Assessment of Plan Provisions to Provide for Human Health and Amenity in accordance with section 32 of the Resource Management Act

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Executive Summary

Waka Kotahi seeks a gradual reduction in health and amenity effects implemented as new activities are established or existing activities are altered in close proximity to the operational state highway network. This outcome aligns with *Toitū Te Taiao – Our Sustainability Action Plan*[1] which in turn implements the Government Policy Statement on Land Transport 2018/2019-2027/2028[2] and the enduring Transport Outcomes: *A framework for shaping our transport system: Enabling New Zealanders to flourish Transport outcomes and mode neutrality, Ministry of Transport*, June 2018.

Achieving these outcomes this will assist regulatory authorities achieving Part 2 of the RMA by providing for the use of natural and physical resources in a way which enables people and communities to provide for their health and safety[3] and the maintenance and enhancement of amenity[4].

There are various regulatory methods (within and outside of the RMA) to achieve this outcome. A district plan based method has been assessed as the most implementable method in the current environment. This assessment considers a range of district plan methods as required under section 32 of the RMA.

The assessment concludes that an integrated suite of district plan provisions is the most effective and efficient method to provide reasonable levels of amenity and health protection for sensitive activities. The recommended provisions are based on a (modelled) noise contour line being established with activities 'inside' the contour being subject to specific requirements to provide improved health and amenity outcomes.

The recommended provisions relate to new or altered (increased) sensitive activities located within the modelled noise contour and the usual operation of the transport network, they do not:

a. apply retrospectively to existing buildings or sensitive activities;
b. require land owner to address effects resulting from transport network defects (eg potholes), which are the responsibility of the road controlling authority; or
c. manage amenity effects from transport noise from new or altered roads where these fall within the ambit of NZS 6806:2010 (Acoustics – Road traffic noise – New and altered roads).

[1] https://www.nzta.govt.nz/assets/About-us/docs/sustainability-action-plan-april-2020.pdf
[2] See paragraphs 123-124 and Table 1 Action 25 – Environment.
[3] Section 5(2), RMA.
[4] Section 7(c), RMA.

1. Introduction

The report has been prepared by Waka Kotahi NZ Transport Agency in accordance with Section 32 of the Resource Management Act 1991 (RMA) to assess the inclusion of human health and amenity provisions within District Plans.

Managing health effects from road noise is a shared responsibility between the road controlling authority and adjacent land users. Territorial authorities also have an important role to play in ensuring that planning instruments appropriately acknowledge and address the issue. Waka Kotahi invests significantly in design, construction and ongoing maintenance to minimise the effects of road noise. It is appropriate that those establishing or modifying land uses adjacent to existing State highways also share responsibility for protecting the health of occupants.

Retrospective management of transport noise effects is generally more difficult and expensive to achieve once activities have established adjacent to transport corridors. Management options are also more limited once activities are in place. For example, some design responses (eg. locating outdoor living areas away from noise sources) are not easily implemented or are precluded, retrospective building improvements can be challenging to implement, costly and disruptive, and property constraints may also limit response options (eg. no land available for acoustic barriers or bunding).

This report evaluates opportunities to provide plan provisions in accordance with section 32 of the RMA (s32). Under the RMA, a section 32 evaluation must:

a. Examine whether the proposed objectives are the most appropriate way to achieve the purpose of the RMA (s32(1)(a));

b. Examine whether the proposed provisions are the most appropriate way to achieve the objectives by identifying other reasonably practicable options, assessing their efficiency and effectiveness and summarising the reasons for deciding on provisions (s32(1)(b));

c. Relative to considering the efficiency and effectiveness of the provisions in achieving the objective, include an assessment of the benefits and costs of the effects anticipated from implementing the provisions (s32(2)); and

d. Contain a level of detail that corresponds to the scale and significance of the environmental, economic, social, and cultural effects that are anticipated from implementing the proposal (s32(1)(c)).

e. For plan changes, evaluate the proposal against both the objectives of the proposed plan change and the objectives of the existing plan (s32(3)).

Each of these matters is addressed by examining the key issues pertaining to the human health and amenity, and how a range of responses could operate in order to achieve the desired outcomes. This report is supplemented by an ‘issue identification’ statement (Section 2) which describes the human health effects at issue and assesses the cost of implementing mitigation.

In addition to RMA Part 2 outcomes (including of providing for communities health[5]), Waka Kotahi seeks a gradual reduction in exposure as existing activities are altered or relocated. This outcome aligns with *Toitū Te Taiao – Our Sustainability Action Plan*[6] which in turn implements the Government Policy Statement on Land Transport 2018/2019-2027/2028[7] and the enduring Transport Outcomes: *A framework for shaping our transport system: Enabling New Zealanders to flourish Transport outcomes and mode neutrality, Ministry of Transport*, June 2018.

[5] Resource Management Act, Part 2, Section 5(1).
[6] https://www.nzta.govt.nz/assets/About-us/docs/sustainability-action-plan-april-2020.pdf
[7] See paragraphs 123-124 and Table 1 Action 25 – Environment.

2. Issue identification

It is widely accepted nationally and internationally that noise from transport networks have the potential to cause adverse health and amenity effects on people living nearby. That potential has been documented by authoritative bodies such as the World Health Organisation (WHO)[8] including the publication *Environmental noise guidelines for the European region* in October 2018 (WHO Europe Guidelines).[9] The WHO Europe Guidelines are based on a critical review of academic literature and followed a rigorous protocol to assess the evidence of adverse effects.

With respect to sound from transport networks, the WHO Europe Guidelines note the potential for the following adverse effects:

i. sleep disturbance;
ii. high annoyance;
iii. hypertension; and
iv. ischaemic heart disease.

Based on the strength of the evidence of adverse effects, WHO recommends that policymakers reduce sound exposure from transport networks to below a range of guideline values.

State highways[10] pass through both urban and rural areas and most have sufficient traffic volumes to generate sound above WHO Europe Guideline levels, indicating there will be impacts on human health and amenity where noise-sensitive activities locate nearby.

In New Zealand, Quality Planning's *Managing Land Transport Noise Under the RMA* 2013 Guidance Note[11] recognises that transport noise has potential health effects and identifies district plan responses (eg. managing sensitive activity location, setbacks, zoning (and re-zoning), and structural restrictions). The Guidance Note provides:

> *One of the environmental results expected with the management of noise in plans should be the protection of people and communities from the impacts of land transport noise exposure*[12].

Within the Guidance Note, five alternative (non-RMA) responses[13] are identified (urban design strategy, bylaws, NZ Standards, Building Code and Waka Kotahi guidance). Two of these (the Building Code and Waka Kotahi guidance) are addressed in this assessment.

[8] World Health Organisation, Guidelines for community noise, 1999; World Health Organisation, Night noise guidelines for Europe, 2009; World Health Organisation, Burden of disease from environmental noise, 2011
[9] World Health Organisation, Environmental noise guidelines for the European region, 2018.
[10] May also apply to high traffic volume roads managed by other Road Controlling Authorities.
[11] https://www.qualityplanning.org.nz/node/825
[12] https://www.qualityplanning.org.nz/node/825 *4. Environmental Effects Expected – Optional*, page 12.
[13] https://www.qualityplanning.org.nz/node/825 *Local Approaches – other mechanisms,* page 14.

3. Objectives Assessment

Section 32(1)(a) of the RMA requires an examination of whether a proposed objective is the most appropriate way to achieve the purpose of the RMA. The purpose of the RMA is set out in Part 2, Section 5 of the Act.

5 Purpose

(1) The purpose of this Act is to promote the sustainable management of natural and physical resources.

(2) In this Act, sustainable management means managing the use, development, and protection of natural and physical resources in a way, or at a rate, which enables people and communities to provide for their social, economic, and cultural well-being and for their health and safety while—

(a) sustaining the potential of natural and physical resources (excluding minerals) to meet the reasonably foreseeable needs of future generations; and

(b) safeguarding the life-supporting capacity of air, water, soil, and ecosystems; and

(c) avoiding, remedying, or mitigating any adverse effects of activities on the environment.

Waka Kotahi has formulated proposed objectives and policies for inclusion in district plans. An assessment of the proposed objective against RMA section 5 is set out in Table 1, below.

Table 1: Assessment of Objective under Section 5

Proposed Provision	**Reason**
Objective 1 Protect sensitive activities from potential health and amenity effects that may arise from operational state highway noise. Policy 1 Locate and design new and altered buildings containing noise sensitive activities to minimise the potential for adverse effects from the designated state highway network. Policy 2 Manage subdivision which could contain noise sensitive activities through setbacks, physical barriers and design controls to ensure subsequent development can be located, designed and constructed to minimise exposure to noise.	Section 2 of this report describes likely adverse effects on sensitive activities where they are located in close proximity to the transport network. The objective (and supporting policies) will enable communities to provide for their social well-being and health by ensuring that noise sensitive activities located in close proximity to a state highway incorporate appropriate protection so as to ensure improved health outcomes and amenity levels.

The balance of Part 2 of the RMA provides the framework for the sustainable management of natural and physical resources. Section 6 lists matters of national importance that shall be recognised and provided for, section 7 lists other matters that all persons exercising functions and powers under the RMA shall have particular regard to and section 8 addresses matters relating to the principles of the Treaty of Waitangi. No relevant matters in sections 6 or 8 have been identified. The proposed objective has been assessed against the following provisions of section 7 in Table 2.

Table 2: Assessment of Objective under Part 2 Section 7	
RMA Provision	**Objective 1**
s7(b) (the efficient use and development of natural and physical resources)	Objective 1 will provide for the efficient use and development of physical resources (land and the State highway network) by enabling the proximity effects of land use and infrastructure to be managed appropriately.
s7(c) (maintain and enhance amenity values)	Objective 1 will give effect to s7(c) by enhancing amenity by reducing effects of noise on noise-sensitive activities.

It is considered that the proposed objective is consistent with Part 2, section 5 of the Act and will result in the sustainable management of natural and physical resources.

4. Provisions Assessment

Sections 32(1)(b) and 32(2) require assessment of the proposed plan provisions to be undertaken. These are summarised as:

a. whether the proposed provisions are the most appropriate way to achieve the objectives by identifying other reasonably practicable options, assessing their *efficiency and effectiveness* and summarising the reasons for deciding on provisions; and
b. relative to considering the **efficiency and effectiveness** of the provisions in achieving the objective, include an assessment of the benefits and costs of the effects anticipated from implementing the provisions.

The cost and benefit assessment must identify and assess the costs and benefits associated with environmental, economic, social, and cultural effects including economic growth and employment that are anticipated to be provided or reduced. If practicable, these are to be quantified.

Section 32(2)(b) also requires an assessment of the risk of acting or not acting if there is uncertain or insufficient information. In this case, there is considered to be sufficient information about the subject to determine the range and nature of effects of the options set out, and so that assessment has not been undertaken.

4.1 Noise

4.1.1 Identifying options

Where the reasonably practical alternative options (assessed in Table 3) include plan provisions, they are framed in the following context:

a. The provisions apply to all new and altered (by increase in floor area) *Noise Sensitive Activities* (defined in **Attachment 1**) which, in addition to residential activities, includes activities such as student or retirement accommodation, educational activity (including in any child care facility), healthcare activity and any congregations within places of worship/marae.

b. Internal noise criteria of between 35 dB $L_{Aeq(24h/1h)}$ and 45 dB $L_{Aeq(24h/1h)}$ have been allocated to the *Noise Sensitive Activities* for the reasons described in **Attachment 2**. Specifications detailing how to achieve internal noise space can be either specified as a *Construction Schedule* included as part of **Attachment 1** or by a design certified by an acoustic consultant.

c. Provisions include ventilation requirements where internal noise criteria are to be met; without ventilation the effectiveness of built acoustic treatment is compromised (ie. windows open for ventilation compromise the performance of building envelope noise mitigation measures). Ventilation requirements are specified in **Attachment 1**.

d. Outdoor living space provisions apply only to areas specifically identified by the district plan as required outdoor living areas.

e. Provisions include a mapped extent to which the provision would apply. This is described as Noise Control Boundary Overlay (NCBO) in accordance with the National Planning Standards Mapping Standard or identified as a 'yard'.

f. The provisions:
   (i) do not apply retrospectively to existing sensitive activities;
   (ii) are not proposed to require a land owner to address effects resulting from transport network defects (eg potholes), which are the responsibility of the road controlling authority; and
   (iii) do not manage amenity effects from transport noise from a new or altered road; these generally fall within the ambit of NZS 6806:2010 (Acoustics – Road traffic noise – New and altered roads).

The reasonably practical alternative options identified include (a) to (d) above and are identified as:

a. **Do nothing:** No plan provisions to protect sensitive activities from potential health and amenity effects.

b. **Modelled setback:** Require specific response to manage noise based on a (modelled) noise contour line (NCBO) being established. Activities 'inside' the NCBO are a permitted activity (for the purposes of noise) if specific requirements are met. For the reasons set out in **Attachment 2**, the recommended extent of the NCBO is set at 57 dB $L_{Aeq(24h)}$. **Attachment 4** explains the basis of the acoustic model which takes into account environmental factors such as traffic volume, road surface, topography and buildings.

c. **Metric setback:** Require specific response to manage noise where a sensitive activity is located within a specific NCBO based on distance (eg 40m, 80m or 100m) from a state highway. The specific setback distance may be based on speed limit (eg 40m for <70k/hr or 80m or 100m >70k/hr). Activities 'inside' the NCBO are a permitted activity if specific requirements are met.

d. **Yard:** A 'no build' setback from state highways. All noise sensitive activities in the yard area are listed non-complying activities. Yard setback could be set based on road speed limit (eg 40m for <70k/hr or 80m or 100m >70k/hr).

An assessment of the *efficiency and effectiveness* of the options assessed in terms of Sections 32(1)(b) and 32(2) is included in Table 3.

Table 3: Alternative Option Assessment			
Option	Effectiveness and Efficiency	Costs	Benefits
Option A: Do Nothing	Highly efficient but not effective. This option requires no action from the regulatory authority or applicants so is efficient. It is considered to be the least effective as it will allow an increase in adverse human health and amenity effects over time.	An increase in adverse health and amenity impacts (including costs). Poorer health and amenity outcomes fall on wider community and can be difficult to identify or resolve at an individual level.	No additional regulatory cost or costs to land owners in terms of compliance or building cost increases.
Option B: Modelled Setback	Highly efficient and effective. Utilising a model based on existing environmental conditions to calculate expected noise levels provides a more effective and efficient approach to setting the extent that a noise control should apply compared with Options C and D (both of which are 'standard width' controls regardless of local conditions).	A range of compliance and construction costs will apply when compared with Option A. These range from building and compliance design costs to meet permitted activity standards through to resource consent costs should standards not be complied with. The costs will fall on applicants and compliance confirmation costs will be borne by the regulatory authority and/or the applicant. Costs of mitigation have been independently assessed by Acoustic Engineering Services Limited[14] and indicate typically a 0% to 2% increase in	Better human health outcomes as there will be less exposure to the causes of negative health and amenity outcomes when compared with Option A. Option B provides a comprehensive regulatory approach which recognises the spatial extent of road traffic noise based on environmental factors (eg traffic volume, topography, road surface, existing building locations). This will result in a more accurate reflection of the extent of likely effects than Options C or D. The provisions do not aim to achieve 'zero' health effects (which is the outcome sought by

[14] **Attachment 3**: Acoustic Engineering Services Limited, Report Reference AC20063 – 01 – R2: Cost of traffic noise mitigation measures, 12 June 2020.

Table 3: Alternative Option Assessment			
Option	Effectiveness and Efficiency	Costs	Benefits
		construction cost for new dwellings and additions[15] in new materials. Waka Kotahi will also bear the cost of maintaining up to date modelling data to support noise contour line establishment.	the WHO Guidelines). Rather, the Modelled Setback/Option B provisions provide for a balance between health and amenity protection, cost and regulatory administration.
Option C: Metric Setback	Moderately efficient and effective. Option provides a reasonable outcome but will 'capture' more sites than is necessary to be highly efficient.	Option C (especially where applied at 80m to 100m) is likely to affect a greater number of sites than Option B. It is a 'blanket' approach which does not reflect individual area conditions. Other costs are the same as for Option B.	Better human health outcomes as there will be reduced exposure to the causes of negative health and amenity outcomes when compared with Option A. Less costly to prepare (set distance rather than modelled) when compared with Option B.
Option D: Yard provision	Highly effective but not efficient. The 'no build' yard will provide a high level of health and amenity protection but does not result in an efficient use of land.	Limits construction on particular areas of a site; high cost borne by land owners as sensitive activity development is limited in these areas.	Good human health outcomes as there will be a reduced number of sensitive activities exposed to the causes of negative health and amenity outcomes.

4.1.2 Assessing reasonably practicable options

Based on the cost benefit analysis presented in Table 3, Table 4 summarises reasonably practicable options.

Table 4: Identifying Reasonably Practicable Options	
Option	Is it reasonably practicable?
Option A: Do nothing This option is currently applied in some District Plans.	✓
Option B: Modelled Setback	✓

[15] **Attachment 3:** Acoustic Engineering Services Limited, Report Reference AC20063 – 01 – R2: Cost of traffic noise mitigation measures, 12 June 2020.

Options similar to this are currently applied in some District Plans.	
Option C: Metric Setback Options similar to this are currently applied in some District Plans.	✓
Option D: Yard requirement Options similar to this are currently applied in some District Plans.	✓

4.1.3 Preferred option

Based on the analysis in Table 3 and the reasonably practicable options identified in Table 4, Table 5 rates each of the reasonably practicable options.

Table 5: Preferred Option			
Least Preferred			Most Preferred
Option A: Do Nothing.	**Option D:** Yard setback	**Option C:** Metric Setback	**Option B:** Modelled Setback

For the reasons set out in Tables 3 and 4, the Modelled Setback/Option B is considered to be the most efficient and effective method for addressing the health and amenity effects of transport noise.

However, as specific modelling is yet to be completed for the Taupo Region at this time Waka Kotahi are seeking a Metric Setback of 100m. Waka Kotahi anticipate that modelling can likely be completed at the time of further submissions and have allowed for scope in the submission to provide for an amendment to provide for a modelled rather than metric setback.

5. Conclusion

The Modelled Setback/Option B is identified as the preferred approach to manage the potential health and amenity effects of transport network operations, and to and provide a reasonable and appropriate balance between cost and benefit. The provisions apply only where an existing noise-sensitive activity is extended or a new noise-sensitive activity is proposed adjacent to a designated transport corridor.

The Modelled Setback/Option B have been detailed and compared against a number of alternatives in terms of their costs, benefits, and efficiency and effectiveness in accordance with the relevant clauses of section 32 of the RMA.

The Modelled Setback/Option B are considered to represent the most appropriate means of achieving the proposed objective and of addressing the underlying resource management issues relating to the transport environment, human health and amenity. However, until modelling is completed for the Taupo Region a 100m Metric Setback / Option C is sought which achieves outcomes similar to Modelled Setback/Option B however does not reflect individual area conditions.

New or altered State highway transport projects will continue to be assessed under NZS 6806:2010 (Acoustics – Road traffic noise – New and altered roads).

Attachment 1: Provisions (Option B)

Objective 1

Protect sensitive activities from potential adverse health and amenity effects that may arise from designated state highway noise.

Policy 1

Locate and design new and altered buildings containing noise sensitive activities to minimise the potential for adverse effects from the designated state highway network.

Policy 2

Manage subdivision which could contain noise sensitive activities through setbacks, physical barriers and design controls to ensure subsequent development can be located, designed and constructed to minimise exposure to noise.

New Definition

Noise Sensitive Activity(s): Means any residential activity including visitor, student or retirement accommodation, educational activity including in any child care facility, healthcare activity and any congregations within places of worship/marae. Excludes those rooms used solely for the purposes of an entrance, passageway, toilet, bathroom, laundry, garage or storeroom.

1. Permitted Activity Rule Indoor Noise

a. Within the Noise Corridor Boundary Overlay, where:
   (i) a new building that contains a noise sensitive activity; or
   (ii) an alteration to an existing building resulting in an increase in floor area of a noise sensitive activity; or
   (iii) a new noise sensitive activity is located in an existing building;

   is proposed, it is to be:

   (iv) Designed, constructed and maintained to achieve indoor design noise levels not exceeding the maximum values in Table 1; and
   (v) If windows must be closed to achieve the design noise levels in (1)(a)(i), the building is designed, constructed and maintained with a mechanical ventilation system that:
      a. For habitable rooms for a residential activity, achieves the following requirements:
         i. Provides mechanical ventilation to satisfy clause G4 of the New Zealand Building Code; and
         ii. is adjustable by the occupant to control the ventilation rate in increments up to a high air flow setting that provides at least 6 air changes per hour; and
         iii. provides relief for equivalent volumes of spill air; and
         iv. provides cooling and heating that is controllable by the occupant and can maintain the inside temperature between 18^0C and 25^0C; and
         v. does not generate more than 35 dB $L_{Aeq(30s)}$ when measured 1 metre away from any grille or diffuser.
b. For other spaces, is as determined by a suitably qualified and experienced person.

c. A report is submitted by a suitably qualified and experienced person to the council demonstrating compliance with clauses (1)(a)(i) and (ii) above (as relevant) prior to the construction or alteration of any building containing an activity sensitive to noise.

Table 1

Occupancy/activity	**Maximum road noise level** [Note 1] $L_{Aeq(24h)}$
Building type: Residential	
Sleeping spaces	40 dB
All other habitable rooms	40 dB
Building type: Education	
Lecture rooms/theatres, music studios, assembly halls	35 dB
Teaching areas, conference rooms, drama studios, sleeping areas	40 dB
Libraries	45 dB
Building type: Health	
Overnight medical care, wards	40 dB
Clinics, consulting rooms, theatres, nurses' stations	45 dB
Building type: Cultural	
Places of worship, marae	35 B

Note 1: The design road noise is to be based on measured or predicted external noise levels plus 3 dB.

2. Permitted Activity Rule Outdoor Living Area

a. Where an outdoor living or outdoor activity space required by another rule in the Plan is within the Noise Corridor Boundary Overlay and the outdoor space is required for a noise sensitive activity, the required outdoor living space is to be designed and maintained to achieve noise levels not exceeding the maximum values in Table 2; and

b. A report is submitted by a suitably qualified and experienced person to the council demonstrating compliance with clauses (2)(a) above prior to the construction or alteration of the any building to which the outdoor living space relates.

Table 2

Activity	Maximum road noise level [Note 1] $L_{Aeq(24h)}$
Required Outdoor Living Space	57 dB

Note 1: The design road noise is to be based on measured or predicted external noise levels plus 3 dB.

3. Restricted Discretionary Activity Rule

Any new or altered noise sensitive activity which does not comply with Permitted Activity (1) or (2).

Restricted Discretionary Activity – Matters of Discretion

Discretion is restricted to:
(a) Location of the building and outdoor living space;
(b) The effects of the non-compliance on the health and amenity of occupants; and
(c) The outcome of any consultation with Waka Kotahi NZ Transport Agency.

Restricted Discretionary Activity – Assessment Criteria

Discretion is restricted to:
(a) Whether the location of the building minimises effects;
(b) Alternative mitigation which manages the effects of the non-compliance on the health and amenity of occupants; and
(c) The outcome of any consultation with Waka Kotahi NZ Transport Agency.

Attachment 2: Technical Basis of Noise Criterion

In preparing the Modelled Setback/Option B, Waka Kotahi has assessed existing research, standards and guidelines to guide selection of appropriate noise criteria.

Two documents are identified as providing national and international guidance and directives for transport noise: the WHO Europe Guidelines and NZS 6806:2010 *Acoustics – Road-traffic noise – New and altered roads* (NZS 6806).

In addition, AS/NZS 2107:2016 *Acoustics – Recommended design sound levels and reverberation times for building interiors* (AS/NZS 2107) is a joint Australia and New Zealand standard which provides compliance measurement methods for background noise and recommends design criteria for occupied spaces.

WHO Europe Guideline

The WHO Europe Guidelines (the Guideline) contains key recommendations in regards to transport noise including:

Road[16]:

- For average noise exposure: recommends reducing noise levels produced by road traffic below 53 dB L_{den}; and
- For night time exposure: recommends reducing noise levels produced by road traffic during night time below 45 dB L_{night}.

The WHO Europe document contains guidelines; it does not set a fixed standard. The Guideline has been prepared as an international research document and its outcomes need to be considered within the New Zealand statutory context before reference or inclusion in planning or policy documents. WHO guidance regarding effects of noise on health (more generally) are reflected in NZS 6806[17].

NZS 6806:2010 Acoustics – Road-traffic noise – New and altered roads

NZS 6806 is the principal national document for management of noise in relation to new and altered roads. The purpose of NZS 6806 is to ensure noise effects on existing sensitive activities (described as Protected Premises and Facilities / PPFs) from new or altered roads are managed. It has been developed with the intention of being suitable to support RMA processes and to set *reasonable noise criteria* for road traffic noise (from new or altered roads) taking into account, among other things, health effects[18].

NZS 6806 is a national standard, has been specifically developed for inclusion within an RMA framework, has been adopted into district plans and utilised in designations for the specific purpose of transport noise management. It is accepted as current good practice in regards to setting requirements which result in *reasonable* noise outcomes.

[16] World Health Organisation, Environmental noise guidelines for the European region, 2018. Section 3.1.
[17] NZS 6806 :2010 Section 4.7.1.
[18] NZS 6806:2010 Acoustics – Road-traffic noise – New and altered roads, section 1.1.4.

NZS 6806 includes an external ("Category A") noise criterion[19] for altered roads (64 dB $L_{Aeq\ (24h)}$), and two criteria for new roads depending on design year traffic volumes (64 dB $L_{Aeq\ (24h)}$ for higher volume roads and 57 dB $L_{Aeq\ (24h)}$ for lower volume roads).

Higher volume roads are those which, at design year, are predicted to carry greater than 75,000 AADT (Average Annual Daily Traffic). Lower volume roads are those which, at design year, are predicted to carry between 2,000 and 75,000 AADT.

Internal noise criterion[20] for habitable spaces are set at 40 dB $L_{Aeq\ (24h)}$ for altered and new roads (regardless of AADT).

Analysis of 2018 AADT data[21] shows the majority of existing state highways carry less than 75,000 AADT. It also indicates that only central parts of the Auckland motorway network currently have an AADT greater than 75,000.

While NZS 6806 applies to new and altered roads (ie. the onus is on the road controlling authority to manage effects), it provides strong guidance as to *reasonable* levels and expectations of noise levels in these environs. If these (<75,000 AADT) state highways were constructed (new) or altered in the current statutory environment, the lower level (57 dB $L_{Aeq(24h)}$) of the NZS 6806 external noise limits would be applied.

For road-traffic noise averaged over 24 hours, the internal 40 dB $L_{Aeq(24h)}$ criterion in residential habitable spaces from NZS 6806 represents a reasonable level as at night the level should reduce (as traffic volumes reduce) so as to avoid undue sleep disturbance.

AS/NZS 2107 Acoustics – Recommended design sound levels and reverberation times for building interiors

The scope of AS/NZS 2107 is to recommend criteria for healthy, comfortable and productive environments and it applies to steady-state or quasi-steady-state sounds. The Standard is ambiguous whether it should apply to transportation noise; regardless it provides an indication of reasonable internal levels for different types of sensitive activities. The criteria adopted in the Modelled Setback/Option B are generally consistent with AS/NZS 2107.

Conclusion

For the Modelled Setback/Option B, Waka Kotahi selected the NZS 6806 external level of 57 dB $L_{Aeq(24h)}$ and internal levels of between 35 dB $L_{Aeq(24h/1h)}$ and 45 dB $L_{Aeq(24h/1h)}$. This is because:

a. the majority of state highway AADT fall within the lower AADT band for external noise within NZS 6806 (which requires external noise levels of 57 dB $L_{Aeq(24h)}$ for a new or altered road); and

[19] NZS 6806:2010 Acoustics – Road-traffic noise – New and altered roads, Table 2 – Noise Criteria, A (primary free-field external noise criterion).
[20] NZS 6806:2010 Acoustics – Road-traffic noise – New and altered roads, Table 2 – Noise Criteria, C (internal noise criterion).
[21] https://www.nzta.govt.nz/resources/state-highway-traffic-volumes/ 2018 data - *State highway volumes by region (in Excel format)*

b. the outdoor noise exposure level of 57 dB and an indoor noise threshold near the top of the design range[22] in AS/NZS 2107:2016 (40 dB) have been selected as these levels are considered to provide a reasonable level of health and amenity protection but are not the most stringent.

[22] *top of the design range* means that the noise limit is at the upper level of range - ie. allows more noise rather than less.

Attachment 3: Building Cost Assessment

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Memorandum

To:	Greg Haldane, Waka Kotahi
From:	Clare Dykes, Acoustic Engineering Services
File Reference:	AC20063 – 01 – R2
Date:	Friday, 12 June 2020
Project:	Cost of traffic noise mitigation measures
Pages:	6

Meeting ☐ Telephone ☐ Memorandum ☑ File Note ☐

Dear Greg,

In March 2020, Waka Kotahi NZ Transport Agency engaged Acoustic Engineering Services (AES) and O'Brien Quantity Surveying to undertake a study relating to the cost of traffic noise insulation measures. The project involved a review of a number of situations where traffic noise mitigation had been installed, including:

- Buildings which required upgrades to reduce traffic noise break-in as a result of their location in proximity to major roads, and;
- New residential neighbourhoods which were constructed near to major roads, where traffic noise barriers were integrated into the overall scheme design so that the upgrading of dwellings was no longer required (or was reduced) and noise in outdoor living areas was reduced.

This memorandum summarises the study, and the general trends visible in the results.

1.0 BUILDING UPGRADES

A common method of ensuring that noise from roads is not intrusive within buildings is to design the building envelope to provide a high level of sound insulation, and to provide a mechanical ventilation system so occupants do not need to open windows for cooling and fresh air.

The Christchurch District Plan contains a rule requiring the design of new noise sensitive buildings to be constructed in higher noise locations to include these sound insulation features. AES have previously completed a study related to the Christchurch District Plan sound insulation rule, which involved a review of the specific circumstances relating to a sample of building projects. The work described in this memo built on aspects of that previous study, and looked to quantify the cost of those building upgrades, to assist Waka Kotahi in understanding the potential financial implications of mandatory traffic noise insulation rules. A number of additional examples from various sources were added to the original sample, to increase the sample size and diversity.

We have also completed a review of the Proposed and Operative District Plans for the 67 New Zealand Districts. Two thirds of the District Plans throughout the country include requirements for sound insulation when dwellings are located in proximity to major roads. Of these, 10 % include a requirement which is very

similar to the Waka Kotahi Guidelines[1] centred around an internal noise level requirement of 40 dB $L_{Aeq\ (24\ hour)}$ in bedrooms and other habitable spaces, and the provision of mechanical ventilation. The remaining rules vary, with common variations including requiring different internal noise levels to be met, omitting any mechanical ventilation requirement (or a reduced mechanical ventilation requirement), and specifying a fixed level of sound insulation performance to be achieved by the building façade. As discussed below, all of these rule variations have a different cost impact.

1.1 The sample

A total of 58 buildings were considered for inclusion in the analysis. However, detailed costings were only completed on 23 of these, primarily because:

- A number of the building projects successfully obtained a Resource Consent to legitimise a partial or complete non-compliance with the relevant sound insulation rule, and so these results would not have assisted with understanding the cost of compliance.
- For a number of the building projects there was not sufficient publicly available information to complete an accurate costing.

The final 23 building projects included 11 detached residential dwellings, seven multi-residential units (such as terraced houses and duplexes), and five apartment buildings. These buildings were expected to experience worst-case traffic noise levels ranging from 55 dB $L_{Aeq\ (24\ hours)}$ to 71 dB $L_{Aeq\ (24\ hours)}$.

As discussed above, a variety of sound insulation rules are encountered throughout the country. The building projects in the sample had been assessed against the following rules:

- 12 of the sample has been assessed against a requirement which is similar to that described in the Waka Kotahi Guidelines, including an internal noise level requirement of 40 dB $L_{Aeq\ (24\ hour)}$ in bedrooms and other habitable spaces, and the provision of mechanical ventilation.
- Two of the sample were assessed using a rule which has a different internal noise level requirement with no mechanical ventilation required.
- Eight of the sample were assessed against rule with a façade reduction requirement or a provided set of constructions intended to provide a fixed façade reduction, and no mechanical ventilation required.
- One involved review against an internal noise level requirement of 40 dB $L_{Aeq\ (24\ hours)}$ for some spaces, and a façade reduction requirement for others.

Overall, the sample was relatively small – however a moderate number of examples could be assessed against a rule similar to that preferred by Waka Kotahi. Otherwise the variety within the sample is typical of the variety in sound insulation rules encountered in New Zealand.

Challenges of extending the sample included the lack of a centralised database to use for establishing a list of building projects of potential interest, and then the lack of availability of publicly available information for projects which provides sufficient detail for accurate costings.

1.2 Assumptions

Key assumptions embodied in this part of the study are as follows:

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[1] Waka Kotahi NZ Transport Agency, *Guide to the management of effects on noise sensitive land use near to the state highway network*, Version 1.0, September 2015

- The reported external noise levels are based on the available traffic numbers, road surface, and speed information for the road adjacent to the building project site at the time, and are for the most exposed building façade.
- The upgrades that were recommended by the acoustic engineers involved in each case were installed and alternative systems were not used.
- The systems where not specified were originally 10 mm Standard Gib plasterboard internal linings for walls, and 13 mm Standard Gib plasterboard linings for ceilings, and 4 mm float glass / 12 mm air space / 4 mm float glass for glazing.
- Where 7 mm Ecoply RAB board was specified for external walls it was assumed that this would have been included regardless of the acoustic upgrades, and so was not included in the upgrade costing.
- Where not specified, the mechanical ventilation system was assumed to be of similar or equal design and performance to those projects where this detail was provided.

1.3 Findings

We have summarised a number of key observations from the analysis below.

Table 1.1 outlines the increase in overall building cost associated with any upgrades to the building façade and/or the installation of mechanical ventilation system, to ensure compliance with the various sound insultation rules.

Table 1.1 – Summary of cost of traffic noise mitigation by building type

Building Type	Range of external noise levels (dB $L_{Aeq\ (24\ hours)}$)	Increase in overall cost of building (per residential unit)	Percentage increase in overall cost of building
Detached residential	55 – 68	$0 – $16,000	0 – 2 %
Residential units	58 – 69	$500 – $15,000	0 – 2 %
Apartment buildings	60 – 71	$500 – $16,000	0 – 1 %

These results illustrate that the overall percentage increase in building cost due to compliance with a sound insulation rule was 2 % or less (noting that none of the buildings in the sample were exposed to external traffic noise levels exceeding 71 dB $L_{Aeq(24\ hour)}$).

For the residential units and apartment buildings, the figures in table 1.1 are based on the total cost of upgrades, divided by the total number of residential units in the development. However, some units did not require any upgrades, as they experience lower external noise levels. If the total cost of upgrades is only divided by the number of units in the development which required upgrading, the percentage increase changes to 1 – 4 %.

In table 1.2 the results are presented based on the type of sound insulation rule that the assessment was undertaken against.

Table 1.2 – Summary of cost of traffic noise mitigation by rule type

Rule	Range of external noise levels (dB $L_{Aeq\ (24\ hours)}$)	Increase in overall cost of building per residential unit	Percentage increase in overall cost of building
Internal noise level of 40 dB $L_{Aeq\ (24\ hours)}$ and mechanical ventilation	55 – 71	$0 – $16,000	0 – 2 %
Alternative internal noise level requirement, no mechanical ventilation	64 – 65	$500 – $1,500	0 – 1 %
Façade reduction requirement or defined constructions, and no mechanical ventilation	55 – 69	$0 - $16,000	0 – 2 %

This summary appears to indicate that the costs associated with both the internal noise level and façade reduction rules are similar (noting that the sample size for the 'alternative internal noise level requirement, no mechanical ventilation' rule was very small, and the external levels were moderate). However, we note the following:

- For the methods which used internal noise levels, the increase in costs is very dependent on the external noise level. The developments which resulted in upgrade costs of less than 1 % typically experienced external noise levels below 65 dB $L_{Aeq\ (24\ hours)}$. There are exceptions to this depending on the layout of the units.

- While the 'façade reduction requirement or defined constructions' rules appear to attract a similar cost to the 'internal noise level' rules, those particular rules did not require mechanical ventilation to be installed. Occupants in some situations would therefore have still had to choose between thermal comfort, and noise. Additional cost should have been involved with installing mechanical ventilation in those situations, as was the case for the 'internal noise level of 40 dB $L_{Aeq\ (24\ hours)}$ and mechanical ventilation' examples. To put it another way, the cost may be been similar, but the benefit is likely to have been less in many cases.

- The required construction upgrades (and therefore the costs) of the 'façade reduction requirement or a defined set constructions' rules are not dependent on external noise levels. This means that while the range of cost increases is similar, in some situations the high costs lead to no benefit, as the external noise levels were low. For the 'internal noise level of 40 dB $L_{Aeq\ (24\ hours)}$ and mechanical ventilation' examples where the costs were high, that was at least in response to high external noise levels and so was justified.

For a small number of developments, no upgrades were required as either external traffic noise levels were very low, or the original design included high mass cladding with small window areas on key facades.

2.0 BARRIERS

An alternative method for reducing the levels of road traffic noise experienced by the occupants of new dwellings is for a barrier to be installed to screen a new residential neighbourhood from the road. This means that individual dwellings are less likely to need to be upgraded, and noise levels in outdoor living areas are also reduced. However, the developer of the new neighbourhood is likely to primarily bear the cost of the barrier, compared to the building upgrades discussed in section 1.0 above, which are paid for by the individual building owners.

2.1 The sample

10 new residential neighbourhoods were included in the analysis. All of these adjoined State Highways and were likely to have been designed with some regard to the Waka Kotahi Guidelines. Each of the neighbourhoods had been screened from the State Highway with a traffic noise barrier, including:

- Seven examples with 'acoustic' fences ranging in height from 2 – 3 metres
- Two examples where earth bunds had been constructed – these were 2 – 3 metres in height, and 8 – 9 metres wide
- One example with a combination of acoustic fencing and earth bund

For each example, we determined the number of dwellings which would have experienced traffic noise levels of greater than 57 dB $L_{Aeq\ (24\ hours)}$ without a barrier. These dwellings would have been the most likely to have required upgrading had the barrier not been constructed, in order to satisfy a traffic noise insulation rule of the type discussed in section 1.0 above. We note that it is possible that some dwellings still required upgrading even with the barrier – for example the upper level of two-storey houses. As above, the barrier also reduces the noise levels in outdoor living areas associated with dwellings – which is a benefit compared to the sound insulation rules discussed in section 1.0, which only modifies the environment within a dwelling.

The number of dwellings which would have experienced traffic noise levels of greater than 57 dB $L_{Aeq\ (24\ hours)}$ without a barrier ranged from 1 through to 120. The number of affected lots was dependent on the overall layout of the subdivision relative to the road, as well as the traffic numbers, road surface, and speed.

2.2 Assumptions

Key assumptions were as follows:

- The acoustic fences were constructed of 125 x 75 mm H4 posts, 75 x 50 mm H3 railings, 150 x 25 mm H3 palings with 50 x 25 mm H3 battens over joins and 150 x 50 mm H3 capping.
- In some cases, the effective height of fences was increased, because they were constructed on top of a retaining wall. It was assumed that the retaining walls would have been required for general site levelling and not specifically to enhance the acoustic effectiveness of the barrier. This was therefore not included within the upgrade cost.
- It was assumed that the subdivision layout without the barrier would have been exactly the same. In reality larger setback distances or other rearrangement of the layout may have been included if the traffic noise had not been largely mitigated by the barrier.
- The earth bund was assumed to be constructed with surplus excavated soil from the site, with a layer of imported topsoil 150 mm thick spread on top for grass.

2.3 Findings

We have summarised a number of key observations from the analysis below.

Table 2.1 shows the cost of each barrier, divided by the number of dwellings which would have experienced a noise level of greater than 57 dB $L_{Aeq\ (24\ hours)}$ without a barrier. We have grouped the results together for different barrier types, and have also shown the situations where are large and small number of dwellings benefited from the barrier separately.

Table 2.1 – Summary of cost of traffic noise mitigation by barrier type

Barrier Type	Approximate number of dwellings which benefited from barrier	Cost of barrier per dwelling
Acoustic fence	1 – 10	$15,000 – $30,000
	30	$10,000
	80 – 110	$3,000 - $5,000
Earth bund	10	$60,000
	50	$6,000
Combination	120	$4,000

Overall, this analysis shows that when the number of affected dwellings is low (i.e. the layout results in few lots near the road, or the volume of traffic is low etc.) the overall cost per dwelling is high. When these absolute costs are viewed as a percentage of the likely final value of each of the affected sections, the range is from 2 % (acoustic fence, benefiting a large number of sections) to 30 % (earth bund, benefiting a few sections). As above, in all of these examples for dwellings constructed on these sections, additional costs in the order of those presented in tables 1.1 and 1.2 above would be largely avoided, and traffic noise levels in outdoor living areas would also be reduced.

We note that a key decision in the above analysis is whether the loss of the land under the footprint of any earth bund is included as a 'cost'. In all of the examples the bund fell within an area which was ultimately sold to a homeowner as part of a site, or was within an area close to the State Highway which was unlikely to have been developed for residential use regardless – so the loss of the land under the bund has not been included as a cost. As an example, for the development with approximately 50 affected dwellings, if the cost of the land under the bund was included in the analysis, the total cost as a percentage of the likely final value of each of the affected sections would increase from 3 % to 16 %.

We trust this is of assistance. If you have any queries, please do not hesitate to contact us.

Kind Regards

Clare Dykes

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Attachment 4: Technical Basis of Model and Data Smoothing

Tonkin+Taylor

Memo

To:	**Stephen Chiles**	**Job No:**	**1014982**
From:	**John Carter**	**Date:**	**3 May 2021**
cc:	**Greg Haldane, Jovanna Leonardo**		
Subject:	**GIS advice on smoothing of noise contours around the state highway network**		

I am writing this memo to provide GIS advice on smoothing of noise contours around the state highway network, as you requested in our meeting on the 15th of April.

There are three main smoothing techniques that could be used to assist your work with Waka Kotahi, in refining rules for acoustic treatment of additions to existing houses or new houses being built near existing state highways. The three most relevant techniques are.

1. Buffer;
2. Simplify; and
3. Smooth.

Buffer

Buffering allows you to set the distance and the side of the line you want to create the buffer around. This is demonstrated in Figure 1 below. The buffer distance in metres can easily be modified based and depending on the distance used, the Figure shows how some of the smaller bends in the noise contour line (the dotted black line) are smoothed by the 5 metre (dark blue) and more so by the 10 metre (light blue) buffers.

Figure 1: Buffer

Pros:

With buffering you will still keep the general shape of the line and have a consistent distance along the entire contour. This can be easily built into models and automated for the entire country.

Cons:

The negatives of this techniques are you still get some unwanted bends/curves, despite an overall more consistent line. The result of a buffer is an area (polygon), so there are two small steps to convert the polygon into a line, then erase the original line to give one new contour line. The other downside is you push the line out (i.e. needlessly increasing the extent of the contour) in a large proportion of areas where it is already smooth, unlike the smoothing and simplifying methods detailed later in this memo. This can be negated relatively simply by offsetting the line back by buffering the results by the same amount as the original buffer but back towards the original line.

Overall, this is a viable option for your needs, but the main issue would be deciding on the appropriate distance to buffer. Buffering could be used in conjunction with the other methods to provide both a smooth and conservative contour line from the raw modelling results.

As discussed in our meeting, this can be done in ArcGIS, FME and QGIS, but I would only recommend ArcGIS or FME for this task and to allow for integration with automation/existing models. More detail is available from ArcGIS provider ESRI: https://pro.arcgis.com/en/pro-app/latest/tool-reference/analysis/buffer.htm.

Simplify Line

Simplify Line simplifies a line by removing points along the line and therefore unwanted bends/curves, while preserving its shape (depending on the degree of simplification set known as ***the tolerance***).

There are four available methods, when using ArcGIS Pro, the two most viable for this task are 'Wang-Muller' which retains critical bends and 'Zhou-Jones' which retains the weighted-effective areas. I have included the 'Wang-Muller' method on the 56 dB contour in Figure 2 below, with tolerance set at 10 metres and 50 metres.

Figure 2: Simplify Line

The Zhou-Jones method needs lower tolerance set in general, as the results of the simplify tool can vary quite a lot from the original line.

Simplify Line with a Barrier

Simplify Line includes an option of having a barrier, which is another layer or feature can be used to prevent the main simplify line touching or crossing the barrier.

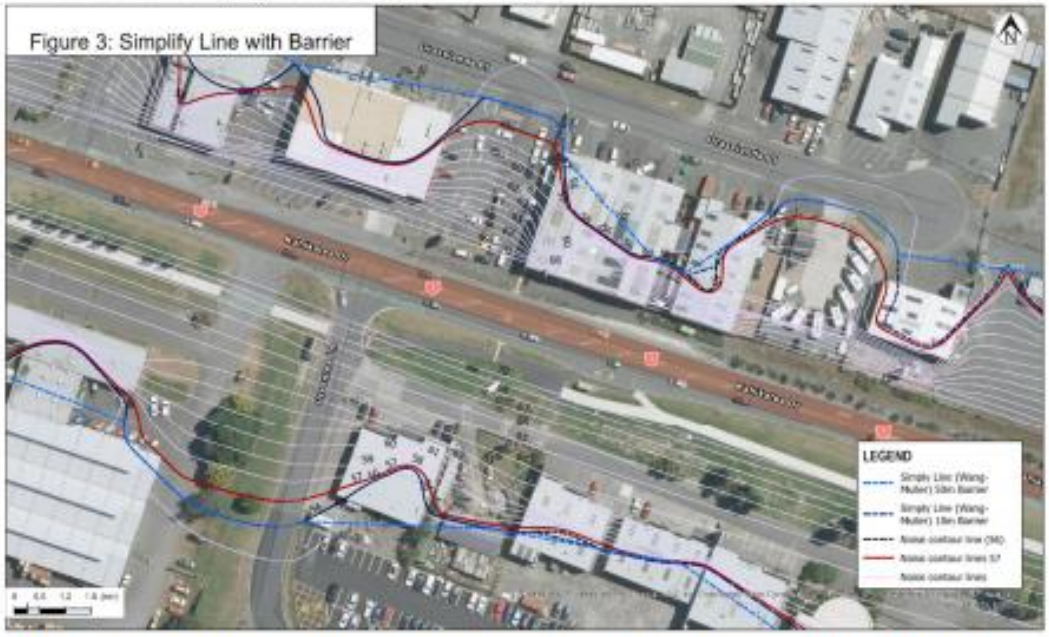

Figure 3: Simplify Line with Barrier

Figure 3 shows how this can be used. The Red line is the decibel (dB) 57 contour, it is included in the method as a barrier, to prevent the simplify line from the 56 dB contour line going across the 57 dB contour. The light Blue line has a tolerance of 50 metres and the dark blue line only has 10 metres tolerance. This should prove very useful when it comes to proving a planning line from noise contours.

Pros:

With simplifying you can set a tolerance to keep very true to the original contour line or really simplify it by setting a higher tolerance to cut out unwanted bends. The barrier should enable more sensible results by preventing modelled results of higher noise to be cut off by smoothing. You will keep the general shape of the line and where the line is already smooth or at least simply the line will match the modelled raw output. This can be easily built into models and automated for the entire country.

Cons

The negatives of this techniques are you still get some unwanted bends, but this can be overcome by adjusting tolerance to suit your wanted outcomes.

Overall, again this is a viable option for your needs, but the main issue would be deciding on the appropriate tolerance distance and barrier location.

More detail is available from ArcGIS provider ESRI: https://pro.arcgis.com/en/pro-app/latest/tool-reference/cartography/simplify-line.htm

Smooth Line

Smoothing lines removes the sharper angles with two main methods or algorithms. The Bezier interpolation method and the Polynomial Approximation with Exponential Kernel (PAEK) method. The Bezier method smooths the lines without using a tolerance, so it is not as viable for this task. The PAEK method, which like the simplify line tool allows you to set the tolerance, although the line may actually be more complicated, or have more points along it, which is something to think about for a national dataset. I have demonstrated the results of the PAEK method in Figure 4 below. The tolerance distance in metres can easily be modified based and barriers are also an option.

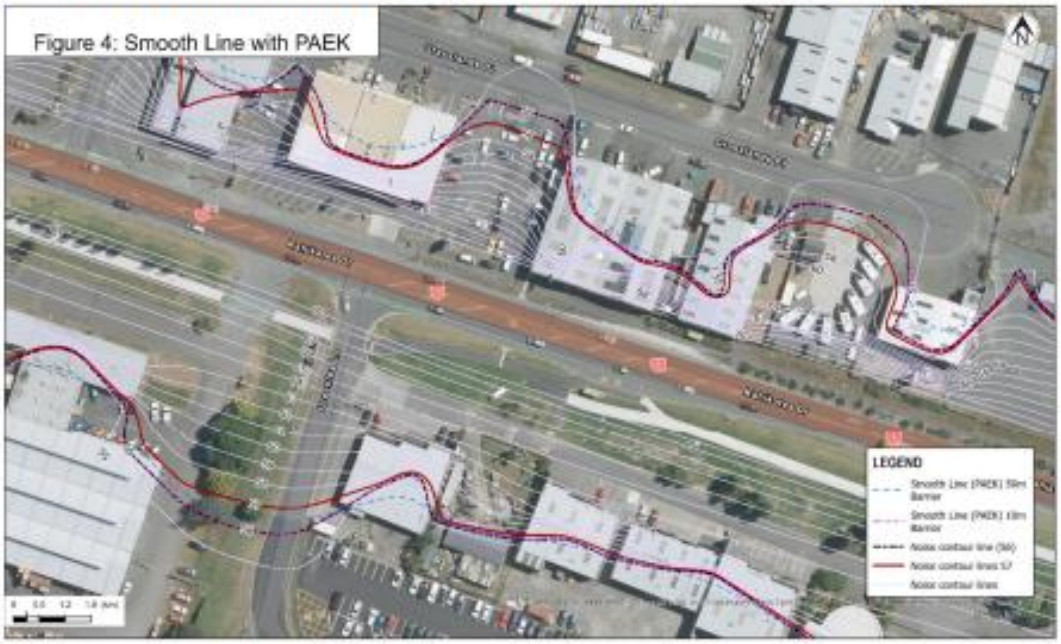

Figure 4: Smooth Line with PAEK

The Figure shows how the difference in the two tolerance values of 10 metres and 50 meters can vary greatly, where the 50 metre tolerance varies a lot from the original contour line.

Pros:

With smoothing you can keep use barriers and set tolerance. This can be easily built into models and automated for the entire country.

Cons

The negatives of this techniques are you may find it moves too much from the original contour. The valleys/peaks are removed, so you can get an overall more consistent line. The other downside is you again will have to set a tolerance that suits, and the line will move if that tolerance is pushed out or has higher values.

Overall, this could be a viable option for your needs, but the main issue would be deciding on the appropriate distance of tolerance.

As discussed in our meeting, this can be done in ArcGIS, FME and QGIS, but I would only recommend ArcGIS or FME for this task and to allow for integration with automation/existing models. More detail is available from ArcGIS provider ESRI: https://pro.arcgis.com/en/pro-app/latest/tool-reference/cartography/smooth-line.htm.

3-May-21

Attachment 5: Other Options Considered

For completeness, Waka Kotahi has also considered methods outside of the district plan to manage the issue; these include both regulatory (Building Code; National Environmental Standard) and private covenants ("no complaints" covenants) and built responses:

Regulatory

The **Building Act** (and Code) currently provides specifications to manage inter-tenancy noise (eg noise between residential apartments within the same building with shared tenancy walls). It does not, however, provide requirements for management of noise generated from outside a building (eg transport noise or nightclub noise from a separate building). A change to the Building Code would be needed to address the issue. While proposals for relevant changes to Clause G6 of the Building Code were circulated in 2016 and remain on MBIE's work programme, these are not imminent.

A **National Environmental Standard** (NES) would require promulgation by central government, there is no current plan to promulgate RMA-based national planning direction in relation to health and amenity effects relative to transport.

There are situations where **covenants** are entered into where parties acknowledge and accept particular types of effects in return for locating in an area; commonly referred to as "no complaints" covenants. There are a number of limitations with this approach:

a. it does not remove the actual effects on health and amenity therefore does not address the matters within Part 2 of the RMA;
b. it is reliant on both parties coming to agreement;
c. application of a covenant requires a 'trigger' to commence negotiations (eg. a request from a resource consent applicant to undertake works).

The primary limitation is however that it does not address actual health and amenity impacts.

Changes to the Building Act or promulgation of a NES are not directly within the control of Waka Kotahi; covenants require a 'trigger', agreement between parties and do not actually address the effects generated. None of these options are preferred.

Built Response

Waka Kotahi has undertaken a preliminary assessment of noise improvements across its network. It estimates a cost of at least $150M[23] to retrospectively manage noise exposure for approximately 50% of persons exposed to noise above 64 dB $L_{Aeq(24h)}$.

Responses could include retrofitting acoustic barriers and/or installing low noise road surfaces.

Retrofitting noise barriers by motorways by Waka Kotahi has been found to cost in the range of $4,000 to $10,000 per linear metre of barrier. Construction of noise fences by individuals or land developers generally have lower costs.

Retrofitting acoustic barriers has a number of limitations:

- available land and/or ground conditions;

[23] Not currently funded.

- potential visual dominance and shading;
- ongoing maintenance costs (eg graffiti, landscape maintenance); and
- may not be effective for buildings of more than one storey.

There are also some benefits:

- for barriers close to buildings (or close to the road) and comprehensively blocking the line-of-sight of sensitive land uses to the state highway carriageway, a reduction of 5-10 dB can be achieved;
- where applied to large land areas, cost of protecting multiple sites will aggregate to be less than cost of protecting a low number of sites;
- reduces the need for individuals building houses to have to consider road noise or to keep windows closed;
- can provide visual screening giving a benefit in reducing both perception of noise and actual noise level; and
- can provide improved amenity for outdoor areas.

A porous asphalt surface (low noise road surface) would be in the order of \$30+/m^2 (standard two coat chipseal surface would be in the order of \$6/m^2 to \$10/m^2). It cannot generally be laid directly on existing roads, because low noise (asphaltic) road surfaces require stiff underlying pavements, otherwise they fail prematurely. For much of the existing network, laying new asphaltic surfaces therefore first requires rebuilding of the structural pavement, which would increase the cost to over \$100/m^2. Low noise road surfaces can provide in the order of 5 dB reduction in noise generated from the tyre/road interface (although will not materially alter other sounds such as truck engine/air-braking noise). For traffic at highway speeds this is a meaningful improvement, although is often not sufficient to reduce sound to below guideline values.

Overall, while both built options provide some benefits, both options have significant costs and result in the full cost being borne by the road controlling authority in situations where the noise sensitive activity establishes after the state highway.