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Possible climate change impacts on transport infrastructure and the assessment of risk

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Why act?

- Resilience – Strengthen resilience now and in the future
- Reputation – Avoid adverse publicity
- Efficiency – Safe money in the long term
- Statutory reasons?

Climate change

- Increased temperature
- Intense rainfall and flooding
- Rising sea levels, increased coastal, erosion and flooding
- Increase in high winds, storms, cyclones and storm surges
- Combined extremes in weather

What are the climate change impacts? Increased temperature

Increased temperature	• Deformation of road asphalt & failure of expansion joints in concrete roads. • Hardcore underpinning cracking – subsidence & heave. • Rail tracks buckling: speed restrictions, line closures & possible derailments. • Breaks and sags in overhead power lines on electrified train routes. • Heat affecting rail lineside equipment – specifically signalling and telecoms equipment. • Traveller discomfort & safety • Vehicle break-downs due to overheating. • Risk to workers' functioning and safety. **Indirect** • Changes in seasonal demand for transport. • Changes in travel patterns, e.g. tourism. • Increased accidents.

What are the climate change impacts? Increased rainfall and flooding

Intense rainfall & flooding	• Intense rainfall overwhelming drainage systems. • Flooding of stations, depots and routes (pedestrian, cycling, vehicle and rail). • Rising water tables flooding underground networks, • Scouring & weakening of bridge foundations with possible collapse. • Embankments vulnerable to washaways or landslips. • Flooding/failure of power sources and electrical equipment (trains & road traffic management). • Flood damage to pavements, roads surfaces and rails. • Reduced visibility. • Risks to travellers and workers' safety. **Indirect** • Increased demand for car use. • Increased accidents.

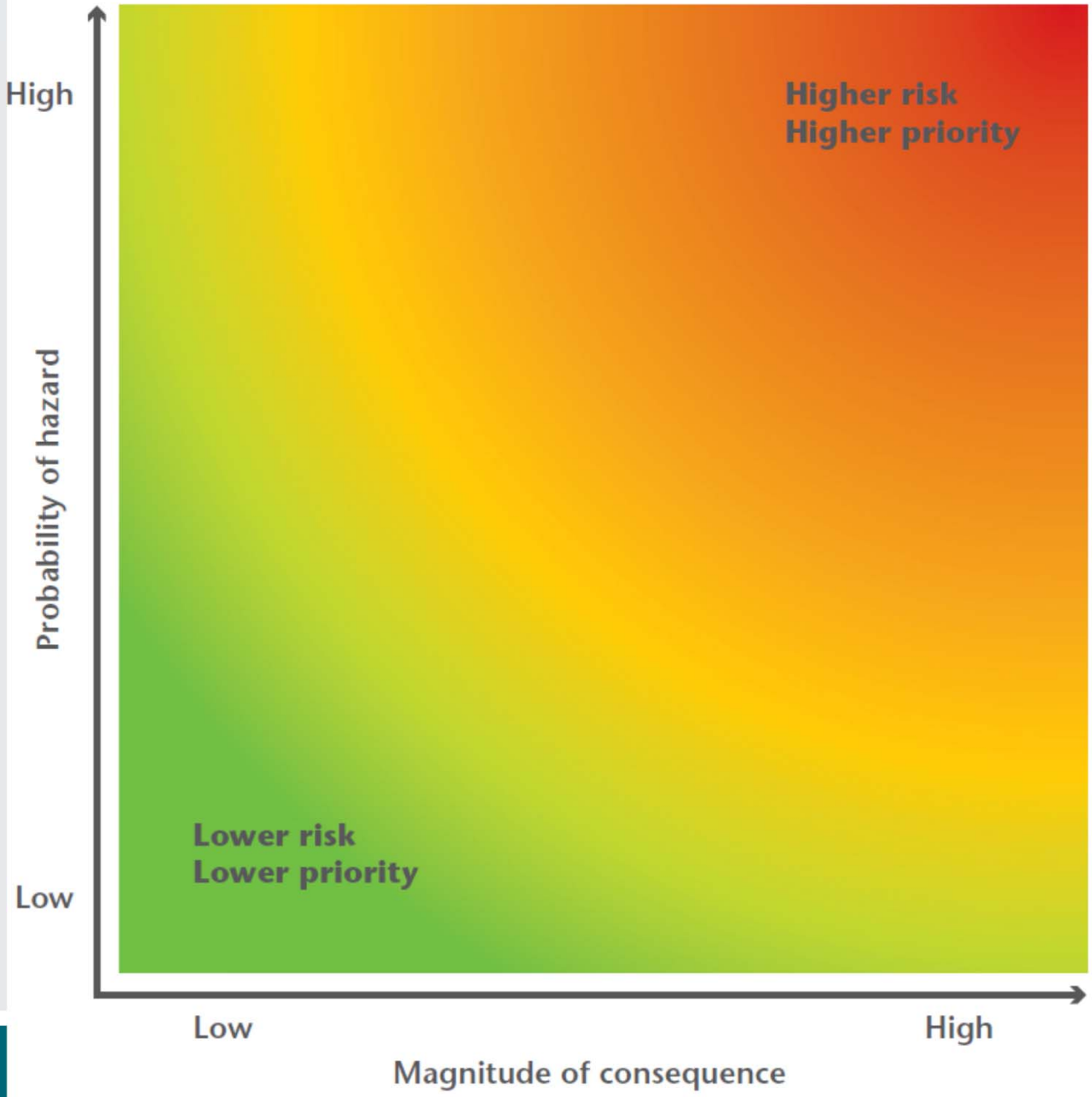
What are the climate change impacts? Rising sea levels, winds, combined weather

Rising sea levels, increased coastal erosion and flooding	• Permanent loss of routes and infrastructure at coastal sites due to erosion. • Periodic flooding of coastal roads, rail, pedestrian & cycling paths. • Risk to travellers and workers' safety.
Increase in high winds, storms and storm surges	• High winds blow trees and other debris (signs, lights, equipment & street furniture) onto roads and rail routes. • Overhead power lines on electrified train routes blown down. • Operational constraints at exposed locations, e.g. bridges, for high sided vehicles. • High sided vehicles and freight wagons blown over. • Sea inundating coastal infrastructure.
Combined extremes in weather	• Damage to power supply from electrical storms, storms, floods. • Asset failure due to long hot dry periods followed by intense rain causing flash floods. • Movement of clay embankments due to moisture fluctuation caused by mixture of intense rainfall and droughts. • Rising sea levels, increased storms and storm surges damaging coastal infrastructure.

Assessing risk

- Probability or likelihood of the impact occurring
- Magnitude or the consequence of the impact should it occur
- Risk = Probability of occurrence x Consequence of the occurrence

Assessing the level of risk



Possible risk scoring system

Overall risk score	Priority
Very high	Requires immediate active management
High	Requires contingency plans, and early warning system
Medium	May require good housekeeping, some risk mitigation
Low	Impact can be tolerated, to be reviewed periodically

Assets and infrastructure risks - Example

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High			
Drainage systems unable to cope causing flash flooding of buildings.	4	5	20
Drainage systems unable to cope causing flash flooding of transport infrastructure (road).	4	5	20
Hot dry conditions cause roads & pavements to subside, melt and crack.	4	4	16
Damage to road & pavement surfaces due to freeze-thaw effect.	4	4	16
Moderate			
Buildings & infrastructure near coast or on floodplains at risk of rising sea levels, coastal erosion.	3	4	12
Drainage systems unable to cope causing public waterway to be contaminated by sewerage.	2	5	10
Long spells of wet weather damages road & pavement surfaces.	4	2	8

Assets and infrastructure risks - Example

Low			
Increased risk of subsidence and heave, affecting built environment.	2	2	4
Storm damage to street lights & signs.	2	2	4
Desiccation of grass verges.	3	1	3
Extra debris on roads after heavy downpours following extended dry periods.	2	1	2

Develop and implement adaptation measures

- Identify adaptation options
- Choose preferred options
- Decide investment priorities
- Incorporate adaptation priorities into relevant plans
- Monitor and review

Examples adaptation options

Risk: Road drainage systems overwhelmed by torrential rain

a. Increase the capacity of all drainage.

b. Increase the capacity of drainage in areas that are most likely to flood.

c. Increase the capacity of drainage in areas where flooding will cause the most damage or delays.

d. Review the type of drainage and its maintenance regime. Determine ownership and maintenance responsibilities.

e. Improve the effectiveness of drainage by more frequent or targeted cleaning.

Examples adaptation options

Risk: Bridges weakened or swept away by floods.

a. Strengthen all bridges.

b. Strengthen bridges crossing rivers that are most likely to flood.

c. Strengthen bridges that carry the most traffic.

d. Assess the bridges which are most at risk to scour.

e. Prepare contingency plans to communicate with drivers about alternative routes and close bridges that are most at risk when flooding is predicted.

Examples adaptation options

Risk: Accidents (vehicles blown off course, debris) caused by high winds

a. Remove possible sources of debris:
   - » Everywhere.
   - » In most exposed locations.
   - » Where they could cause most damage.

b. Improve the ability of trees, equipment etc. to withstand high winds:
   - » Everywhere.
   - » In most exposed locations.
   - » Where they could cause most damage.

c. Prepare contingency plans to communicate with drivers about alternative routes and close routes that are most at risk when high winds are predicted.

Generic adaptation designs

Option	Examples of action to take
Business as usual	Minimum action to maintain a safe and serviceable network. May include contingency plans, monitoring changes and routine asset repairs and/or replacements.
Future proof designs	Updating design requirements including technical standards and specifications to provide additional capacity and/or functionality in the event of gradual climatic change or *ad hoc* weather events. The designs could be for new assets, renewals or improvements.
Retro-fit solutions	Modifications to existing assets and/or activities outside the normal renewal cycle. Determine where (all sites or high risk sites) and when (now or at a certain threshold) it needs to be actioned.
Develop contingency plans	Pre-planned responses for when/if climate change risks are realised so immediate effects can be managed. Could be an option to use in the period before other measures are implemented or for when no other mitigation measures have been identified.

Generic adaptation designs

Option	Examples of action to take
Update operating procedures	Update existing operating procedures to take account of the impacts of climate change, e.g. procedures for working in high temperatures.
Research	Research to identify vulnerabilities of different transport sectors, determine probable risks, identify adaptation options or reduce uncertainty to determining preferred adaptation action.
Monitor	Monitor the rate of climate change and/or subsequent effects on specific transport mode assets or operations to help determine the most appropriate adaptation measures and identify indicators of change and threshold "triggers" for action.

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Any questions?

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