Appendix D

Report 610.15897R2

Train Passby Noise and Vibration Measurements

1.1 Train Passby Measurements

Train passby noise and vibration measurements were carried out between 16 June 2016 and 4 July 2016 at four locations within the study area.

Noise and/or vibration measurements were undertaken at four locations (OP01 through OP04) representative of the varying rail operations and conditions across the study area. Noise measurement locations are denoted by the '.N1' suffix in the measurement location title while vibration measurement locations are denoted by the '.V1' suffix.

Operator attended train passby measurements were performed at two locations within the study area and focused on passenger train passby events. Operator attended noise and vibration measurements were undertaken for up to four hours at each location. Train passby events measured during the attended surveys were mostly passenger trains as freight train passby events occur less frequently.

Due to the irregular timetabling and infrequency of freight train passby events within the study area, unattended train passby measurements were performed at three locations within the study area over the period of approximately one week and focused on freight train passby events.

1.1.1 Attended Passby Noise Measurements

Operator attended train passby noise measurements captured A-weighted, fast response L_{Amax} and L_{AE} (sound exposure level). One third octave L_{eq} and L_{max} measurements were also obtained for each train passby event. The L_{max} values are the maximum levels occurring in each 1/3 octave band during the train passby, and are therefore not necessarily time coincident.

The measurements commenced as the train noise rose significantly above the background level and were terminated as the train noise approached the background level. In the event that noise from other sources significantly affected the measurement results, the measurement was discarded.

The instrumentation used for the attended passby measurements comprised of a calibrated Brüel & Kjær Type 2260 Sound Level Meter, Brüel & Kjær Type 2250L Sound Level Meter, and one Brüel & Kjær Type 4231 Acoustic Calibrator. Calibration of the sound level meters was carried out before, during and after the measurements at each location and no significant calibration drift was noted. The equipment utilised for the attended noise surveys is outlined in **Table 1**.

Table 1 Attended Train Passby Noise Survey Instrumentation

Device Category	Device Make and Model	Serial Number
Sound Level Meter	Brüel & Kjær Type 2250L	3003632
Sound Level Meter	Brüel & Kjær Type 2260	2115053
Acoustic Calibrator	Brüel & Kjær Type 4231	2022772

1.1.2 Unattended Passby Noise Measurements

Unattended freight train passby measurements were performed at three locations within the study area over the period of approximately one week. At each location, continuous unattended noise monitoring was undertaken 15 m from the nearest freight track. Time synchronised concurrent vibration monitoring was undertaken at the rail track to determine the presence of a freight train in either the Up or Down direction.

The instrumentation used for the unattended passby measurements comprised of calibrated Brüel & Kjær Type 2250L noise loggers, Svantek Type 957 vibration loggers, and one Brüel & Kjær Type 4231 Acoustic Calibrator. Calibration of the noise loggers was carried out before and after the measurements at each location and no significant calibration drift was noted. The equipment utilised for the unattended noise surveys is outlined in **Table 2**.

Table 2 Unattended Train Passby Noise Survey Instrumentation

Device Category	Device Make and Model	Serial Number
Noise Logger	Brüel & Kjær Type 2250L	3003389
Noise Logger	Brüel & Kjær Type 2250L	3004635
Noise Logger	Brüel & Kjær Type 2250L	3004636
Vibration Logger	SVANTEK Type 957 Sound Level Meter	23244
Vibration Logger	SVANTEK Type 957 Sound Level Meter	20669
Vibration Logger	SVANTEK Type 957 Sound Level Meter	20644
Acoustic Calibrator	Brüel & Kjær Type 4231	2022772

1.1.3 Train Passby Noise Measurement Locations

The passby measurements (free-field) were conducted at the locations described in **Table 3**. A map showing the measurement locations in relation to the surrounding environment is presented in **Appendix B**.

Table 3 Train Passby Measurements - Noise Locations

Reference	Line	Chainage (km)	Measurement Dates	Distance to Near Track (m)	Description
OP01.N1	Goods Line	6.050	27/06/2016 to 04/07/2016	15	Corridor access road boundary between Goods Line and T3 Bankstown Line. Central Corridor reserve.
OP02.N1	T3 Bankstown Line	8.290	24/11/2015 and 27/06/2016 to 04/07/2016	7.5	Corridor access gate at the end of Terrace Lane, Dulwich Hill. Up side of corridor.
OP03.N1	T3 Bankstown Line	11.180	24/11/2015	15	Corridor access road opposite Gould Street, Campsie. Down side of corridor
OP04.N1	Goods Line	12.420	24/11/2015 and 27/06/2016 to 04/07/2016	15	Corridor access road adjacent Loftus Street, Campsie. Up side of corridor

1.1.3.1 Passby Noise Measurement Location OP01.N1

A map showing measurement location OP01 in relation to the surrounding environment is presented in **Appendix B**.

Measurement location OP01.N1 was 15 m from the near (Down Goods) track at approximate chainage 6.050 km. This measurement location was selected due to its close proximity to the adjacent 250 m radius curve on the Goods Line. Only measurements of freight train traffic operating on the Goods Line were conducted at this location. The Goods Line track condition was observed to be acceptable for acoustic measurements and free from rail joints.

Unattended noise measurements were undertaken continuously at measurement location OP01.N1 from 27 June 2016 to 04 July 2016. Noise levels from freight train passbys indicated almost all freight train passby events on the Goods Line Down track exhibited curving noise including wheel squeal and/or flanging.

Noise measurements obtained for freight train passbys on the Goods Line Up track indicated that curving noise was not a regular feature of this track at this location with less than 8% of passbys exhibiting some form of curving noise.

L_{Aeq} and L_{Amax} noise levels at this location were heavily influenced by curving noise on the Goods Line Down track and are typical of freight operations on tight radius curves on the broader network.

1.1.3.2 Passby Noise Measurement Location OP02.N1

A map showing measurement location OP02 in relation to the surrounding environment is presented in **Appendix B**.

Measurement Location OP02.N1 was 7.5 m from the near (Up Goods) track at approximate chainage 8.290 km. The track condition in the area was observed to be acceptable for acoustic measurements and free from audible rail joints.

Measurement location OP02.N1 was selected due to its close proximity to the adjacent 400 m radius curve on the Goods Line and T3 Bankstown Line.

Noise levels from almost all passenger train passbys on the T3 Bankstown Line were observed to exhibit curving noise including flanging on both the Up and Down tracks. Passenger train passbys in both up and down directions also exhibited higher levels of track singing than is typical for most parts of the Sydney Trains network and in most cases track singing noise was clearly audible above the daytime background noise level for approximately seven seconds before and after the train passby event.

The observed passenger train speeds were typically 5 km/h slower than the 60 km/h line speed in both directions.

Unattended noise measurements were undertaken continuously at measurement location OP02.N1 from 27 June 2016 to 04 July 2016. Unattended measurements were only conducted on freight train passbys operating on the Goods Line. Noise levels from freight train passbys indicated approximately 65% of freight train passby events on the Goods Line exhibited curving noise including wheel squeal and/or flanging.

Freight train L_{Aeq} and L_{Amax} noise levels at this location were heavily influenced by curving noise and are typical of freight operations on moderate radius curves on the broader network.

1.1.3.3 Passby Noise Measurement Location OP03.N1

A map showing measurement location OP03 in relation to the surrounding environment is presented in **Appendix B**.

Measurement Location OP03.N1 was 15 m from the near (Down T3 Bankstown) track at approximate chainage 11.180 km. Attended noise monitoring at location OP03.N1 focused primarily on obtaining passenger train passby noise levels for operations on tangent track and did not include detailed measurements of freight train operations on the Goods Line.

The T3 Bankstown Line track was observed to exhibit significant levels of track whine at this location with passbys on the down track indicating higher levels of rolling noise than the up track (including accounting for differences in propagation attenuation). This would indicate that at the time of the measurements the track head roughness in this part of the network was in worse condition than that typically observed across the broader network. Based on the attended noise measurements it is assumed that the track roughness was outside the target track roughness limits specified in ISO 3095 - 2013 '*Railway Applications – Acoustics – Measurement of noise emitted by railbound vehicles'*.

The observed passenger train speeds were typically close to the 65 km/h line speed on the Up track and approximately 6 km/h slower than the 65 km/h line speed on the Down track.

L_{Amax} noise levels were generated by occasional wheel flats. These L_{Amax} events are typical of operations on the broader network.

1.1.3.4 Passby Noise Measurement Location OP04.N1

A map showing measurement location OP04 in relation to the surrounding environment is presented in **Appendix B**.

Measurement location OP04.N1 was 15 m from the near (Up Goods) track at approximate chainage 12.420 km. This measurement location was selected due to its close proximity to the adjacent 200 m radius curve on the Goods Line. Only measurements of freight train traffic operating on the Goods Line were conducted at this location. The Goods Line track condition was observed to be acceptable for acoustic measurements and free from audible rail joints.

Unattended noise measurements were undertaken continuously at measurement location OP04.N1 from 27 June 2016 to 04 July 2016. Noise levels from freight train passbys indicated approximately 65% of freight train passby events on the Goods Line Up track exhibited significant levels of curving noise including wheel squeal and/or flanging.

Noise measurements obtained for freight train passbys on the Goods Line Down track indicated that curving noise was not a regular feature of this track at this location with less than 15% of passbys exhibiting minor levels of curving noise.

L_{Aeq} and L_{Amax} noise levels at this location were heavily influenced by curving noise on the Goods Line Down track and are typical of freight operations on tight radius curves on the broader network.

1.1.4 Attended Passby Noise Levels

Table 4 presents a summary of the measured noise levels at each location. For each track, the average noise levels (L_{AE} and L_{Amax}) have been determined, along with the 95th percentile L_{Amax} levels recorded during the attended measurements.

The passenger train speeds observed during the attended measurements at each location for each track are included in **Table 4**. These speeds were estimated by measuring the passby time with a stopwatch, and observing the number of carriages and the typical carriage lengths.

Table 4 Summary of Attended Measured Noise Levels

Location	Track	Distance from track centre (m)	Average Speed (km/h)[1]	Average L_{AE} (dBA)[2]	Average L_{Amax} (dBA)	95th Percentile L_{Amax} (dBA)
OP01.N1	Goods Up	19	-	92	80	89
	Goods Down	15	-	100	90	103
OP02.N1	Main Up	19	56	88	79	80
	Main Down	23	54	88	80	85
	Goods Up	10	-	101	91	98
	Goods Down	14	-	97	90	96
OP03.N1	Main Up	19	63	82	73	78
	Main Down	15	59	88	79	83
OP04.N1	Goods Up	15	-	100	88	104
	Goods Down	19	-	95	83	91

Note 1: Passenger train speeds presented for attended monitoring locations.

Note 2: Logarithmic average.

1.1.5 Attended Passby Vibration Measurements

The attended vibration measurements captured un-weighted, slow response L_{max} and L_{eq} vibration levels. One third octave L_{max} measurements were also obtained for each train passby event. The L_{max} values are the maximum levels occurring in each 1/3 octave band during the train passby, and are therefore not necessarily time coincident.

The L_{eq} measurements were commenced as the train vibration rose significantly above the background level and were terminated as the train noise approached the background level. In the event that vibration from other sources significantly affected the measurement results, the measurement was discarded.

Vibration transducers were fixed to steel stakes by use of magnetic bases. The stakes were driven into the raw earth to a minimum depth of 200 mm. The measurements were conducted with a Brüel & Kjær Type 2260 vibration level meter and a B&K Type 4370 accelerometers. Calibration of the measurement system was checked before and after each set of measurements and no significant measurement drift was observed.

1.1.6 Train Passby Vibration Measurement Locations

Attended passby vibration measurements were conducted at two locations adjacent the existing T3 Bankstown Line, and Goods Line.

The attended passby vibration measurements locations are described in **Table 5**.

Table 5 Train Passby Measurements - Vibration Locations

Reference	Chainage (km)	Measurement Date	Distance to Near Track (m)
OP2.V1	8.290	27/06/2016	7.5
OP3.V1	11.180	27/06/2016	7.5

The equipment utilised for the attended passby vibration measurements surveys are outlined in **Table 4** below.

Table 6 Attended Train Passby Vibration Survey Instrumentation

Device Category	Device Make and Model	Serial Number
Accelerometer	Brüel & Kjær Type 4370	1068049
Charge Amplifier	Brüel & Kjær Type 2635	1155816
Vibration Level Meter	Brüel & Kjær Type 2260	241604
Data Recorder	Rion DA20	10991284
Vibration Calibrator	Brüel & Kjær Type 4294	1859764

1.1.6.1 Passby Vibration Measurement Location OP2.V1

A map showing measurement location OP02 in relation to the surrounding environment is presented in **Appendix B**. Measurement Location OP02.N1 was 7.5 m from the near (Up Goods) track at approximate chainage 8.290 km. The track condition in the area was observed to be acceptable for vibration measurements and free from rail joints.

Attended vibration monitoring at location OP02.V1 focused primarily on obtaining passenger train passby vibration levels for operations on curved track and did not incorporate detailed measurements of freight train operations on the Goods Line.

Attended vibration measurements undertaken at location OP02.V1 were observed to achieve an acceptable signal to ambient vibration ratio for all for adjacent rail tracks. Any measurements potentially affected by vibration induced from road traffic on The Parade were discarded.

1.1.6.2 Passby Vibration Measurement Location OP3.V1

A map showing measurement location OP03 in relation to the surrounding environment is presented in **Appendix B**. Vibration measurements were undertaken 7.5 m from the near (Down Main) track at approximate chainage 11.180 km.

As discussed in **Section 1.1.3.3**, The T3 Bankstown Line track was observed to exhibit signs of unusually high rail head roughness. Based on the attended passby vibration observations, rail head condition was observed to have negligible influence in the critical frequency range of the passenger train passby vibration measurement results presented in **Section 1.1.7**.

L_{max} vibration levels were generated by wheel flats. These L_{max} events are typical of operations on the broader network.

1.1.7 Attended Passby Vibration Levels

Table 7 presents a summary of the measured vibration levels at each location. The average vibration levels (L_{eq} and L_{max}) have been determined. The maximum L_{max} levels recorded during the attended measurements are also shown. Maximum results presented in **Table 7** are unweighted slow-response maximum vibration levels.

Table 7 Summary of Measured Vibration Levels

Location	Track	Distance from track centre (m)	Average Speed (km/h)[1]	Average L_{eq} (dB)[2]	Average L_{max} (dB)	Maximum L_{max} (dB)
OP02.V1	Main Up	19	56	91	99	105
	Main Down	23	54	86	91	97
OP03.V1	Main Up	11.5	63	97	104	108
	Main Down	7.5	59	100	106	110

Note 1: Passenger train speeds presented for attended monitoring locations.

Note 2: Logarithmic average.