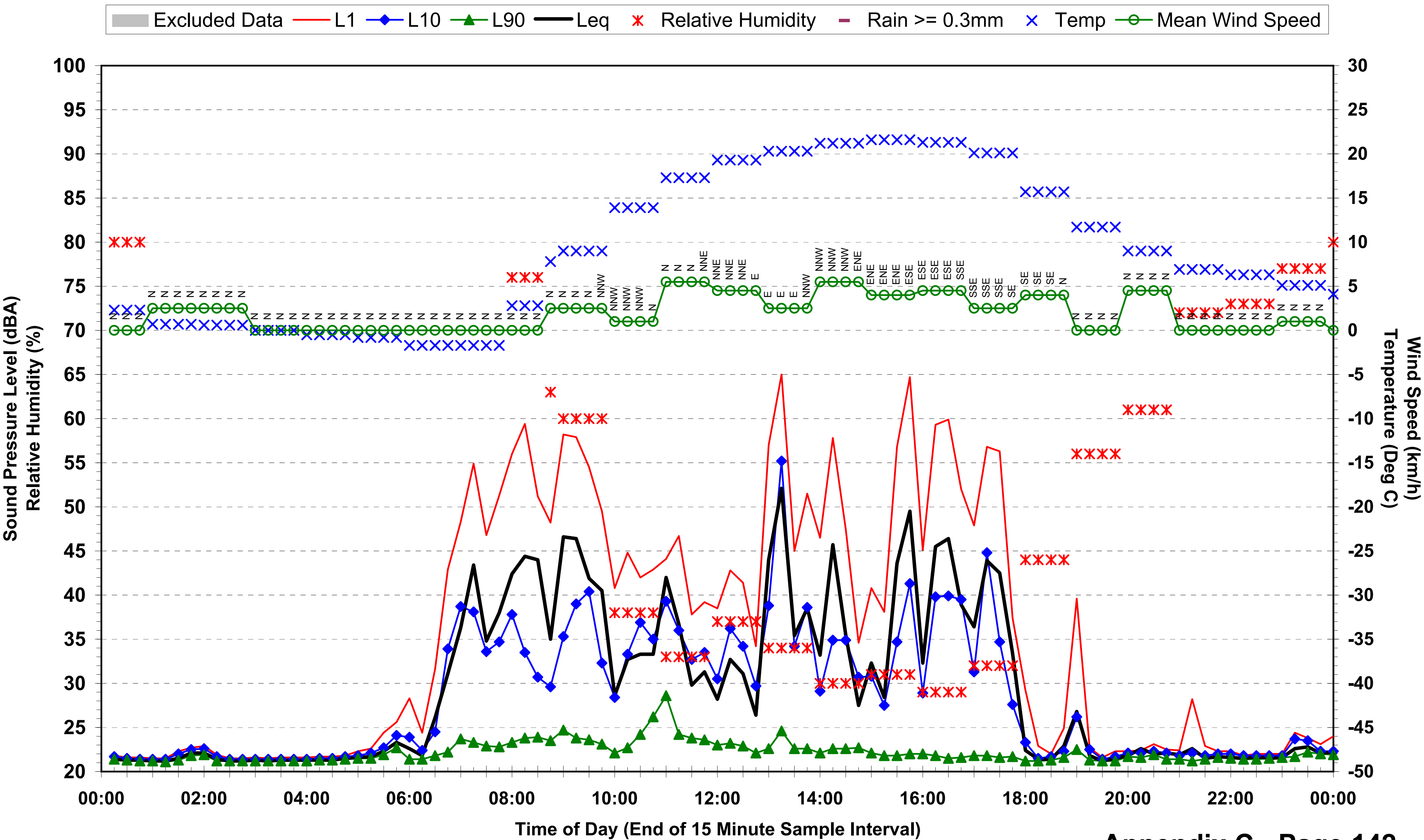


Statistical Ambient Noise Levels
20-2014 - Gas & Pipeline Site 5 - Acadia Valley - Friday 27 June 2008
Excluded Data
L1
L10
L90
Leq
Relative Humidity
Rain >= 0.3mm
Temp
Mean Wind Speed
Sound Pressure Level (dBA)
Relative Humidity (%)
Wind Speed (km/h)
Temperature (Deg C)
Time of Day (End of 15 Minute Sample Interval)

Statistical Ambient Noise Levels
20-2014 - Gas & Pipeline Site 5 - Acadia Valley - Saturday 28 June 2008



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Ambient Conditions

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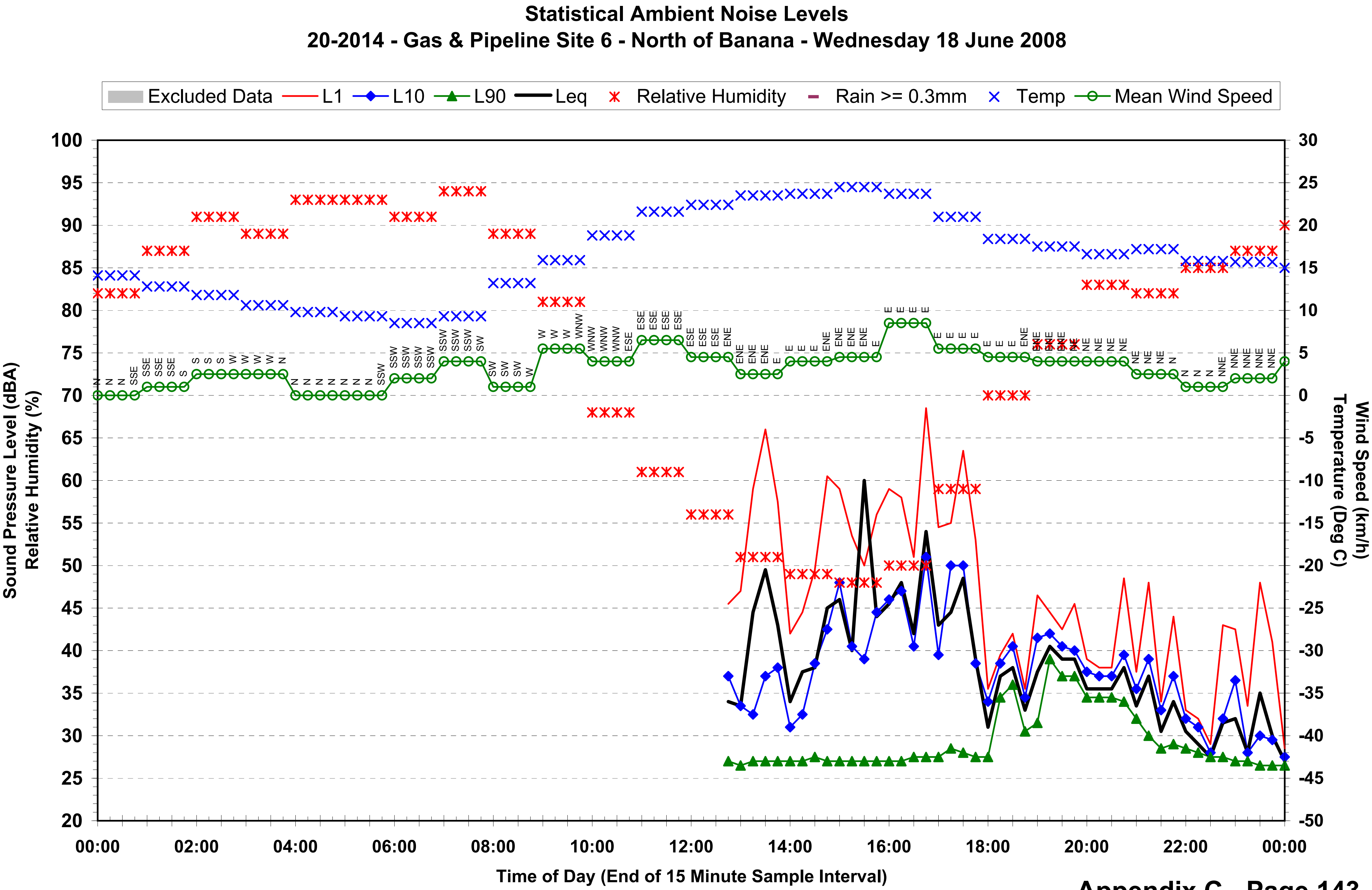

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Ambient Conditions

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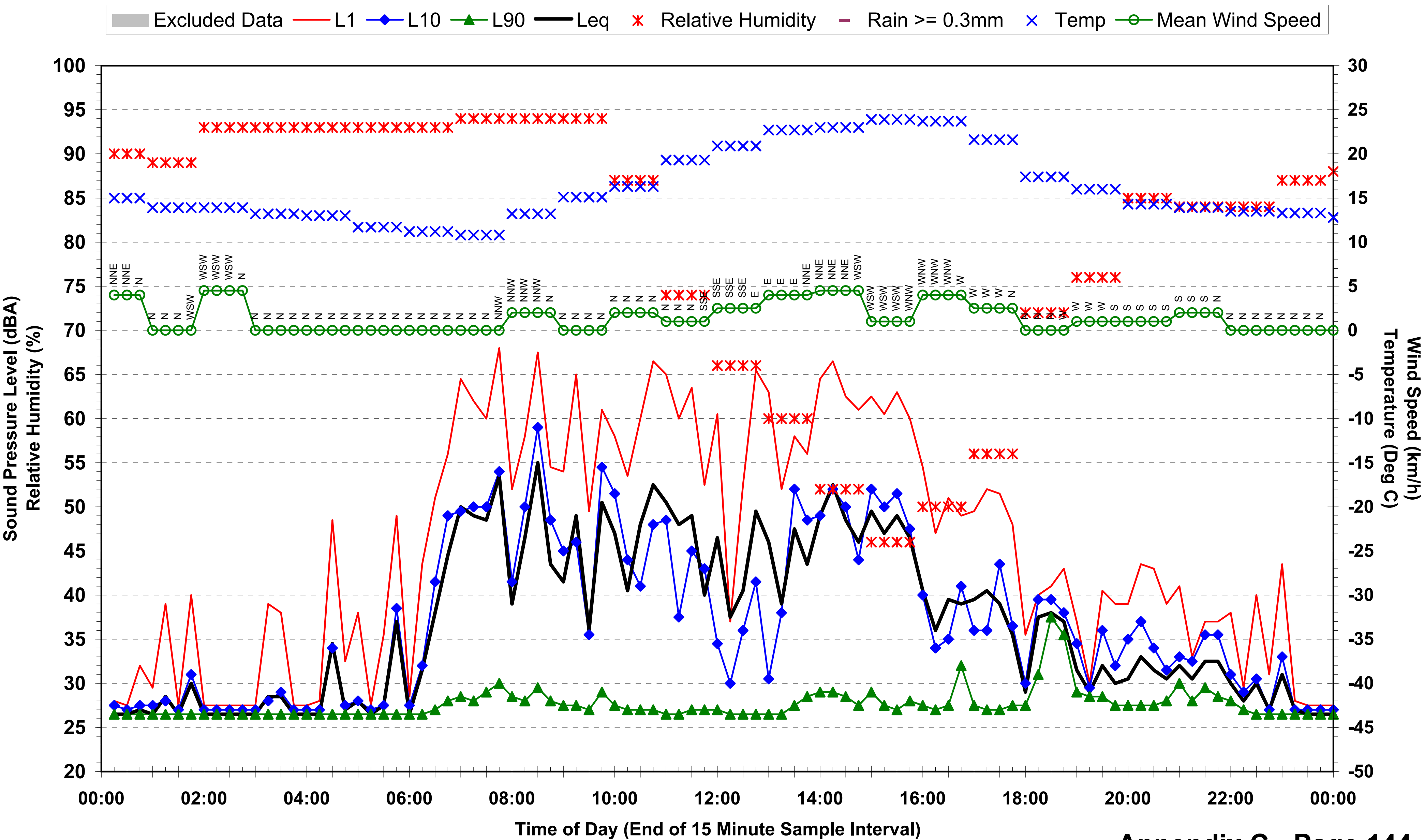
Statistical Ambient Noise Levels
20-2014 - Gas & Pipeline Site 6 - North of Banana - Thursday 19 June 2008



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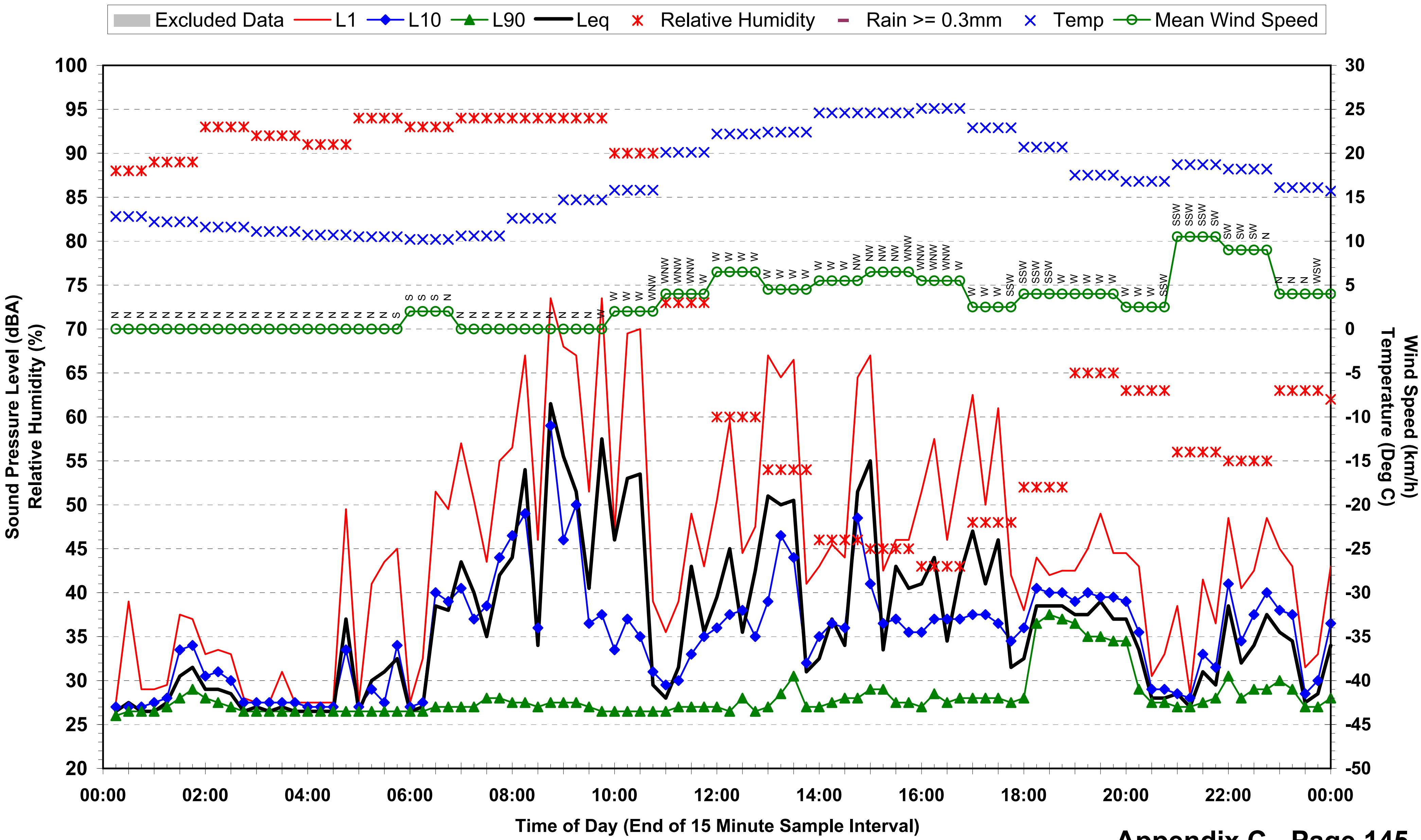
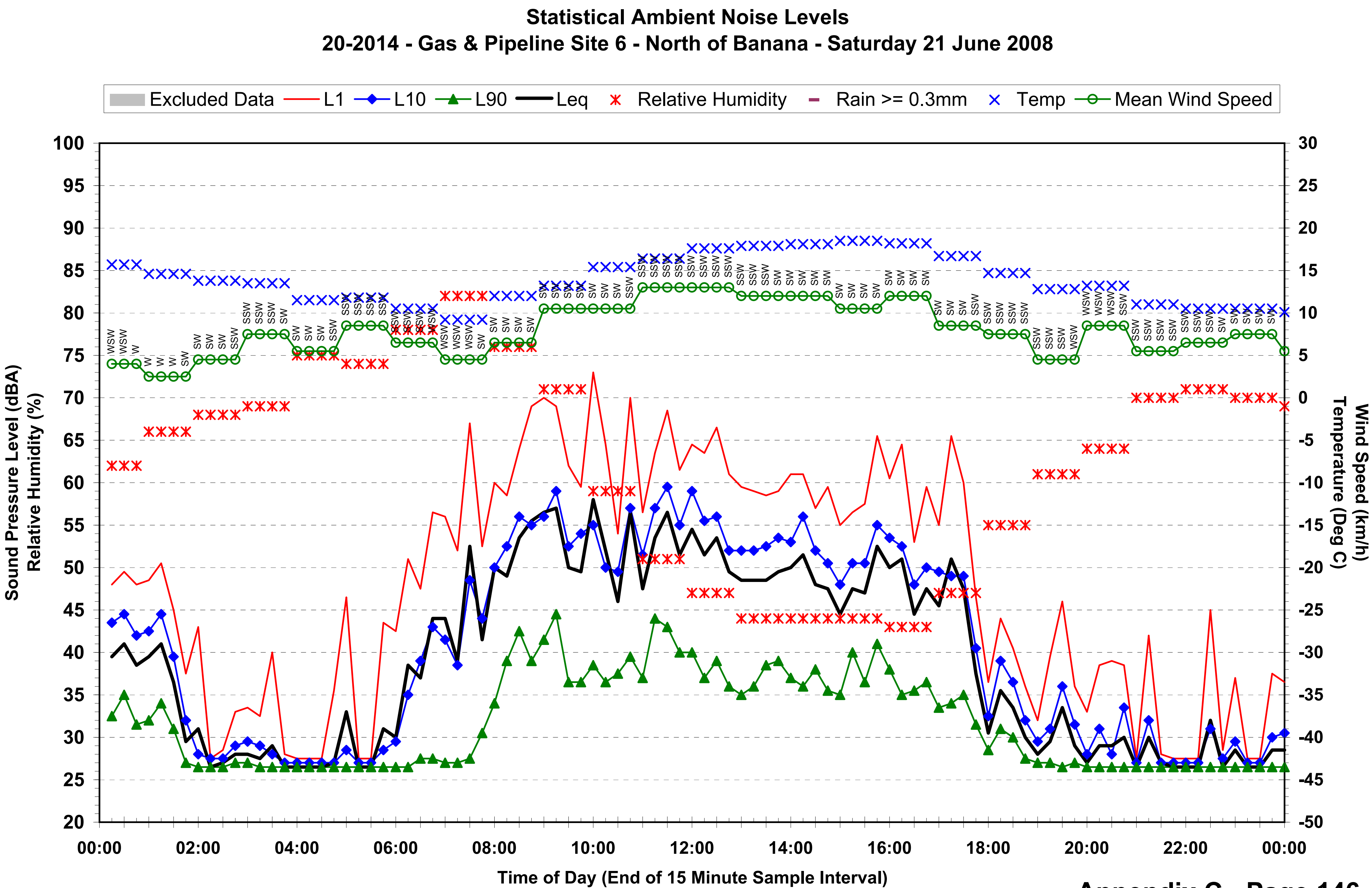
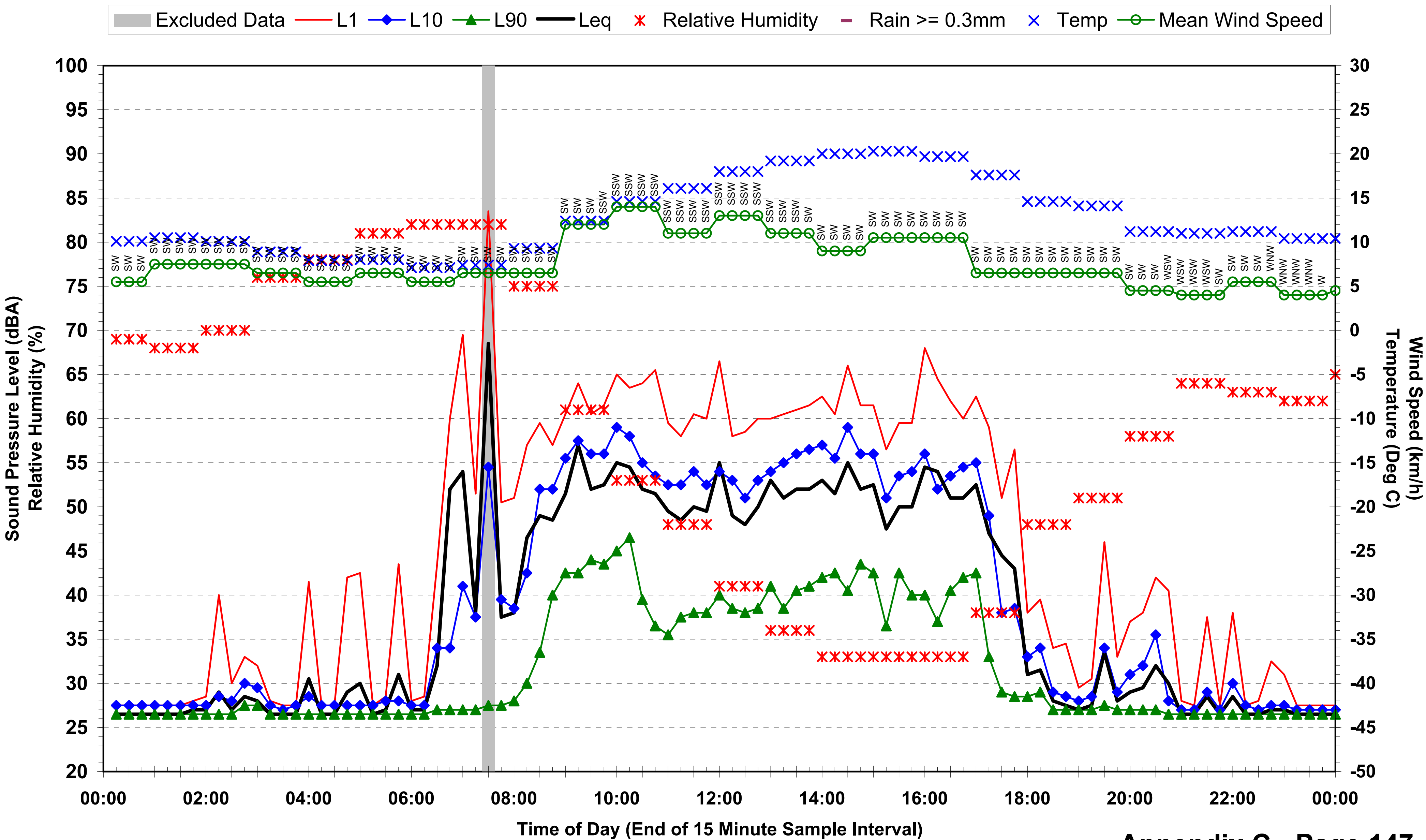
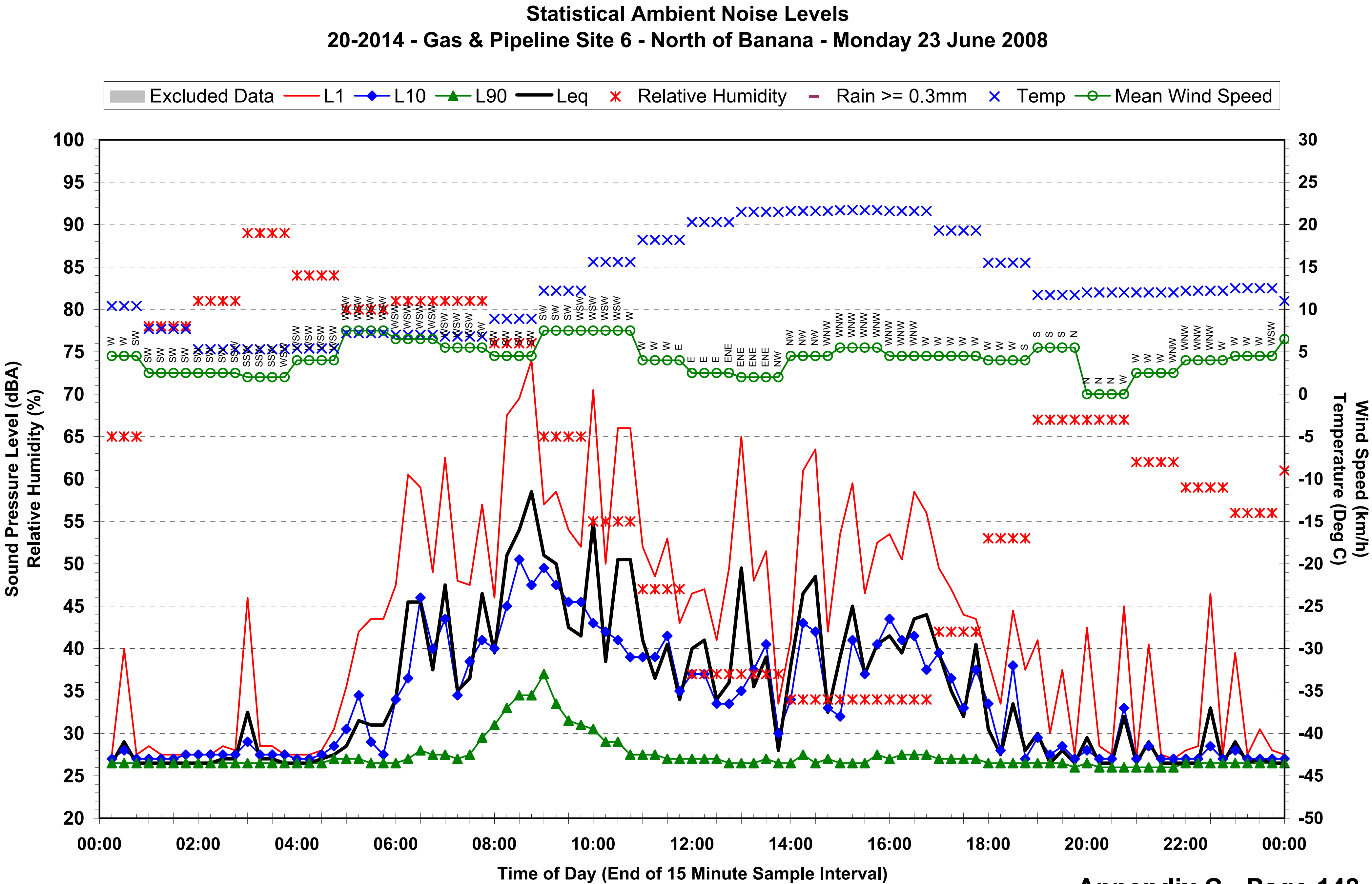
Statistical Ambient Noise Levels
20-2014 - Gas & Pipeline Site 6 - North of Banana - Friday 20 June 2008




Statistical Ambient Noise Levels
20-2014 - Gas & Pipeline Site 6 - North of Banana - Saturday 21 June 2008
Excluded Data
L1
L10
L90
Leq
Relative Humidity
Rain >= 0.3mm
Temp
Mean Wind Speed
Sound Pressure Level (dBA)
Relative Humidity (%)
Wind Speed (km/h)
Temperature (Deg C)
Time of Day (End of 15 Minute Sample Interval)
00:00
02:00
04:00
06:00
08:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
00:00

Statistical Ambient Noise Levels
20-2014 - Gas & Pipeline Site 6 - North of Banana - Sunday 22 June 2008





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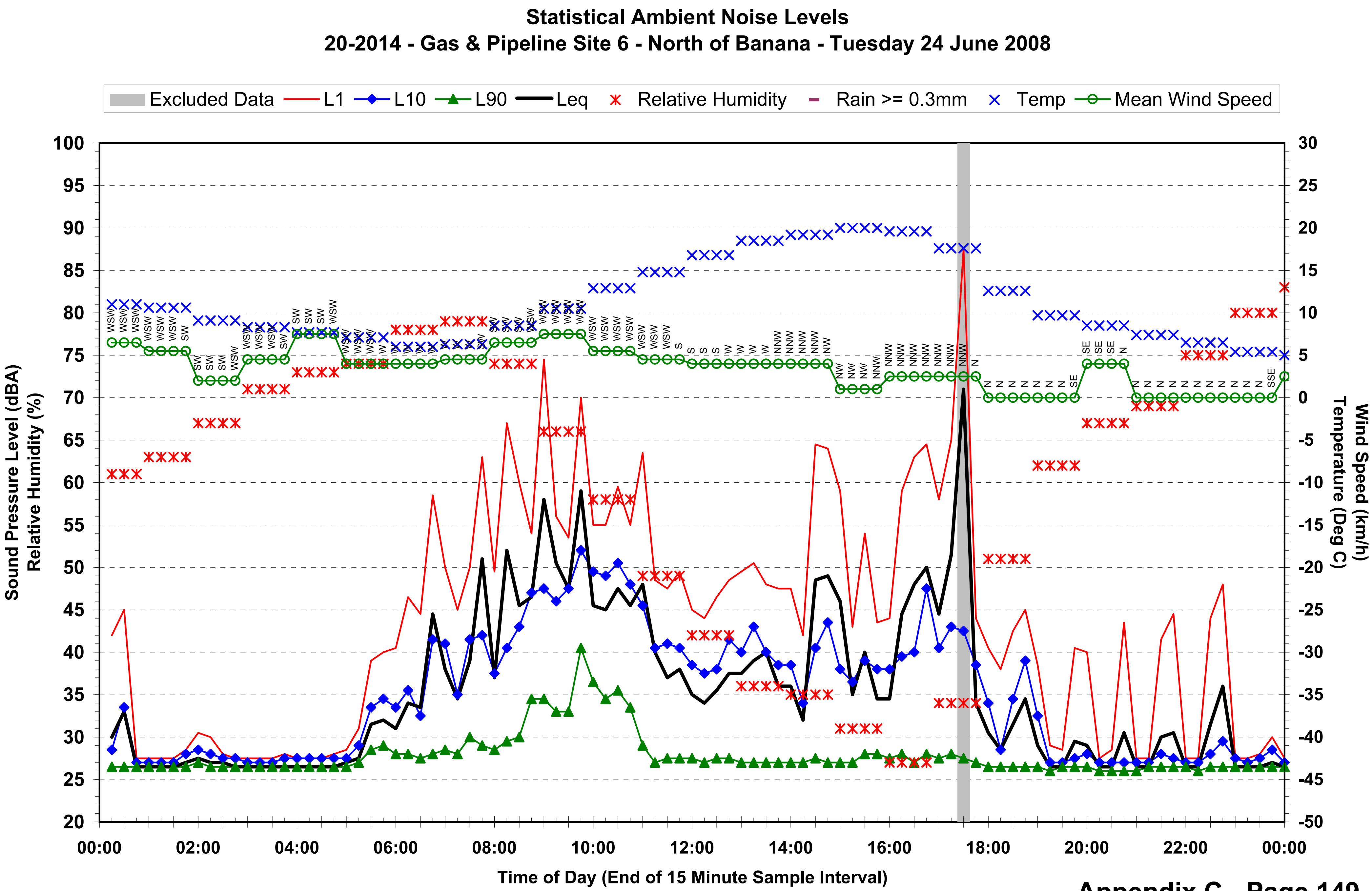
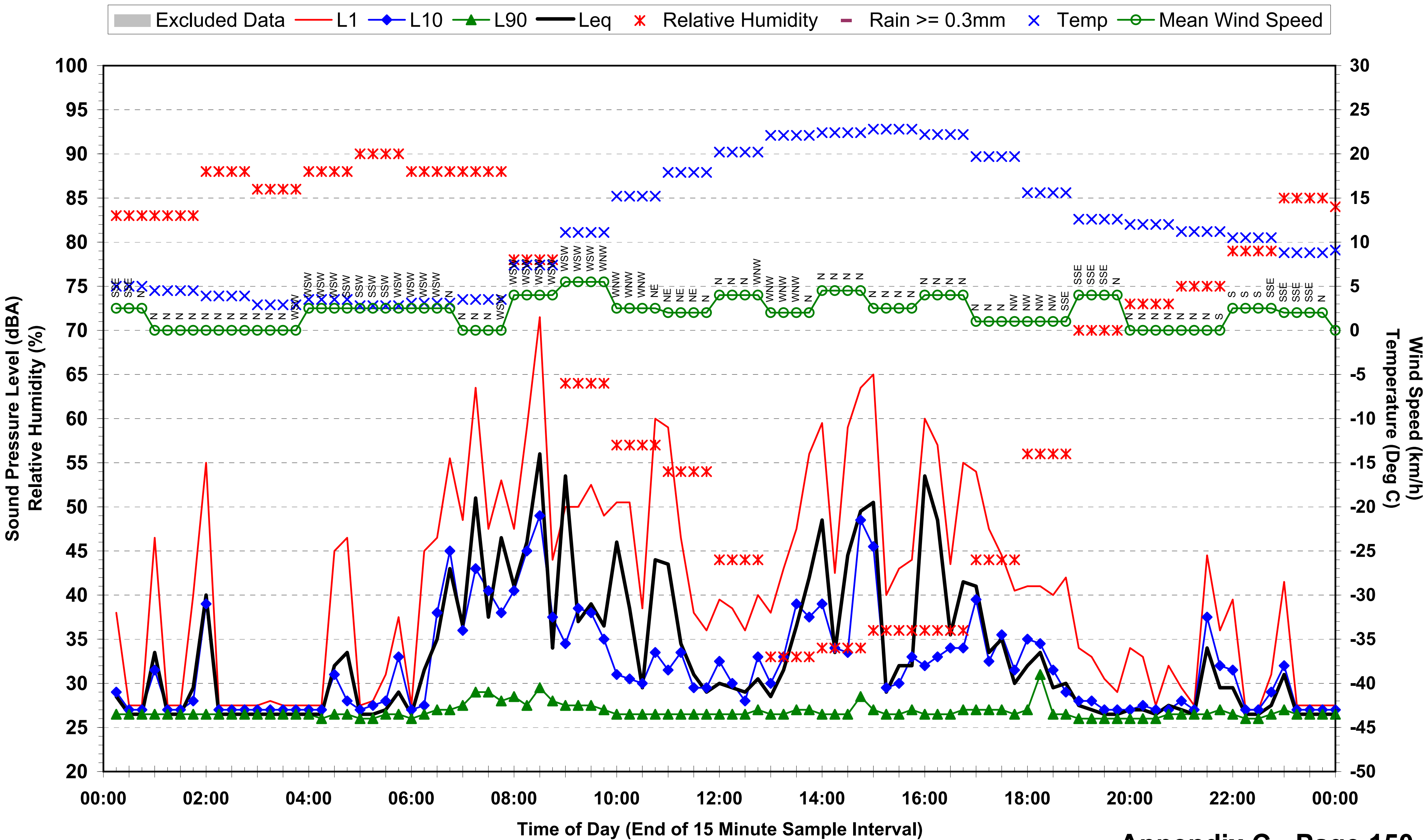
Ambient Conditions

RHA Report 20-2014


Statistical Ambient Noise Levels
20-2014 - Gas & Pipeline Site 6 - North of Banana - Tuesday 24 June 2008
Excluded Data
L1
L10
L90
Leq
Relative Humidity
Rain >= 0.3mm
Temp
Mean Wind Speed
Sound Pressure Level (dBA)
Relative Humidity (%)
Wind Speed (km/h)
Temperature (Deg C)
Time of Day (End of 15 Minute Sample Interval)

Statistical Ambient Noise Levels
20-2014 - Gas & Pipeline Site 6 - North of Banana - Wednesday 25 June 2008



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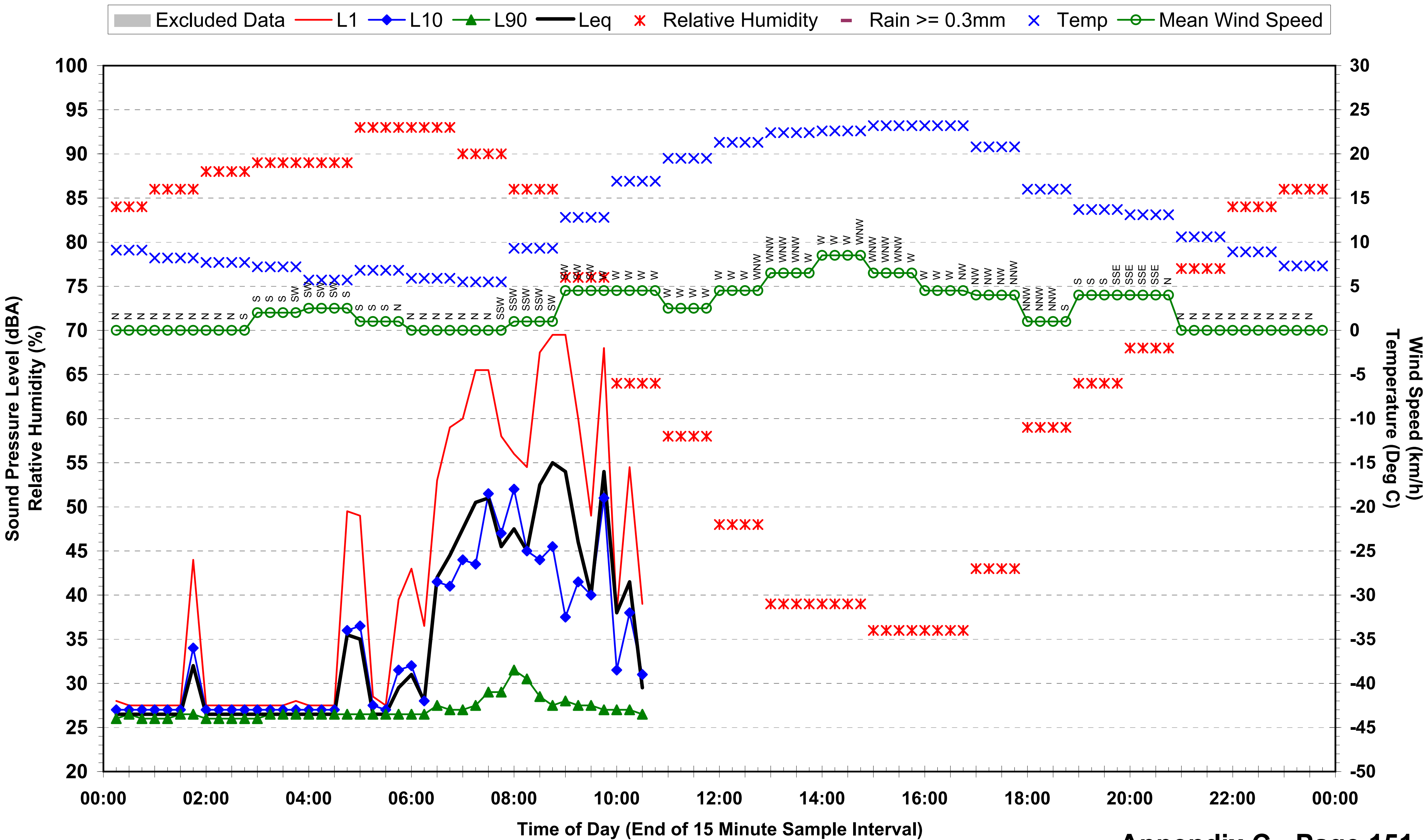
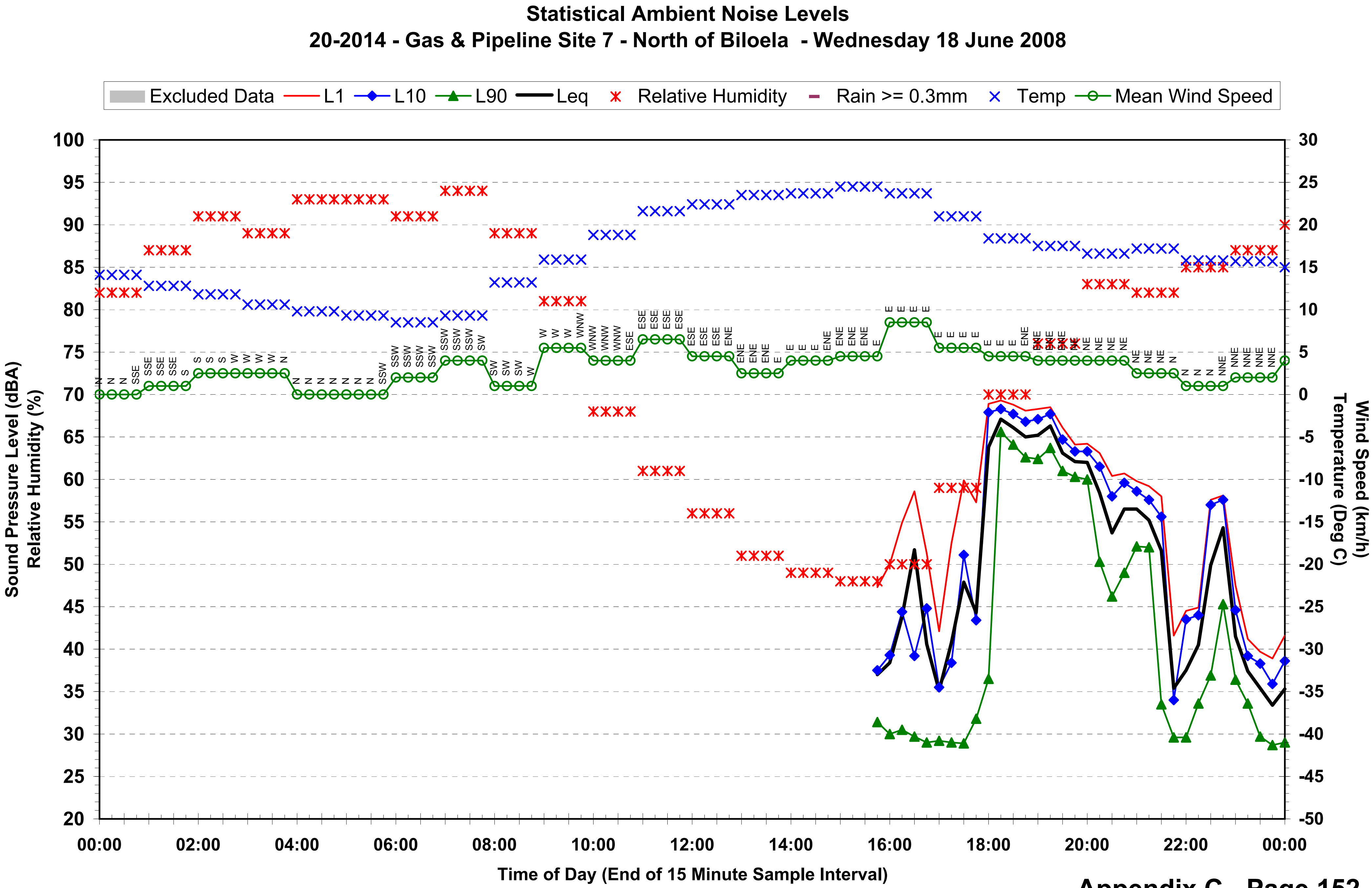
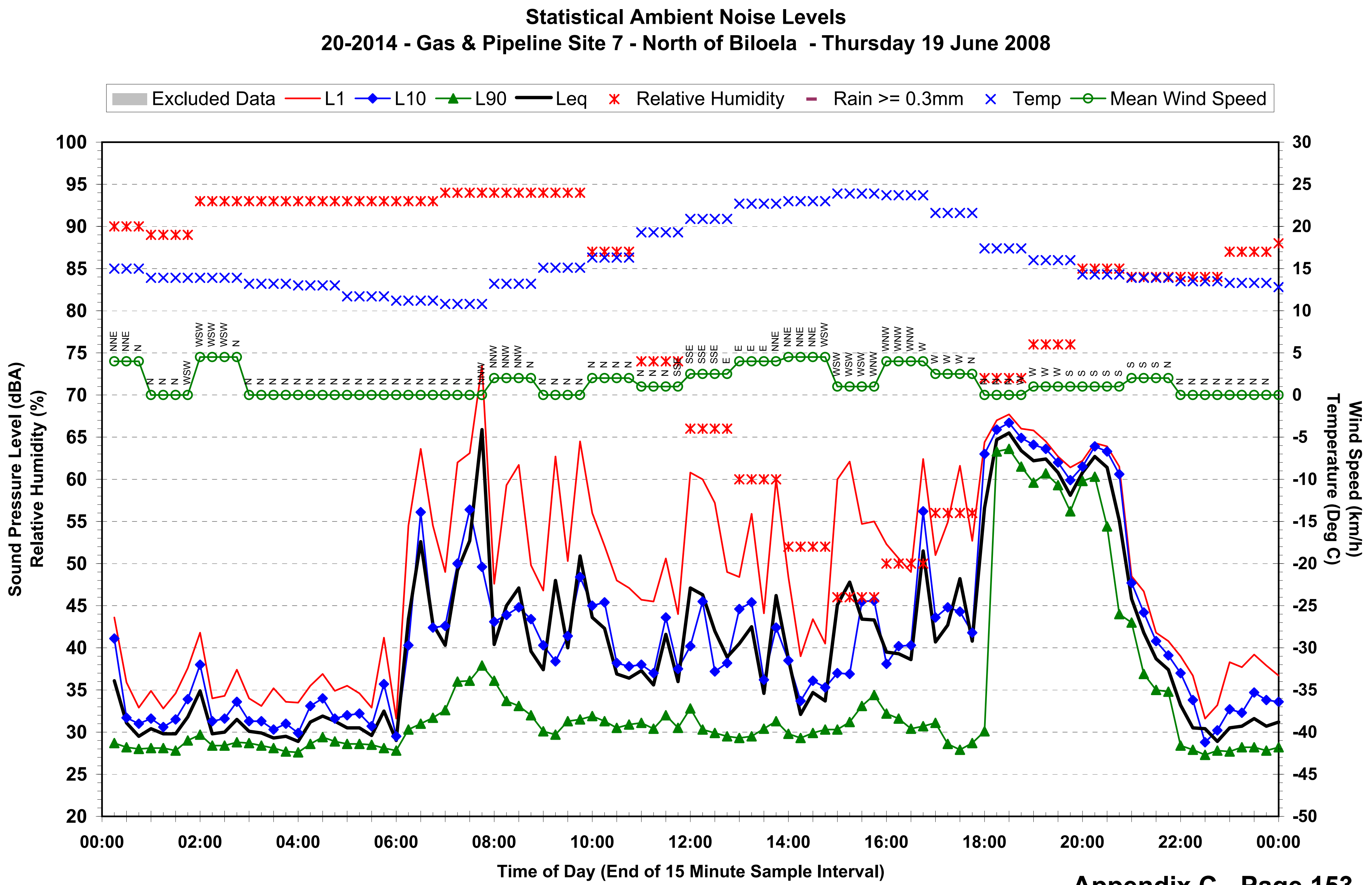
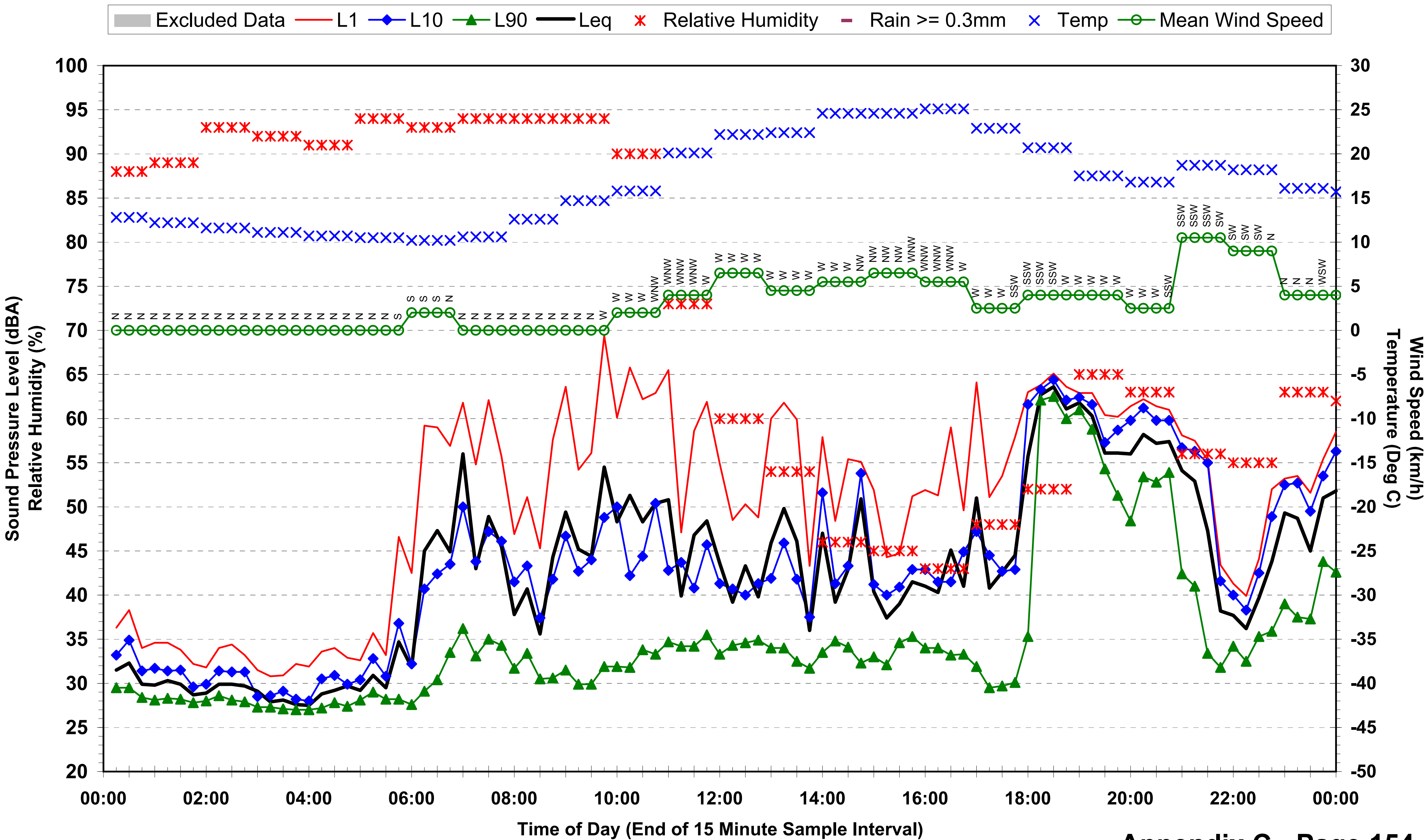
Statistical Ambient Noise Levels
20-2014 - Gas & Pipeline Site 6 - North of Banana - Thursday 26 June 2008

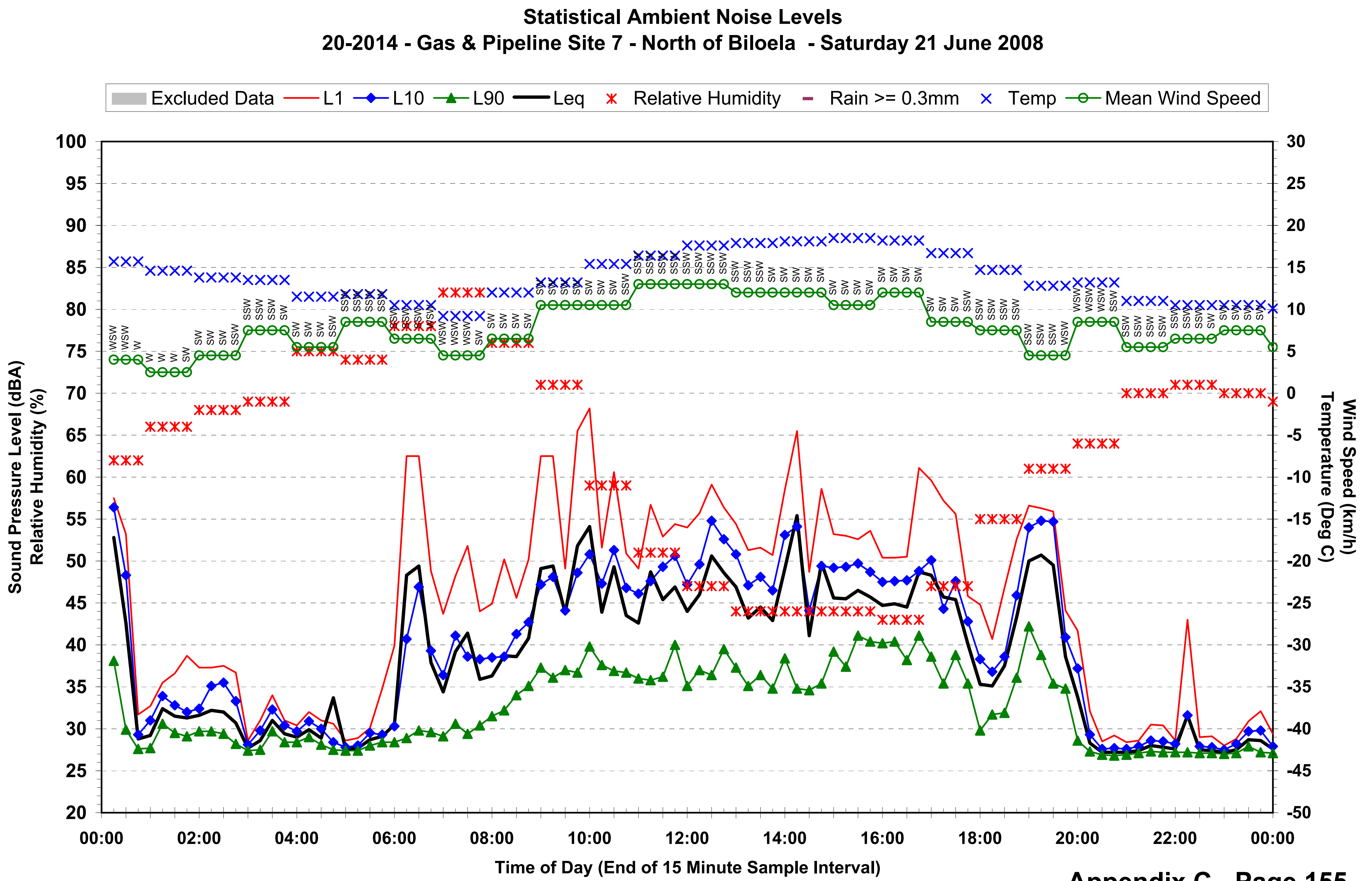



Statistical Ambient Noise Levels
20-2014 - Gas & Pipeline Site 7 - North of Biloela - Wednesday 18 June 2008
Excluded Data
L1
L10
L90
Leq
Relative Humidity
Rain >= 0.3mm
Temp
Mean Wind Speed
Sound Pressure Level (dBA)
Relative Humidity (%)
Wind Speed (km/h)
Temperature (Deg C)
Time of Day (End of 15 Minute Sample Interval)

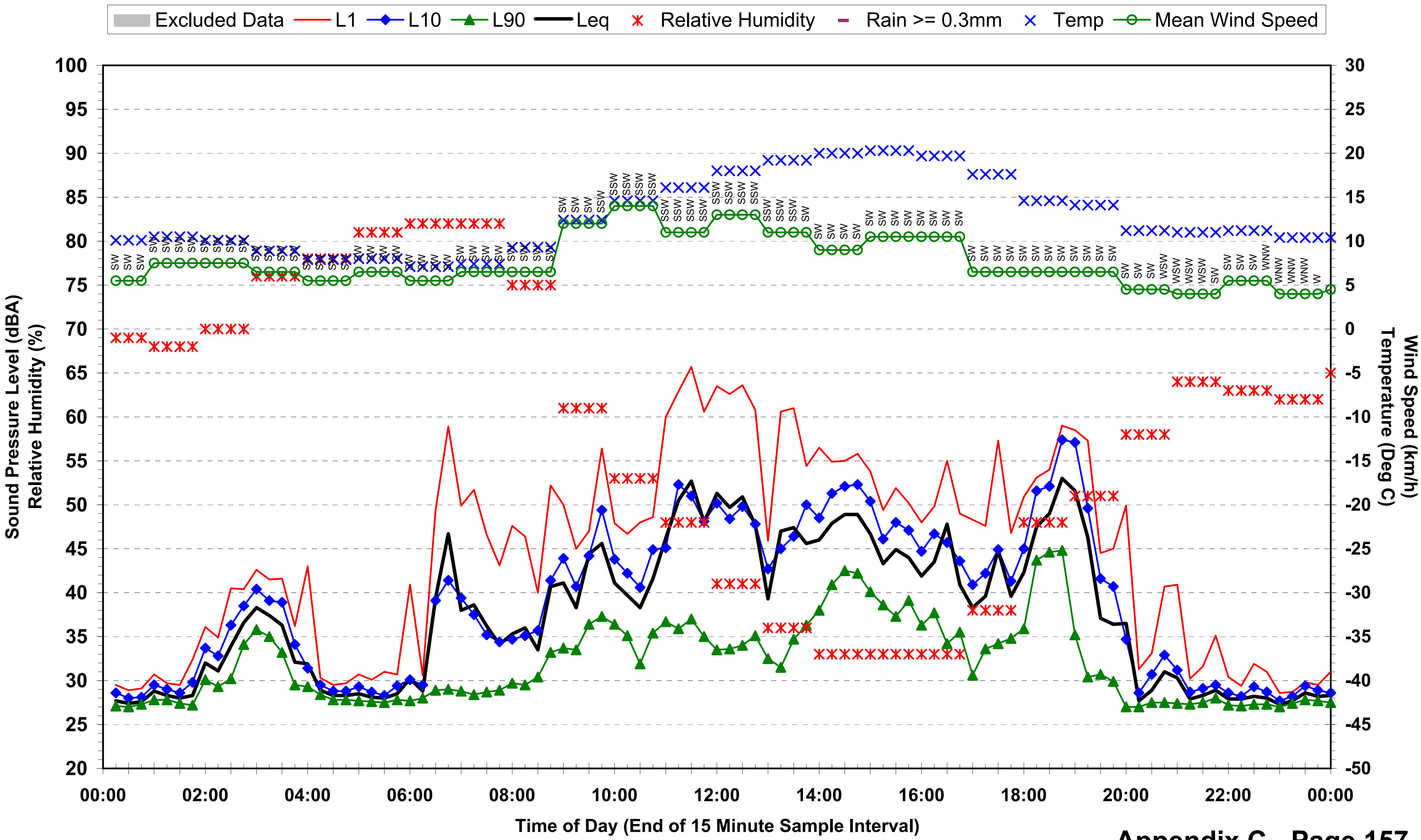

Statistical Ambient Noise Levels
20-2014 - Gas & Pipeline Site 7 - North of Biloela - Thursday 19 June 2008
Excluded Data
L1
L10
L90
Leq
Relative Humidity
Rain >= 0.3mm
Temp
Mean Wind Speed
Sound Pressure Level (dBA)
Relative Humidity (%)
Wind Speed (km/h)
Temperature (Deg C)
Time of Day (End of 15 Minute Sample Interval)

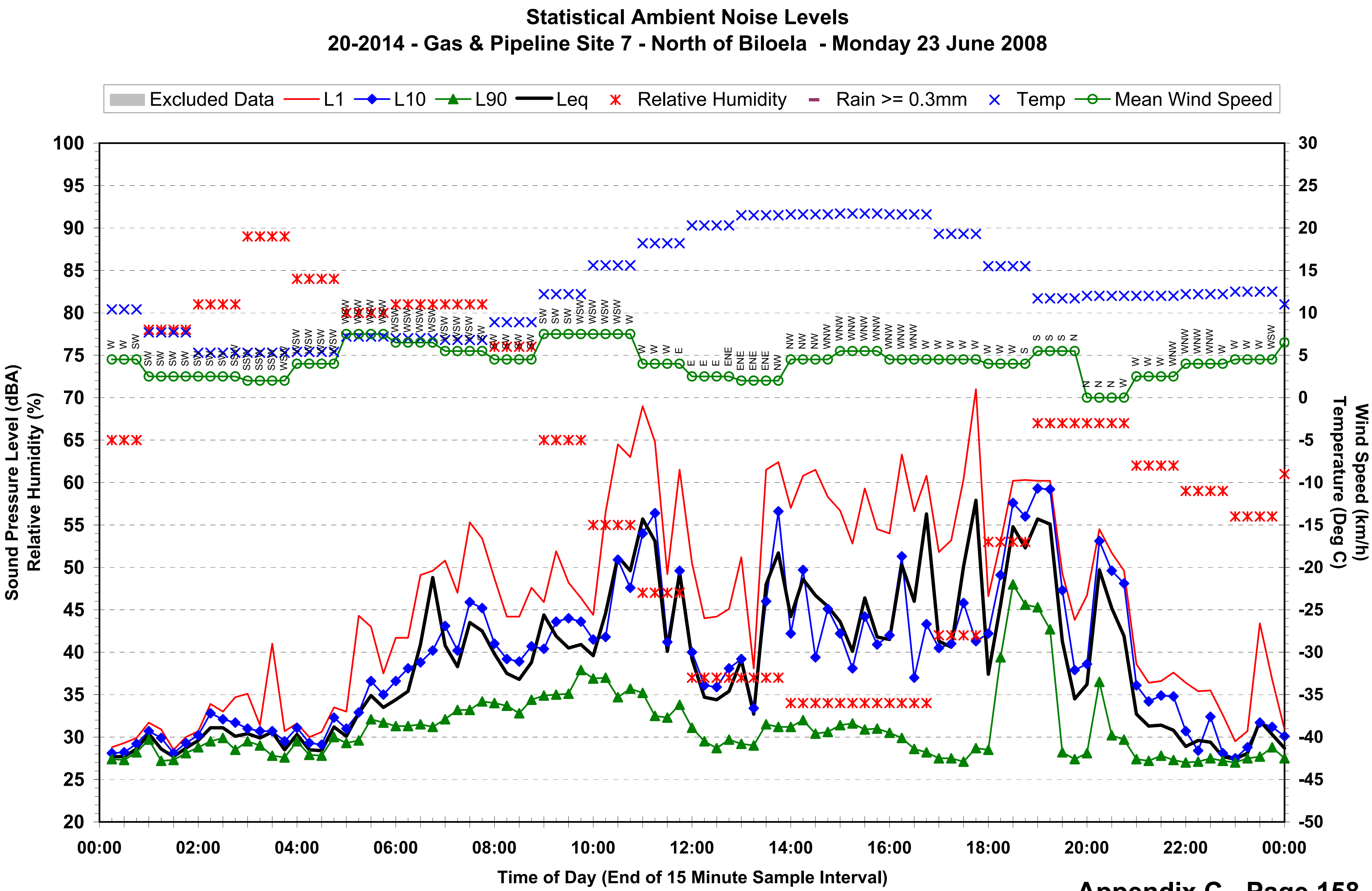
Statistical Ambient Noise Levels
20-2014 - Gas & Pipeline Site 7 - North of Biloela - Friday 20 June 2008




Statistical Ambient Noise Levels
20-2014 - Gas & Pipeline Site 7 - North of Biloela - Saturday 21 June 2008
Excluded Data
L1
L10
L90
Leq
Relative Humidity
Rain >= 0.3mm
Temp
Mean Wind Speed
Sound Pressure Level (dBA)
Relative Humidity (%)
Wind Speed (km/h)
Temperature (Deg C)
Time of Day (End of 15 Minute Sample Interval)

Statistical Ambient Noise Levels
20-2014 - Gas & Pipeline Site 7 - North of Biloela - Sunday 22 June 2008





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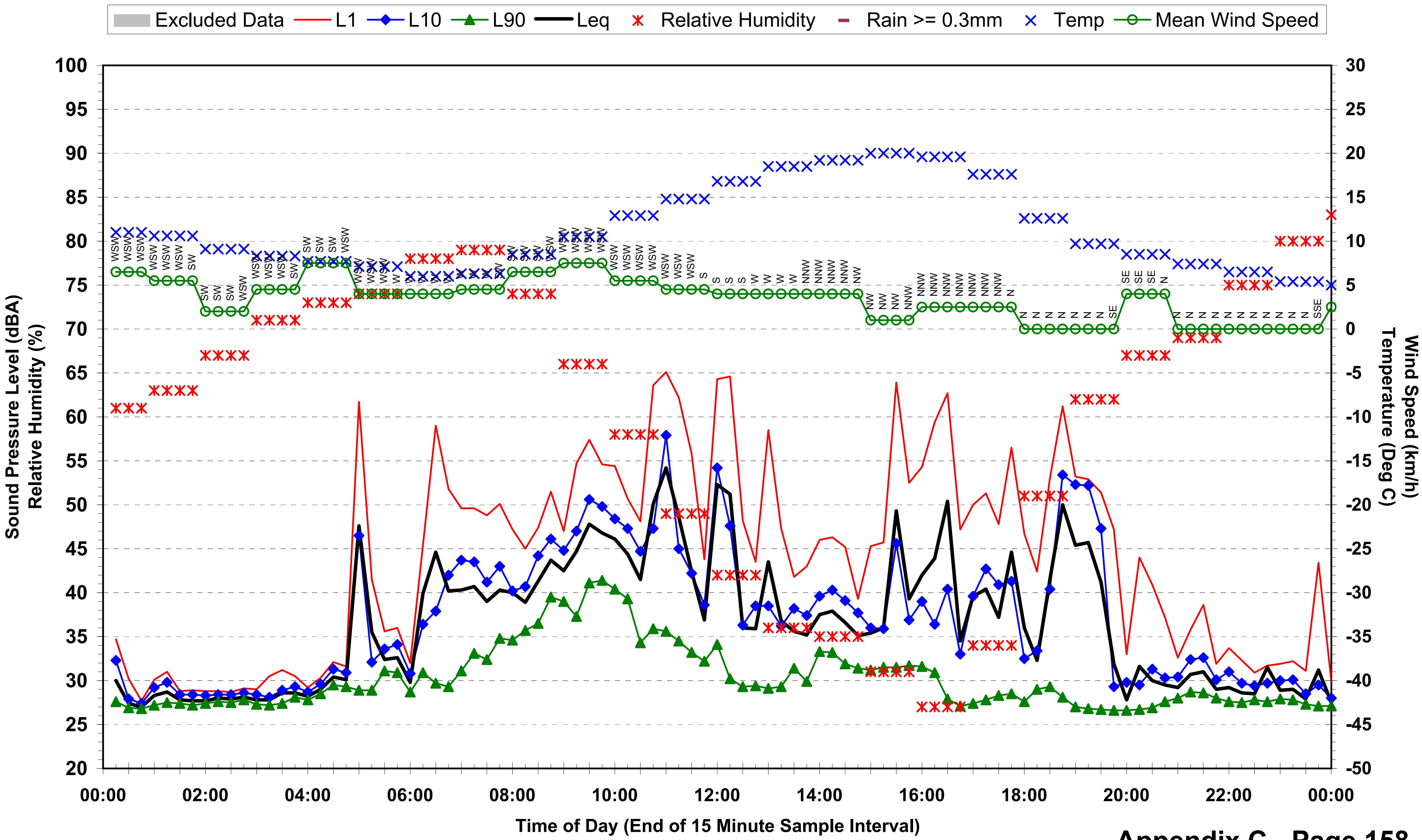
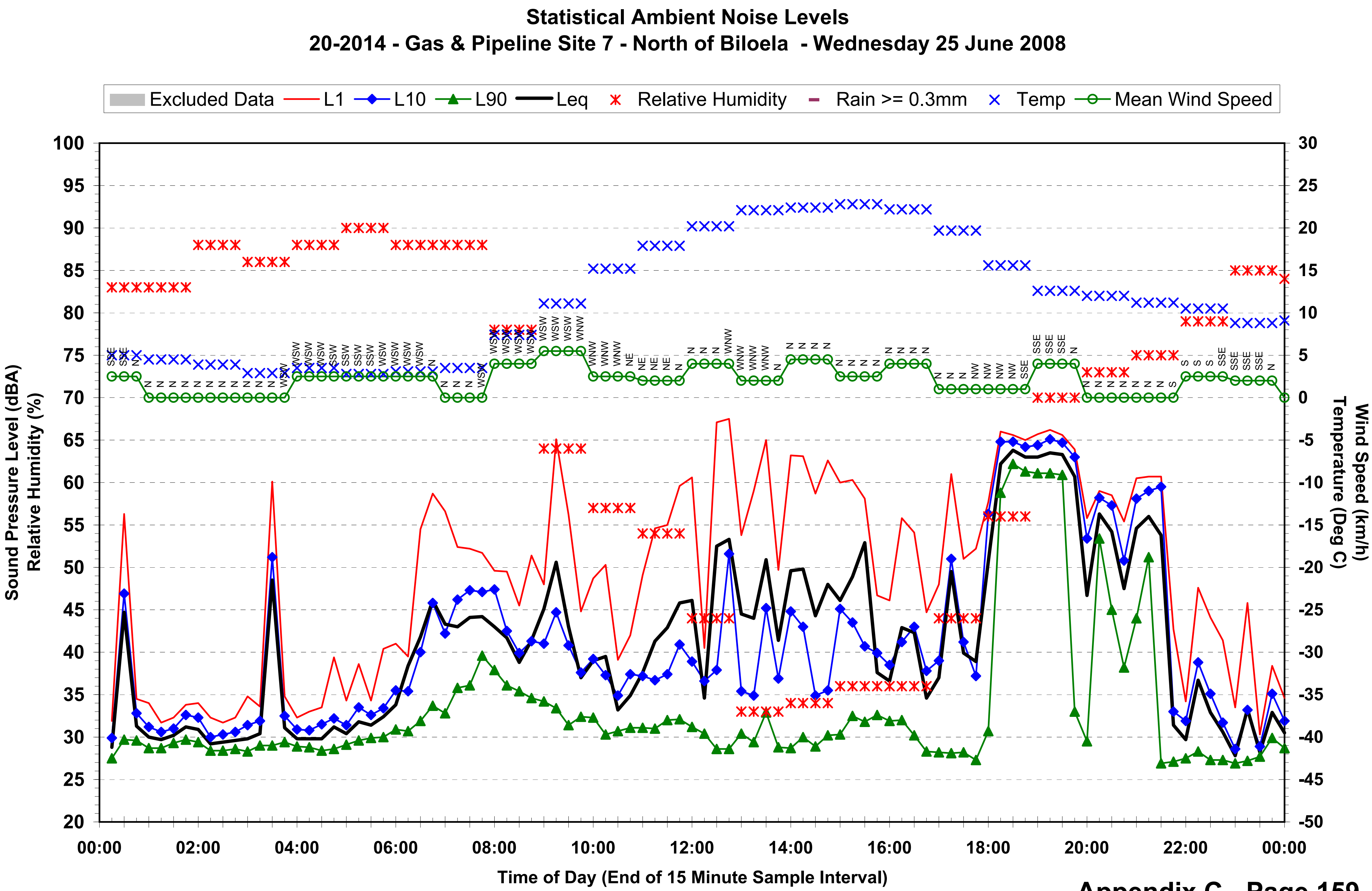
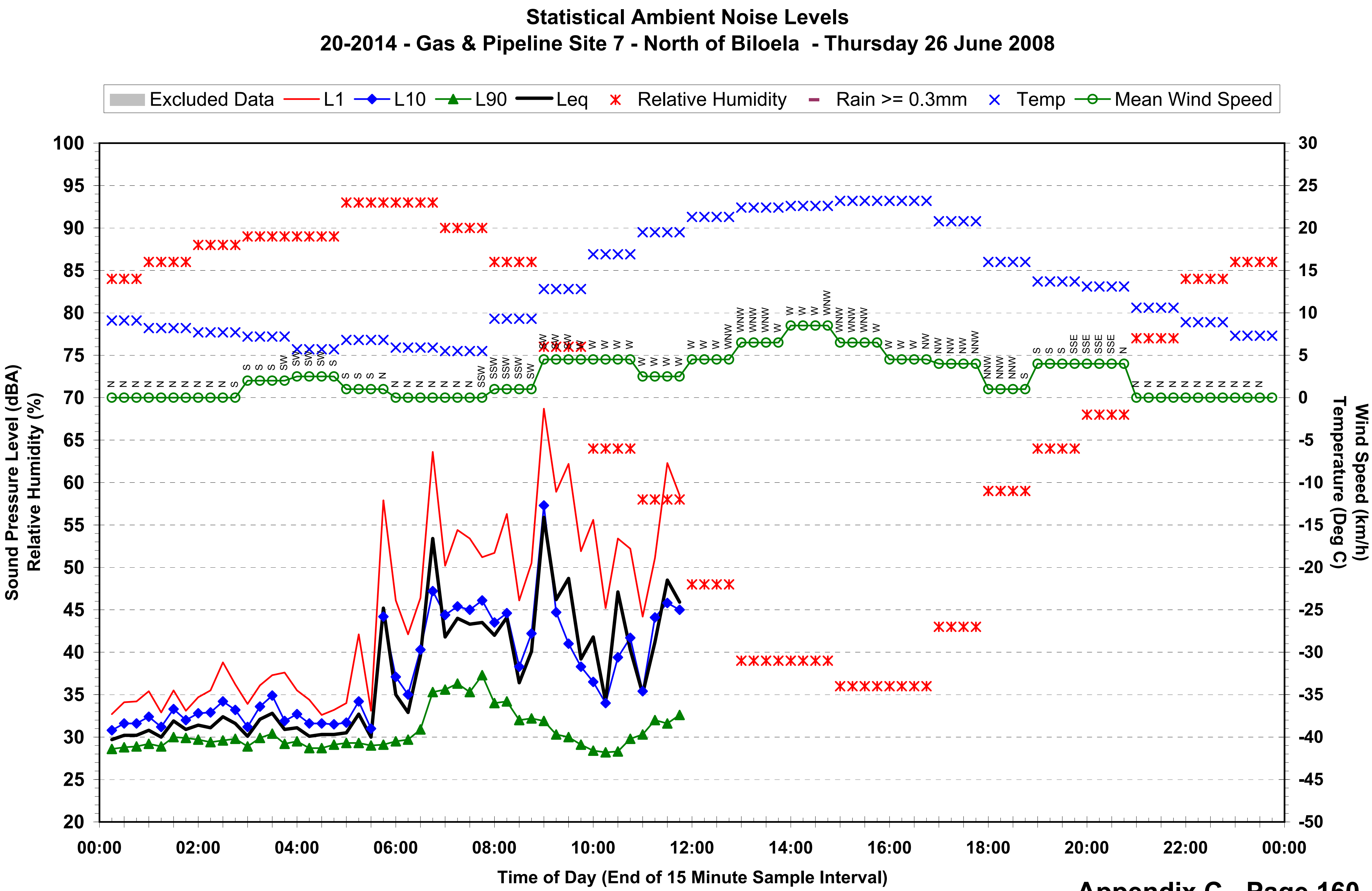
Statistical Ambient Noise Levels
20-2014 - Gas & Pipeline Site 7 - North of Biloela - Tuesday 24 June 2008





Statistical Ambient Noise Levels
20-2014 - Gas & Pipeline Site 7 - North of Biloela - Wednesday 25 June 2008
Excluded Data
L1
L10
L90
Leq
Relative Humidity
Rain >= 0.3mm
Temp
Mean Wind Speed
Sound Pressure Level (dBA)
Relative Humidity (%)
Wind Speed (km/h)
Temperature (Deg C)
Time of Day (End of 15 Minute Sample Interval)
00:00
02:00
04:00
06:00
08:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
00:00



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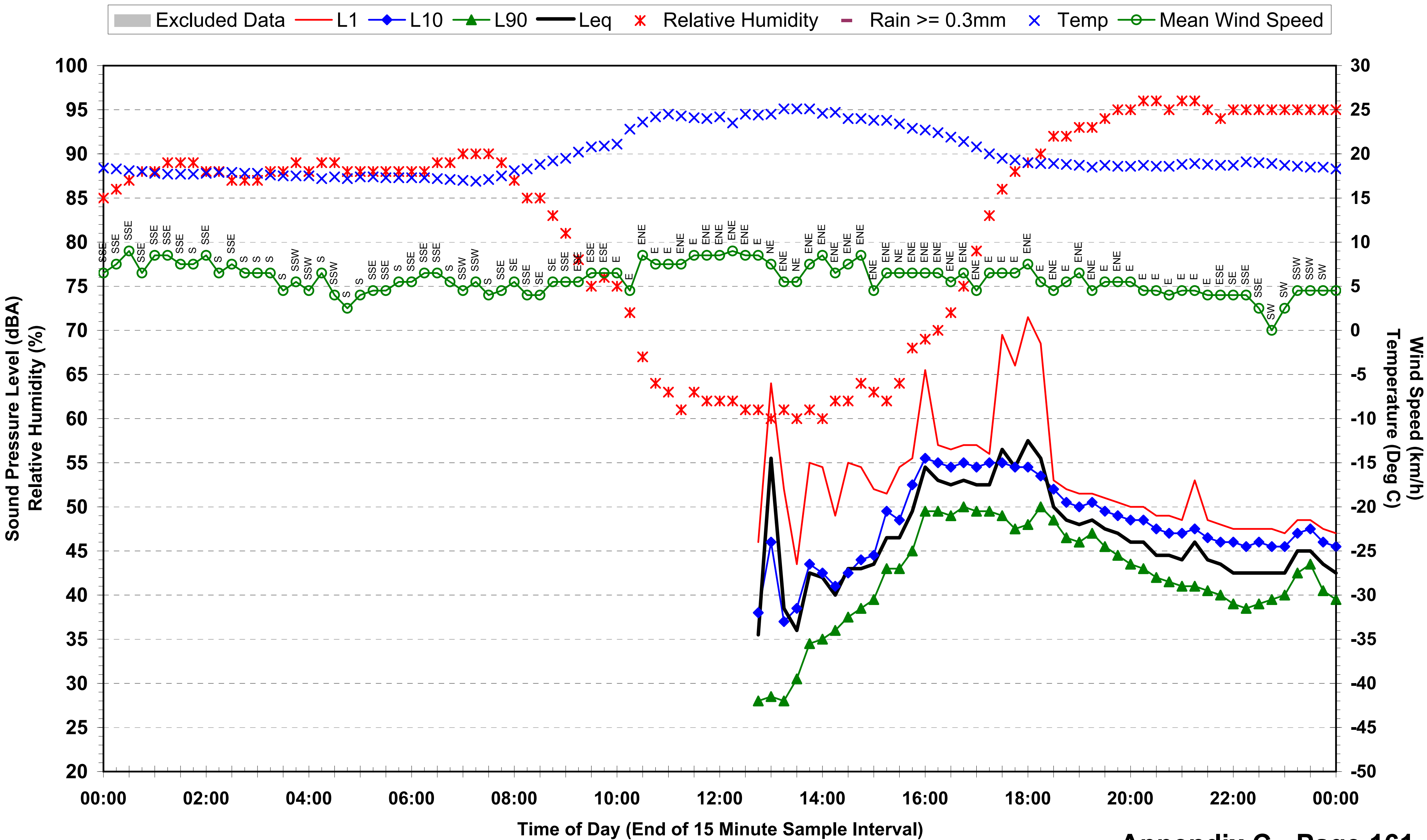
Ambient Conditions
RHA Report 20-2014

Statistical Ambient Noise Levels
20-2014 - Gas & Pipeline Site 8 - West of Gladstone - Thursday 19 June 2008



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Ambient Conditions

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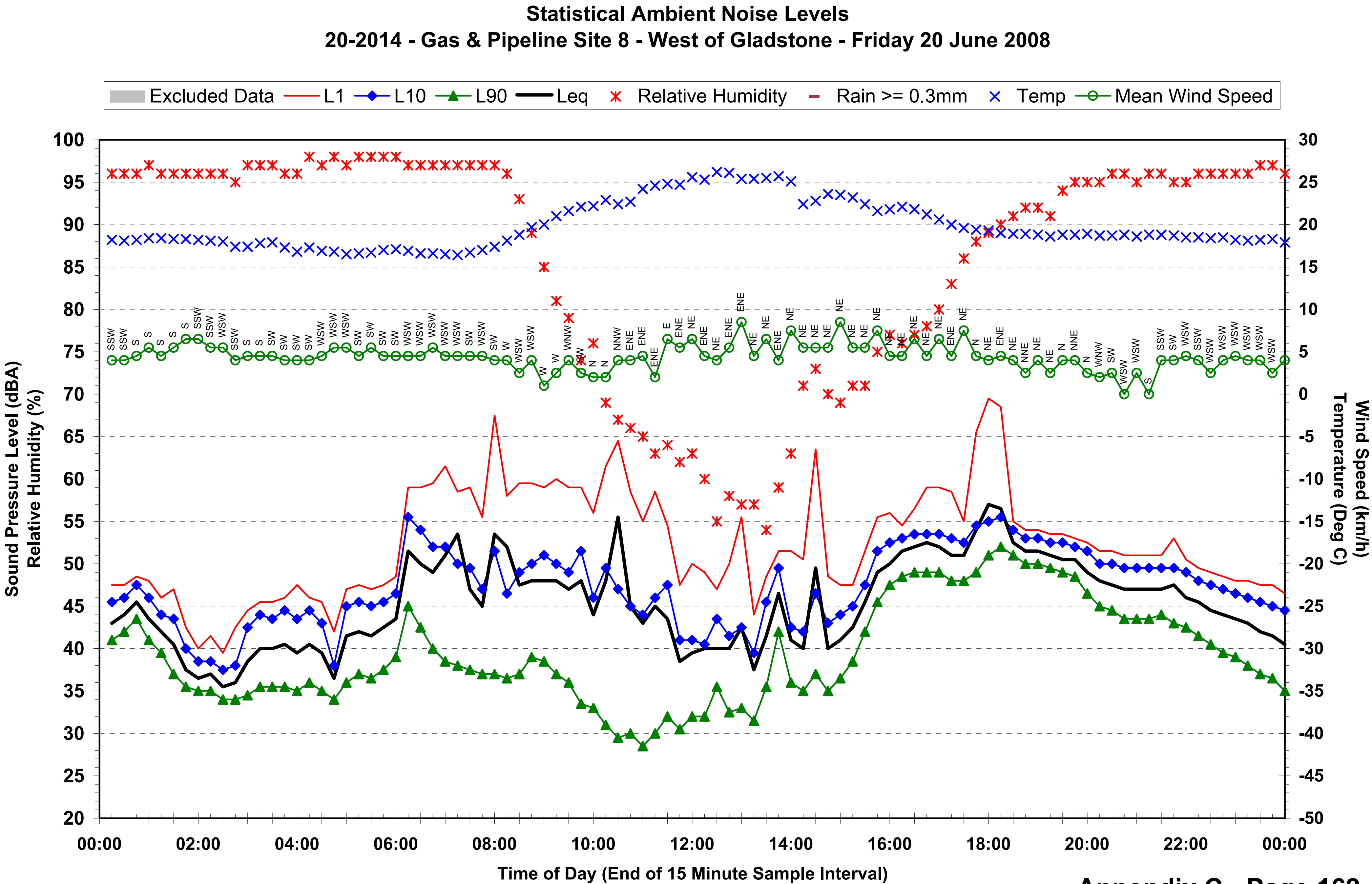
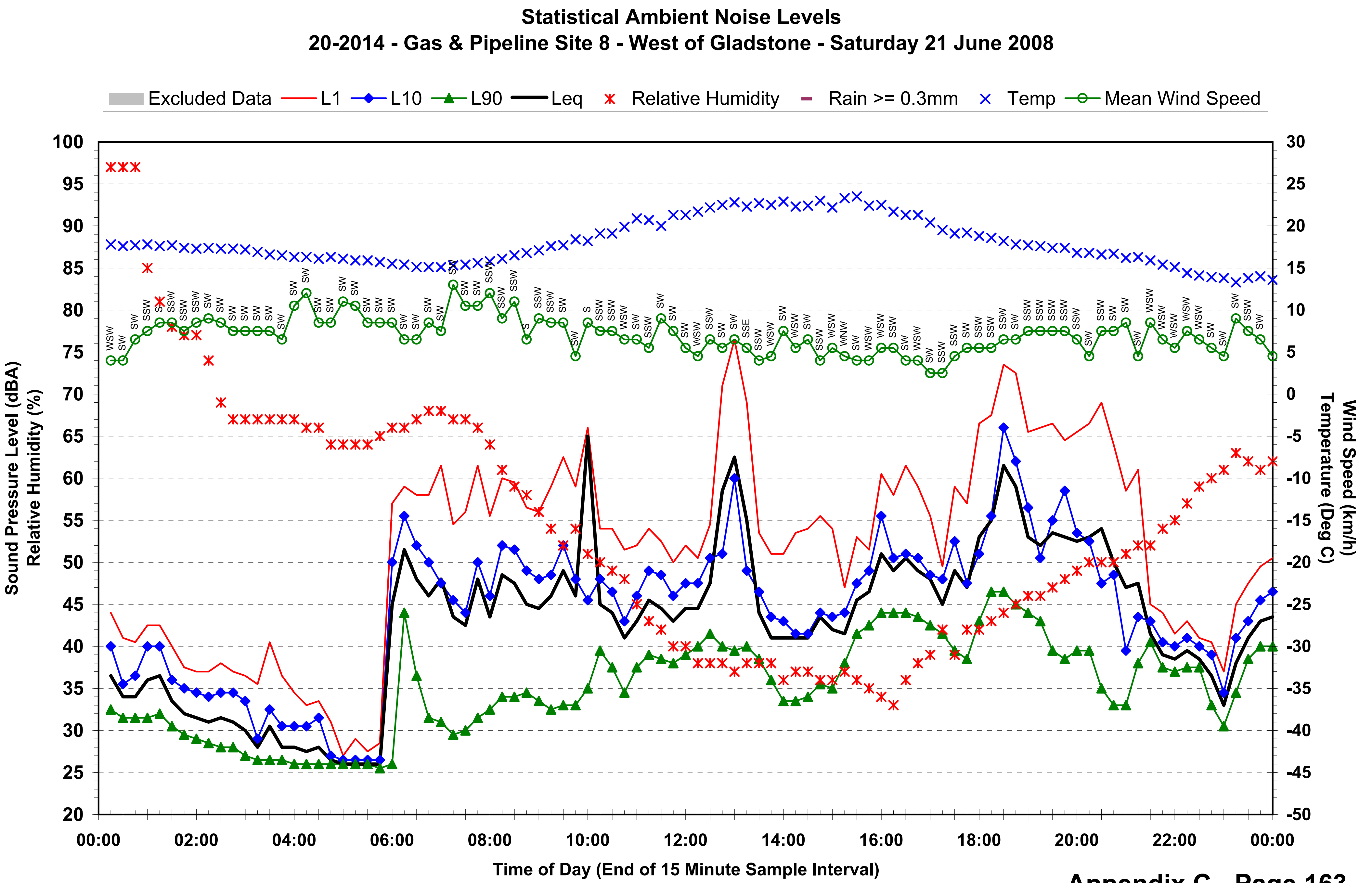
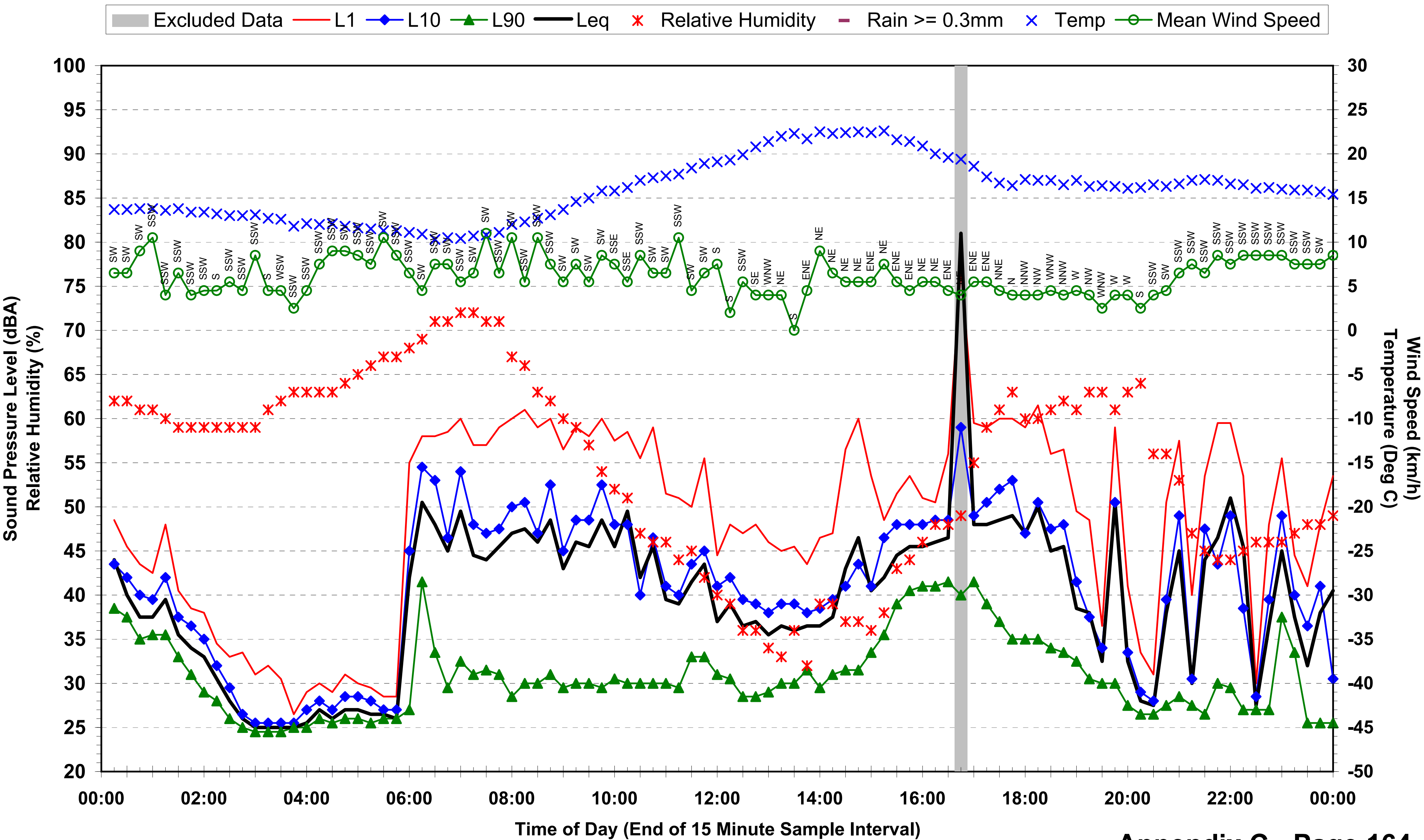
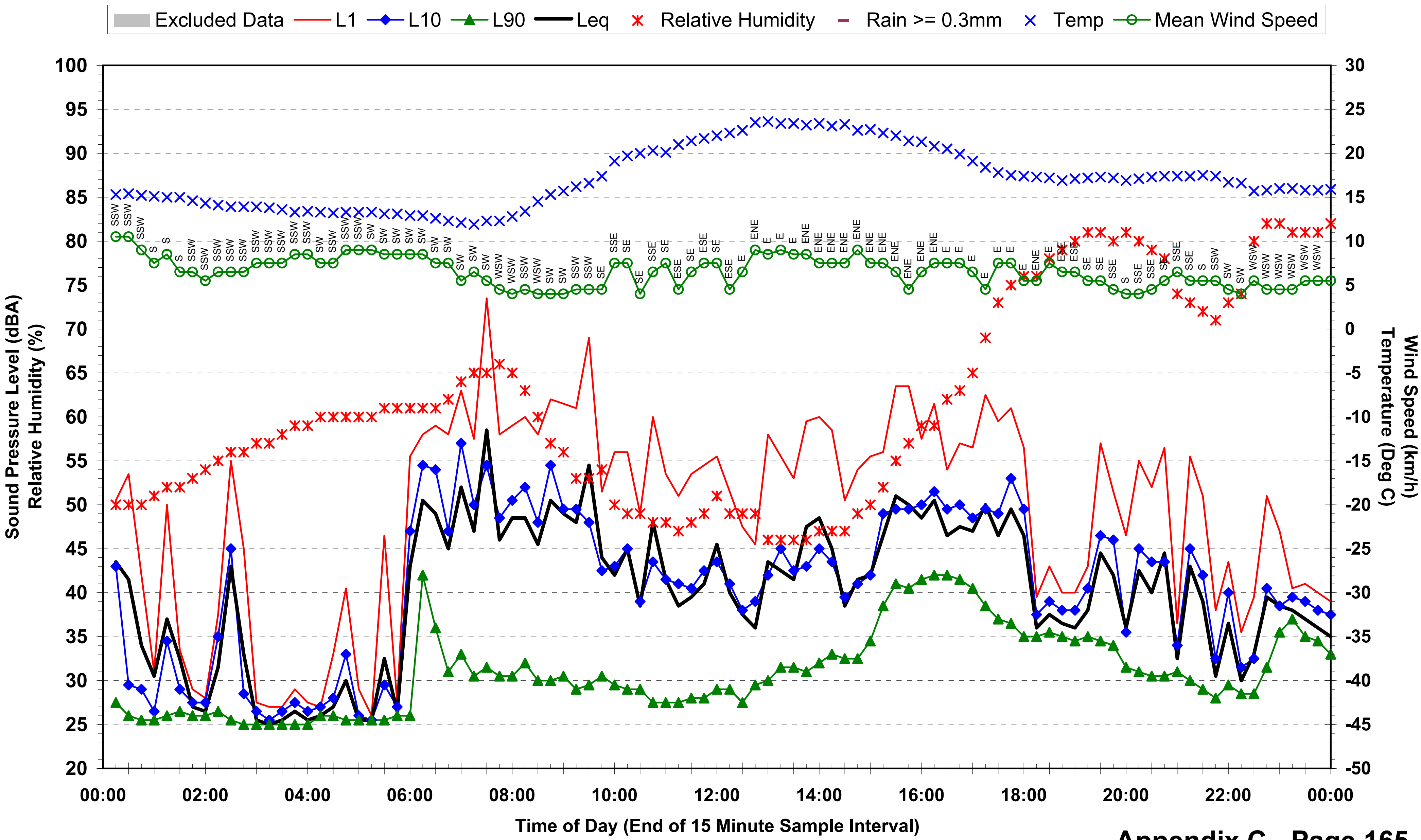

Statistical Ambient Noise Levels
20-2014 - Gas & Pipeline Site 8 - West of Gladstone - Friday 20 June 2008
Excluded Data
L1
L10
L90
Leq
Relative Humidity
Rain >= 0.3mm
Temp
Mean Wind Speed
Sound Pressure Level (dBA)
Relative Humidity (%)
Wind Speed (km/h)
Temperature (Deg C)
Time of Day (End of 15 Minute Sample Interval)
00:00
02:00
04:00
06:00
08:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
00:00


Statistical Ambient Noise Levels
20-2014 - Gas & Pipeline Site 8 - West of Gladstone - Saturday 21 June 2008
Excluded Data
L1
L10
L90
Leq
Relative Humidity
Rain >= 0.3mm
Temp
Mean Wind Speed
Sound Pressure Level (dBA)
Relative Humidity (%)
Wind Speed (km/h)
Temperature (Deg C)
Time of Day (End of 15 Minute Sample Interval)

Statistical Ambient Noise Levels
20-2014 - Gas & Pipeline Site 8 - West of Gladstone - Sunday 22 June 2008

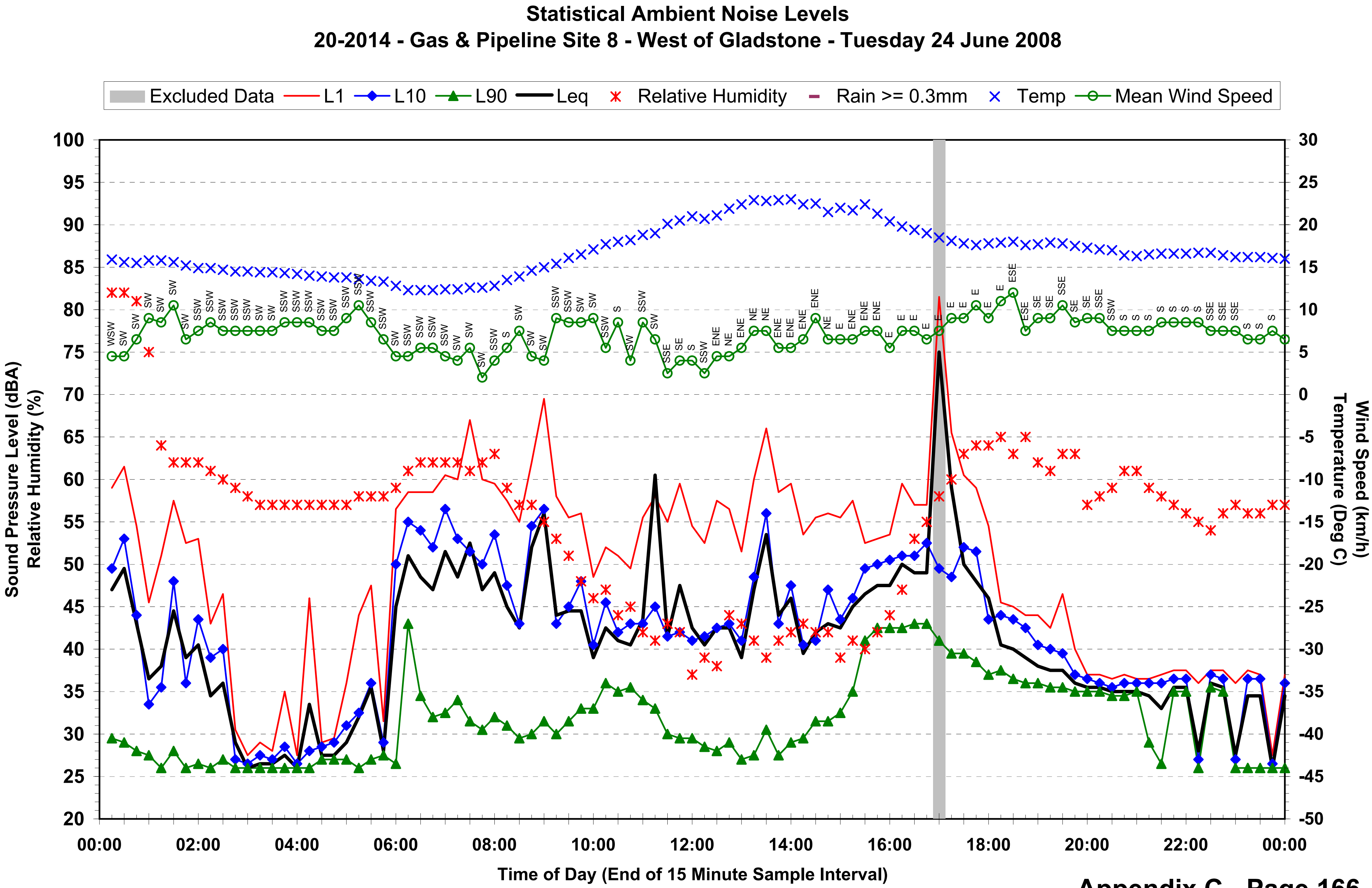


Statistical Ambient Noise Levels
20-2014 - Gas & Pipeline Site 8 - West of Gladstone - Monday 23 June 2008

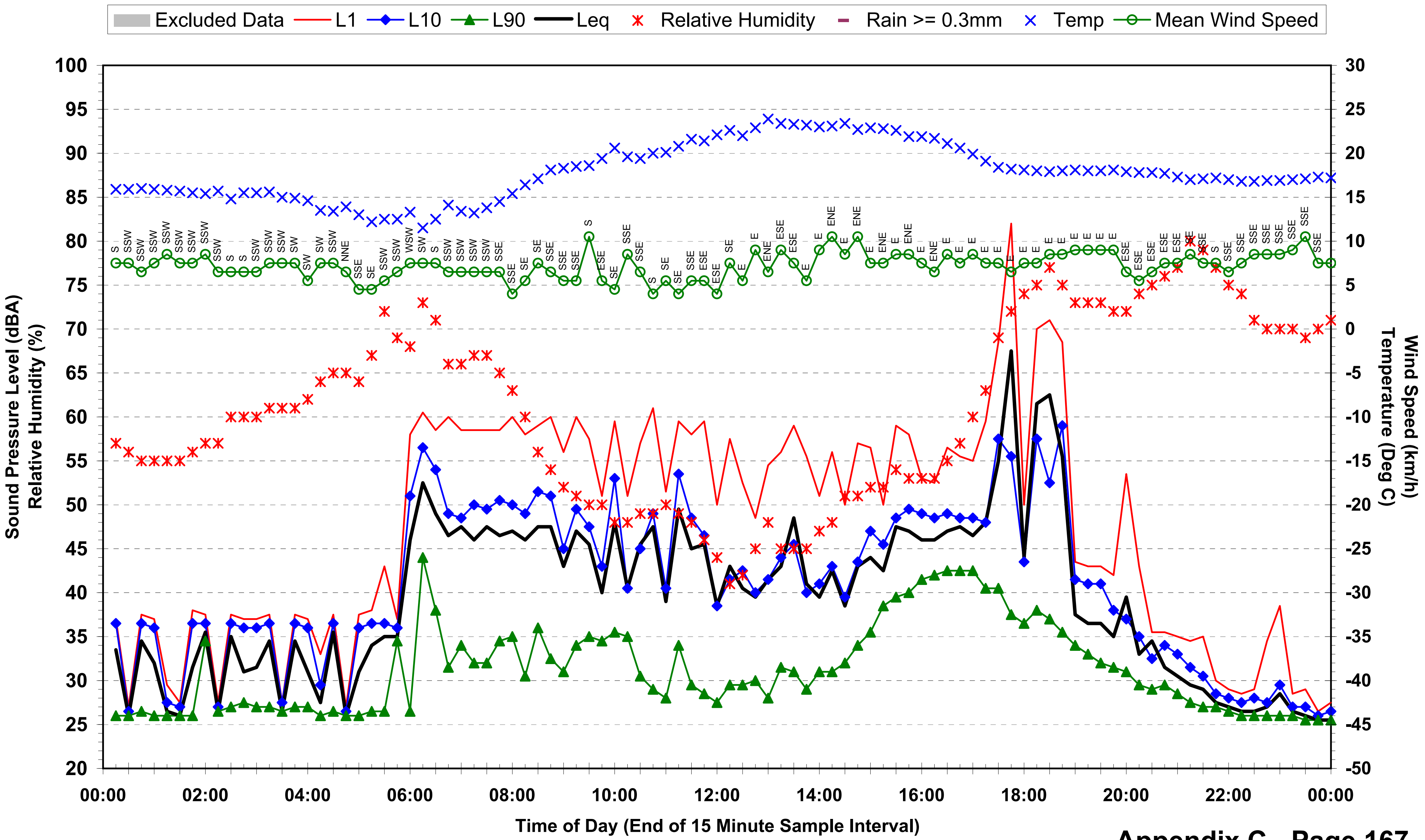


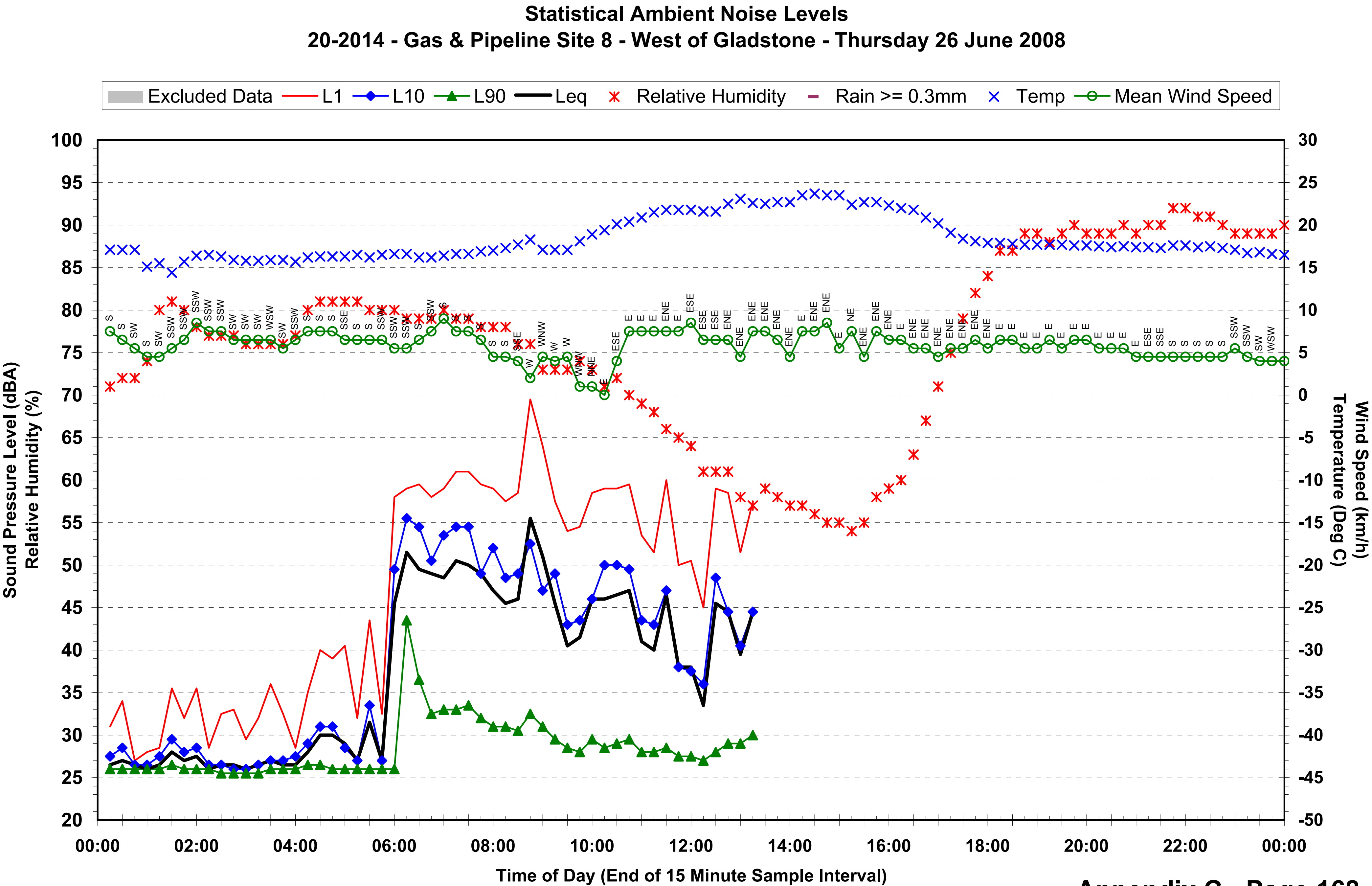
Ambient Conditions

RHA Report 20-2014


Statistical Ambient Noise Levels
20-2014 - Gas & Pipeline Site 8 - West of Gladstone - Tuesday 24 June 2008
Excluded Data
L1
L10
L90
Leq
Relative Humidity
Rain >= 0.3mm
Temp
Mean Wind Speed
Sound Pressure Level (dBA)
Relative Humidity (%)
Wind Speed (km/h)
Temperature (Deg C)
Time of Day (End of 15 Minute Sample Interval)

Statistical Ambient Noise Levels
20-2014 - Gas & Pipeline Site 8 - West of Gladstone - Wednesday 25 June 2008





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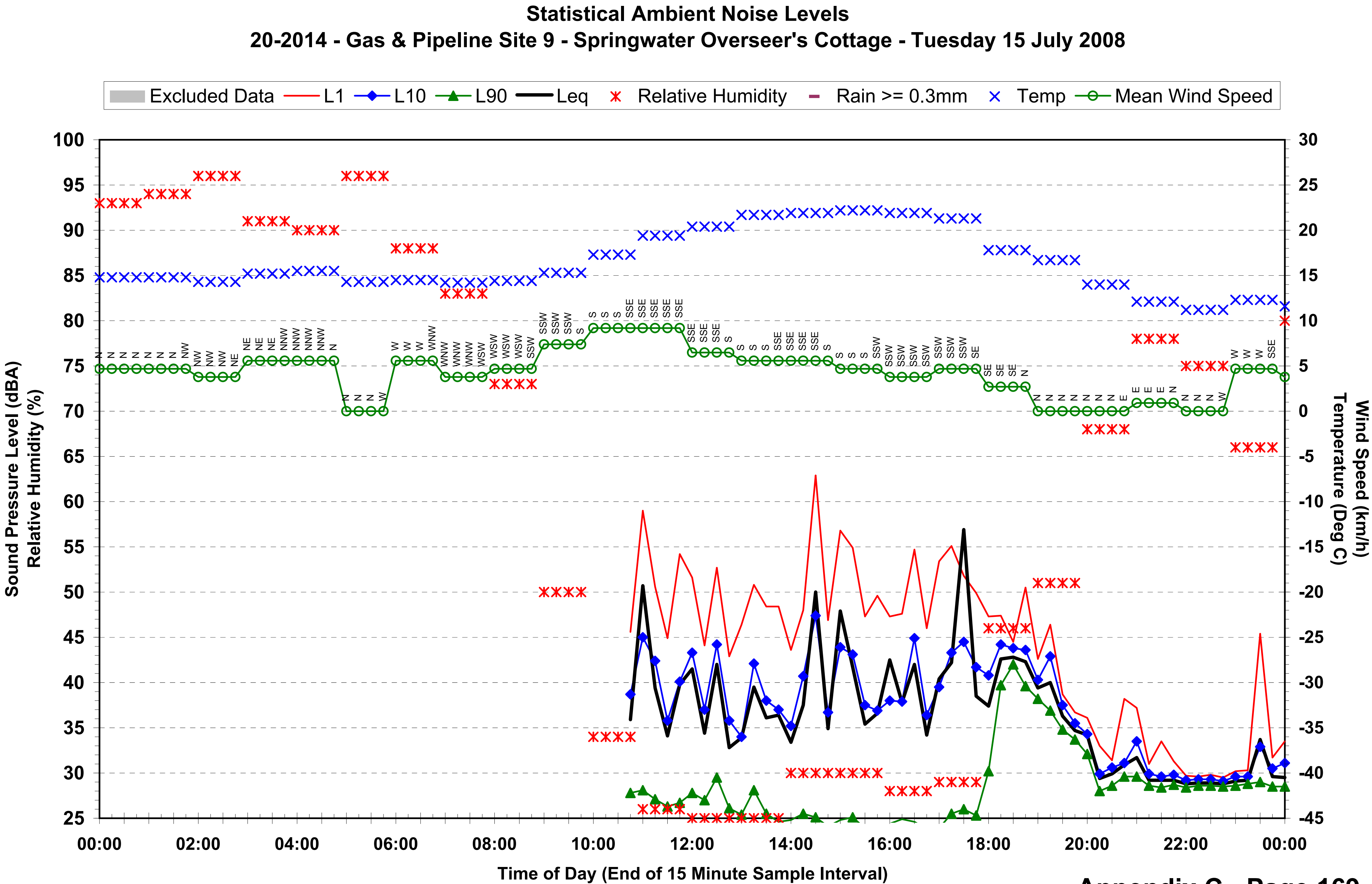

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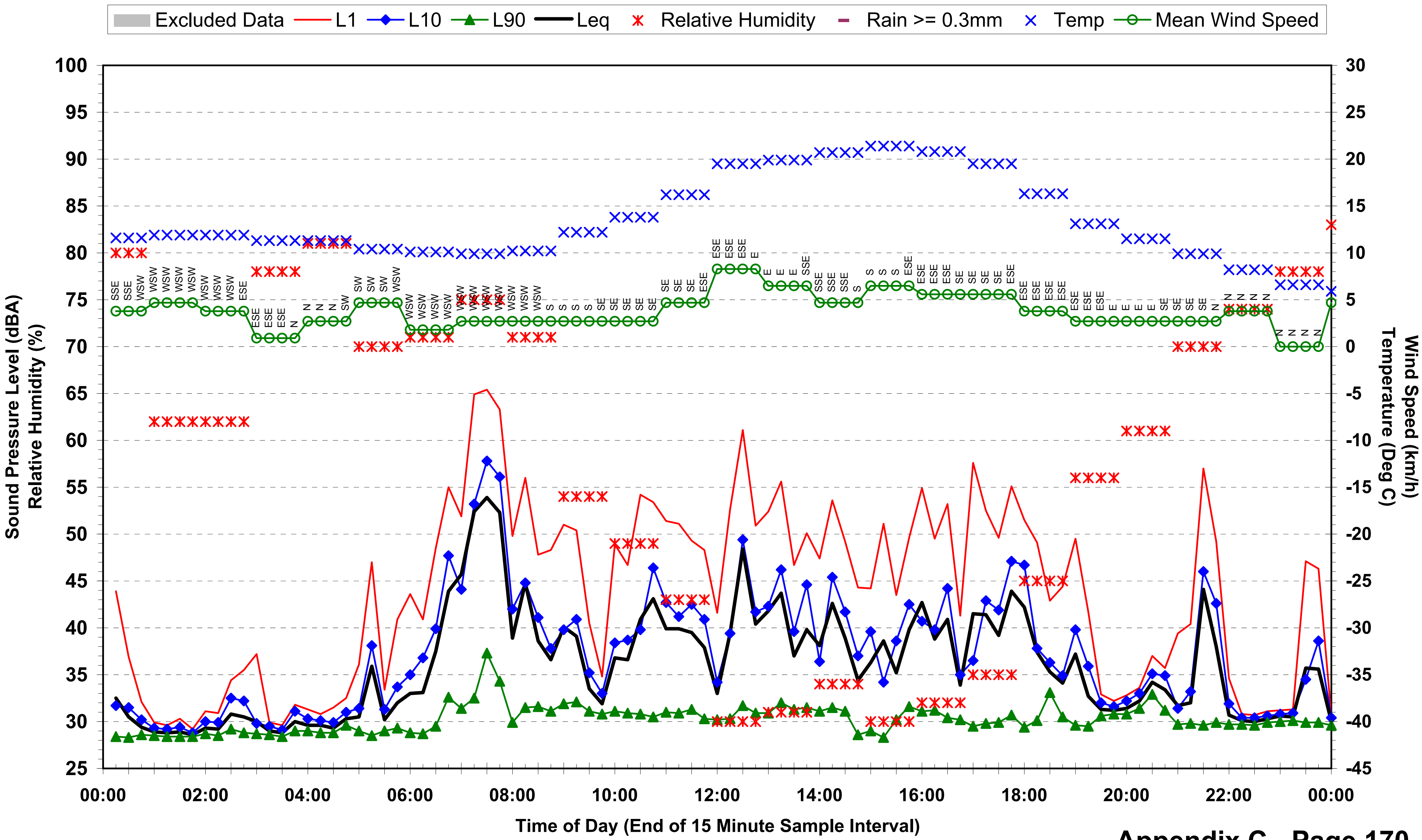
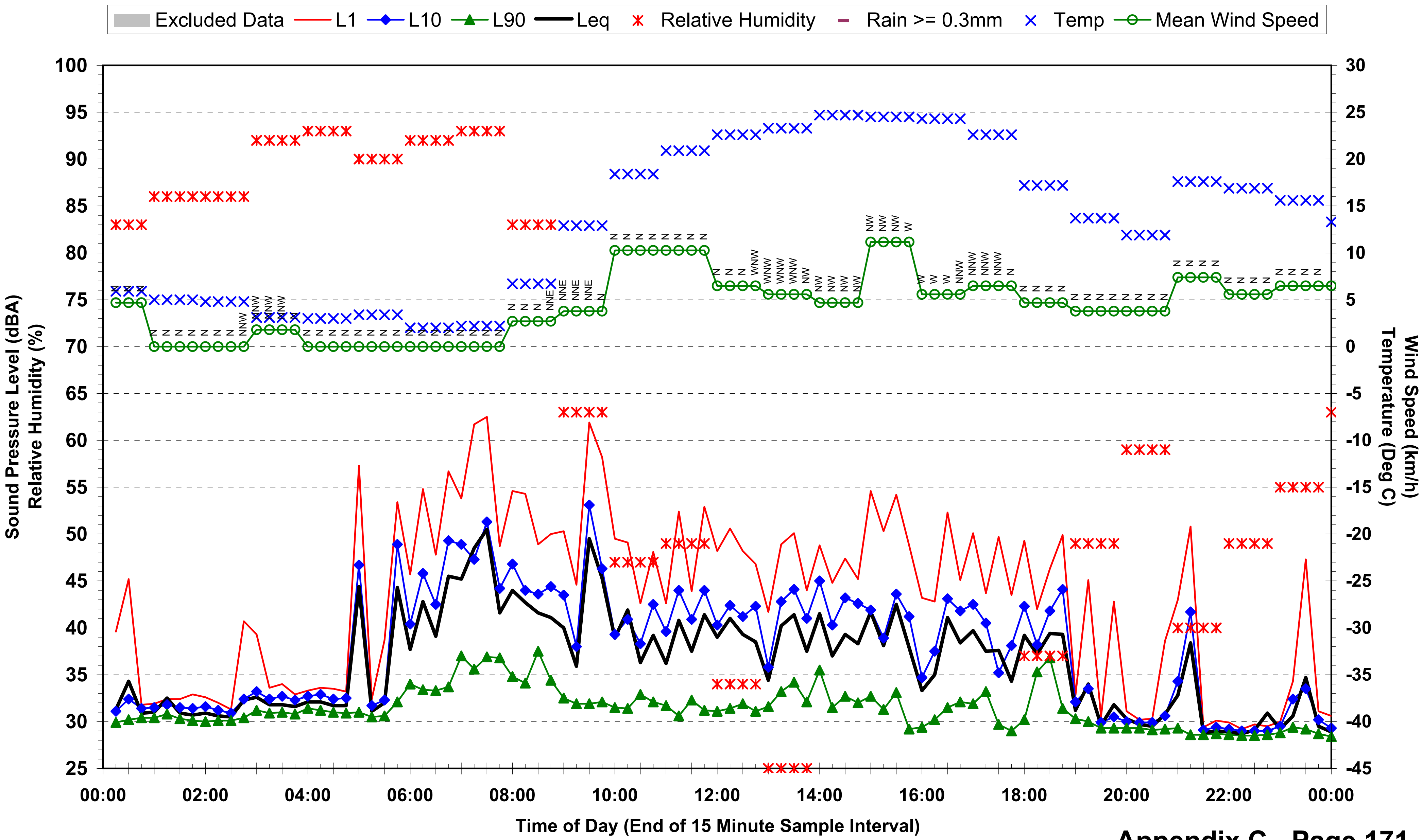
Statistical Ambient Noise Levels
20-2014 - Gas & Pipeline Site 9 - Springwater Overseer's Cottage - Wednesday 16 July 2008

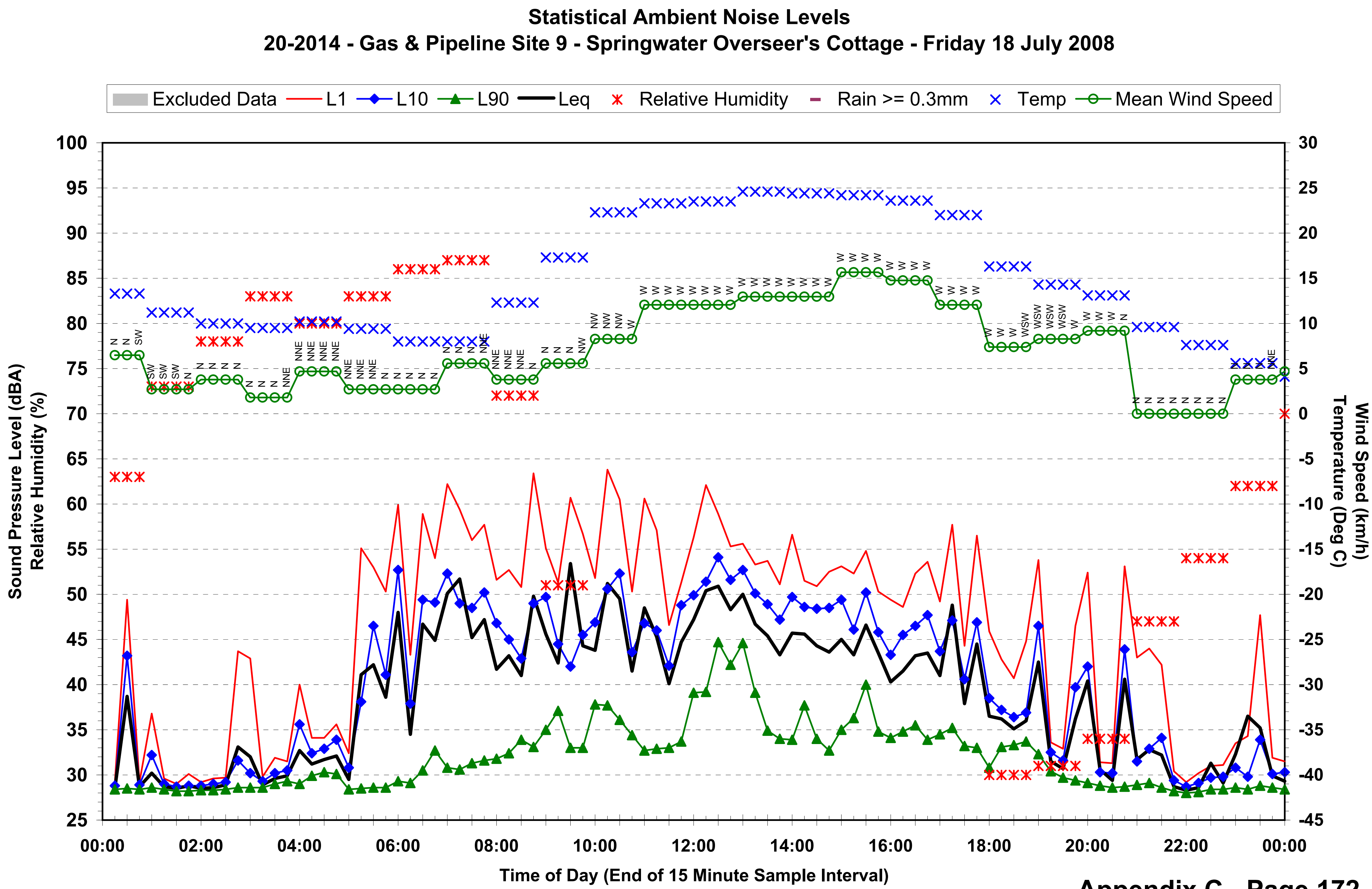


Ambient Conditions

RHA Report 20-2014

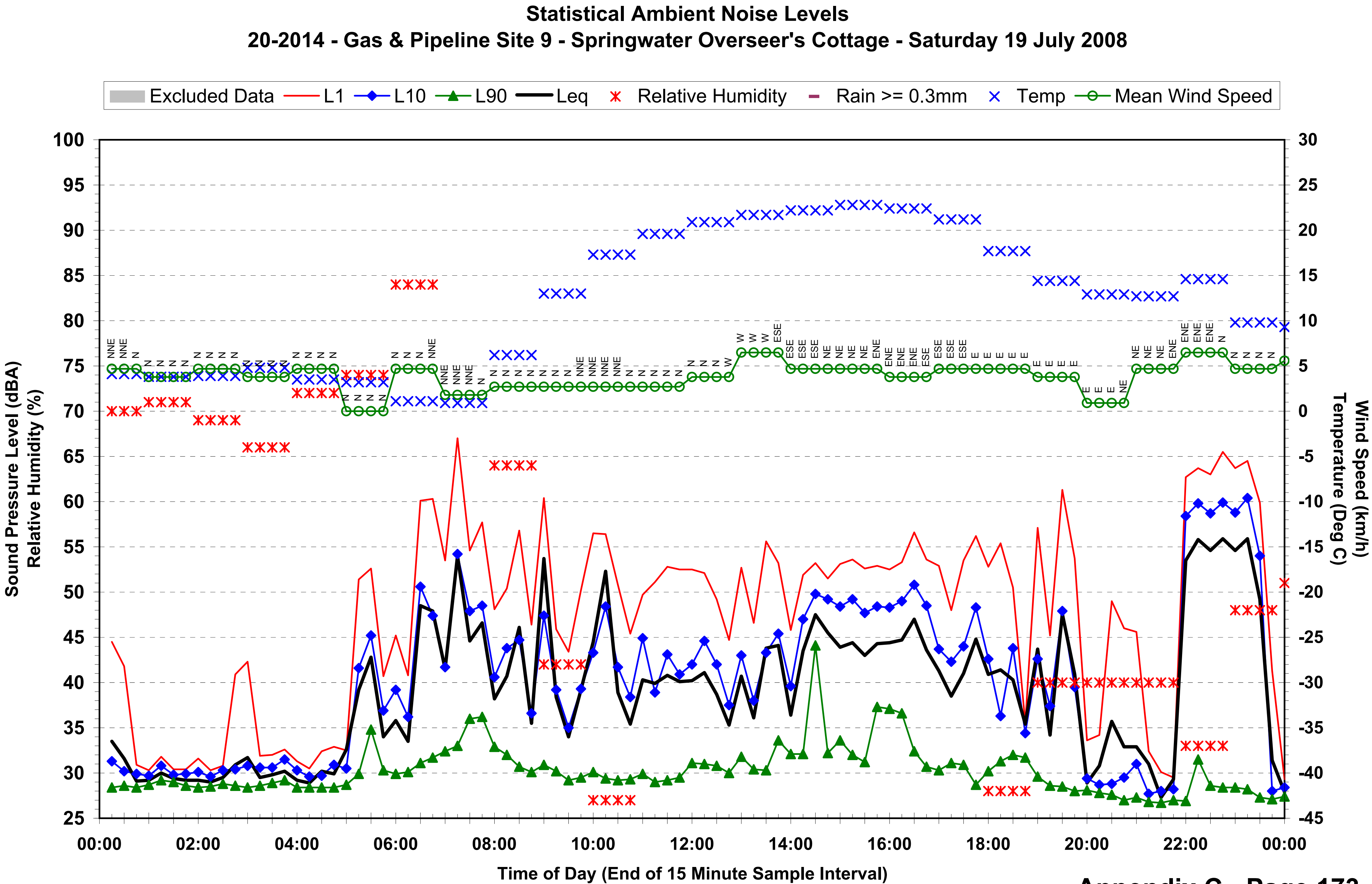
Statistical Ambient Noise Levels
20-2014 - Gas & Pipeline Site 9 - Springwater Overseer's Cottage - Thursday 17 July 2008





Ambient Conditions

RHA Report 20-2014



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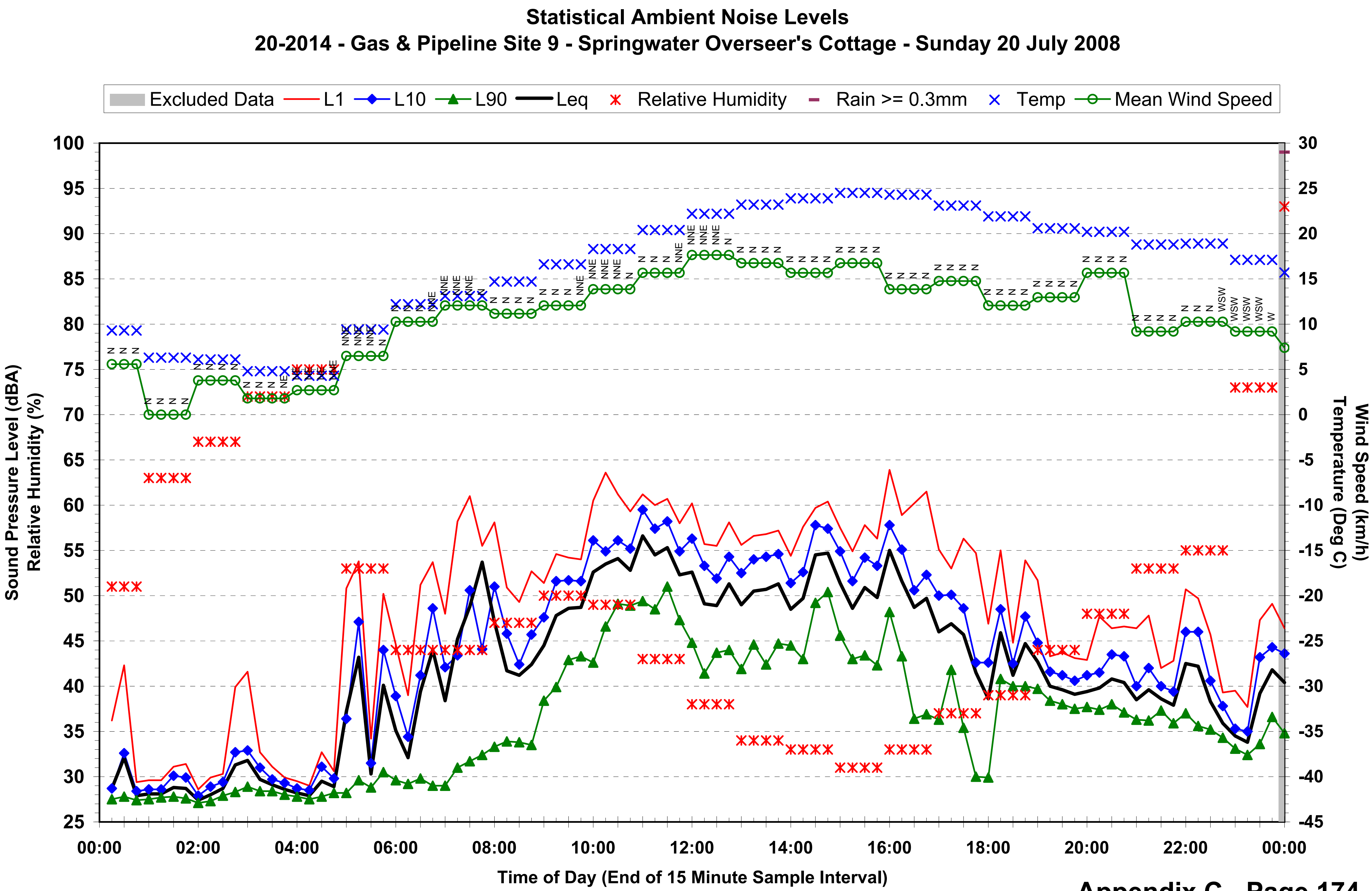

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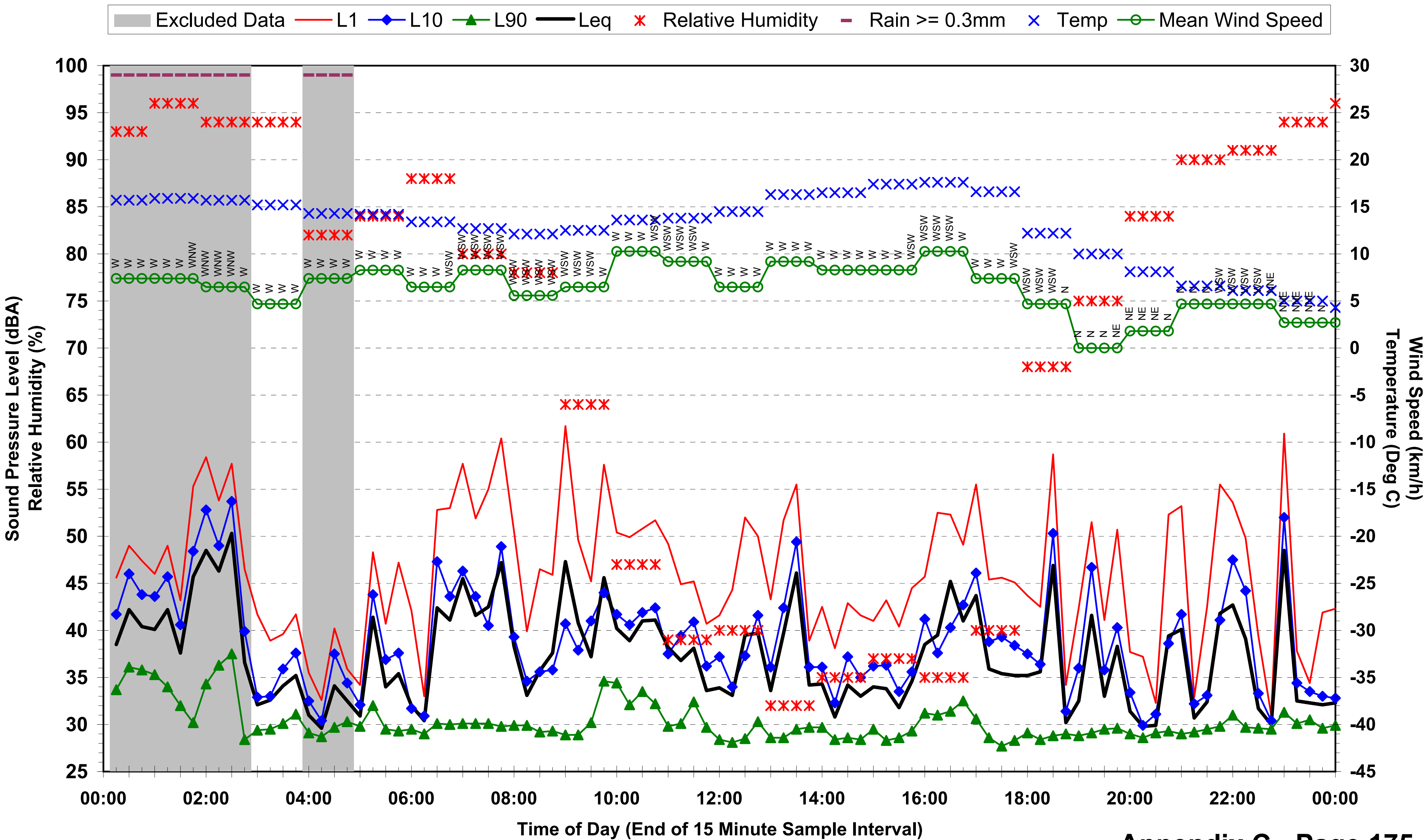
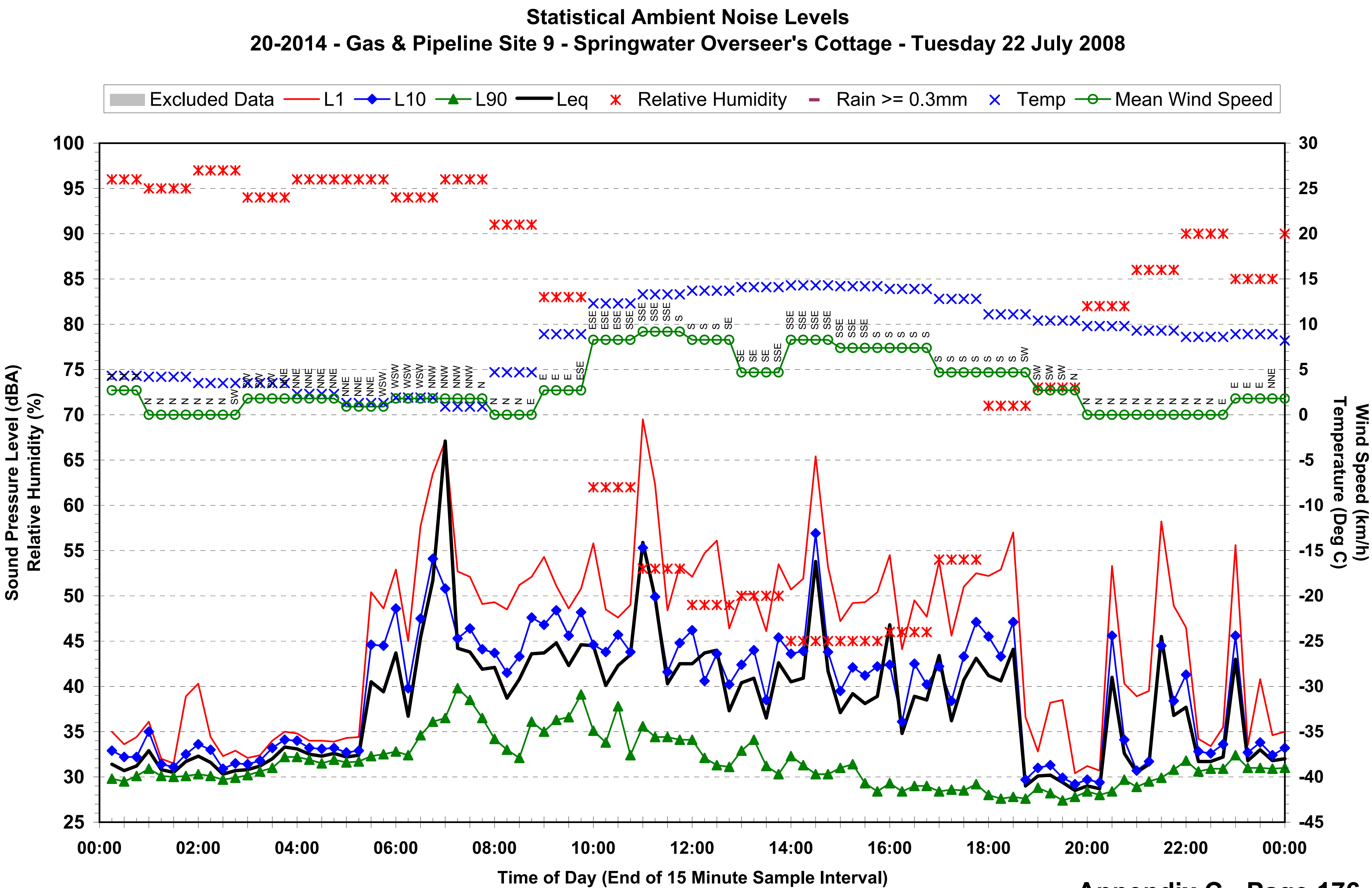
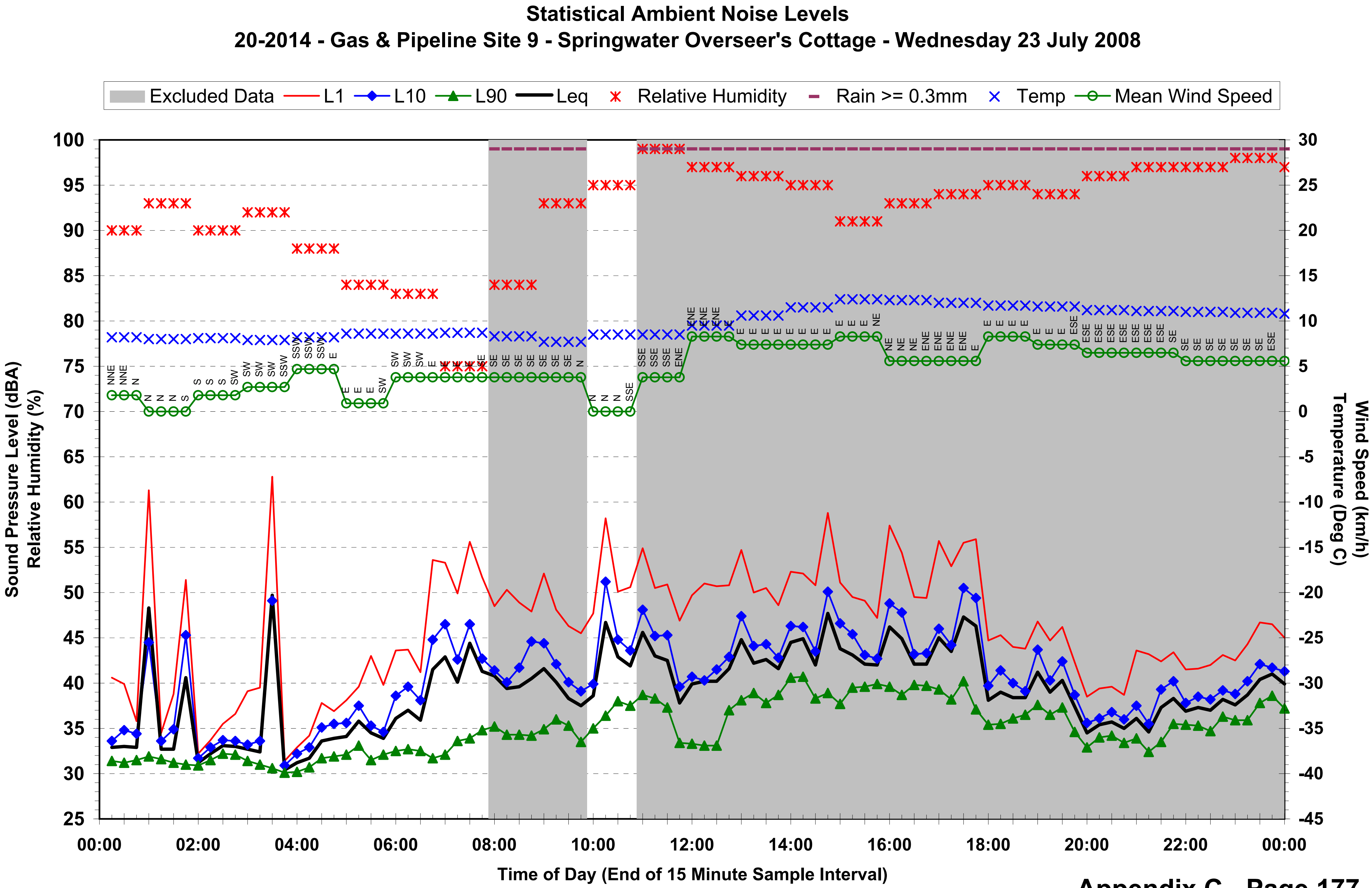
Ambient Conditions

RHA Report 20-2014

Statistical Ambient Noise Levels
20-2014 - Gas & Pipeline Site 9 - Springwater Overseer's Cottage - Monday 21 July 2008




Statistical Ambient Noise Levels
20-2014 - Gas & Pipeline Site 9 - Springwater Overseer's Cottage - Tuesday 22 July 2008
Excluded Data
L1
L10
L90
Leq
Relative Humidity
Rain >= 0.3mm
Temp
Mean Wind Speed
Sound Pressure Level (dBA)
Relative Humidity (%)
Wind Speed (km/h)
Temperature (Deg C)
Time of Day (End of 15 Minute Sample Interval)



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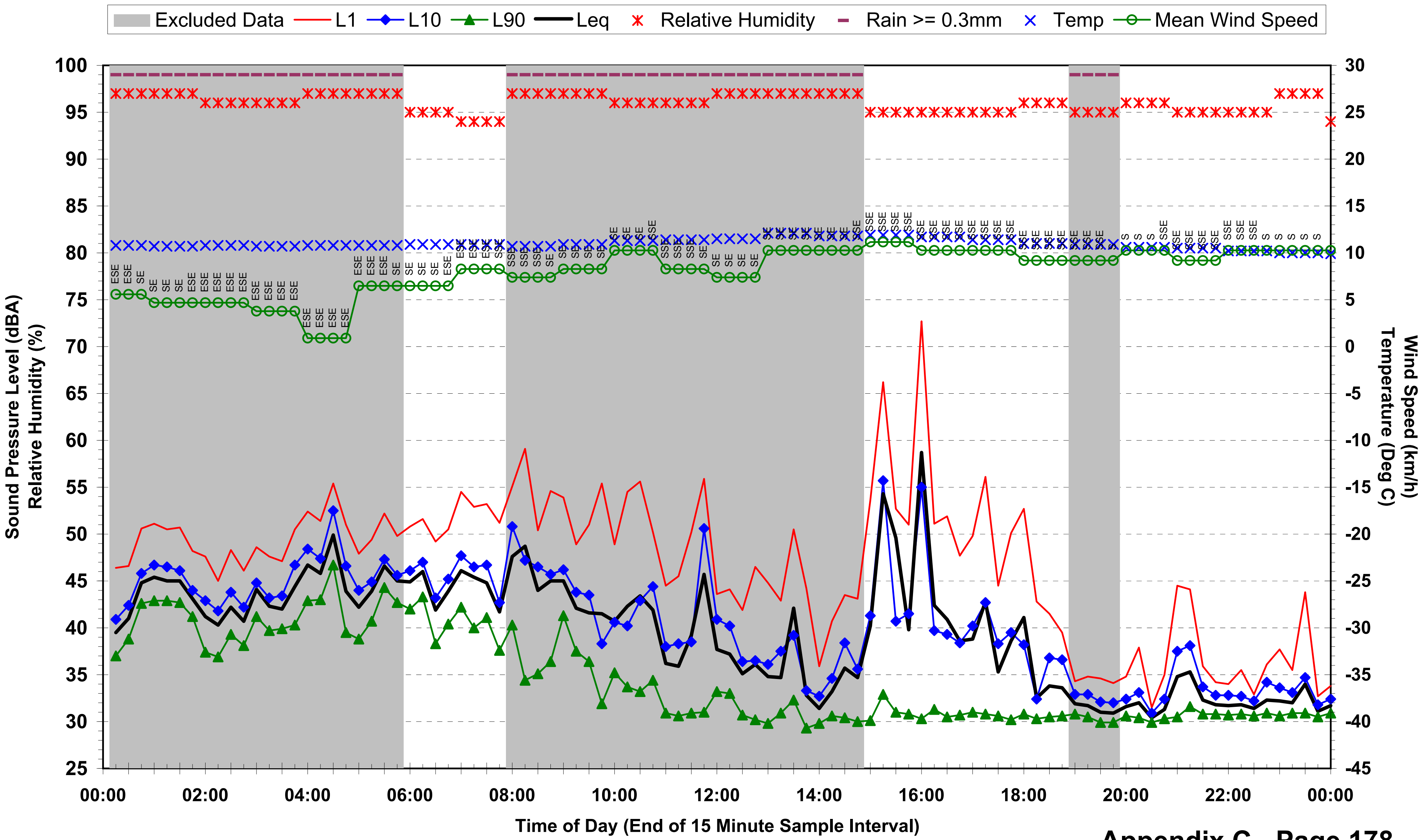
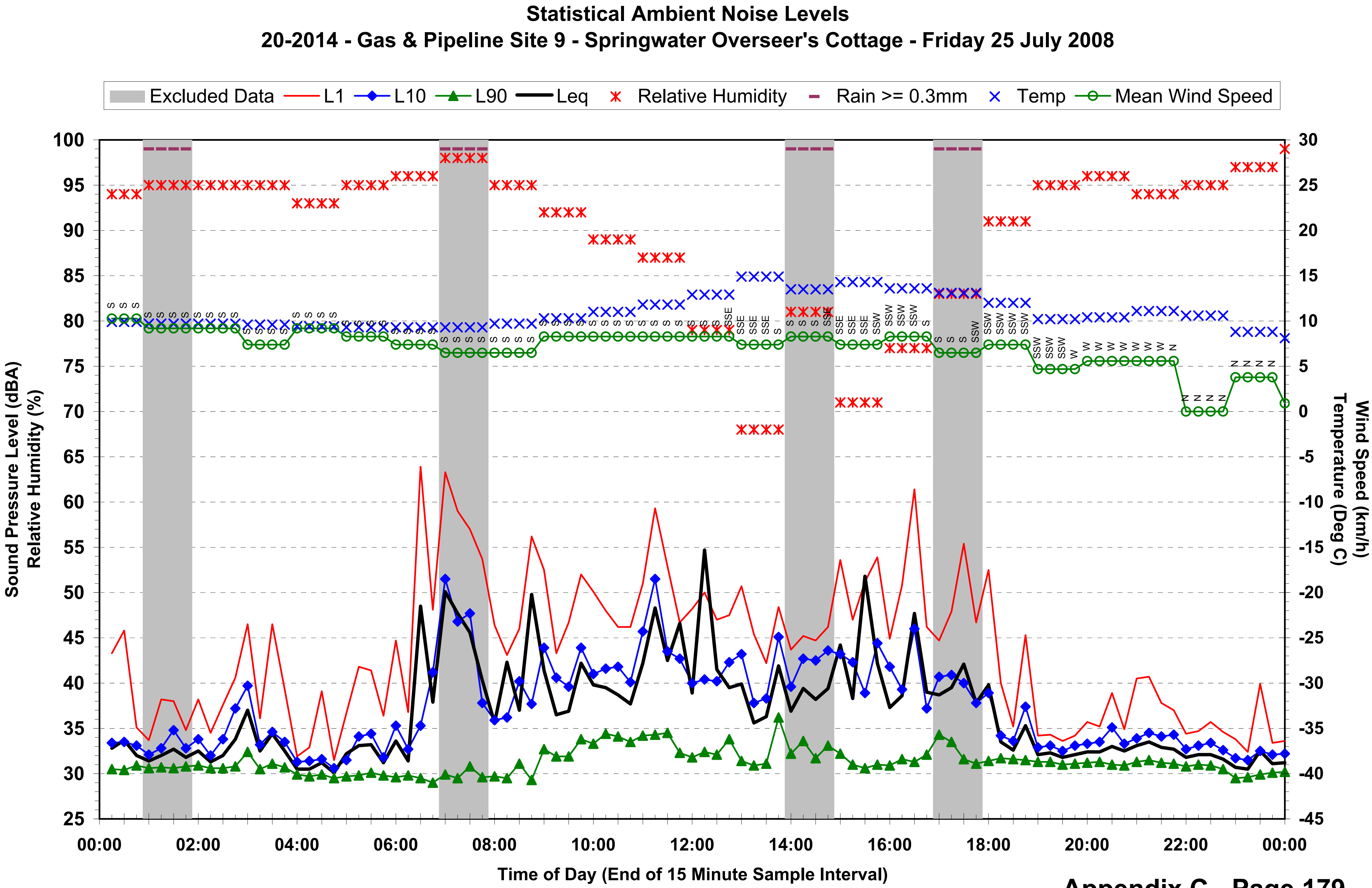
Ambient Conditions

RHA Report 20-2014

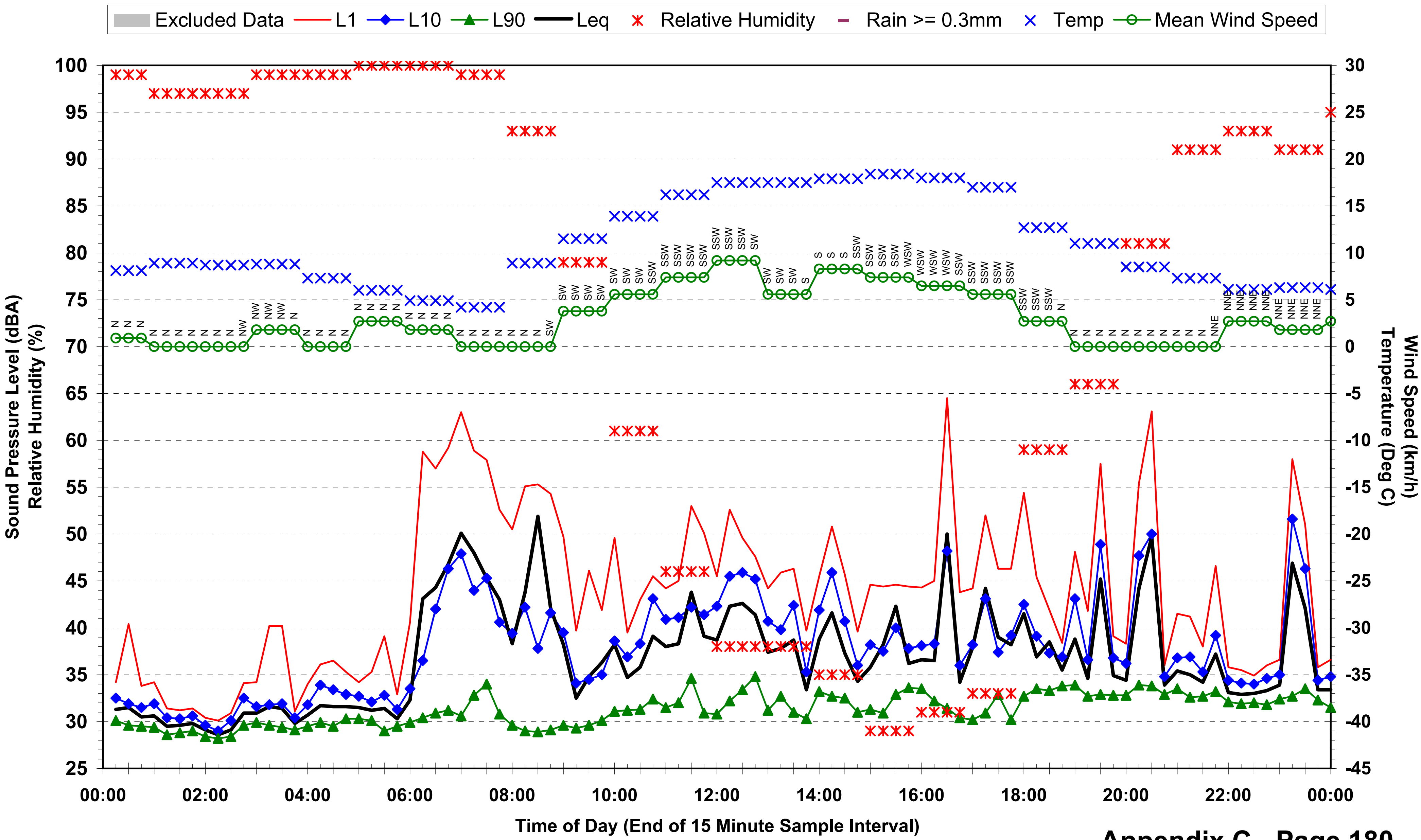
Statistical Ambient Noise Levels
20-2014 - Gas & Pipeline Site 9 - Springwater Overseer's Cottage - Thursday 24 July 2008

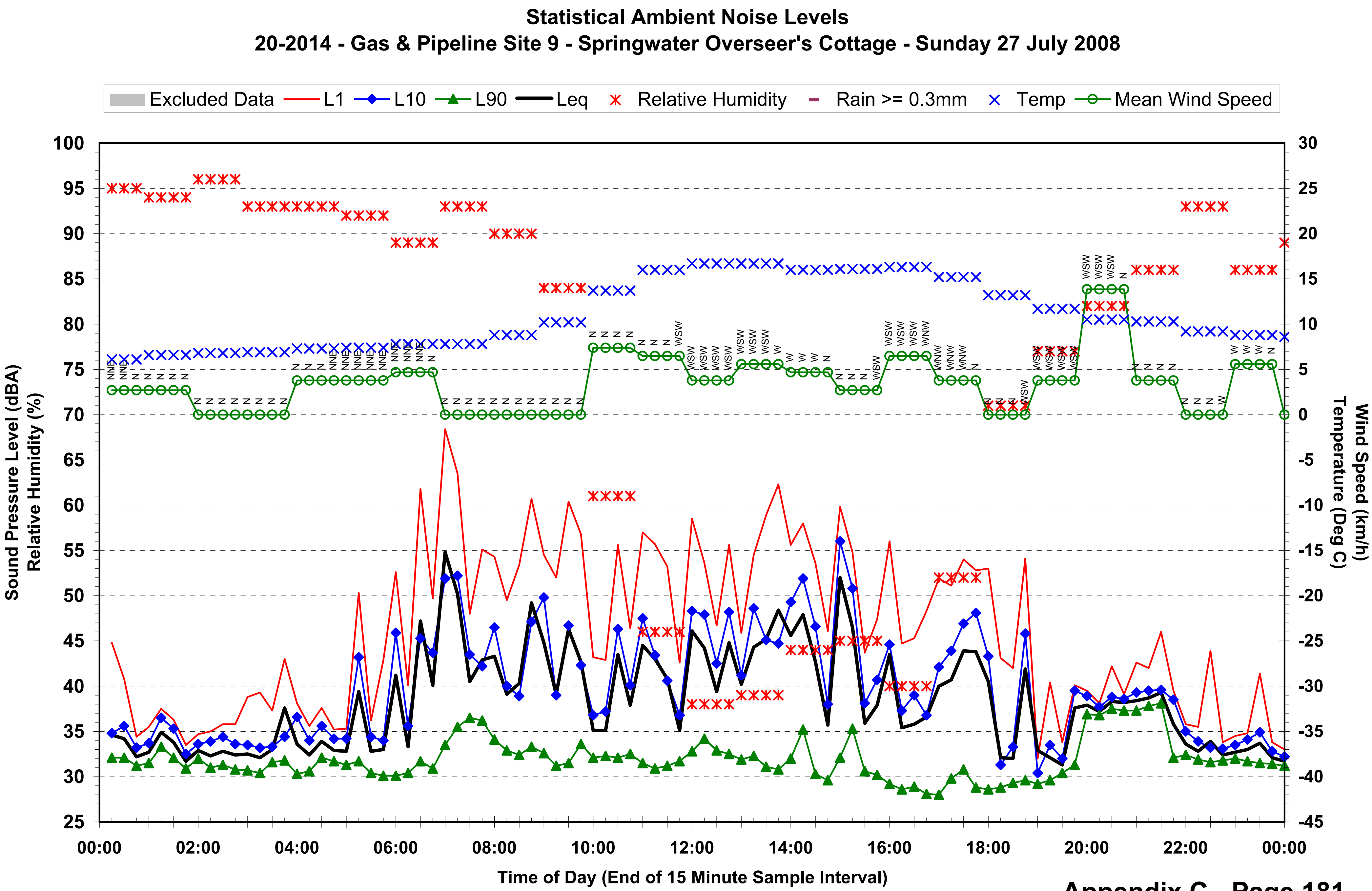




Statistical Ambient Noise Levels
20-2014 - Gas & Pipeline Site 9 - Springwater Overseer's Cottage - Friday 25 July 2008
Excluded Data
L1
L10
L90
Leq
Relative Humidity
Rain >= 0.3mm
Temp
Mean Wind Speed
Sound Pressure Level (dBA)
Relative Humidity (%)
Wind Speed (km/h)
Temperature (Deg C)
Time of Day (End of 15 Minute Sample Interval)

Statistical Ambient Noise Levels
20-2014 - Gas & Pipeline Site 9 - Springwater Overseer's Cottage - Saturday 26 July 2008





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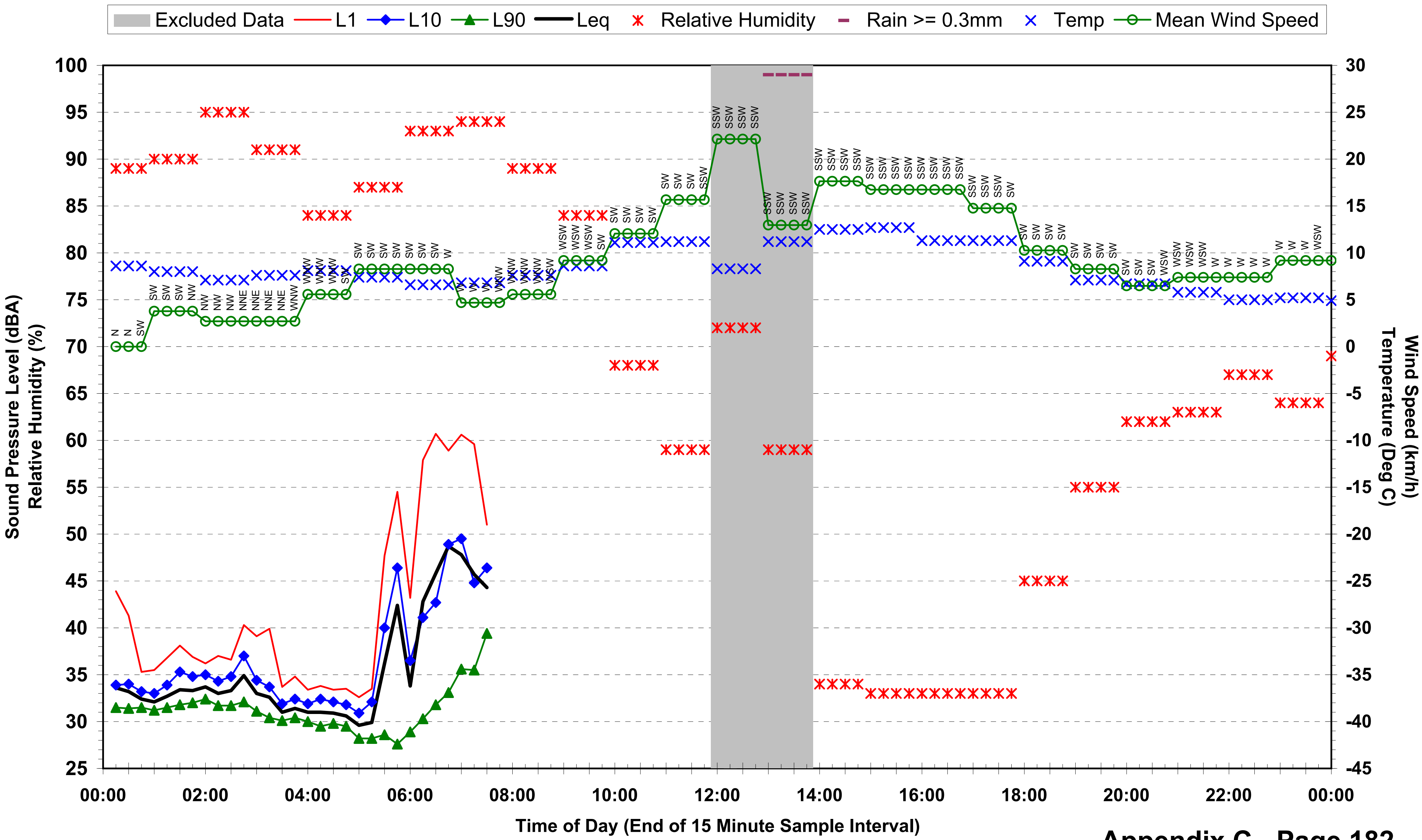
Ambient Conditions

RHA Report 20-2014

Statistical Ambient Noise Levels

20-2014 - Gas & Pipeline Site 9 - Springwater Overseer's Cottage - Monday 28 July 2008



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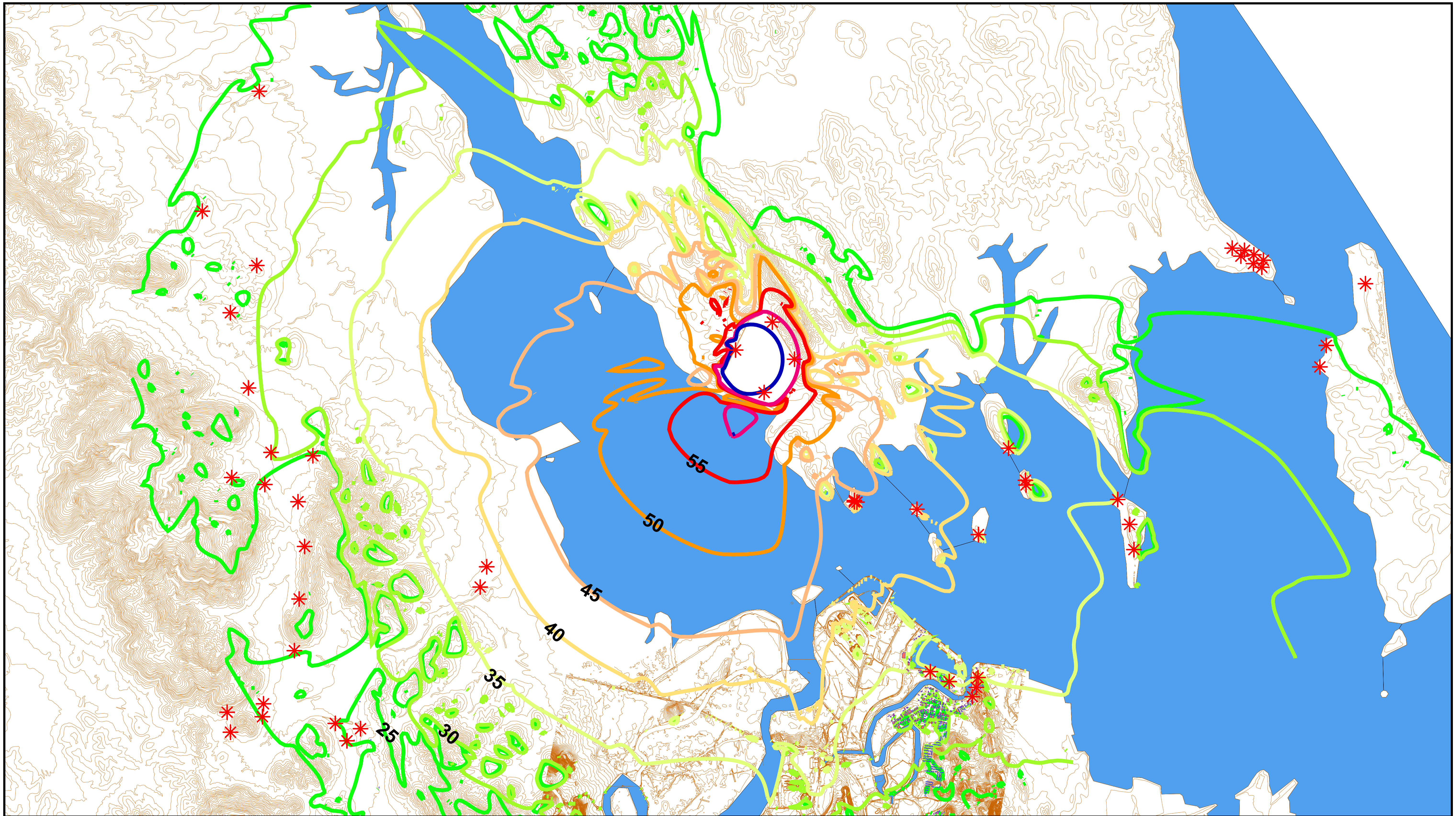
PREDICTED NOISE CONTOURS FOR THE LNG FACILITY



LA90 (dBA)

	<= 25
25 <	<= 30
30 <	<= 35
35 <	<= 40
40 <	<= 45
45 <	<= 50
50 <	<= 55
55 <	<= 60
60 <	<= 65
65 <	

Legend

- Building
- Elevation line
- Water
- Point receiver

Note:

Predictions at 1.5m above ground and assumes "Worst Case" weather

Contours are interpolated. Check single point calculations in Section 9.2.1 for exact levels.

N

Scale 1:75000

0 0.5 1 2 3 4

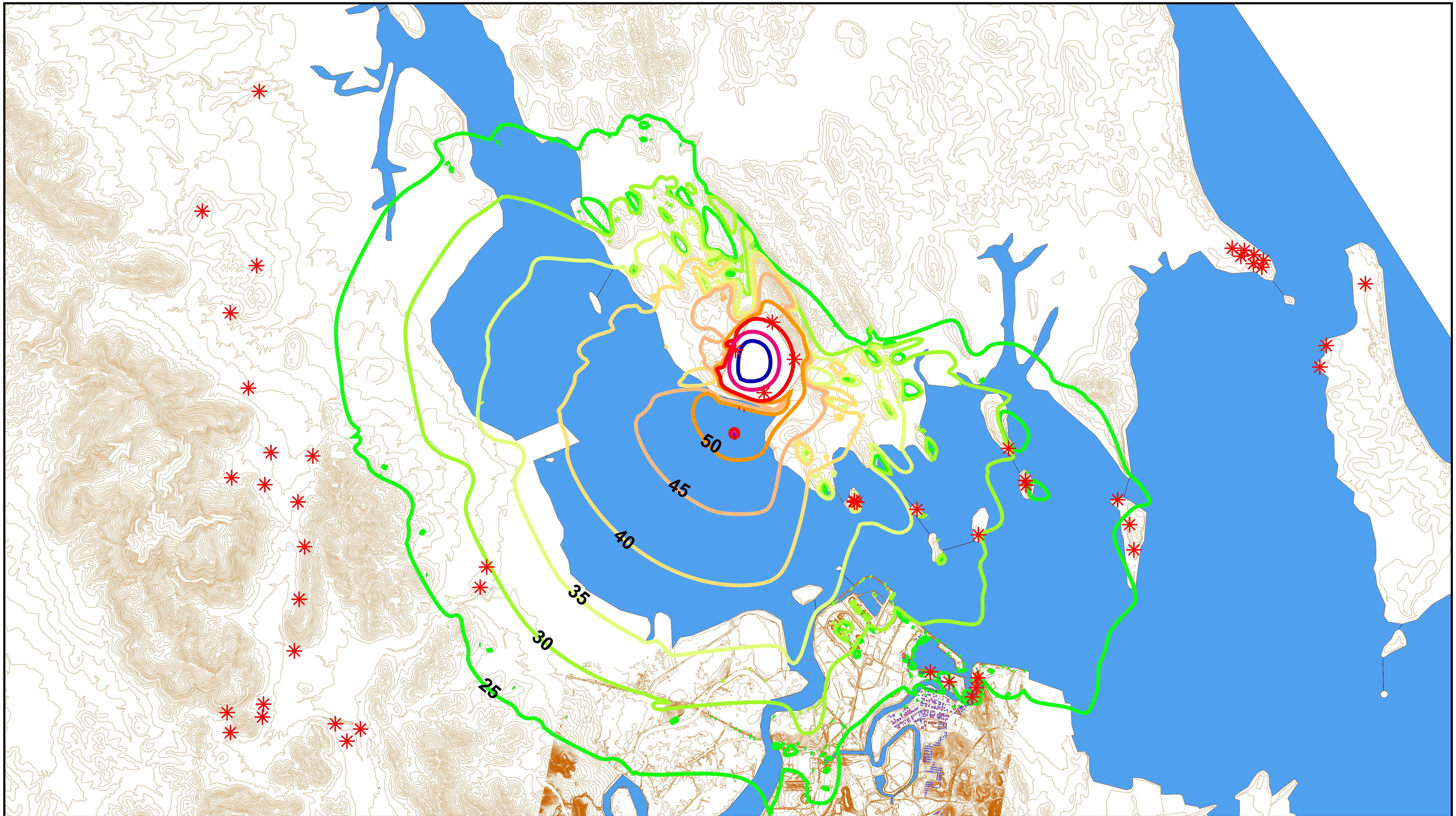
20-2014-R1
Gladstone LNG EIS
(LA90) Noise Contours

	Name	Date
Prepared	HM	17/10/08
Checked	MC	17/10/08
Authorised	MC	17/10/08

Appendix D
Map 1

Predicted Noise Contours (LA90)
OCP LNG Facility
No Mitigation

HEGGIES



LA90 (dBA)
<= 25
25 < <= 30
30 < <= 35
35 < <= 40
40 < <= 45
45 < <= 50
50 < <= 55
55 < <= 60
60 < <= 65
65 <

Legend
- Building
- Elevation line
- Water
- Point receiver

Note:

Predictions at 1.5m above ground and assumes "Worst Case" weather

Contours are interpolated. Check single point calculations in Section 9.2.1 for exact levels.

N

Scale 1:75000

0 0.5 1 2 3 4

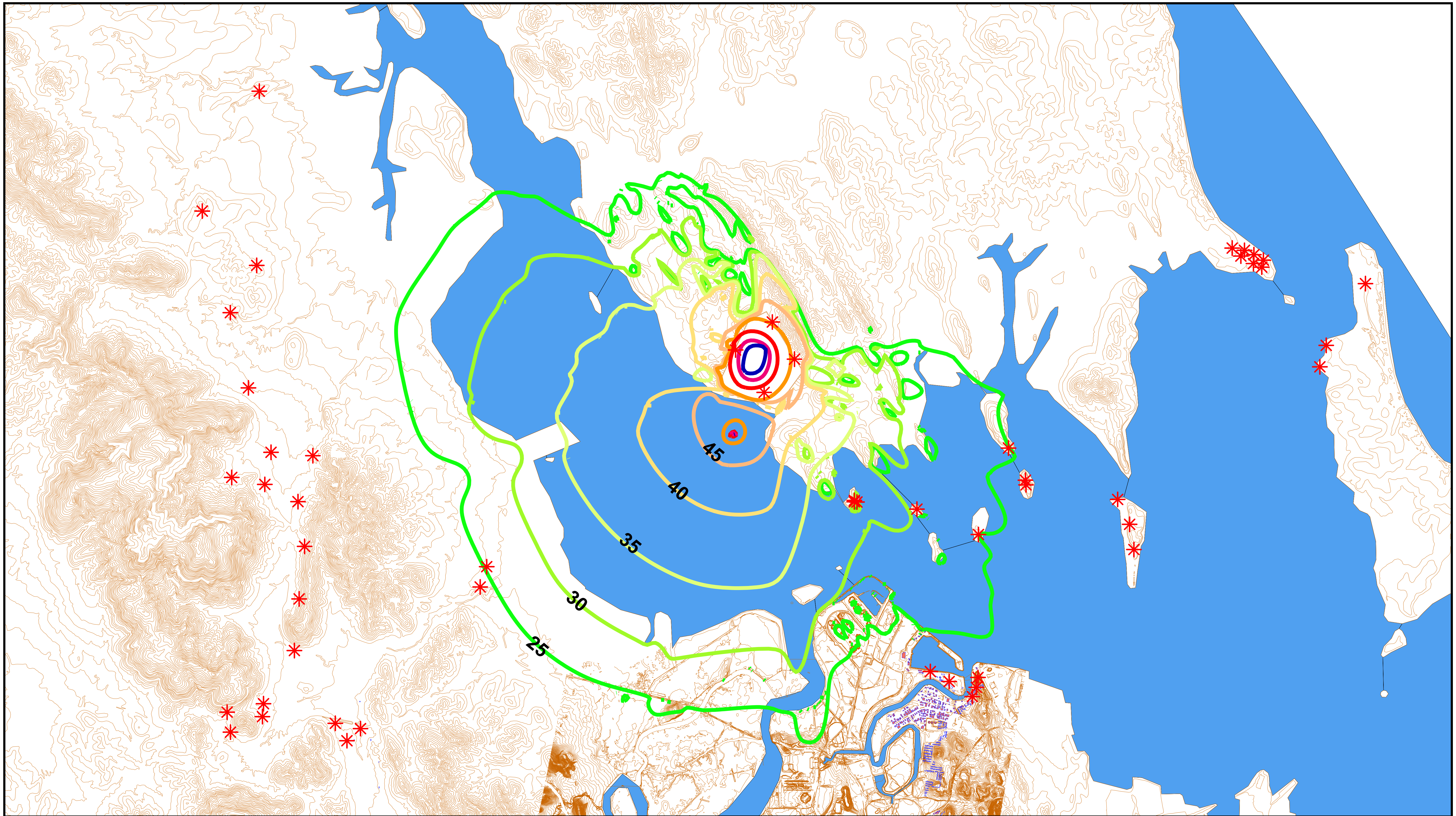
20-2014-R1
Gladstone LNG EIS
(LA90) Noise Contours

	Name	Date
Prepared	HM	17/10/08
Checked	MC	17/10/08
Authorised	MC	17/10/08

Appendix D
Map 2

Predicted Noise Contours (LA90)
OCP LNG Facility
Mitigation Scenario 2

HEGGIES



LA90 (dBA)
<= 25
25 < <= 30
30 < <= 35
35 < <= 40
40 < <= 45
45 < <= 50
50 < <= 55
55 < <= 60
60 < <= 65
65 <

Legend
Building
Elevation line
Water
Point receiver

Note:

Predictions at 1.5m above ground and assumes "Worst Case" weather

Contours are interpolated. Check single point calculations in Section 9.2.1 for exact levels.

N

Scale 1:75000

0 0.5 1 2 3 4

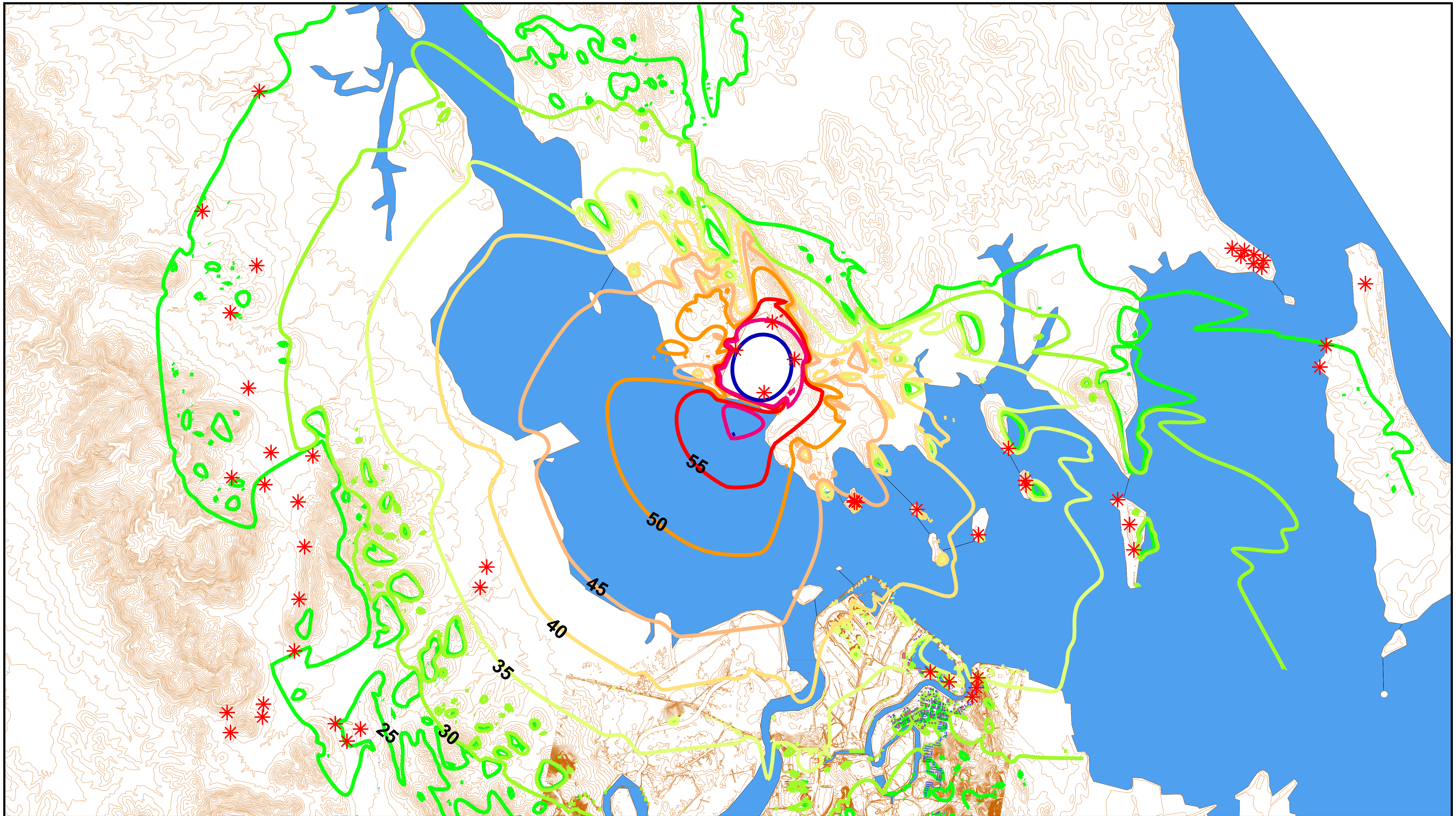
20-2014-R1
Gladstone LNG EIS
(LA90) Noise Contours

	Name	Date
Prepared	HM	17/10/08
Checked	MC	17/10/08
Authorised	MC	17/10/08

Appendix D
Map 3

Predicted Noise Contours (LA90)
OCP LNG Facility
Mitigation Scenario 3

HEGGIES



LA90 (dBA)

LA90 (dBA)	
	<= 25
25 <	<= 30
30 <	<= 35
35 <	<= 40
40 <	<= 45
45 <	<= 50
50 <	<= 55
55 <	<= 60
60 <	<= 65
65 <	

Legend

- Building
- Elevation line
- Water
- Point receiver

Note:

Predictions at 1.5m above ground and assumes "Worst Case" weather

Contours are interpolated. Check single point calculations in Section 9.2.1 for exact levels.

N

Scale 1:75000

0 0.5 1 2 3 4

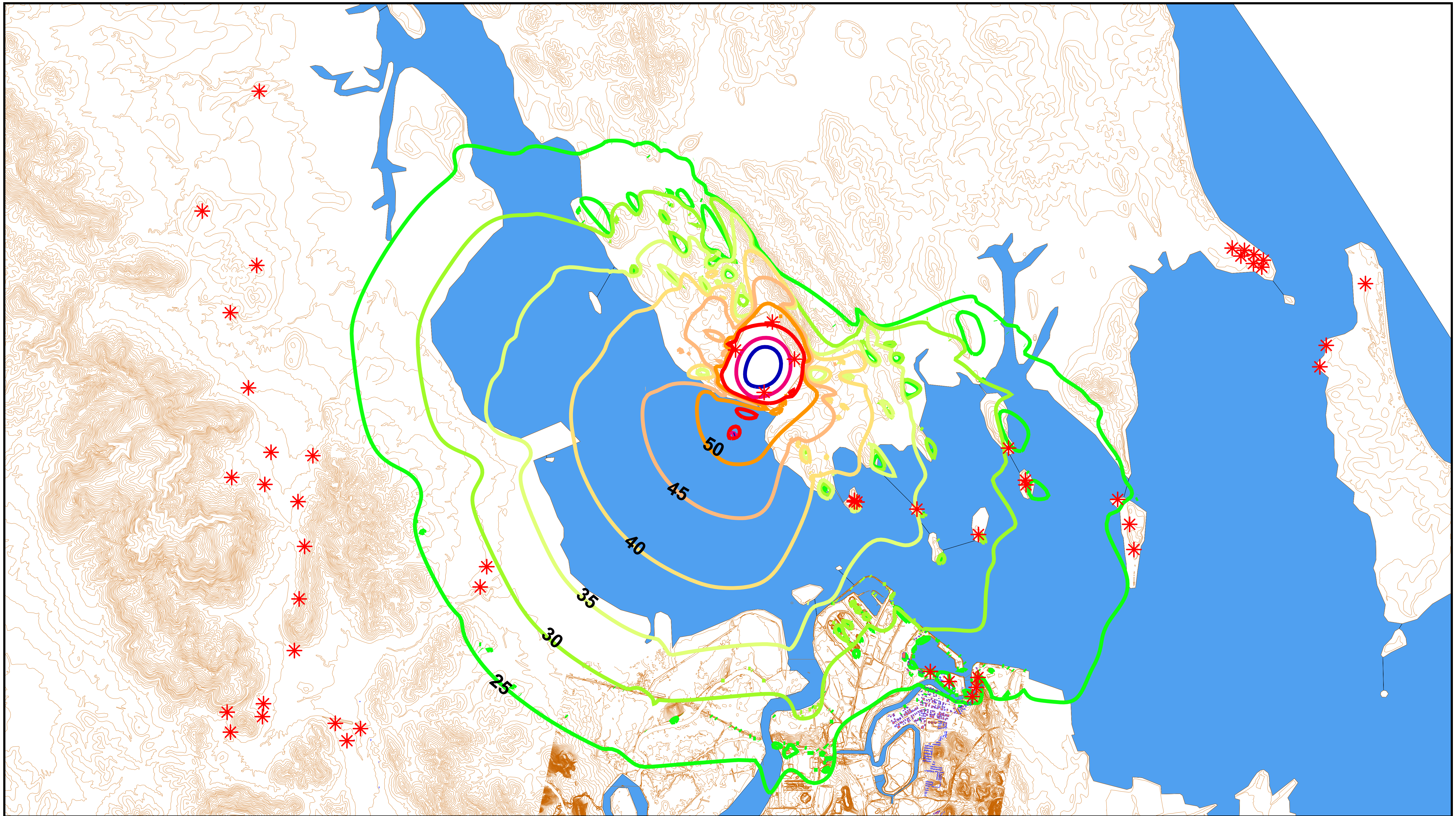
20-2014-R1
Gladstone LNG EIS
(LA90) Noise Contours

	Name	Date
Prepared	HM	17/10/08
Checked	MC	17/10/08
Authorised	MC	17/10/08

Appendix D
Map 4

Predicted Noise Contours (LA90)
C3MR LNG Facility
No Mitigation

HEGGIES



LA90 (dBA)

	<= 25
25 <	<= 30
30 <	<= 35
35 <	<= 40
40 <	<= 45
45 <	<= 50
50 <	<= 55
55 <	<= 60
60 <	<= 65
65 <	

Legend

- Building
- Elevation line
- Water
- Point receiver

Note:

Predictions at 1.5m above ground and assumes "Worst Case" weather

Contours are interpolated. Check single point calculations in Section 9.2.1 for exact levels.

N

Scale 1:75000

0 0.5 1 2 3 4

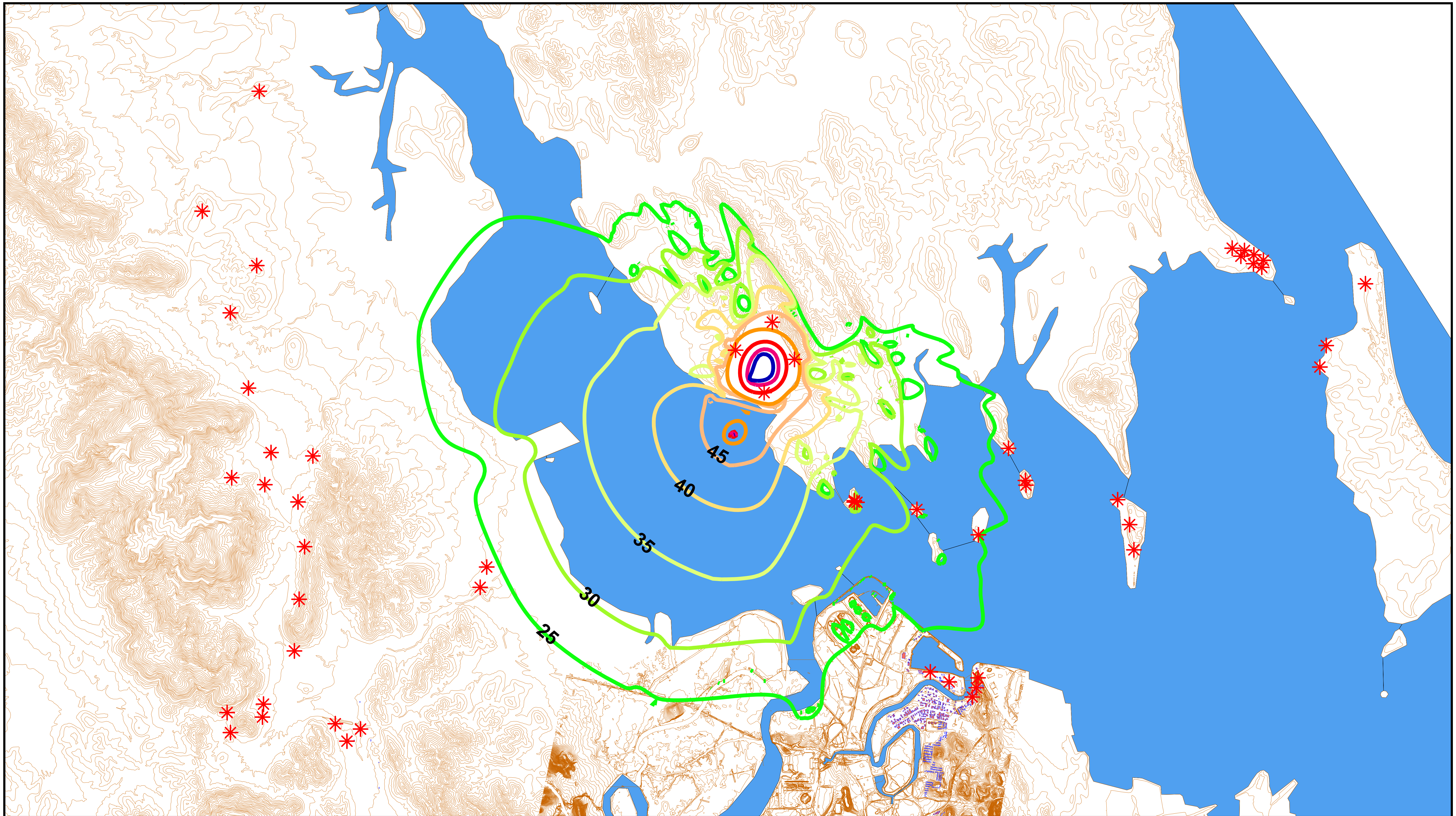
20-2014-R1
Gladstone LNG EIS
(LA90) Noise Contours

	Name	Date
Prepared	HM	17/10/08
Checked	MC	17/10/08
Authorised	MC	17/10/08

Appendix D
Map 5

Predicted Noise Contours (LA90)
C3MR LNG Facility
Mitigation Scenario 2

HEGGIES



LA90 (dBA)

	<= 25
25 <	<= 30
30 <	<= 35
35 <	<= 40
40 <	<= 45
45 <	<= 50
50 <	<= 55
55 <	<= 60
60 <	<= 65
65 <	

Legend

- Building
- Elevation line
- Water
- Point receiver

Note:

Predictions at 1.5m above ground and assumes "Worst Case" weather

Contours are interpolated. Check single point calculations in Section 9.2.1 for exact levels.

N

Scale 1:75000

0 0.5 1 2 3 4

20-2014-R1
Gladstone LNG EIS
(LA90) Noise Contours

	Name	Date
Prepared	HM	17/10/08
Checked	MC	17/10/08
Authorised	MC	17/10/08

Appendix D
Map 6

Predicted Noise Contours (LA90)
C3MR LNG Facility
Mitigation Scenario 3

HEGGIES