



Pavement Delivery System Review

Workstream 4: Strategic Risks

PDSR authors

1 November 2022

V1 Final

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1.0 Purpose of this Report

The 'Review of State Highway Pavement Delivery' report was communicated to the New Zealand Pavement Industry by Waka Kotahi in March 2020. This holistic and collaboratively sourced review examined the steps Waka Kotahi and the wider industry could take to improve their collective performance in the end-to-end delivery of new and rehabilitated pavement construction in New Zealand. The review was guided by Waka Kotahi's value for money investment principle; *"the delivery of the right outcomes, at the right time, at the right cost and financed at the right level of risk"*.

Whilst the review was not expected to generate a fundamental change to systems and processes, it did identify areas where further focus, refinement and discipline would improve design, delivery and reliability confidence. Opportunities to improve, clarify and supplement existing pavement specifications, design processes and construction delivery were also highlighted. These opportunities were summarised within nine recommendations that were subsequently endorsed by Waka Kotahi. The recommendations of the report are summarised in Figure 1.

"To review the current NZ Transport Agency end to end system delivery requirements for new pavement and rehabilitation construction and to assess these requirements in terms of best value for money to deliver on New Zealand's land transport objectives."

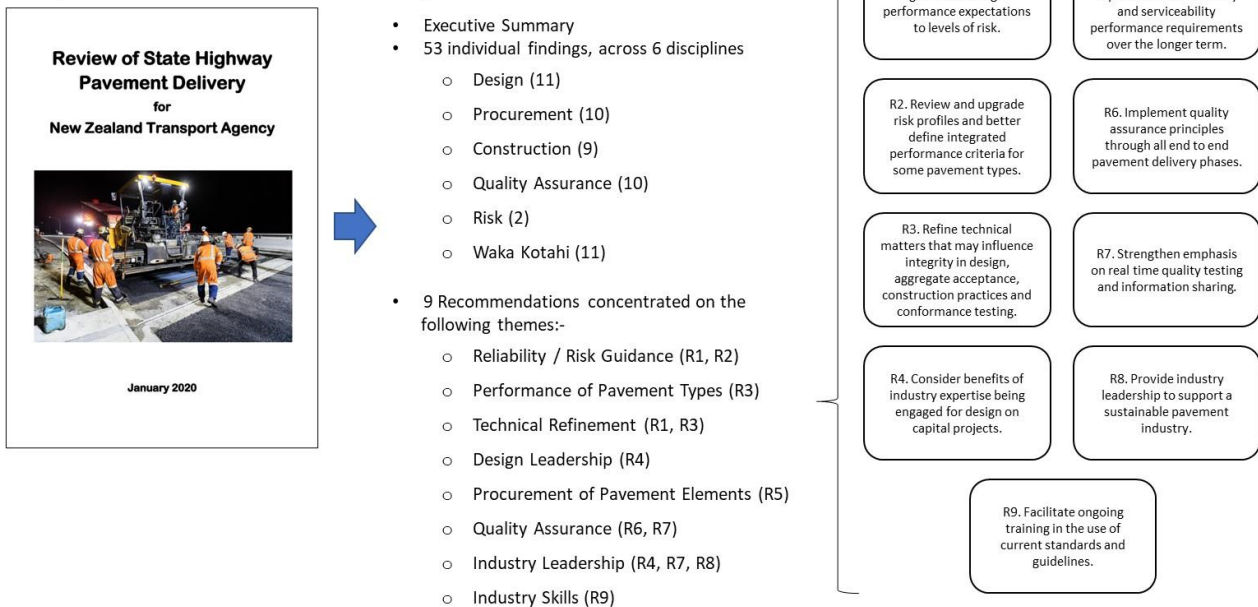


Figure 1: A summary of the outputs from the 'Review of State Highway Pavement Delivery' report.

An Industry Steering Group was then established to plan, resource and enable the implementation of the nine recommendations. The Industry Steering Group, shown in Figure 2, is chaired by Janice Brass of Waka Kotahi and is supported by senior industry representatives across its targeted workstreams.

- Workstream 1 – Technical Matters
- Workstream 2 – Whole of Life
- Workstream 3 – Procurement
- **Workstream 4 – Strategic Risks**
- Workstream 5¹ – Quality of Project Delivery
- Workstream 6 – Industry Capability

¹ In June 2022, the Steering Group agreed to combine the outputs of a separate workstream, targeting improved awareness of Z01 and Z08 quality related documentation, into the scope of Workstream 5 – Quality of Project Delivery.

- Workstream 7 – Cross Industry Communications

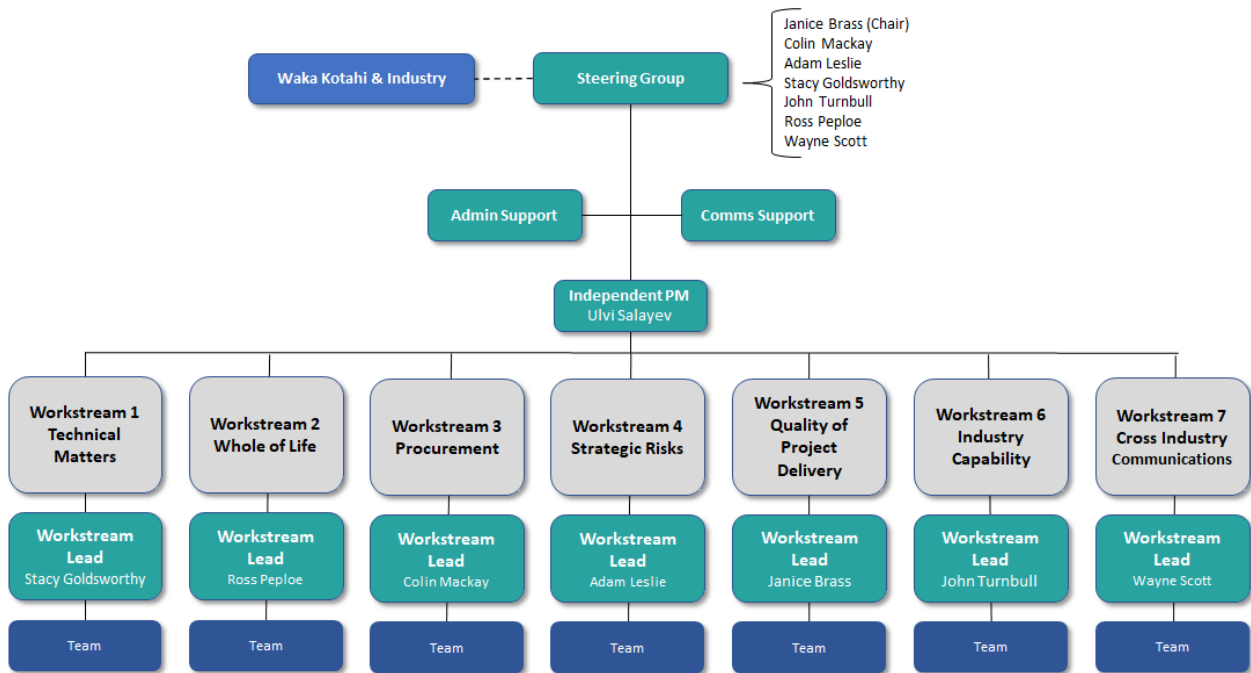


Figure 2: The structure of the Industry Steering Group, showing Workstream 4: Strategic Risks

The Workstream 4 Team were tasked to consider the Report’s Recommendations that targeted improvements related specifically to ‘Reliability / Risk Guidance’, these being described in Table 2 below: -

Ref.	Report Recommendation: Taken from the Recommendation statement on page 5 of the Report.
R1	Reliability/Risk Guidance: The Agency reviews the NZ Guide to align performance expectations relative to Reliability Factor and Pavement Design Risks to better define pavement types most suited for sustainable transportation routes.

Table 2: The Report recommendations investigated by Workstream 1.

2.0 Structure of this Report

This report comprises three sections. The section titles and their contents are described in Figure 3 below:-

Section Title	Content
1: Purpose of this Report	Describes the creation and purpose of the Workstreams operating under the Pavement Design System Review (PDSR) Steering Group.
2: Structure of this Report	Describes the structure of the report, typically comprising background information, headline findings and Required Responses.
3: Headline Findings and Required Responses	A written summary of the individual headline findings of the workstream team and the Required Responses they have determined, in order to achieve the level of improvement expected from this review.
Appendices	
Appendix 1	An initial list of pavement based risk topics.

Figure 3: Report structure

2.1 Prioritisation of Required Responses:

The Required Responses made by the Strategic Risks Workstream are presented in this report.

Given that each of the separate workstreams described in Figure 2 is challenged to produce its own report, and recognising that some considerations between these workstreams overlap, the decision has been made by the Steering Group to consider and prioritise the Required Responses as a whole, once all reports are complete. The full list of prioritised Required Responses, complete with the Implementation Plan describing their enactment, is provided within an overarching PDSR Steering Group Report, titled **PDSR Summary Report** which is accessible via this [link](#).

3.0 Workstream Findings and Required Responses

3.1 Pavement Risk Management

Finding WS4.1

The *Review of State Highway Pavement Delivery* report highlighted that whilst pavement design is 'risk based', there are inconsistencies in both the appreciation of those risks and the manner in which they are managed. The following three issues are seen to combine to create this situation:-

1. There is currently no single pavement based Risk Management System or common process operating in New Zealand. Practitioners currently align their risk management approach with the NZTA Z/44 guidelines, which is based on the principles and generic guidelines of ISO31000:2018. This is not a pavement-based standard, being aimed more at setting out the requirements for a risk management system.
2. Current risk management practices also lack transparency and lean towards the selection of pavement types primarily on a traffic demand basis. Other risks are often considered, but the extent of their consideration is too reliant upon the designer's level of knowledge of those risks.
3. A mixed approach to contract formation, where a prescribed design is combined with required performance outcomes, creating conflict between contracted parties. The inclusion of defects liability requirements within these mixed contracts can result in confusion over risk ownership, and the risk transfer conversations that often result.

There is a need for a risk management framework that can identify the various risks from throughout the different phases of pavement delivery at a system level that can inform those involved of the risks and the current means of mitigating those risks. The identification of system risks will ensure that there is adequate guidance and mitigation of risks that can then flow down to project level documentation and controls.

Current Status

An initial list of pavement based risk topics has now been identified. A copy of this list is provided as Appendix 1 of this report. Whilst the list is not exhaustive, it is intended that the items will form the basis for a consistent pavement based Risk Register for use in New Zealand. The next phases of work to be undertaken are described in the four steps below: -

1. Finalise the list of risks and settle on the format of a new Pavement Risk Register. The Waka Kotahi Pavement Risk Register will look at the system risks across the pavement delivery phases, describing those that occur during (for example) investigation and design, scoping and procurement, construction and maintenance. Risks will be identified alongside any current guidance as to the management or mitigation of those risks. The Pavement Risk Register will be publicly available and utilised through: -
 - Use as a reference document for those working across the pavement delivery system, to ensure awareness of known risks within the different phases and links to their management or mitigation measures.
 - Use as a prioritisation tool for the development of the Waka Kotahi pavement priorities, with respect to those risks that are not well defined or currently lacking in guidance.
2. Complete a gap analysis of the final draft of the Pavement Risk Register content with practitioners, so as to ensure that all known risks across the pavement delivery system are covered as well as understanding how the risks are currently managed.
3. Complete a Risk Scoring process, such that each risk can be evaluated in a consistent manner and provide guidance around the current scale of each risk.
4. Develop and finalise a Prioritisation Mechanism to enable risk items to be addressed in a logical manner. Improvement to the pavement delivery system should align with the priorities identified from the Risk Scoring.

Required Response WS4.1

Once the Pavement Risk Register is completed, Waka Kotahi will use it to establish a formal Waka Kotahi Risk Management System (RMS) that fully covers all aspects of the pavement delivery system. The RMS will also include:-

- a) A commitment by Waka Kotahi to the appropriate identification of risks across the pavement delivery phases in an ongoing manner.
- b) Guidance on the mitigation measures that have been or need to be adopted for those risks.
- c) Guidance on how risk ownership is established and assigned to the most suitable person or organisation. Risk ownership should relate to the task and the organisation which has the most direct ability to influence the positive outcome of managing the risk. Industry requires clear documentation around who owns the risk and the mitigations to be taken to ensure that allocation is understood and that a uniform approach can be taken across different projects.
- d) A formal roll-out process for the new Risk Management System, with training materials and tools made readily available to practitioners.

Appendices

Appendix 1

A list of initial pavement based risk topics (dated 01/04/2022), used in the development of the Pavement Risk Register. (shown below)

Phase	Element	Risk Description	Outcome	Consequence
01 Scope	System Process	Scope is inadequate leading to over or under estimation of the works	Lack of investigation leading to uncertainty within the scope	Under scoped works require price level adjustment to increase scope of works.
01 Scope	System Process	Scope is inadequate leading to over or under estimation of the works	Lack of funding leading to poor decision making	Under scoped works requires cost reductions resulting in decreased reliability of pavement
01 Scope	System Process	Scope is inadequate leading to over or under estimation of the works	Lack of review signoff resulting in errors in the scope	Over scoped works results in uneconomic spending on asset, with missed opportunity for other works to occur.
01 Scope	System Process	Scope is inadequate leading to over or under estimation of the works	Time pressures resulting in rushing to get the document completed	
01 Scope	System Process	Scope is inadequate leading to over or under estimation of the works	Lack of clarity on the objectives of the project	
01 Scope	System Process	Procurement drivers are set out in contrast to the performance objectives of the project.	Procurement method selected	Performance of pavement is reduced due to commercial behaviour
01 Scope	System Process	Procurement drivers are set out in contrast to the performance objectives of the project.	Unclear or ambiguous Principal Requirements	
01 Scope	System Process	Drivers for sustainability and performance are not well aligned	Unawareness of local context	Pavement is not sustainably constructed. Environmental damage as well as reputational damage could occur
01 Scope	System Process	Drivers for sustainability and performance are not well aligned	Uncertainty around potential options	Pavement is sustainably constructed but doesn't perform well. This leads to reputational damage, environmental cost due to rework as well as the time and cost of the rework
01 Scope	System Process	Drivers for sustainability and performance are not well aligned	Procurement expectations not well defined	Delay could occur while discussions around performance vs environmental trade-offs are made. This costs time and money while also extending the period of disruption.
01 Scope	System Process	Scope creep	The original scope was not well defined	Delays to works while scope adjustments are made. This results in reputational cost as well as time related costs
01 Scope	System Process	Scope creep	Additional funding has become available	
01 Scope	System Process	Scope creep	Stakeholder pressures to meet a certain LoS	
01 Scope	System Process	Performance specifications are not able to be met	Performance requirements not well aligned with the pavement options	Commercial discussions to resolve the works can result in time delays to the project. Pavement performance may not be as expected due to contractual requirements.
01 Scope	System Process	Performance specifications are not able to be met	Conflicting or ambiguous performance requirements	
02 Fixed Site Risks	Construction	Site climate impacts the construction	Site climate not sufficiently allowed for in the construction programme	Programme delays along with associated time and cost escalations.
02 Fixed Site Risks	Construction	Site climate impacts the construction	Unexpected weather event	Programme delays along with associated time and cost escalations.
02 Fixed Site Risks	Design	Site issue not properly being addressed	Inexperienced designer did not know how to address the issue	Pavement performance is reduced leading to early interventions with associated reputational and financial implications
02 Fixed Site Risks	Design	Site issue not properly being addressed	Unclear or ambiguous guidance on designing for such issue	
02 Fixed Site Risks	Design	Site issue remains undiscovered	Seasonal variation in condition resulting in issue not being present during investigation and construct phases	
02 Fixed Site Risks	Environment	Unexpected site issue (hazard, archaeological, water) being encountered	Insufficient site investigation missed detection of the issue	Time and cost escalations along with the programme delays while solutions are determined
02 Fixed Site Risks	Environment	Unexpected site issue (hazard, archaeological, water) being encountered	Seasonal variation between time of investigation and time of build	
02 Fixed Site Risks	Environment	Site issue remains undiscovered	Deep seated issue that was not discovered during investigation or construction	Pavement performance is reduced leading to early interventions with associated reputational and financial implications
02 Fixed Site Risks	System Process	Site issue not properly being addressed	Insufficient funding allocated to project	
03 Investigation	Construction	Investigation inaccurately characterised the site	Sensitivity of material when comparing lab to field condition	
03 Investigation	Construction	Investigation inaccurately characterised the site	Tests undertaken but not assessed	
03 Investigation	Design	Root cause finding incorrect leading to inappropriate design	Pavement fails earlier than design life	
03 Investigation	Design	Poor characterisation of existing pavement due to insufficient/inappropriate investigations	Either conservative treatment selection or incorrect treatment that fails early	
03 Investigation	Design	Inexperience/fudging of NPV calculations to force inappropriate treatment selection	Either conservative treatment selection or incorrect treatment that fails early	
03 Investigation	Design	Investigation failed to identify an issue	Type of testing undertaken	
03 Investigation	Design	Investigation inaccurately characterised the site	Inexperienced designer misinterprets results	Pavement does not perform as well as expected
03 Investigation	Design	Investigation inaccurately characterised the site	Conflicting results for various test reports	
03 Investigation	Design	Investigation inaccurately characterised the site	Unclear guidance on how to interpret results	
03 Investigation	Design	Investigation inaccurately characterised the site	Selection of an inappropriate statistical parameter during analysis (i.e. average r.t. 10th percentile)	
03 Investigation	Materials	Moisture sensitivity of fine grained subgrades	Subgrade stiffness lower than design value when subgrade gets wet	
03 Investigation	Materials	Failure to determine when expansive soils are present due to lack of soaked CBR testing on natural soils or not recognizing laboratory results as potentially expansive	Risk of volume change soils not being kept at equilibrium moisture content, risk of shape loss in future	
03 Investigation	Materials	Investigation failed to identify an issue	Level of investigation intensity	Pavement does not perform as well as expected.
03 Investigation	Materials	Investigation failed to identify an issue	Lack of funding availability to investigate site	
03 Investigation	Moisture	Consideration of moisture sources - upslope, surface, capillary rise	Elevated moisture contents in pavement layers - loss of strength	
05 Design	Construction	Minimums on minimums leading to constructed pavement not meeting design criteria	Pavement doesn't meet design criteria	
05 Design	Construction	Rutting/early failure of new pavement due to tie-ins to existing pavement located in future wheelpath/s	Pavement fails earlier than design life	

Phase	Element	Risk Description	Outcome	Consequence
05 Design	Design	Insufficient cover to sensitive subgrades	Gross failure of subgrade	
05 Design	Design	Road classification leads to conservative design when local conditions/materials are better than "the NZ average"	Over investment due to selection of an overly conservative treatment	
05 Design	Design	Failure to allow tolerances in design thickness of layers to account for construction variations. This commonly occurs in competitive design/construct or Alliance or PPP tenders where constructor requires no tolerance built into design, and there are no mandatory thickness additions to critical layers in the standard design process	Risk of minimums on minimums and construction variations result in design not being achieved in construction	
05 Design	Design	Adoption of asphalt fatigue factors for conventional contracts (Client/Engineer/Contractor) that are not conservative enough for the variance in suppliers production. Supplier not known at time of design. VicRoads approach is to have table of standard modulus and k values for various mix types to be used in design	Risk that asphalt supplier has difficulty providing asphalt meeting design stiffness without additives such as Sasobit	
05 Design	Design	Pavement type is not suitable for the site	There is unclear performance evidence for pavement types	
05 Design	Design	Design assumptions are not met	The use of experimental materials or design concepts	
05 Design	Design	Design is erroneous	Design criteria not followed	
05 Design	Design	Design is erroneous	Inexperienced design and / or reviewer	
05 Design	Materials	Characterisation of new materials with unproven performance	Pavement doesn't meet design criteria	
05 Design	Materials	Material characterisation outside of NZG values leading to inappropriate designs	Pavement doesn't meet design criteria	
05 Design	Materials	National material specifications don't match local material characteristics	Either conservative or poor pavement performance. Is there enough flexibility/tolerance in material specifications?	
05 Design	Materials	T/10 requirements can't be met due to suitable aggregates/materials not being available	Noncompliant surface friction creating a safety hazard	
05 Design	Materials	Failure to recognize that materials with soaked CBR swell >2.5% should have: 1) Adequate cover to the material to protect from moisture changes, 2) Have suitable low permeability capping, 3) Subsoil drains kept out of the material to prevent moisture changes (water in or water out) thereby maintaining equilibrium water content	Risk of volume change occurring due to changing moisture levels in the expansive material	
05 Design	Materials	Failure to apply shift factor between soaked CBR of natural subgrade or subgrade improvement layers (mechanical or chemical stabilisation) to account for difference in strength between laboratory testing in a steel mold and construction in a relatively unconfined state. VicRoads approach is to take average of the lowest 2 of 3 soaked CBR tests and then divide by 3 for design value to be used	Risk of design assumptions for strength of subgrade or subgrade improvement layer not realized in construction or in long term operations	
05 Design	Materials	Design assumptions are not met	Materials with the assumed properties are not available	
05 Design	Materials	Materials comply with the requirements but do not perform as expected	Empirical quality standards not applicable to the material adopted.	
05 Design	System Process	Design is erroneous	Design criteria ambiguous	
05 Design	System Process	Design is erroneous	Review process not followed	
05 Design	System Process	Design is erroneous	Conflicting or ambiguous design criteria (which could include regulations and other ancillary requirements)	
05 Design	Traffic	Design traffic underestimated for intersections and roundabouts. In heavy duty pavement design guides it is typical to add 30% to loads for road trucks tight turning and 20% for braking. Road design standards do not mandate axle load increases of this order. A 30% increase in design ESA is not equivalent to a 30% increase in load. Fourth power rule equates a 30% increase in load at roundabouts due to trucks turning to a 2.86 increase in ESA	Risk that roundabouts and intersections are under designed due to not factoring up design traffic enough to account for increased stresses of trucks turning and/or braking	
05 Design	Traffic	Design does not allow for construction traffic for adjacent land development as additional to design traffic for through traffic road use. This is applicable to new roads in urban developments	Risk that pavement under designed for traffic levels that will occur especially in early stages of pavement life	
05 Design	Traffic	Assessment of future traffic	Pavement fails earlier than design life due to higher traffic volumes than	
05 Design	Traffic	Sensitivity of assumed TLD for site	Pavement fails earlier than design life	
06 Construction	Construction	Constructability of design wrt TTM	Quality comprised due to early trafficking and/or inappropriate piecemeal construction	
06 Construction	Construction	Constructability of design wrt plant size/capacity	Quality comprised due to inappropriate construction methodology due to site constraints	
06 Construction	Construction	Constructed pavement not meeting design assumptions with respect to material properties	Pavement doesn't meet design criteria	
06 Construction	Construction	Design cannot be constructed	Appropriately skilled workforce not available	Design needs to be redone, resulting in programme delays and associated costs.
06 Construction	Construction	Design cannot be constructed	Equipment not available	
06 Construction	Construction	Construction takes longer than expected	Breakdown in critical equipment	Increased disruption and dissatisfaction
06 Construction	Construction	Construction takes longer than expected	Delays in communication between parties on critical decisions	
06 Construction	Construction	Construction takes longer than expected	Service / utility strikes	Initial performance requirements

Phase	Element	Risk Description	Outcome	Consequence
06 Construction	Construction	Construction does not meet the requirements	Work methods not appropriate	Construction QC
06 Construction	Construction	Construction meets the requirements but does not perform	Lack of independence for QA processes / reviews	
06 Construction	Design	Inherent variability of Benkelman Beam/deflection testing to prove design assumptions coupled with how the BB target deflection is modelled	Contractual dispute due to inappropriate/unjustified criteria or incorrect characterisation of constructed pavement compared to the design	
06 Construction	Environment	Surfacing allowing moisture ingress	Elevated moisture contents in pavement layers - loss of strength	
06 Construction	Materials	Availability of materials away from main centres	Departures required for pavement design	
06 Construction	Materials	Failed/inadequate/missing QA testing or records	Pavement doesn't meet design criteria	
06 Construction	Materials	Construction does not meet the requirements	Performance criteria are not achievable	Construction/materials QA
06 Construction	Materials	Construction does not meet the requirements	Material of insufficient quality	Construction QA procedural compliance auditing
06 Construction	Materials	Construction meets the requirements but does not perform	Missing critical tests from requirements	
06 Construction	Timing	Winter pavement construction - consideration when setting project programmes/durations	Pavement/Surfacing failures	
06 Construction	Timing	Design cannot be constructed	Staging of the works does not permit the required activities	
06 Construction	Timing	Construction takes longer than expected	Timing for the works was inappropriate	
07 Maintenance	Construction	Lack of investigation leads to incorrect treatment selection	Early failure of treatment	
07 Maintenance	Construction	Optimal NOC treatments not implemented due to capacity/programming constraints	Either conservative treatment selection or incorrect treatment that fails early	
07 Maintenance	Construction	Increased safety risk to maintenance workers due to inappropriate pavement design requiring ongoing maintenance	Increased risk to workers due to increased exposure to traffic	
07 Maintenance	Construction	Constructed pavement is unable to be maintained to appropriate standards	Skills and/or equipment required for maintenance operations is lacking	
07 Maintenance	Construction	Constructed pavement is unable to be maintained to appropriate standards	Appropriate standards for maintenance not understood	
07 Maintenance	Environment	Constructed pavement is unable to be maintained to appropriate standards	Unable to access site	
07 Maintenance	System Process	Constructed pavement is unable to be maintained to appropriate standards	Funding to maintain pavement is not available	
07 Maintenance	Timing	Critical maintenance not being done in timely matter leading to moisture ingress which leads to pavement failure	Elevated moisture contents in pavement layers - loss of strength	