

Under the Resource Management Act 1991
In the matter of Notices of Requirement to enable the construction, operation and
maintenance of the City Rail Link

Between

Auckland Transport

Requiring Authority

and

Auckland Council

Consent Authority

Statement of Evidence of Matthew James Harrison

Qualifications and Experience

1. My full name is Matthew James Harrison.
2. I have a Master of Engineering Science Degree in Noise and Vibration from the University of New South Wales (NSW) and a Bachelor Degree in Mechanical Engineering from the University of Sydney.
3. I have more than 20 years' experience working in the field of noise and vibration. I am an active member of the acoustic community and am currently the Chairman of the NSW Division of the Australian Acoustical Society (AAS), having previously been a Federal AAS Committee member. I sat on the organizing committee of the International Congress on Sound and Vibration (ICSV14) in 2007 prior to leaving Sydney to work in Europe. I lectured a one-week course in Acoustics at a technical college for a five year period and have written papers on Acoustic topics included co-authoring one for the 9th International Workshop on Railway Noise and Vibration entitled "Structure-Borne Noise and Vibration Control for Chatswood Interchange".
4. I have worked as an expert witness on many projects in the Land and Environment Court and the Supreme Court in both NSW and the Australia Central Territory (ACT). In one recent case this year I was retained to provide evidence and design advice to enable a gymnasium to operate in a mixed commercial and residential building on a 24hr basis. Regenerated noise and vibration from the dropping of weights and other activities were required to meet very stringent design criteria.
5. I am currently employed as the Technical Discipline Manager for the acoustics and vibration group of SLR Consulting Australia Pty Ltd. We are the largest group of acousticians in Australia with approximately 60 engineers and scientists.
6. In terms of project experience that is directly relevant to the City Rail Link (CRL) project, SLR has during the last five years been the acoustical adviser and primary acoustic consultant on the following major rail tunnel projects:

- (a) Epping Chatswood Rail Line (ECRL), Sydney
- (b) Sydney Metro (SM), Sydney
- (c) Lowering of Fremantle Railway Line (LFRL), Perth
- (d) Cross River Rail (CRR), Brisbane
- (e) Perth City Link Rail Project (PCLR), Perth
- (f) 413 George Street Sydney – Vibration Study
- (g) North West Rail Link (NWRL), Sydney
- (h) Sydney Opera House Vehicle Access Pedestrian Safety (VAPS) Project

7. As the Technical Discipline Manager for the acoustics and vibration group at SLR I have had direct involvement on the current NWRL project. I have also a continuing role on delivering Sydney Opera House Vehicle Access Pedestrian Safety (VAPS) Project. This project involves the construction of vehicle tunnels and loading dock spaces underneath the Sydney Opera House.
8. In my previous employment I was also involved with the design of building vibration isolation from rail tunnels below the new office development at 413 George Street, Sydney and I was also responsible for the delivery of the noise and vibration design of the Chatswood Transport Interchange development project.
9. A more detailed summary of some of the abovementioned projects is included in **Appendix 1** to my evidence.

Background and Role

10. The City Rail Link (CRL) project is a 3.4km underground passenger railway (including two tracks and three underground stations) running between Britomart Station and the North Auckland Line (NAL) in the vicinity of the existing Mount Eden Station. CRL also requires an additional 850m of track modifications within the NAL. The stations

included in the CRL NoR have been temporarily named Aotea Station, Karangahape Station, Newton Station.

11. SLR was engaged by Auckland Transport as part of the Principal Advisor (PA) team for the CRL project. The PA is led by Aurecon NZ Ltd and comprises the principal partners of Aurecon NZ Ltd, Mott MacDonald, Jasmax and Grimshaw. The PA reports directly to Auckland Transport's Infrastructure Delivery work stream which is responsible for delivery of the CRL project. The PA is also supporting the Notice of Requirement (NoR) and Property work streams.
12. My role in the CRL project team includes:
 - (a) Leading the review of the vibration and regenerated noise assessments undertaken by Marshall Day Acoustics Ltd (MDA) for the construction and operation of the CRL.
 - (b) Providing additional experience of rail projects similar to CRL with a particular focus on the effects of vibration on the sensitive receivers identified in the MDA Noise and Vibration Report.
13. I am familiar with the project location, track alignment and the site specific locations for each proposed station. I have walked the proposed route and visited all proposed station sites and I am familiar with the physical environment within which the CRL station indicative designs have been developed.
14. I have read the Code of Conduct for Expert Witnesses as contained in the Environment Court Consolidated Practice Note (2011), and I agree to comply with it as if this hearing was before the Environment Court. My qualifications as an expert are set out above. I confirm that the issues addressed in this brief of evidence are within my area of expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed.

Scope of Evidence

15. The focus of my evidence is on the assessment of actual and potential adverse effects from the vibration and regenerated noise from the construction and operation of the CRL on notable receivers¹.
16. My evidence includes reference to '*Volume 3, Part 1, Appendix 2 – Marshall Day Acoustics report*' ('assessment report'), *Marshall Day Acoustics Memorandum Document No. Mm012*, the Structural Engineer Technical Expert Report and Mr James Whitlock's evidence.
17. My evidence will address the following:
 - (a) Review of the NoR assessment of environmental vibration effects, with particular regard to the sensitive receivers identified in the relevant documents², particularly with respect to the following:
 - (i) Vibration performance standards
 - (ii) Assessment of vibration effects for the construction phase
 - (iii) Assessment of vibration effects for the operational phase
 - (b) Review of response to Planner's Report³; and
 - (c) Review of proposed draft CRL NoR conditions⁴.

¹ Notable receivers has been defined by Craig Fitzgerald and James Whitlock to be: public performance theatres; and in relation to sensitive equipment – recording studios (both sound and television), medical facilities and scientific laboratories.

² Appendix 2, Volume 3 CRL suite of documents.

³ Auckland Council Section 42A Report referred to here after in my evidence as the Planners report. This includes the relevant technical reports supporting the Section 42A Report.

⁴ The full suite of proposed draft CRL NoR conditions are attached to the evidence of Fiona Blight.

Summary of Evidence

18. The key result of my review of the vibration and regenerated noise assessments, as set out above, is that the approach taken by James Whitlock is that of a screening assessment that inherently includes a good deal of conservatism. Although this approach is appropriate for an initial review of potential effects, in my opinion care must be taken to avoid adopting mitigation measures or making decisions on what can be allowed based on these predictions. The methodology employed is intended to show where the potential for adverse effects exists so that a more detailed analysis can be made to determine whether any mitigation measures are required, and if required, what they might be to ensure reasonable levels of vibration.

19. Mitigation of construction vibration and regenerated noise may be required during the construction of the CRL, and appropriate methods and measures to manage and mitigate these adverse effects have been identified and incorporated into the proposed CEMP⁵. These include measures such as scheduling of activities, selection of alternative construction techniques, the use of alternative accommodation etc.

NoR Assessment of Environmental Vibration Effects – SLR Review

20. SLR was specifically engaged to provide an independent review of the Marshall Day Acoustics (MDA) technical assessment of the vibration and regenerated noise effects associated with the proposed CRL.

Review of Project Construction Vibration Criteria

21. I have reviewed the Project construction vibration criteria proposed by James Whitlock and in general I agree with the conservative approach for vibration damage criteria in accordance with the German Standard DIN 4150-3:1999 that has been adopted at this stage of the project to identify areas where the potential for cosmetic damage exists.

⁵ See proposed draft condition 21, Attachment 2 to the evidence of Fiona Blight.

22. DIN 4150-3:1999 provides the following criteria for long – term (continuous) vibration in terms of PPV in the horizontal plane of the highest floor at all frequencies:
- Commercial / industrial 10 mm/s
 - Residential / School 5 mm/s
 - Historic or sensitive structures 2.5 mm/s
23. There is, however, also support for less stringent building damage vibration criteria, especially for the heritage listed buildings, in British Standard 7385 Part 2 1993 Evaluation and measurement for vibration in buildings Part 2. BS 7385 Part 2 states “A building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive”.
24. Furthermore, BS 7385 Part 2 also states “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”.
25. I have also been involved in large infrastructure projects where higher noise limits have been specified. The recent North West Rail Link (NWRL) project in Sydney adopted a vibration damage screening level of 7.5 mm/s for all structures including heritage structures, unless it was known that the heritage structure was already structurally unsound – in which case, a lower screening level may be applicable.
26. I agree with the night-time (2200 – 0700 hrs) vibration and ground-borne noise criteria proposed in Paragraph 170 of James Whitlock’s evidence to protect against sleep disturbance, noting that complying with the regenerated noise level criteria strongly indicates that the human comfort vibration criteria will also be complied with.

Review of Project Operational Vibration Criteria

27. I have reviewed the project operational ground-borne noise and vibration criteria proposed by James Whitlock and in general I agree with the proposed project criteria.
28. Once again, it should be remembered that these FTA criteria are very conservative and are intended to identify where the potential for annoyance might exist. It is noted that all these nominated PPV values are below 0.3 mm/s, which is the level at which vibration might be just perceptible in residential environments.
29. In my experience, the proposed ground-borne noise and vibration criteria for commercial and industrial buildings is more stringent than what SLR has successfully applied to similar projects based on an international review of applicable standards and guidelines. For example, on both the CRR and NWRL projects an operational vibration criterion of 112 dBV was adopted (i.e. 9 dB less stringent) for commercial receivers in accordance with AS2670.2 1990 *Evaluation of Human Exposure to Whole Body Vibration - Part 2: Continuous and Shock Induced Vibration in Buildings (1 Hz to 80 Hz)*.
30. I understand that James Whitlock supports the adoption of vibration dose values (**VDV**) for rail operations, in accordance with British Standard 6472:2008 *Evaluation of Human Exposure to Vibration in Buildings*, at the detailed design stage of the project once the frequency of train movements become more certain. At this stage of the Project he believes the adoption of VDV criteria would complicate matters because it is wholly separate from the FTA criteria. I agree that the FTA method is suitable for this stage of the Project provided that it is used as a screening tool to determine whether the potential for operational impacts exist and more detailed analysis would then determine whether and what level of mitigation may be required.
31. With respect to the assessment of noise impacts on the MediaWorks TV3 studio, in my opinion it is relevant to challenge the nominated criteria of 25 dBA given in the FTA guideline. I was involved in the design of Channel 7's News Studio in Martin Place, Sydney. We were

informed by the 7 Network that their studios in Melbourne had an ambient noise level criterion of NR 35 (approximately 40 dBA). They found this level to be adequate for their needs in Melbourne and considered it to also be adequate for their new Sydney studios. We therefore provided recommendations to ensure that the noise level in the studio achieved a noise level criterion of not less than NR30 and not more than NR35. I propose that a similar noise level criterion could also be successfully applied for the TV3 Studios particularly for regenerated construction noise impacts. I further recommend that ambient noise level measurements be conducted in the existing studio spaces to provide a benchmark level against which a proposed increase in the TV Studio noise level criterion to 35-40 dBA can be compared.

Review of Construction Assessment and Mitigation

32. I agree with James Whitlock's evidence stating that the two primary adverse construction vibration effects are the potential for building damage and human response (ie annoyance or disturbance to undertake normal activities).
33. I note that James Whitlock's evidence refers to the construction noise contours in Appendix H of the MDA assessment report⁶. Marshall Day Acoustics has undertaken a further more detailed worksite assessment and this includes revised source vibrations for TBM and roadheader tunneling work resulting in significantly shorter emission radii compared to those in the original MDA assessment report. As Mr James Whitlock's states in his evidence, it is important that Appendix H of the MDA assessment report and Appendix A and B of the Structural Engineer Technical Report are revised during the detailed design and / or just prior to construction in order to identify and confirm where it is appropriate that a building condition survey is undertaken. It is appropriate to confirm this at those stages so that building condition surveys are not unnecessarily undertaken on buildings where there is

⁶ Appendix 2, Volume 3 CRL NoR suite of documents.

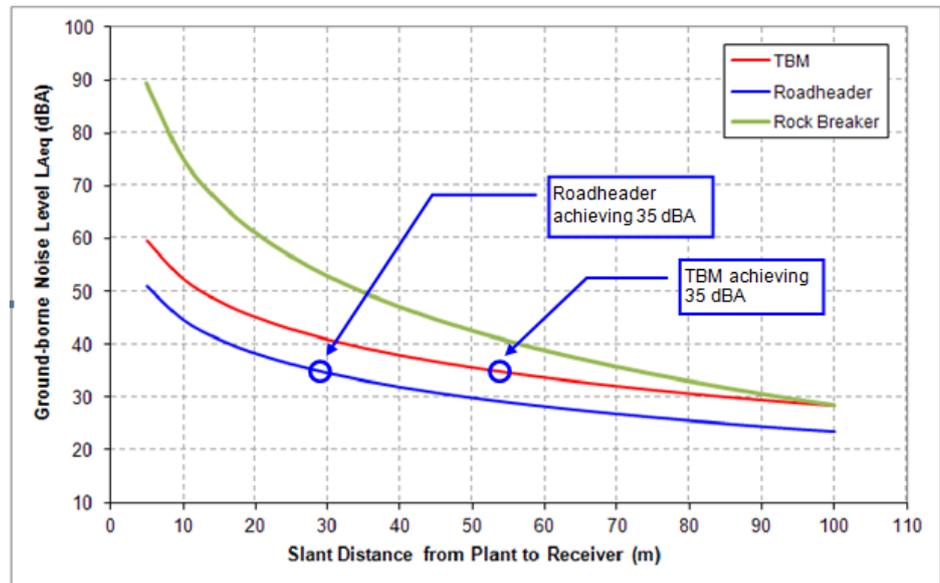
predicted to be no risk. The proposed draft CRL NoR conditions reflect this⁷.

34. I agree with the five notable receivers (Aotea Centre, MediaWorks TV3 studio, Roundhead Studios, Ministry of Justice and The Mercury Theatre), James Whitlock's evidence refers to as having the *potential* of being affected by construction vibration that results in regenerated noise. It is however my opinion that the actual and potential adverse effects that have been identified through the assessment done by James Whitlock is very conservative. I have previously indicated that the Project Construction and Operational Vibration criteria proposed for notable receivers, including TV3, is much lower than levels that have been accepted by other television networks.
35. It should be noted that for most of the construction activities the significant vibration sources (ie TBM, roadheaders, vibratory rollers and pilling) will be moving along the tunnel alignment and only cause temporary vibration effects at any one location⁸ for a relatively short period of time. For example the TBM will typically only have the potential to cause adverse vibration effects for a few days when travelling past any one receiver. The adverse vibration effects may include night-time sleep disturbance or disturbance to sensitive activities (those activities defined as a notable receiver for the purposes of the CRL NoR). This transient effect is more fully explained in Section 4.3 of the SLR document *Review of Ground-borne Noise and Vibration Assessment*, a copy of which is tended with this evidence.
36. The following graphs, extracted from Section 4.3 of the above mentioned document, shows the approximate slant distances required to achieve the night-time noise criteria for various vibration producing items of plant and the likely duration of impact for a TBM progressing at approximately 20m/day. The first graph below shows that approximately 30 m is required for the Roadheader and 55 m for the

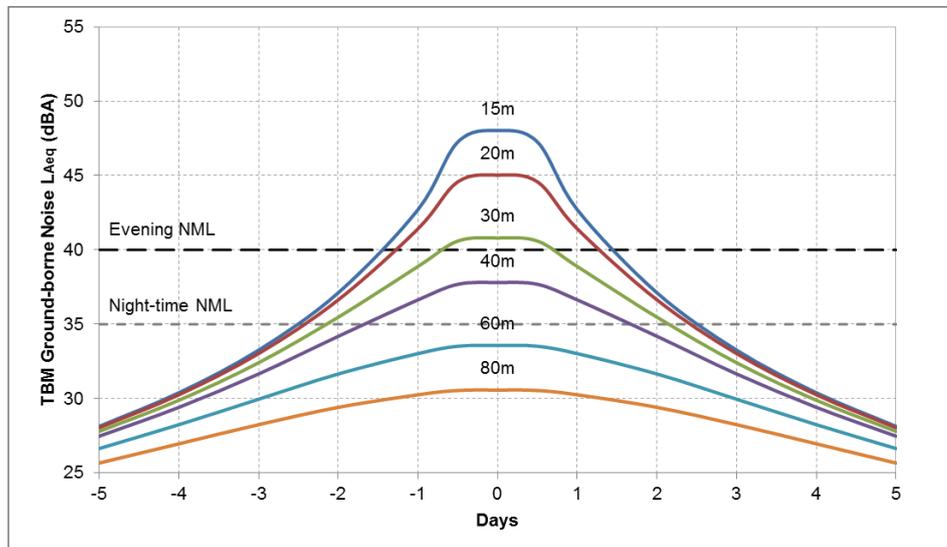
⁷ Proposed draft conditions, Attachment 2 to the evidence of Fiona Blight.

⁸ The evidence of Bill Newns provides the indicative construction methodology and construction programme.

TBM to generate noise levels at the night-time regenerated noise level criterion of 35 dBA. The second graph shows that a TBM operating at a slant distance of as little as 25 m will exceed the night time noise criterion for approximately 3 days.



Source: TBM and roadheader data is from Australian Acoustical Society Technical Meeting – Tunnelling Noise and Vibration Management, Wilkinson Murray, December 2003. Rock breaker data was obtained from SLR Consulting's noise database.



37. It is also relevant to note that our own preliminary assessment of regenerated noise in TV3 due to the construction activity, namely the Roadheader at approximately 15 m, results in a noise level of 41 dBA and 0.25 mm/s. It is possible that the noise monitoring at TV3 will indicate that noise at this level is already present in the Studios (from sources such as data projectors) and may well be tolerated for the relatively short period of time that they occur.

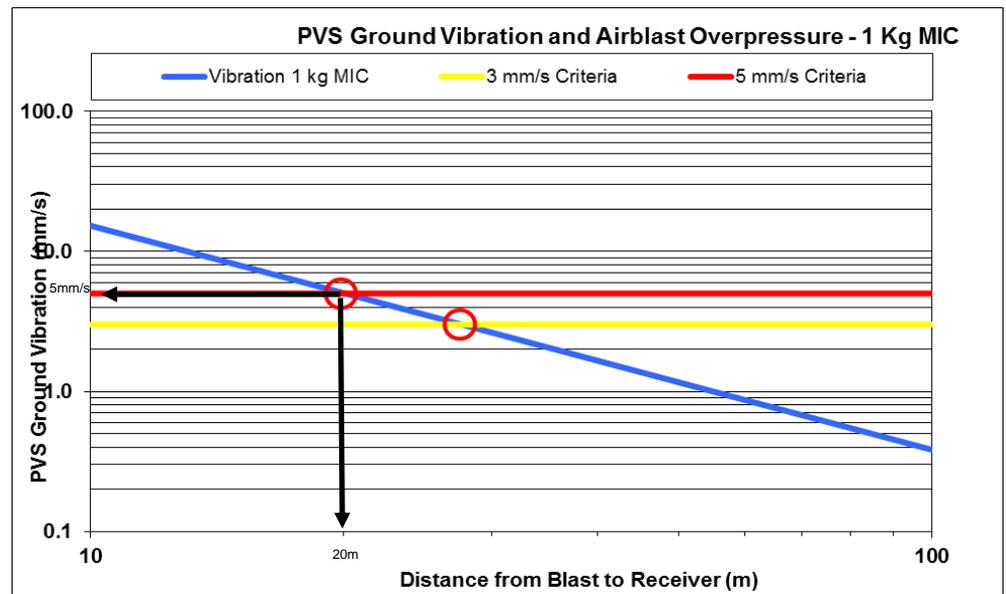
38. In addition to the above, it is relevant to note that the tunnelling works associated with the Clearwater project performed about 5 years ago required the replacement of a 1950 Ø sewer line located in Nikau Street and, and to the best of our knowledge, did not appear to have caused any significant level of disturbance to TV3. These construction works were performed by a Pipejack operating at a similar slant distance of approximately 15 m to the studio buildings as will the tunnelling works associated with the CRL tunnels. It is thought that a Pipejack would generate similar levels of vibration and regenerated noise as a Roadheader. The location of the new sewer pipe in relation to TV3 is shown in the image below. ‘



39. It is my opinion that through the proposed Construction Environmental Management Plan (CEMP), Communication and Consultation Plan, and where required, Site Specific Vibration Management Plans (SSCVMP), the potential adverse construction effects from vibration and regenerated noise can be appropriately managed and mitigated.
40. I note that the highest construction vibration impacts, other than for blasting, are predicted to be from the vibratory roller work associated

with the cut and cover tunnelling⁹. The proposed cut and cover work is no different from normal road upgrades (ie asphalt/concrete cutting, compaction etc) or high rise building constructions (ie excavation, rock breaking, pilling etc) which occur all over the city.

41. I agree with James Whitlock and Bill Newns that blasting trials can be reasonably undertaken in the area without causing significant effects to MediaWorks studios or other receivers. These tests will provide data from which site-specific attenuation parameters can be derived. An example of the vibration levels that might be expected for a 1 kg MIC blast is given in the graph below. James Whitlock provides indicative emission radii required to meet the DIN 4150-3:1999 short term vibration criteria in the 1-10 Hz range for a 3 Kg MIC blast in Appendix A to his Statement of Evidence. For the Residential criteria, this distance is 40 m. For a 1 Kg MIC blast, this figure below shows that the emission radius is reduced to 20 m to meet this 5 mm/s criterion.



42. I agree with the statements made in the evidence of James Whitlock around rock blasting and the methodology proposed to manage and mitigate the effects of blasting activities¹⁰. The site laws in combination with appropriate blast design to minimise ground vibration and airblast

⁹ Paragraph 15 of James Whitlock’s evidence.

¹⁰ Paragraphs 62 to 68 of James Whitlock’s evidence.

overpressure, communication regarding timing of blasts and monitoring will enable appropriate management of potential impacts from blasting.

Review of Operational Assessment and Mitigation

43. I agree that the United States' Federal Transit Administration (FTA) General Assessment Method that MDA have used to assess the ground-borne noise and vibration from rail operations is an appropriate screening procedure to determine if the *potential* for impacts exist. I also believe that some of the parameters used in the application of the methodology have been selected conservatively. Of particular relevance is the assumption that jointed track and conventional rail on ballast will be used in the construction of the CRL. It is my experience that continuously welded rail is used almost exclusively on new rail lines. Jointed track causes vibration levels to be about 5 dB higher than welded track. I believe this conservative assumption of jointed track is unwarranted and results in unnecessarily high predictions. Additionally, it is increasingly more common to use resilient fasteners rather than conventionally ballasted track in rail tunnels for a number of practical reasons (i.e. increased space and maintenance requirements).
44. It is my opinion, after preparing preliminary operational vibration predictions, that the proposed ground-borne noise and vibration criteria can be achieved at all notable receiver locations through implementation of continuously welded rail and resilient rail fasteners, with the additional mitigation of very high resilient rail fasteners or floating slab track at a few key receivers. The specific rail mitigation measures required to achieve the project operational criteria throughout the CRL will need to be identified through the more refined assessment in the detailed design stage.
45. As has been stated in the planners' report and in Mr. James Whitlock's evidence, a rolling stock maintenance plan to ensure maintaining wheel and track within specified good condition is strongly recommended.

Response to Planner's Report

46. I have read the sections relating to vibration and reradiated noise in the Planners' report and reviewed the response to the planners report made in James Whitlock's evidence.

Construction Vibration

47. I agree with the proposed night-time vibration criterion of 0.3 mm/s to be used as a trigger level for further investigation. In my opinion a slightly higher night-time vibration level could be accepted for short term (2-3 nights) construction works. However, in my experience it will be the night-time ground-borne noise criterion of 35 dBA LAeq,15 minute that will be the limiting criterion (i.e. occupants will generally hear the ground-borne noise before perceiving the ground-borne vibration).

Planners' Proposed Changes to Vibration Conditions

48. With regards to the proposed change to Condition (21), I agree with Mr. James Whitlock's statement in paragraph 170 of his evidence that the identified buildings subject to building condition survey in the CEMP will need to be revised throughout the detailed design and construction phases of the project as predictions are refined. Refer to my comments on this in Paragraph 33 of my evidence.

Operational Vibration

49. I agree with Mr. James Whitlock's statement in Section 175 and 176, meeting the FTA criteria will ensure appropriate vibration amenity of adjacent buildings. Building damage is in my opinion not an issue during operation of CRL.
50. I agree that at three notable receivers (Aotea Centre, MediaWorks TV3 studio and Roundhead Studios) track mitigation is required. What level (ie highly resilient, very highly resilient or floating slab track) will need to be determined when more detailed modelling has been undertaken. My preliminary predictions indicate that floating slab track may not be required.

51. I agree with the Planners report Section 9.3.5 which states the ground-borne noise criteria in the Table 6.3.2 of the MDA report is $L_{Amax,Slow}$ (ie 1 second maximum noise level).
52. I agree with the Styles Group report when stating that post construction remedial mitigation will be very expensive and it is paramount that the design includes adequate mitigation to achieve the appropriate project criteria. I am confident that by including measurements of ground-borne noise and vibration from different mitigation options a reasonable design (without building in too much costly conservatism) can be achieved.

Response to Proposed Conditions

53. I have reviewed the proposed draft CRL NoR conditions relating to ground-borne noise and vibration from construction and operation of the CRL.
54. I agree in general with the proposed ground-borne noise and vibration criteria, with the reservation as outlined in Section 21 to 25 of this evidence.

Matthew James Harrison

2nd July, 2013

Error! Unknown document property name.**Epping to Chatswood Rail Line (ECRL)**

Client: Parramatta - Rail Link

SLR Consulting were appointed advisers to the Dept of Transport on this project to provide noise and vibration assessments and air quality for the Representations Report as well as development of the Reference Design in relation to noise and vibration. Areas assessed included baseline noise and vibration / air quality measurements; community liaison during approvals process; ongoing acoustics advice and design studies for TIDC, including noise barrier assessments at Chatswood and Epping. The outcome was preparation of the operational noise and vibration impact assessment for the CTI project - Review of Environmental Factors.

CBD Metro

Client: Sydney Metro Authority

SLR Consulting was engaged by Sydney Metro Authority who required an appropriately experienced technical contractor to provide acoustic advice for both the CBD Metro Project and the West Metro Project. The CBD Metro is proposed to be an approximately 7km long line from Rozelle to Central, with new stations at Rozelle, Pyrmont, Barangaroo-Wynyard, Martin Place, Town Hall square and Central, and the safeguarding of a station at White Bay. The CBD Metro is the first step in a revolution in the quality of Sydney's public transport network and increasing the heavy rail service capacity to the CBD by 50% by using the underutilised Central Terminus platforms and providing onward connections through the city.

NW Metro (NVM)

Client: Transport Infrastructure Dev Corp.

In this project SLR Consulting was the Acoustic Technical Advisor (ATA) for TIDC's proposed North West Metro (NWM). The ATA provides specialist acoustical advice to the NWM Project Team on all aspects which form part of the Concept Design/Preliminary Design and Environmental Assessment stages of the NWM project. This role covers a large range of potential noise and vibration issues associated with its construction and operation, including operations at-grade, in-tunnel or on overhead structures such as bridges and viaducts. The role also covers issues such as bus and traffic noise near stations, noise emissions from electrical substations, station acoustics design, complaint investigations, train stabling noise and mechanical services design.

413 George Street Sydney – Vibration Study

Client: Grocon

SLR Consulting was engaged to review & verify the design and assist in supervising testing and installation of the building vibration isolation system for this new 14 level building which was to be constructed above four existing railway tunnels. This commission included performing surface and in-tunnel train vibration measurements and ground borne noise and vibration predictions. SLR Consulting was also engaged by Grocon to carry out a compliance test after the installation of the bearings and isolation material to verify that the rail induced noise and vibration criteria set for various space-occupancies within the building had been met.

Perth City Link Rail Tunnel (PCLRT)

Client: Perth City Link Rail Alliance

During the Concept Design Stage, our role was to identify the key noise and vibration issues associated with the proposed lowering of the Fremantle Line and the underground Bus Station. SLR Consulting prepared a Strategic Plan for the project, identifying the preferred means by which construction and operational noise and vibration impacts would be mitigated, with specific reference to existing sensitive receivers and the proposed Perth City Link development. SLR Consulting assisted PTA in addressing queries raised during the Tender Assessment Period. When seconded to the Perth City Link Rail Alliance, SLR Consulting undertook background noise and vibration measurements and prepared technical studies identifying impacts and recommending mitigation measures. Shane is the Project Director and am responsible for meeting the SLR team meeting the PTA timeframes as well as providing the technical peer review and authorisation of reports.

Cross River Rail (CRR)

Client: SKM-Aurecon Joint Venture

SLR Consulting provided all the noise and vibration services throughout the approvals process for this (approx) 6 km long rail tunnel. All aspects of the project were investigated including construction related regenerated noise and vibration from bored tunnelling, operational regenerated noise and vibration during operation, surface based construction for numerous new stations, operational ventilation and construction-related (e.g. spoil) transportation. SLR Consulting provided input to the EIS, Supplementary EIS, community consultation and regulatory authority consultation. Shane was the Project Director for this work and was responsible for most of the community and regulatory authority consultation as well as being one of the technical peer reviewers.

Error! Unknown document property name.**Chatswood Transport Interchange (CTI)**

Client: CRI and Lang O'Rourke (personal experience whilst at another Consultancy)

The CTI is a residential and retail airspace development above the Chatswood Rail Station in Sydney. The residential component comprises approximately 500 units in three high rise towers. A major project challenge was the design of an isolation system to reduce structure-borne noise and vibration. One of the residential towers is located directly over the rail lines, which are in turn supported on a slab on columns. This configuration means that structure-borne noise and vibration in the tower is of paramount concern. A track isolation system consisting of discontinuous double-tie floating slabs supported on rubber pads, and resilient rail fasteners, was designed using various Finite Element Models implemented in NE Nastran. The design fits within tight space constraints, and achieves the stringent structure-borne noise criterion in the residential units.

Sydney Opera House – Vehicle Access Pedestrian Safety (VAPS) Project

Client: Sydney Opera House Trust

SLR Consulting were engaged to determine structure borne noise and vibration criteria and management options for the construction of vehicle tunnels and loading dock spaces underneath the Sydney Opera House. The design phase of this project involved providing advice on control of noise and vibration from planned construction methodologies with regard to structural integrity and "Business-as-usual" Integrity for SOH operations. Design advice concerning noise and vibration control regarding operational design, including vehicle-induced vibrations and loading dock activities was also provided. SLR are currently providing acoustic and vibration services during the construction and delivery phase of the VAPS Project. This involves providing critical site inspections and compliance measurements, as well as reviewing the Contractor's Consultant's work, to ensure that the correct noise control measures and acoustic materials are being installed in accordance with the Acoustic Design requirements.