Ngā Haerenga
NEW ZEALAND CYCLE TRAILS

Ngā Haerenga New Zealand Cycle Trails Design Guide

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NEW ZEALAND CYCLE TRAILS

MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
HĪKINA WHAKATUTUKI

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PREPARED FOR NGĀ HAERENGA NEW ZEALAND CYCLE TRAILS AND THE MINISTRY OF BUSINESS INNOVATION AND EMPLOYMENT

Cover photo: Alps 2 Ocean Cycle Trail – Benmore Dam (Photo: Clare Toia-Bailey)

Document Background

This design guide was prepared for Ngā Haerenga New Zealand Cycle Trails and the Ministry of Business, Innovation and Employment (MBIE).

This is the sixth edition of the design guide. The first edition was prepared by ViaStrada Ltd and published in March 2010. The structure of the guide was designed by Andrew Macbeth and most of the initial content was written by Andrew and Megan Fowler (now Gregory). The considerable efforts of Jonathan Kennett in revising the design guide are greatly appreciated.

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Any person, including, without limitation, their respective consultants, employees and agents, referring to or relying on this document do so at their own risk in all respects. Every person referring to or relying on this document must satisfy themselves that cycle trails are designed and constructed in accordance with sound and acceptable engineering standards and in compliance with any applicable legislation.

Explanatory Note to Cycle Trail Design, Sixth Edition

The *New Zealand Cycle Trail Design Guide* was first published in February 2010 to assist people involved in planning, designing or building cycle trails that would make up the Ngā Haerenga New Zealand Cycle Trails (NZCT).

During the construction of the 'Great Rides', lessons have been learnt along the way and this sixth edition updates and clarifies key technical information, particularly relating to grading, climate change and resilience, and trail accessibility. It also introduces new references to other recent relevant industry guidelines. A list of significant amendments is provided below.

Schedule of Amendments

(Based on First edition, February 2010)

Second edition (August 2011)

- Simplified and more consistent guidance on gradients (Sections 3 and 4)
- Introduction of a Grade 5 on-road trail type (Section 4)
- Amended guidance on gravel roads (Section 4.4)
- Guidance for audio-tactile profile road markings and raised reflective pavement markers (Section 4.5)
- Information on seasonal traffic volume variations (Section 4.6).
- Provision of an appendix summarising trail gradient information (Appendix 1)

Third edition (September 2012)

- Revised introduction to better reflect document's current status and purpose
- Modified requirements on widths for sealed trails
- Modified recommendations for barriers and guard rails, plus added advice about sight rails for Grades 3–5 trails
- Extended guidance on path end treatments
- Quantified volume ranges in Table 14
- Technical detail on motorcycle barriers added (Section 3.13.1)

Fourth edition (February 2015)

- Gradient table (Table 5) amended to include greater slope
- Further guidance added to section on chip seal (section 3.9.6) and amalgamated with section on asphaltic concrete
- Inclusion of framework to assess viability of open roads to accommodate NZCT routes (section 4.9), and associated updates to other tables and figures.
- Addition of 'squeeze barrier' specifications to prevent motorcycle use of cycle trails (section 3.13.1)
- Various photo updates

Fifth edition (March 2019)

- Some additions/updates to the glossary
- Updated guidance regarding trail funding (Section 1.1.1)
- Addition of section on lessons learnt (Section 1.4)
- Addition of section on climate change and resilience (Section 2.8)
- Included consideration of e-bikes (Section 3.1.4)
- Revision of off-road trail criteria to align better with NZ Mountain Bike Specifications (Section 3.2)
- Addition of information on bermed corners (Section 3.7)
- Updated guidance on surface materials (Section 3.9)
- Revision of path end treatments (Section 3.13)
- Update on squeeze barrier design (Section 3.13.1)
- Inclusion/update of environmental considerations (Section 3.14)
- Inclusion of information on archaeological protocols and Heritage NZ (Section 3.14.1)
- Addition of Grade 6 on-road category (Sections 4.2 and 4.9)
- Addition of section on traffic speed management (Section 4.3)
- Updated guidance on audio-tactile profiled markings (Section 4.11)
- Updated guidance on railway crossings (Section 5.5)
- Updated specification of various road signs (Section 7)
- Addition of section on bike parking (Section 8.7)
- Updated references
- Addition of sample trail signage location guidance (Appendix 2)
- Addition of trail specification sheets for contractors (Appendix 3)
- Various photo updates

Sixth edition (July 2024)

- Additional material on resilience and future-proofing (Section 1.6) (United Nations Intergovernmental Panel on Climate Change AR6 report 2021)
- Removal of guidance regarding trail funding (formerly Section 1.1.1)
- Removal of discussion of NZTA's *Cycling Network Guidance* (formerly Section 1.2.5)

- Removal of discussion of Austroads *Guide to Road Design Part 6A: Pedestrian and Cycle Paths* (formerly Section 1.2.6)
- Removal of section on route planning (formerly Section 2)
- Removal of section on electric bicycles (formerly Section 3.1.4)
- Change to gradient requirement for Grade 1 and Grade 2 tracks (Table 2)
- Removal of Grade 6 from Section 2 (off-road trails), including from Table 2
- Detailed design specifications moved from Section 3 to each of the Grade design sheets in Appendices 3A to 3E
- Removal of table showing DOC track classification from *HB 8630* (formerly Tables 15 and 17; remaining content is in Section 5.1)
- Material regarding handrail heights moved to each of the Grade design sheets in Appendices 3A to 3E
- Removal of image and text regarding kissing gates (formerly Section 6.4.3)
- Update of signage material (was Section 7, now Section 6)
- Previous information quality control (formerly Section 9.5) removed, and note added to Introduction
- Section on slope stability added (Section 2.5)
- Section on retaining walls added (Section 5.5)
- Fall heights information added to each Grade sheet in Appendices 3A to 3E
- Monitoring and evaluation material (was Section 10, now Section 9) updated and section on crowdsourcing, and table showing data types and monitoring/collection methods deleted
- Update of references, including new URLs where websites have changed
- Removal of references to MOTSAM (replaced by TCD Manual)
- Additional material on accessibility added and collected in new accessibility sections (Section 5.6.4 and Appendices 3A to 3E)
- Note on additional shy space next to roadside crash barriers and/or steep drops added (Section 3.7)
- Changes to on-road trails section (Section 3) to incorporate updated advice and new publications from NZTA
- Gradients stated as percentages rather than degrees throughout text on advice of NZTA
- Removal of gradient map example (was figure 44) showing gradients for Christchurch–Akaroa (Le Race) as not suitable for NZCT audience

- Changes to gradient tables in on-road section (previously figures 45–47, now figures 17–19)
- Changes to shoulder or cycle lane widths in on-road section (was Table 14, now Table 5) to separate Grade 5 from Grade 6, and to indicate that Great Rides should aim for the desirable minimum width, while for Heartland/Connector Rides, the minimum tolerable width is acceptable.
- Link provided to new TCD material on ATP markings added (was Section 4.11, now Section 3.11)
- Guidance about uncontrolled intersections on on-road trails strengthened (was Section 5.2, now Section 4.2)
- Additional guidance on widths of tunnels and underpasses added (was Section 6.5, now Section 5.4)
- NZTA guidance on markings and delineation updated (Section 3.11 and Appendices 3A to 3E)

Executive Summary

The *Ngā Haerenga New Zealand Cycle Trails Design Guide* draws on a wealth of trail design and construction techniques from New Zealand and around the world. It will help you and your team build the best possible trail with the resources available.

This guide compiles information from a number of existing guides, referring directly to them for more detail if needed. These other guides provide specific information relating to different components of the NZCT, whether they be mountain bike tracks, rail trails, urban cycle paths or sections of quiet country roads. This guide incorporates New Zealand Transport Agency Waka Kotahi (NZTA) knowledge, expertise and experience in delivering a safe cycling environment on the national road network.

The basis for trail design is the selection of a trail Grade, and recognition of the trail criteria that define that Grade. This selection will reflect the chosen target audience, from 'renaissance riders' seeking easy Grade 1 trails to mountain biking enthusiasts looking for higher Grade trails to test their fitness and skill.

Consistency is the key to the NZCT's success. The NZCT comprises trails throughout the country, and people cycling will form their impression of the NZCT based on their experiences of individual trails. On a well-designed trail, users will enjoy the beautiful scenery and riding experience, without being distracted by design flaws, such as a gap in signage or uncharacteristically difficult sections. Their memories will be of the scenery, the camaraderie and the sense of accomplishment, not whether the trail was too hard for them in places, or they got lost along the way. The *Cycle Trail Design Guide* explains how to avoid these pitfalls and plan a trail that will be consistent, not only from one end to the other, but also within the whole NZCT network.

Many trails are in remote parts of New Zealand, allowing access to pristine environments and iconic landscapes. The cycle trails in these locations need to be designed, built and maintained appropriately to fit into their natural surroundings.

This guide streamlines the design process and provides an invaluable range of criteria and techniques to ensure you build sustainable trails that meet the expectations of the target audience, and require minimum ongoing maintenance. It includes sections on:

- route planning
- off-road trails
- on-road trails
- crossings and intersections
- structural design

- signage
- supporting facilities
- trail and road maintenance
- monitoring and evaluation
- resilience and future-proofing
- accessibility.

A Quality Assurance programme has been established for the Great Rides. This includes periodic audits against the *NZCT Design Guidelines*.

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Glossary

Term	Definition or explanation
AADT	Annual average daily traffic. The calculated mean daily traffic volume of a facility across a whole year, taking into account seasonal variations.
AC	Asphaltic concrete, a relatively expensive road surface usually used for higher-volume roads. Because it provides a smooth and durable riding surface it may be suitable for high-volume or more urban cycle trails.
Austroads	The association of Australian and New Zealand road transport and traffic authorities. It aims to promote improved road transport outcomes.
Berm (or super-elevation)	Term used by mountain bike trail designers for a slope across a trail provided to assist cornering on bends. An inwards slope or berm on a bend allows higher speeds of travel than would otherwise be possible with a flat track. See also 'super-elevation'.
Carriageway	The portion of road where vehicles travel (i.e. the width of seal or gravel of a formed road).
Clearance	The distance (vertical or horizontal) between a trail and an obstruction (e.g. overhead bridge, fence, tree).
Climbing turn	A curve in a trail located on a sloped section.
Cycle lane	A longitudinal strip within a roadway designed for the passage of cyclists. This is a type of on-road trail for cycling, delineated by paint, where motor vehicles are not permitted.
Cycle path	A path that is physically separated from the roadway and is principally designed for, and used by, cyclists. See also 'separated path'.
Cycle route	A course of direction for cycling between two key locations or connecting a series of key locations. May comprise on-road and/or off-road sections.
Cycleway	A dedicated route for cycling, usually featuring specific cycle facilities (although it may also include shared paths).
DOC	Department of Conservation

Gateway	A feature used to provide an attractive threshold at the start of a trail.
Grade reversal	Deliberately designed section of trail where long slopes are interrupted by short sections where the longitudinal gradient reverses.
Grade separation	Where a cycle trail crosses a road at a different elevation by way of a bridge or underpass.
Great Ride	A New Zealand Cycle Trail route that is predominantly off-road and is approved by the Minister of Tourism based on recommendations from NZCT Inc. to use the Great Ride brand.
Greenway	See 'path'. This term is commonly used in the UK.
Ground Effect	A company specialising in cycle clothing and accessories that will generally provide copies of the IMBA guide to non-profit trail-building groups.
Heartland Ride	NZCT route that is predominantly on-road and aims to encourage cycling away from busy state highways and onto the safest and most enjoyable roads and paths where riders will experience quintessential New Zealand.
IMBA	International Mountain Biking Association
Inter-visibility	The ability of two road or trail users to see each other as they approach each other.
In-slope	When the cross-section of a trail on the side of a hill is angled down towards the inside (uphill side) – see also 'out-slope'.
Key attraction	An 'iconic' location that will generate cycle tourism
Level of service	The quality of use experienced by someone on a trail.
MBIE	Ministry of Business, Innovation and Employment; the primary agency responsible for funding and oversight of the New Zealand Cycle Trail.
Midblock	A section of road between (not at) intersections.
Mode	A form of transport e.g. cycling, walking, motor vehicle.

Ngā Haerenga New Zealand Cycle Trails (NZCT)	An initiative started by the New Zealand government and managed by MBIE to create a series of iconic cycle routes throughout the country.
Ngā Haerenga New Zealand Cycle Trail Inc (NZCT Inc.)	The national organisation for Ngā Haerenga New Zealand Cycle Trails, covering Ngā Haerenga Great Rides of New Zealand, Ngā Haerenga Heartland Rides and Connector Rides. Ngā Haerenga New Zealand Cycle Trails is a membership organisation and Great Rides pay an annual membership fee.
Ngā Haerenga Great Rides of New Zealand (Great Rides)	23 premium New Zealand cycling experiences. Predominantly multi-day, off-road cycling experiences showcasing the best scenery, cultural and heritage.
NZTA	New Zealand Transport Agency Waka Kotahi
Out-slope	When the cross-section of a trail on the side of a hill is angled down towards the outside (downhill side) – see also 'in-slope'.
Path	An off-road trail for cycling and/or walking. This is the official engineering term, as opposed to 'track'. See also 'trail'.
Pedestrian	Any person on foot or using a wheelchair. While legally it does not include scooters, skateboards or other wheeled means of conveyance propelled by human power or a small electric motor (other than a cycle), often these devices are grouped together with pedestrians for planning purposes.
Pinch point	A localised section of a trail where width provision for cycling is substandard.
Rail trail	A path formed along a railway corridor (the railway may be either active or disused).
Route	A link between two key locations or connecting a series of key locations. In the NZCT context 'routes' are provided specifically for cycling, although they may also be used for other purposes, such as walking.
RRPM	Raised reflective pavement marker.

Segregated path	A type of off-road trail for cycling and walking where the two modes are designated their own sections through use of ‘soft’ measures (e.g. paint markings) rather than physical separation.
Separated path	A type of off-road trail for cycling only, running parallel and adjacent to a similar facility for walking only.
Shared path	A path that is physically separated from the roadway and is intended for the passage of pedestrians, cyclists, riders of mobility devices and riders of wheeled recreational devices. This is a type of off-road trail for cycling and walking without separation or segregation of the two mode groups.
Single track	A mountain biking path designed for cyclists to ride single file, sometimes in one direction only.
Super-elevation (or berm)	A slope across a trail often used to assist cornering on bends. An inwards slope allows higher speeds of travel than would otherwise be possible with a flat track. See also ‘berm’.
Sustrans	UK charity that administers its national cycle trail.
Switchback	A curve in a trail on level ground, even if the approach and departure to the curve are on sloped sections.
TCD Manual (NZTA)	Traffic Control Devices Manual. New Zealand Transport Agency Waka Kotahi guidance on industry best practice for use of traffic control devices, including creating and installing road signs and markings.
Track	This term is commonly used for natural surface cycle paths or mountain biking trails. See also ‘path’ and ‘trail’.

1 Introduction

1.1 Cycle trail design guide purpose

This cycle trail design guide is intended to help anyone planning, designing or building parts of the Ngā Haerenga New Zealand Cycle Trail (NZCT). It is also useful for those applying for NZCT funding, to ensure that they meet the appropriate route standards.

Consistency is the key to the NZCT's success. The NZCT comprises multiple routes throughout the country, and people cycling form their impression of the NZCT (and even of New Zealand) based on their experiences on individual routes. On a well-designed route, users will not be distracted or endangered by design flaws or the task of riding, and so will be able to enjoy the iconic scenery and riding experience. Their memories will be of the scenery, the camaraderie and the sense of accomplishment, not whether the surface was too rough, the gradients too steep, or the trail too narrow.

Consider all potential users – all NZCT are multi-use trails that are used by walkers, trampers, runners, people with disabilities, kids on scooters and skateboards, and in some cases other users such as hunters, horse riders, road cyclists and commuters. By sharing a trail, the land manager gets more returns for their investment.

1.2 Related documents and design guides

Besides this design guide, designers are also likely to require access to other manuals and design guides as outlined below. These sources contain useful information related to design and construction of NZCT routes, but none of them provides comprehensive, stand-alone guidance for the NZCT. This design guide aims to tie together the relevant parts of various existing manuals. It also supplements and advises on their use where necessary. These manuals are cited throughout this guide, with full references and web-links, where appropriate, given at the end of the document. This guide is intended to represent best practice and should be used for guidance where other documents indicate different advice or values for design parameters. Designers should always use sound engineering judgement in their designs and seek external qualified advice where necessary.

1.2.1 DOC track construction and maintenance guidelines

Designers of off-road trails should also use the Department of Conservation's (DOC) *Track Construction and Maintenance Guidelines* (2008) in conjunction with this guide. The DOC guide gives a comprehensive account of all major steps in the development of an off-road trail, including landscape considerations, design, construction, water management and maintenance. It is intended principally for trails used by walkers but sometimes includes advice for mountain bike trails. Not all sections in the DOC guide are considered relevant to the NZCT, for example, steps (covered in Chapters 19 and 33) are not recommended on the NZCT.

DOC's *Track Construction and Maintenance Guidelines* is freely available online from the DOC website.

1.2.2 Mountain bike trail guidelines

Recreation Aotearoa (formerly the NZ Recreation Association) has prepared *New Zealand Mountain Bike Trail Design & Construction Guidelines* (Recreation Aotearoa 2018). This short guide provides a detailed specification for constructing new trails at each of the five Grades defined in Section 2.2 below, and also provides a template for the maintenance and auditing of existing trails.

Designers of off-road trails may also find the International Mountain Bicycling Association's (IMBA) *Trail Solutions* (2004) guide useful. The IMBA guide provides appropriate guidance for NZCT trails in some circumstances; however, the important concepts are all covered in the DOC *Track Construction and Maintenance Guide* (Section 1.2.1), which is freely available and tailored to the New Zealand context. The IMBA guide principally covers the design of mountain bike tracks but is less useful for less technical or demanding off-road trails (such as rail trails), or on-road facilities.

Ground Effect (a Christchurch company specialising in cycle clothing and accessories) supplies the IMBA guide free of charge to suitable non-profit trail developers.

1.2.3 Sustrans guidance

The *Connect2 and Greenways Design Guide* (Sustrans, 2009) was developed by Sustrans, the organisation responsible for the 20,000km national cycle network in the UK, to aid in the design, construction and ongoing use of both off-road and on-road trails. Some of Sustrans' more recent guides touch on trail design, but some chapters from the *Connect2 and Greenways Design Guide* are considered to be particularly useful with direct applications for NZ, and it is thus referenced throughout this guide.

The *Sustrans Design Manual* and its summary version, *Handbook for cycle-friendly design* (Sustrans, 2014), provide a wealth of information on planning and designing cycle routes, updating the previous Sustrans guidance based on experience of having installed and managed more routes throughout the UK.

Sustrans has recently removed access to these guides from their website, preferring to link to other official agency guidance. However, electronic copies of Sustrans guides can still be found for free download at other related websites.

1.2.4 Standards New Zealand HB 8630:2004

The discussion on design of structures on off-road trails in Chapter 6 is based on the *New Zealand Handbook for Tracks and Outdoor Visitor Structures – SNZ HB 8630:2004* (Standards New Zealand, 2004a) but only designers requiring a more detailed understanding need to purchase the standard. *HB 8630* is due to be updated in the near future.

Structural design for on-road structures (including 'clip-on' paths to road bridges) should follow *NZS 4121:2001* (Standards New Zealand, 2001), *AS/NZS 1170* (Standards NZ, 2004b) and the NZTA *Bridge Manual* (NZTA 2013) with geometric features of cycle trails designed according to the Austroads *Guide to Road Design* suite, (primarily parts 3 (Austroads, 2016), 4 (Austroads, 2017b) and 6A (Austroads, 2017c), modified where appropriate by the *Cycling Network Guidance* (NZTA, 2019a).

HB 8630 and other standards are available for purchase from Standards New Zealand. The NZTA *Bridge Manual* is freely available through the NZTA website.

1.3 Terminology

This design guide uses many terms specific to designing for cycling. The glossary gives descriptions of important terms.

Some terms can have different meanings associated with them by people of different disciplines. Types of off-road cycle provision in particular can be called by many different names. In the traffic engineering industry, the usual name for an off-road cycle route is 'path'. This term covers both urban and rural routes that are usually (but not always) shared with pedestrians. It applies to the flat, wide paths built on railway corridors ('rail trails') as well as paths built on more adventurous terrain for mountain biking, which are often termed 'tracks'.

In the UK, paths are called 'greenways' and in the USA they are called 'trails'. The use of the word 'trail' in the New Zealand Cycle Trail, however, is not limited to off-road paths, as the NZCT includes on-road routes also. In New Zealand, on-road quiet traffic-calmed routes are termed 'neighbourhood greenways'.

This guide uses the term 'path' to describe an off-road route, unless quoting another source or a commonly used term such as 'rail trail' or 'mountain biking track'.

Thus 'trails' in the NZCT can be either off-road paths or on-road cycle routes. A 'Great Ride' is predominantly off-road, and has been approved to use the Great Ride brand by the Minister of Tourism based on recommendations from NZCT Inc. There are 23 Great Rides of New Zealand as of 2024. A 'Heartland Ride' is predominantly an on-road cycling route. These routes along with connections form part of the NZ cycling network, and are all assessed by the NZTA to make sure they meet the required criteria before being approved.

The terminology in this guide differs somewhat to that used in the *Cycling Network Guidance (CNG)* (NZTA, 2019a), e.g. where 'trail' in the *CNG* generally only refers to unsealed paths. Be aware of these differences in terminology when referring to different cycling guidance.

1.4 Learning from the past

In the first ten years of the NZCT project, regular trail audits were conducted. The most common themes from those audits are summarised below and represent a list of lessons learnt, often the hard way.

Surfacing: Except for volcanic soils, all trails should be surfaced and compacted.

Resurfacing: Trails require resurfacing at end of life of the surface, and this needs to be planned for by estimating life cycle and budgeting for upcoming work.

Resilience: An increasing number of storms caused by climate change is creating unexpected drainage challenges and causing millions of dollars of damage on Great Rides. Areas most at risk are by rivers and coasts. When planning routes, route options need to be considered carefully, with future conditions (not current or historic conditions) in mind.

Squeeze gates: Refer to accessibility section (Section 5.6.4) of Guidelines and Appendix 3A to 3E (chicane gates, croquet hoops and squeeze gates) for guidance on use of squeeze bars.

Wayfinding signs have often been poorly planned by people who know the trail like the back of their hand. Riders get lost on most trails.

Km marker posts should not be counting up from both directions. That means that each km marker post has two different numbers on it, so it loses part of its usefulness (being a single identifying location point on the trail). The km marker posts should start at 0km and go up from there, 1, 2, 3, 4, etc., rather than counting down. It is more intuitive.

Interpretation signs: Stories are often not being told, and so users miss out on cultural and natural highlights.

Replacement signs: Trails need to have replacement wayfinding signs in stock and ready to use when existing signs are vandalised or stolen.

Drainage: It has been common for culverts to be too small for storm events, and for trails not to have enough grade reversals. The result has been major water scour. Review whether larger culverts are needed, and action where required.

Gradient: Almost all trails with steep sections are having to repair them and/or reroute them, or seal them to reduce a chronic maintenance burden. If constantly having to repair these sections, consideration needs to be given to rerouting this section of Trail.

Barriers designed to keep motorbikes off the trails, such as bollards and kissing gates, are a common source of complaint. Bollards have been crashed into, and no one can ride through kissing gates. Weigh up whether barriers are needed against accessibility needs.

Gravel paths beside sealed roads are often not used because the road is easier. Roadside paths should be smoother than the road.

Shelters and toilets are required more frequently – riders need basic amenities at regular intervals (should relate to time, rather than distance – i.e., consider target market and hills). Review whether toilets are in the right place on the Trail.

Environment: Identify opportunities to reduce maintenance by implementing a native planting programme.

Think like a cyclist to design for cycling. This requires riding trails, especially your own, to understand how they flow when riding. Take time to assess your trail(s) from the perspective of someone unfamiliar with the area or a less experienced rider.

Road crossing treatments are often inadequate – clearer guidance is required at crossings.

Inconsistent grading: Constantly review the Trail against marketed grade level to ensure it meets this grade.

Trail inspection/feedback: Trails should be ridden regularly by Trail managers to assess that the Trail meets the Trail grade, to assess maintenance and safety aspects and that the Trail fulfils customer expectations with regard to the experience promised.

1.5 Off-road and on-road trails

The NZCT consists of off-road and on-road cycle trails. These two categories provide differently for cycling and have different design requirements:

- off-road trails/cycle paths (discussed in Section 2)
- on-road trails (including 'quiet roads', cycle lanes and road shoulders, discussed in Section 3).

Section 4, which discusses crossing and intersections, is also particularly important as it examines the interactions of trails (both off- and on-road) with roads.

1.6 Climate change and resilience

Since the NZCT project was first announced in 2009, New Zealand has experienced a number of changes in climate that have directly impacted the trails. The changes, listed below, are predicted to continue and should be planned for (United Nations Intergovernmental Panel on Climate Change AR6).

- The mean temperature has increased by approximately 1 degree Celsius compared with the 20th century average and is expected to increase by up to a further 1 degree Celsius by 2040.
- Average rainfall has increased in the west and decreased in the east and north.
- Mean sea levels have risen by approximately 3mm per year and will continue to rise.
- The number of extreme weather events (heat, storms, droughts) has increased.
- The risk of wild fires has increased as many areas of New Zealand experience more frequent dry periods.

These climatic changes impact on trails in the following ways.

- **Record high rainfall** events have caused flooding that has seen rivers breach their banks and caused water scour, bank erosion and depositing of silt on trails. Bridges are now being built to allow for flood levels 500mm (or more) higher than in the past. Culverts are being enlarged, more are being installed, trails are being raised and some sections chip-sealed or concreted.
- **Coastal sections** of trail have been washed away, resulting in parts of the Great Taste Trail, Remutaka Cycle Trail, Motu Trails and Hawke's Bay Trails having to be realigned away from the coast and/or rebuilt to a more robust standard. Rock walls are being enlarged or built for the first time.
- **Construction in coastal areas** must now comply with the *NZ Coastal Policy Statement* (DOC 2010), which requires designers to plan for the 'cumulative effects of

sea level rise, storm surge and wave height under storm conditions'. This is a requirement of the Resource Management Act.

- **Cyclones** have resulted in significant damage to trail infrastructure and trail closures due to significant treefall on the West Coast Wilderness Trail and Dun Mountain Trail, and landslides on the Mountains to Sea Trail.
- **Temperature increases** are contributing to weakened soil conditions and high fire risk. In 2019, Tasman's Great Taste Trail was closed when a wild fire spread through thousands of hectares of forest. Trails need to play a role in reducing fire risk, and prepare for trail closures in production forests during extremely dry periods.
- **During extremely dry conditions,** machinery should not be used due to risk of starting a fire, and soil friability.

Examples of resilience work from the trails are:

- more and larger culverts
- higher bridges with abutments further away from a riverbank
- sealing sections of trail that are prone to flooding and water scour damage
- moving sections of trail away from flood zones and coastal fringes
- building stronger boardwalks.

These changes are aimed at reducing future costs of maintenance and repairs.

Government policy has changed to reflect climate change and more policy is likely to be introduced in the near future. Trail managers will need to keep informed as the climate, and the associated regulations, change over time.

2 Off-Road Trails

IMBA's *Trail Solutions* (2004) provides excellent off-road trail-building advice for all stages of trail planning and construction. Its main strengths are proven design guidance for fun and sustainable trails. It is widely used by those building mountain bike trails in New Zealand

2.1 Preliminary considerations

2.1.1 Sharing with pedestrians

It is common in New Zealand that off-road provision for cycling is combined with pedestrian provision. The term 'pedestrian' is often used in New Zealand to cover all people travelling by foot (e.g. walkers and runners) plus wheelchair users, people pushing baby buggies or on small-wheeled devices such as skateboards, push-scooters or mobility scooters (even though people using many of these devices are legally not 'pedestrians').

All trails on NZCT are to be available for people walking, although in many of the more rural trails the numbers of pedestrians is expected to be low. In general, with good design for cycling, no particular provisions for pedestrians will be needed on NZCT. However, it is also worth considering other potential mobility devices, such as scooters, skateboards and wheelchairs.

Four general off-road trail types cater for cycling:

1. shared (the most common type)
2. segregated (by mode or by direction)
3. separated
4. exclusive.

It is important to communicate to users that the Trail is shared use and to expect both cyclists and pedestrians to be on the Trail.

Shared paths are available to both cyclists and pedestrians, without any form of segregation of users. This is a common type of path on the NZCT. An example of a shared path is the Nelson unsealed path shown in Figure 1.

Figure 1: Shared path, Nelson

Segregation can occur in two distinct forms: by mode or by direction. Paths segregated by mode allocate different spaces for walking and cycling by signs, markings or guidance measures such as varied surface types. Path users are supposed to remain in their allocated section but are not physically prevented from crossing over to the other section.

Generally, segregation by mode has a poor level of compliance as users tend to travel where best suits them in terms of their course of travel or scenic opportunities, and often prefer to keep left. Segregation by mode can also be confusing for some users, for example, those on roller skates or parents walking beside small children on bikes who don't know whether to walk on the side of the path for pedestrians or the side for cyclists.

Segregation by direction of travel is a more effective mechanism that divides the path in two and requires users to keep to the side on their left, similar to a two-lane road operation. This minimises conflicts between users by fostering a more orderly approach.

Segregation by direction of travel is a suitable treatment for paths of high volume but it is generally not necessary to specify it for rural paths. Segregation by direction may be a useful localised treatment for sections leading up to intersections, for example, the Nelson Rail Reserve shown in Figure 2. Designers should not assume that the keep left principle will come naturally to users; many overseas users will be from countries where they drive on the right side of the road and need to be reminded that we use the left in New Zealand.

Figure 2: Segregation by direction, Nelson Rail Reserve

Separated paths are similar to segregated paths in that they allocate different spaces for walking and cycling. However, separated paths divide pedestrians and cyclists by physical measures, so that it is difficult or impossible for users to cross to the other mode's path. Separation can be achieved through use of physical structures such as kerbs or even fences, or by wide gaps between the two paths, with grass berms or plantings in between. An example of a separated path is Christchurch's Rutland Street path, as shown in Figure 3. The cycle path (coloured green) is adjacent to the road carriageway and separated from the footpath (next to the property boundary) by a kerb and grass berm.

Figure 3: Separated paths on Rutland Street, Christchurch

Exclusive cycle paths, as the name suggests, cater solely for people cycling without any nearby pedestrian path. Such paths are rare as pedestrians are generally provided for in some way, even for purely recreational trails.

2.1.2 Sharing with equestrians

It is not recommended NZCT's routes be designed to accommodate equestrian use. Horses can damage track surfaces, requiring more intensive maintenance or reducing surface quality from a cycling perspective. Sharing the trails with horses requires a much wider track and can have safety issues if horses are spooked by approaching cyclists.

The path specifications in this guide are not intended to accommodate horses and horse-riding. In particular, paths designed to include equestrians would require wider widths, higher overhead clearances, increased loadings for structural design and alternative gateways for horses at cattle stops.

If a path is already established, or terrain allows for dual cycle and equestrian paths, accommodation of horses is at the discretion of trail designers, owners and operators.

There are fewer complications for on-road trails, as roads are strong enough to accommodate horses and equestrians are legally allowed to ride on road shoulders.

2.1.3 Sharing with motor vehicles

NZCT off-road trails should be designed to exclude public motor vehicle access along the trails – this includes motorbikes and four-wheel drive vehicles – as motorised vehicles result in increased path maintenance costs, safety issues due to greater speed differential of users, and noise pollution. However, at some points it will be necessary for off-road trails and roads to cross, as discussed in Section 4. The design of access points will need to consider how to exclude motor vehicles.

2.1.4 Relationships to roads

There is a spectrum regarding how 'off-road' an off-road trail really is. There are two main levels of off-road trails:

1. adjacent to the road carriageway (whether within or adjacent to the legal road reserve); and completely separate from any roads.

Where cyclists are expected to use the road or road shoulder, this is classified as an on-road trail and is dealt with in Section 3.

An off-road trail within the road corridor is similar to a footpath. An example of an off-road trail within the road corridor is the Birchs Road pathway in Selwyn District, which forms part of the Little River Rail Trail, as illustrated in Figure 4. This path is shared with pedestrians and is separated from the adjacent road carriageway by a grass verge.

Figure 4: Off-road trail within road corridor – Little River Rail Trail (Photo: Jonathan Kennett)

An off-road trail adjacent to (but not within) the road corridor follows the same general alignment of the road corridor. However, it will have greater separation from the carriageway (and perhaps fewer opportunities of accessing the carriageway) than a path within the road corridor. An example of an off-road trail adjacent to the road corridor is Palmerston North's Tennent Drive, as shown in Figure 5; note the separation of cyclists and pedestrians.

Figure 5: Off-road trail adjacent to road – Tennent Drive, Palmerston North

If an unsealed or poorly surfaced cycle path is provided beside a quiet, rural sealed road and it has little or no separation from the road, it will be unlikely to be used for cycling (refer Figure 6). Most cyclists will prefer to use the sealed road, as it has an easier riding surface. Therefore, if a cycle path is to be built right beside a sealed road, the path should also be sealed. Alternatively, the path could be well separated from the road or the road itself could be used for the trail (so long as the conditions identified in Section 3 are met).

Figure 6: Poorly surfaced cycle paths next to low-volume roads will not be used by cyclists

Alternatively, an off-road trail may be completely separate from any road corridors. Such paths provide cyclists and pedestrians with the ability to access locations where motorists cannot drive. They may provide shortcuts or access to scenic attractions. An example of an off-road trail separate from roads is the New Plymouth coastal pathway, as shown in Figure 7.

Figure 7: Off-road trail separate from roads – New Plymouth

2.1.5 Aesthetics

To be iconic, a route should fit naturally with the surrounding landscape, emphasise the local scenic attractions and, in some cases, provide additional visual stimulation. For example, placement of artwork, vegetation or a viewing platform can emphasise the surrounds. Path alignment and width should be developed with respect to natural attractions and historic structures.

Figure 8: Cyclist on Prospect Hill track – Kopuwai Conservation Area (Photo: John Robinson)

DOC (2008, Chapters 5 and 6) describes the important components of landscapes and different types of landforms. It also details how landscape features such as 'anchors', 'edges', 'gateways' and historic features can be used to produce a more aesthetically pleasing path and more enjoyable riding experience. Landscape is an important component of initial route planning.

Trails should always include some curvature as curved trails look better than long straight lines across a landscape; however, they should not be so convoluted that riders create shortcuts from one section to another and damage the trail surface and surrounding landscape.

'Gateways' are features used to provide an attractive threshold at the start of a trail.

Sustrans (2009a) outlines useful techniques for establishing gateways (in its Chapter 10) and important considerations for the 'travelling landscape' (Chapter 13).

Figure 9: Curvature on the Around the Mountains Cycleway, Garston (Photo: Jonathan Kennett)

Figure 10: Sculptures adjacent to Nelson Rail Reserve Pathway

Figure 11: Railway hut and wagon on Little River Rail Trail, Canterbury (Photo: Chris Freear)

2.2 General design specifications

Design specifications for **off-road** trails:

Grade 1	Grade 2	Grade 3	Grade 4	Grade 5
Easiest	Easy	Intermediate	Advanced	Expert

2.2.1 Grade 1 (Easiest)

Description: Flat, wide, smooth trail. Trail feels safe to ride. Ideal as a first ride for non-cyclists, and those wanting an easy gradient or experience. Trail allows for cyclists to ride two abreast most of the time, and provides a social component to the ride. Cyclists will be able to ride the total distance of the trail without dismounting for obstacles.

Gradient: 0–3.5% for at least 90% of trail; between 3.5–5% for steeper slopes up to 100 metres long, and between 5–7% for steeper slopes of up to 10 metres long. If the track is designed and promoted to be ridden predominantly in one direction, then the downhills can be steeper (up to 7% for up to 100m). Sealed trails can be steeper (same as the equivalent Grade of on-road trail; see Table 4).

Width: 'Double trail' preferred = 2.5m to 4m for 90% of trail, where cyclists may ride side by side. 'Single trail' width of 1.5m, with 1.2m minimum. Horizontal clearances as in Appendix 3A, Section A2.

Vertical clearance: Minimum vertical clearance of 2.2m to overhead hazards. A 2.0m vertical clearance may be used for discrete overhead hazards, such as tree branches or existing structures.

Radius of turn: 6m minimum to outside of turn.

Surface: Compacted/stabilised base course, under a top course aggregate of maximum AP 20mm. The surface shall be smooth and even, and easy to ride in all weather conditions.

Watercourses: All water courses bridged.

Bridge width: Recommended bridge width of at least 1.5m, absolute minimum width of 1.2m with handrail/barrier to fall. The approach should be the same width as the structure for 10 metres.

Obstacles: None. No stiles. Cattle stops should preferably be at least 1.5m wide, and minimum 1.2m wide.

Length: 3.5 to 4.5 hours/day (30 to 50 km/day).

Barriers/guard rails: Areas such as bluffs or bridges where a fall would result in death or serious harm require handrails. The 'Fall heights' sections in Appendices 3A to 3E (*Design information for contractors*) contain a calculation process for confirming whether barriers are required – 'Decision framework for determining fall treatment'.

2.2.2 Grade 2 (Easy)

Description: Some gentle climbs, smooth trail. Suitable for confident beginner riders, the trail is predictable with no surprises. Social component with riders able to ride side by side at times, but possibly large sections of single trail.

Gradient: 0–6% for at least 90% of trail; between 6–8.8% for steeper slopes up to 100m long, and between 8.8–10.5% for steeper slopes up to 10m long. If the track is designed and promoted to be ridden predominantly in one direction, then the downhills can be steeper (up to 14%). Sealed trails can be steeper (same as the equivalent Grade of on-road trail; see Table 4).

Width: Between 0.9m and 1.5m for single trail and minimum 2.2m for double trail sections with adequate clearances. Horizontal clearances as in Appendix 3B, Section B2.

Vertical clearance: Minimum vertical clearance of 2.2m to overhead hazards. A 2.0m vertical clearance may be used for discrete overhead hazards, such as tree branches or existing structures.

Radius of turn: 4m minimum with at least 5m desirable to outside of turn.

Surface: Compacted/stabilised base course, under a maximum top course aggregate of maximum AP 30mm. The surface should be smooth and easy to ride in all weather conditions.

Watercourses: Watercourses bridged, except for fords with less than 100mm of water in normal flow, which can be easily ridden. Surface should be as smooth as adjacent trail.

Bridge width: Recommended bridge width at least 1.5m, minimum width of 1.0m with handrail/barrier to fall. The approach should be the same width as the structure for 10 metres.

Obstacles: Some rocks/roots/ruts that can either be avoided, or are less than 50mm high. No stiles. Cattle stops should be minimum 1.2m wide.

Length: 4 to 5 hours/day (30 to 50km/day).

Barriers/guard rails: Areas such as bluffs or bridges where a fall would result in death or serious harm require handrails. The 'Fall heights' sections in Appendices 3A to 3E (*Design information for contractors*) have a calculation process for confirming whether barriers are required – 'Decision framework for determining fall treatment'.

2.2.3 Grade 3 (Intermediate)

Description: Narrow trail, there will be some hills to climb, obstacles may be encountered on the trail, and there may be exposure on the edge of the trail.

Gradient: 0–8.8% for at least 90% of trail; between 8.8–12.3% for steeper slopes up to 100m long, and a maximum of 17.5% for steeper slopes up to 10m long. If the track is designed and promoted to be ridden predominantly in one direction, then the downhills can be steeper (up to 19.5%). Sealed trails can be steeper (same as the equivalent Grade of on-road trail; see Table 4).

Width: 0.9m for 90% of the trail, 0.6m minimum with adequate clearances. Horizontal clearances as in Appendix 3C, Section C2.

Vertical clearance: Minimum vertical clearance of 2.2m to overhead hazards. A 2.0m vertical clearance may be used for discrete overhead hazards, such as tree branches or existing structures.

Radius of turn: 2.5m minimum, with at least 4m desirable to outside of turn.

Surface: Generally firm, but may have some short muddy or loose sections.

Watercourses: Watercourses bridged, except for fords with less than 200mm of water in normal flow, which can be easily ridden.

Bridge width: Recommended at least 1.0m; minimum 0.75m deck if the width at handlebar height is 1.2m. If there are no handrails, then minimum width of 1m for structures less than 0.5m high.

Obstacles: Occasional rocks/roots and ruts may be up to 100mm high/deep and may be unavoidable.

Length: 4 to 6 hours/day (30 to 50km/day for an intermediate cyclist).

Barriers/guard rails: Areas such as bluffs or bridges where a fall would result in death require handrails. Areas where a fall would likely result in serious harm require either handrails or sight rails or a warning sign, depending on the nature of the drop-off and likelihood of a fall. The 'Fall heights' sections in Appendices 3A to 3E (*Design information for contractors*) have a calculation process for confirming whether barriers are required – 'Decision framework for determining fall treatment'.

2.2.4 Grade 4 (Advanced)

Description: Steep climbs, with unavoidable obstacles on a narrow trail, and there will be poor traction in places. Possibly some walking sections.

Gradient: 0–12.3% for at least 90% of trail; between 12.3–16% for steeper slopes up to 100m long, and maximum 21% for steeper slopes up to 10m long. If the track is designed and promoted to be ridden predominantly in one direction, then the downhills can be steeper (up to 27%). Sealed trails can be steeper (same as the equivalent Grade of on-road trail; see Table 4).

Width: 0.6m minimum on steep terrain with drop-offs, 0.3m minimum on flat ground. Horizontal clearances as in Appendix 3D, Section D2.

Vertical clearance: Minimum vertical clearance of 2.2m to overhead hazards. A 2.0m vertical clearance may be used for discrete overhead hazards, such as tree branches or existing structures.

Radius of turn: 2m minimum, with 3m desirable to outside of turn.

Surface: Firm and loose.

Watercourses: Watercourses bridged, except for fords with less than 300mm of water in normal flow, which can be easily ridden.

Bridge width: Recommended 1.0m; minimum 0.6m.

Obstacles: Many rocks/roots and ruts up to 200mm high/deep. Also, some purpose-built obstacles to liven things up, such as drop-offs and jumps.

Length: 4 to 8 hours/day (30 to 60km/day) for advanced cyclists.

Barriers/guard rails: Areas such as bluffs or bridges where a fall would result in death require handrails. Areas where a fall would likely result in serious harm require either handrails or sight rails or a warning sign, depending on the nature of the drop off and likelihood of a fall. The 'Fall heights' sections in Appendices 3A to 3E (*Design information for contractors*) have a calculation process for confirming whether barriers are required – 'Decision framework for determining fall treatment'.

2.2.5 Grade 5 (Expert)

Description: Technically challenging, with big hills, often lots of rocks, some walking likely. May traverse a wide range of terrain and cater for riders with expert skills and experience. Popular trails of this Grade should be one-way.

Gradient: 0–17.5% for at least 90% of trail; between 17.5–23% for steeper slopes up to 100m long and between 21–27% for steeper slopes up to 10m long. Sealed trails can be steeper (same as the equivalent Grade of on-road trail; see Table 4). If the track is designed and promoted to be ridden predominantly in one direction, then the downhills can be steeper (up to 36%).

Width: 0.4m average, 0.25m minimum. Horizontal clearances as in Appendix 3E, Section E2.

Vertical clearance: Minimum vertical clearance of 2.2m to overhead hazards. A 2.0m vertical clearance may be used for discrete overhead hazards, such as tree branches or existing structures.

Radius of turn: 1.5m minimum, with more desirable.

Surface: Huge variety of surfaces.

Bridge Width: Recommended 0.8m; minimum 0.m.

Obstacles: Many rocks, roots and ruts, up to 0.6m high/deep. If there are no obstacles then they are likely to be added afterwards (i.e. jumps, and wooden structures).

Length: 4 to 12 hours/day (30 to 100km/day) for advanced cyclists.

Notes:

1. Any sections of trail that are harder should only be one Grade harder, but only in short sections of no more than 100m.
2. Maximum downhill gradient applicable only if trail is designed and promoted to be ridden in one direction.

3. If a short section of a trail is steeper than that recommended for the trail Grade, this may be compensated for by making the trail wider, easing the turns, improving the surface, or other compensatory measures. Other criteria can be similarly compensated for to allow the trail to meet the requirements for a lower trail Grade.
4. The widths given are minimum widths. If the terrain beside a track is rideable for the target market (i.e. flat mown grass beside a concrete path for Grade 1), then the minimum width can be reduced if need be (e.g. from 2.5m down to 2.2m for Grade 1). In some cases, it will be possible to provide wider paths. However, care should be taken to not make the path too wide as cyclists will feel they are on a road rather than a cycle trail – see Appendices 3A to 3E. In natural environments overly wide trails also impact on the scenic values that are sought by visitors.
5. An acceptable alternative to barriers, guardrails or handrails at bluffs, steep drop-offs or water bodies is adequate horizontal clearance of at least 1.5m for Grade 1 from the edge of the trail.
6. Any steep section of trail should be preceded and followed by a grade reversal, or flat section (on uphills it gives people rest, and it stops water flowing down the track for too long).
7. Maximum trail gradients of 9% are most sustainable. Trail gradients that are steeper than this for long sections are physically unsustainable, will erode over time, and require higher levels of maintenance, or sealing/rock armouring.
8. Maximum trail gradients stated in this guide may need to be less because of local environmental factors (See Table 1 below).
9. As the side slope on the downhill side of the track increases, the consequence of fall increases, and therefore extra track width is required (refer to Appendices 3A to 3E – 'Horizontal clearances').
10. Out-slope of 5% is generally recommended, so that water runs straight across the track, rather than down the track. A common exception is for bermed corners, where an in-slope will make it easier for people to ride around them.
11. Grade reversals (see Appendices 3A to 3E) are recommended at intervals relative to the gradient and soil type of the trail. Spacing between grade reversals should decrease as gradient increases. Also, a grade reversal should occur at every unbridged water crossing (even if the water crossing is dry at the time of construction).

Table 1: Factors influencing maximum sustainable trail gradient

Factor	Description
Half rule	Longitudinal gradient should not exceed half the gradient of the cross-section side slope – if it does, it is considered a fall-line track, and will be prone to water erosion.
Soil or surface type	Learn the local cohesion and drainage properties of the soil. Some soils will support more/less steep gradients than others. Natural surfaces that include rocks or roots can often sustain very high gradients.
Grade reversals	Frequent use of grade reversals may be needed for steeper gradients.
User types	Walkers and cyclists are low impact users. If high impact users share the trail (i.e. horses, motorbikes, quad bikes), then more robust construction techniques, gentler gradients and more frequent maintenance should be considered.
Number of users	High use trails may also need gentler gradients, more robust surfacing and more frequent maintenance.
Level of difficulty	Grade 4–5 trails, with steeper gradients, may require more grade reversals and tread armouring in places.
Annual rainfall	Very high, and very low rainfall areas may need to be designed with gentler gradients.
Climate change	NIWA states that wet regions are becoming wetter and dry regions are becoming dryer, and sea level is rising. Plan appropriately for climate change in your region.

2.3 Unsealed trail gradients

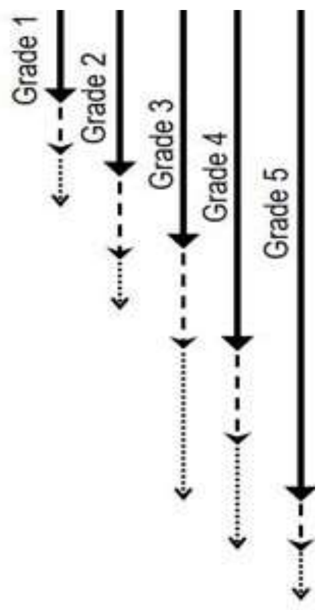
Gradient requirements for off-road unsealed trails (and gravel roads) are summarised in Appendix 1.

One of the key factors that determines whether a route will suit less experienced and less energetic cyclists is the gradient. Disused railways are ideally suited to conversion to cycle trails (coined 'rail trails') and are especially popular because the gradients are gentle. Rail trails typically have gradients less than 3.5%. It is also possible to form rail trails along live rail corridors adjacent to the railway line; this requires fencing if the path is close to the railway line. The greater the separation distance between the path and the railway line the better; KiwiRail will typically require at least 5m separation from active railway centrelines.

Clinometers (instruments to measure the gradient) are essential for track design and construction, especially for Grade 1 and 2 trails. Gradient is one of the most important distinguishing characteristics for the different Grades of trail, so it is important to assess and maintain appropriate trail gradients accurately, and advise riders accordingly.

Designers typically use degrees, percent or slope to indicate gradient; this guide uses percent. The relationship between degrees, percent and slope with the corresponding off-road Grades is shown in Table 2. Appendix 1 provides further methods of converting between the three gradient measures.

Table 2: Relationship between off-road Grade, degrees, percent and slope

Indicative off-road trail Grade	Degrees	Percent	Slope
	0°	0%	NA
	1°	1.7%	1:57
	2°	3.5%	1:29
	3°	5.2%	1:19
	4°	7.0%	1:14
	5°	8.7%	1:11
	6°	10.5%	1:10
	7°	12%	1:8
	8°	14%	1:7
	9°	16%	1:6
	10°	18%	1:6
	12°	21%	1:5
	15°	27%	1:4
	20°	36%	1:3
	30°	58%	1:2

Note: 7% (4 degrees) is the desirable maximum gradient for paths that may be used by wheelchairs. Refer to Section 14.4 of NZTA (2009) for further guidance about accessible pathways.

Berms: In some cases, trail users or designers mistakenly refer to super-elevated turns as switchbacks. Technically switchbacks do not have banked corners.

Generally, a 'berm' or super-elevated turn has a curved (rather than straight) cross-sectional profile, as illustrated in Figure 12; this allows slower, less confident cyclists to ride on the flat part near the inside of the curve and faster, more experienced cyclists to ride on the outer sloped sections. The slope of berm should be dictated by the Grade of the trail. For example:

- Grade 1 berm slope of up to 17.5%
- Grade 2 berm slope of up to 36%
- Grade 3 berm slope of up to 84%
- Grade 4 berm slope of up to 100%
- Grade 5 berm slope of up to 120%.

Super-elevation on bends also keeps water off the track, as it will run around the inside of the corner.

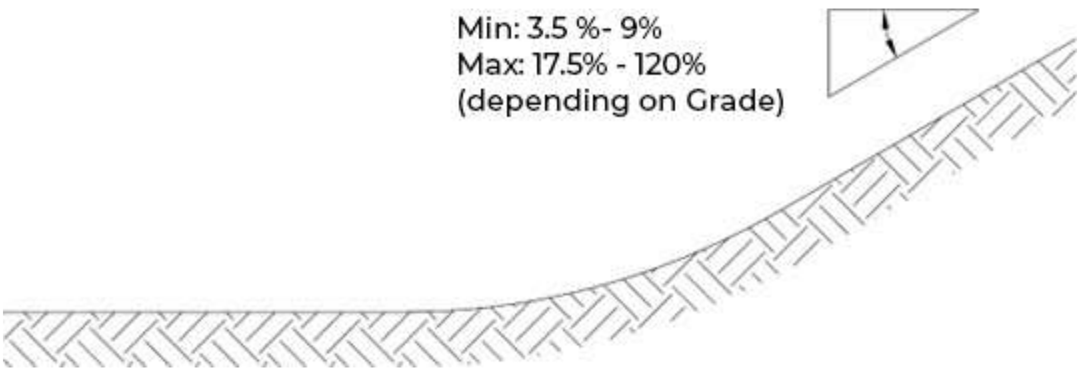


Figure 12: Cross-section for super-elevated (or bermed) turns

- Designers need to make an assessment of rider speed into a corner to determine the ideal berm radius and camber.
- Climbing speeds on off-road trails are typically 5–10kph.
- E-bike climbing speeds are typically 10–15kph.
- Descending speeds vary greatly from 10–50kph, but are typically higher on wide trails and trails with more experienced riders.
- Designers need to select locations for turns where there is room for an adequate radius, while minimising the need for excavation and retaining walls.
- Trail gradient through the turn should match the overall trail gradient, but may be steeper in steep terrain, if grade reversals are situated before and after.
- The gradient radius combined will determine the height difference between the entry and exit of the corner.

Table 3 summarises ideal combinations of camber angles for different curve radii and approach speeds.

Table 3: Ideal camber angles for bermed corners of different approach speeds and radius

Speed into corner	2m radius	3m radius	4m radius	5m radius	6m radius
5km/h	5% berm	9%	7%	5%	3.5%
10km/h	36%	27%	17/5%	16%	12.3%
15km/h	84%	58%	47%	36%	27%
20km/h	160%	100%	70%	58%	53%
25km/h	n/a	166%	119%	100%	84%
30km/h	n/a	n/a	173%	143%	119%
40km/h	n/a	n/a	n/a	275%	214%

Grade reversals are deliberately designed features of trails where long slopes are interrupted by short sections where the gradient reverses (see Figure 13), ideally for 2–4 metres length with typically 5–9% of fall. Grade reversals should be provided on either side of all super-elevated turns, switchbacks and climbing turns to aid drainage and improve the trail's sustainability. On natural surface trails, grade reversals are the best possible insurance against water scour, and if well-built, they are also fun to ride.

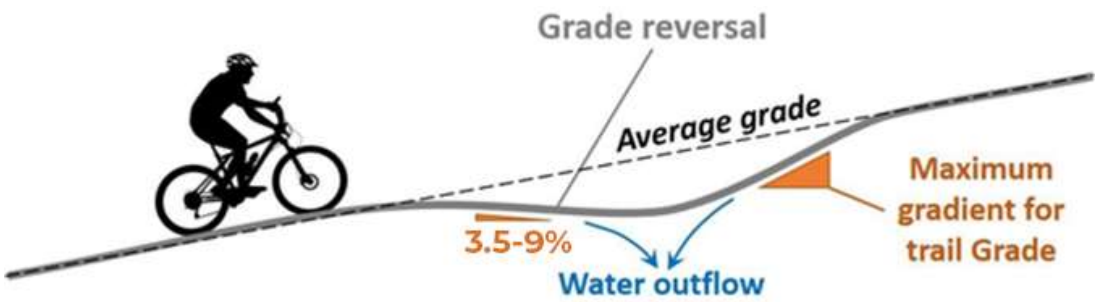


Figure 13: Grade reversal

2.4 Drainage

It is best practice to design grade reversals into trails from the very start. Grade reversals reduce the watershed of each section of the trail so that less rainwater is collected.

Water can then be drained across the trail more easily, rather than running down the trail and causing erosion.

Grade reversals should mimic the natural water run-off. They enhance long-term asset management, as they will work to stop water running down a track for decades into the future, even if maintenance is not done on culverts. Also, grade reversals are fun to ride if they are designed well (i.e. long and shallow).

When a trail crosses a stream, it should drop into the stream and then climb out. This is, in effect, a grade reversal. When crossing a spur, a trail should climb over it. If the trail drops down to a spur and then climbs out, water will pond on the track and a bog will develop.

Grade 1 and 2 off-road cycle trails need particular attention to drainage beyond what is required for more conventional mountain bike trails, because these trails have greater widths, higher geometric standards and higher user expectations. In particular, ponding and flooding need to be prevented by careful consideration of surface types, longitudinal and transverse gradients, camber and the number of culverts/grade reversals/bridges and bridges.

Use of conventional open cross drains (i.e. 'box drains') is not advised. These drains may be easy to construct and initially effective, but will soon block with material flowing down the track.

2.5 Slope stability

Tracks typically traverse a wide variation in topography and ground conditions. Full engineering assessment would be impractical and a poor return on investment. As areas of instability may become apparent following construction, the defects liability period is expected to address these issues.

For any slope stability scenario, a slope is considered to have suitable long-term stability if its performance and design is fit for purpose. Stakeholder agreement is required on what constitutes fit for purpose for the project.

The proposed definition of long-term stability for a gravel off-road rural cycle trail is as follows.

- The slopes, either cut or fill, should be formed so that deep-seated failure affecting a significant portion of the track does not occur in the static (non-seismic) case, or result in the closure of the trail, provided the slope profile, track condition and drainage are maintained.
- It is acceptable to have slope angles that result in minor fretting and slumping that can be addressed via cyclic maintenance using readily available tools and equipment.
- Slopes and batters are resistant to scouring and sediment run-off.
- No significant failures are observed within two years of completion.

2.6 Surface materials

Trail surfaces have an estimated lifespan, which varies predominantly according to surface material used, how it was applied, the trail gradient, adequacy of drainage features, whether the design encourages skidding or not, how well the trail is maintained, vegetation cover and climate (rainfall, freeze thaw, sun, wind).

3 On-Road Trails

3.1 Introduction

On-road trails (quiet roads, cycle lanes or sealed road shoulders) provide for cycling within the road 'carriageway' (i.e. that portion of the road where motor vehicles travel). In urban areas, the carriageway is often defined by kerbs; in rural areas the carriageway is either the sealed area or the gravel area available for vehicles.

In **urban** areas, no special physical measures are needed if motor vehicle operating speeds and traffic volumes are low. At higher speeds and volumes, the main type of on-road provision that caters for urban cycle travel is a cycle lane. Although there are several different ways of distinguishing a cycle lane from adjacent general traffic lanes (e.g. painted line or coloured surfacing) cycle lanes are, by definition, on-road. Cycle paths, conversely, are off-road. Cycle lanes are given legal status through a bylaw/traffic resolution and the presence of white cycle markings painted at frequent intervals along the lane.

Sustrans (2014) gives an excellent description of how to create cycle-friendly urban on- road provisions such as 'quiet streets', 'cycle streets' and 'home zones'. New Zealand- specific advice is also now available in the *Cycling Network Guidance* (NZTA, 2019a).

On rural roads, no special cycling provisions are generally needed if motor vehicle operating speeds are below 100km/h and traffic volumes are below 1000 vehicles/day. Otherwise, sealed shoulders are the main type of provision for cycling on country roads. However, even at low traffic volumes, trails on rural roads are more likely to be Grade 3 or higher – see figures 17–19 in Section 3.5 below. It is essential that good inter-visibility between cyclists and motorists is achieved, particularly for higher speed locations.

Gravel roads can be considered appropriate if their characteristics fit in the 'mixed traffic' areas of the figures.

It may be sufficient for cyclists to use low volume, low speed rural roads without any specific form of provision. In some cases, it will be necessary to provide marked cycle lanes or wide shoulders so that cyclists have a designated cycling space. Many cyclists on the NZCT will be inexperienced riders, from New Zealand, Australia or North America. Others, especially those from continental Europe are likely to be experienced cyclists used to off-road paths, but not experienced in on-road rural cycling.


Figure 14: Cyclist on rural road with wide shoulder, OTT Trail, Taihape (Photo: Jonathan Kennett)

3.2 General design specifications

The design specifications for on-road trails categorised are into six trail Grades, outlined below. These Grades are designed to correspond to the off-road Grades, but no on-road facilities would be specifically designed for an 'extreme' (Grade 6) level (or be considered suitable for the NZCT 'brand' in the on-road context). If a route involves both on-road and off-road sections, the Grades of the two components should be reasonably consistent. As with off-road routes (Section 2.2), ideally on-road trail Grades should not change dramatically over the course of the route (i.e. increase more than one Grade above the stated overall Grade).

Design specifications for on-road trails

Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6
Easiest	Easy	Intermediate	Advanced	Expert	Extreme

3.2.1 Grade 1 (Easiest)

Description: On-road route suitable for cyclists with little on-road cycling experience and low level of fitness. Mostly flat.

Traffic conditions: Low motor traffic volumes and speeds and high-quality trails, as shown in Figure 17 (Section 3.5).

Width: As shown in Section 3.7.

Gradient: 0–4.4% for at least 90% of route; between 4.4–6% for steeper slopes up to 100m long and between 6–8% for steeper slopes up to 10m long. If the route is designed and promoted to be ridden predominantly in one direction, then the downhills can be steeper (up to 8%). Unsealed roads should be less steep (same as the equivalent Grade of off-road trail; see Table 2, Section 2.3).

Surface: Gravel roads in low volume, low speed situations. Asphaltic concrete or concrete is smoother than chip seal.

Road requirements: No multi-lane roundabouts. Cycling provision at signalised intersections. Crossing facilities if cyclists required to cross roads.

Length: 3.5–4.5 hours/day (30–50km/day)

3.2.2 Grade 2 (Easy)

Description: On-road route suitable for cyclists with little on-road cycling experience but reasonable level of fitness. Some gentle climbs.

Traffic conditions: Low motor traffic volumes and speeds and high-quality roads, as shown in Figure 17 (Section 3.5).

Width: As shown in Section 3.7.

Gradient: 0–7% for at least 90% of route; between 7–8.8% for steeper slopes up to 100m long and between 8.8–12.3% for steeper slopes up to 10m long If the route is designed and promoted to be ridden predominantly in one direction, then the downhills can be steeper (up to 12.3%). Unsealed roads should be less steep (same as the equivalent Grade of off-road trail; see Table 2, Section 2.3).

Surface: Gravel roads in low volume, low speed situations. Asphaltic concrete or concrete is smoother than chip seal.

Road requirements: No multi-lane roundabouts. Cycling provision at signalised intersections. Crossing facilities if cyclists required to cross roads.

Length: 4–5 hours/day (40–60km/day)

3.2.3 Grade 3 (Intermediate)

Description: On-road route suitable for cyclists with some on-road cycling experience and reasonable level of fitness. Moderate exertion levels expected. Some steep climbs.

Traffic conditions: As shown in Figure 18 (Section 3.5).

Width: As shown in Section 3.7.

Gradient: 0–10.5% for at least 90% of route; between 10.5–14% for steeper slopes up to 100 metres long, and between 14–17.5% for steeper slopes up to 10 metres long. If the route is designed and promoted to be ridden predominantly in one direction, then the downhills can be steeper (up to 17.5%). Unsealed roads should be less steep (same as the equivalent Grade of off-road trail; see Table 2, Section 2.3).

Length: 4–6 hours/day (50–80 km/day)

3.2.4 Grade 4 (Advanced)

Description: On-road route suitable for cyclists with some on-road cycling experience and reasonable level of fitness. Considerable exertion levels expected. Some steep climbs.

Traffic conditions: As shown in Figure 18 (Section 3.5).

Width: As shown in Section 3.7.

Gradient: 0–14% for at least 90% of route; between 14–17.5% for steeper slopes up to 100m long, and between 17.5–23% for steeper slopes up to 10m long. If the route is designed and promoted to be ridden predominantly in one direction, then the downhills can be steeper (up to 23%). Unsealed roads should be less steep (same as the equivalent Grade of off-road trail; see Table 2, Section 2.3).

Length: 4–8 hours/day (60–100km/day)

3.2.5 Grade 5 (Expert)

Description: On-road route suitable for cyclists with considerable on-road cycling experience and reasonable levels of fitness. Considerable exertion levels expected with some steep climbs. The speed and volume of adjacent motor vehicle traffic will be considered unpleasant and/or unsafe by many Grade 1 and Grade 2 trail users.

Traffic conditions: As shown in Figure 19 (Section 3.5).

Width: As shown in Section 3.7.

Gradient: 0–17.5% for at least 90% of route; between 17.5–27% for steeper slopes up to 100m long, and between 27–32.5% for steeper slopes up to 10m long. If the route is designed and promoted to be ridden predominantly in one direction, then the downhills can be steeper (up to 32.5%). Unsealed roads should be less steep (same as the equivalent Grade of off-road trail; see Table 2, Section 2.3).

Length: 4–10 hours/day (70–160km/day)

3.2.6 Grade 6 (Extreme)

Description: On-road route suitable for cyclists at least 16 years old with considerable on-road cycling experience, and possibly high levels of fitness (or an e-bike). Considerable exertion levels expected with some steep climbs possible. The speed and volume of adjacent motor vehicle traffic will be considered unpleasant and/or unsafe by Grade 3–5 riders; however, at certain times of the day or year, when traffic volumes are lower, these routes may feel similar to Grades 4 or 5. **Not currently appropriate for Heartland Rides and plans should be in place to improve the standard to Grade 5 or better.**

Traffic conditions: Based on Grade 5, as shown in Section 3.2.5; Grade 6 riders will also accept lane sharing on an open road with AADT >2000 for short stretches (i.e. up to 100m uphill, 500m on the flat and 2000m downhill where sight-lines are good and speed differentials are less than 30kph). Riding on roads with a high AADT may be acceptable even for Grade 5 riders by avoiding peak traffic periods. Tolerances for traffic will change where a significant proportion of heavy vehicles are present.

Width: As shown in Section 3.7.

Gradient: 0–17.5% for at least 90% of trail; between 17.5–27% for steeper slopes up to 100m long, and between 27–32.5% for steeper slopes up to 10m long. If the track is designed and promoted to be ridden predominantly in one direction, then the downhills can be steeper (up to 32.5%). Unsealed roads should be less steep (same as the equivalent Grade of off-road trail; see Table 2, Section 2.3).

Length: Unlimited number of days or distance. Road sections are to meet relevant roading control authority specifications.

Figure 23 (Section 3.9) summarises the key differences between the Grades of on-road routes, in terms of traffic volume and shoulder width, and which combinations are considered unacceptable.

3.3 Traffic speed management

A key tool for ensuring safe and enjoyable on-road cycling is to create road environments that support appropriate traffic speeds. The likelihood of death or serious injury from traffic collisions is greatly reduced when traffic impact speeds are reduced (especially below 60km/h). *Speed Management Guide: Road to Zero edition* by NZTA (2022) supports regional transport committees (RTCs), regional councils and road controlling authorities (RCAs) to develop high-quality speed management plans that will deliver safe and appropriate speed limits in line with Te Ara ki te Ora – Road to Zero (New Zealand's road safety strategy to 2030) and the Land Transport Rule: Setting of Speed Limits 2022. It enables easier specification of speed limits below the traditional 100km/h (rural) and 50km/h (urban) defaults. Note, however, this Guide is under review.

Figure 15: Gated 80 km/h speed limit signs, near Fairlie

Many on-road cycle touring routes take advantage of lower volume minor roads where possible. Typically, these roads are justified in having lower speed limits now, based on NZTA's guidelines and network data. Having a higher-than-expected volume of people cycling on these routes is an additional reason to reduce existing posted speeds.

Even without any changes to the road environment, simply posting roads with lower speed limits typically has some effect on observed traffic speeds. A rough rule of thumb is that **for every 10km/h change in posted speed limit, there is likely to be a 2–3km/h change in the observed mean speed** (and potentially greater changes in observed speeds by the faster drivers).

There are a number of additional ways that lower traffic speeds can be encouraged.

- More regular use of speed limit signs, potentially 'gated' on both sides of the road (see Figure 15) and/or with large backing boards.
- Narrowing of traffic lanes, by either shifting existing edge-lines and/or marking widened centre
- lines and edge-lines.

- The removal of road markings, particularly centrelines (care needs to be taken to still provide suitable delineation through curves).
- Traffic calming (e.g. vertical humps, chicanes, platforms) – typically only on urban streets, although rural options are possible (see Figure 16).

Figure 16: An example of rural traffic calming on a 60km/h road, Hooker Valley

- 'Sharrow' (shared arrow) markings on traffic lanes (see right). NB: refer to NZTA guidance on suitable traffic volume/speed combinations for their use (NZTA, 2016b).
- Unsealed or textured road surfaces (including transverse rumble strips).
- Install static or dynamic advisory warning signs approaching narrow bridges and other pinch points – refer to Section 3.10 for more details.

On-road cycle route planners are encouraged to discuss speed management with transport staff in the relevant road controlling authorities (local councils, NZTA, DOC) or their network consultants. They will have access to the NZTA network speed management data for your route and can advise on options for adjusting the existing speed environment. Changes to posted speed limits require a formal regulatory and consultation process, but simple engineering treatments may be possible under minor works budgets.

3.4 Sealed trail gradients

Gradient requirements for sealed on-road and off-road trails are summarised in Table 4.

Table 4: Gradient requirements for sealed trails

Trail Grade	Main uphill gradient range	Steeper slopes up to 200 m long	Steeper slopes up to 20 m long	Maximum downhill gradient
1	0–4.4% for 90% of length	4.4–6%	6–8%	8%
2	0–7% for 90% of length	7–8.8%	8.8–12.3%	12.3%
3	0–10.5% for 90% of length	10.5–14%	14–17.5%	17.5%
4	0–14% for 90% of length	14–17.5%	17.5–23%	23%
5 & 6	0–17.5% for 90% of length	17.5–27%	27–32.5%	32.5%

Notes:

- This table applies to on-road sealed trails and off-road sealed (concrete or asphalt) trails. For unsealed roads and trails, refer to Table 2.
- Uphill sections of trail that are steeper than these gradient criteria should only be one Grade harder and only in sections of up to 100m length. It is undesirable to have harder sections of trail as some riders are likely to be forced to walk these sections.
- Maximum downhill gradient applicable for 100m and only if trail is designed and promoted to be ridden in one direction.
- This table is repeated in Appendix 1 along with the comparable table for off-road trails.

3.5 Vehicle speed and volume

Figure 17 shows the motor vehicle traffic speed and volume characteristics for Grade 1 and 2 on-road trails. At low combinations of traffic volume and speed, no special provisions for cycling, other than NZCT signage and branding, are required. At higher levels, a cycle lane or wide shoulder is required. Figure 18 gives the equivalent values for Grade 3 and 4 trails. Figure 19 covers Grade 5 on-road trails. Where cycle lanes or wide shoulders are required, these should be provided according to Table 5.

These figures should also be read in conjunction with the notes that follows them. Note that the Y-axes are at different scales.

Traffic volumes in the figures are two-way. As traffic volumes increase, so do the chances of cyclists meeting two cars from opposite directions at the same time. This is when road space is at a premium; thus, two-way traffic volumes are just as important to cycling safety and perception of safety as the traffic volume on the adjacent lane.

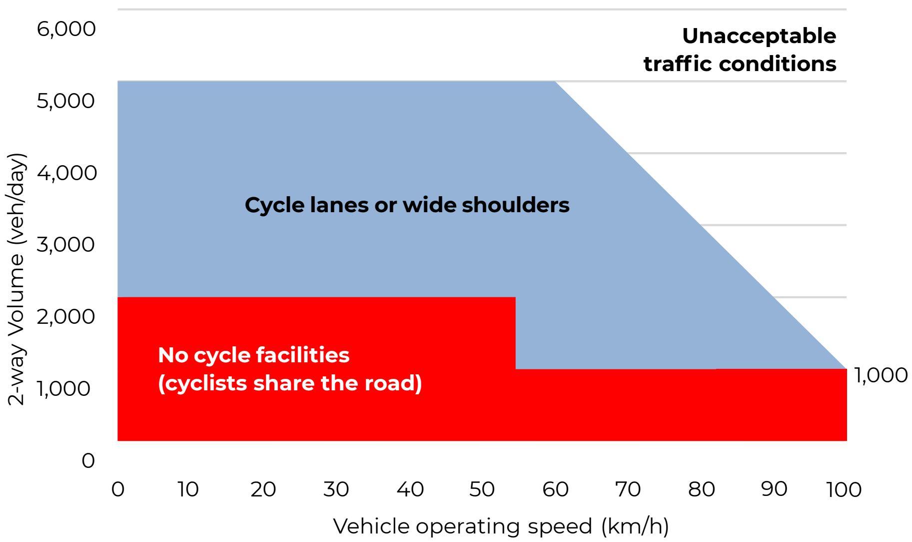


Figure 17: Trail type for Grade 1 and 2 on-road trails

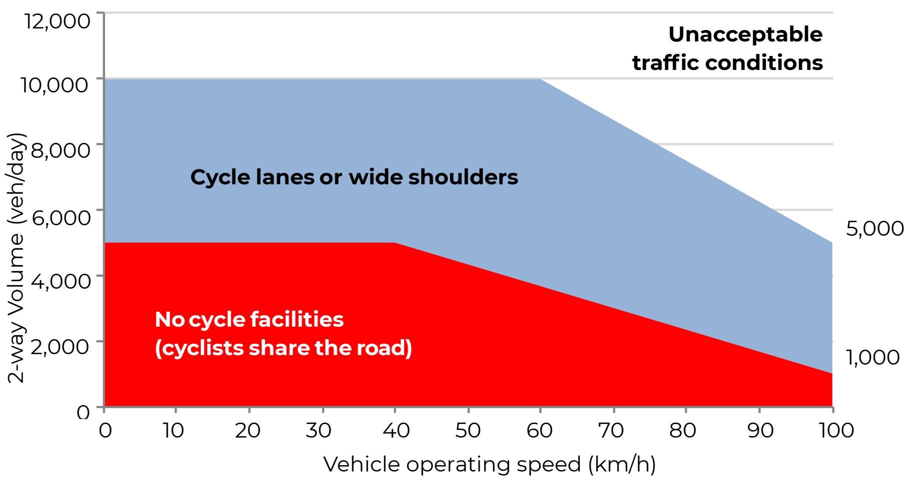


Figure 138: Trail type for Grade 3 and 4 on-road trails

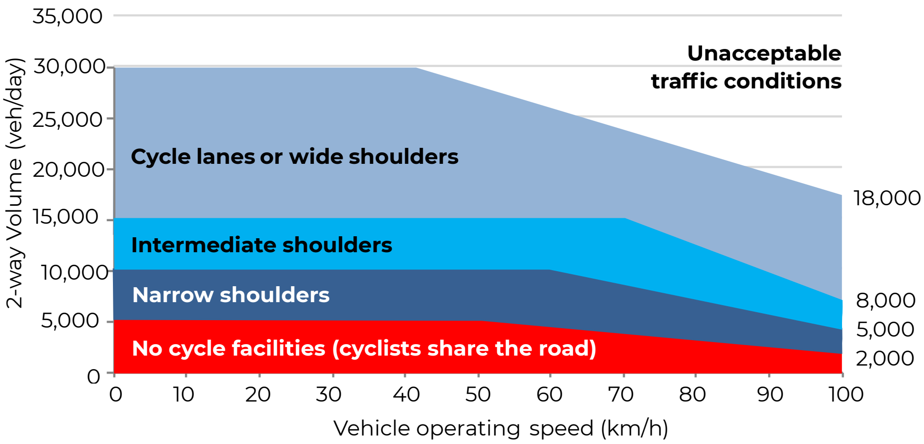


Figure 19: Trail type for Grade 5 on-road trails

Notes:

- Where the 85th percentile operating speed is known it should be used (on the X-axis) in Figure 17 to Figure 19, otherwise the speed limit should be used.
- Traffic volumes (Y-axis) are two-way motor vehicle traffic volumes, per day.
- A road with a motor vehicle volume and speed combination outside the shaded areas in Figure 17 is not suitable as a Grade 1 or 2 trail on an NZCT route. Likewise, a road with a motor vehicle volume and speed combination outside the shaded areas in Figure 18 is not suitable as a Grade 3 or 4 trail.
- Where necessary, measures should be taken to reduce the motor vehicle speeds or volumes to achieve a combination appropriate to the desired trail type. If this cannot be achieved an alternative route should be considered.
- Paint marking cannot be applied to unsealed (gravel) roads and therefore unsealed roads cannot include cycle lanes or shoulders suitable for cycling. Gravel roads satisfying the 'mixed traffic' requirements in the figures may be used for the appropriate on-road trail Grade.
- Grade 5 on-road routes are typically links between 'Great Rides' and will not necessarily be iconic rides in their own right.

Figure 20: Separated shoulder for contra-flow cycling, SH6 near Wakefield (Photo: Miro Kennett)

3.6 Gravel roads

Some NZCT routes will include gravel roads, along with dirt/unmetalled roads; these may be appropriate under the mixed traffic category in Figure 17 to Figure 19. There must be a commitment by road controlling authorities and their contractors that these gravel/unmetalled road sections will be maintained to a standard that is suitable for cycling, consistent with the route Grade. On easier Grade routes, this may require changes to design, construction and maintenance practices, including the selection, application, compaction and maintenance of road metal, and to inspection frequencies. The road camber, especially at bends, may need to be reduced to improve cycle stability.

Regular maintenance should be undertaken to ensure the edge of the road where cyclists ride does not experience a build-up of loose gravel. This can occur as motor traffic causes gravel to migrate the side of the road, and can result in an unstable, uncomfortable and potentially dangerous surface.

This can be a particular problem where uncrushed graded river gravels are used for road metal. Excessive gravel build-up on parts of the carriageway (such as dips and the inside of bends) should be removed. Crushed or stabilised gravels bind much better and provide a more stable riding surface, for motor vehicles and cycles alike.

Trail designers, operators and roading authorities will need to consider the surface quality of gravel roads both immediately after resurfacing and after the road surface is worn. It is preferable for gravel roads to be bordered by a flat, mown or grazed grass verge where cyclists can pull over if necessary.

3.7 On-road shoulder or cycle lane widths

Where shoulders are provided on sealed roads for NZCT trails, their widths and the widths of adjacent general traffic lanes should be as described in Table 5. In determining how much width is available for cycling in a shoulder on an existing road, or on a road redesigned to accommodate cyclists, the effective shoulder width should be considered. This is exclusive of raised reflective pavement markers (RRPMs) or audio-tactile profile (ATP) markings (aka 'rumble strips'), and should be measured from the centre of the edge-line to the edge of seal. If RRPMs or ATP markings exist or are planned, then the available width should be measured from the edge of the RRPMs/ATPs to the edge of seal. Refer to Section 3.11 for further guidance on markings and delineation.

Table 5: Shoulder or cycle lane widths (with no adjacent parking)

Grade	Shoulder or cycle lane width	Speed limit		
		50 km/h	70–80 km/h	100 km/h
	Minimum adjacent traffic lane width	**3.0m**	**3.3m**	**3.5m**
1 and 2	Desirable minimum width	1.6m	1.9m	2.5m
	Tolerable range	1.2–2.2m	1.6–2.5m	2.0–2.5m
3 and 4	Desirable minimum width	1.2m	1.5m	2.0m
	Tolerable range	1.0–1.5m	1.0–1.7m	1.0–2.0m
5 (Narrow shoulder for 2000–10,000 AADT)	Desirable minimum width	1.0m	1.2m	1.5m
	Tolerable range	0.6–1.0m	0.6–1.5m	0.6–1.8m
5 (Intermediate width shoulder for 5000– 15,000 AADT)	Desirable minimum width	1.2m	1.5m	1.8m
	Tolerable range	1.0–1.5m	1.0–1.8m	1.0–2.0m
5 (Wide shoulder for 8000–30,000 AADT)	Desirable minimum width	1.5 m	1.8 m	2.0 m
	Tolerable range	1.2–2.0m	1.5–2.0m	1.5–2.2m

Notes:

1. The speed limit is used unless the 85th percentile operating speed is significantly higher.
2. Interpolation for different speed limits is acceptable.
3. Cycle lane or shoulder widths wider than the minima are recommended. Great Rides should aim for the desirable minimum width; for Heartland/Connector Rides, the minimum tolerable width is acceptable.
4. When greater than 2.5m of shoulder or cycle lane exists, chevron pavement markings should be provided to suggest a cycling area of between 1.5m and 2.0m in width and to separate the cycling area from the general traffic lane. In such cases, the chevron markings should be at least 1.0m wide.
5. Additional shoulder or cycle lane width is required if on-road parking is present. See the *Cycling Network Guidance* (NZTA) section on cycle lanes, concept design considerations, for all trail Grades.
6. If on-road an audio-tactile profile (ATP) or raised reflective pavement markers (RRPM) are present, the shoulder width should be at least 1.5m (but a minimum 1m), unless the requirement from Table 5 is greater. The shoulder width should be measured from the road edge to the ATPs / RRPMs or the edge-line, whichever is less.
7. The lower end of the tolerable shoulder or cycle lane ranges may be used for NZCT on-road cycle trails where it is not practicable to provide the desirable minimum width shoulder or cycle lane. Where the full width of the shoulder or cycle lane is not available (e.g. next to a kerb), then the desirable minimum width should be used.
8. The lower end of the tolerable range should only be used when motor vehicle traffic volumes are relatively low. These shoulder widths do not comply with 'best practice' for cycle lanes or sealed shoulders (as outlined in the *Cycling Network Guidance* (NZTA)) but may be all the width that is available on some NZCT routes. Designers should use sound engineering judgement to satisfy themselves that such shoulder widths will be safe.
9. For Grade 5 trails, different shoulder widths are specified depending on the traffic volume and operating speed environment. The wider shoulder width should be considered for uphill sections of the trail to allow for 'wobble' factors.
10. Where minimum traffic lane width requirements are not met, the desirable minimum cycle lane/shoulder width should be increased accordingly.
11. Where compromises from desirable minimum width are necessary, consider providing more shoulder width in the uphill direction, to accommodate cyclist 'wobble'.
12. Heavy vehicles (trucks, buses and camper vans) are wider than cars and cause more discomfort to cyclists in terms of side drafts, noise and vibration. Additional width allowance should be made on roads with a significant proportion of heavy vehicles, with considerable effort expended where necessary to ensure that desirable minimum widths according to Table 5 are provided.

13. Where the surface beside the shoulder is easily rideable (i.e. flat mown grass, or compacted gravel) for mountain bikes, and the cycle route is one for which mountain bikes are required (e.g. the Mountains to Sea trail) then the minimum shoulder required can be reduced for short pinch points.
14. Where the surface beyond a sealed shoulder is unrideable (for example, next to a steep drop), the minimum shoulder widths in the table may be insufficient, and extra space should be considered.
15. Where roadside crash barriers are in place, designers should add shy space.

Figure 21: Smooth shoulder widening, SH6 near Murchison (Photo: Miro Kennett)

3.8 Seasonal traffic volume variations

All roads experience uneven traffic volume distributions over time. Some roads at certain times of day or year may be unsuitable for most cyclists (because of the intensity of traffic), but may be perfectly acceptable at other times of the day or year. If potential NZCT trail users are made aware of the normal traffic variations and patterns, they may be able to be ridden safely and enjoyably, simply by choosing a quieter time of day.

The following methodology is applicable to Grade 5 and 6 routes only and takes account of traffic conditions experienced by cyclists. An average annual daily traffic volume (AADT) can be used in conjunction with Figure 19, but what matters to cyclists is the volume of traffic experienced at the time of riding a route. There are two considerations to take into account.

- Cyclists themselves can have an influence on the traffic volume by avoiding busy times on the road. For this to be realistic, they need to have the appropriate information.
- Some roads have a distinctly seasonal nature, often coinciding with peak holiday periods. Where this is the case, the busy times to be avoided may be longer during the holiday period than for the rest of the year. That is, an AADT may not necessarily be sufficient when determining what advice to give to cyclists.

Figure 22 shows an example of seasonal road traffic volumes at a particular site.

Figure 22: Daily traffic volume distribution throughout the year

In this example, a trail operator may decide that cyclists should be advised to avoid using the road during the middle of the day when traffic volumes exceed 1,000 vehicles per day. The graph indicates that this only generally applies between December and March and at Easter. During these times, hourly traffic volumes in the middle part of the day regularly exceed 100 vehicles per hour. Therefore, it may be prudent to only ride between May and November, or only during the start and end of the day in busier months.

It can be seen that being aware of hourly volume distributions, and how these may vary during peak times of the year, can possibly be an important management tool.

The *Cycling Network Guidance* (NZTA) gives advice on counting cycle traffic, to understand daily, weekly and seasonal trends.

3.9 Assessing cycle routes on open roads (100km/h speed limit)

The flowchart presented in Figure 23 below provides some initial guidance for assessing the viability of roads with a 100km/h speed limit for accommodating on-road cycle routes for the New Zealand Cycle Trail (NZCT) network.

The volume of traffic (Average Annual Daily Traffic or AADT) and shoulder width are key factors in determining the suitability of roads for the NZCT. These have been discussed in the preceding sub-sections of Section 3.

Important points to note:

- This chart is for assessing cycle routes using open roads with a 100km/h speed limit. Where the speed limit (or 85th percentile operating speed) is lower than 100km/h (see Section 3.3), the required shoulder width will reduce (refer to section 3.7).
- Gravel roads and many minor sealed roads have no shoulder. If such roads are to accommodate an NZCT route, the AADT must be less than 2,000 veh/day to fit the NZCT criteria.
- Roads that have an AADT over 18,000 veh/day are not acceptable for NZCT routes.
- This chart is an outline only. There are a number of factors that determine the final Grade assigned to an on-road cycle route, in addition to the AADT and shoulder width. The other considerations outlined in this Cycle Trail Design Guide should be considered in decision making.
- A high percentage of heavy vehicles (e.g. >20%) may increase a road's grading. An absence of heavy vehicles may decrease a road's grading.
- Numerous intersections (particularly multi-lane roundabouts) and hilly terrain may increase the risks associated with a particular route.
- Riders are likely to tolerate a small percentage of the ride (i.e. <5%) being one grade higher than desirable.
- Riders may time their ride so that the route is effectively a grade easier, by choosing a time of day or day of the week when traffic volumes are relatively low.

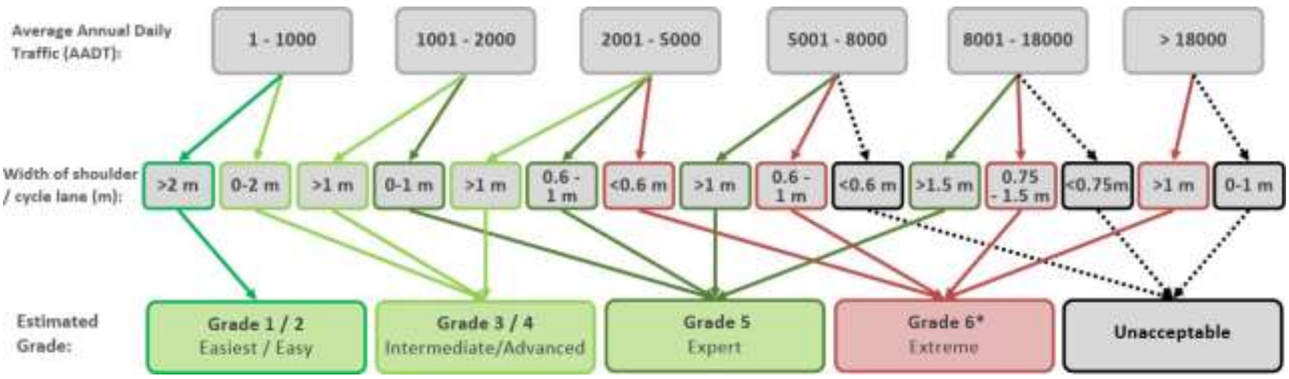


Figure 23: Determination of viability of cycle routes on open roads (100km/h)

* Note that Grade 6 is not currently seen as appropriate for Heartland Rides and plans should be in place to improve the standard to Grade 5 or better.

3.10 Pinch points

A pinch point is a localised narrowing of a trail due to physical features restricting the width. These can occur on- or off-road. Off-road pinch points can cause conflict between users travelling in different directions; generally, this is not a great problem especially if visibility is sufficient to recognise the pinch point and take action before encountering other users.

For on-road pinch points, the greatest danger to cyclists is that of passing motor vehicles. Narrow bridges or road sections (e.g. cuttings) are common on-road pinch points. If it is not possible to provide the appropriate cycling width on-road (as outlined in Section 3.7) then off-road alternatives should be considered.

However, mitigation treatments may be applied to short sections of on-road trails where the required standard is not met, and it is not feasible to provide off-road alternatives (in the immediate future). These are good short-term improvements while a more permanent solution is developed.

Such treatments may include active warning signs, such as those shown in Figure 24. These are a significant improvement over simple static warning signs, which are easily ignored if a cyclist is not present most times that a motorist is driving along. Active warning signs may be activated either by a push button, which the cyclist must ride up to, or an inductive loop sensor in the pavement, which must be positioned so that the cyclist will ride over it. Inductive loop detectors are preferred as they do not require cyclists to stop; however, the loop positioning must be carefully determined, and detection equipment must be able to detect cyclists but not motor vehicles (regular inspections and maintenance are important to avoid failures).

Figure 24: Inductive loop activated warning sign on Appleby bridge, SH 60, near Nelson (Photo: NZTA)

Active warning signs can also be useful at complicated on-road sites where there are many demands on motorists' attention and cyclists might not otherwise be noticed, such as at locations where cyclists cross the open road, or at intersections. Figure 25 shows an active warning sign used at the Ngauranga interchange on State Highway 2, near Wellington. Cyclists cross the motor vehicle on-ramp, but motorists are warned to look out for cyclists by the sign, which is activated by inductive loops on the cycling approach plus a push button option at the crossing.

Figure 25: Active warning sign at Ngauranga interchange, SH 2, Wellington (Photo: NZTA)

In situations where a bridge or other pinch point is short and sight-lines are reasonable, cyclists could be directed to wait for a gap in traffic before riding through the pinch point. For example, a block of green coloured surfacing in the shoulder with a cycle symbol and an adjacent hold-rail could be located immediately before the pinch point, with a message on the hold-rail stating, 'LOOK FOR GAP IN TRAFFIC'.

Reducing the motor vehicle speed limit can also mitigate the effect of on-road pinch points although this requires a thorough technical and legal process. It may be suitable on some rural roads where traffic operating speeds are already well below the 100km/h rural limit, and an 80km/h limit may also be more appropriate for motor vehicle (as well as cyclist) safety. Another option is an advisory speed sign with a lower speed limit when cyclists are present (see Figure 26). This would be particularly useful at longer narrow bridges or pinch points where it would be difficult for a cyclist to pick a gap in traffic without holding up motor traffic. See further guidance on speeds in Section 3.3.

Figure 26: Example of an advisory speed sign on a narrow State Highway bridge, Hurunui

While 'chokes' may be used on off-road trails (as outlined in Appendices 3A to 3E – 'Sight distances and visibility') pinch points should not purposefully be designed into on-road trails as this will put cyclists into danger from motor vehicles.

3.11 Markings and delineation

Markings and delineations for on-road cycle trails and road shoulders should be designed according to the *Traffic Control Devices (TCD) Manual.* This includes specifications for line styles, cycle logos, application of coloured surfacing and intersection treatments. It also has advice on raised reflective pavement markers (RRPMs) and audio-tactile profile (ATP) markings.

The *TCD Manual Part 5* (Traffic control devices for general use – between intersections) provides the latest advice from NZTA *for audio-tactile profile (ATP) markings*; it notes:

- 150mm wide ribs at 250 or 500mm centres should be laid either on or immediately outside of the edge-lines (see Figure 27), depending on the available shoulders.
- Attempt to maintain a 1.0m clear shoulder width outside of ATP wherever possible. This shoulder width needs to be clean, clear and well-maintained. Where a 1.0m shoulder width cannot be achieved then clear reasons for installing the ATP need to be well-documented (includes consideration of cycle use and the crash history). An absolute minimum clear shoulder width of 600mm is required to provide a cycling space outside of ATP.
- If there is only a 300–600mm clear shoulder space, then consider options to widen the shoulder (or narrow the traffic lane).

Otherwise, do not install ATP or consider installing structured ('splatter') edge-line markings.

- If there is less than 300mm shoulder available, then apply the ATP entirely in the shoulder.
- The minimum acceptable clear shoulder dimensions for use with ATP should be increased where necessary to account for steep gradients, steep edge drop-offs, or proximity to safety barriers.
- Gaps should be left in ATP markings in the presence of gravel driveways, notable shoulder width changes, cycleway crossing points, or sudden changes in forward sight distance.

Figure 27: Example of audio-tactile profile (ATP) markings outside an edge-line

- Ideally, maintain a 3.35m minimum clear traffic lane between any centreline and edge-line ATPs.
- Edge-line ribs are to be stopped well in advance (preferably 30m minimum) of any shoulder narrowing, bridge structures, intersections etc.
- It is strongly recommended that consultation is undertaken with local cycle groups where ATP is being laid, particularly when the shoulder width is less than 1m. This will also help to determine the cycle frequency on these corridors and whether or not ATP should be laid.

More extensive advice on path markings can be found in NZTA's best practice guidance note *Signs and Markings to Designate Paths for Pedestrians and Cyclists* (NZTA, 2019b) and *Path Behaviour Markings Guidance* (NZTA, 2021).

4 Crossings and intersections

4.1 Introduction

For the purposes of this guide, a 'crossing' is a junction between an off-road cycle path and a road. An 'intersection' is either a junction between two off-road cycle trails or a junction between two roads (one or both of which may accommodate an NZCT on-road cycle trail). Crossings are the most common form of junction on the NZCT, and designers should aim to eliminate user conflict where these crossings are required.

'At-grade' crossings are the most common crossing type, where cyclists cross the road surface. More expensive crossings are 'grade-separated', where the cycle path is at a different elevation to the road, as in a bridge or underpass.

In practice, gravel roads have relatively low traffic volumes and cycle crossings are fairly easy for adult cyclists, so long as good visibility exists.

4.2 Crossings

4.2.1 'Uncontrolled' crossings

Uncontrolled (i.e. without 'Stop' or 'Give Way' signs, or other traffic controls) crossings of roads by cycle trails are best avoided, even if the traffic volumes are low (under 1,000 vehicles per day) and visibility is good. Some trails, for example in forests, have poor visibility of approaching road crossings and may thus need to be controlled, even when traffic volumes are low.

4.2.2 'Stop' or 'Give Way' crossings

At 'Stop' or 'Give Way' crossings, cyclists on the trail will either have to give way to traffic on the intersecting road or vice versa. The situation where cyclists have to give way gives the lowest level of service to riders. Yet 'Stop' and 'Give Way' crossings are likely to be common given that they involve low costs whilst generally providing adequate safety levels and levels of service.

Median islands will be required at some 'Stop' or 'Give Way' crossings where the road traffic volume is too high to provide sufficient opportunities for cyclists to cross the entire road in one movement. They will also be required at some 'Stop' or 'Give Way' crossings where high traffic speeds may make it difficult to judge a gap in both directions of traffic. Median islands allow riders to cross half of the road then wait in safety at the centre for a gap in the traffic on the other side of the road. The median should include a cycle holding rail to aid cyclists waiting in the median.

Median islands should be designed to allow cyclists ample room to wait at the centre of the road. Designers may consider using a group of five riders as the design standard; this will mean there is also ample room for tandem cycles or cyclists towing trailers.

Additional treatments may also be required to ensure cyclists are aware of the presence of opposing traffic and their obligations to give way. Some international cyclists (especially continental Europeans) will be unfamiliar with this arrangement as in some countries it is uncommon for roads to have priority over major cycle paths. Therefore, it is important that the message is clear. Treatments where users of off-road trails must give way to traffic on intersecting roads, especially where traffic speeds and/or volumes are high, should include:

- a change in path alignment leading up to the crossing that requires cyclists to slow down (i.e. combination of curves of decreasing radii)
- ‘Give Way’ (or ‘Stop’) signs and limit lines
- adequate inter-visibility between cyclists and motorists.

Treatments may also include:

- a change in path surface texture and/or colour
- introduction of a centreline on path approaches to separate directional flows
- chicanes to slow path users on the approach to a crossing
- kerb extensions on the road to reduce the crossing distance.

Paths should cross roads at right angles (90°) to minimise the crossing distance and ensure appropriate visibility in each direction.

In most cases it will not be necessary to force cyclists to dismount at a crossing. If there is sufficient visibility, then cyclists should be given the opportunity to ride across a crossing. However, in some circumstances (for example, at the bottom of downhill slopes) riders may not easily judge the safety implications and the trail design should require them to slow down to check for motor vehicles. This can be done by providing bollards, grade reversals or curves on the crossing approaches.

The case of a crossing where road users must give way to trail users will be rare in urban areas and is not recommended on roads with speed limits over 50km/h, as motorists will have difficulty seeing cyclists about to cross in sufficient time to stop. If designers are considering this type of crossing for a rural road, preference should be given to providing ‘grade separation’ (a bridge or underpass).

If the trail has priority over the road (by requiring motorists to give way or stop at the trail crossing), cyclists have a better level of service (theoretically they will face no delay) but the crossing may have compliance and therefore safety issues. This treatment is likely to be acceptable only if the cycle volume using the trail is comparable to (or higher than) the volume of motor vehicles on the road. The *Cycling Network Guidance* (NZTA) section on unsignalised crossings outlines the required treatment for a ‘dual cycle priority/zebra crossing’ where road users are required to give way to cyclists and pedestrians. This involves a zebra crossing with an adjacent, green-surfaced cycle crossing on a platform, ‘Give Way’ signs and markings for approaching traffic plus a supplementary plate ‘to pedestrians and cyclists’, and the option of a general information sign ‘watch for traffic’ for cyclists.

The frequency of use of the crossing by cyclists is also an important factor in considering giving a trail priority over a road at a crossing.

Like zebra crossings for pedestrians, crossings where the trail has priority over the road are likely to have poor motorist compliance if they have a low rate of use.

4.2.3 Signalised crossings

Signalised crossings may be safer than 'Give Way' or 'Stop' crossings in some locations. However, signalised crossings should not be used in locations with speed limits greater than 80km/h because of the high risk and potential severity of crashes if signals are not complied with at these speeds. Signalised crossings are therefore not appropriate for a large number of NZCT road crossings.

In rural settings, even where speed limits are 80km/h or less, traffic signals may be inconsistent with surrounding intersection controls and thus may take drivers by surprise, which can result in poor compliance. Signals in rural locations require a high degree of conspicuousness. There is a danger that low numbers of trail users at signalised crossings will result in motorists becoming 'conditioned' to green lights and not stop when they (rarely) receive a red light to allow users to cross.

Signalised crossings will be most appropriate in or near large urban areas, where motorists are used to experiencing traffic signals and the surrounding infrastructure supports their installation. In these circumstances, signalised crossings can improve the level of service for cycling, especially in situations with high traffic volumes that would offer few gaps for crossing opportunities under a scenario where road users have priority. Cyclists can be detected by inductive loops positioned prior to the crossing so that the crossing phase can be called as they arrive. A good example of this is seen on Christchurch's Railway Cycleway, as illustrated in Figure 28.

Alternatively, a push button arrangement or inductive loop detector can be provided for cyclists at the crossing location. Advanced detection via inductive loops is recommended but it is also advisable to provide detection at the crossing as a back-up.

Figure 28: Advance cycle detection for signals, Railway Cycleway, Christchurch

The *Cycling Network Guidance* (NZTA) has a section on signalised crossings, as well as extensive guidance on providing for cycling at signalised intersections in general.

4.2.4 Grade-separated crossings

Grade separation (bridges or underpasses) are useful techniques for crossing busy or high-speed roads but they are expensive. Most crossings of the NZCT will be 'at-grade' (i.e. cyclists and motorists share the same surface), but in some circumstances grade separation can be justified.

Grade separation can take two main forms:

- underpass for cyclists
- overpass (or bridge) for cyclists.

Underpasses for cyclists require less vertical deviation than overpasses due to the height required for overpasses to clear large trucks. Cyclists also generally prefer the geometric characteristics of underpasses as they can gain momentum on the initial downward slope, which aids in climbing the subsequent upwards slope. In contrast, overpasses require riders to first cycle uphill.

Recent advances in design and installation of stock underpasses can be applied to providing cost-effective underpasses for cycling. However, underpasses may be more expensive to construct than overpasses if the water table is high. If flooding is not an issue, there may be opportunities to convert existing culverts into trail underpasses.

Security issues are more prevalent for underpasses than overpasses. Underpasses should have clear visibility from end to end and on the approaches. It may be necessary to provide lighting within the underpass. Provision of ample width is also important so that cyclists feel comfortable, and shy space due to the walls is accounted for (see Appendices 3A to 3E – 'Horizontal clearances').

If an NZCT route is intended to provide for commuter cyclists in urban settings it is important that the deviation imposed on cyclists is minimised, otherwise riders may choose to forgo the route and cross the road at-grade. This is less important for cycle tourists who are generally willing to travel longer distances for the sake of the journey and favour safety over directness. What is more important for those cyclists is the gradient of the slopes involved in a structure. Section 3.4 gives more guidance on suitable gradients for isolated sections such as underpasses and overpasses as well as the trail generally.

Figure 29: Otago Central Rail Trail underpass (Photo: courtesy of OCRT Trust)

The structural design aspects of bridges and underpasses are discussed further in Appendices 3A to 3E.

4.3 Selection of crossing type

When determining the type of crossing provision, the following factors should be taken into account:

- traffic volumes
- proportion of heavy vehicles
- speed environment
- inter-visibility
- crossing distances (width of road)
- surrounding environment (e.g. urban/rural)
- crossing provision at other nearby locations along the trail and intersection controls along the road.

Figure 30 shows the suggested crossing types for trails according to various combinations of traffic volume and speed limit. This should be applied to Grade 1 and 2 trails in particular. New crossings for Grade 3–5 uses will have to be designed on a case-by-case basis. The appropriateness of the treatments shown in Figure 30 may vary with site-specific factors, especially those listed above. The boundaries between the various treatments are not rigidly defined and a 10% tolerance either side is considered acceptable. The minimum level of provision possible for an NZCT crossing is to have 'Give Way' signs on the trail approaches without any additional treatments.

Figure 30 does not include the situation where road traffic must give way to cyclists. These situations will be uncommon and should only occur in locations where the speed limit is 50km/h or less and cycle volumes are equal to or greater than motor vehicle volumes and there are at least 50 cyclists per hour in the peak hour of traffic each day, throughout the year.

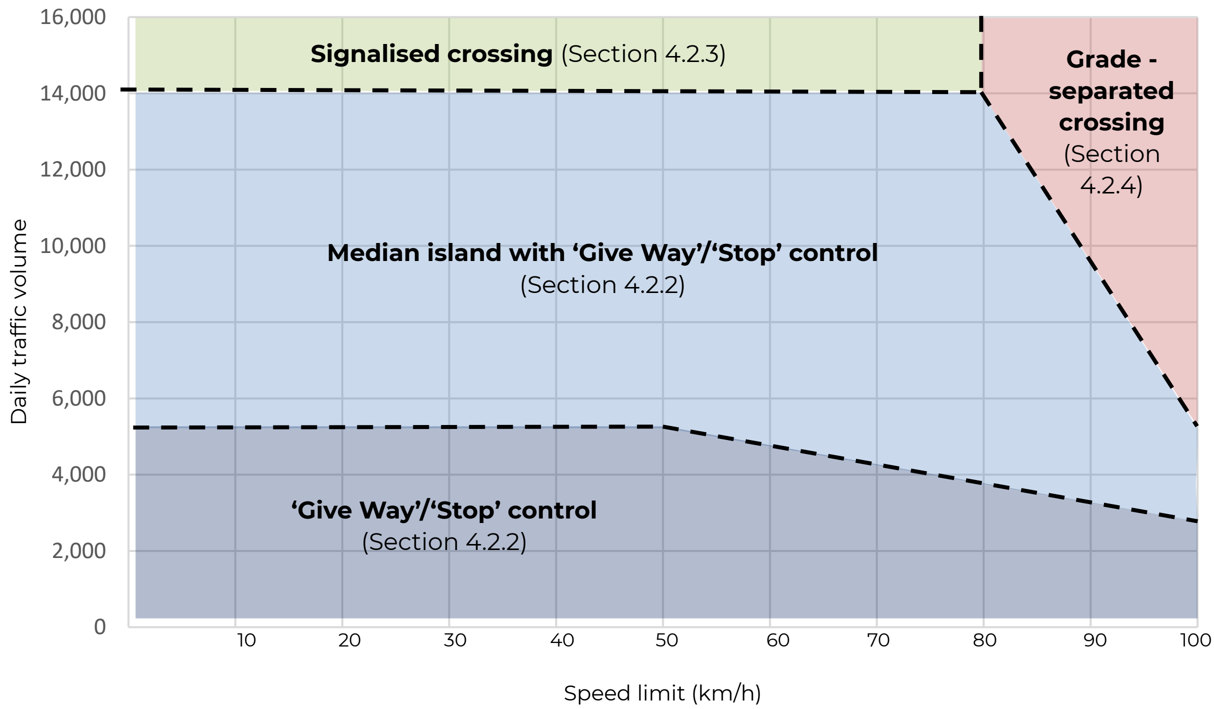


Figure 30: Crossing types (for Grade 1 and 2 trails)

Notes:

- A 10% tolerance either side of the boundaries shown can be used.
- Speed limit is specified; however, if the operating speed is known, the 85th percentile speed should be used instead.
- The maximum crossing distance to a median island is 4.5m at up to 60km/h; 5.0m at 80km/h and 5.5m at 100km/h.

4.4 On-road intersections

Where cyclists remain on-road at intersections, the markings and delineations should be designed according to the links given in the *Cycling Network Guidance* (NZTA, 2019a).

The type of crossing provision will be governed by the motor vehicle interactions on the intersecting roads and therefore on-road NZCT routes are likely to have intersections controlled by 'Give Way' or 'Stop' signs (the route may have priority over, or may have to give way to, the intersecting road traffic) or by traffic signals. Small roundabouts are also acceptable, but intersections with high volume or multi-lane roundabouts should be avoided for NZCT routes unless a cycle bypass is provided.

It may be necessary to provide separate cycle facilities at the intersection, for example creating an off-road section that takes cyclists around the corner of the intersection and provides a midblock crossing facility with median island or grade separation.

Where cycle trails are on a road that does not have priority over an intersecting road, the guidelines outlined in Section 4.2.1 for off-road trails also apply.

On-road cycle facilities at signalised intersections include advanced stop boxes, advanced stop lines, hook turn boxes and dedicated signals for cyclists. Design of these facilities is detailed in the *Cycling Network Guidance* (NZTA) and in the *Traffic Control Devices (TCD) Manual Part 4*.

4.5 Path intersections

The key consideration for intersections between off-road trails is inter-visibility between users. Even for rural paths with low volumes there will be situations where users approach the intersection from each path simultaneously. If they have sufficient warning of each other, they can adjust their paths and negotiate the intersection safely. There is usually no need to specify which path must give way, but this may be a useful treatment for paths with higher volumes and particularly poor visibility. Figure 31 shows an example of a path with poor inter-visibility between the approaches; this is compounded by the slope of the bridge, which will increase cycling approach speeds at the intersection.

Figure 31: Poor inter-visibility at path intersection – Auckland

4.6Railway crossings

KiwiRail has strict requirements regarding whether level railway crossings may be installed, and how they must be designed – these are detailed in the *Design Guidance for Pedestrian and Cycle Rail Crossings* (KiwiRail, 2017).

Key points:

- The provision of new level crossings is strongly discouraged. Generally, a new level crossing cannot be installed across the rail corridor unless a level crossing of equivalent (or worse) risk is closed elsewhere.
- All proposals for new or modified level crossings must undergo a Level Crossing Safety Impact Assessment (LCSIA), which is outlined in the *Level Crossing Risk Assessment Guidance* (KiwiRail, 2022).
- Level crossings should be designed according to the safe system principles – acknowledging that humans make mistakes, humans are vulnerable, and a shared responsibility is required.
- It is important to consider site factors such as whether motor traffic is also involved, sight distances and visibility, gradients, crossing angle, number of train tracks etc.
- Grade separation is the preferred treatment. If the crossing must be at-grade, treatments (in order of decreasing effectiveness and cost) are: automatic barriers; audible and visual warning (flashing lights and bells); physical calming (e.g. chicanes or mazes on the approaches); and simple passive control (signs and markings only). Layout details for all treatments can be found in KiwiRail (2019).
- Level crossings on the NZCT are often in rural locations, with low train volumes and few crossing users; therefore, crossings involving physical calming or simple passive control may be acceptable.

Figure 32: Level crossing, Clutha Gold Trail (Photo: Janet Purdey)

Some trails on roads cross railway lines on bridges. If road traffic volumes are low (fewer than 1,000 vehicles per day), cyclists may be able to share the bridge comfortably and safely with motor vehicles if adequate visibility and width exist. Refer to Section 3.10 regarding treatment of pinch points.

Where road crossings carry higher traffic volumes, separation from motor vehicles should be considered by providing a separate, off-road at-grade crossing or by providing clip-on bridges alongside the main bridge.

Separation from motor vehicles will be especially important if the trail is Grade 1 or 2. Many existing rail over-bridges have inadequate width for safe cycling (see Figure 33).

Figure 33: Many railway over-bridges have inadequate shoulder width and may require clip-on bridges on each side for cycling safety (Photo: Jonathan Kennett)

5 Structural Design

5.1 NZ Handbook for Tracks and Outdoor Visitor Structures (HB 8630)

This section is designed to supplement the *New Zealand Handbook for Tracks and Outdoor Visitor Structures* – SNZ HB 8630:2004 (Standards NZ, 2004a; hereafter referred to as 'HB 8630'), which is due to be updated in the near future. The Department of Conservation (DOC) was a major player in the development of this Standards New Zealand document.

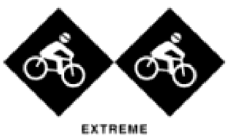
HB 8630 is intended for off-road trails only and therefore should generally not be applied to on-road structures for cyclists. Structural design for on-road structures (including 'clip- on' paths to road bridges) should follow the standard for design for access and mobility, NZS 4121:2001 (Standards New Zealand, 2001); structural design standard, AS/NZS 1170 (Standards NZ, 2004b); and the NZTA (2013) *Bridge Manual* with geometric features of cycle trails and facilities (such as dimensions and gradients) designed according to the *Cycling Aspects of Austroads* (Austroads, 2017) and the *Cycling Network Guidance* (NZTA, 2019a).

HB 8630 was developed principally for walking tracks and, while it mentions cycling as an allowable activity in some circumstances, it is not written primarily for cyclists. Some of the advice is inappropriate for cycling trails and the purpose of this section is to clarify when HB 8630 can be used and when other guidance is required.

Six track classifications are used in HB 8630 for six[1] 'visitor groups' (also referred to as 'user groups'). They describe the various abilities and motivations of track users. A useful summary of HB 8630's various track classifications and their design specifications is given in Table 6.

[1] There is also a seventh visitor group, 'Overnighters' ('ON') presented in HB 8630. This group includes both domestic and international visitors and local community visitors seeking an overnight experience in a predominantly natural setting. For the purposes of HB 8630 the DV (day visitors) category is used for ON visitors and ON itself does not feature in subsequent design tables. Therefore the ON category is not used for NZCT route design.

Table 6: Relationship of NZCT off-road Grades to HB 8630 track classes and visitor groups NZCT Grade

NZCT Grade	Equivalent HB 8630 User Group and Track Classification	HB 8630 Visitor Group	Reasoning / comments
1. 	2. Short walk	SST	Easiest non-urban category in HB 8630. All watercourses bridged. NZCT route distances will be longer than those suggested in HB 8630.
2. 	3. Walking track	DV	Similar experience level. Similar steps between adjacent categories.
3. 	4. Great walk/ easy tramping track	BCC	Similar experience level. Moderate exertion levels. Similar steps between adjacent categories.
4. 	5. Tramping track	BCA	Similar experience level. Considerable exertion levels. HB 8630 specifies some tramping tracks may be unformed – unlikely for NZCT trails.
5. 			
6. 	6. Route	RS	HB 8630 specifies routes as unformed – may be appropriate for extreme NZCT trails.

5.2 Bridges and boardwalks

5.2.1 General requirements

The majority of bridges on the NZCT will be short (i.e. 10m long or less) and be made from timber or steel. Swing and suspension bridges (Appendices 3A to 3E – 'Bridges and boardwalks') are typically cost effective only for longer spans.

The widths specified for structures in HB 8630 are generally inadequate for cycle paths and should not be used. They are too narrow in many cases to allow any but the most skilled riders to cycle across, and they are also too narrow to comfortably walk across beside a bicycle. If bridges are too narrow, cyclists may need to unload their bikes of panniers and luggage and do multiple trips across a bridge to continue their journey.

Figure 34: Manuherikia Bridge, Otago Central Rail Trail (Photo: DOC)

Six important considerations for bridges and boardwalks are:

- width
- handrails
- passing/viewing bays
- vertical clearance
- drainage
- skid resistance.

5.3 Cattle stops

5.3.1 Design

Cattle stops are generally short structures, used instead of gates in farm fences. Bars of 30mm galvanised pipe are recommended for a cattle stop 1.4m wide, with a central (longitudinal) support. To achieve a wider structure either stronger bars or more internal supports are required. The bars should be placed with a 70mm gap between bars (i.e. at 100mm centres). The length of the structure should be at least 2.2m to ensure stock will not jump over it. Details for a cattle stop are shown in Figure 35.

Handrails should be used on all cattle stops on the NZCT. These aid cycling safety by protecting riders against falling off the cattle stop and onto the adjacent fence or into the ditch below. It also prevents stock from jumping diagonally across the cattle stop from one paddock to the next, at the gap in the fence.

Cattle stops should be raised 200mm above ground level. This ensures there is a pit below the bars and reduces the risk of sediment or debris from building up to the level of the bars, which would render the cattle stop useless. The pit should be at least 400mm deep below the bars and the bars should be removable to allow the pit to be cleaned. The pit can include an internal ramp that provides an exit opportunity for hedgehogs or other wildlife that may walk into them.

An approach ramp should also be used to provide a smooth approach to the cattle stop deck and to provide an additional visual obstacle to stock, discouraging them from attempting to walk over the cattle stop. Approach ramps, however, should be relatively flat and meet the level of the cattle stop deck without an abrupt step. Ramps can be constructed out of timber or compacted trail material. The design should ensure that ponding does not occur at the bases of the ramps as this will lead to pot-holes and undesirable path damage.

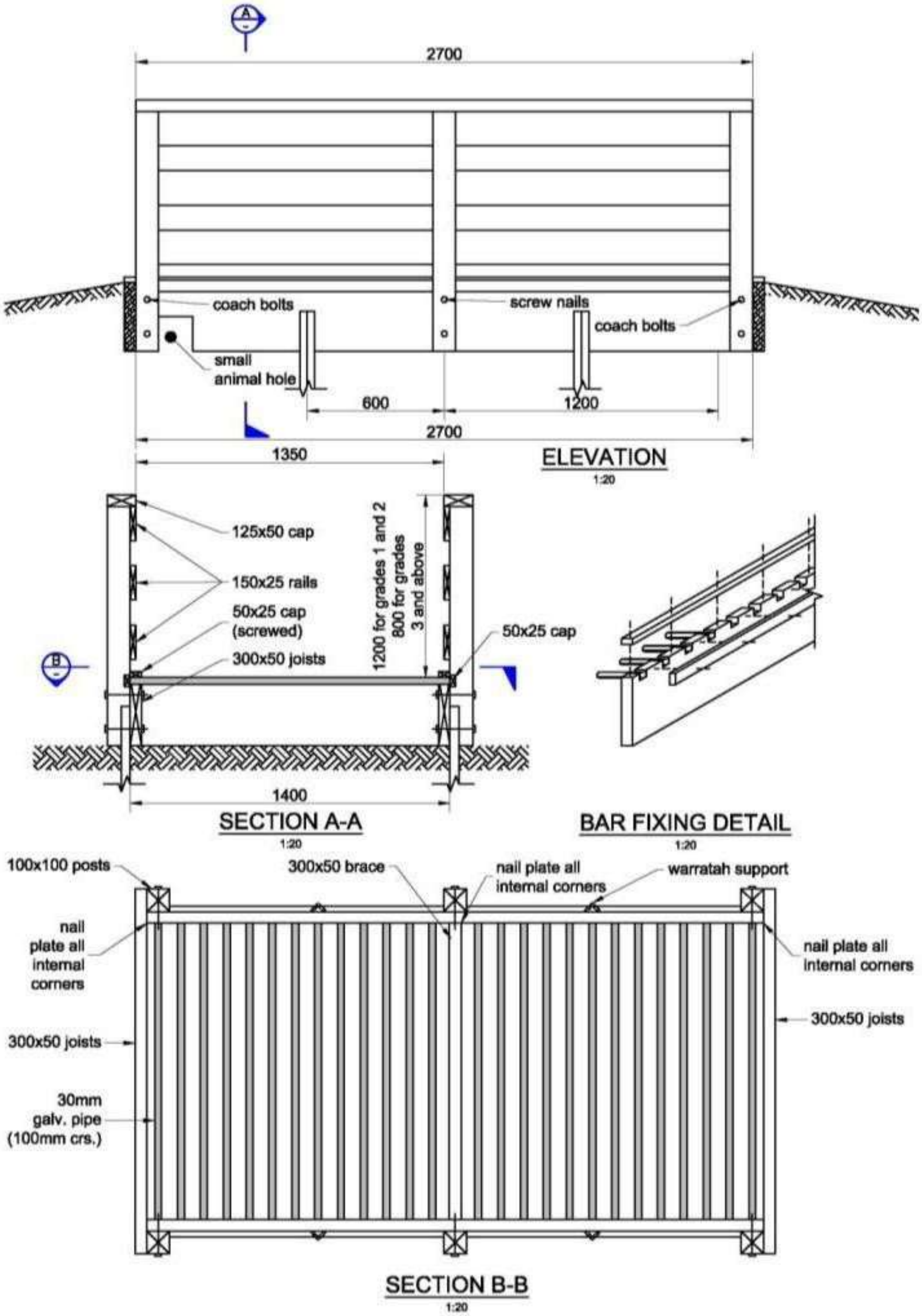


Figure 35: Cattle stop design – plan view (note that width can reduce on higher Grade trails to as little as 0.9m)

5.3.2 Positioning

The position of a cattle stop relative to the track is important. If a cattle stop is placed on a straight section of track, it is possible for stock (sheep or cattle) to get agitated and achieve enough speed to jump over the cattle stop. Figure 36 shows an example of a cattle stop extending beyond a straight section of track. This is undesirable due to the risk of stock jumping the cattle stop and is compounded by the cattle stop being at ground level. Figure 37 shows a method taken to remove this risk after the cattle stop was installed – a gate placed at one end of the cattle stop. It is undesirable to use a gate in conjunction with a cattle stop as this requires cyclists to stop to open the gate.

This defeats the purpose of the cattle stop, which is to allow cyclists to ride through a fence without having to stop. It also negates the need for a cattle stop as a gate alone would suffice to manage stock.

Figure 36: Cattle stop placed on straight alignment of track

Figure 37: Gate added – a poor solution for cycling

It is better, therefore, to place a cattle stop on a bend in the track. This makes the path less obvious to stock and prevents them from achieving a high enough speed to jump over the stop. Obviously, the bend should not be so severe that it forces cyclists to stop or causes any safety issues. Figure 38 shows a correctly aligned cattle stop (which could be improved by fixing the rut on the approach ramp) and Figure 39 shows the standard cattle stop used for the Otago Central Rail Trail (which is level with the path).

Figure 38: Cattle stop with good alignment, Port Hills (Photo: Nick Singleton)

Figure 39: Best practice cattle stop, Otago Central Rail Trail (Photo: DOC)

Cattle stops should not be placed in areas where stock gather (for example near the corner of a paddock) otherwise it is possible that an animal will be stampeded onto the cattle stop.

Figure 40 shows how motorcycle access can be discouraged from a trail. This solution will somewhat inconvenience cyclists and prevent access by wheelchair users and wider prams.

Figure 40: A central post and wing barriers help prevent motorcycle access and reduce the likelihood of stock jumping the cattle stop, but hinder accessibility for cyclists with adapted bikes or panniers (Photo: Jonathan Kennett)

5.3.3 Gates instead of cattle stops

Cattle stops are much more convenient than gates for cyclists, as they don't need to be opened or closed. In some situations, however, gates may be required or preferred by trail designers or landowners.

A double gate system, such as that shown in Figure 41, provides extra security to prevent stock from moving between paddocks but is less convenient for cyclists.

Figure 41: Double gate, Waikato River Trail

Springs can be attached to standard gates to make them 'self-closing'. This lessens the demand on cyclists to unlock the gate and lock it again after passing through and can be favoured by farmers worried about their stock getting through a gate accidentally left unlocked. Thus, for a variety of reasons, cattle stops are generally the preferred solution.

5.4 Tunnels and underpasses

Tunnels and underpasses should comply with Section 4.2.4 and their gradients should match the requirements for the trail as specified in Sections 2.3 and 3.4. The trail Grade (which relates to target market) and length should be considered when determining the tunnel width. A longer tunnel feels more confined and is more likely to involve users passing each other than a shorter tunnel. The minimum recommended width of tunnels on trails of Grade 1 or 2 is 2.0m but for trails of Grade 3 to Grade 5, the bridge widths given in Appendices 3A to 3E may not be sufficient, and designers should consider the full cycle operating space shown in the Appendices. The ideal minimum height is 2.4m and the absolute minimum height is 2.0m.

Drainage is an important consideration for tunnels and underpasses, especially when they fall below the existing ground level. The water table level should be identified with respect to the planned underpass level; if the underpass is to be lower than the water table level water will need to be pumped out from the underpass. It is also important that surface water run-off is properly diverted so that it does not collect at the bottom of the underpass without any way of draining.

Lighting may be required if an underpass does not receive enough natural light for cyclists to adequately distinguish the path, other trail users or obstacles. It may be impractical to provide a powered lighting source in a remote location and thus cyclists should be informed prior to starting on the track that they will need bicycle or head lights. If path lighting is provided it should be vandal resistant and powered by a reliable source.

Figure 42: Tunnel on the Hauraki Rail Trail (Photo: Jonathan Kennett)

5.5 Retaining walls

Retaining walls may be required on paths cut into a sloped section to reinforce the path or prevent the adjacent wall from caving onto the path.

Retaining walls should be designed to withstand the combination of loads that they are likely to experience during construction or alteration and throughout their lives. Some timber suppliers provide generic timber wall details; however, if the site conditions differ from the generic design, then a suitably qualified person should provide further advice.

Key items for consideration are:

- walls over 1.5m in height require a building consent
- walls of any height where there is surcharge (whether that be sloped backfill, traffic, etc), are to be designed by a suitably qualified person and will require building consent
- barriers may be required depending on the fall height
- depending on the location some retaining walls may require a resource consent
- stainless fixings should be used for exterior applications where the fixings are in contact with CuAz and ACQ treated timbers.

Further advice can be found at BRANZ or SESOC.

5.6 Other issues

5.6.1 Gradients and crossfall

Structures should preferably be 0–5% in gradient with a maximum of 9%. Structures may have a gentle crossfall (up to 3.5%), to assist with drainage, but may often be easier to construct without crossfall.

5.6.2 Visibility

The visibility requirements outlined in Appendices 3A to 3E also apply to structures. These requirements will have particular ramifications for underpasses, tunnels or bridges with high enclosed walls, which may obscure views on crooked or curved path alignments. Safety and personal security are increased by being able to see all the way through an underpass or tunnel before entering. Thus, there are benefits in having straight alignments for underpasses or tunnels.

5.6.3 Steps

Steps should not be used on cycle trails. Steps require cyclists to dismount and carry their bikes (plus any panniers and other luggage). They can pose a serious hazard to cyclists travelling downhill in particular, especially if encountered unexpectedly.

If steps already exist on a trail, or must be installed on a new trail because the terrain is too difficult to avoid using them, they should have a 'roll board' (narrow ramp) on both sides so that people can wheel their bikes up or down.

5.6.4 Accessibility

On-road and off-road trails may be used by cyclists with disabilities, using a range of equipment that may differ in size from a bicycle. These include:

- tricycles (recumbent and upright)
- tandem bicycles
- hand cycles (recumbent and upright)
- e-bikes
- wheelchair tandems
- wheelchair clip-ons
- cargo bicycles and tricycles
- cycle trailers
- bicycles with stabiliser wheels.

Further guidance on making cycle trails inclusive can be found in NZTA's *Accessible cycling infrastructure: Design guidance note* and in Appendices 3A to 3E ('Grade design information for contractors').

5.6.4.1 Trail barrier remediation

Unless there is a well-documented and informed health and safety concern or issue to address on your trail, barrier removal should be a priority.

Gates and barrier structures along trails should not be a barrier to access for trail users. However, preventing motorcycles and other prohibited vehicles from accessing trails is difficult when trying to accommodate possible legitimate trail users. Meeting the needs of those with modified cycles or cycles with child trailers, adaptive equipment, and parents with prams, as well as not creating hazards for people who are blind or vision impaired, may be a challenge, but requires consideration.

Recreation Aotearoa is working with the Outdoor Accessibility Working Group, supported by the University of Canterbury's Dept. of Mechanical Engineering, to develop a decision-making-matrix to support more effective decision making about the use of barriers and access control mechanisms on trails.

Removing barriers to trail accessibility requires consideration of the following.

- Is the barrier necessary?
- What other control mechanisms could be used?
- Implement the Least Restrictive Access principle – aim to achieve the most accessible option, or the least restrictive option for a specific feature, such as a gate or barrier.

5.6.4.2 Existing barrier structures

Bollards and concrete blocks

Bollards and concrete blocks should have **at least a 1.7m** clear width between adjacent bollards and no linking chain or rope of any kind between bollards. They should be clearly marked with a visible colour paint, with lighting or a reflector band around the top. They should also either be no more than 700mm high (below handlebar height) or alternatively at least 1.5m high (clearly above handlebar height).

Chicane gates, croquet hoops and squeeze gates

If you have identified that you **must** have a croquet hoop, or squeeze gate, traditional specifications have been modified, in consultation with local trail users, to be made more accessible. See Appendices 3A to 3E ('Grade design information for contractors') for specific design requirements.

Notifying trail users of barriers and limitations

Things trail users will want to know ahead of time include the following.

- Where is the barrier on the trail?
- What does it look like? Can a photo or diagram be included on the trail map and website?
- What are the dimensions of the barrier? What equipment can fit through?

- Are there alternate entrances, such as nearby gates which can be unlocked, that users can arrange ahead of time?

5.6.4.3 Trail accessibility

Physical restrictions have historically been used as path end or 'terminal' treatments at ends of trails to indicate approaching transition to on-road trails or roads without cycle provisions and to prevent motor vehicles from accessing the paths. However, these should not be seen as the default treatment. Many trails will operate very well without them. See Appendices 3A to 3E for further information on path end treatments.

6 Signage

6.1 General signage principles

A comprehensive signage regime is required to make the NZCT successful.

A sign's size and level of information should be designed in accordance with the level of information that can be taken in by its viewer, given their travel speed and viewing distance. Providing too much information may serve as a distraction and therefore be a hazard to the intended audience as well as surrounding road or path users. Conversely, it is sometimes necessary to convey a large amount of information to ensure route users are properly prepared for their journey. In this case, signs should be placed in a location where viewers can stop and read them without inconveniencing other users.

Thus, there are a variety of sign types that are used on NZCT routes for a number of different purposes.

6.2 Signs for cyclists

6.2.1 Trail head signage

These are used at the start of a route to describe the route's location, distance, expected time for completion and level of difficulty or experience required. Generally, a large sign including at least a map, hazards, grading explanation and branding should be included. It is important that trail head signage clearly indicates the grade of the track, so users are aware of degree of difficulty and/or potential challenges/hazards that may be present. Connections with other nearby routes should be identified. The sign may also include additional information on the features or attractions encountered along the route, facilities provided and opportunities available at its end.

Figure 43: Route commencement sign, Great Lake Trail (Photo: Bike Taupo)

These signs can be used away from a trail to direct users to the start of a trail or used partway along a trail where there are several different route options available. Figure 44 shows an urban wayfinding map example from Nelson that also incorporates information on the development of the walking and cycling networks and the history of cycling in the area.

Figure 44: Nelson cycle and walk map

6.2.2 Information signs

These are used along a route to describe various features, such as iconic scenery, historical attractions, wildlife or other points of interest unique to the route. Generally, these signs will be situated in places where visitors can stop and take time to view them. There is an important balance between providing interesting information and providing too much information that takes too long to read. Pictures and diagrams are a useful way of making educational signs more interesting and grabbing the attention of route users.

Figure 45: Information sign, Waikato River Trail

Figure 46: Information sign in shelter, Otago Central Rail Trail (Photo: DOC)

Figure 47: Information sign, The Timber Trail (Photo: Jonathan Kennett)

Information signs can also be used to teach cycling techniques. This is particularly relevant to mountain biking tracks, which tend to have various features that require technical expertise to ride effectively. Special tracks can be created that involve several mountain biking features and have an information sign at the start of each one explaining to cyclists how to best negotiate the feature.

6.2.3 Wayfinding signs

These are used along a route to specify the route alignment when faced with a variety of options at an intersection or to confirm to riders that they are still on the route.

As well as specifying the route name, directional signs may direct cyclists to a particular location. Once a location has been indicated on a sign, all subsequent signs should include it until the location has been reached. Major locations such as towns, cities or important iconic features should be signposted for a greater distance than less important locations.

It is useful to include travel distances to the signposted locations. This gives people an idea of how long they will have to travel to reach the destination and makes it easier to plan the journey. Cyclists can feel like they are 'out in the middle of nowhere' and knowing how far it is until the next stop gives them peace of mind and improves their experience. Often it is the last hour that makes or breaks a cyclist's impression of the entire journey; route information can go a long way in making this impression a favourable one.

Directional signs should be installed prior to a trail's opening so that users do not get lost.

It may be useful to also specify on a directional sign the amount of time expected for cyclists to take; however, designers should be aware that cycling travel speeds vary greatly according to rider ability and the demands of the route. For longer trips, cyclists will also stop for breaks, which increase the total travel time.

Generally, it is best to predict travel times for a novice or less energetic cyclist, unless the route is specifically aimed at riders of higher abilities. The timing measures should be consistent throughout a trail so that individual users can gauge whether they are generally faster or slower than the stated times. A travel speed of 10km/h is generally appropriate for slower cyclists travelling on a relatively flat route, but additional time is needed if riders are likely to take breaks or look at scenery, for example. However, it may be best to wait until the route has been established and monitor the journey times of route users to determine what values should be added to the directional signs.

Users should generally not have to stop to view a directional sign, consider the information it gives and make any necessary resulting decisions or actions. Therefore, the information presented should be kept as simple as possible, with lettering legible from an appropriate distance.

Figure 48 shows a simple NZCT route marker that can be used along a route to confirm to users that they are still on the route. Where multiple routes exist in an area the marker should specify which route it belongs to; this can take the form of a route name, logo or specific colour. Figure 49 indicates the trail direction on the Waikato River Trail.

Figure 50 is a good example of a directional sign that provides route length information; specifications for these signs can be found on NZTA's *CNG* website.

NZTA provides some examples of how wayfinding signs should be located at key direction change points along a trail.

Figure 48: NZCT route marker

Figure 49: Directional sign, Wilderness Trail

Figure 50: Directional sign, Nelson Rail Reserve

6.2.4 Regulatory signs

Regulatory signs are used to convey the rules of the road or path on which the route is located. They include 'Stop', 'Give Way' and speed limit signs, which apply to both cyclists and motorists (both being legally 'vehicles').

There are also regulatory signs that apply only to cyclists such as 'no cycling' (RG-24 – shown in Figure 51), 'all cyclists must exit' (RG-26b – shown in Figure 52) and path signs that apply to pedestrians also and specify whether the path is shared, segregated or separate. These signs are detailed in the *Traffic Control Devices (TCD) Manual*[2]. The *Cycling Network Guidance* (NZTA) also gives advice on where such signs should be applied.

As of June 2019, a change to the *Traffic Control Devices Rule* enables road controlling authorities to identify shared paths with markings only (instead of signs) where appropriate[3].

Figure 51 'No cycling' regulatory sign – R5-1 (TCD Rule)

Figure 52: 'All cyclists must exit' regulatory sign –R5-6 (TCD Rule)

Cyclists may be exempted from rules that apply to generally traffic by adding the R3-5.2 (TCD Rule) 'Except Cycles' sign to another regulatory sign, e.g. a one-way sign or a no entry sign.

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[2] Sign layout details can be found at NZTA's Sign Specifications webpage: https://www.nzta.govt.nz/resources/traffic-control-devices-manual/sign-specifications/

[3] Best practice guidance can be found at: https://www.nzta.govt.nz/resources/signs-and-markings- to-designate-paths-for-pedestrians-and-cyclists/

Figure 53: R3-5.2 (TCD Rule) 'Except Cycles' sign

There is a new 'no exit' sign exempting cyclists and pedestrians, AJ11A (TCD Rule A40-1.1) shown in Figure 54.

Figure 54: AJ11A (TCD Rule) 'No exit except pedestrians and cyclists' sign

Figure 55 shows a regulatory sign used at the Arapuni swing bridge on the Waikato River Trail. This sign also includes an informational aspect – historical facts about the swing bridge's construction.

Figure 55: Regulatory sign, Waikato River Trail

6.2.5 Advisory signs

Advisory signs emphasise aspects that are not regulated but are suggested for safety or courtesy reasons. They include warning signs at dangerous locations (e.g. road crossings) (Figure 56) and behavioural signs (e.g. 'keep left', 'warn when approaching'). The 'hook turn' sign (Figure 57) can now be used at signalised intersections to help cyclists turn right in two stages – more information is given in the *Cycling Network Guidance* (NZTA). The 'NZ Cycle Trail route' sign (Figure 58) is now included in the *Traffic Control Devices (TCD) Rule*.

Figure 56: AU2L 'Cross here with care' sign (TCD rule)

Figure 57: A43-5 (TCD Rule) 'Hook turn' sign (TCD rule)

Figure 58: A43-4 'New Zealand Cycle Trail' sign (TCD rule)

Where riders need to cross the road, the A43-7 sign (TCD rule) can be used (Figure 59).

Figure 59: A43-7 'Cyclists watch for traffic' sign (TCD rule)

Figure 60 gives two examples of advisory signs on the Nelson Rail Reserve path – one to advise of the low underpass (note that NZCT underpasses should have an overhead clearance of 2.4m, as discussed in Section 4.2.4), and the other to warn that the path may be submerged due to tidal flows.

Figure 60: Advisory signs, Nelson Coastal Route

Landowners may also require signs voiding them of responsibility in case of accident, warning of the presence of stock, or advising that water is unsafe for drinking.

6.3 Signs for motorists

NZCT signs for motorists are largely regulatory or advisory. There are also some signs directing those accessing routes by vehicle to the start of the route; these should be designed according to NZTA's *Traffic Control Devices Manual*[4]; in particular, Part 2 on guide signs.

The most common sign for motorists regarding cycle trails is the W16-7 (TCD Rule) 'cyclist' permanent warning sign PW-35 (NZTA, 2008) as illustrated in Figure 61. This is used at on-road locations where cyclists may be present but do not have dedicated cycle lanes or other provisions. It can also be used in the form of an active warning sign, which is illuminated when cyclists are present, as shown in Section 3.10. A variation (W16-7.1 in the TCD Rule) can be used to draw motorists' attention to a NZCT trail road crossing location. Supplementary warning sign 'merging' (Figure 62) can be used under a 'cyclists' warning sign at the end of a cycle path/lane/shoulder, where riders need to move into a narrow traffic lane. Another

[4] https://www.nzta.govt.nz/resources/traffic-control-devices-manual/

supplementary sign, 'crossing' (Figure 63) can be used with W16-7 to help drivers to expect riders crossing the road.

Approaching pinch points (such as narrow bridges) on popular cycling routes, a W16-10 advisory speed sign can be used to suggest a lower travel speed when cyclists are present (see Section 3.10).

Figure 61: W16-7 (TCD Rule) - permanent warning sign for motorists

Figure 62: W16-7.2 (TCD Rule) 'merging' supplementary sign for W16-7

Figure 63: W16-7.3 (TCD Rule) 'crossing' supplementary sign for W16-7

Figure 64: W16-7.1 (TCD Rule) 'Cycle path – crossing' permanent warning sign for motorists

Some regulatory signs are also directed primarily at motorists. These include the 'cycle lane' (RG-26 – shown in Figure 65) and 'cycles only' (RG-26a – shown in Figure 66) signs used for on-road applications.

Figure 65: 'Cycle Lane' regulatory sign R4-9 (TCD Rule)

Figure 66: 'Cycles only' regulatory sign R4-9.1 (TCD Rule)

Supplementary 'to cyclists' and 'to pedestrians & cyclists' signs can be added to 'Give Way' signs to inform motorists to give way to path users (see Figure 67).

Figure 67: Supplementary 'to cyclists' plate on give way sign at midblock priority cycle crossing, Uni-Cycle route, Christchurch

Safe passing behaviour by motorists when around cyclists is critical, and signs reminding drivers of this can used in locations where there is limited shoulder space or sight distance.

Although not currently a legal requirement, signs are available (see Figure 68) suggesting a 1.5m gap when passing riders (another version is also available without a distance specified, which may be more relevant for lower speed environments). Historically, more generic 'share the road' signs have also been used, but it is recommended that the newer 'pass safely' signs be installed instead.

Figure 68: Pass safely sign (A43-6B TCD Rule)

Figure 69: 'Share the Road' sign, near Tekapo

6.4 Maps and supplementary information

Maps and supplementary information leaflets can be provided to assist cyclists in planning their journey and for reference along the route. These give riders additional confidence as they can carry maps with them, rather than having to wait to encounter a directional or information sign. Maps should be accurate and consistent with the signage used. Ideally, they will be specific to the NZCT.

All publicity for a particular NZCT route should be consistent and accurately convey the level of experience and fitness required to ride the route, as described in the Grades referred to in Sections 2.2 and 3.2. It is important to provide an indication of how long to allow for each leg of the journey. Service providers may be tempted to encourage anyone and everyone to ride the route, but this may not always be appropriate. If a cyclist has a bad experience because their fitness and competence levels did not match the demands of the trail, it will decrease the likelihood of them, or those they talk to, of returning to a NZCT route and may tarnish the NZCT brand. It may be useful to provide an example of a fitness test or training programme so that potential users can gauge a route's suitability, plan the legs of their journey appropriately, or prepare physically for the ride.

Maps and leaflets should provide accessibility information wherever possible, for example, trails that can be used by mobility trikes.

Maps can include information regarding the attractions at towns and cities along the routes. Local businesses may sponsor their production as an advertising opportunity.

Any information necessary for the journey should be provided freely to all cyclists using the route. Brochures involving supplementary, non-critical information may be charged for.

The guidelines for signage and the use of the New Zealand Cycle Trail brand (MBIE, 2012) include further guidance on maps and supplementary information.

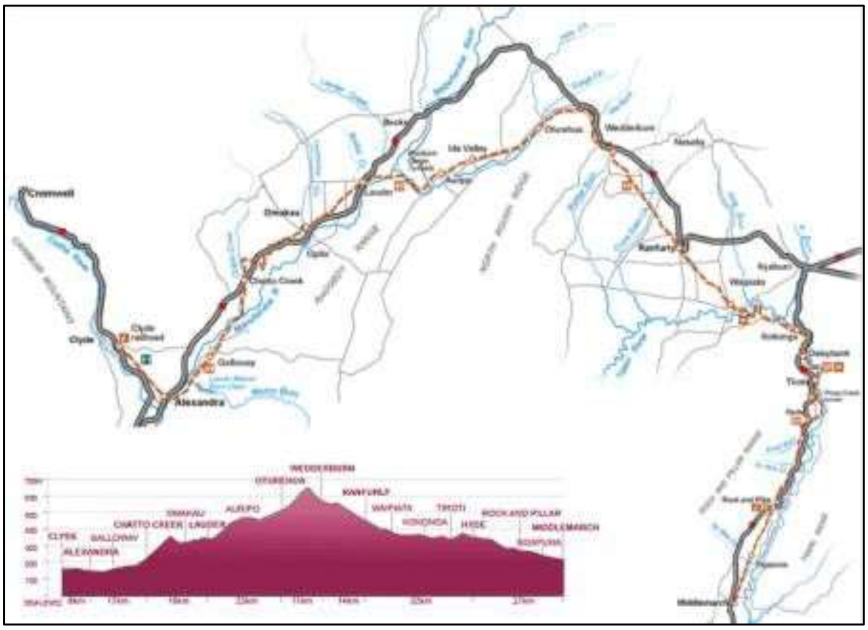


Figure 70: Otago Central Rail Trail map (Image: courtesy of OCRT Trust)

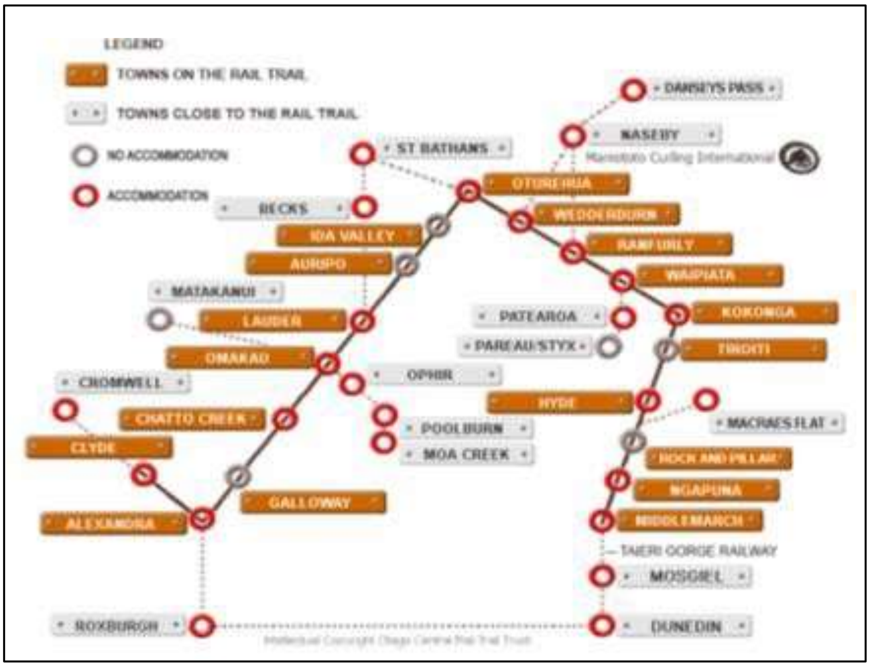


Figure 71: OCRT interactive online map (courtesy of OCRT Trust)

Maps are also a useful tool for pre-planning and understanding journeys. Cyclists are increasingly using technology to obtain trail information. Electronic media, such as Trail websites, provide a useful interface to include additional information, for example the Otago Central Rail Trail interactive online map (Figure 71) that has links to information on each of the towns and attractions encountered along the trail; contrast this with the more traditional topographic map of the route (Figure 70). Trail descriptions developed on the hosts' websites can be referenced from the Ministry of Business, Innovation and Employment (MBIE) and other websites.

Trail information provided to Great Rides can also be downloaded from the Great Rides app (free to download and install from the App Store or Google Play). The app is a useful way of providing updated trail information to users. Once a trail is downloaded it can work offline to track position along the trail using a phone's GPS.

7 Supporting facilities

7.1 Water supplies

Cyclists need sufficient opportunities to replenish their water supplies while riding. A shortage of water can have extreme effects on a trail user's enjoyment of the journey and opinion of the NZCT experience.

At least one intermediate water station should be provided during a day's travel (see Sections 2.2 and 3.2, for travel distances) and clear information should be given at the start of each leg regarding water supply. Taps or drinking fountains should be provided where there is no access *en route* to potable water. Drinking fountains should include water bottle fill stations as it can be difficult to fill bottles from standard water fountains.

If the only available source is a non-potable water supply (e.g. a rainwater supply at a shelter), then users should be clearly advised of safe treatment requirements. Otherwise, they run the risk of illness from drinking water contaminated by the likes of giardia and Escherichia coli (*E.coli*). DOC and many local councils have standard wording and signs for warning about these situations; seek their advice.

7.2 Rest areas

Providing rest areas along a route allows cyclists to stop, rest and enjoy the route's iconic scenery. In some locations, especially on remote routes, rest areas may allow for camping and thus facilities for cooking and toilets may be considered.

Toilet opportunities should be provided according to Table 7. Designers should err on the side of over-provision rather than the opposite.

Table 7: Toilet provision

Grade	Distance between toilet facilities
1–2	7.5–10km
3–6	15–20km

It can also be useful to provide opportunities for shelter from heat, rain or wind along a route. The Otago Central Rail Trail uses old 'gangers' sheds' or railway stations, which provide shelter in an authentic and aesthetically pleasing way.

Where mains power is available or can easily be brought to the rest area, providing and sign-posting a standard outdoor 220V power point will be appreciated by trail users who need to boost the charge on their phone or e-bike. A solar powered installation could also be an option for charging low-powered devices such as phones.

Figure 72: Shelter on Otago Central Rail Trail (Photo: DOC)

Clearings and sheltered places for refreshment and lunch breaks are appreciated too. These could include picnic tables and toilets, as for roadside picnic areas. Opportunities for shade under existing or newly planted trees are also valuable and contribute to users' overall impressions of the trail. Trail users may wish to meet up with non-cycling companions (who may be walking part of the trail or simply visiting the region) and therefore value rest areas near road access.

Figure 73: Volunteer built hut on the Old Ghost Road (Photo: Jonathan Kennett)

7.3 Lighting

The rural, remote nature of most NZCT routes makes it difficult and cost-prohibitive to provide lighting along their lengths. In most cases visitors ride in daylight hours only.

However, it is advisable to provide lighting in locations where routes link to towns or cities if paths have low natural surveillance and little lighting gained from nearby sources (e.g. road lighting).

Lighting will generally be impractical in tunnels (for example, refer to Figure 74, but opportunities for techniques for improving visibility in tunnels are provided in Section 5.4.) Solar-powered installations may provide lighting power for remote sites.

Figure 74: Cyclists with headlamps in tunnel on Otago Central Rail Trail

7.4 Rubbish collection

It is up to trail operators to determine whether they want to provide and service rubbish bins along the trail or whether they will require users to carry all rubbish out with them. The first option may be more expensive but could possibly decrease the chance of litter along the trail. Either way, appropriate signage and forewarning will be required to properly communicate to users their responsibilities with regards to rubbish disposal.

7.5 Car-parking facilities and transport links

It is helpful for trails to start and finish near towns so that cyclists have access to accommodation, shops and service facilities. Many riders will drive to the trails and require somewhere to park their cars, preferably in a location with natural surveillance from nearby shops or houses. Other cyclists will rely on shuttle or bus services to drop them off and thus car parking areas should include locations for buses to park and manoeuvre.

In addition, some trail users will arrive or leave by cycle and so roads accessing trails should be safe for cycling.

It can also be advantageous to provide links with other transport modes. For example, it is popular among users of the Otago Central Rail Trail to journey on the train that runs between the Middlemarch end of the trail and Dunedin.

7.6 Off-site facilities

Cyclists travelling on NZCT routes and staying overnight along the way expect various services and provisions at their stops. Most of these requirements are satisfied by private business operators, but it can be useful for route designers to explain the various needs of cyclists to local businesses and accommodation providers to ensure that trail users are catered for from the route's launch.

Cyclists expect that their bicycles will be safely and securely stored during their stay when they are not riding. At smaller locations a simple bike stand will be sufficient to achieve this. In larger towns or cities, covered, secure parking will be preferred.

Cyclists also often need to purchase supplies and services for their trip, for example food, drink and bicycle maintenance and accessories.

7.7 Bicycle parking

Good bike parking, in sufficient quantities, is necessary at stops along a trail. Monitoring of peak cycling demands (see Appendices 3A to 3E – 'Data collection') should be used to determine the amount of parking that should be provided.

A cycle stand should:

1. support the cycle frame, not only the wheel, with more than one point of contact
2. be secure in the ground and enable secure locking of the wheels and frame
3. be safe for all users and cycles (i.e. no sharp edges or obstructions)
4. work for many types of cycles, including e-bikes, mobility trikes, children's cycles
5. work for users of all ages and abilities (i.e. not requiring strength or height to use)
6. look and work like cycle parking, while still allowing for artistic options.

Typically, simple inverted hoop-style parking (e.g. 'Sheffield stands') is preferred to meet these criteria (see Figure 75); 'slot' stands that only support a single wheel are typically poor at properly holding and securing the whole bike and may not be compatible with all types of tyres (e.g. 'fat bikes').

Figure 75: Hoop-style bike parking at the end of the Little River Rail Trail

The Transport Agency's *Cycling Network Guidance* (NZTA) has a Technical Note on 'Cycle parking planning and design' that outlines best practice principles and goes into more detail regarding design styles and stand placement.

8 Trail and road maintenance

8.1 Introduction

The maintenance requirements for NZCT routes are highly site-specific and depend on a number of factors including the type of surface used, geographical features, weather conditions (especially rainfall), conditions of motor vehicle access and user volumes. Therefore, this chapter aims to identify maintenance considerations but does not specify associated frequencies or costs for these items.

Regular maintenance makes trails more sustainable. A proactive approach in recognising and diagnosing problems and preventing them from recurring, rather than repeatedly reacting to problems, saves time and money over the life of a trail. Maintenance issues include:

- the principles of sustainable maintenance
- vegetation maintenance
- drainage system maintenance
- track surface maintenance
- switchback maintenance.

Experience from existing off-road trails, such as the Otago Central Rail Trail and the Little River Rail Trail, testify that the quality of initial construction is a major factor in the amount of ongoing maintenance required. The lowest bidder for new trail construction will not necessarily provide the same quality of workmanship as other contractors; this can be avoided by constructing initial trial sections to determine these specifications and using the experience from these to develop detailed construction specifications. Experienced trail builders (at the grade and quality sought) will also generally be more cost-effective in the long run.

Similarly, good initial route planning will also help to minimise ongoing maintenance issues. For example, appropriate location of trails in relation to rivers and coastlines (to minimise exposure to storm water surges) will reduce the risk of damage and resulting repair work when significant weather events occur.

8.2 Maintaining natural and compacted surfaces

Without maintenance, off-road trails built on natural surfaces will, over a year or two, deteriorate into a harder Grade (e.g. change from Grade 3 to Grade 4). This is mainly due to the forces of compaction and displacement. Compaction is where the centre of the track is worn more frequently than the sides and thus sinks. Displacement is where material from the centre of the track is moved out to the sides. Both of these processes are due to people riding and walking along the centre of the track and both result in the development of a ‘dish’ profile where the centre of the track is lower than the sides.

The problems of compaction and displacement can all be reduced, but not eliminated, through good trail design and construction (e.g. building a trail with a crowned profile, adding grade reversals, ensuring good drainage and plate compacting the surface, etc.).

Displacement also exposes rocks and roots at the surface. These apparently growing rocks and roots need to be dug out or covered with compacted base course. In the case of roots, it is generally better to cover them as they actually do a very good job of providing a type of 'armouring' that stops ruts from forming. Also, some trees can die after having roots removed.

Water is the foremost destroyer of natural and compacted surfaces; it magnifies the problems of compaction and displacement by moving loosened material and wearing away at weak areas. Thus, the level of drainage provided and its interaction with the path's geometry will have a big effect on the amount of material displacement and therefore the amount of maintenance required.

Trails in locations with high rainfall will generally require more maintenance than trails in low rainfall areas. The best time to inspect tracks for drainage issues is during rain. At this time, it is apparent where the water is coming from, and it can be directed off the track at strategic locations.

Motor vehicle access has a major influence on path stability. While none of the NZCT paths have public vehicle access, some motor vehicles do still travel over them. These can be service vehicles related to path maintenance or adjacent facilities (e.g. railway trucks or farm vehicles on private farm roads). Vehicle access to paths should be minimised and restricted to smaller vehicles wherever possible. Heavy vehicles damage pavements much more than light vehicles.

On a natural surface trail, the ruts and berms that develop will need to be removed. A good way of doing this is to completely fill the central riding rut with a suitable base course. The rut should be overfilled by up to 100mm and then compacted using a plate compactor.

If it is not practical to have base course delivered to site, then it may be possible to quarry some from beside the track in places. If on-site quarrying is not practical, then the berms (high sides) of the track should be dug out to below the level of the centre of the track. It may be tempting to use the removed material to fill the centre rut, but this will not last long, as the material from the sides is lacking in strength.

8.3 Maintaining hard surfaces

Hard surfaces (such as asphaltic concrete) are more durable than natural or compacted surfaces and thus require less maintenance. However, underlying vegetation and tree roots can grow and damage asphaltic concrete surfaces, and measures to prevent such occurrences should be taken during construction. Figure 76 shows a newly constructed asphaltic concrete path that was not properly prepared and now (within weeks of construction) has vegetation growing through its surface. Hard surfaces will also require regular sweeping of detritus that may come from the sides of the path, nearby roads or intersecting gravel driveways.

Figure 76: Vegetation growing through new asphaltic concrete path; good construction specifications and contract supervision are required

Sealed paths may have painted markings that will require remarking.

The *Specification for Design, Construction and Maintenance of Cycling and Shared Path Facilities* (NZTA, 2018) details maintenance requirements for sealed cycling facilities.

While on-road trails should be maintained according to existing road maintenance contracts, the specific maintenance requirements of new cycle trails may need to be written into maintenance contracts. Road debris often accumulates in cycle lanes or wide shoulders as it is pushed off the carriageway by passing motor vehicles; this can decrease the riding comfort to cyclists and increase the likelihood of punctures. Regular sweeping of on-road trails is required, and it is imperative that contractors do not sweep debris into the space dedicated for cycling.

Road re-seals should include consideration of on-road cycling trails, in particular that a smooth riding surface is maintained. Where active warning signs are used, inductive loop sensors may need to be replaced during a reseal and the equipment recalibrated afterwards to ensure it still works correctly.

8.4 Common maintenance requirements for all trail types

Trails need to be well maintained if they are to keep bringing people back and to encourage users to recommend the trails to others.

All trails will require upkeep of adjacent verges or vegetation. At least twice a year (during spring and autumn) vegetation growing into the riding corridor may need removing. Invasive weeds such as *tradescantia*, gorse, barberry and African clubmoss will need to be sprayed twice a year, to stop them from growing into the riding line and spreading down the track.

After storms, trails should be inspected for fallen trees and branches, and culverts and table drains may need clearing. The sooner this is done the better as a blocked culvert or table drain can send water onto the track, and in some cases a blocked culvert can result in major soil saturation and a land slip.

Signage will also need replacing, either due to vandalism, exposure to the elements or to include new information.

Wherever an off-road trail crosses a road, and a bollard or similar threshold treatment is used it should be expected that motor vehicle damage to this treatment will occur periodically. At-grade road crossing facilities are particularly exposed to motor vehicle damage and are likely to require higher frequencies of maintenance than grade-separated facilities.

8.5 Quality control

MBIE introduced a dual quality control assessment process over the 2019/20 financial year that includes a physical trail audit against the *NZCT Design Guide* and the current 'Warrant of Fitness' system. All NZCT-branded Great Rides are currently required to undertake an annual Warrant of Fitness (WOF) report.

Typically, a WOF will assess the existing state of the entire trail, noting any challenges to maintaining the quality of the route, and proposing any required improvements or other major works. The WOF also assesses the user experience regarding marketing, signage and interpretation, etc. Finally, the WOF assesses the trail's governance, as a lack of governance capability is often the reason a trail fails to perform in all other areas.

9 Monitoring and evaluation

9.1 Importance of data collection

NZCT are targeted at cycle tourists (both domestic and international). It is expected that these cyclists will stay in local towns and cities and spend money on various goods, services and additional tourist attractions. This will stimulate the local economy and warrant the initial investment in developing the route, and can be especially beneficial in small towns. Thus, the viability of a cycle route depends on the number of people using it.

Monitoring a cycle route by collecting accurate data about the cyclists using it is essentially an exercise in understanding the route better. Understanding how a route functions allows operators to manage and improve it.

Obviously, a route cannot be monitored before it is built and thus the business case for establishing an NZCT route should be based on predictions of cycle volumes. By monitoring the actual numbers of cyclists who then go on to use the route, the prediction methods can be refined. Thus, monitoring is important to inform those developing other trails and to the government for future funding decisions.

The data collected on a particular route will also be of great use to the route owner itself. Data can show seasonal trends and thus be used in preparing local accommodation, services and goods providers so that the level of demand is appropriately supplied each season. Maintenance requirements can be better understood by comparing the amount of wear on a trail with the amount of use it has been subjected to. This in turn can help in choosing the appropriate surfacing treatments and major maintenance opportunities.

9.2 Monitoring and data collection methods

Three main methods may be used to collect NZCT data:

- automatic counters
- manual counters
- surveys.

Automatic counters are machines that, once installed and correctly set up, can count cyclists without requiring human assistance. This is advantageous as automatic counters can provide continuous data over long periods. However, they are effectively a 'blind' technology that can count numbers of cyclists and possibly give information on speed and direction, but cannot give additional information on cyclist gender, age or cycle type, for example.

Manual counters are people who record volumes of cyclists passing a site. Manual counts offer more flexibility in terms of data coverage as people can record supplementary information such as cyclist gender, age, cycle type, trip type. Manual counting can be used to substantiate automatic counter data.

Figure 77: Manual cycle counting

The disadvantage of manual counting is that it is difficult to sustain for long periods. A single person counting will require regular breaks (say every two hours) for food and toilet stops and should only be expected to work a standard shift per day. To conduct a week-long, continuous manual count, several staff working in shifts would be required – a prohibitively expensive process.

Surveys can be conducted on the spot, by using manual counters stationed on the route interviewing users as they pass by, or local businesspeople interviewing those who come into their shop or accommodation. Surveys can also be conducted after cyclists have completed their route by asking them to fill out a form and mail it back or to complete an online form.

Surveys can be used to interview cyclists and extract information on their home town and country, length of stay, trip origins and destinations, demographic data (such as age, employment status and income), expenditure and their impressions of the trail(s) travelled. Surveys can also be targeted at local business owners to determine the effect of the route on their business operations.

References

- Austroads (2017). *Cycling Aspects of Austroads Guides*. Austroads Inc, Sydney, Australia. https://austroads.com.au/publications/traffic-management/ap-g88-17
- Austroads (2021). *Guide to Road Design Part 3: Geometric Design*. Austroads Inc. Sydney, Australia. https://austroads.com.au/publications/road-design/agrd03
- Austroads (2021). *Guide to Road Design Part 6A: Paths for Walking and Cycling*. Austroads Inc. Sydney, Australia. https://austroads.com.au/publications/road-design/agrd06a
- Austroads (2023). *Guide to Road Design Part 4: Intersections and Crossings: General*. Austroads Inc. Sydney, Australia. https://austroads.com.au/publications/road-design/agrd04
- Department of Conservation (DOC) (2008). *Track Construction and Maintenance Guidelines – VC 1672*. DOC, Wellington, New Zealand. https://doc.govt.nz/globalassets/documents/about-doc/role/policies-and-plans/track-construction-maintenance-guidelines.pdf
- Department of Conservation (DOC) (2010). *New Zealand Coastal Policy Statement*. Nov 2010. https://www.doc.govt.nz/globalassets/documents/conservation/marine-and-coastal/coastal-management/nz-coastal-policy-statement-2010.pdf
- International Mountain Bicycling Association (IMBA) (2004). *Trail Solutions: IMBA's Guide to Building Sweet Singletrack*. IMBA, Boulder, Colorado, USA. Order: www.imba.com/resource/trail-solutions
- KiwiRail (2017). *Design Guidance for Pedestrian & Cycle Rail Crossings* (Version 2). KiwiRail, Wellington, New Zealand. Available: https://www.kiwirail.co.nz/how-can-we-help/level-crossings/new-crossings/
- KiwiRail (2022). *Level Crossing Risk Assessment Guidance*. Version 5, KiwiRail, Wellington, New Zealand. Available: https://www.kiwirail.co.nz/assets/Uploads/documents/Level-Crossing-Risk-Assessment-Guidance.pdf
- Ministry for the Environment (MfE) (2017). *Adapting to Climate Change in New Zealand: Stocktake Report from the Climate Change Adaptation Technical Working Group.* Wellington. https://environment.govt.nz/publications/adapting-to-climate-change-in-new-zealand-stocktake-report-from-the-climate-change-adaptation-technical-working-group/
- Ministry for the Environment (MfE) (2018). *Climate Change Projections for New Zealand: Atmosphere Projections Based on Simulations from the IPCC Fifth Assessment*, 2nd Edition. Wellington: Ministry for the Environment. https://environment.govt.nz/publications/climate-change-projections-for-new-zealand/
- Ministry of Economic Development (MED) (2012), *Guidelines for Signing On-Road Routes*. Draft 1.0, May 2012.

- New Zealand Transport Agency (NZTA) (2008). *Traffic control devices manual*. Wellington, NZ. https://www.nzta.govt.nz/resources/traffic-control-devices-manual/
- New Zealand Transport Agency (NZTA) (2009). *Pedestrian Planning and Design Guide*. Wellington, NZ. Superseded by: https://www.nzta.govt.nz/walking-cycling-and-public-transport/walking/walking-standards-and-guidelines/pedestrian-network-guidance/
- New Zealand Transport Agency (NZTA) (2013). *Bridge Manual*, Third Edition. NZTA, Wellington, New Zealand. https://www.nzta.govt.nz/resources/bridge-manual/
- New Zealand Transport Agency (NZTA) (2016a). *Speed Management Guide*. First Edition, Nov 2016. Replaced by: https://www.nzta.govt.nz/resources/speed-management-guide-road-to-zero-edition/
- New Zealand Transport Agency (NZTA) (2016b). *Sharrow Markings: Best Practice Guidance Note*, Feb 2016. https://www.nzta.govt.nz/resources/sharrow-markings/
- New Zealand Transport Agency (NZTA) (2018). *Specification for Design, Construction and Maintenance of Cycling and Shared Path Facilities*. Online. Available: https://www.nzta.govt.nz/resources/specification-for-design-construction-and-maintenance- of-cycling-and-shared-path-facilities/
- New Zealand Transport Agency (NZTA) (2019a). *Cycling Network Guidance*. Available: www.nzta.govt.nz/cng
- New Zealand Transport Agency (NZTA) (2019b). *Signs and Markings to Designate Paths for Pedestrians and Cyclists*. Online. Available: https://www.nzta.govt.nz/assets/resources/signs-and-markings-to-designate-paths-for-pedestrians-and-cyclists/Signs-and-markings-to-designate-paths-for-pedestrians-and-cyclists-best-practice-guidance-note.pdf
- New Zealand Transport Agency (NZTA) (2021). *Path Behaviour Markings Guidance*. Available: https://www.nzta.govt.nz/assets/resources/path-behaviour-markings/path-behaviour-markings-guidance-note.pdf
- New Zealand Transport Agency (NZTA) (2024). *Accessible cycling infrastructure: Design guidance note*. Available: https://www.nzta.govt.nz/assets/resources/accessible-cycling-infrastructure/accessible-cycling-infrastructure-design-guidance-note-draft.pdf
- Recreation Aotearoa (2018). *New Zealand Mountain Bike Trail Design & Construction Guidelines*. https://www.nzrecreation.org.nz/includes/download.ashx?ID=154625
- Standards New Zealand (2001). *Standard for Design for Access and Mobility*, NZS 4121:2001. Standards New Zealand, Wellington, New Zealand. https://www.standards.govt.nz/shop/nzs-41212001/
- Standards New Zealand (2004a). *New Zealand Handbook for Tracks and Outdoor Visitor Structures, SNZ HB 8630:2004*. Standards New Zealand, Wellington, New Zealand. https://www.standards.govt.nz/shop/snz-hb-86302004/

- Standards NZ (2004b). *Structural Design Actions Set, AS/NZS 1170*. Standards NZ, Wellington, New Zealand.
- Sustrans (2009). *Connect2 and Greenway Design Guide*, Chapter 10: Welcoming Gateways and Links to Destinations. Sustrans, Bristol, UK.
- Sustrans (2014). *Design Manual: Handbook for cycle-friendly design*. Sustrans, Bristol, UK. https://www.academia.edu/32678316/Sustrans_Design_Manual_Handbook_for_cycle_friendly_design
- Tourism Resource Consultants (2009). *The New Zealand Cycleway: Market Research*. Research report prepared for NZ Ministry of Tourism.
- United Nations Intergovernmental Panel on Climate Change (2021). *Sixth Assessment report (AR6)*. https://www.ipcc.ch/assessment-report/ar6/

Appendices

Appendix 1 – Gradient Summary Tables

Gradient summary for off-road trails

Trail Grade	Main uphill gradient range	Steeper slopes up to 100 m long	Steeper slopes up to 10 m long	Maximum Downhill Gradient (up to 100 m long)
1	0–3.5% for 90% of length	3.5–5%	5–7%	7%
2	0–6% for 90% of length	6–8.8%	8.8–10.5%	14%
3	0–8.8% for 90% of length	8.8–12.3%	12.3–17.5%	19.5%
4	0–12.3% for 90% of length	12.3–16%	16–21%	27%
5	0–17.5% for 90% of length	17.5–23%	23–27%	36%

Notes:

1. This table applies to off-road unsealed trails and gravel roads.
2. Maximum downhill gradient applicable only if trail is to be ridden in one direction.
3. IMBA recommends a maximum gradient of 10% (5.7 degrees). Steeper trails will require more maintenance due to increased erosion from skidding tyres and water scour.

Gradient summary for on-road trails (from Table 4, Section 3)

Trail Grade	Main uphill gradient range	Steeper slopes up to 100 m long	Steeper slopes up to 10 m long	Maximum Downhill Gradient (up to 100 m long)
1	0–4.4% for 90% of length	4.4–6%	6–8%	8%
2	0–7% for 90% of length	7–8.8%	8.8–12.3%	12.3%
3	0–10.5% for 90% of length	10.5–14%	14–17.5%	17.5%
4	0–14% for 90% of length	14–17.5%	17.5–23%	23%
5	0–17.5% for 90% of length	17.5–27%	27–32.5%	32.5%

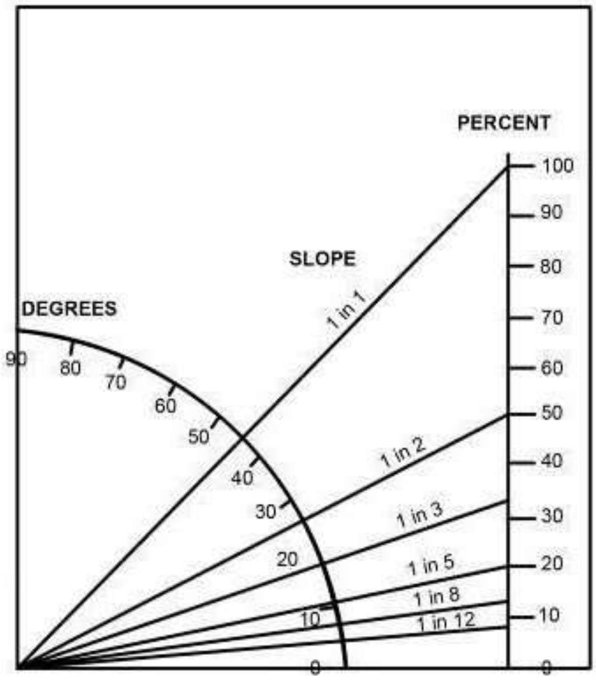
Notes:

1. This table applies to on-road sealed trails and off-road sealed (concrete or asphalt) trails.
2. Maximum downhill gradient applicable only if trail is to be ridden in one direction.

Conversion and relationship between percent, degrees and slope

Percent	Degrees	Slope
1%	0.6°	1:100
2%	1.1°	1:50
3%	1.7°	1:33
4%	2.3°	1:25
5%	2.9°	1:20
6%	3.4°	1:17
8%	4.6°	1:13
10%	5.7°	1:10
12%	7°	1:8
15%	9°	1:7
20%	11°	1:5
30%	17°	1:3

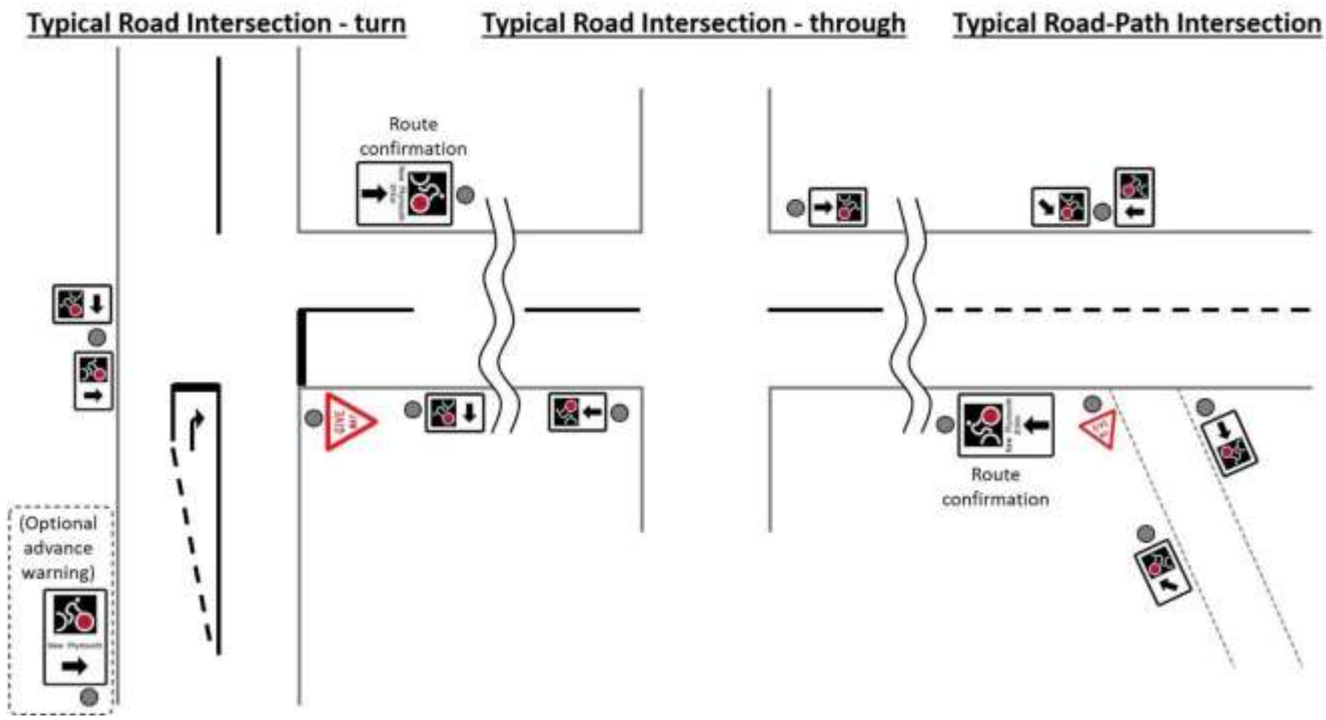
Conversion between degrees, percent and slope

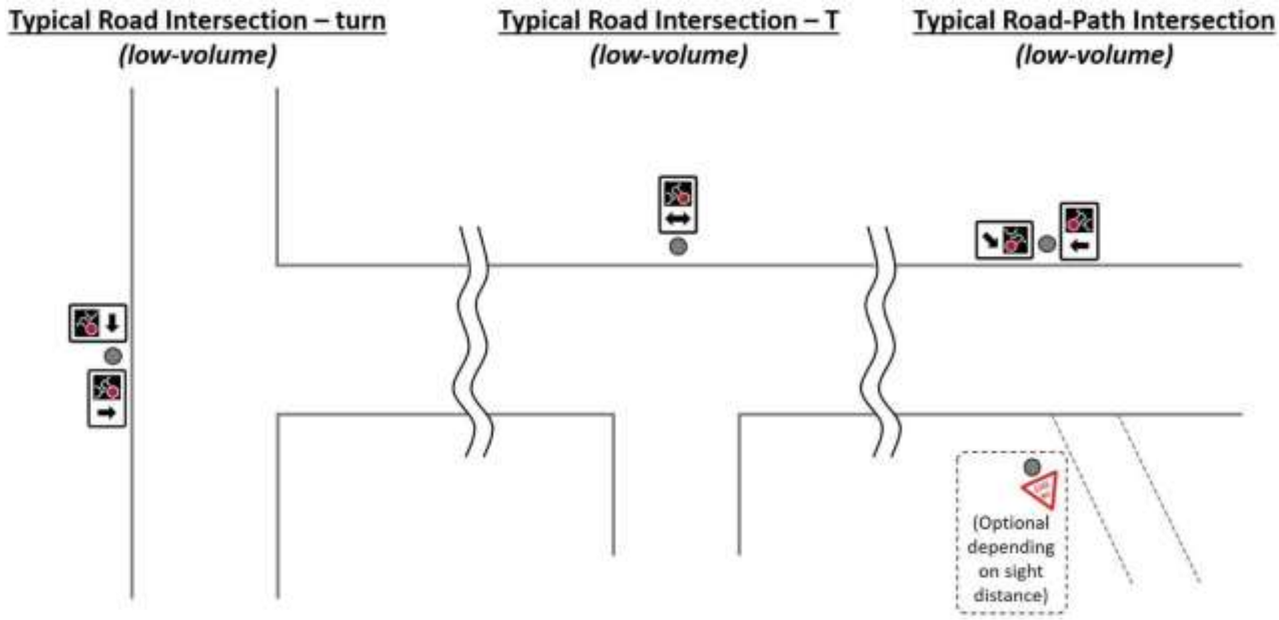


Relationship between degrees, percent and slope

Appendix 2 – Sample Sign Location Layout Plans

The diagrams below indicate suggested layouts for placement of wayfinding signs at key changes of direction or major junctions along a cycle trail. Low-volume options are also provided, where minimal use of signs is preferred. Further guidance can be found in *Guidelines for Signing On-Road Routes* (MBIE, 2012).




Typical Road Intersection – turn
(low-volume)
Typical Road Intersection – T
(low-volume)
Typical Road-Path Intersection
(low-volume)
(Optional depending on sight distance)

Appendix 3 Grade Design Information for Contractors

Appendix 3A Grade 1 design information for contractors

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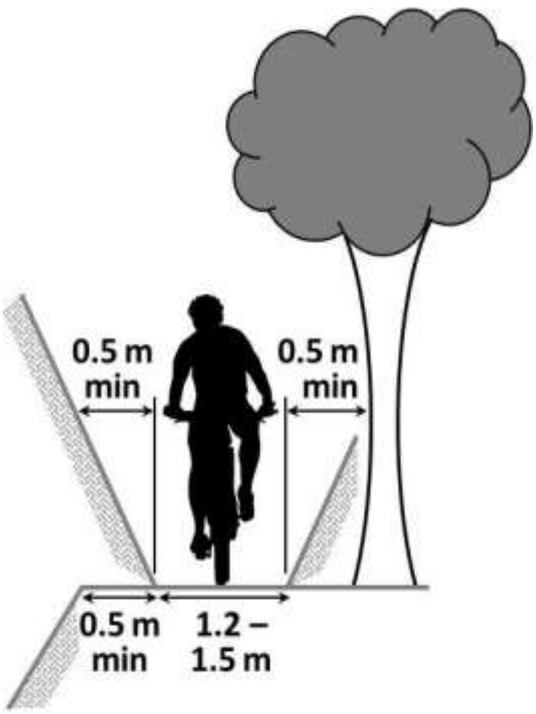
A. Grade 1 (Easiest)

Gradient

- **0–3.5%** for at least 90% of the trail (2 degrees = 3.9% = 1:29)
- **3.5–5%** for steeper slopes up to 100m long
- **5–7%** for steeper slopes up to **10m** long (the less the better)
- Maximum **downhill** gradient **7%**

9.2.1.1 Width

- Double track: **2.5–3.0** metres wide
- Single track: **1.2–1.5** metres wide (with adequate horizontal clearance to drops or banks/trees)



9.2.1.2 Formation

- Mono-slope with **3.5–5%** side slope or crowned surface with **3.5–5%** side slopes

9.2.1.3 Surface

- Compacted top-course aggregate of maximum **AP20mm**

9.2.1.4 Radius of turn

- **6 metre minimum** to outside of turn (the more the better)

9.2.1.5 Grade reversals

- **Required** at dry water courses if they are not bridged or culverted (water courses that normally have water flowing will be bridged or culverted)
- Where appropriate, grade reversals will be large enough to add fun

Grade 1	Grade description
EASIEST	**Description**: Flat, wide, smooth trail. Trail feels safe to ride. Ideal as a first ride for non-cyclists, and those wanting an easy gradient or experience. Trail allows for cyclists to ride two abreast most of the time, and provides a social component to the ride. Cyclists will be able to ride the total distance of the trail without dismounting for obstacles. **Gradient**: 0–3.5% for at least 90% of trail; between 3.5–5% for no more than 100 metres at a time, and between 5–7% for no more than 10m at a time. If the track is designed and promoted to be ridden predominantly in one direction, then the downhills can be steeper (up to 7% for up to 100m). Sealed trails can be steeper (same as the equivalent Grade of on-road trail; see Section 3.4, Table 5). **Width**: 'Double trail' preferred = 2.5m to 4m for 90% of trail, where cyclists may ride side by side. 'Single trail' width of 1.5m, with 1.2m minimum. Horizontal clearances as in Section A2. **Vertical clearance**: Minimum vertical clearance of 2.2m to overhead hazards. A 2.0m vertical clearance may be used for discrete overhead hazards, such as tree branches, or existing structures. **Radius of turn**: 6m minimum to outside of turn. **Sightlines**: Best endeavours must be made to address sightline issues. **Surface**: Compacted/stabilised base course, under a top course aggregate of maximum AP 20mm. The surface shall be smooth and even, and easy to ride in all weather conditions. **Watercourses**: All water courses bridged. **Bridge width:** Recommended bridge width of at least 1.5m, absolute minimum width of 1.2m with handrail/barrier to fall. The approach should be the same width as the structure for 10 metres. **Obstacles**: None. No stiles. Cattle stops should preferably be at least 1.5m wide, and minimum 1.2m wide. **Length**: 3.5–4.5 hours/day (30–50 km/day). **Barriers/guardrails**: Areas such as bluffs or bridges where a fall would result in death or serious harm require handrails.

A1 Gradient requirements for unsealed trails

It is most important that the trail's Grade does not increase more than one Grade over the course of the route. It is acceptable to have short sections of a trail one Grade more difficult than the intended Grade, but it is generally undesirable to have harder sections of trail as some riders are likely to be forced to walk these sections. There is no point building a path that incorporates Grades 2 to Grade 4, as the Grade 4 sections will be impossible to negotiate by those riders whose level of experience and skill is suited for a Grade 2 trail. It will be necessary to improve the Grade 4 sections to Grade 3 standard, or it will not be necessary to build Grade 2 sections, as Grade 3 features will suffice.

Table A1: Gradient requirements for unsealed Grade 1 trails

Trail grade	Main uphill gradient range	Steeper slopes up to 100m long	Steeper slopes up to 10m long	Maximum downhill gradient (up to 100m long)
1	0–3.5% for 90% of length	3.5–5%	5–7%	7%

Notes:

- This table applies to off-road unsealed trails and gravel roads.
- Maximum downhill gradient applicable only if trail is to be ridden in one direction.
- IMBA recommends a maximum gradient of 10% (5.7 degrees). Steeper trails will require more maintenance due to increased erosion from skidding tyres and water scour.

A2 Horizontal clearances

Figure A1 shows the operating space required for cycling. An important aspect of the operating space is the angle between the pedals and handlebars; the handlebars protrude further than the pedals and are more likely to catch on adjacent objects. This is why banks should be 'battered' (i.e. sloped, not vertical) and fences should ideally slope away from the path. This issue is increasingly pertinent as more bikes are sold with wider handlebars (e.g. nearly 800mm).

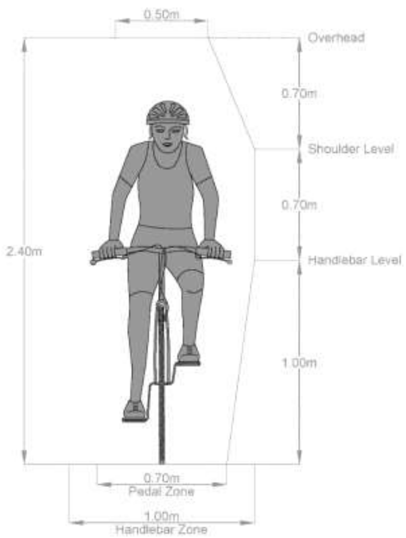


Figure A1: Cycle operating space

When travelling on a lean (for example, when travelling around a banked corner) the location of the cyclist's head and shoulders is also important. Cyclists may hit their heads or shoulders on trees placed too close to the inside of a curve. This can also be a conflict issue between cyclists and pedestrians on banked curves, as cyclists will be leaning while pedestrians are walking upright.

Cycle travel is dynamic. It is difficult to ride exactly in a straight line and less experienced users, in particular, require a fair amount of wriggle room or manoeuvring space.

If a path is restricted horizontally, for example by fences, bridge rails or discrete features such as trees or large rocks, an additional 'shy space' is required. Shy space is needed because cyclists are physically unable to ride on the edge of the path due to their handlebars and pedals extending further than their tyres. Cyclists also need space to allow for a certain amount of wobble and to ensure that they do not need to focus so hard on keeping to the trail that they are unable to appreciate their surroundings. Slower and less experienced cyclists wobble more than faster and more experienced ones.

As it is expected that the majority of cyclists will not choose to ride in the shy space, the clearance does not necessarily need to be constructed from the same materials as the actual path itself. Depending on the context, the shy space could be a grass verge or strip of compacted aggregate. In an urban area, maintenance requirements (e.g. mowing of grass verges) will generally make it more appropriate to create the shy space from the same material as the path. However, in rural areas, there is no point in building a trail right beside a fence as the native ground cover will need no special maintenance.

Horizontal constraints to a path also limit the ability for path users to deviate from the path in extreme circumstances where the path is not wide enough to accommodate all users. Thus, in addition to the path width given in Table A2, further width should be added for situations where at least one side of the path is constrained by adjacent elements. These elements may be either continuous or discrete, and examples are given in Table A2, along with the required clearances.

Table A2: Off-road trail horizontal clearance requirements

Feature Type	Continuous	Discrete
Examples	Fences	Trees
	Walls	Large rocks
	Buildings	Bridge abutments
	Guardrails	Sculptures
	Steep slopes	Power and light poles
	Rock faces	Sign posts
	Parallel drains	Perpendicular drains
	Lakes, rivers and coastlines	
	Hedges	
Recommended clearance each side	1.0m	0.3m
Minimum clearance each side	0.3m	0.15m

Note:

- Extra clearance up to 0.8m is necessary on bends, where cyclists will lean into the corner.
- For example, on a path with fences (i.e. continuous features) on either side, the width between the fences should be the width of the path plus 1.0m. Clearances for continuous or discrete features in Table A2 should be measured at handlebar and shoulder height relative to the path edge.
- If a trail is built on hill with a side slope it is preferable to situate the trail with trees on the downhill side rather than close to the uphill side. This means riders are more likely to naturally keep clear of the drop at the edge of the path.

A3 Pinch points

It may not always be practicable to provide the required width for the entire path length. Large trees, rocks, bluffs, steep cross slopes or other geographic features may produce ‘pinch points’ on a path. These features can be tolerated as long as there is adequate visibility leading to them or advance signage, and safe opportunities for path users to stop before the pinch point and give way to oncoming users or wheel their cycles.

Particular care should be taken to avoid pinch points on Grade 1 paths.

However, pinch points can be specifically incorporated in the design to enhance safety by slowing down cyclists at approaches to hazards such as road crossings or blind corners. These deliberate pinch points are termed 'chokes' and are covered also in Section A6.

A4 Vertical clearances

Refer to Figure A1 for operating space requirements. Overhead hazards can include tree branches, overbridges, tunnel soffits, signs, wires and cables. A minimum vertical clearance of 2.2m to overhead hazards is recommended for all trail Grades. However, a 2.0m vertical clearance may be used for discrete overhead hazards, such as tree branches or existing structures. Users should be advised of such hazards in advance and at the restriction (see Figure A2), and, if necessary, slowed down before reaching the hazard.

Figure A2: Warning sign for a low underpass, Nelson

A5 Trail alignment and shape

When a path must bend or turn a corner there are four main methods that can be used: standard bends, switchbacks, climbing turns and super-elevated ('in-sloped' or 'berm') turns. These are summarised in Table A3.

Table A3: Types of curve

Corner type	Description	Application and notes
Standard bend	The curve and its approaches are on level ground, and no specific treatment is required.	Apply to flat sections of trail. Most common on Grades 1 and 2.
Super-elevated ('in-sloped' or 'bermed') turn	The outer edge of the curve is banked to allow for faster travel around the corner.	Very popular, particularly on Grade 3–5 tracks. Angle of berm depends on the Grade of the track and radius of the corner. More experienced riders enjoy steep berms. Berms enable people to ride around corners easier and faster.
Switchback	The gradient of the path as it turns is flat while the approach and departure to the curve are on sloped sections.	A common method of providing turns on steep terrain, where berms are not easy to build. Also important for shared use trails where high speeds are not desired.
Climbing turn	The curve itself is located on a sloped section of path (which possibly includes super-elevation/a berm).	Can only be applied to gently sloping hills. Much easier to construct but may require more maintenance than switchbacks.

A6 Sight distances and visibility

Path safety depends on users being able to detect a potential hazard and either stop safely before encountering it or manoeuvre safely around it. The required distance is called 'stopping sight distance' (SSD). Good trail building practice and maintenance will endeavour to eliminate blind corners and create good lines of sight.

If visibility is limited around corners it may be necessary to set back vegetation or fences so that cyclists can maintain the appropriate line of sight around the corner. However, it may be difficult to achieve this, and the result might damage the trail's aesthetics. An alternative is to provide two separate trails around a blind corner, with signs advising users to keep to the left (or in some cases, the right), of the trail. Or, if a trail is reasonably wide, 'keep left' signage in itself may be sufficient (or marked arrows and a centreline on a sealed track).

'Chokes' (localised narrowings) or grade reversals can be used to slow cyclists down on approaches to blind corners, intersections or other potentially dangerous locations.

For more experienced mountain bikers, part of the enjoyment comes from the challenge of having to react quickly rather than having plenty of warning before encountering a path feature. This should be balanced with the likelihood of two cyclists (or a cyclist and a walker or jogger) encountering each other head-on without sufficient warning.

In urban areas, visibility of trails by the public is also important for personal safety and security.

The track needs to be built and maintained to the visibility/sightlines assessed as appropriate for the Grade of trail. If the required sightline cannot be practicably achieved for sections of the track due to extenuating circumstances (such as, but not limited to, archaeological, cultural, ecological, geological/geotechnical, landscapes/visual or statutory reasons), then the track must achieve the maximum practicable sightlines, and other treatments and mitigations must be considered and implemented where appropriate.

A7 Fall heights

Decision framework for determining fall treatment

Aspect – Consequence	Key question	Yes/No
Height of fall/slope steepness (i.e. slope so steep and long that arrest is unlikely and is no different to a free fall)	Is the height or length of fall likely to result in death or serious harm?	**Yes/No**
Secondary consequences of a fall (i.e. being swept away in a river)	Are there secondary consequences present that if the fall is survived, are likely to lead to death or serious harm?	**Yes/No**
Presence of hidden hazards (e.g. proximity of undercut riverbank)	Is there a hidden hazard(s) present that is likely to contribute to a fall that is likely to result in death or serious harm?	**Yes/No**
	If yes to any of the above, a likelihood assessment must be undertaken in order to determine risk level and adequate risk treatment.	

Note: In the interests of conservatism and safety, if the height of fall/slope steepness has been selected as a **yes** then further consideration is triggered and treatment is warranted.

Aspect – Likelihood	Likely (1)	Possible (2)	Unlikely (3)
(a) Width of track (e.g. a 2m wide track will be less hazardous than a 0.3m wide one)	<1.2m	2.5–4.0m	>5m
(b) Track conditions (e.g. even, slippery or rough surface)	Unstable, rough, out-sloping and/or slippery	Stable, loose and rough	Stable, firm and relatively smooth
(c) The presence of vegetation on the downslope bank/bluff/slope	None	Some – may arrest/break fall	Abundant, sturdy, likely to arrest/break fall
(d) The alignment of the track relative/adjacent to the hazardous section and the visibility (line of sight) relative to the hazardous section	Blind corner leading into drop-off	Curvy trail but with line of sight equal or greater than stopping distance	Straight, ample line of sight
(e) Expected level of rider ability	Grade 1 and 2	Grade 3	Grade 4 and 5

Perceived level of risk	High (score 5–7)	Moderate (score 8–10)	Low (score 11–15)
Suggested risk treatment	Engineered safety fence as per design code	Physical treatment using any or a combination of outer bunds, natural barriers (i.e. large placed rocks); physical impediments (i.e. gate system); inside safety cable; specific warning signs	Generic advisory and communication as per mechanisms outlined in this document

A8 Surface materials

A8.1 Design

Gradient and drainage features are the two most significant predeterminants of trail life expectancy; refer to the earlier Sections 2.3 and 2.4 for more guidance on these aspects. On a steep track with no drainage features, skidding tyres and running water will result in chronic loss of the track surface. The finer materials will be transported down the track until it reaches a grade reversal. Left behind will be rocks, roots, ruts and bedrock. On a poorly designed track, this can happen within 12 months, making the track a Grade or two higher, and resulting in considerable soil erosion.

Loss of surface material can be greatly reduced by using out-slope and grade reversals. Out-slope can be lost over a few years of track use as compaction and displacement lead to dishing (the stage before rutting) along the centre of the track where use is greatest. That is why grade reversals are critical. They break up the water catchment and, if they are large enough, they take a long time to fill up.

Where out-slope is not used, the track should either have a crown, or in-slope (see Figure A3). In-slope is common on berms, where the water is directed into the hillside of the track for a short distance, and then directed into a culvert, or across the track at a grade reversal.

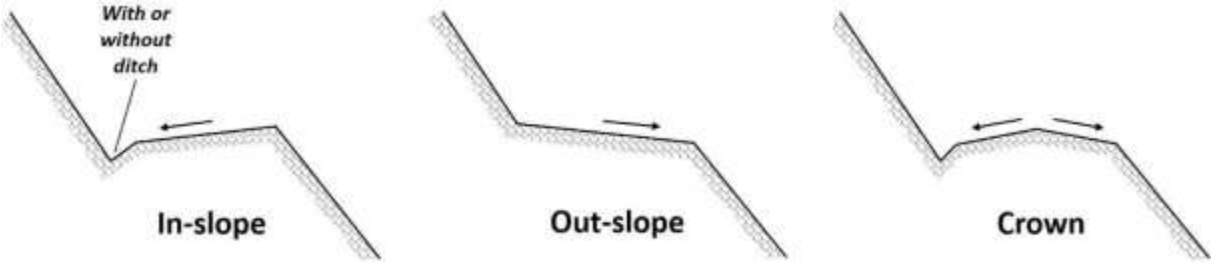


Figure A3: Different options for trail cross-sections

Imagine you are rolling a ball down your freshly built track – it should run off the track as soon as possible.

A8.2 Surface material solutions

Except for volcanic soils, all trails should be surfaced and compacted.

Where surface erosion is a problem, usually due to gradient, the common solutions are to apply a harder, more erosion-proof surface. On mountain bike tracks it is common to use rock armouring, by gathering material from around the track and starting from the bottom, building up a rock layer. This is time consuming, but very effective.

Closer to urban areas, several of the New Zealand Cycle Trails have resorted to sealing steep sections, or sections that are prone to flooding. Materials used are concrete (the most expensive and longest lasting material), asphalt, and chip seal (4 + 6 chip size). Chip seal is the cheapest, but also the bumpiest (generally not an issue for trail riders, but any commuter and sports training riders present may prefer smoother surfaces).

Vegetation cover greatly increases life expectancy by reducing climatic extremes of rainfall, heat and wind.

A8.3 Compacted gravel or crushed limestone

These paths are formed by laying a compacted gravel layer and thus have a semi-loose surface. It is imperative that the gravel is relatively fine and crushed, as round stones do not bind to make a firm surface and will result in a difficult riding surface.

Uncrushed river gravels, or any other material with round stones, should not be used. Often 'dirty rock' with a range of aggregate sizes from a local quarry can be a cheap, effective trail building material.

A component of fine material (limestone or clay) is required in compacted gravel to aid binding. Limestone has the advantage of having natural cement properties but will not be cost-effective unless it is available locally.

The top layer of these surfaces is generally constructed with a crown at the centre and very little material at the sides. Over time, as cyclists generally ride on the centre of the trail, the trail flattens out.

Users of off-road NZCT routes are expected to be using mountain bikes, which have wider tyres than road bikes, so compacted gravel can be one of the more cost-effective and appropriate surfaces. Coarse or loose gravel surfaces are unsuitable for bicycles with narrow tyres such as road cycles, which are favoured by most touring and long-distance, multi-day cyclists. Designers should determine what type of bike (and therefore tyre) will be used on the trail and specify materials accordingly.

Gravel is often a cheaper option, especially if rocks excavated on-site can be crushed and used to surface adjacent sections of trail. Another advantage of using naturally occurring surface materials is that the surface looks natural and fits into the environment. However, the low capital cost required for these trails can be offset by high operational costs to maintain them. It is important that compacted gravel paths are cleared of vegetative matter during construction and plants are prevented from growing in them. The aggregate is likely to spread and thus it may be necessary to sweep loose aggregate back onto the path where it spreads onto drainage features, roads, driveways or other critical locations.

Figure A4: Compacted gravel section of Little River Rail Trail at Catons Bay

A8.4 Compaction

Compaction binds the trail aggregate and removes air gaps that water would otherwise get into. It makes the track strong and impermeable to water. Do not compact more than 200mm thickness of material at a time.

Gravel should be at the optimum moisture content when compacted. If it is too wet it will stick to the plate compactor machinery and hinder the process. If it is too dry it will not bind. Gravel should be of mixed size to facilitate binding into a dense and firm riding surface.

The material beneath the surface is also important. Gap-graded aggregates (like railway ballast used on rail trails) form a good structural base with excellent drainage properties and can provide surplus water storage if there is a known flooding problem in the area. However, too much drainage in dry environments can also cause problems. Experience on the Otago Central Rail Trail (OCRT) shows that a very dry surface can prevent the establishment of a firm, cohesive surface. To counter this, the OCRT operators use a consolidated AP40[5] layer between the railway ballast and surface material (well-graded AP20 with a high clay content).

There is no single formula that provides the solution for all trail surfaces. The appropriate surface for a section of a trail will depend on underlying substrate, topography, trail Grade, projected use and climate. Solutions that may give the best durability may be prohibitively expensive for the number and type of users on a given trail. Over the length of a trail there is likely to be a variety of substrates so the trail surface and underlying layers will need to vary as well.

[5] A specification for medium-sized gravel – ‘all passing 40mm’ sieve. Will ideally contain a mix of stone sizes, including clay.

A8.5 Natural surface

Low volume farm roads with natural (i.e. uncovered soil) surfaces, where motor vehicles provide compaction and prevent vegetation from growing, may also be appropriate for off-road trails. In most cases, natural soil surfaces are likely to be only applicable to mountain biking paths of higher Grade.

Natural surfaces can also include the volcanic soils commonly found in the central North Island. Regardless of the soil type, all organic matter should be removed and only mineral material used. Organic matter decreases a soil's strength, promotes vegetation growth and water retention, and accelerates surface deterioration.

Stabilising products can be used on natural surfaces in critical areas to strengthen the trail and provide higher skid resistance for cycling. Figure A5 shows a 'geomat' applied on a steep track with loose surface in Tongariro National Park; aggregate is then placed on top of this base. Geotextiles are useful at sites with high use, extreme weather conditions and erodible soil.

Figure A5: 'Geomat' surface stabilisers (prior to having aggregate placed on top), Tongariro National Park (Photo: John Bradley)

A more natural alternative to surface stabilisation is to apply 'rock armouring' or 'stone pitching' whereby rocks are used to pave the ground surface. Finer gravel or sand can be applied on top of the rocks to produce a smoother surface, depending on the target skill level of riders. This is, however, generally a labour-intensive treatment. Figure A6 shows an example of a rock armoured path.

Figure A6: Rock armoured path – Nichols Creek Track, Dunedin (Photo: Kennett Brothers)

A8.6 Chip seal and asphaltic concrete (AC)

Chip seal and asphaltic concrete (AC) are two surface types that are commonly used for paving roads and can be appropriate for NZCT routes. They have similar construction methods and requirements for underlying base courses.

Chip seal will generally provide a much superior ride compared with gravel and costs much less than an asphaltic concrete surface. Figure A7 shows a path where a suitable grade of chip seal has been applied to produce a high quality and natural looking riding surface.

Figure A7: Chip seal path in Queenstown

When providing a chip seal surface, attention should be paid to the evenness and strength of the underlying surface and the size of chip (a smaller chip allows for a smoother ride). The chip used should be a grade 4 chip with a grade 6 fill (this is also suitable for road bike tyres, but still too rough for small wheel devices such as skateboards).

Asphaltic concrete (AC) is a common road surface that is great for scooters and skateboards. It is faster to construct than concrete or pavers and has a lower capital cost.

It is also suited to paths with limited space or constrained topography, or paths in urban areas with utilitarian trips by local residents (to work or school, for example). It may be suitable for urban trails but generally not for most NZCT rural trails due to the higher capital cost over chip seal.

For both chip seal and AC paths, the design of the underlying surface, a metal (aggregate) course, is generally dependent on the size of the construction or maintenance vehicles that will travel along the path. Heavy duty paths (those likely to cater for maintenance vehicles) also require a sub-base layer of a larger aggregate. This is an important consideration that is often overlooked, and can result in significant damage, as shown in Figure A8.

Figure A8: Heavy truck causing edge break on new pathway during construction

Where ground material is either wet or soft (e.g. swamp or peat), then a filter fabric should be added to stop the construction metal course from mixing with the ground and thus achieve a long-lasting path. Where a high proportion of clay is present and vehicles cross the pathway (e.g. at driveways), construction depth needs to be increased. Advice from a roading engineer should be sought in these situations, to avoid high construction and maintenance costs.

Table A4 shows the required AC thicknesses or chip sizes and aggregate types for footpaths and cycle paths; this should be used in conjunction with the *Specification for Design, Construction and Maintenance of Cycling and Shared Path Facilities* (NZTA, 2018).

Table A4: AC and chip seal path requirements

Path type	Surface type		Metal (base) course	Sub-base
	AC	Chip seal		
Footpath	20mm	Grades 3&5 chip (rougher) or grades 4&6 chip (smoother)	75mm AP20	NA
Light duty cycle path	20mm		125mm AP40	NA
Heavy duty cycle path	20–25mm		125mm AP40	150mm AP65

Figure A9 shows an example of an asphaltic concrete path. Note that this path is not bordered by timber battens along the grassy edge.

Figure A9: Asphaltic concrete path on the Little River Rail Trail (Photo: Jonathan Kennett)

Treatment with timber edging battens has been traditionally used on AC paths, but a new methodology has recently been developed without timber battens whereby a base course is laid and the AC surfacing is set on top. The base course should extend 200mm wider than the intended path width with edges battered at a 1:3 gradient. The contractor will square up the edges of the AC (with a spade or temporary timbers) to achieve an even thickness of surfacing. This treatment provides adequate strength to the edge of seal and allows topsoil to be placed right to the edge of the path. Experience shows that this technique is cheaper to construct, requires less maintenance, and is less prone to vegetation sprouting through the surface. This method could also be applied to a chip seal path. An indicative cross-section of this is shown in Figure A10.

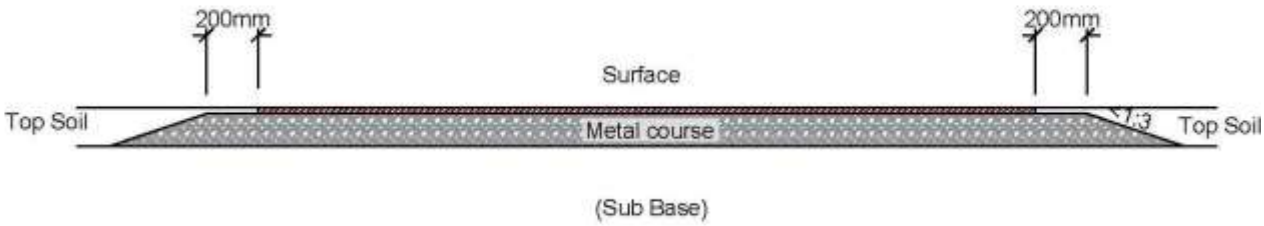


Figure A10: Cross-section for chip seal or AC path without timber edging battens

A8.7 Concrete

Concrete paths are strong and highly durable. However, the construction and capital costs are typically higher than for other path types. Construction joints from one panel to the next can produce an uncomfortable, bumpy ride. Concrete is unlikely to be cost-effective for NZCT routes.

A8.8 Paving stones

Paving stones provide a high quality, durable and attractive surface for paths. They can be easily removed and reinstated for access to sub-surface services. Maintenance is still required for clearing the path of debris and spraying weeds that may grow between the pavers.

The high cost of this treatment is likely to make it an unsuitable option for most NZCT routes. It may, however, be appropriate for small sections where aesthetics are particularly important, for example, end treatments at urban locations. Some trails may be able to make use of wide, flat stones found locally to serve as paving stones.

A8.9 Recommended surface types for path grades

Table A5 outlines the recommended surface types for Grade 1. The appropriateness of natural surfaces also depends on site and user characteristics; stabilising materials may be required.

Table A5: Recommended surface types for off-road Grade 1 trail

Grade 1	Recommended surface type
	Compacted gravel/lime-sand chip seal (4 + 6) Paving stones (even surface essential) Asphaltic concrete Concrete

A9 Construction

Here are ten useful guiding principles for track construction.

- Keep water away from the track surface
- Construct sustainable gradients
- Make the track flow
- Provide a suitable surface
- Maintain a good surface
- Maintain when required
- Be environmentally astute
- Protect your investment
- Train staff
- Respect and keep historic values

Cyclists have indicated that they like to feel as if they are exploring the 'wilderness' but not as if they are biking on a country road. It is important to communicate this message to contractors who may be tempted to provide extra but unnecessary width. Contractors normally involved in road construction may not understand the specific requirements of Grade 3 and above trails; whereas roads are built to be smooth, straight, level and consistent, more experienced riders appreciate some challenges in the form of curves, grade reversals, slopes and changes in path alignment.

The best way to communicate the trail requirements to a contractor may be to ask them to ride a trail of a similar Grade with a trail designer and then discuss the trail's characteristics and desirable aspects from a design perspective.

A9.1 Vegetation clearance

Trees and shrubs should be assessed for their ecological value, and where possible, exotic species removed rather than native species. Trail alignment should be adjusted to avoid removing rare and/or large native trees, which are valuable to the landscape amenity and ecological values of the trail. At all times vegetation clearance should comply with statutory requirements.

All limbs should be cut flush (or to within 10mm) of the trunk or main branch, or ground level. This makes the cut branches less of a danger if people fall onto the cut branches, and it is also healthier for the tree.

The danger of cut branches and stumps on or near trails cannot be overstated. Potential injuries include stab wounds, broken bones, facial lacerations and lost eyes. All trimmed branches near trails should be cut flush with the main branch or tree trunk. Stumps should be dug out of the ground or cut at or below ground level.

All cut woody vegetation should be removed from the track surface and either chipped or moved out of sight of the track (this applies to DOC and council reserves, and other areas where the native vegetation is valued). In pine plantations it is not usually necessary to move cut vegetation out of sight.

A9.2 Markings and delineation

Painted markings can be used on permanent solid path surfaces (e.g. asphaltic concrete, concrete or paving stones) to:

- segregate users (e.g. logos used to identify separate areas for cyclists and pedestrians)
- segregate directions of travel (e.g. by using painted line and arrow markings)
- convey instructions (e.g. keep left, warn when approaching – see Figure A11)
- delineate intersections (e.g. 'Give Way' limit lines).

Figure A11: Transition between shared path, footpath and separated cycleway, Matai Street, Christchurch

Such treatments are not required on most NZCT paths, and the nature of most path surfaces precludes the possibility. Painted markings are, however, useful on sealed paths with higher user volumes, especially paths near urban areas and for paths of lower Grades where users may require more guidance.

The *Traffic Control Devices Rule* enables road controlling authorities to identify shared paths with markings only (instead of signs) where appropriate.

Coloured surfacing treatments are also useful to emphasise large areas of trail, particularly for on-road situations. Coloured surfacing can be used either to attract users' attention or serve as a warning to motorists of conflict zones in on-road trails or crossings. The *Cycling Network Guidance* (NZTA, 2019) gives further guidance on the application of coloured surfacing.

More extensive advice on path markings can be found in NZTA's best practice guidance note *Signs and Markings to Designate Paths for Pedestrians and Cyclists* (NZTA, 2019b) and *Path Behaviour Markings Guidance* (NZTA, 2021).

A10 Data collection

All Great Rides are required to have automatic counters appropriately placed along the trail to provide the number of Trail users. As part of governance and management of a trail, Great Rides are required to provide an annual target number of completed surveys. Trail managers need to encourage users to complete the survey. Survey alerts are a useful tool for trail management.

A11 Accessibility

On-road and off-road trails may be used by cyclists with disabilities, using a range of equipment that may differ in size from a bicycle. This includes:

tricycles (recumbent and upright)

- tandem bicycles
- hand cycles (recumbent and upright)
- e-bikes
- wheelchair tandems
- wheelchair clip-ons
- cargo bicycles and tricycles
- cycle trailers
- bicycles with stabiliser wheels.

Further guidance on making cycle trails inclusive can be found in NZTA's Accessible cycling infrastructure: Design guidance note.

A11.1 Trail barrier remediation – least restrictive access

Physical gates and barriers present significant challenges for the accessibility of outdoor tracks and trails. Many people, including those with disabilities, are affected by such barriers.

Gates and barrier structures along trails should not be a barrier to access for trail users. However, preventing motorcycles and other prohibited vehicles from accessing trails is difficult when trying to accommodate possible legitimate trail users. Meeting the needs of those with modified cycles or cycles with child trailers, adaptive equipment, and parents with prams, as well as not creating hazards for people who are Blind or vision-impaired, may be a challenge, but requires consideration.

Recreation Aotearoa is working with the Outdoor Accessibility Working Group, supported by the University of Canterbury's Dept. of Mechanical Engineering, to develop a decision-making matrix to support more effective decision-making about the use of barriers and access control mechanisms on trails.

Below is the most up-to-date guidance relating to improving barrier accessibility.

A11.2 Is the barrier necessary?

Several types of gate and barrier structures have historically been implemented to address motorbike concerns on trails. It's important to **re-consider if historic rationale for barrier use is still valid on your trail**. Read about an example cycle trail in the UK that re-assessed the need for such barriers and implemented a trial period to understand the effect of changing a barrier.

Unless there is a well-documented and informed health and safety concern or issue to address on your trail, barrier removal should be a priority.

A11.3 What other control mechanisms can be used?

Signage discouraging the use of prohibited vehicles and motorcycles (including information on relevant consequences, such as confiscation of prohibited vehicles and equipment).

Partnering with local police and authorities to provide more frequent surveillance of areas identified as problematic with anti-social behaviour.

Bluetooth keypads with changeable pin-codes (with clear, readily available guidance on how users obtain a code for access).

A11.4 The Least Restrictive Access principle

The principle of Least Restrictive Access (LRA) is that all new work and maintenance repairs should aim to achieve the most accessible option. Least Restrictive Access is achieved by identifying the least restrictive option for a specific feature, such as a gate or barrier. This is not just about selecting the type of structure, but also how to make and install the chosen structure in the least obstructive way for trail users, to maximise accessibility for as many people as possible.

The UK Sensory Trust, on behalf of Natural England, has modified the principle of By All Reasonable Means, Least Restrictive Access to the outdoors to the following:

> *A gap, or no barrier, is less restrictive than the modified squeeze gate (specifications below), which is less restrictive than a traditional squeeze gate. So, when a traditional squeeze gate needs repair or removal, the first option is to remove it entirely. If this is not an option, it is replaced by the modified squeeze gate. The last resort is to replace the traditional squeeze gate.*

A11.5 Existing barrier structures

A11.5.1 Bollards and concrete blocks

These mechanisms do not prevent motorcycle access.

If you are using bollards or concrete blocks to prevent 4-wheeled, or car access, make sure that there is **at least a 1.7m** clear width between adjacent bollards; there is no linking chain or rope of any kind between bollards; the bollard strongly colour contrasts to the background, and there is lighting or a reflector band around the top (visible from any direction).

The bollard should be clearly marked, by painting it in a visible colour, with reflective disks. On paved surfaces, a white diamond should be painted around the bollard, leading at least 10m (greater if the approach speed is likely to be over 30kph) before and after the bollard, and 300mm either side (ideally 450mm). Also, bollards should either be no more than 700mm high, to be below handlebar height, or they should be at least 1.5m high so that they are clearly above handlebar height. The worst height for bollards is around handlebar height, as this means people find it hard to judge if they will miss it or not.

A11.5.2 Chicane gates, croquet hoops and squeeze gates

These can limit access for prams, child bike trailers, larger mobility equipment, like mobility scooters, and many pieces of adaptive equipment such as adaptive mountain bikes, recumbent cycles, tandem cycles, trikes, as well as e-bikes and heavier equipment that users must lift or manoeuvre to navigate the chicane or squeeze gate.

If there is a grass area around the side of the chicane, squeeze gate or croquet hoop, this will not prevent motorcycle access.

If a croquet hoop or squeeze gate **must** be used, traditional specifications have been modified, in consultation with local trail users, to be made more accessible.

Powder coating the barrier (in a high-contrasting colour to the background) also enhances its accessibility for people who have low vision and sight impairments.

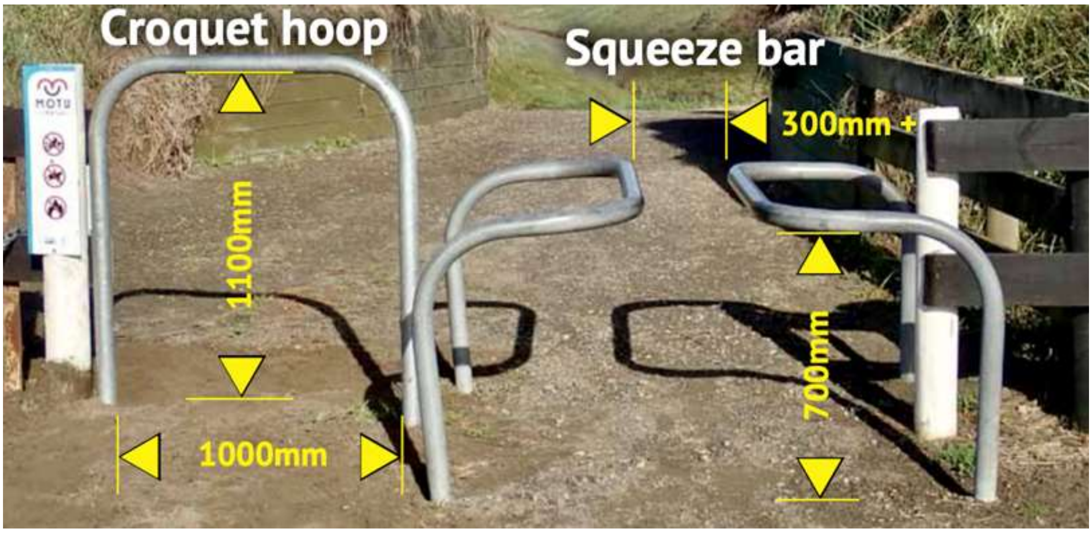


Figure A12: Accessibility modifications for hoop and squeeze barriers

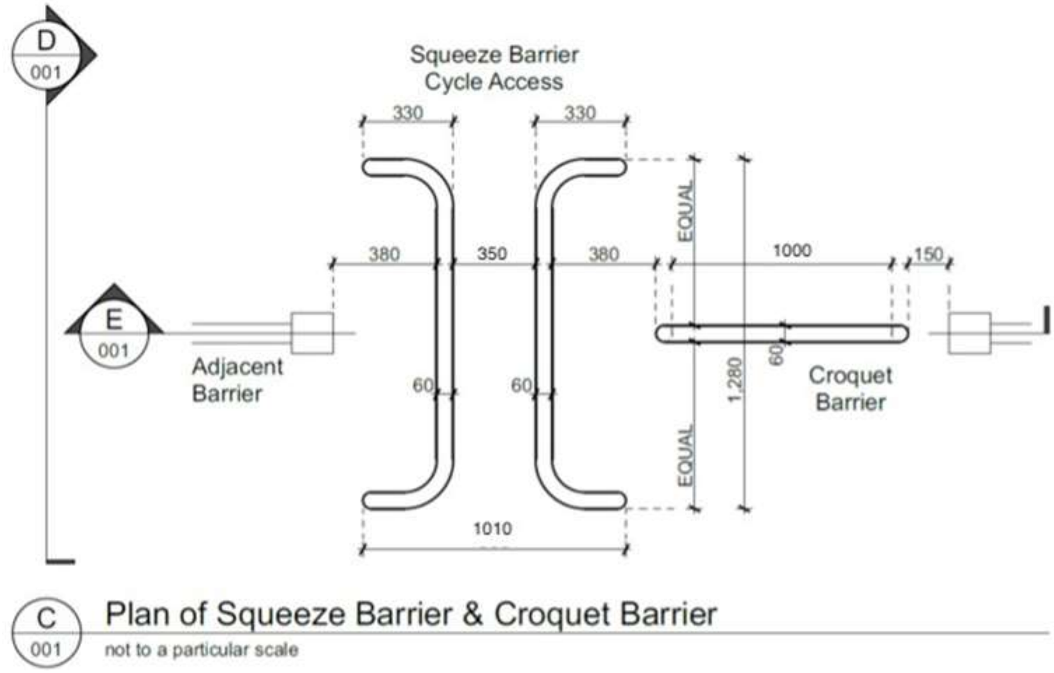


Figure A13: Dimensions for accessibility modifications

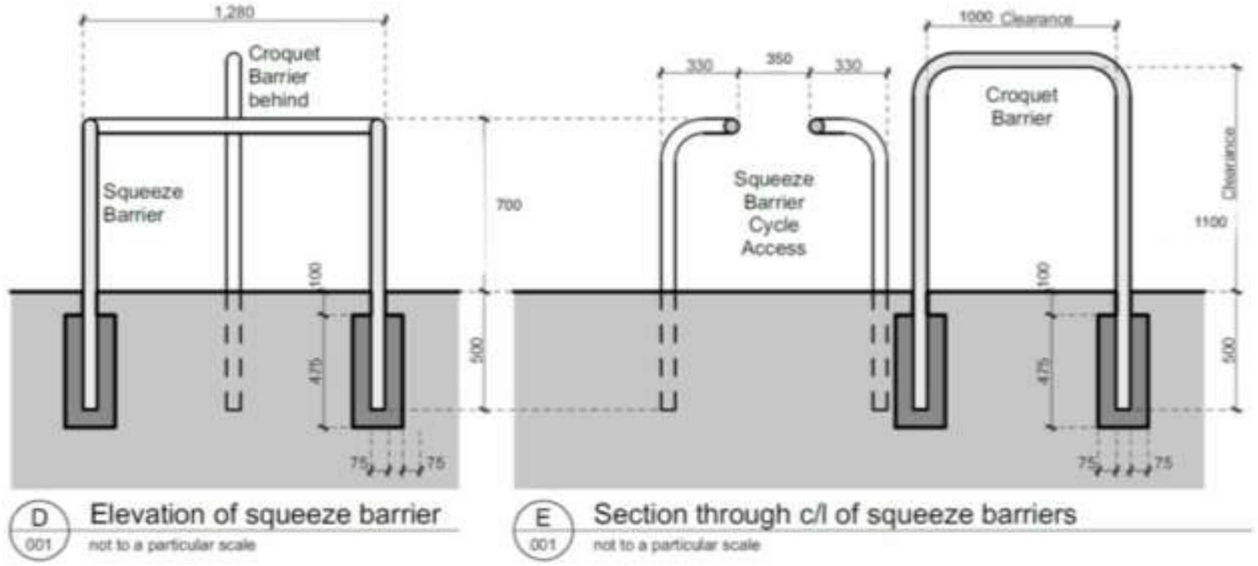


Figure A14: Dimensions for accessibility modifications

Although these specifications are more accessible than traditional squeeze gate and croquet hoop design, **they are not 100% accessible** for all types of mobility devices or adaptive equipment.

Evaluating the absolute necessity of this barrier, including its appropriateness for your type and Grade of trail, and its placement on the trail, remain important considerations.

A11.6 Notifying trail users of barriers and limitations

Trail users will want to know ahead of time:

- Where is the barrier on the trail?
- What does it look like? Can a photo or diagram be included in the trail map or website?
- What are the dimensions of the barrier? What equipment can fit through?
- Are there alternate entrances, such as nearby gates which can be unlocked, that users can arrange ahead of time?
- Who can users contact for more information?

Motu Trails has a great example of displaying this information. Read more about their barrier access on trails, with supporting access information here.

For information specific to urban cycleways and access control mechanisms and barriers, see NZTA's *Accessible cycling infrastructure: design guidance note*.

For further advice on trail accessibility and barriers, or to be kept up to date with the barrier guidance, please contact Katie Owen, Disability and Inclusion Programme Manager.

A11.7 Path end treatments

Path end or 'terminal' treatments are used at ends of off-road trails (paths) to warn people of the approaching transition to on-road trails (or simply a road, without cycle provisions) and to prevent motor vehicles from accessing the paths. While physical restrictions have been commonly used historically at path ends, they should not be seen as a default treatment, and many trails will operate very well without them.

Path end treatments should not necessarily be designed with the aim of slowing cyclists down and should not provide an obstacle that distracts riders' attention from the impending transition to the roadway. Circumstances where cyclists should be required to dismount are rare, so route end treatments should allow people to comfortably ride through without awkward manoeuvring.

Bollards and staggered fences or U-rails are preferred path end treatments, where necessary. These devices can be designed to prevent access by motor vehicles, including motorbikes, without limiting access by users with disabilities.

Figure A15: Path end treatments, West Coast Wilderness Trail, Greymouth

Frangible plastic hold rail could be used at highway crossings where NZTA may not allow a fixed steel hold rail due to risk of highway users hitting it in a crash.

Figure A16: Path end treatment, Hawkes Bay Trails (Photo: Jonathan Kennett)

A11.8 Excluding motorcycles

Motorcycles can be problematic on cycle trails. Various techniques exist to discourage this nuisance, including the positioning of central posts in trails and at gateways or cattle-stops to discourage their use.

However, note the discussion above about ascertaining whether the problem is real (and significant) or perceived, particularly where any barrier treatment would severely restrict other legitimate trail users.

One technique, a 'squeeze barrier', is illustrated in Figures A13 and A14 above. Note that if this barrier arrangement is used on trails where cyclists use pannier bags, the horizontal bars should be installed at the maximum stated height of 870mm. Accurate installation is critical. The width and height of these barriers must be consistent throughout a trail. A jig will be needed for installation, and the trail surface should be checked annually, as if it compacts from wear and tear, then the effective bar height will be higher. A sealed surface underneath might be advised, so that the height stays the same. If there is a notable gradient on the trail, then the tops of the barrier should also mirror that gradient, to be parallel with the track surface.

Riders need a straight approach for 10 metres before a squeeze barrier. They cannot be installed on corners as riders cannot ride through them.

Figure A17: 'Squeeze barrier' to discourage motorcycles, Remutaka Cycle Trail (Photo: Jonathan Kennett)

A12 Environmental considerations

Trail designers and builders must consider the environmental impact of the trail construction (for example vegetation clearance, rare plants, wildlife, siltation of streams and wetlands). Efforts should be made to design the trail to get the most out of the environmental beauty of an area by working around trees, passing natural features, and transplanting small seedlings that are in the path of the track.

For a natural surface trail to be sustainable it should incorporate the principles of sustainable gradients (as discussed in Section 2.5), frequent grade reversals (to aid drainage – as discussed in Section 2.4) and weed control (as discussed in Section 8).

Opening a natural surface trail to light can encourage weed growth and degrade the microclimate. The natural tree canopy should not be disturbed if possible. Some invasive weeds (for example, African clubmoss and didymo) are easily transferred from one trail to another, even by bicycle tyres. At the design and construction stage, these weeds need to be identified and eradicated or controlled (where possible). If infestations occur after the trail has been built, on-going control techniques will be required. Clean all earthworks machinery, hand tools and PPE before taking onto a new site, to avoid importing weeds. Imported gravel, soil and rocks must be from a weed-free source.

In areas of native forest, the environmental values should be assessed first. An Environmental Impact Assessment (EIA) report from a qualified ecologist may be required. Mitigation of the effects of trail building can enhance a track and the users' experience. For example, at Makara Peak Mountain Bike Park in Wellington a native tree is planted for every metre of track built. This mitigation measure is very popular as it results in a combination of recreation and conservation that people appreciate. Several NZCTs have planted thousands of trees beside their trails.

Tree planting provides shade, bird habitat and wind breaks (which help to prolong the life of the trail surface). Over time, native trees also replace undesirable introduced plants such as gorse and blackberry.

Some trails also have stoat/rat traps set up alongside the trail to improve the environment for native birds.

It is preferable to fill between and over roots rather than digging them out. See Section 8.2 for further guidance about maintenance of trails with roots.

As discussed in Section 2.1.5, the natural landscape is an important factor that should be considered during initial design stages. There are often opportunities to 'recycle' local materials (e.g. crushing excavated rocks to be used as base course or surfacing over roots) when building trails. This adds continuity to the trail, decreases environmental impact and can cost less than importing materials.

Councils have rules restricting the amount of earth that can be moved and the maximum cross slope of terrain that a track can be built on. Trail designers and builders need to become familiar with these rules, which make sense from both environmental and track sustainability standpoints. Check local council plans and rules to be informed of restrictions, as well as Resource Management Act requirements, before design and construction stages.

Culverts may disturb the natural movement of native fauna. Boardwalks and bridges have less impact on watercourses, but are more expensive than culverts.

After construction, undertake a special trip to remove survey tags, construction materials/signs and any general rubbish.

A13 Culture and heritage

Consideration under the Treaty of Waitangi Partnership and the *Heritage New Zealand Pouhere Taonga Act 2014* requires trail managers to consider cultural and archaeological factors. Engagement with iwi will help at the trail planning stage, and an archaeology report may need to be written.

Middens, pā and urupā are taonga and there is a legal requirement to treat historical sites (over 100 years old) with respect and have them examined by an archaeologist. These clues to the past can be explained through interpretation panels and will enrich the riding experience by connecting people to the unique environment and stories that contribute to who we are as New Zealanders.

Among solutions to challenges noted in the heritage and archaeological space are the following.

- You may need to identify any existing heritage orders for sites you are developing, as described under Part 8 of the *Resource Management Act 1991*.
- Walking and cycling trails commonly involve earthworks on previously unmodified ground. Archaeological heritage might be missed as it is more invisible and involves a separate consenting process from Heritage NZ.
- Heritage NZ maintains the New Zealand Heritage List and the National Historic Landmarks list where you can identify notable historic and cultural sites around the country.
- It's a small cost to get a high-level archaeological risk assessment for starters – the full Heritage Impact Assessment/AEE can come later if required. Identifying any archaeology early in the process will greatly help forward planning.
- The NZ Archaeological Association's database records are indicative only. Additional information on potential for sites should be sourced from iwi/hapū, Heritage NZ, and an archaeologist with local knowledge.
- Repurposing heritage structures (bridges/tunnels, etc.) has been particularly successful in adding existing infrastructure to walking/cycling trails in a cost-efficient manner.
- Build a relationship early in the project life with regional Heritage NZ staff so you can tap their expertise.

Heritage represents an opportunity to enhance sense of place and identity and build community well-being. For more guidance, refer to NZTA's factsheet *Considering historic heritage in walking and cycling projects* (2019).

A14 Bridges and boardwalks

Ideally bridge and boardwalk widths should be consistent with the overall path and therefore designed according to the path width requirements outlined in Section A2 plus additional clearances for 'shy space' due to handrails or walls etc. However, this may not always be feasible, especially for long spans or constrained locations, in which case the minimum bridge widths outlined in Table A6 can be used.

A14.1 Bridges

A14.1.1 Width

It is usually relatively cheap to provide additional width for a cycle bridge. A bridge that is 50% wider than the minimum width will generally be much less than 50% more expensive, yet provide a much more pleasant cycling experience.

Table A6: Bridge and boardwalk widths

Grades	Recommended bridge width	Minimum bridge width *
1, 2	1.5–2.5m	1.0m

Notes:

- Handrails on minimum bridge widths should be flared out.to provide handlebar clearance.

A14.1.2 Handrails

It is preferable to slope handrails outwards (17.5–27% from the vertical) to allow more space for handlebars and thus allow more of the bridge deck to be safely ridden on. Flaring the handrails in this manner increases the effective width of the structure at minimal cost and generally improves the appearance of the structure. The minimum bridge width (from Table A6) is required at the surface of the bridge but flaring the handrails allows more clearance at handlebar height (taken as 1.0m) and therefore makes the experience more comfortable for riders.

Handrail barrier height should be at 1.2m high. Any current barriers being replaced, or new barriers, must meet this height requirement. Existing guardrails and barriers should only be replaced at the end of their life where a significant hazard exists. This excludes on-road assets. Handrails for new bridges and replacement bridges on road sections are to comply with Waka Kotahi New Zealand Transport Agency standards.

If a bridge or boardwalk does not have handrails, people will be wary of cycling too close to the edge for fear of falling and suitable clearances for 'shy space' should be provided (see A2 – 'Clearances'). Table A6 indicates the recommended bridge width according to path Grade. It may be appropriate to increase this width where possible, especially for bridges of length 20m or longer or on curved sections as cyclists need more space when cornering. Passing/viewing bays should be provided at 50m intervals on bridges (if feasible) and boardwalks; they should be 5m long by 2.5m wide and have handrails. It is not practicable to provide passing bays on suspension bridges and cyclists will need to ride in single file. If cyclists approach such a bridge from opposite ends, one direction will need to give way to the other.

Handrails should be used on significantly curved bridges or bridges 20m or longer if only the minimum width is provided. If the bridge is at least 0.5m wider than the minimum width, handrails are optional (unless the fall height governs). HB 8630 uses an equivalent value of 1.0m but the risk and safety implications of falling off a bridge or boardwalk are likely to be more severe for cyclists than pedestrians. Cyclists travel at faster speeds and fall from a greater height (due to their position on the cycle) than pedestrians. Cycles can also complicate a fall by catching pedals or handlebars on a structure during the fall or hurting the rider on landing. Refer to Section A14 for the decision framework on fall heights.

The guidance in this section does not override any legislative requirements.

A14.1.3 Passing/viewing bays

When designing these structures, consideration of the requirements for cyclists passing each other is needed. Similarly, the effects of cross-winds can make cycling unstable and this needs to be addressed when choosing appropriate widths and deciding whether or not to provide handrails.

A typical (although notably narrow) boardwalk is shown in Figure A18 – it would require handrails and passing bays for a Grade 1 or 2 trail.

Figure A18: Boardwalk – Twizel River Trail (Photo: Kennett Brothers)

A14.1.4 Vertical clearance

The vertical clearance of a bridge above a river should take into account the potential river flood height. In some cases, it may be acceptable that a river level will occasionally rise above the bridge deck, but this risks the integrity of the structure. It is up to the trail owner to specify the appropriate flood design in this circumstance, to erect suitable warning signs and to ensure a suitable inspection and maintenance regime is in place.

A14.1.5 Drainage

NZCT path drainage guidance (Section 2.4) should be used for structures where appropriate rather than HB 8630 track drainage standards, which apply to natural surface walking tracks.

A14.1.6 Skid resistance

UV stable polymer mesh should be used on bridges and boardwalks to increase skid resistance. Wooden surfaces can be dangerously slippery when wet and make corners particularly difficult to negotiate. Wire netting is also a possibility, but it tends to wear out quickly on wooden boardwalks. Boardwalks are very susceptible to frosts and can become hazardous for early morning users. Consideration should be given to surfacing treatments in frost sensitive areas to mitigate the effects of ice on the path surface.

A14.2 Swing and suspension bridges

The terms 'swing bridge' and 'suspension bridge' mean different things to different people. In this design guide, a suspension bridge is a bridge suspended from cables with a fairly rigid deck and may be wide enough for two people to walk across side by side. A swing bridge is a lighter structure, also suspended from cables, but the deck is flexible and often made from steel cables and metal bars, perhaps with wire mesh. They are often used on tramping tracks and are just wide enough to walk across.

In some situations, the type of bridge to be used will be governed by physical features, financial considerations and possibly the logistics of getting construction materials to the site. A swing bridge is often the preferred bridge structure for walking tracks and may also be the most practical alternative for more remote cycle trails, especially when crossing long spans.

Figure A19: Suspension bridge on the Old Ghost Road (Photo: Jonathan Kennett)

Due to their freedom of movement, swing bridges will generally not be suitable for cyclists to ride over. Some cyclists may try to ride over swing bridges, however, which could result in injury from impacts with the bridge sides. Thus, if swing bridges are used, they should be made as rigid as possible with signs to warn cyclists of the dangers of riding across.

Suspension bridges are more stable than swing bridges and can thus be used for all Grades of trail. Suspension bridges are generally a cheaper option than solid timber or metal constructions for longer spans.

Figure A20 : Suspension bridge, Ōparara Valley Track

Swing and suspension bridges should comply with the requirements of HB 8630 (unless contrary guidance is provided in this guide).

A14.2.1 Approaches

A bridge or boardwalk narrower than the path will require end treatments to ensure cyclists are channelled onto the structure rather than off the side. This can be achieved by guardrails on either side. A storage space for cyclists to pull over on the approach to the structure (to rest or avoid passing or overtaking inside the structure) would also be appropriate. If provided, this should be on the left side approaching the structure.

A14.2.2 Aesthetics

Bridges provide the opportunity to add to a route's iconic nature.

Appendix 3B Grade 2 design information for contractors

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B. Grade 2 (Easy)

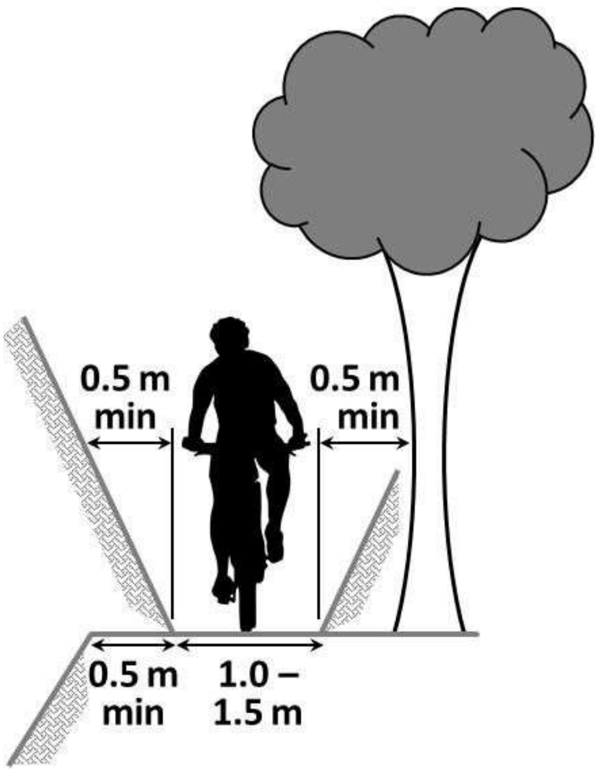
Gradient

- **0–6%** for at least 90% of the trail (3.5 degrees = 6.0% = 1:17)
- **6–8.8%** for steeper slopes up to **100m** long
- **8.8–10.5%** for steeper slopes up to **10m** long (the less the better)
- Maximum **downhill** gradient **14%**

Width

- Double track: **2.2–3.0** metres wide
- Single track: **1.0–1.5** metres wide

(with adequate horizontal clearance to drops or banks/trees)



Formation

- **Mono**-slope with **3.5–5%** side slope or crowned surface with **3.5–5%** side slopes

Surface

- Compacted top-course aggregate of **maximum AP30mm**

Radius of turn

- **4–5 metre minimum** to outside of turn (the more the better)

Grade reversals

- **Required** at dry water courses if they are not bridged or culverted (water courses that normally have water flowing will be bridged or culverted)
- Where appropriate, grade reversals will be large enough to add fun

Grade 2	Grade description
EASY	**Description**: Some gentle climbs, smooth trail. Suitable for confident beginner riders, the trail is predictable with no surprises. Social component with riders able to ride side by side at times, but possibly large sections of single trail. **Gradient**: 0–6% for at least 90% of trail; between 6–8.8% for no more than 100 metres at a time, and between 8.8–10.5% for no more than 10m at a time. If the track is designed and promoted to be ridden predominantly in one direction, then the downhills can be steeper (up to 14%). Sealed trails can be steeper (same as the equivalent Grade of on-road trail; see Section 3.4, Table 5), **Width**: Between 0.9m and 1.5m for single trail and minimum 2.2m for double trail sections with adequate clearances. Horizontal clearances as in Section B2. **Vertical clearance**: Minimum vertical clearance of 2.2m to overhead hazards. A 2.0m vertical clearance may be used for discrete overhead hazards, such as tree branches, or existing structures. **Radius of turn**: 4m minimum with at least 5m desirable to outside of turn. **Sightlines:** Best endeavours must be made to address sightline issues. **Surface**: Compacted/stabilised base course, under a maximum top course aggregate of maximum AP 30mm. The surface should be smooth and easy to ride in all weather conditions. **Watercourses**: Watercourses bridged, except for fords with less than 100mm of water in normal flow, which can be easily ridden. Surface should be as smooth as adjacent trail. **Bridge width:** Recommended bridge width at least 1.5m, minimum width of 1.0m with handrail/barrier to fall. The approach should be the same width as the structure for 10 metres. **Obstacles**: Some rocks/roots/ruts that can either be avoided, or are less than 50mm high. No stiles. Cattle stops should be minimum 1.2m wide. **Length**: 4–5 hours/day (30–50 km/day). **Barriers/guardrails**: Areas such as bluffs or bridges where a fall would result in death or serious harm require handrails.

B1 Gradient requirements for unsealed trails

It is most important that the trail's Grade does not increase more than one Grade over the course of the route. It is acceptable to have short sections of a trail one Grade more difficult than the intended Grade, but it is generally undesirable to have harder sections of trail as some riders are likely to be forced to walk these sections. There is no point building a path that incorporates Grades 2 to Grade 4, as the Grade 4 sections will be impossible to negotiate by those riders whose level of experience and skill is suited for a Grade 2 trail. It will be necessary to improve the Grade 4 sections to Grade 3 standard, or it will not be necessary to build Grade 2 sections, as Grade 3 features will suffice.

Table B1: Gradient requirements for unsealed Grade 2 trails

Trail grade	Main uphill gradient range	Steeper slopes up to 100m long	Steeper slopes up to 10m long	Maximum downhill gradient (up to 100m long)
2	0–6% for 90% of length	6–8.8%	8.8–10.5%	14%

Notes:

- This table applies to off-road unsealed trails and gravel roads.
- Maximum downhill gradient applicable only if trail is to be ridden in one direction.
- IMBA recommends a maximum gradient of 10% (5.7 degrees). Steeper trails will require more maintenance due to increased erosion from skidding tyres and water scour.

B2 Horizontal clearances

Figure B1 shows the operating space required for cycling. An important aspect of the operating space is the angle between the pedals and handlebars; the handlebars protrude further than the pedals and are more likely to catch on adjacent objects. This is why banks should be 'battered' (i.e. sloped, not vertical) and fences should ideally slope away from the path. This issue is increasingly pertinent as more bikes are sold with wider handlebars (e.g. nearly 800mm).

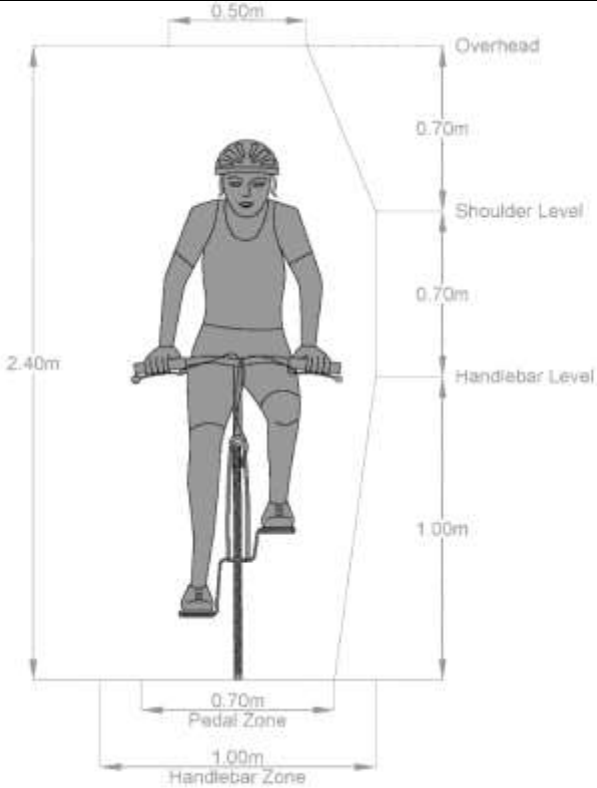


Figure B1: Cycle operating space

When travelling on a lean (for example, when travelling around a banked corner) the location of the cyclist's head and shoulders is also important. Cyclists may hit their heads or shoulders on trees placed too close to the inside of a curve. This can also be a conflict issue between cyclists and pedestrians on banked curves, as cyclists will be leaning while pedestrians are walking upright.

Cycle travel is dynamic. It is difficult to ride exactly in a straight line and less experienced users, in particular, require a fair amount of wriggle room or manoeuvring space.

If a path is restricted horizontally, for example by fences, bridge rails or discrete features such as trees or large rocks, an additional 'shy space' is required. Shy space is needed because cyclists are physically unable to ride on the edge of the path due to their handlebars and pedals extending further than their tyres. Cyclists also need space to allow for a certain amount of wobble and to ensure that they do not need to focus so hard on keeping to the trail that they are unable to appreciate their surroundings. Slower and less experienced cyclists wobble more than faster and more experienced ones.

As it is expected that the majority of cyclists will not choose to ride in the shy space, the clearance does not necessarily need to be constructed from the same materials as the actual path itself. Depending on the context, the shy space could be a grass verge or strip of compacted aggregate. In an urban area, maintenance requirements (e.g. mowing of grass verges) will generally make it more appropriate to create the shy space from the same material as the path. However, in rural areas, there is no point in building a trail right beside a fence as the native ground cover will need no special maintenance.

Horizontal constraints to a path also limit the ability for path users to deviate from the path in extreme circumstances where the path is not wide enough to accommodate all users. Thus, in addition to the path width given in Table B2, further width should be added for situations where at least one side of the path is constrained by adjacent elements. These elements may be either continuous or discrete, and examples are given in Table B2, along with the required clearances:

Table B2: Off-road trail horizontal clearance requirements

Feature Type	Continuous	Discrete
Examples	Fences	Trees
	Walls	Large rocks
	Buildings	Bridge abutments
	Guardrails	Sculptures
	Steep slopes	Power and light poles
	Rock faces	Sign posts
	Parallel drains	Perpendicular drains
	Lakes, rivers and coastlines	
	Hedges	
Recommended clearance each side	1.0m	0.3m
Minimum clearance each side	0.3m	0.15m

Note:

- Extra clearance up to 0.8m is necessary on bends, where cyclists will lean into the corner.
- For example, on a path with fences (i.e. continuous features) on either side, the width between the fences should be the width of the path plus 1.0m. Clearances for continuous or discrete features in Table B2 should be measured at handlebar and shoulder height relative to the path edge.
- If a trail is built on hill with a side slope it is preferable to situate the trail with trees on the downhill side rather than close to the uphill side. This means riders are more likely to naturally keep clear of the drop at the edge of the path.

B3 Pinch points

It may not always be practicable to provide the required width for the entire path length. Large trees, rocks, bluffs, steep cross slopes or other geographic features may produce ‘pinch points’ on a path. These features can be tolerated as long as there is adequate visibility leading to them or advance signage, and safe opportunities for path users to stop before the pinch point and give way to oncoming users or wheel their cycles. Particular care should be taken to avoid pinch points on Grade 1 or 2 paths.

However, pinch points can be specifically incorporated in the design to enhance safety by slowing down cyclists at approaches to hazards such as road crossings or blind corners. These deliberate pinch points are termed ‘chokes’ and are covered also in Section B6.

B4 Vertical clearances

Refer to Figure B1 for operating space requirements. Overhead hazards can include tree branches, overbridges, tunnel soffits, signs, wires and cables. A minimum vertical clearance of 2.2m to overhead hazards is recommended for all trail Grades. However, a 2.0m vertical clearance may be used for discrete overhead hazards, such as tree branches, or existing structures. Users should be advised of such hazards in advance and at the restriction (see Figure B2), and, if necessary, slowed down before reaching the hazard.

Figure B2: Warning sign for a low underpass, Nelson

B5 Trail alignment and shape

When a path must bend or turn a corner there are four main methods that can be used: standard bends, switchbacks, climbing turns and super-elevated (‘in-sloped’ or ‘berm’) turns. These are summarised in Table B3.

Table B3: Types of curve

Corner type	Description	Application and notes
Standard bend	The curve and its approaches are on level ground, and no specific treatment is required.	Apply to flat sections of trail. Most common on Grades 1 and 2.
Super-elevated ('in-sloped' or 'bermed') turn	The outer edge of the curve is banked to allow for faster travel around the corner.	Very popular, particularly on Grade 3–5 tracks. Angle of berm depends on the Grade of the track and radius of the corner. More experienced riders enjoy steep berms. Berms enable people to ride around corners easier and faster.
Switchback	The gradient of the path as it turns is flat while the approach and departure to the curve are on sloped sections.	A common method of providing turns on steep terrain, where berms are not easy to build. Also important for shared use trails where high speeds are not desired.
Climbing turn	The curve itself is located on a sloped section of path (which possibly includes super-elevation/a berm).	Can only be applied to gently sloping hills. Much easier to construct but may require more maintenance than switchbacks.

B6 Sight distances and visibility

Path safety depends on users being able to detect a potential hazard and either stop safely before encountering it or manoeuvre safely around it. The required distance is called 'stopping sight distance' (SSD). Good trail building practice and maintenance will endeavour to eliminate blind corners and create good lines of sight.

If visibility is limited around corners it may be necessary to set back vegetation or fences so that cyclists can maintain the appropriate line of sight around the corner. However, it may be difficult to achieve this, and the result might damage the trail's aesthetics. An alternative is to provide two separate trails around a blind corner, with signs advising users to keep to the left (or in some cases, the right), of the trail. Or, if a trail is reasonably wide, 'keep left' signage in itself may be sufficient (or marked arrows and a centreline on a sealed track).

'Chokes' (localised narrowings) or grade reversals can be used to slow cyclists down on approaches to blind corners, intersections or other potentially dangerous locations.

For more experienced mountain bikers, part of the enjoyment comes from the challenge of having to react quickly rather than having plenty of warning before encountering a path feature. This should be balanced with the likelihood of two cyclists (or a cyclist and a walker or jogger) encountering each other head on without sufficient warning.

In urban areas, visibility of trails by the public is also important for personal safety and security.

The track needs to be built and maintained to the visibility/sightlines assessed as appropriate for the Grade of trail. If the required sightline cannot be practicably achieved for sections of the track due to extenuating circumstances (such as, but not limited to, archaeological, cultural, ecological, geological/geotechnical, landscapes/visual or statutory reasons), then the track must achieve the maximum practicable sightlines, and other treatments and mitigations must be considered, and implemented where appropriate.

B7 Fall heights

Decision framework for determining fall treatment

Aspect – Consequence	Key question	Yes/No
Height of fall/slope steepness (i.e. slope so steep and long that arrest is unlikely and is no different to a free fall)	Is the height or length of fall likely to result in death or serious harm?	**Yes/No**
Secondary consequences of a fall (i.e. being swept away in a river)	Are there secondary consequences present that if the fall is survived, are likely to lead to death or serious harm?	**Yes/No**
Presence of hidden hazards (e.g. proximity of undercut riverbank)	Is there a hidden hazard(s) present that is likely to contribute to a fall that is likely to result in death or serious harm?	**Yes/No**
	If yes to any of the above, a likelihood assessment must be undertaken in order to determine risk level and adequate risk treatment	

Note: In the interests of conservatism and safety, if the height of fall/slope steepness has been selected as a **yes** then further consideration is triggered and treatment is warranted.

Aspect – Likelihood	Likely (1)	Possible (2)	Unlikely (3)
(a) Width of track (e.g. a 2m wide track will be less hazardous than a 0.3m wide one)	<0.6m	0.6–1.5m	>1.5m
(b) Track conditions (e.g. even, slippery or rough surface)	Unstable, rough, out-sloping and/or slippery	Stable, loose and rough	Stable, firm and relatively smooth
(c) The presence of vegetation on the downslope bank/bluff/slope	None	Some – may arrest/break fall	Abundant, sturdy, likely to arrest/break fall
(d) The alignment of the track relative/adjacent to the hazardous section and the visibility (line of sight) relative to the hazardous section	Blind corner leading into drop off	Curvy trail but with line of sight equal or greater than stopping distance	Straight, ample line of sight
(e) Expected level of rider ability	Grade 1 and 2	Grade 3	Grade 4 and 5

Perceived level of risk	High (score 5–7)	Moderate (score 8–10)	Low (score 11–15)
Suggested risk treatment	Engineered safety fence as per design code	Physical treatment using any or a combination of outer bunds, natural barriers (i.e. large placed rocks); physical impediments (i.e. gate system); inside safety cable; specific warning signs	Generic advisory and communication as per mechanisms outlined in this document

B8 Surface materials

B8.1 Design

Gradient and drainage features are the two most significant predeterminants of trail life expectancy; refer to the earlier Sections 2.3 and 2.4 for more guidance on these aspects. On a steep track with no drainage features, skidding tyres and running water will result in chronic loss of the track surface. The finer materials will be transported down the track until it reaches a grade reversal. Left behind will be rocks, roots, ruts and bedrock. On a poorly designed track, this can happen within 12 months, making the track a Grade or two higher, and resulting in considerable soil erosion.

Loss of surface material can be greatly reduced by using out-slope and grade reversals. Out-slope can be lost over a few years of track use as compaction and displacement lead to dishing (the stage before rutting) along the centre of the track where use is greatest. That is why grade reversals are critical. They break up the 'water catchment' and, if they are large enough, they take a long time to fill up.

Where out-slope is not used, the track should either have a crown, or in-slope (see Figure B3). In-slope is common on berms, where the water is directed into the hillside of the track for a short distance, and then directed into a culvert, or across the track at a grade reversal.

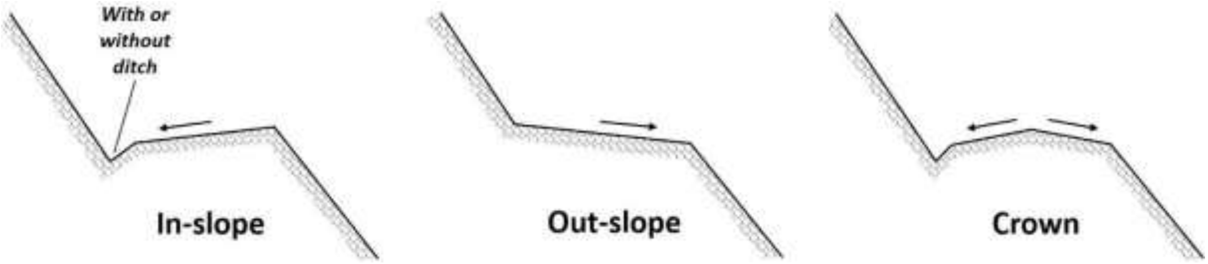


Figure B3: Different options for trail cross-sections

Imagine you are rolling a ball down your freshly built track – it should run off the track as soon as possible.

B8.2 Surface material solutions

Except for volcanic soils, all trails should be surfaced and compacted.

Where surface erosion is a problem, usually due to gradient, the common solutions are to apply a harder, more erosion-proof surface. On mountain bike tracks it is common to use rock armouring, by gathering material from around the track and starting from the bottom, building up a rock layer. This is time consuming, but very effective.

Closer to urban areas, several of the New Zealand Cycle Trails have resorted to sealing steep sections, or sections that are prone to flooding. Materials used are concrete (the most expensive and longest lasting material), asphalt, and chip seal (4 + 6 chip size). Chip seal is the cheapest, but also the bumpiest (generally not an issue for trail riders, but any commuter and sports training riders present may prefer smoother surfaces).

Vegetation cover greatly increases life expectancy by reducing climatic extremes of rainfall, heat, and wind.

B8.3 Compacted gravel or crushed limestone

These paths are formed by laying a compacted gravel layer and thus have a semi-loose surface. It is imperative that the gravel is relatively fine and crushed, as round stones do not bind to make a firm surface and will result in a difficult riding surface.

Uncrushed river gravels, or any other material with round stones, should not be used. Often 'dirty rock' with a range of aggregate sizes from a local quarry can be a cheap, effective trail building material.

A component of fine material (limestone or clay) is required in compacted gravel to aid binding. Limestone has the advantage of having natural cement properties but will not be cost-effective unless it is available locally.

The top layer of these surfaces is generally constructed with a crown at the centre and very little material at the sides. Over time, as cyclists generally ride on the centre of the trail, the trail flattens out.

Users of off-road NZCT routes are expected to be using mountain bikes, which have wider tyres than road bikes, so compacted gravel can be one of the more cost-effective and appropriate surfaces. Coarse or loose gravel surfaces are unsuitable for bicycles with narrow tyres such as road cycles, which are favoured by most touring and long-distance, multi-day cyclists. Designers should determine what type of bike (and therefore tyre) will be used on the trail and specify materials accordingly.

Gravel is often a cheaper option, especially if rocks excavated on-site can be crushed and used to surface adjacent sections of trail. Another advantage of using naturally occurring surface materials is that the surface looks natural and fits into the environment. However, the low capital cost required for these trails can be offset by high operational costs to maintain them. It is important that compacted gravel paths are cleared of vegetative matter during construction and plants are prevented from growing in them. The aggregate is likely to spread and thus it may be necessary to sweep loose aggregate back onto the path where it spreads onto drainage features, roads, driveways or other critical locations.

Figure B4: Compacted gravel section of Little River Rail Trail at Catons Bay

B8.4 Compaction

Compaction binds the trail aggregate and removes air gaps that water would otherwise get into. It makes the track strong and impermeable to water. Do not compact more than 200mm thickness of material at a time.

Gravel should be at the optimum moisture content when compacted. If it is too wet it will stick to the plate compactor machinery and hinder the process. If it is too dry it will not bind. Gravel should be of mixed size to facilitate binding into a dense and firm riding surface.

The material beneath the surface is also important. Gap-graded aggregates (like railway ballast used on rail trails) form a good structural base with excellent drainage properties and can provide surplus water storage if there is a known flooding problem in the area. However, too much drainage in dry environments can also cause problems. Experience on the Otago Central Rail Trail (OCRT) shows that a very dry surface can prevent the establishment of a firm, cohesive surface. To counter this, the OCRT operators use a consolidated AP40[6] layer between the railway ballast and surface material (well-graded AP20 with a high clay content).

There is no single formula that provides the solution for all trail surfaces. The appropriate surface for a section of a trail will depend on underlying substrate, topography, trail Grade, projected use and climate. Solutions that may give the best durability may be prohibitively expensive for the number and type of users on a given trail. Over the length of a trail there is likely to be a variety of substrates so the trail surface and underlying layers will need to vary as well.

B8.5 Natural surface

Low volume farm roads with natural (i.e. uncovered soil) surfaces, where motor vehicles provide compaction and prevent vegetation from growing, may also

[6] A specification for medium-sized gravel – 'all passing 40mm' sieve. Will ideally contain a mix of stone sizes, including clay.

be appropriate for off-road trails. In most cases, natural soil surfaces are likely to be only applicable to mountain biking paths of higher Grade.

Natural surfaces can also include the volcanic soils commonly found in the central North Island. Regardless of the soil type, all organic matter should be removed and only mineral material used. Organic matter decreases a soil's strength, and promotes vegetation growth and water retention, and accelerates surface deterioration.

Stabilising products can be used on natural surfaces in critical areas to strengthen the trail and provide higher skid resistance for cycling. Figure B5 shows a 'geomat' applied on a steep track with loose surface in Tongariro National Park; aggregate is then placed on top of this base. Geotextiles are useful at sites with high use, extreme weather conditions and erodible soil.

Figure B5: 'Geomat' surface stabilisers (prior to having aggregate placed on top), Tongariro National Park (Photo: John Bradley)

A more natural alternative to surface stabilisation is to apply 'rock armouring' or 'stone pitching' whereby rocks are used to pave the ground surface. Finer gravel or sand can be applied on top of the rocks to produce a smoother surface, depending on the target skill level of riders. This is, however, generally a labour-intensive treatment. Figure B6 shows an example of a rock armoured path.

Figure B6: Rock armoured path – Nichols Creek Track, Dunedin (Photo: Kennett Brothers)

B8.6 Chip seal and asphaltic concrete (AC)

Chip seal and asphaltic concrete (AC) are two surface types that are commonly used for paving roads and can be appropriate for NZCT routes. They have similar construction methods and requirements for underlying base courses.

Chip seal will generally provide a much superior ride compared with gravel and costs much less than an asphaltic concrete surface. Figure B7 shows a path where a suitable grade of chip seal has been applied to produce a high quality and natural looking riding surface.

Figure B7: Chip seal path in Queenstown

When providing a chip seal surface, attention should be paid to the evenness and strength of the underlying surface and the size of chip (a smaller chip allows for a smoother ride). The chip used should be a grade 4 chip with a grade 6 fill (this is also suitable for road bike tyres, but still too rough for small wheel devices such as skateboards).

Asphaltic concrete (AC) is a common road surface that is great for scooters and skateboards. It is faster to construct than concrete or pavers and has a lower capital cost.

It is also suited to paths with limited space or constrained topography, or paths in urban areas with utilitarian trips by local residents (to work or school, for example). It may be suitable for urban trails but generally not for most NZCT rural trails due to the higher capital cost over chip seal.

For both chip seal and AC paths, the design of the underlying surface, a metal (aggregate) course, is generally dependent on the size of the construction or maintenance vehicles that will travel along the path. Heavy duty paths (those likely to cater for maintenance vehicles) also require a sub-base layer of a larger aggregate. This is an important consideration that is often overlooked, and can result in significant damage, as shown in Figure B8.

Figure B8: Heavy truck causing edge break on new pathway during construction

Where ground material is either wet or soft (e.g. swamp or peat), then a filter fabric should be added to stop the construction metal course from mixing with the ground and thus achieve a long-lasting path. Where a high proportion of clay is present and vehicles cross the pathway (e.g. at driveways), construction depth needs to be increased. Advice from a roading engineer should be sought in these situations, to avoid high construction and maintenance costs.

Table B4 shows the required AC thicknesses or chip sizes and aggregate types for footpaths and cycle paths; this should be used in conjunction with the *Specification for Design, Construction and Maintenance of Cycling and Shared Path Facilities* (NZTA, 2018).

Table B4: AC and chip seal path requirements

Path type	Surface type		Metal (base) course	Sub-base
	AC	Chip seal		
Footpath	20mm	Grades 3&5 chip (rougher) or grades 4&6 chip (smoother)	75mm AP20	NA
Light duty cycle path	20mm		125mm AP40	NA
Heavy duty cycle path	20–25mm		125mm AP40	150mm AP65

Figure B9 shows an example of an asphaltic concrete path. Note that this path is not bordered by timber battens along the grassy edge.

Figure B9: Asphaltic concrete path on the Little River Rail Trail (Photo: Jonathan Kennett)

Treatment with timber edging battens has been traditionally used on AC paths, but a new methodology has recently been developed without timber battens whereby a base course is laid and the AC surfacing is set on top. The base course should extend 200mm wider than the intended path width with edges battered at a 1:3 gradient. The contractor will square up the edges of the AC (with a spade or temporary timbers) to achieve an even thickness of surfacing. This treatment provides adequate strength to the edge of seal and allows topsoil to be placed right to the edge of the path. Experience shows that this technique is cheaper to construct, requires less maintenance, and is less prone to vegetation sprouting through the surface.

This method could also be applied to a chip seal path. An indicative cross-section of this is shown in Figure B10.

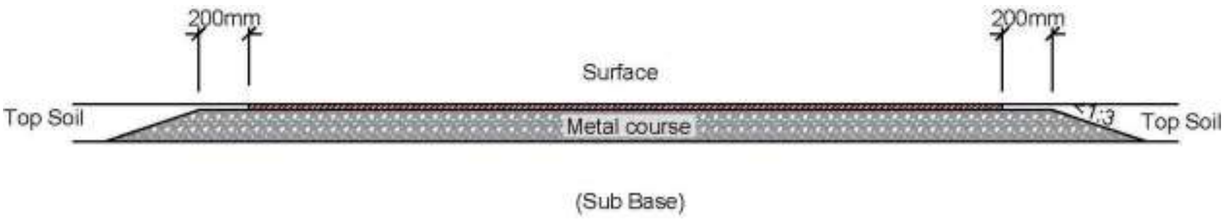


Figure B10: Cross-section for chip seal or AC path without timber edging battens

B8.7 Concrete

Concrete paths are strong and highly durable. However, the construction and capital costs are typically higher than for other path types. Construction joints from one panel to the next can produce an uncomfortable, bumpy ride. Concrete is unlikely to be cost-effective for NZCT routes.

B8.8 Paving stones

Paving stones provide a high quality, durable and attractive surface for paths. They can be easily removed and reinstated for access to sub-surface services. Maintenance is still required for clearing the path of debris and spraying weeds that may grow between the pavers.

The high cost of this treatment is likely to make it an unsuitable option for most NZCT routes. It may however be appropriate for small sections where aesthetics are particularly important, for example, end treatments at urban locations. Some trails may be able to make use of wide, flat stones found locally to serve as paving stones.

B8.9 Recommended surface types for path grades

Table B5 outlines the recommended surface types for Grade 2. The appropriateness of natural surfaces also depends on site and user characteristics; stabilising materials may be required.

Table B5: Recommended surface types for off-road Grade 2 trails

Grade 2	Recommended surface type
EASY	Compacted gravel/lime-sand Chip seal (4 + 6) Paving stones Asphaltic concrete Concrete

B9 Construction

Here are ten useful guiding principles for track construction.

- Keep water away from the track surface
- Construct sustainable gradients
- Make the track flow
- Provide a suitable surface
- Maintain a good surface
- Maintain when required
- Be environmentally astute
- Protect your investment
- Train staff
- Respect and keep historic values

Cyclists have indicated that they like to feel as if they are exploring the 'wilderness' but not as if they are biking on a country road. It is important to communicate this message to contractors who may be tempted to provide extra but unnecessary width. Contractors normally involved in road construction may not understand the specific requirements of Grade 3 and above trails; whereas roads are built to be smooth, straight, level and consistent, more experienced riders appreciate some challenges in the form of curves, grade reversals, slopes and changes in path alignment.

The best way to communicate the trail requirements to a contractor may be to ask them to ride a trail of a similar Grade with a trail designer and then discuss the trail's characteristics and desirable aspects from a design perspective.

B9.1 Vegetation clearance

Trees and shrubs should be assessed for their ecological value, and where possible, exotic species removed rather than native species. Trail alignment should be adjusted to avoid removing rare and/or large native trees, which are valuable to the landscape amenity and ecological values of the trail. At all times, vegetation clearance should comply with statutory requirements.

All limbs should be cut flush (or to within 10mm) of the trunk or main branch, or ground level. This makes the cut branches less of a danger if people fall onto the cut branches, and it is also healthier for the tree.

The danger of cut branches and stumps on or near trails cannot be overstated. Potential injuries include stab wounds, broken bones, facial lacerations and lost eyes. All trimmed branches near trails should be cut flush with the main branch or tree trunk. Stumps should be dug out of the ground or cut at or below ground level.

All cut woody vegetation should be removed from the track surface and either chipped or moved out of sight of the track (this applies to DOC and council reserves, and other areas where the native vegetation is valued). In pine plantations it is not usually necessary to move cut vegetation out of sight.

B9.2 Markings and delineation

Painted markings can be used on permanent solid path surfaces (e.g. asphaltic concrete, concrete or paving stones) to:

- segregate users (e.g. logos used to identify separate areas for cyclists and pedestrians)
- segregate directions of travel (e.g. by using painted line and arrow markings)
- convey instructions (e.g. keep left, warn when approaching – see Figure A11)
- delineate intersections (e.g. 'Give Way' limit lines).

Figure B11: Transition between shared path, footpath and separated cycleway, Matai Street, Christchurch

Such treatments are not required on most NZCT paths, and the nature of most path surfaces precludes the possibility. Painted markings are, however, useful on sealed paths with higher user volumes, especially paths near urban areas and for paths of lower Grades where users may require more guidance.

The *Traffic Control Devices Rule* enables road controlling authorities to identify shared paths with markings only (instead of signs) where appropriate.

Coloured surfacing treatments are also useful to emphasise large areas of trail, particularly for on-road situations. Coloured surfacing can be used either to attract users' attention or serve as a warning to motorists of conflict zones in on-road trails or crossings. The *Cycling Network Guidance* (NZTA, 2019) gives further guidance on the application of coloured surfacing.

More extensive advice on path markings can be found in NZTA's best practice guidance note *Signs and Markings to Designate Paths for Pedestrians and Cyclists* (NZTA, 2019b) and *Path Behaviour Markings Guidance* (NZTA, 2021).

B10 Data collection

All Great Rides are required to have automatic counters appropriately placed along the trail to provide the number of Trail users. As part of governance and management of a trail, Great Rides are required to provide an annual target number of completed surveys. Trail managers need to encourage users to complete the survey. Survey alerts are a useful tool for trail management.

B11 Accessibility

On-road and off-road trails may be used by cyclists with disabilities, using a range of equipment that may differ in size from a bicycle. This includes:

- tricycles (recumbent and upright)
- tandem bicycles
- hand cycles (recumbent and upright)
- e-bikes
- wheelchair tandems
- wheelchair clip-ons
- cargo bicycles and tricycles
- cycle trailers
- bicycles with stabiliser wheels.

Further guidance on making cycle trails inclusive can be found in NZTA's Accessible cycling infrastructure: Design guidance note.

B11.1 Trail barrier remediation – least restrictive access

Physical gates and barriers present significant challenges for the accessibility of outdoor tracks and trails. Many people, including those with disabilities, are affected by such barriers.

Gates and barrier structures along trails should not be a barrier to access for trail users. However, preventing motorcycles and other prohibited vehicles from accessing trails is difficult when trying to accommodate possible legitimate trail users. Meeting the needs of those with modified cycles or cycles with child trailers, adaptive equipment, and parents with prams, as well as not creating hazards for people who are Blind or vision-impaired, may be a challenge, but requires consideration.

Recreation Aotearoa is working with the Outdoor Accessibility Working Group, supported by the University of Canterbury's Dept. of Mechanical Engineering, to develop a decision-making matrix to support more effective decision-making about the use of barriers and access control mechanisms on trails.

Below is the most up-to-date guidance relating to improving barrier accessibility.

B11.2 Is the barrier necessary?

Several types of gate and barrier structures have historically been implemented to address motorbike concerns on trails. It's important to **re-consider if historic rationale for barrier use is still valid on your trail**. Read about an example cycle trail in the UK that re-assessed the need for such barriers and implemented a trail period to understand the effect of changing a barrier.

Unless there is a well-documented and informed health and safety concern or issue to address on your trail, barrier removal should be a priority.

B11.3 What other control mechanisms can be used?

- Signage discouraging the use of prohibited vehicles and motorcycles (including information on relevant consequences, such as confiscation of prohibited vehicles and equipment).
- Partnering with local police and authorities to provide more frequent surveillance of areas identified as problematic with anti-social behaviour.
- Bluetooth keypads with changeable pin-codes (with clear, readily available guidance on how users obtain a code for access).

B11.4 The Least Restrictive Access principle

The principle of Least Restrictive Access (LRA) is that all new work and maintenance repairs should aim to achieve the most accessible option. Least Restrictive Access is achieved by identifying the least restrictive option for a specific feature, such as a gate or barrier. This is not just about selecting the type of structure, but also how to make and install the chosen structure in the least obstructive way for trail users, to maximise accessibility for as many people as possible.

The UK Sensory Trust, on behalf of Natural England, has modified the principle of By All Reasonable Means, Least Restrictive Access to the outdoors to the following:

> *A gap, or no barrier, is less restrictive than the modified squeeze gate (specifications below), which is less restrictive than a traditional squeeze gate. So, when a traditional squeeze gate needs repair or removal, the first option is to remove it entirely. If this is not an option, it is replaced by the modified squeeze gate. The last resort is to replace the traditional squeeze gate.*

B11.5 Existing barrier structures

B11.5.1 Bollards and concrete blocks

These mechanisms do not prevent motorcycle access.

If you are using bollards or concrete blocks to prevent 4-wheeled, or car, access, make sure that there is **at least a 1.7m** clear width between adjacent bollards; there is no linking chain or rope of any kind between bollards; the bollard strongly colour contrasts to the background, and there is lighting or a reflector band around the top (visible from any direction).

The bollard should be clearly marked, by painting it in a visible colour, with reflective disks. On paved surfaces, a white diamond should be painted around the bollard, leading at least 10m (greater if the approach speed is likely to be over 30kph) before and after the bollard, and 300mm either side (ideally 450mm). Also, bollards should either be no more than 700mm high, to be below handlebar height, or they should be at least 1.5m high so that they are clearly above handlebar height. The worst height for bollards is around handlebar height, as this means people find it hard to judge if they will miss it or not.

B11.5.2 Chicane gates, croquet hoops and squeeze gates

These can limit access for prams, child bike trailers, larger mobility equipment, like mobility scooters, and many pieces of adaptive equipment such as adaptive mountain bikes, recumbent cycles, tandem cycles, trikes, as well as e-bikes and heavier equipment that users must lift or manoeuvre to navigate the chicane or squeeze gate.

If there is a grass area around the side of the chicane, squeeze gate or croquet hoop, this will not prevent motorcycle access.

If a croquet hoop or squeeze gate **must** be used, traditional specifications have been modified, in consultation with local trail users, to be made more accessible.

Powder coating the barrier (in a high-contrasting colour to the background) also enhances its accessibility for people who have low vision and sight impairments.

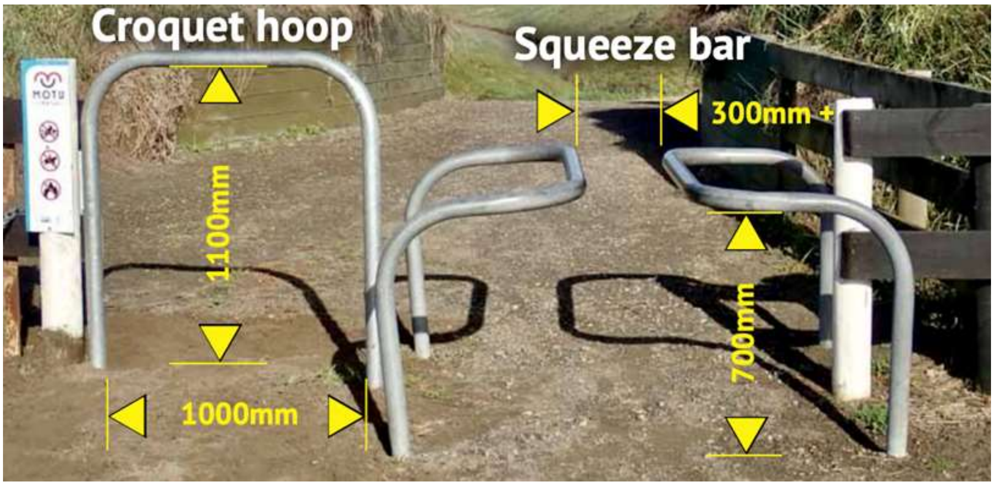


Figure B12: Accessibility modifications for hoop and squeeze barriers

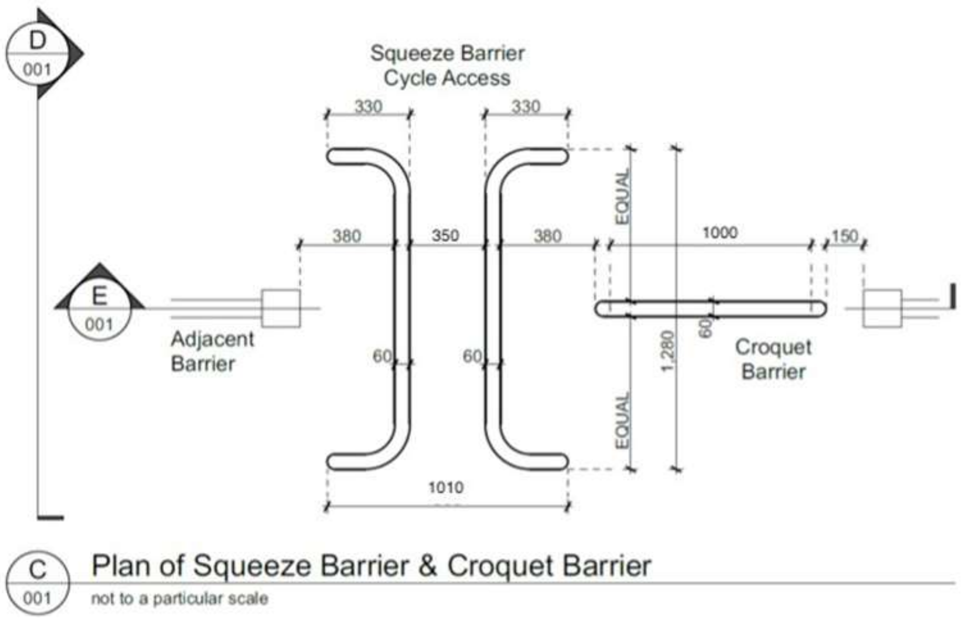


Figure B13: Dimensions for accessibility modifications

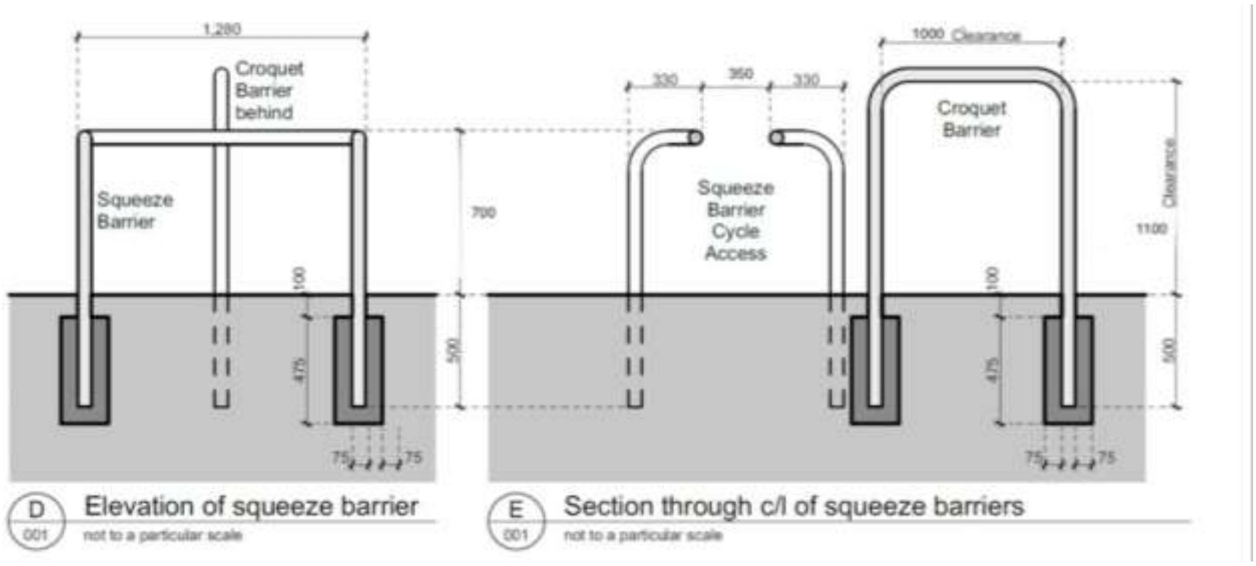


Figure B14: Dimensions for accessibility modifications

Although these specifications are more accessible than traditional squeeze gate and croquet hoop design, **they are not 100% accessible** for all types of mobility devices or adaptive equipment.

Evaluating the absolute necessity of this barrier, including its appropriateness for your type and grade of trail, and its placement on the trail, remain important considerations.

B11.6 Notifying trail users of barriers and limitations

Trail users will want to know ahead of time:

- Where is the barrier on the trail?
- What does it look like? Can a photo or diagram be included in the trail map or website?
- What are the dimensions of the barrier? What equipment can fit through?
- Are there alternate entrances, such as nearby gates which can be unlocked, that users can arrange ahead of time?
- Who can users contact for more information?

Motu Trails has a great example of displaying this information. Read more about their barrier access on trails, with supporting access information here.

For information specific to urban cycleways and access control mechanisms and barriers, see NZTA's *Accessible cycling infrastructure: design guidance note*.

For further advice on trail accessibility and barriers, or to be kept up to date with the barrier guidance, please contact Katie Owen, Disability and Inclusion Programme Manager.

B11.7 Path end treatments

Path end or 'terminal' treatments are used at ends of off-road trails (paths) to warn people of the approaching transition to on-road trails (or simply a road, without cycle provisions) and to prevent motor vehicles from accessing the paths. While physical restrictions have been commonly used historically at path ends, they should not be seen as a default treatment, and many trails will operate very well without them.

Path end treatments should not necessarily be designed with the aim of slowing cyclists down and should not provide an obstacle that distracts riders' attention from the impending transition to the roadway. Circumstances where cyclists should be required to dismount are rare, so route end treatments should allow people to comfortably ride through without awkward manoeuvring.

Bollards and staggered fences or U-rails are preferred path end treatments, where necessary. These devices can be designed to prevent access by motor vehicles, including motorbikes, without limiting access by users with disabilities.

Figure B15: Path end treatments, West Coast Wilderness Trail, Greymouth

Frangible plastic hold rail could be used at highway crossings where NZTA may not allow a fixed steel hold rail due to risk of highway users hitting it in a crash.

Figure B16: Path end treatment, Hawkes Bay Trails (Photo: Jonathan Kennett)

B11.8 Excluding motorcycles

Motorcycles can be problematic on cycle trails. Various techniques exist to discourage this nuisance, including the positioning of central posts in trails and at gateways or cattle-stops to discourage their use.

However, note the discussion above about ascertaining whether the problem is real (and significant) or perceived, particularly where any barrier treatment would severely restrict other legitimate trail users.

One technique, a 'squeeze barrier', is illustrated in Figures B13 and B14 above. Note that if this barrier arrangement is used on trails where cyclists use pannier bags, the horizontal bars should be installed at the maximum stated height of 870mm. Accurate installation is critical. The width and height of these barriers must be consistent throughout a trail. A jig will be needed for installation, and the trail surface should be checked annually, as if it compacts from wear and tear, then the effective bar height will be higher. A sealed surface underneath might be advised, so that the height stays the same. If there is a notable gradient on the trail, then the tops of the barrier should also mirror that gradient, to be parallel with the track surface.

Riders need a straight approach for 10 metres before a squeeze barrier. They cannot be installed on corners as riders cannot ride through them.

Figure B17: 'Squeeze barrier' to discourage motorcycles, Remutaka Cycle Trail (Photo: Jonathan Kennett)

B12 Environmental considerations

Trail designers and builders must consider the environmental impact of the trail construction (for example vegetation clearance, rare plants, wildlife, siltation of streams and wetlands). Efforts should be made to design the trail to get the most out of the environmental beauty of an area by working around trees, passing natural features, and transplanting small seedlings that are in the path of the track.

For a natural surface trail to be sustainable it should incorporate the principles of sustainable gradients (as discussed in Section 2.5), frequent grade reversals (to aid drainage – as discussed in Section 2.4) and weed control (as discussed in Section 8).

Opening a natural surface trail to light can encourage weed growth and degrade the microclimate. The natural tree canopy should not be disturbed if possible. Some invasive weeds (for example, African clubmoss and didymo) are easily transferred from one trail to another, even by bicycle tyres. At the design and construction stage, these weeds need to be identified and eradicated or controlled (where possible). If infestations occur after the trail has been built, on-going control techniques will be required. Clean all earthworks machinery, hand tools and PPE before taking onto a new site, to avoid importing weeds. Imported gravel, soil and rocks must be from a weed-free source.

In areas of native forest, the environmental values should be assessed first. An Environmental Impact Assessment (EIA) report from a qualified ecologist may be required. Mitigation of the effects of trail building can enhance a track and the users' experience. For example, at Makara Peak Mountain Bike Park in Wellington a native tree is planted for every metre of track built. This mitigation measure is very popular as it results in a combination of recreation and conservation that people appreciate. Several NZCTs have planted thousands of trees beside their trails.

Tree planting provides shade, bird habitat and wind breaks (which help to prolong the life of the trail surface). Over time, native trees also replace undesirable introduced plants such as gorse and blackberry.

Some trails also have stoat/rat traps set up alongside the trail to improve the environment for native birds.

It is preferable to fill between and over roots rather than digging them out. See Section 8.2 for further guidance about maintenance of trails with roots.

As discussed in Section 2.1.5, the natural landscape is an important factor that should be considered during initial design stages. There are often opportunities to ‘recycle' local materials (e.g. crushing excavated rocks to be used as base course or surfacing over roots) when building trails. This adds continuity to the trail, decreases environmental impact and can cost less than importing materials.

Councils have rules restricting the amount of earth that can be moved and the maximum cross slope of terrain that a track can be built on. Trail designers and builders need to become familiar with these rules, which make sense from both environmental and track sustainability standpoints. Check local council plans and rules to be informed of restrictions, as well as Resource Management Act requirements, before design and construction stages.

Culverts may disturb the natural movement of native fauna. Boardwalks and bridges have less impact on watercourses, but are more expensive than culverts.

After construction, undertake a special trip to remove survey tags, construction materials/signs and any general rubbish.

B13 Culture and heritage

Consideration under the Treaty of Waitangi Partnership and the *Heritage New Zealand Pouhere Taonga Act 2014* requires trail managers to consider cultural and archaeological factors. Engagement with iwi will help at the trail planning stage, and an archaeology report may need to be written.

Middens, pā and urupā are taonga and there is a legal requirement to treat historical sites (over 100 years old) with respect and have them examined by an archaeologist. These clues to the past can be explained through interpretation panels and will enrich the riding experience by connecting people to the unique environment and stories that contribute to who we are as New Zealanders.

Among solutions to challenges noted in the heritage and archaeological space are the following.

- You may need to identify any existing heritage orders for sites you are developing, as described under Part 8 of the *Resource Management Act 1991*.
- Walking and cycling trails commonly involve earthworks on previously unmodified ground. Archaeological heritage might be missed as it is more invisible and involves a separate consenting process from Heritage NZ.
- Heritage NZ maintains the New Zealand Heritage List and the National Historic Landmarks list where you can identify notable historic and cultural sites around the country.
- It's a small cost to get a high-level archaeological risk assessment for starters – the full Heritage Impact Assessment/AEE can come later if required. Identifying any archaeology early in the process will greatly help forward planning.
- The NZ Archaeological Association's database records are indicative only. Additional information on potential for sites should be sourced from iwi/hapū, Heritage NZ, and an archaeologist with local knowledge.
- Repurposing heritage structures (bridges/tunnels, etc.) has been particularly successful in adding existing infrastructure to walking/cycling trails in a cost-efficient manner.
- Build a relationship early in the project life with regional Heritage NZ staff so you can tap their expertise.

Heritage represents an opportunity to enhance sense of place and identity and build community well-being. For more guidance, refer to NZTA's factsheet *Considering historic heritage in walking and cycling projects* (2019)

B14 Bridges and boardwalks

Ideally bridge and boardwalk widths should be consistent with the overall path and therefore designed according to the path width requirements outlined in Section B2 plus additional clearances for 'shy space' due to handrails or walls etc. However, this may not always be feasible, especially for long spans or constrained locations, in which case the minimum bridge widths outlined in Table B6 can be used.

B14.1 Bridges

B141.1 Width

It is usually relatively cheap to provide additional width for a cycle bridge. A bridge that is 50% wider than the minimum width will generally be much less than 50% more expensive, yet provide a much more pleasant cycling experience.

Table B6: Bridge and boardwalk widths

Grades	Recommended bridge width	Minimum bridge width *
1, 2	1.5–2.5m	1.0m

Notes:

- Handrails on minimum bridge widths should be flared out.to provide handlebar clearance.

B14.1.2 Handrails

It is preferable to slope handrails outwards (17.5–27% from the vertical) to allow more space for handlebars and thus allow more of the bridge deck to be safely ridden on. Flaring the handrails in this manner increases the effective width of the structure at minimal cost and generally improves the appearance of the structure. The minimum bridge width (from Table B6) is required at the surface of the bridge but flaring the handrails allows more clearance at handlebar height (taken as 1.0m) and therefore makes the experience more comfortable for riders.

Handrail barrier height should be at 1.2m high. Any current barriers being replaced, or new barriers, must meet this height requirement. Existing guardrails and barriers should only be replaced at the end of their life where a significant hazard exists. This excludes on-road assets. Handrails for new bridges and replacement bridges on road sections are to comply with Waka Kotahi New Zealand Transport Agency standards.

If a bridge or boardwalk does not have handrails, people will be wary of cycling too close to the edge for fear of falling and suitable clearances for 'shy space' should be provided (see B2 – 'Clearances'). Table B6 indicates the recommended bridge width according to path Grade. It may be appropriate to increase this width where possible, especially for bridges of length 20m or longer or on curved sections as cyclists need more space when cornering. Passing/viewing bays should be provided at 50m intervals on bridges (if feasible) and boardwalks; they should be 5m long by 2.5m wide and have handrails. It is not practicable to provide passing bays on suspension bridges and cyclists will need to ride in single file. If cyclists approach such a bridge from opposite ends, one direction will need to give way to the other.

Handrails should be used on significantly curved bridges or bridges 20m or longer if only the minimum width is provided. If the bridge is at least 0.5m wider than the minimum width, handrails are optional (unless the fall height governs). HB 8630 uses an equivalent value of 1.0m but the risk and safety implications of falling off a bridge or boardwalk are likely to be more severe for cyclists than pedestrians. Cyclists travel at faster speeds and fall from a greater height (due to their position on the cycle) than pedestrians. Cycles can also complicate a fall by catching pedals or handlebars on a structure during the fall or hurting the rider on landing. Refer to Section B14 for the decision framework on fall heights.

The guidance provided in this section does not override any legislative requirements.

B14.1.3 Passing/viewing bays

When designing these structures, consideration of the requirements for cyclists passing each other is needed. Similarly, the effects of cross-winds can make cycling unstable and this needs to be addressed when choosing appropriate widths and deciding whether or not to provide handrails.

A typical (although notably narrow) boardwalk is shown in Figure B18 – it would require handrails and passing bays for a Grade 1 or 2 trail.

Figure B18: Boardwalk – Twizel River Trail (Photo: Kennett Brothers)

B14.1.4 Vertical clearance

The vertical clearance of a bridge above a river should take into account the potential river flood height. In some cases, it may be acceptable that a river level will occasionally rise above the bridge deck, but this risks the integrity of the structure. It is up to the trail owner to specify the appropriate flood design in this circumstance, to erect suitable warning signs and to ensure a suitable inspection and maintenance regime is in place.

B14.1.5 Drainage

NZCT path drainage guidance (Section 2.4) should be used for structures where appropriate rather than HB 8630 track drainage standards, which apply to natural surface walking tracks.

B14.1.6 Skid resistance

UV stable polymer mesh should be used on bridges and boardwalks to increase skid resistance. Wooden surfaces can be dangerously slippery when wet and make corners particularly difficult to negotiate. Wire netting is also a possibility, but it tends to wear out quickly on wooden boardwalks. Boardwalks are very susceptible to frosts and can become hazardous for early morning users. Consideration should be given to surfacing treatments in frost sensitive areas to mitigate the effects of ice on the path surface.

B14.2 Swing and suspension bridges

The terms 'swing bridge' and 'suspension bridge' mean different things to different people. In this design guide, a suspension bridge is a bridge suspended from cables with a fairly rigid deck and may be wide enough for two people to walk across side by side. A swing bridge is a lighter structure, also suspended from cables, but the deck is flexible and often made from steel cables and metal bars, perhaps with wire mesh. They are often used on tramping tracks and are just wide enough to walk across.

In some situations, the type of bridge to be used will be governed by physical features, financial considerations and possibly the logistics of getting construction materials to the site. A swing bridge is often the preferred bridge structure for walking tracks and may also be the most practical alternative for more remote cycle trails, especially when crossing long spans.

Figure B19: Suspension bridge on the Old Ghost Road (Photo: Jonathan Kennett)

Due to their freedom of movement, swing bridges will generally not be suitable for cyclists to ride over. Some cyclists may try to ride over swing bridges, however, which could result in injury from impacts with the bridge sides. Thus, if swing bridges are used, they should be made as rigid as possible with signs to warn cyclists of the dangers of riding across.

Suspension bridges are more stable than swing bridges and can thus be used for all Grades of trail. Suspension bridges are generally a cheaper option than solid timber or metal constructions for longer spans.

Figure B20: Suspension bridge, Ōparara Valley Track

Swing and suspension bridges should comply with the requirements of HB 8630 (unless contrary guidance is provided in this guide).

B14.2.1 Approaches

A bridge or boardwalk narrower than the path will require end treatments to ensure cyclists are channelled onto the structure rather than off the side. This can be achieved by guardrails on either side. A storage space for cyclists to pull over on the approach to the structure (to rest or avoid passing or overtaking inside the structure) would also be appropriate. If provided, this should be on the left side approaching the structure.

B14.2.2 Aesthetics

Bridges provide the opportunity to add to a route's iconic nature.

Appendix 3C Grade 3 design information for contractors

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C. Grade 3 (Intermediate)

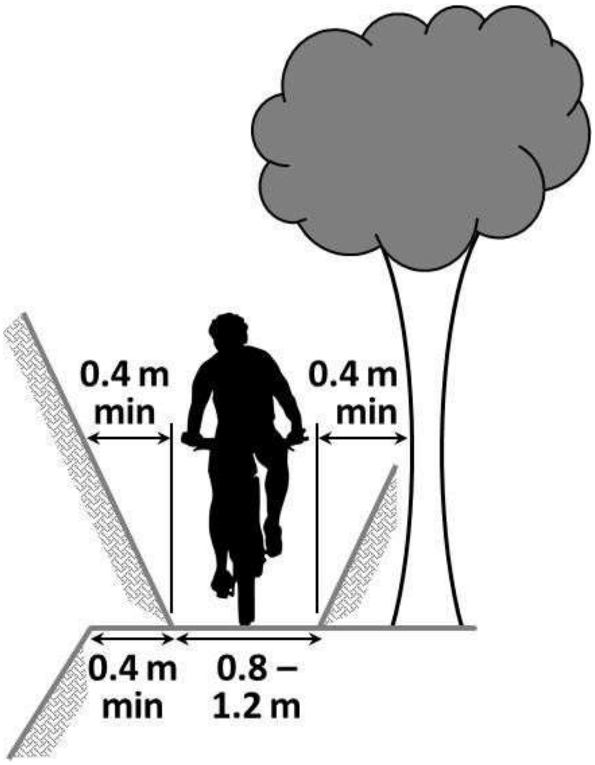
Gradient

- **0–8.8%** for at least 90% of the trail (3.5 degrees = 6.0% = 1:17)
- **8.8–12.3%** for steeper slopes up to **100m** long
- **12.3–17.5%** for steeper slopes up to **10m** long (the less the better)
- Maximum **downhill** gradient **19.5%**

Width

- Single track: **0.8–1.2 metres** wide

(with adequate horizontal clearance to drops or banks/trees)

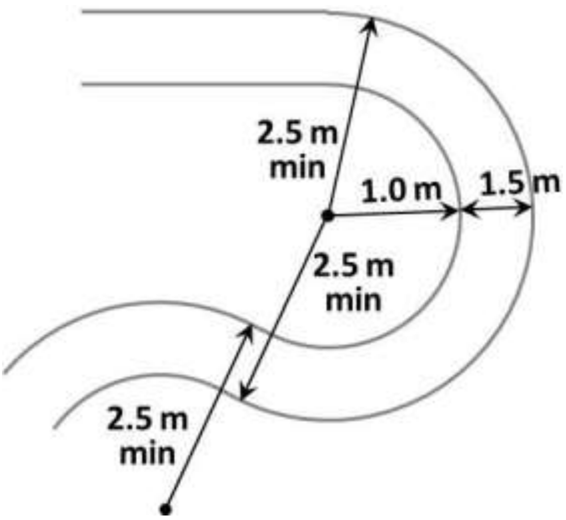


Formation

- Mono-slope with **3.5–5%** side slope (crowned surfaces are not desirable, but slope will be dictated by terrain and weather conditions)
- **Greater** side slope (super-elevation = berms) up to **36%** around corners

Surface

- Generally firm, but may have some short muddy or loose sections



Radius of turn

- **2.5–4 metre minimum** to outside of turn (the more the better)

Grade reversals

- **Required** at regular intervals including all water courses (some may have occasional water flowing across them) if they are not bridged or culverted
- Where appropriate, grade reversals will be large enough to add fun

Grade 3	Grade description
 	**Description**: Narrow trail, there will be some hills to climb, obstacles may be encountered on the trail, and there may be exposure on the edge of the trail. **Gradient**: 0–8.8% for at least 90% of trail; between 8.8–12.3% for no more than 100 metres at a time, and a maximum of 17.5% for no more than 10m at a time. If the track is designed and promoted to be ridden predominantly in one direction, then the downhills can be steeper (up to 19.5%). Sealed trails can be steeper (same as the equivalent Grade of on-road trail; see Section 3.4, Table 5). **Width**: 0.9m for 90% of the trail, 0.6m minimum with adequate clearances. Horizontal clearances as in Section 3.4, Table 6. **Vertical clearance**: Minimum vertical clearance of 2.2m to overhead hazards. A 2.0m vertical clearance may be used for discrete overhead hazards, such as tree branches, or existing structures. **Radius of turn**: 2.5m minimum, with at least 4m desirable to outside of turn. **Sightlines:** Best endeavours must be made to address sightline issues. **Surface**: Generally firm, but may have some short muddy or loose sections. **Watercourses**: Watercourses bridged, except for fords with less than 200mm of water in normal flow, which can be easily ridden. **Bridge width:** Recommended at least 1.0m; minimum 0.75m deck if the width at handlebar height is 1.2m. If there are no handrails, then minimum width of 1m for structures less than 0.5m high. **Obstacles**: Occasional rocks/roots and ruts may be up to 100mm high/deep and may be unavoidable **Length**: 4–6 hours/day (30–50 km/day). **Barriers/guardrails**: Areas such as bluffs or bridges where a fall would result in death require handrails. Areas where a fall would likely result in serious harm require either handrails or sight rails or a warning sign, depending on the nature of the drop-off and likelihood of a fall.

C1 Gradient requirements for unsealed trails

It is most important that the trail's Grade does not increase more than one Grade over the course of the route. It is acceptable to have short sections of a trail one Grade more difficult than the intended Grade, but it is generally undesirable to have harder sections of trail as some riders are likely to be forced to walk these sections. There is no point building a path that incorporates Grades 2 to Grade 4, as the Grade 4 sections will be impossible to negotiate by those riders whose level of experience and skill is suited for a Grade 2 trail. It will be necessary to improve the Grade 4 sections to Grade 3 standard, or it will not be necessary to build Grade 2 sections, as Grade 3 features will suffice.

Table C1: Gradient requirements for unsealed Grade 3 trails

Trail grade	Main uphill gradient range	Steeper slopes up to 100m long	Steeper slopes up to 10m long	Maximum downhill gradient (up to 100m long)
3	0–8.8% for 90% of length	8.8–12.3%	12.3–17.5%	19.5%

Notes:

- This table applies to off-road unsealed trails and gravel roads.
- Maximum downhill gradient applicable only if trail is to be ridden in one direction.
- IMBA recommends a maximum gradient of 10% (5.7 degrees). Steeper trails will require more maintenance due to increased erosion from skidding tyres and water scour.

C2 Horizontal clearances

Figure C1 shows the operating space required for cycling. An important aspect of the operating space is the angle between the pedals and handlebars; the handlebars protrude further than the pedals and are more likely to catch on adjacent objects. This is why banks should be ‘battered’ (i.e. sloped, not vertical) and fences should ideally slope away from the path. This issue is increasingly pertinent as more bikes are sold with wider handlebars (e.g. nearly 800mm).

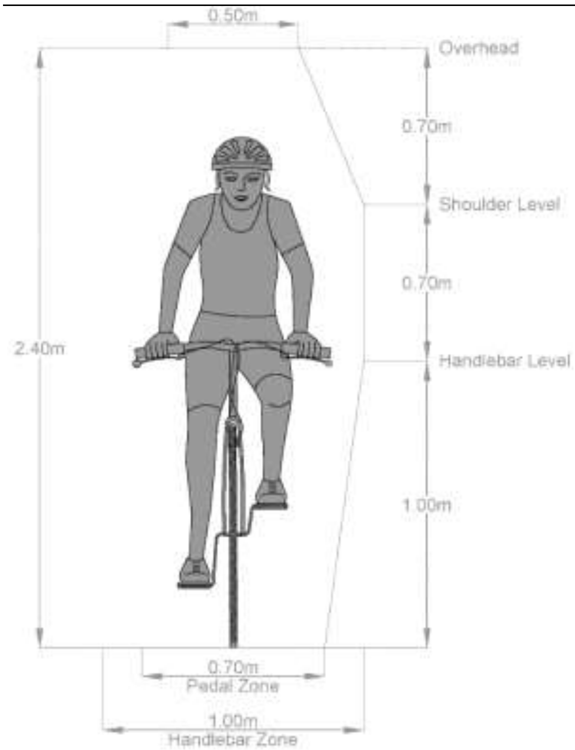


Figure C1: Cycle operating space

When travelling on a lean (for example, when travelling around a banked corner) the location of the cyclist's head and shoulders is also important. Cyclists may hit their heads or shoulders on trees placed too close to the inside of a curve. This can also be a conflict issue between cyclists and pedestrians on banked curves, as cyclists will be leaning while pedestrians are walking upright.

Cycle travel is dynamic. It is difficult to ride exactly in a straight line and less experienced users, in particular, require a fair amount of wriggle room or manoeuvring space.

If a path is restricted horizontally, for example by fences, bridge rails or discrete features such as trees or large rocks, an additional 'shy space' is required. Shy space is needed because cyclists are physically unable to ride on the edge of the path due to their handlebars and pedals extending further than their tyres. Cyclists also need space to allow for a certain amount of wobble and to ensure that they do not need to focus so hard on keeping to the trail that they are unable to appreciate their surroundings. Slower and less experienced cyclists wobble more than faster and more experienced ones.

As it is expected that the majority of cyclists will not choose to ride in the shy space, the clearance does not necessarily need to be constructed from the same materials as the actual path itself. Depending on the context, the shy space could be a grass verge or strip of compacted aggregate. In an urban area, maintenance requirements (e.g. mowing of grass verges) will generally make it more appropriate to create the shy space from the same material as the path. However, in rural areas, there is no point in building a trail right beside a fence as the native ground cover will need no special maintenance.

Horizontal constraints to a path also limit the ability for path users to deviate from the path in extreme circumstances where the path is not wide enough to accommodate all users. Thus, in addition to the path width given in Table C2, further width should be added for situations where at least one side of the path is constrained by adjacent elements. These elements may be either continuous or discrete, and examples are given in Table C2, along with the required clearances.

Table C2: Off-road trail horizontal clearance requirements

Feature Type	Continuous	Discrete
Examples	Fences	Trees
	Walls	Large rocks
	Buildings	Bridge abutments
	Guardrails	Sculptures
	Steep slopes	Power and light poles
	Rock faces	Sign posts
	Parallel drains	Perpendicular drains
	Lakes, rivers and coastlines	
	Hedges	
Recommended clearance each side	1.0m	0.3m
Minimum clearance each side	0.3m	0.15m

Note:

- Extra clearance up to 0.8m is necessary on bends, where cyclists will lean into the corner.
- For example, on a path with fences (i.e. continuous features) on either side, the width between the fences should be the width of the path plus 1.0m. Clearances for continuous or discrete features in Table C2 should be measured at handlebar and shoulder height relative to the path edge.
- If a trail is built on hill with a side slope it is preferable to situate the trail with trees on the downhill side rather than close to the uphill side. This means riders are more likely to naturally keep clear of the drop at the edge of the path.

C3 Pinch points

It may not always be practicable to provide the required width for the entire path length. Large trees, rocks, bluffs, steep cross slopes or other geographic features may produce 'pinch points' on a path. These features can be tolerated as long as there is adequate visibility leading to them or advance signage, and safe opportunities for path users to stop before the pinch point and give way to oncoming users or wheel their cycles. Particular care should be taken to avoid pinch points on Grade 1 or 2 paths.

However, pinch points can be specifically incorporated in the design to enhance safety by slowing down cyclists at approaches to hazards such as road crossings or blind corners. These deliberate pinch points are termed 'chokes' and are covered also in Section C6.

C4 Vertical clearances

Refer to Figure C1 for operating space requirements. Overhead hazards can include tree branches, overbridges, tunnel soffits, signs, wires and cables. A minimum vertical clearance of 2.2m to overhead hazards is recommended for all trail Grades. However, a 2.0m vertical clearance may be used for discrete overhead hazards, such as tree branches or existing structures. Users should be advised of such hazards in advance and at the restriction (see Figure C2), and ,if necessary, slowed down before reaching the hazard.

Figure C2: Warning sign for a low underpass, Nelson

C5 Trail alignment and shape

When a path must bend or turn a corner there are four main methods that can be used: standard bends, switchbacks, climbing turns and super-elevated ('in-sloped' or 'berm') turns. These are summarised in Table C3.

Table C3: Types of curve

Corner type	Description	Application and notes
Standard bend	The curve and its approaches are on level ground, and no specific treatment is required.	Apply to flat sections of trail. Most common on Grades 1 and 2.
Super-elevated ('in-sloped' or 'bermed') turn	The outer edge of the curve is banked to allow for faster travel around the corner.	Very popular, particularly on Grade 3–5 tracks. Angle of berm depends on the Grade of the track and radius of the corner. More experienced riders enjoy steep berms. Berms enable people to ride around corners easier and faster.
Switchback	The gradient of the path as it turns is flat while the approach and departure to the curve are on sloped sections.	A common method of providing turns on steep terrain, where berms are not easy to build. Also important for shared use trails where high speeds are not desired.
Climbing turn	The curve itself is located on a sloped section of path (which possibly includes super-elevation/a berm).	Can only be applied to gently sloping hills. Much easier to construct but may require more maintenance than switchbacks.

C6 Sight distances and visibility

Path safety depends on users being able to detect a potential hazard and either stop safely before encountering it or manoeuvre safely around it. The required distance is called 'stopping sight distance' (SSD). Good trail building practice and maintenance will endeavour to eliminate blind corners and create good lines of sight.

If visibility is limited around corners it may be necessary to set back vegetation or fences so that cyclists can maintain the appropriate line of sight around the corner. However, it may be difficult to achieve this, and the result might damage the trail's aesthetics.

An alternative is to provide two separate trails around a blind corner, with signs advising users to keep to the left (or in some cases, the right), of the trail.

Or, if a trail is reasonably wide, 'keep left' signage in itself may be sufficient (or marked arrows and a centreline on a sealed track).

'Chokes' (localised narrowings) or grade reversals can be used to slow cyclists down on approaches to blind corners, intersections or other potentially dangerous locations.

For more experienced mountain bikers, part of the enjoyment comes from the challenge of having to react quickly rather than having plenty of warning before encountering a path feature. This should be balanced with the likelihood of two cyclists (or a cyclist and a walker or jogger) encountering each other head on without sufficient warning.

In urban areas, visibility of trails by the public is also important for personal safety and security.

The track needs to be built and maintained to the visibility/sightlines assessed as appropriate for the Grade of trail. If the required sightline cannot be practicably achieved for sections of the track due to extenuating circumstances (such as, but not limited to, archaeological, cultural, ecological, geological/geotechnical, landscapes/visual or statutory reasons), then the track must achieve the maximum practicable sightlines, and other treatments and mitigations must be considered, and implemented where appropriate.

C7 Fall heights

Decision framework for determining fall treatment

Aspect – Consequence	Key question	Yes/No
Height of fall/slope steepness (i.e. slope so steep and long that arrest is unlikely and is no different to a free fall)	Is the height or length of fall likely to result in death or serious harm?	**Yes/No**
Secondary consequences of a fall (i.e. being swept away in a river)	Are there secondary consequences present that if the fall is survived, are likely to lead to death or serious harm?	**Yes/No**
Presence of hidden hazards (e.g. proximity of undercut riverbank)	Is there a hidden hazard(s) present that is likely to contribute to a fall that is likely to result in death or serious harm?	**Yes/No**
	If yes to any of the above, a likelihood assessment must be undertaken in order to determine risk level and adequate risk treatment	

Note: In the interests of conservatism and safety, if the height of fall/slope steepness has been selected as a **yes** then further consideration is triggered and treatment is warranted

Aspect – Likelihood	Likely (1)	Possible (2)	Unlikely (3)
(a) Width of track (e.g. a 2m wide track will be less hazardous than a 0.3m wide one)	<0.6m	0.6–1.5m	>1.5m
(b) Track conditions (e.g. even, slippery or rough surface)	Unstable, rough, out-sloping and/or slippery	Stable, loose and rough	Stable, firm and relatively smooth
(c) The presence of vegetation on the downslope bank/bluff/slope	None	Some – may arrest/break fall	Abundant, sturdy, likely to arrest/break fall
(d) The alignment of the track relative/adjacent to the hazardous section and the visibility (line of sight) relative to the hazardous section	Blind corner leading into drop-off	Curvy trail but with line of sight equal or greater than stopping distance	Straight, ample line of sight
(e) Expected level of rider ability	Grade 1 and 2	Grade 3	Grade 4 and 5

Perceived level of risk	**High (score 5–7)**	**Moderate (score 8–10)**	**Low (score 11–15)**
Suggested risk treatment	Engineered safety fence as per design code	Physical treatment using any or a combination of outer bunds, natural barriers (i.e. large placed rocks); physical impediments (i.e. gate system); inside safety cable; specific warning signs	Generic advisory and communication as per mechanisms outlined in this document

C8 Surface materials

C8.1 Design

Gradient and drainage features are the two most significant predeterminants of trail life expectancy; refer to the earlier Sections 2 and 2.4 for more guidance on these aspects. On a steep track with no drainage features, skidding tyres and running water will result in chronic loss of the track surface. The finer materials will be transported down the track until it reaches a grade reversal. Left behind will be rocks, roots, ruts and bedrock. On a poorly designed track, this can happen within 12 months, making the track a Grade or two higher, and resulting in considerable soil erosion.

Loss of surface material can be greatly reduced by using out-slope and grade reversals. Out-slope can be lost over a few years of track use as compaction and displacement lead to dishing (the stage before rutting) along the centre of the track where use is greatest. That is why grade reversals are critical. They break up the 'water catchment' and, if they are large enough, they take a long time to fill up.

Where out-slope is not used, the track should either have a crown, or in-slope (see Figure C3). In-slope is common on berms, where the water is directed into the hillside of the track for a short distance, and then directed into a culvert, or across the track at a grade reversal.

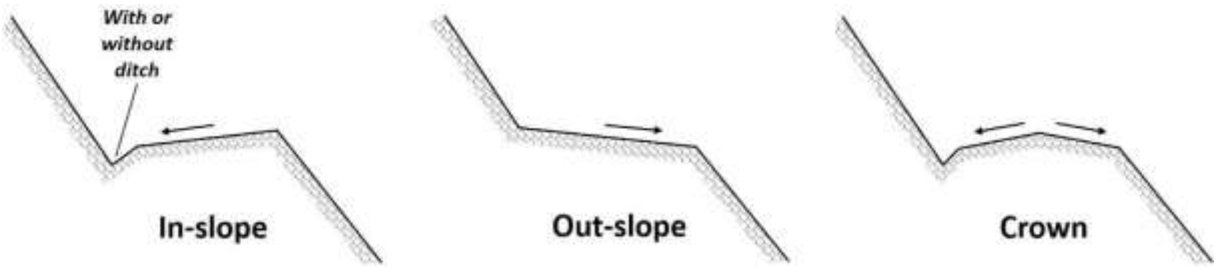


Figure C3: Different options for trail cross-sections

Imagine you are rolling a ball down your freshly built track – it should run off the track as soon as possible.

C8.2 Surface material solutions

Except for volcanic soils, all trails should be surfaced and compacted.

Where surface erosion is a problem, usually due to gradient, the common solutions are to apply a harder, more erosion-proof surface. On mountain bike tracks it is common to use rock armouring, by gathering material from around the track and starting from the bottom, building up a rock layer. This is time consuming, but very effective.

Closer to urban areas, several of the New Zealand Cycle Trails have resorted to sealing steep sections, or sections that are prone to flooding. Materials used are concrete (the most expensive and longest lasting material), asphalt, and chip seal (4 + 6 chip size). Chip seal is the cheapest, but also the bumpiest (generally not an issue for trail riders, but any commuter and sports training riders present may prefer smoother surfaces).

Vegetation cover greatly increases life expectancy by reducing climatic extremes of rainfall, heat, and wind.

C8.3 Compacted gravel or crushed limestone

These paths are formed by laying a compacted gravel layer and thus have a semi-loose surface. It is imperative that the gravel is relatively fine and crushed, as round stones do not bind to make a firm surface and will result in a difficult riding surface.

Uncrushed river gravels, or any other material with round stones, should not be used. Often 'dirty rock' with a range of aggregate sizes from a local quarry can be a cheap, effective trail building material.

A component of fine material (limestone or clay) is required in compacted gravel to aid binding. Limestone has the advantage of having natural cement properties but will not be cost-effective unless it is available locally.

The top layer of these surfaces is generally constructed with a crown at the centre and very little material at the sides. Over time, as cyclists generally ride on the centre of the trail, the trail flattens out.

Users of off-road NZCT routes are expected to be using mountain bikes, which have wider tyres than road bikes, so compacted gravel can be one of the more cost-effective and appropriate surfaces. Coarse or loose gravel surfaces are unsuitable for bicycles with narrow tyres such as road cycles, which are favoured by most touring and long-distance, multi-day cyclists. Designers should determine what type of bike (and therefore tyre) will be used on the trail and specify materials accordingly.

Gravel is often a cheaper option, especially if rocks excavated on-site can be crushed and used to surface adjacent sections of trail. Another advantage of using naturally occurring surface materials is that the surface looks natural and fits into the environment. However, the low capital cost required for these trails can be offset by high operational costs to maintain them. It is important that compacted gravel paths are cleared of vegetative matter during construction and plants are prevented from growing in them. The aggregate is likely to spread and thus it may be necessary to sweep loose aggregate back onto the path where it spreads onto drainage features, roads, driveways, or other critical locations.

Figure C4: Compacted gravel section of Little River Rail Trail at Catons Bay

C8.4 Compaction

Compaction binds the trail aggregate and removes air gaps that water would otherwise get into. It makes the track strong and impermeable to water. Do not compact more than 200mm thickness of material at a time.

Gravel should be at the optimum moisture content when compacted. If it is too wet it will stick to the plate compactor machinery and hinder the process. If it is too dry it will not bind. Gravel should be of mixed size to facilitate binding into a dense and firm riding surface.

The material beneath the surface is also important. Gap-graded aggregates (like railway ballast used on rail trails) form a good structural base with excellent drainage properties and can provide surplus water storage if there is a known flooding problem in the area. However, too much drainage in dry environments can also cause problems. Experience on the Otago Central Rail

Trail (OCRT) shows that a very dry surface can prevent the establishment of a firm, cohesive surface. To counter this, the OCRT operators use a consolidated AP40[7] layer between the railway ballast and surface material (well-graded AP20 with a high clay content).

There is no single formula that provides the solution for all trail surfaces. The appropriate surface for a section of a trail will depend on underlying substrate, topography, trail Grade, projected use and climate. Solutions that may give the best durability may be prohibitively expensive for the number and type of users on a given trail. Over the length of a trail there is likely to be a variety of substrates so the trail surface and underlying layers will need to vary as well.

C8.5 Natural surface

Low volume farm roads with natural (i.e. uncovered soil) surfaces, where motor vehicles provide compaction and prevent vegetation from growing, may also be appropriate for off-road trails. In most cases, natural soil surfaces are likely to be only applicable to mountain biking paths of higher Grade.

The natural surface may be a more rocky surface, such as gravel or even large rocks. Such surfaces can be appropriate for paths of higher Grade trails where riders are experienced in riding on loose surfaces. Figure C5 shows an example of a path with a natural gravel surface.

Figure C5: Natural surface, Great Lake Trail, Taupō (Photo: Jonathan Kennett)

Natural surfaces can also include the volcanic soils commonly found in the central North Island. Regardless of the soil type, all organic matter should be removed and only mineral material used. Organic matter decreases a soil's strength, promotes vegetation growth and water retention, and accelerates surface deterioration.

[7] A specification for medium-sized gravel – 'all passing 40mm' sieve. Will ideally contain a mix of stone sizes, including clay.

Stabilising products can be used on natural surfaces in critical areas to strengthen the trail and provide higher skid resistance for cycling. Figure C6 shows a 'geomat' applied on a steep track with loose surface in Tongariro National Park; aggregate is then placed on top of this base. Geotextiles are useful at sites with high use, extreme weather conditions and erodible soil.

Figure C6: 'Geomat' surface stabilisers (prior to having aggregate placed on top), Tongariro National Park (Photo: John Bradley)

A more natural alternative to surface stabilisation is to apply 'rock armouring' or 'stone pitching' whereby rocks are used to pave the ground surface. Finer gravel or sand can be applied on top of the rocks to produce a smoother surface, depending on the target skill level of riders. This is, however, generally a labour-intensive treatment. Figure C7 shows an example of a rock armoured path.

Figure C7: Rock armoured path – Nichols Creek Track, Dunedin (Photo: Kennett Brothers)

C8.6 Recommended surface types for path grades

Table C4 outlines the recommended surface types for Grade 3. The appropriateness of natural surfaces also depends on site and user characteristics; stabilising materials may be required.

Table C4: Recommended surface types for Grade 3 trails

Grade 3	Recommended surface type
 INTERMEDIATE	Compacted gravel/lime-sand Natural surface (except loose gravel)

C9 Construction

Here are ten useful guiding principles for track construction.

- Keep water away from the track surface
- Construct sustainable gradients
- Make the track flow
- Provide a suitable surface
- Maintain a good surface
- Maintain when required
- Be environmentally astute
- Protect your investment

- Train staff
- Respect and keep historic values

Cyclists have indicated that they like to feel as if they are exploring the 'wilderness' but not as if they are biking on a country road. It is important to communicate this message to contractors who may be tempted to provide extra but unnecessary width. Contractors normally involved in road construction may not understand the specific requirements of Grade 3 and above trails; whereas roads are built to be smooth, straight, level and consistent, more experienced riders appreciate some challenges in the form of curves, grade reversals, slopes and changes in path alignment.

The best way to communicate the trail requirements to a contractor may be to ask them to ride a trail of a similar Grade with a trail designer and then discuss the trail's characteristics and desirable aspects from a design perspective.

C9.1 Vegetation clearance

Trees and shrubs should be assessed for their ecological value, and where possible, exotic species removed rather than native species. Trail alignment should be adjusted to avoid removing rare and/or large native trees, which are valuable to the landscape amenity and ecological values of the trail. At all times, vegetation clearance should comply with statutory requirements.

All limbs should be cut flush (or to within 10mm) of the trunk or main branch, or ground level. This makes the cut branches less of a danger if people fall onto the cut branches, and it is also healthier for the tree.

The danger of cut branches and stumps on or near trails cannot be overstated. Potential injuries include stab wounds, broken bones, facial lacerations and lost eyes. All trimmed branches near trails should be cut flush with the main branch or tree trunk. Stumps should be dug out of the ground or cut at or below ground level.

All cut woody vegetation should be removed from the track surface and either chipped or moved out of sight of the track (this applies to DOC and council reserves, and other areas where the native vegetation is valued). In pine plantations it is not usually necessary to move cut vegetation out of sight.

C10 Data collection

All Great Rides are required to have automatic counters appropriately placed along the trail to provide the number of Trail users. As part of governance and management of a trail, Great Rides are required to provide an annual target number of completed surveys. Trail managers need to encourage users to complete the survey. Survey alerts are a useful tool for trail management.

C11 Accessibility

On-road and off-road trails may be used by cyclists with disabilities, using a range of equipment that may differ in size from a bicycle. This includes:

- tricycles (recumbent and upright)
- tandem bicycles
- hand cycles (recumbent and upright)
- e-bikes
- wheelchair tandems
- wheelchair clip-ons
- cargo bicycles and tricycles
- cycle trailers
- bicycles with stabiliser wheels.

Further guidance on making cycle trails inclusive can be found in NZTA's Accessible cycling infrastructure: Design guidance note.

C11.1 Trail barrier remediation – least restrictive access

Physical gates and barriers present significant challenges for the accessibility of outdoor tracks and trails. Many people, including those with disabilities, are affected by such barriers.

Gates and barrier structures along trails should not be a barrier to access for trail users. However, preventing motorcycles and other prohibited vehicles from accessing trails is difficult when trying to accommodate possible legitimate trail users. Meeting the needs of those with modified cycles or cycles with child trailers, adaptive equipment, and parents with prams, as well as not creating hazards for people who are Blind or vision-impaired, may be a challenge, but requires consideration.

Recreation Aotearoa is working with the Outdoor Accessibility Working Group, supported by the University of Canterbury's Dept. of Mechanical Engineering, to develop a decision-making matrix to support more effective decision-making about the use of barriers and access control mechanisms on trails.

Here is the most up-to-date guidance relating to improving barrier accessibility.

C11.2 Is the barrier necessary?

Several types of gate and barrier structures have historically been implemented to address motorbike concerns on trails. It's important to **re-consider if historic rationale for barrier use is still valid on your trail**. Read about an example cycle trail in the UK that re-assessed the need for such barriers and implemented a trail period to understand the effect of changing a barrier.

Unless there is a well-documented and informed health and safety concern or issue to address on your trail, barrier removal should be a priority.

C11.3 What other control mechanisms can be used?

Signage discouraging the use of prohibited vehicles and motorcycles (including information on relevant consequences, such as confiscation of prohibited vehicles and equipment).

Partnering with local police and authorities to provide more frequent surveillance of areas identified as problematic with anti-social behaviour.

Bluetooth keypads with changeable pin-codes (with clear, readily available guidance on how users obtain a code for access).

C11.4 The Least Restrictive Access principle

The principle of Least Restrictive Access (LRA) is that all new work and maintenance repairs should aim to achieve the most accessible option. Least Restrictive Access is achieved by identifying the least restrictive option for a specific feature, such as a gate or barrier. This is not just about selecting the type of structure, but also how to make and install the chosen structure in the least obstructive way for trail users, to maximise accessibility for as many people as possible.

The UK Sensory Trust, on behalf of Natural England, has modified the principle of By All Reasonable Means, Least Restrictive Access to the outdoors to the following:

> *A gap, or no barrier, is less restrictive than the modified squeeze gate (specifications below), which is less restrictive than a traditional squeeze gate. So, when a traditional squeeze gate needs repair or removal, the first option is to remove it entirely. If this is not an option, it is replaced by the modified squeeze gate. The last resort is to replace the traditional squeeze gate.*

C11.5 Existing barrier structures

C11.5.1 Bollards and concrete blocks

These mechanisms do not prevent motorcycle access.

If you are using bollards or concrete blocks to prevent 4-wheeled, or car, access, make sure that there is **at least a 1.7m** clear width between adjacent bollards; there is no linking chain or rope of any kind between bollards; the bollard strongly colour contrasts to the background, and there is lighting or a reflector band around the top (visible from any direction).

The bollard should be clearly marked, by painting it in a visible colour, with reflective disks. On paved surfaces, a white diamond should be painted around the bollard, leading at least 10m (greater if the approach speed is likely to be over 30kph) before and after the bollard, and 300mm either side (ideally 450mm). Also, bollards should either be no more than 700mm high, to be below handlebar height, or they should be at least 1.5m high so that they are clearly above handlebar height. The worst height for bollards is around handlebar height, as this means people find it hard to judge if they will miss it or not.

C11.5.2 Chicane gates, croquet hoops and squeeze gates

These can limit access for prams, child bike trailers, larger mobility equipment, like mobility scooters, and many pieces of adaptive equipment such as adaptive mountain bikes, recumbent cycles, tandem cycles, trikes, as well as e-bikes and heavier equipment that users must lift or manoeuvre to navigate the chicane or squeeze gate.

If there is a grass area around the side of the chicane, squeeze gate or croquet hoop, this will not prevent motorcycle access.

If a croquet hoop or squeeze gate **must** be used, traditional specifications have been modified, in consultation with local trail users, to be made more accessible.

Powder coating the barrier (in a high-contrasting colour to the background) also enhances its accessibility for people who have low vision and sight impairments.

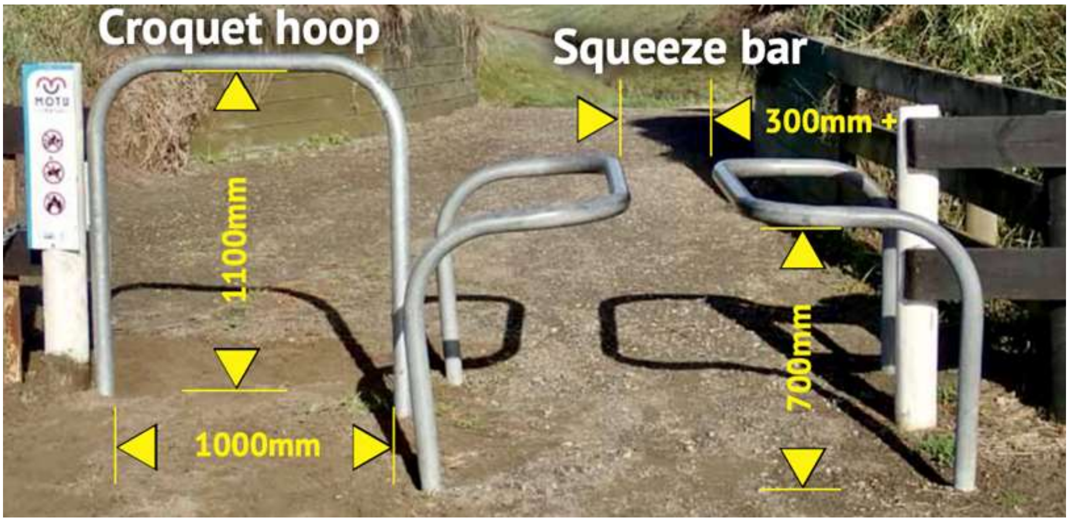


Figure C8: Accessibility modifications for hoop and squeeze barriers

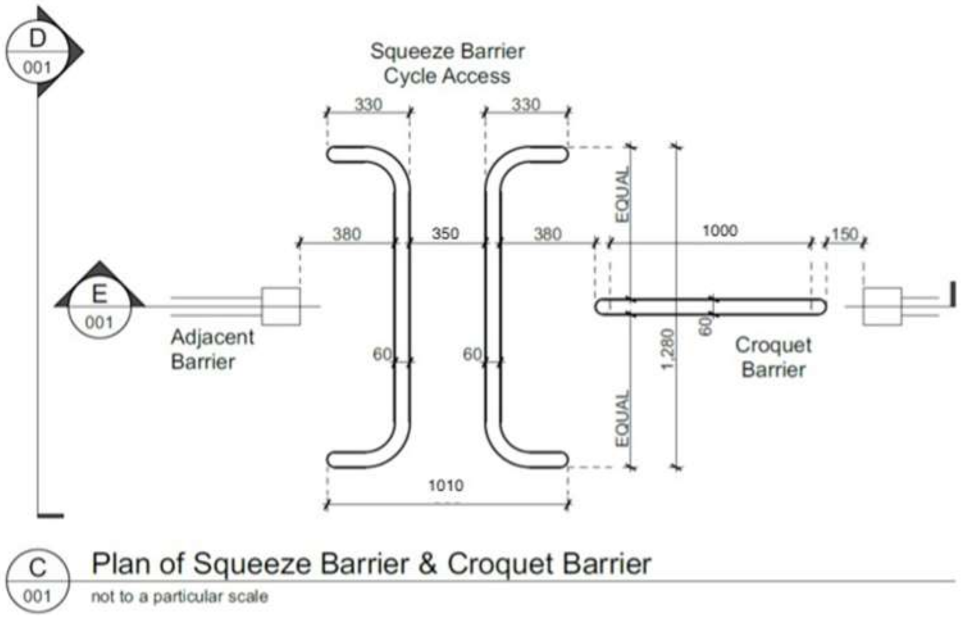


Figure C9: Dimensions for accessibility modifications

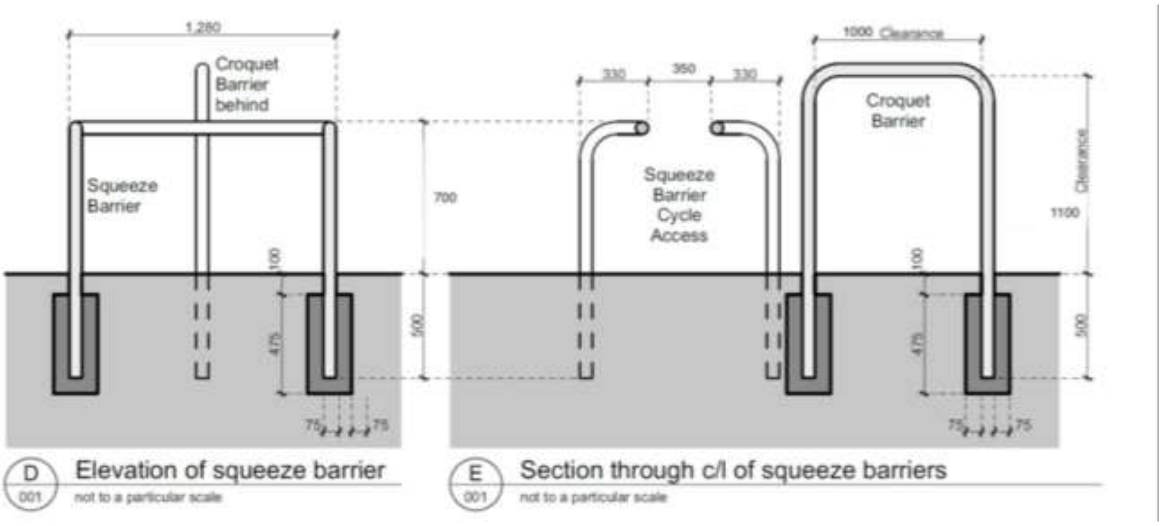


Figure C10: Dimensions for accessibility modifications

Although these specifications are more accessible than traditional squeeze gate and croquet hoop design, **they are not 100% accessible** for all types of mobility devices or adaptive equipment.

Evaluating the absolute necessity of this barrier, including its appropriateness for your type and Grade of trail, and its placement on the trail, remain important considerations.

C11.6 Notifying trail users of barriers and limitations

Trail users will want to know ahead of time:

- Where is the barrier on the trail?
- What does it look like? Can you attach a photo or diagram to your map?
- What are the dimensions of the barrier? What equipment do you know can fit through?
- Are there alternate entrances, such as nearby gates which can be unlocked, that users can arrange ahead of time?
- Who can users contact for more information?

Motu Trails has a great example of displaying this information. Read more about their barrier access on trails, with supporting access information here.

For information specific to urban cycleways and access control mechanisms and barriers, see NZTA's *Accessible cycling infrastructure: design guidance note*.

For further advice on trail accessibility and barriers, or to be kept up to date with the barrier guidance, please contact Katie Owen, Disability and Inclusion Programme Manager.

C11.7 Trail accessibility

Path end or 'terminal' treatments are used at ends of off-road trails (paths) to warn people of the approaching transition to on-road trails (or simply a road, without cycle provisions) and to prevent motor vehicles from accessing the paths. While physical restrictions have been commonly used historically at path ends, they should not be seen as a default treatment, and many trails will operate very well without them.

Path end treatments should not necessarily be designed with the aim of slowing cyclists down and should not provide an obstacle that distracts riders' attention from the impending transition to the roadway. Circumstances where cyclists should be required to dismount are rare, so route end treatments should allow people to comfortably ride through without awkward manoeuvring.

Bollards and staggered fences or U-rails are preferred path end treatments, where necessary. These devices can be designed to prevent access by motor vehicles, including motorbikes. It is recommended that designers seeking further guidance in this area read the NZ-specific guidance on 'Access Control Devices', which will be referenced in the *Cycling Network Guidance* (NZTA, 2019). To support 'safe system' principles, the default position in the new NZTA guidelines is that access control devices should typically ***not*** be used on facilities used by cyclists.

Barriers at path ends that block entry to users of wheelchairs, trikes, etc., should be avoided if possible. They stop some valid users from accessing the trail and will lead to complaints, so consider if they are really needed. Barriers to stop cars do not need to be so narrow that they also stop non-motorised devices.

New barrier designs are starting to be developed that allow for a wider range of legitimate users to gain access – e.g. Figure C11.

Figure C11: Example of a wheelchair-accessible barrier, Belmont Regional Park (Photo: Greater Wellington Regional Council)

Bollards are a hazard to users. If they are used then they should be spaced 1.6 to 1.7 metres apart, and not in the centre of the trail. The bollard should be clearly marked, by painting it in a visible colour, with reflective disks. On paved surfaces, a white diamond should be painted around the bollard, leading at least 10m (greater if the approach speed is likely to be over 30kph) before and after the bollard, and 300mm either side (ideally 450mm). Also, bollards should either be no more than 700mm high, to be below handlebar height (see Figure C12), or they should be at least 1.5m high so that they are clearly above handlebar height. The worst height for bollards is around handlebar height, as this means people find it hard to judge if they will miss it or not.

Figure C12: Path end treatments, West Coast Wilderness Trail, Greymouth

Frangible plastic hold rail could be used at highway crossings where NZTA may not allow a fixed steel hold rail due to risk of highway users hitting it in a crash.

Figure C13: Path end treatment, Hawkes Bay Trails (Photo: Jonathan Kennett)

C11.8 Excluding motorcycles

Motorcycles can be problematic on cycle trails. Various techniques exist to discourage this nuisance, including the positioning of central posts in trails and at gateways or cattle-stops to discourage their use. However, note the discussion above about ascertaining whether the problem is real (and significant) or perceived, particularly where any barrier treatment would severely restrict other legitimate trail users.

One technique, a ‘squeeze barrier’, is illustrated in Figure C14, with the full design specifications given in Figure C15. Note that if this barrier arrangement is used on trails where cyclists use pannier bags, the horizontal bars should be installed at the maximum stated height of 870mm. Accurate installation is critical. The width and height of these barriers must be consistent throughout a trail. A jig will be needed for installation, and the trail surface should be checked annually, as if it compacts from wear and tear, then the effective bar height will be higher. A sealed surface underneath might be advised, so that the height stays the same. If there is a notable gradient on the trail, then the tops of the barrier should also mirror that gradient, to be parallel with the track surface.

Riders need a straight approach for 10 metres before a squeeze barrier. They cannot be installed on corners as riders cannot ride through them.

Figure C14: 'Squeeze barrier' to discourage motorcycles, Remutaka Cycle Trail (Photo: Jonathan Kennett)

C12 Environmental considerations

Trail designers and builders must consider the environmental impact of the trail construction (for example vegetation clearance, rare plants, wildlife, siltation of streams and wetlands). Efforts should be made to design the trail to get the most out of the environmental beauty of an area by working around trees, passing natural features, and transplanting small seedlings that are in the path of the track.

For a natural surface trail to be sustainable it should incorporate the principles of sustainable gradients (as discussed in Section 2.5), frequent grade reversals (to aid drainage – as discussed in Section 2.4) and weed control (as discussed in Section 8).

Opening a natural surface trail to light can encourage weed growth and degrade the microclimate. The natural tree canopy should not be disturbed if possible. Some invasive weeds (for example, African clubmoss and didymo) are easily transferred from one trail to another, even by bicycle tyres. At the design and construction stage, these weeds need to be identified and eradicated or controlled (where possible). If infestations occur after the trail has been built, on-going control techniques will be required. Clean all earthworks machinery, hand tools and PPE before taking onto a new site, to avoid importing weeds. Imported gravel, soil and rocks must be from a weed-free source.

In areas of native forest, the environmental values should be assessed first. An Environmental Impact Assessment (EIA) report from a qualified ecologist may be required. Mitigation of the effects of trail building can enhance a track and the users' experience. For example, at Makara Peak Mountain Bike Park in Wellington a native tree is planted for every metre of track built.

This mitigation measure is very popular as it results in a combination of recreation and conservation that people appreciate. Several NZCTs have planted thousands of trees beside their trails.

Tree planting provides shade, bird habitat and wind breaks (which help to prolong the life of the trail surface). Over time, native trees also replace undesirable introduced plants such as gorse and blackberry.

Some trails also have stoat/rat traps set up alongside the trail to improve the environment for native birds.

It is preferable to fill between and over roots rather than digging them out. See Section 8 for further guidance about maintenance of trails with roots.

As discussed in Section 2.1.5, the natural landscape is an important factor that should be considered during initial design stages. There are often opportunities to 'recycle' local materials (e.g. crushing excavated rocks to be used as base course or surfacing over roots) when building trails. This adds continuity to the trail, decreases environmental impact and can cost less than importing materials.

Councils have rules restricting the amount of earth that can be moved and the maximum cross slope of terrain that a track can be built on. Trail designers and builders need to become familiar with these rules, which make sense from both environmental and track sustainability standpoints. Check local council plans and rules to be informed of restrictions, as well as Resource Management Act requirements, before design and construction stages.

Culverts may disturb the natural movement of native fauna. Boardwalks and bridges have less impact on watercourses but are more expensive than culverts.

After construction, undertake a special trip to remove survey tags, construction materials/signs and any general rubbish.

C13 Culture and heritage

Consideration under the Treaty of Waitangi Partnership and the *Heritage New Zealand Pouhere Taonga Act 2014* requires trail managers to consider cultural and archaeological factors. Engagement with iwi will help at the trail planning stage, and an archaeology report may need to be written.

Middens, pā and urupā are taonga and there is a legal requirement to treat historical sites (over 100 years old) with respect and have them examined by an archaeologist. These clues to the past can be explained through interpretation panels and will enrich the riding experience by connecting people to the unique environment and stories that contribute to who we are as New Zealanders.

Among solutions to challenges noted in the heritage and archaeological space are the following.

- You may need to identify any existing heritage orders for sites you are developing, as described under Part 8 of the *Resource Management Act 1991*.
- Walking and cycling trails commonly involve earthworks on previously unmodified ground. Archaeological heritage might be missed as it is more invisible and involves a separate consenting process from Heritage NZ.
- Heritage NZ maintains the New Zealand Heritage List and the National Historic Landmarks list where you can identify notable historic and cultural sites around the country.
- It's a small cost to get a high-level archaeological risk assessment for starters – the full Heritage Impact Assessment/AEE can come later if required. Identifying any archaeology early in the process will greatly help forward planning.
- The NZ Archaeological Association's database records are indicative only. Additional information on potential for sites should be sourced from iwi/hapū, Heritage NZ, and an archaeologist with local knowledge.
- Repurposing heritage structures (bridges/tunnels, etc.) has been particularly successful in adding existing infrastructure to walking/cycling trails in a cost-efficient manner.

Build a relationship early in the project life with regional Heritage NZ staff so you can tap their expertise.

Heritage represents an opportunity to enhance sense of place and identity and build community well-being. For more guidance, refer to NZTA's factsheet *Considering historic heritage in walking and cycling projects* (2019).

C14 Bridges and boardwalks

Ideally bridge and boardwalk widths should be consistent with the overall path and therefore designed according to the path width requirements outlined in Section C2 plus additional clearances for 'shy space' due to handrails or walls etc. However, this may not always be feasible, especially for long spans or constrained locations, in which case the minimum bridge widths outlined in Table C5 can be used.

C14.1 Bridges

C14.1.1 Width

It is usually relatively cheap to provide additional width for a cycle bridge. A bridge that is 50% wider than the minimum width will generally be much less than 50% more expensive, yet provide a much more pleasant cycling experience.

Table C5: Bridge and boardwalk widths

Grades	Recommended bridge width	Minimum bridge width *
3	1.2–1.5m	0.8m

Note:

- Handrails on minimum bridge widths should be flared out.to provide handlebar clearance.

C14.1.2 Handrails

It is preferable to slope handrails outwards (17.5–27% from the vertical) to allow more space for handlebars and thus allow more of the bridge deck to be safely ridden on. Flaring the handrails in this manner increases the effective width of the structure at minimal cost and generally improves the appearance of the structure. The minimum bridge width (from Table C5) is required at the surface of the bridge but flaring the handrails allows more clearance at handlebar height (taken as 1.0m) and therefore makes the experience more comfortable for riders.

Handrail barrier height should be at 1.2m high. Any current barriers being replaced, or new barriers, must meet this height requirement. Existing guardrails and barriers should only be replaced at the end of their life where a significant hazard exists. This excludes on-road assets. Handrails for new bridges and replacement bridges on road sections are to comply with Waka Kotahi New Zealand Transport Agency standards.

If a bridge or boardwalk does not have handrails, people will be wary of cycling too close to the edge for fear of falling and suitable clearances for 'shy space' should be provided (see C2 – clearances). Table C5 indicates the recommended bridge width according to path Grade. It may be appropriate to increase this width where possible, especially for bridges of length 20m or longer or on curved sections as cyclists need more space when cornering. Passing/viewing bays should be provided at 50m intervals on bridges (if feasible) and boardwalks; they should be 5m long by 2.5m wide and have handrails. It is not practicable to provide passing bays on suspension bridges and cyclists will need to ride in single file. If cyclists approach such a bridge from opposite ends, one direction will need to give way to the other.

Handrails should be used on significantly curved bridges or bridges 20m or longer if only the minimum width is provided. If the bridge is at least 0.5m wider than the minimum width, handrails are optional (unless the fall height governs). HB 8630 uses an equivalent value of 1.0m but the risk and safety implications of falling off a bridge or boardwalk are likely to be more severe for cyclists than pedestrians. Cyclists travel at faster speeds and fall from a greater height (due to their position on the cycle) than pedestrians. Cycles can also complicate a fall by catching pedals or handlebars on a structure during the fall or hurting the rider on landing. Refer to Section C14 for decision framework on fall heights.

The guidance provided in this section does not override any legislative requirements.

C14.1.3 Passing/viewing bays

When designing these structures, consideration of the requirements for cyclists passing each other is needed. Similarly, the effects of cross-winds can make cycling unstable and this needs to be addressed when choosing appropriate widths and deciding whether or not to provide handrails.

A typical (although notably narrow) boardwalk is shown in Figure C15 – it would require handrails and passing bays for a Grade 1 or 2 trail.

Figure C15: Boardwalk – Twizel River Trail (Photo: Kennett Brothers)

C14.1.4 Vertical clearance

The vertical clearance of a bridge above a river should take into account the potential river flood height. In some cases, it may be acceptable that a river level will occasionally rise above the bridge deck, but this risks the integrity of the structure. It is up to the trail owner to specify the appropriate flood design in this circumstance, to erect suitable warning signs and to ensure a suitable inspection and maintenance regime is in place.

C14.1.5 Drainage

NZCT path drainage guidance (Section 2.4) should be used for structures where appropriate rather than HB 8630 track drainage standards, which apply to natural surface walking tracks.

C14.1.6 Skid resistance

UV stable polymer mesh should be used on bridges and boardwalks to increase skid resistance. Wooden surfaces can be dangerously slippery when wet and make corners particularly difficult to negotiate. Wire netting is also a possibility, but it tends to wear out quickly on wooden boardwalks. Boardwalks are very susceptible to frosts and can become hazardous for early morning users. Consideration should be given to surfacing treatments in frost sensitive areas to mitigate the effects of ice on the path surface.

C14.2 Swing and suspension bridges

The terms 'swing bridge' and 'suspension bridge' mean different things to different people. In this design guide, a suspension bridge is a bridge suspended from cables with a fairly rigid deck and may be wide enough for two people to walk across side by side. A swing bridge is a lighter structure, also suspended from cables, but the deck is flexible and often made from steel cables and metal bars, perhaps with wire mesh. They are often used on tramping tracks and are just wide enough to walk across.

In some situations, the type of bridge to be used will be governed by physical features, financial considerations and possibly the logistics of getting construction materials to the site. A swing bridge is often the preferred bridge structure for walking tracks and may also be the most practical alternative for more remote cycle trails, especially when crossing long spans.

Figure C16: Suspension bridge on the Old Ghost Road (Photo: Jonathan Kennett)

Due to their freedom of movement, swing bridges will generally not be suitable for cyclists to ride over. Some cyclists may try to ride over swing bridges, however, which could result in injury from impacts with the bridge sides. Thus, if swing bridges are used, they should be made as rigid as possible with signs to warn cyclists of the dangers of riding across.

Suspension bridges are more stable than swing bridges and can thus be used for all Grades of trail. Suspension bridges are generally a cheaper option than solid timber or metal constructions for longer spans.

Figure C17: Suspension bridge, Ōparara Valley Track

Swing and suspension bridges should comply with the requirements of HB 8630 (unless contrary guidance is provided in this guide).

C14.2.1 Approaches

A bridge or boardwalk narrower than the path will require end treatments to ensure cyclists are channelled onto the structure rather than off the side. This can be achieved by guardrails on either side. A storage space for cyclists to pull over on the approach to the structure (to rest or avoid passing or overtaking inside the structure) would also be appropriate. If provided, this should be on the left side approaching the structure.

C14.2.2 Aesthetics

Bridges provide the opportunity to add to a route's iconic nature.

Appendix 3D Grade 4 design information for contractors

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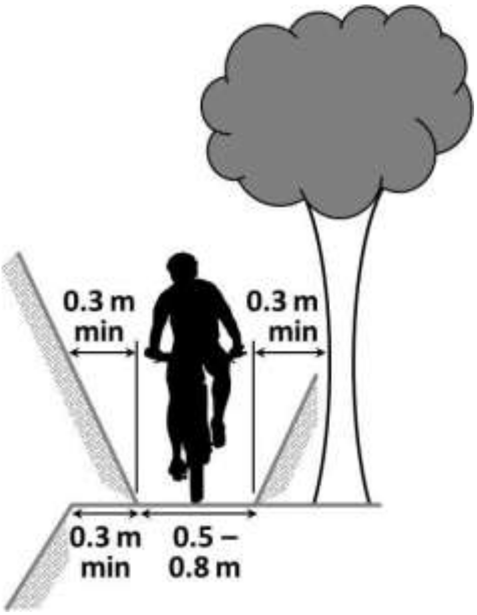
D. Grade 4 (Advanced)

Gradient

- **0–12.3%** for at least 90% of the trail (3.5 degrees = 6.0% = 1:17)
- **12.3–16%** for steeper slopes up to **100m** long
- **16–21%** for steeper slopes up to **10m** long (the less the better)
- Maximum **downhill** gradient **27%**

Width

- Single track: **0.5–0.8** metres wide (with adequate horizontal clearance to drops or banks/trees)



Formation

- Mono-slope with **3.5–7%** side slope (crowned surfaces are not desirable, but slope will be dictated by terrain and weather conditions)
- Greater side slope (super-elevation = berms) up to **58%** around corners

Surface

- Mix of firm and loose with some rocks and/or roots

Radius of turn

- **2–3 metre minimum** to outside of turn (the more the better)

Grade reversals

- **Required** at regular intervals including all water courses (some may have occasional water flowing across them) if they are not bridged or culverted
- Where appropriate, grade reversals will be large enough to add fun

Grade 4	Grade description
ADVANCED	**Description:** Steep climbs, with unavoidable obstacles on a narrow trail, and there will be poor traction in places. Possibly some walking sections. **Gradient:** 0–7% at least 90% of trail; between 12.3–16% for no more than 100 metres at a time, and maximum 21% for up to 10m at a time. If the track is designed and promoted to be ridden predominantly in one direction, then the downhills can be steeper (up to 27%). Sealed trails can be steeper (same as the equivalent Grade of on-road trail; see Section 3.4, Table 5). **Width:** 0.6m minimum on steep terrain with drop-offs, 0.3m minimum on flat ground. Horizontal clearances as in Section 3.4 Table 6. **Vertical clearance**: Minimum vertical clearance of 2.2m to overhead hazards is recommended for all trail Grades. A 2.0m vertical clearance may be used for discrete overhead hazards, such as tree branches, or existing structures. **Radius of turn:** 2m minimum, with 3m desirable to outside of turn. **Sightlines**: Best endeavours must be made to address sightline issues. **Surface:** Firm and loose. **Watercourses:** Watercourses bridged, except for fords with less than 300mm of water in normal flow, which can be easily ridden. **Bridge width:** Recommended 1.0m; minimum 0.6m. **Obstacles:** Many rocks/roots and ruts up to 200mm high/deep. Also, some purpose-built obstacles to liven things up, such as drop-offs and jumps. **Length:** 4–8 hours/day for advanced cyclists. **Barriers/guardrails:** Areas such as bluffs or bridges where a fall would result in death require handrails. Areas where a fall would likely result in serious harm require either handrails or sight rails or a warning sign, depending on the nature of the drop off and likelihood of a fall.

D1 Gradient requirements for unsealed trails

It is most important that the trail's Grade does not increase more than one Grade over the course of the route. It is acceptable to have short sections of a trail one Grade more difficult than the intended Grade, but it is generally undesirable to have harder sections of trail as some riders are likely to be forced to walk these sections. There is no point building a path that incorporates Grades 2 to Grade 4, as the Grade 4 sections will be impossible to negotiate by those riders whose level of experience and skill is suited for a Grade 2 trail.

It will be necessary to improve the Grade 4 sections to Grade 3 standard, or it will not be necessary to build Grade 2 sections, as Grade 3 features will suffice.

Table D1: Gradient requirements for unsealed Grade 4 trails

Trail grade	Main uphill gradient range	Steeper slopes up to 100m long	Steeper slopes up to 10m long	Maximum downhill gradient (up to 100m long)
4	0–12.3% for 90% of length	12.3–16%	16–21%	27%

Notes:

- This table applies to off-road unsealed trails and gravel roads.
- Maximum downhill gradient applicable only if trail is to be ridden in one direction.
- IMBA recommends a maximum gradient of 10% (5.7 degrees). Steeper trails will require more maintenance due to increased erosion from skidding tyres and water scour.

D2 Horizontal clearances

Figure D1 shows the operating space required for cycling. An important aspect of the operating space is the angle between the pedals and handlebars; the handlebars protrude further than the pedals and are more likely to catch on adjacent objects. This is why banks should be 'battered' (i.e. sloped, not vertical) and fences should ideally slope away from the path. This issue is increasingly pertinent as more bikes are sold with wider handlebars (e.g. nearly 800mm).

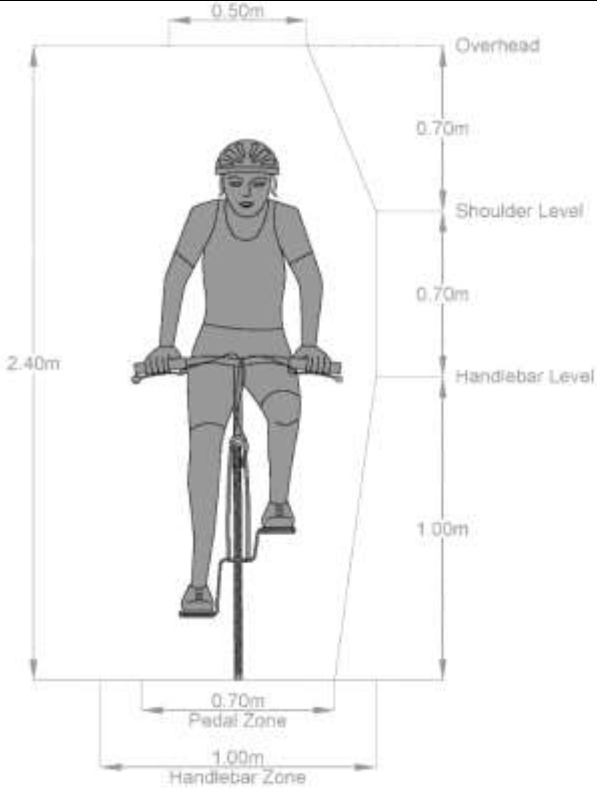


Figure D1: Cycle operating space

When travelling on a lean (for example, when travelling around a banked corner) the location of the cyclist's head and shoulders is also important. Cyclists may hit their heads or shoulders on trees placed too close to the inside of a curve. This can also be a conflict issue between cyclists and pedestrians on banked curves, as cyclists will be leaning while pedestrians are walking upright.

Cycle travel is dynamic. It is difficult to ride exactly in a straight line and less experienced users, in particular, require a fair amount of wriggle room or manoeuvring space.

If a path is restricted horizontally, for example by fences, bridge rails or discrete features such as trees or large rocks, an additional 'shy space' is required. Shy space is needed because cyclists are physically unable to ride on the edge of the path due to their handlebars and pedals extending further than their tyres. Cyclists also need space to allow for a certain amount of wobble and to ensure that they do not need to focus so hard on keeping to the trail that they are unable to appreciate their surroundings. Slower and less experienced cyclists wobble more than faster and more experienced ones.

As it is expected that the majority of cyclists will not choose to ride in the shy space, the clearance does not necessarily need to be constructed from the same materials as the actual path itself. Depending on the context, the shy space could be a grass verge or strip of compacted aggregate. In an urban area, maintenance requirements (e.g. mowing of grass verges) will generally make it more appropriate to create the shy space from the same material as the path. However, in rural areas, there is no point in building a trail right beside a fence as the native ground cover will need no special maintenance.

Horizontal constraints to a path also limit the ability for path users to deviate from the path in extreme circumstances where the path is not wide enough to accommodate all users. Thus, in addition to the path width given in Table D2, further width should be added for situations where at least one side of the path is constrained by adjacent elements. These elements may be either continuous or discrete, and examples are given in D2, along with the required clearances.

Table D2: Off-road trail horizontal clearance requirements

Feature Type	Continuous	Discrete
Examples	Fences	Trees
	Walls	Large rocks
	Buildings	Bridge abutments
	Guardrails	Sculptures
	Steep slopes	Power and light poles
	Rock faces	Sign posts
	Parallel drains	Perpendicular drains
	Lakes, rivers and coastlines	
	Hedges	
Recommended clearance each side	1.0m	0.3m
Minimum clearance each side	0.3m	0.15m

Note:

- Extra clearance up to 0.8m is necessary on bends, where cyclists will lean into the corner.
- For example, on a path with fences (i.e. continuous features) on either side, the width between the fences should be the width of the path plus 1.0m. Clearances for continuous or discrete features in Table D2 should be measured at handlebar and shoulder height relative to the path edge.
- If a trail is built on hill with a side slope it is preferable to situate the trail with trees on the downhill side rather than close to the uphill side. This means riders are more likely to naturally keep clear of the drop at the edge of the path.

D3 Pinch points

It may not always be practicable to provide the required width for the entire path length. Large trees, rocks, bluffs, steep cross slopes or other geographic features may produce 'pinch points' on a path. These features can be tolerated as long as there is adequate visibility leading to them or advance signage, and safe opportunities for path users to stop before the pinch point and give way to oncoming users or wheel their cycles. Particular care should be taken to avoid pinch points on Grade 1 or 2 paths.

However, pinch points can be specifically incorporated in the design to enhance safety by slowing down cyclists at approaches to hazards such as road crossings or blind corners. These deliberate pinch points are termed 'chokes' and are covered also in Section D6.

D4 Vertical clearances

Refer to Figure D1 for operating space requirements. Overhead hazards can include tree branches, overbridges, tunnel soffits, signs, wires and cables. A minimum vertical clearance of 2.2m to overhead hazards is recommended for all trail Grades. However, a 2.0m vertical clearance may be used for discrete overhead hazards, such as tree branches, or existing structures. Users should be advised of such hazards in advance and at the restriction (see Figure D2), and, if necessary, slowed down before reaching the hazard.

Figure D2: Warning sign for a low underpass, Nelson

D5 Trail alignment and shape

When a path must bend or turn a corner there are four main methods that can be used: standard bends, switchbacks, climbing turns and super-elevated ('in-sloped' or 'berm') turns. These are summarised in Table D3.

Table D3: Types of curve

Corner type	Description	Application and notes
Standard bend	The curve and its approaches are on level ground, and no specific treatment is required.	Apply to flat sections of trail. Most common on Grades 1 and 2.
Super-elevated ('in-sloped' or 'bermed') turn	The outer edge of the curve is banked to allow for faster travel around the corner.	Very popular, particularly on Grade 3–5 tracks. Angle of berm depends on the Grade of the track and radius of the corner. More experienced riders enjoy steep berms. Berms enable people to ride around corners easier and faster.
Switchback	The gradient of the path as it turns is flat while the approach and departure to the curve are on sloped sections.	A common method of providing turns on steep terrain, where berms are not easy to build. Also important for shared use trails where high speeds are not desired.
Climbing turn	The curve itself is located on a sloped section of path (which possibly includes super-elevation/a berm).	Can only be applied to gently sloping hills. Much easier to construct but may require more maintenance than switchbacks.

D6 Sight distances and visibility

Path safety depends on users being able to detect a potential hazard and either stop safely before encountering it or manoeuvre safely around it. The required distance is called 'stopping sight distance' (SSD). Good trail building practice and maintenance will endeavour to eliminate blind corners and create good lines of sight.

If visibility is limited around corners it may be necessary to set back vegetation or fences so that cyclists can maintain the appropriate line of sight around the corner. However, it may be difficult to achieve this, and the result might damage the trail's aesthetics. An alternative is to provide two separate trails around a blind corner, with signs advising users to keep to the left (or in some cases, the right), of the trail. Or, if a trail is reasonably wide, 'keep left' signage in itself may be sufficient (or marked arrows and a centreline on a sealed track).

'Chokes' (localised narrowings) or grade reversals can be used to slow cyclists down on approaches to blind corners, intersections or other potentially dangerous locations.

For more experienced mountain bikers, part of the enjoyment comes from the challenge of having to react quickly rather than having plenty of warning before encountering a path feature. This should be balanced with the likelihood of two cyclists (or a cyclist and a walker or jogger) encountering each other head on without sufficient warning.

In urban areas, visibility of trails by the public is also important for personal safety and security.

The track needs to be built and maintained to the visibility/sightlines assessed as appropriate for the Grade of trail. If the required sightline cannot be practicably achieved for sections of the track due to extenuating circumstances (such as, but not limited to, archaeological, cultural, ecological, geological/geotechnical, landscapes/visual or statutory reasons), then the track must achieve the maximum practicable sightlines, and other treatments and mitigations must be considered, and implemented where appropriate.

D7 Fall heights

Decision framework for determining fall treatment

Aspect – Consequence	Key question	Yes/No
Height of fall/slope steepness (i.e. slope so steep and long that arrest is unlikely and is no different to a free fall)	Is the height or length of fall likely to result in death or serious harm?	**Yes/No**
Secondary consequences of a fall (i.e. being swept away in a river)	Are there secondary consequences present that if the fall is survived, are likely to lead to death or serious harm?	**Yes//No**
Presence of hidden hazards (e.g. proximity of undercut riverbank)	Is there a hidden hazard(s) present that is likely to contribute to a fall that is likely to result in death or serious harm?	**Yes/No**
	If yes to any of the above, a likelihood assessment must be undertaken in order to determine risk level and adequate risk treatment	

Note: In the interests of conservatism and safety, if the height of fall/slope steepness has been selected as a **yes** then further consideration is triggered and treatment is warranted.

Aspect – Likelihood	Likely (1)	Possible (2)	Unlikely (3)
(a) Width of track (e.g. a 2m wide track will be less hazardous than a 0.3m wide one)	<0.6m	0.6–1.5m	>1.5m
(b) Track conditions (e.g. even, slippery or rough surface)	Unstable, rough, out-sloping and/or slippery	Stable, loose and rough	Stable, firm and relatively smooth
(c) The presence of vegetation on the downslope bank/bluff/slope	None	Some - may arrest/break fall	Abundant, sturdy, likely to arrest/break fall
(d) The alignment of the track relative/adjacent to the hazardous section and the visibility (line of sight) relative to the hazardous section	Blind corner leading into drop-off	Curvy trail but with line of sight equal or greater than stopping distance	Straight, ample line of sight
(e) Expected level of rider ability	Grade 1 and 2	Grade 3	Grade 4 and 5

Perceived level of risk	High (score 5–7)	Moderate (score 8–10)	Low (score 11–15)
Suggested risk treatment	Engineered safety fence as per design code	Physical treatment using any or a combination of outer bunds, natural barriers (i.e. large placed rocks); physical impediments (i.e. gate system); inside safety cable; specific warning signs	Generic advisory and communication as per mechanisms outlined in this document

D8 Surface materials

D8.1 Design

Gradient and drainage features are the two most significant predeterminants of trail life expectancy; refer to the earlier Sections 2.3 and 2.4 for more guidance on these aspects. On a steep track with no drainage features, skidding tyres and running water will result in chronic loss of the track surface. The finer materials will be transported down the track until it reaches a grade reversal. Left behind will be rocks, roots, ruts and bedrock. On a poorly designed track, this can happen within 12 months, making the track a Grade or two higher, and resulting in considerable soil erosion.

Loss of surface material can be greatly reduced by using out-slope and grade reversals. Out- slope can be lost over a few years of track use as compaction and displacement lead to dishing (the stage before rutting) along the centre of the track where use is greatest. That is why grade reversals are critical. They break up the 'water catchment' and, if they are large enough, they take a long time to fill up.

Where out-slope is not used, the track should either have a crown, or in-slope (see Figure D3). In-slope is common on berms, where the water is directed into the hillside of the track for a short distance, and then directed into a culvert, or across the track at a grade reversal.

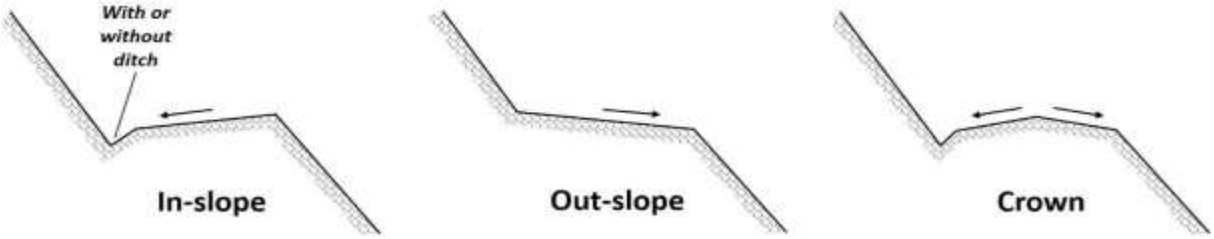


Figure D3: Different options for trail cross-sections

Imagine you are rolling a ball down your freshly built track – it should run off the track as soon as possible.

D8.2 Surface material solutions

Except for volcanic soils, all trails should be surfaced and compacted.

Where surface erosion is a problem, usually due to gradient, the common solutions are to apply a harder, more erosion-proof surface. On mountain bike tracks it is common to use rock armouring, by gathering material from around the track and starting from the bottom, building up a rock layer. This is time consuming, but very effective.

Closer to urban areas, several of the New Zealand Cycle Trails have resorted to sealing steep sections, or sections that are prone to flooding. Materials used are concrete (the most expensive and longest lasting material), asphalt, and chip seal (4 + 6 chip size). Chip seal is the cheapest, but also the bumpiest (generally not an issue for trail riders, but any commuter and sports training riders present may prefer smoother surfaces).

Vegetation cover greatly increases life expectancy by reducing climatic extremes of rainfall, heat, and wind.

D8.3 Compacted gravel or crushed limestone

These paths are formed by laying a compacted gravel layer and thus have a semi-loose surface. It is imperative that the gravel is relatively fine and crushed, as round stones do not bind to make a firm surface and will result in a difficult riding surface.

Uncrushed river gravels, or any other material with round stones, should not be used. Often 'dirty rock' with a range of aggregate sizes from a local quarry can be a cheap, effective trail building material.

A component of fine material (limestone or clay) is required in compacted gravel to aid binding. Limestone has the advantage of having natural cement properties but will not be cost-effective unless it is available locally.

The top layer of these surfaces is generally constructed with a crown at the centre and very little material at the sides. Over time, as cyclists generally ride on the centre of the trail, the trail flattens out.

Users of off-road NZCT routes are expected to be using mountain bikes, which have wider tyres than road bikes, so compacted gravel can be one of the more cost-effective and appropriate surfaces. Coarse or loose gravel surfaces are unsuitable for bicycles with narrow tyres such as road cycles, which are favoured by most touring and long-distance, multi-day cyclists. Designers should determine what type of bike (and therefore tyre) will be used on the trail and specify materials accordingly.

Gravel is often a cheaper option, especially if rocks excavated on-site can be crushed and used to surface adjacent sections of trail. Another advantage of using naturally occurring surface materials is that the surface looks natural and fits into the environment. However, the low capital cost required for these trails can be offset by high operational costs to maintain them. It is important that compacted gravel paths are cleared of vegetative matter during construction and plants are prevented from growing in them. The aggregate is likely to spread and thus it may be necessary to sweep loose aggregate back onto the path where it spreads onto drainage features, roads, driveways or other critical locations.

Figure D4: Compacted gravel section of Little River Rail Trail at Catons Bay

D8.4 Compaction

Compaction binds the trail aggregate and removes air gaps that water would otherwise get into. It makes the track strong and impermeable to water. Do not compact more than 200mm thickness of material at a time.

Gravel should be at the optimum moisture content when compacted. If it is too wet it will stick to the plate compactor machinery and hinder the process. If it is too dry it will not bind. Gravel should be of mixed size to facilitate binding into a dense and firm riding surface.

The material beneath the surface is also important. Gap-graded aggregates (like railway ballast used on rail trails) form a good structural base with excellent drainage properties and can provide surplus water storage if there is a known flooding problem in the area. However, too much drainage in dry environments can also cause problems. Experience on the Otago Central Rail Trail (OCRT) shows that a very dry surface can prevent the establishment of a firm, cohesive surface.

To counter this, the OCRT operators use a consolidated AP40[8] layer between the railway ballast and surface material (well-graded AP20 with a high clay content).

There is no single formula that provides the solution for all trail surfaces. The appropriate surface for a section of a trail will depend on underlying substrate, topography, trail Grade, projected use and climate. Solutions that may give the best durability may be prohibitively expensive for the number and type of users on a given trail. Over the length of a trail there is likely to be a variety of substrates so the trail surface and underlying layers will need to vary as well.

[8] A specification for medium-sized gravel – 'all passing 40mm' sieve. Will ideally contain a mix of stone sizes, including clay.

D8.5 Natural surface

Low volume farm roads with natural (i.e. uncovered soil) surfaces, where motor vehicles provide compaction and prevent vegetation from growing, may also be appropriate for off-road trails. In most cases, natural soil surfaces are likely to be only applicable to mountain biking paths of higher Grade.

The natural surface may be a more rocky surface, such as gravel or even large rocks. Such surfaces can be appropriate for paths of higher Grade trails where riders are experienced in riding on loose surfaces. Figure D5 shows an example of a path with a natural gravel surface.

Figure D5: Natural surface, Great Lake Trail, Taupō (Photo: Jonathan Kennett)

Natural surfaces can also include the volcanic soils commonly found in the central North Island. Regardless of the soil type, all organic matter should be removed and only mineral material used. Organic matter decreases a soil's strength, promotes vegetation growth and water retention, and accelerates surface deterioration.

Stabilising products can be used on natural surfaces in critical areas to strengthen the trail and provide higher skid resistance for cycling. Figure D6 shows a 'geomat' applied on a steep track with loose surface in Tongariro National Park; aggregate is then placed on top of this base. Geotextiles are useful at sites with high use, extreme weather conditions and erodible soil.

Figure D6: 'Geomat' surface stabilisers (prior to having aggregate placed on top), Tongariro National Park (Photo: John Bradley)

A more natural alternative to surface stabilisation is to apply 'rock armouring' or 'stone pitching' whereby rocks are used to pave the ground surface. Finer gravel or sand can be applied on top of the rocks to produce a smoother surface, depending on the target skill level of riders. This is, however, generally a labour-intensive treatment. Figure D7 shows an example of a rock armoured path.

Figure D7: Rock armoured path – Nichols Creek Track, Dunedin (Photo: Kennett Brothers)

D8.6 Paving stones

Paving stones provide a high quality, durable and attractive surface for paths. They can be easily removed and reinstated for access to sub-surface services. Maintenance is still required for clearing the path of debris and spraying weeds that may grow between the pavers.

The high cost of this treatment is likely to make it an unsuitable option for most NZCT routes. It may however be appropriate for small sections where aesthetics are particularly important, for example end treatments at urban locations. Some trails may be able to make use of wide, flat stones found locally to serve as paving stones.

D8.7 Recommended surface types for path grades

Table D4 outlines the recommended surface types for Grade 4. The appropriateness of natural surfaces also depends on site and user characteristics; stabilising materials may be required.

Table D4: Recommended surface types for Grade 4 trails

Grade 4	Recommended surface type
 ADVANCED	Natural surface Compacted gravel/lime-sand

D9 Construction

Here are ten useful guiding principles for track construction.

- Keep water away from the track surface
- Construct sustainable gradients
- Make the track flow
- Provide a suitable surface
- Maintain a good surface
- Maintain when required
- Be environmentally astute
- Protect your investment
- Train staff
- Respect and keep historic values

Cyclists have indicated that they like to feel as if they are exploring the 'wilderness' but not as if they are biking on a country road. It is important to communicate this message to contractors who may be tempted to provide extra but unnecessary width. Contractors normally involved in road construction may not understand the specific requirements of Grade 3 and above trails; whereas roads are built to be smooth, straight, level and consistent, more experienced riders appreciate some challenges in the form of curves, grade reversals, slopes and changes in path alignment.

The best way to communicate the trail requirements to a contractor may be to ask them to ride a trail of a similar Grade with a trail designer and then discuss the trail's characteristics and desirable aspects from a design perspective.

D9.1 Vegetation clearance

Trees and shrubs should be assessed for their ecological value, and where possible, exotic species removed rather than native species. Trail alignment should be adjusted to avoid removing rare and/or large native trees, which are valuable to the landscape amenity and ecological values of the trail. At all times, trail alignment should comply with statutory requirements.

All limbs should be cut flush (or to within 10mm) of the trunk or main branch, or ground level. This makes the cut branches less of a danger if people fall onto the cut branches, and it is also healthier for the tree.

The danger of cut branches and stumps on or near trails cannot be overstated. Potential injuries include stab wounds, broken bones, facial lacerations and lost eyes. All trimmed branches near trails should be cut flush with the main branch or tree trunk. Stumps should be dug out of the ground or cut at or below ground level.

All cut woody vegetation should be removed from the track surface and either chipped or moved out of sight of the track (this applies to DOC and council reserves, and other areas where the native vegetation is valued). In pine plantations it is not usually necessary to move cut vegetation out of sight.

D10 Data collection

All Great Rides are required to have automatic counters appropriately placed along the trail to provide the number of Trail users. As part of governance and management of a trail, Great Rides are required to provide an annual target number of completed surveys. Trail managers need to encourage users to complete the survey. Survey alerts are a useful tool for trail management.

D11 Accessibility

On-road and off-road trails may be used by cyclists with disabilities, using a range of equipment that may differ in size from a bicycle. This includes:

- tricycles (recumbent and upright)
- tandem bicycles
- hand cycles (recumbent and upright)
- e-bikes
- wheelchair tandems
- wheelchair clip-ons
- cargo bicycles and tricycles
- cycle trailers
- bicycles with stabiliser wheels.

Further guidance on making cycle trails inclusive can be found in NZTA's Accessible cycling infrastructure: Design guidance note.

D11.1 Trail barrier remediation – least restrictive access

Physical gates and barriers present significant challenges for the accessibility of outdoor tracks and trails. Many people, including those with disabilities, are affected by such barriers.

Gates and barrier structures along trails should not be a barrier to access for trail users. However, preventing motorcycles and other prohibited vehicles from accessing trails is difficult when trying to accommodate possible legitimate trail users. Meeting the needs of those with modified cycles or cycles with child trailers, adaptive equipment, and parents with prams, as well as not creating hazards for people who are Blind or vision-impaired, may be a challenge, but requires consideration.

Recreation Aotearoa is working with the Outdoor Accessibility Working Group, supported by the University of Canterbury's Dept. of Mechanical Engineering, to develop a decision-making matrix to support more effective decision-making about the use of barriers and access control mechanisms on trails.

Here is the most up-to-date guidance relating to improving barrier accessibility.

D11.2 Is the barrier necessary?

Several types of gate and barrier structures have historically been implemented to address motorbike concerns on trails.

It's important to **re-consider if historic rationale for barrier use is still valid on your trail**. Read about an example cycle trail in the UK that re-assessed the need for such barriers and implemented a trail period to understand the effect of changing a barrier.

Unless there is a well-documented and informed health and safety concern or issue to address on your trail, barrier removal should be a priority.

D11.3 What other control mechanisms can be used?

Signage discouraging the use of prohibited vehicles and motorcycles (including information on relevant consequences, such as confiscation of prohibited vehicles and equipment).

Partnering with local police and authorities to provide more frequent surveillance of areas identified as problematic with anti-social behaviour.

Bluetooth keypads with changeable pin-codes (with clear, readily available guidance on how users obtain a code for access).

D11.4 The Least Restrictive Access principle

The principle of Least Restrictive Access (LRA) is that all new work and maintenance repairs should aim to achieve the most accessible option. Least Restrictive Access is achieved by identifying the least restrictive option for a specific feature, such as a gate or barrier. This is not just about selecting the type of structure, but also how to make and install the chosen structure in the least obstructive way for trail users, to maximise accessibility for as many people as possible.

The UK Sensory Trust, on behalf of Natural England, has modified the principle of By All Reasonable Means, Least Restrictive Access to the outdoors to the following:

> *A gap, or no barrier, is less restrictive than the modified squeeze gate (specifications below), which is less restrictive than a traditional squeeze gate. So, when a traditional squeeze gate needs repair or removal, the first option is to remove it entirely. If this is not an option, it is replaced by the modified squeeze gate. The last resort is to replace the traditional squeeze gate.*

D11.5 Existing barrier structures

D11.5.1 Bollards and concrete blocks

These mechanisms do not prevent motorcycle access.

If you are using bollards or concrete blocks to prevent 4-wheeled, or car, access, make sure that there is **at least a 1.7m** clear width between adjacent bollards; there is no linking chain or rope of any kind between bollards; the bollard strongly colour contrasts to the background, and there is lighting or a reflector band around the top (visible from any direction).

The bollard should be clearly marked, by painting it in a visible colour, with reflective disks. On paved surfaces, a white diamond should be painted around the bollard, leading at least 10m (greater if the approach speed is likely to be over 30kph) before and after the bollard, and 300mm either side (ideally 450mm).

Also, bollards should either be no more than 700mm high, to be below handlebar height, or they should be at least 1.5m high so that they are clearly above handlebar height. The worst height for bollards is around handlebar height, as this means people find it hard to judge if they will miss it or not.

D11.5.2 Chicane gates, croquet hoops and squeeze gates

These can limit access for prams, child bike trailers, larger mobility equipment, like mobility scooters, and many pieces of adaptive equipment such as adaptive mountain bikes, recumbent cycles, tandem cycles, trikes, as well as e-bikes and heavier equipment that users must lift or manoeuvre to navigate the chicane or squeeze gate.

If there is a grass area around the side of the chicane, squeeze gate or croquet hoop, this will not prevent motorcycle access.

If you have identified that you **must** have a croquet hoop, or squeeze gate, traditional specifications have been modified, in consultation with local trail users, to be made more accessible.

Powder coating the barrier (in a high-contrasting colour to the background) also enhances its accessibility for people who have low vision and sight impairments.

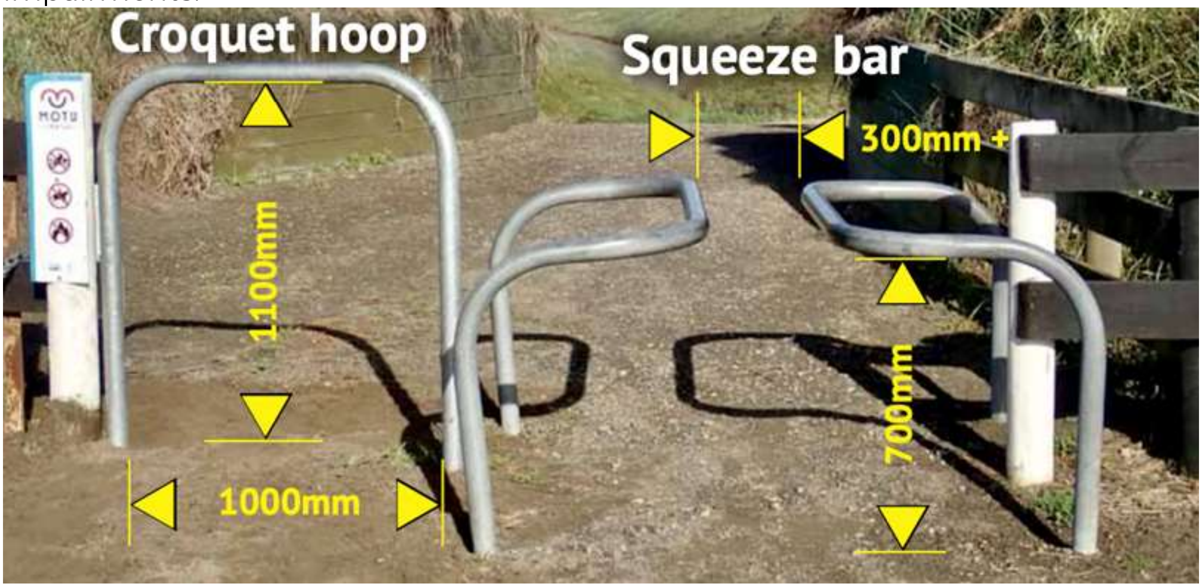


Figure D8: Accessibility modifications for hoop and squeeze barriers

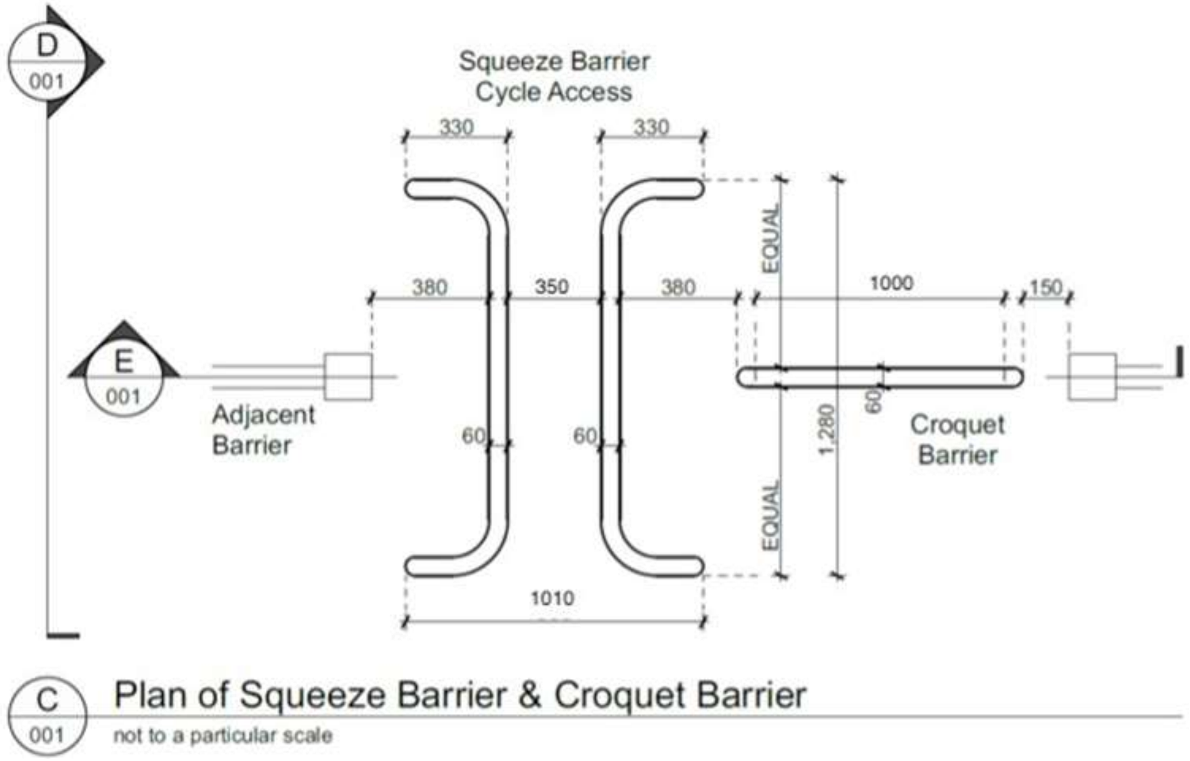


Figure D9: Dimensions for accessibility modifications

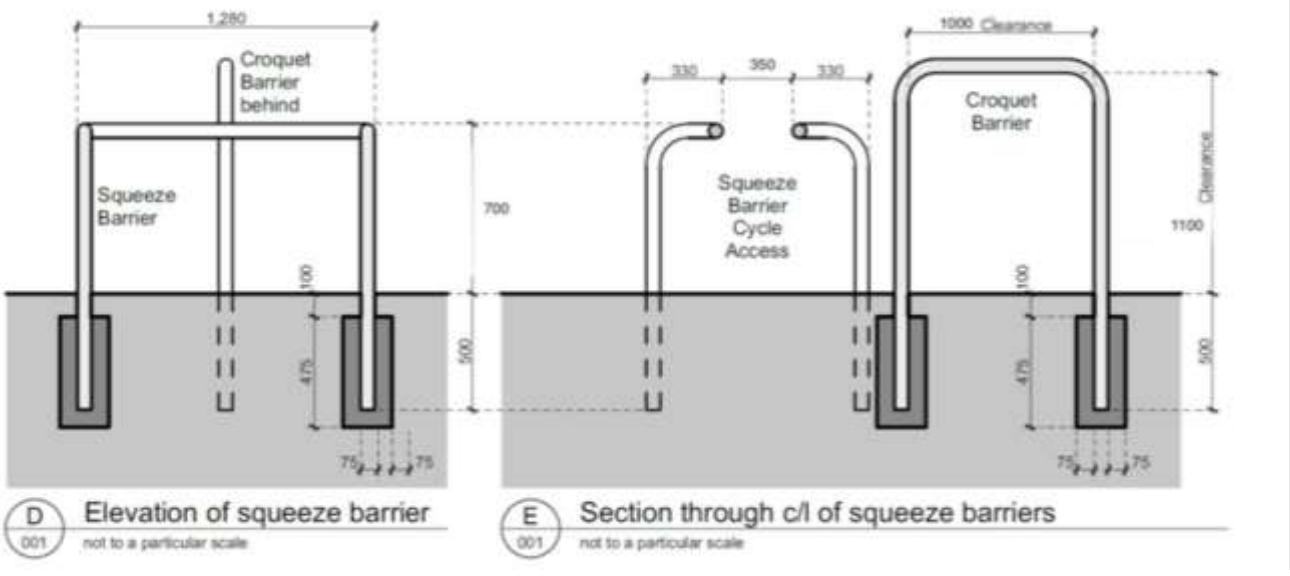


Figure D10: Dimensions for accessibility modifications

Although these specifications are more accessible than traditional squeeze gate and croquet hoop design, **they are not 100% accessible** for all types of mobility devices or adaptive equipment.

Evaluating the absolute necessity of this barrier, including its appropriateness for your type and grade of trail, and its placement on the trail, remain important considerations.

D11.6 Notifying trail users of barriers and limitations

Trail users will want to know ahead of time:

- Where is the barrier on the trail?
- What does it look like? Can a photo or diagram be included in the trail map or website?
- What are the dimensions of the barrier? What equipment can fit through?
- Are there alternate entrances, such as nearby gates which can be unlocked, that users can arrange ahead of time?
- Who can users contact for more information?

Motu Trails has a great example of displaying this information. Read more about their barrier access on trails, with supporting access information here.

For information specific to urban cycleways and access control mechanisms and barriers, see NZTA's *Accessible cycling infrastructure: design guidance note*.

For further advice on trail accessibility and barriers, or to be kept up to date with the barrier guidance, please contact Katie Owen, Disability and Inclusion Programme Manager.

D11.7 Trail accessibility

Path end or 'terminal' treatments are used at ends of off-road trails (paths) to warn people of the approaching transition to on-road trails (or simply a road, without cycle provisions) and to prevent motor vehicles from accessing the paths. While physical restrictions have been commonly used historically at path ends, they should not be seen as a default treatment, and many trails will operate very well without them.

Path end treatments should not necessarily be designed with the aim of slowing cyclists down and should not provide an obstacle that distracts riders' attention from the impending transition to the roadway. Circumstances where cyclists should be required to dismount are rare, so route end treatments should allow people to comfortably ride through without awkward manoeuvring.

Bollards and staggered fences or U-rails are preferred path end treatments, where necessary. These devices can be designed to prevent access by motor vehicles, including motorbikes. It is recommended that designers seeking further guidance in this area read the NZ-specific guidance on 'Access Control Devices', which will be referenced in the *Cycling Network Guidance* (NZTA, 2019). To support 'safe system' principles, the default position in the new NZTA guidelines is that access control devices should typically ***not*** be used on facilities used by cyclists.

Barriers at path ends that block entry to users of wheelchairs, trikes, etc., should be avoided if possible. They stop some valid users from accessing the trail and will lead to complaints, so consider if they are really needed. Barriers to stop cars do not need to be so narrow that they also stop non-motorised devices.

New barrier designs are starting to be developed that allow for a wider range of legitimate users to gain access – e.g. Figure D11.

Figure D11: Example of a wheelchair-accessible barrier, Belmont Regional Park (Photo: Greater Wellington Regional Council)

Bollards are a hazard to users. If they are used then they should be spaced 1.6 to 1.7 metres apart, and not in the centre of the trail. The bollard should be clearly marked, by painting it in a visible colour, with reflective disks. On paved surfaces, a white diamond should be painted around the bollard, leading at least 10m (greater if the approach speed is likely to be over 30kph) before and after the bollard, and 300mm either side (ideally 450mm). Also, bollards should either be no more than 700mm high, to be below handlebar height (see Figure D12), or they should be at least 1.5m high so that they are clearly above handlebar height. The worst height for bollards is around handlebar height, as this means people find it hard to judge if they will miss it or not.

Figure D12: Path end treatments, West Coast Wilderness Trail, Greymouth

Frangible plastic hold rail could be used at highway crossings where NZTA may not allow a fixed steel hold rail due to risk of highway users hitting it in a crash.

Figure D13: Path end treatment, Hawkes Bay Trails (Photo: Jonathan Kennett)

D11.8 Excluding motorcycles

Motorcycles can be problematic on cycle trails. Various techniques exist to discourage this nuisance, including the positioning of central posts in trails and at gateways or cattle-stops to discourage their use. However, note the discussion above about ascertaining whether the problem is real (and significant) or perceived, particularly where any barrier treatment would severely restrict other legitimate trail users.

One technique, a 'squeeze barrier', is illustrated in Figure D14, with the full design specifications given in Figure D15. Note that if this barrier arrangement is used on trails where cyclists use pannier bags, the horizontal bars should be installed at the maximum stated height of 870mm. Accurate installation is critical. The width and height of these barriers must be consistent throughout a trail. A jig will be needed for installation, and the trail surface should be checked annually, as if it compacts from wear and tear, then the effective bar height will be higher. A sealed surface underneath might be advised, so that the height stays the same. If there is a notable gradient on the trail, then the tops of the barrier should also mirror that gradient, to be parallel with the track surface.

Riders need a straight approach for 10 metres before a squeeze barrier. They cannot be installed on corners as riders cannot ride through them.

Figure D14: 'Squeeze barrier' to discourage motorcycles, Remutaka Cycle Trail (Photo: Jonathan Kennett)

D12 Environmental considerations

Trail designers and builders must consider the environmental impact of the trail construction (for example vegetation clearance, rare plants, wildlife, siltation of streams and wetlands). Efforts should be made to design the trail to get the most out of the environmental beauty of an area by working around trees, passing natural features, and transplanting small seedlings that are in the path of the track.

For a natural surface trail to be sustainable it should incorporate the principles of sustainable gradients (as discussed in Section 2.5), frequent grade reversals (to aid drainage – as discussed in Section 2.4) and weed control (as discussed in Section 8).

Opening a natural surface trail to light can encourage weed growth and degrade the microclimate. The natural tree canopy should not be disturbed if possible. Some invasive weeds (for example African clubmoss and didymo) are easily transferred from one trail to another, even by bicycle tyres. At the design and construction stage, these weeds need to be identified and eradicated or controlled (where possible). If infestations occur after the trail has been built, on-going control techniques will be required. Clean all earthworks machinery, hand tools and PPE before taking onto a new site, to avoid importing weeds. Imported gravel, soil and rocks must be from a weed-free source.

In areas of native forest, the environmental values should be assessed first. An Environmental Impact Assessment (EIA) report from a qualified ecologist may be required. Mitigation of the effects of trail building can enhance a track and the users' experience. For example, at Makara Peak Mountain Bike Park in Wellington a native tree is planted for every metre of track built.

This mitigation measure is very popular as it results in a combination of recreation and conservation that people appreciate. Several NZCTs have planted thousands of trees beside their trails.

Tree planting provides shade, bird habitat and wind breaks (which help to prolong the life of the trail surface). Over time, native trees also replace undesirable introduced plants such as gorse and blackberry.

Some trails also have stoat/rat traps set up alongside the trail to improve the environment for native birds.

It is preferable to fill between and over roots rather than digging them out. See Section 8 for further guidance about maintenance of trails with roots.

As discussed in Section 2.1.5, the natural landscape is an important factor that should be considered during initial design stages. There are often opportunities to 'recycle' local materials (e.g. crushing excavated rocks to be used as base course or surfacing over roots) when building trails. This adds continuity to the trail, decreases environmental impact and can cost less than importing materials.

Councils have rules restricting the amount of earth that can be moved and the maximum cross slope of terrain that a track can be built on. Trail designers and builders need to become familiar with these rules, which make sense from both environmental and track sustainability standpoints. Check local council plans and rules to be informed of restrictions, as well as Resource Management Act requirements, before design and construction stages.

Culverts may disturb the natural movement of native fauna. Boardwalks and bridges have less impact on watercourses, but are more expensive than culverts.

After construction, undertake a special trip to remove survey tags, construction materials/signs and any general rubbish.

D13 Culture and heritage

Consideration under the Treaty of Waitangi Partnership and the *Heritage New Zealand Pouhere Taonga Act 2014* require trail managers to consider cultural and archaeological factors. Engagement with iwi will help at the trail planning stage, and an archaeology report may need to be written.

Middens, pā and urupā are taonga and there is a legal requirement to treat historical sites (over 100 years old) with respect and have them examined by an archaeologist. These clues to the past can be explained through interpretation panels and will enrich the riding experience by connecting people to the unique environment and stories that contribute to who we are as New Zealanders.

Among solutions to challenges noted in the heritage and archaeological space are the following.

- You may need to identify any existing heritage orders for sites you are developing, as described under Part 8 of the *Resource Management Act 1991*.
- Walking and cycling trails commonly involve earthworks on previously unmodified ground. Archaeological heritage might be missed as it is more invisible and involves a separate consenting process from Heritage NZ.
- Heritage NZ maintains the New Zealand Heritage List and the National Historic Landmarks list where you can identify notable historic and cultural sites around the country.
- It's a small cost to get a high-level archaeological risk assessment for starters – the full Heritage Impact Assessment/AEE can come later if required. Identifying any archaeology early in the process will greatly help forward planning.
- The NZ Archaeological Association's database records are indicative only. Additional information on potential for sites should be sourced from iwi/hapū, Heritage NZ, and an archaeologist with local knowledge.
- Repurposing heritage structures (bridges/tunnels, etc.) has been particularly successful in adding existing infrastructure to walking/cycling trails in a cost-efficient manner.
- Build a relationship early in the project life with regional Heritage NZ staff so you can tap their expertise.

Heritage represents an opportunity to enhance sense of place and identity and build community well-being. For more guidance, refer to NZTA's factsheet *Considering historic heritage in walking and cycling projects* (2019), available from the CNG website.

D14 Bridges and boardwalks

Ideally bridge and boardwalk widths should be consistent with the overall path and therefore designed according to the path width requirements outlined in D2 plus additional clearances for 'shy space' due to handrails or walls etc. However, this may not always be feasible, especially for long spans or constrained locations, in which case the minimum bridge widths outlined in Table D5 can be used.

D14.1 Bridges

D14.1.1 Width

It is usually relatively cheap to provide additional width for a cycle bridge. A bridge that is 50% wider than the minimum width will generally be much less than 50% more expensive, yet provide a much more pleasant cycling experience.

Table D5: Bridge and boardwalk widths

Grades	Recommended bridge width	Minimum bridge width *
4	1.0m	0.6m

Note:

- Handrails on minimum bridge widths should be flared out.to provide handlebar clearance.

D14.1.2 Handrails

It is preferable to slope handrails outwards (17.5–27% from the vertical) to allow more space for handlebars and thus allow more of the bridge deck to be safely ridden on. Flaring the handrails in this manner increases the effective width of the structure at minimal cost and generally improves the appearance of the structure. The minimum bridge width (from Table D5) is required at the surface of the bridge but flaring the handrails allows more clearance at handlebar height (taken as 1.0m) and therefore makes the experience more comfortable for riders.

Handrail barrier height should be at 1.2m high. Any current barriers being replaced, or new barriers, must meet this height requirement. Existing guardrails and barriers should only be replaced at the end of their life where a significant hazard exists. This excludes on-road assets. Handrails for new bridges and replacement bridges on road sections are to comply with Waka Kotahi New Zealand Transport Agency standards.

If a bridge or boardwalk does not have handrails, people will be wary of cycling too close to the edge for fear of falling and suitable clearances for 'shy space' should be provided (see D2 – clearances). Table D5 indicates the recommended bridge width according to path Grade. It may be appropriate to increase this width where possible, especially for bridges of length 20m or longer or on curved sections as cyclists need more space when cornering. Passing/viewing bays should be provided at 50m intervals on bridges (if feasible) and boardwalks; they should be 5m long by 2.5m wide and have handrails. It is not practicable to provide passing bays on suspension bridges and cyclists will need to ride in single file. If cyclists approach such a bridge from opposite ends, one direction will need to give way to the other.

Handrails should be used on significantly curved bridges or bridges 20m or longer if only the minimum width is provided. If the bridge is at least 0.5m wider than the minimum width, handrails are optional (unless the fall height governs). HB 8630 uses an equivalent value of 1.0m but the risk and safety implications of falling off a bridge or boardwalk are likely to be more severe for cyclists than pedestrians. Cyclists travel at faster speeds and fall from a greater height (due to their position on the cycle) than pedestrians. Cycles can also complicate a fall by catching pedals or handlebars on a structure during the fall or hurting the rider on landing. Refer to Section D13 for decision framework on fall heights.

The guidance provided in this section does not override any legislative requirements.

D14.1.3 Passing/viewing bays

When designing these structures, consideration of the requirements for cyclists passing each other is needed. Similarly, the effects of cross-winds can make cycling unstable and this needs to be addressed when choosing appropriate widths and deciding whether or not to provide handrails.

A typical (although notably narrow) boardwalk is shown in Figure D15 – it would require handrails and passing bays for a Grade 1 or 2 trail.

Figure D15: Boardwalk – Twizel River Trail (Photo: Kennett Brothers)

D14.1.4 Vertical clearance

The vertical clearance of a bridge above a river should take into account the potential river flood height. In some cases, it may be acceptable that a river level will occasionally rise above the bridge deck, but this risks the integrity of the structure. It is up to the trail owner to specify the appropriate flood design in this circumstance, to erect suitable warning signs and to ensure a suitable inspection and maintenance regime is in place.

D14.1.5 Drainage

NZCT path drainage guidance (Section 2.4) should be used for structures where appropriate rather than HB 8630 track drainage standards, which apply to natural surface walking tracks.

D14.1.6 Skid resistance

UV stable polymer mesh should be used on bridges and boardwalks to increase skid resistance. Wooden surfaces can be dangerously slippery when wet and make corners particularly difficult to negotiate. Wire netting is also a possibility, but it tends to wear out quickly on wooden boardwalks. Boardwalks are very susceptible to frosts and can become hazardous for early morning users. Consideration should be given to surfacing treatments in frost sensitive areas to mitigate the effects of ice on the path surface.

D14.2 Swing and suspension bridges

The terms 'swing bridge' and 'suspension bridge' mean different things to different people. In this design guide, a suspension bridge is a bridge suspended from cables with a fairly rigid deck and may be wide enough for two people to walk across side by side. A swing bridge is a lighter structure, also suspended from cables, but the deck is flexible and often made from steel cables and metal bars, perhaps with wire mesh. They are often used on tramping tracks and are just wide enough to walk across.

In some situations, the type of bridge to be used will be governed by physical features, financial considerations and possibly the logistics of getting construction materials to the site. A swing bridge is often the preferred bridge structure for walking tracks and may also be the most practical alternative for more remote cycle trails, especially when crossing long spans.

Figure D16: Suspension bridge on the Old Ghost Road (Photo: Jonathan Kennett)

Due to their freedom of movement, swing bridges will generally not be suitable for cyclists to ride over. Some cyclists may try to ride over swing bridges, however, which could result in injury from impacts with the bridge sides. Thus, if swing bridges are used, they should be made as rigid as possible with signs to warn cyclists of the dangers of riding across.

Suspension bridges are more stable than swing bridges and can thus be used for all Grades of trail. Suspension bridges are generally a cheaper option than solid timber or metal constructions for longer spans.

Figure D17: Suspension bridge, Ōparara Valley Track

Swing and suspension bridges should comply with the requirements of HB 8630 (unless contrary guidance is provided in this guide).

D14.2.1 Approaches

A bridge or boardwalk narrower than the path will require end treatments to ensure cyclists are channelled onto the structure rather than off the side. This can be achieved by guardrails on either side. A storage space for cyclists to pull over on the approach to the structure (to rest or avoid passing or overtaking inside the structure) would also be appropriate. If provided, this should be on the left side approaching the structure.

D14.2.2 Aesthetics

Bridges provide the opportunity to add to a route's iconic nature.

Appendix 3E Grade 5 design information for contractors

Blowhard Track, Mt Thomas Forest (Photo: Jonathan Kennett)

Table of Contents

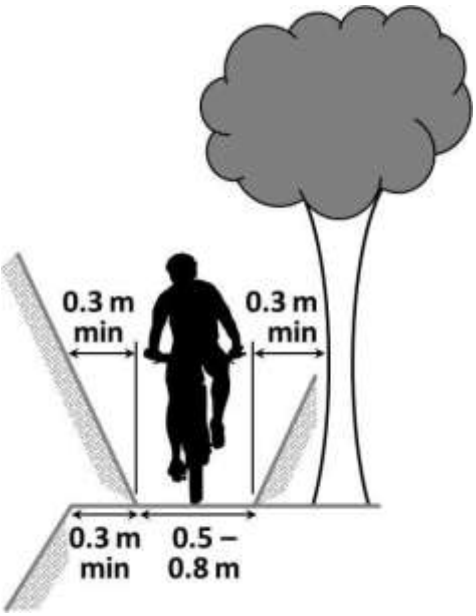
E. Grade 5 (Expert)

Gradient

- **0–17.5%** for at least 90% of the trail (3.5 degrees = 6.0% = 1:17)
- **17.5–23%** for steeper slopes up to **100m** long
- **23–27%** for steeper slopes up to **10m** long (the less the better)
- Maximum **downhill** gradient **36%**

Width

- Single track: **0.5–0.8** metres wide (with adequate horizontal clearance to drops or banks/trees)



Formation

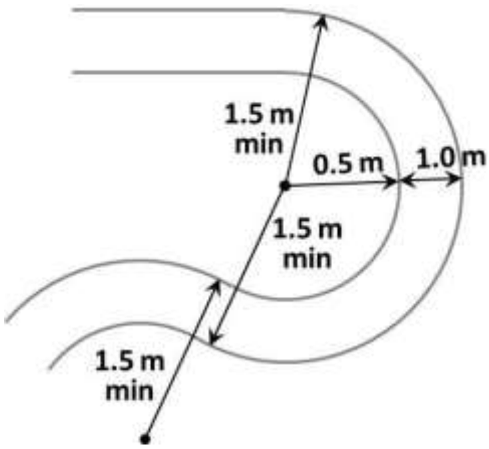
- Mono-slope with **3.5–8.7%** side slope (crowned surfaces are not desirable)
- Greater side slope (super-elevation = berms) **up to 100%** around corners

Surface

- Huge variety of surfaces with obstacles such as roots and/or rocks

Radius of turn

- **1.5–3 metre minimum** to outside of turn (the more the better)



Grade reversals

- **Required** at regular intervals including all water courses if they are not bridged or culverted (water courses that normally have water flowing will be bridged or culverted)
- Grade reversals will be large enough to add fun (e.g. pumps or jumps or rollers)

Grade 5	Grade description
 EXPERT	**Description**: Technically challenging, with big hills, often lots of rocks, some walking likely. May traverse a wide range of terrain and cater for riders with expert skills and experience. Popular trails of this Grade should be one-way. **Gradient**: 0–17.5% for at least 90% of trail; between 17.5–23% for no more than 100 metres at a time, and between 21–27% for no more than 10m at a time. Sealed trails can be steeper (same as the equivalent Grade of on-road trail; see Section 3.4, Table 5). If the track is designed and promoted to be ridden predominantly in one direction, then the downhills can be steeper (up to 36%). **Width**: 0.4m average, 0.25m minimum. Horizontal clearances as in Section 3.4 Table 6. **Vertical clearance**: Minimum vertical clearance of 2.2m to overhead hazards is recommended for all trail Grades. A 2.0m vertical clearance may be used for discrete overhead hazards, such as tree branches, or existing structures. **Radius of turn**: 1.5m minimum, with more desirable. **Sightlines**: Best endeavours must be made to address sightline issues. **Surface**: Huge variety of surfaces. **Bridge Width:** Recommended 0.8m; minimum 0.4m. **Obstacles**: Many rocks, roots and ruts, up to 0.6m high/deep. If there are no obstacles then they are likely to be added afterwards (i.e. jumps, and wooden structures). **Length**: 4–12 hours/day.

E1 Gradient requirements for unsealed trails

Table E1: Gradient requirements for unsealed Grade 5 trails

Trail grade	Main uphill gradient range	Steeper slopes up to 100m long	Steeper slopes up to 10m long	Maximum downhill gradient (up to 100m long)
5	0–17.5% for 90% of length	17.5–23%	23–27%	36%

Notes:

- This table applies to off-road unsealed trails and gravel roads.
- Maximum downhill gradient applicable only if trail is to be ridden in one direction.

- IMBA recommends a maximum gradient of 10% (5.7 degrees). Steeper trails will require more maintenance due to increased erosion from skidding tyres and water scour.

E2 Horizontal clearances

Figure E1 shows the operating space required for cycling. An important aspect of the operating space is the angle between the pedals and handlebars; the handlebars protrude further than the pedals and are more likely to catch on adjacent objects. This is why banks should be 'battered' (i.e. sloped, not vertical) and fences should ideally slope away from the path. This issue is increasingly pertinent as more bikes are sold with wider handlebars (e.g. nearly 800mm).

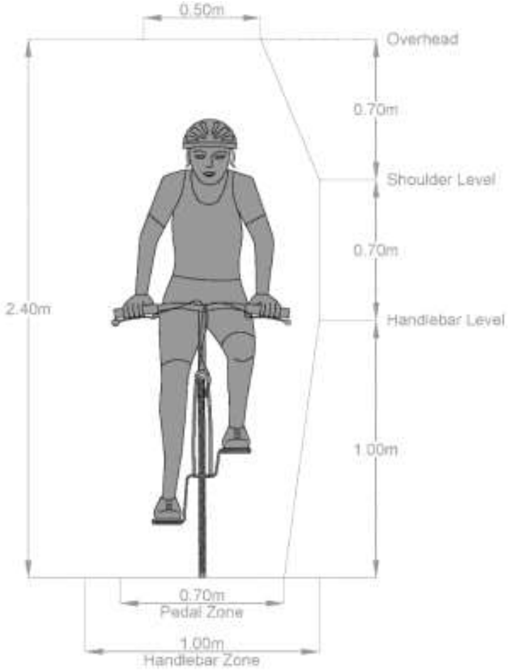


Figure E1: Cycle operating space

When travelling on a lean (for example, when travelling around a banked corner) the location of the cyclist's head and shoulders is also important. Cyclists may hit their heads or shoulders on trees placed too close to the inside of a curve. This can also be a conflict issue between cyclists and pedestrians on banked curves, as cyclists will be leaning while pedestrians are walking upright.

Cycle travel is dynamic. It is difficult to ride exactly in a straight line and less experienced users, in particular, require a fair amount of wriggle room or manoeuvring space.

If a path is restricted horizontally, for example by fences, bridge rails or discrete features such as trees or large rocks, an additional 'shy space' is required. Shy space is needed because cyclists are physically unable to ride on the edge of the path due to their handlebars and pedals extending further than their tyres. Cyclists also need space to allow for a certain amount of wobble and to ensure that they do not need to focus so hard on keeping to the trail that they are unable to appreciate their surroundings. Slower and less experienced cyclists wobble more than faster and more experienced ones.

As it is expected that the majority of cyclists will not choose to ride in the shy space, the clearance does not necessarily need to be constructed from the same materials as the actual path itself. Depending on the context, the shy space could be a grass verge or strip of compacted aggregate. In an urban area, maintenance requirements (e.g. mowing of grass verges) will generally make it more appropriate to create the shy space from the same material as the path. However, in rural areas, there is no point in building a trail right beside a fence as the native ground cover will need no special maintenance.

Horizontal constraints to a path also limit the ability for path users to deviate from the path in extreme circumstances where the path is not wide enough to accommodate all users. Thus, in addition to the path width given in Table E2, further width should be added for situations where at least one side of the path is constrained by adjacent elements. These elements may be either continuous or discrete, and examples are given in E2, along with the required clearances:

Table E2: Off-road trail horizontal clearance requirements

Feature Type	Continuous	Discrete
Examples	Fences	Trees
	Walls	Large rocks
	Buildings	Bridge abutments
	Guardrails	Sculptures
	Steep slopes	Power and light poles
	Rock faces	Sign posts
	Parallel drains	Perpendicular drains
	Lakes, rivers and coastlines	
	Hedges	
Recommended clearance each side	1.0m	0.3m
Minimum clearance each side	0.3m	0.15m

Note:

- Extra clearance up to 0.8m is necessary on bends, where cyclists will lean into the corner.
- For example, on a path with fences (i.e. continuous features) on either side, the width between the fences should be the width of the path plus 1.0m. Clearances for continuous or discrete features in Table 2 should be measured at handlebar and shoulder height relative to the path edge.
- If a trail is built on hill with a side slope it is preferable to situate the trail with trees on the downhill side rather than close to the uphill side. This means riders are more likely to naturally keep clear of the drop at the edge of the path.

E3 Pinch points

It may not always be practicable to provide the required width for the entire path length. Large trees, rocks, bluffs, steep cross slopes or other geographic features may produce 'pinch points' on a path. These features can be tolerated as long as there is adequate visibility leading to them or advance signage, and safe opportunities for path users to stop before the pinch point and give way to oncoming users or wheel their cycles. Particular care should be taken to avoid pinch points on Grade 1 or 2 paths.

However, pinch points can be specifically incorporated in the design to enhance safety by slowing down cyclists at approaches to hazards such as road crossings or blind corners. These deliberate pinch points are termed 'chokes' and are covered also in Section E6.

E4 Vertical clearances

Refer to Figure E1 for operating space requirements. Overhead hazards can include tree branches, overbridges, tunnel soffits, signs, wires and cables. A minimum vertical clearance of 2.2m to overhead hazards is recommended for all trail Grades. However, a 2.0m vertical clearance may be used for discrete overhead hazards, such as tree branches, or existing structures. Users should be advised of such hazards in advance and at the restriction (see Figure E2), and, if necessary, slowed down before reaching the hazard.

Figure E2: Warning sign for a low underpass, Nelson

E5 Trail alignment and shape

When a path must bend or turn a corner there are four main methods that can be used: standard bends, switchbacks, climbing turns and super-elevated (‘in-sloped’ or ‘berm’) turns. These are summarised in Table E3.

Table E3: Types of curve

Corner type	Description	Application and notes
Standard bend	The curve and its approaches are on level ground, and no specific treatment is required.	Apply to flat sections of trail. Most common on Grades 1 and 2.
Super-elevated (‘in-sloped’ or ‘bermed’) turn	The outer edge of the curve is banked to allow for faster travel around the corner.	Very popular, particularly on Grade 3–5 tracks. Angle of berm depends on the Grade of the track and radius of the corner. More experienced riders enjoy steep berms. Berms enable people to ride around corners easier and faster.
Switchback	The gradient of the path as it turns is flat while the approach and departure to the	A common method of providing turns on steep terrain, where berms are not easy to build. Also important for shared use trails

Corner type	Description	Application and notes
	curve are on sloped sections.	where high speeds are not desired.
Climbing turn	The curve itself is located on a sloped section of path (which possibly includes super-elevation/a berm).	Can only be applied to gently sloping hills. Much easier to construct but may require more maintenance than switchbacks.

E6 Sight distances and visibility

Path safety depends on users being able to detect a potential hazard and either stop safely before encountering it or manoeuvre safely around it. The required distance is called 'stopping sight distance' (SSD). Good trail building practice and maintenance will endeavour to eliminate blind corners and create good lines of sight.

If visibility is limited around corners it may be necessary to set back vegetation or fences so that cyclists can maintain the appropriate line of sight around the corner. However, it may be difficult to achieve this, and the result might damage the trail's aesthetics. An alternative is to provide two separate trails around a blind corner, with signs advising users to keep to the left (or in some cases, the right), of the trail. Or, if a trail is reasonably wide, 'keep left' signage in itself may be sufficient (or marked arrows and a centreline on a sealed track).

'Chokes' (localised narrowings) or grade reversals can be used to slow cyclists down on approaches to blind corners, intersections or other potentially dangerous locations.

For more experienced mountain bikers, part of the enjoyment comes from the challenge of having to react quickly rather than having plenty of warning before encountering a path feature. This should be balanced with the likelihood of two cyclists (or a cyclist and a walker or jogger) encountering each other head on without sufficient warning.

In urban areas, visibility of trails by the public is also important for personal safety and security.

The track needs to be built and maintained to the visibility/sightlines assessed as appropriate for the Grade of trail. If the required sightline cannot be practicably achieved for sections of the track due to extenuating circumstances (such as, but not limited to, archaeological, cultural, ecological, geological/geotechnical, landscapes/visual or statutory reasons), then the track must achieve the maximum practicable sightlines, and other treatments and mitigations must be considered, and implemented where appropriate.

E7 Fall heights

Decision framework for determining fall treatment

Aspect – Consequence	Key question	Yes/No
Height of fall/slope steepness (i.e. slope so steep and long that arrest is unlikely and is no different to a free fall)	Is the height or length of fall likely to result in death or serious harm?	**Yes/No**
Secondary consequences of a fall (i.e. being swept away in a river)	Are there secondary consequences present that if the fall is survived, are likely to lead to death or serious harm?	**Yes/No**
Presence of hidden hazards (e.g. proximity of undercut riverbank)	Is there a hidden hazard(s) present that is likely to contribute to a fall that is likely to result in death or serious harm?	**Yes/No**
	If yes to any of the above, a likelihood assessment must be undertaken in order to determine risk level and adequate risk treatment	

Note: In the interests of conservatism and safety, if the height of fall/slope steepness has been selected as a **yes** then further consideration is triggered and treatment is warranted.

Aspect – Likelihood	Likely (1)	Possible (2)	Unlikely (3)
(a) Width of track (e.g. a 2m wide track will be less hazardous than a 0.3m wide one)	<0.6m	0.6–1.5m	>1.5m
(b) Track conditions (e.g. even, slippery or rough surface)	Unstable, rough, out-sloping and/or slippery	Stable, loose and rough	Stable, firm and relatively smooth
(c) The presence of vegetation on the downslope bank/bluff/slope	None	Some – may arrest/break fall	Abundant, sturdy, likely to arrest/break fall

(d) The alignment of the track relative/adjacent to the hazardous section and the visibility (line of sight) relative to the hazardous section	Blind corner leading into drop-off	Curvy trail but with line of sight equal or greater than stopping distance	Straight, ample line of sight
(e) Expected level of rider ability	Grade 1 and 2	Grade 3	Grade 4 and 5

Perceived level of risk	High (score 5–7)	Moderate (score 8–10)	Low (score 11–15)
Suggested risk treatment	Engineered safety fence as per design code	Physical treatment using any or a combination of outer bunds, natural barriers (i.e. large placed rocks); physical impediments (i.e. gate system); inside safety cable; specific warning signs	Generic advisory and communication as per mechanisms outlined in this document

E8 Surface materials

E8.1 Design

Gradient and drainage features are the two most significant predeterminants of trail life expectancy; refer to the earlier Sections 2.3 and 2.4 for more guidance on these aspects. On a steep track with no drainage features, skidding tyres and running water will result in chronic loss of the track surface. The finer materials will be transported down the track until it reaches a grade reversal. Left behind will be rocks, roots, ruts and bedrock. On a poorly designed track, this can happen within 12 months, making the track a Grade or two higher, and resulting in considerable soil erosion.

Loss of surface material can be greatly reduced by using out-slope and grade reversals. Out- slope can be lost over a few years of track use as compaction and displacement lead to dishing (the stage before rutting) along the centre of the track where use is greatest. That is why grade reversals are critical. They break up the 'water catchment' and, if they are large enough, they take a long time to fill up.

Where out-slope is not used, the track should either have a crown, or in-slope (see Figure E3). In-slope is common on berms, where the water is directed into the hillside of the track for a short distance, and then directed into a culvert, or across the track at a grade reversal.

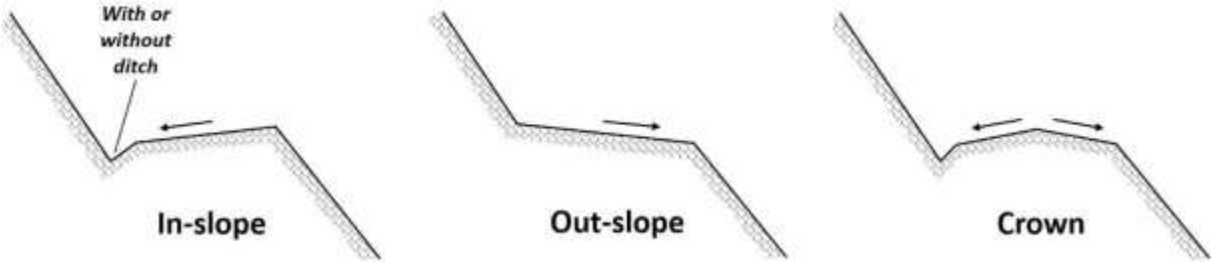


Figure E3: Different options for trail cross-sections

Imagine you are rolling a ball down your freshly built track – it should run off the track as soon as possible.

E8.2 Surface material solutions

Except for volcanic soils, all trails should be surfaced and compacted.

Where surface erosion is a problem, usually due to gradient, the common solutions are to apply a harder, more erosion-proof surface. On mountain bike tracks it is common to use rock armouring, by gathering material from around the track and starting from the bottom, building up a rock layer. This is time consuming, but very effective.

Closer to urban areas, several of the New Zealand Cycle Trails have resorted to sealing steep sections, or sections that are prone to flooding. Materials used are concrete (the most expensive and longest lasting material), asphalt, and chip seal (4 + 6 chip size). Chip seal is the cheapest, but also the bumpiest (generally not an issue for trail riders, but any commuter and sports training riders present may prefer smoother surfaces).

Vegetation cover greatly increases life expectancy by reducing climatic extremes of rainfall, heat, and wind.

E8.3 Compacted gravel or crushed limestone

These paths are formed by laying a compacted gravel layer and thus have a semi-loose surface. It is imperative that the gravel is relatively fine and crushed, as round stones do not bind to make a firm surface and will result in a difficult riding surface.

Uncrushed river gravels, or any other material with round stones, should not be used. Often 'dirty rock' with a range of aggregate sizes from a local quarry can be a cheap, effective trail building material.

A component of fine material (limestone or clay) is required in compacted gravel to aid binding. Limestone has the advantage of having natural cement properties but will not be cost-effective unless it is available locally.

The top layer of these surfaces is generally constructed with a crown at the centre and very little material at the sides. Over time, as cyclists generally ride on the centre of the trail, the trail flattens out.

Users of off-road NZCT routes are expected to be using mountain bikes, which have wider tyres than road bikes, so compacted gravel can be one of the more cost-effective and appropriate surfaces. Coarse or loose gravel surfaces are unsuitable for bicycles with narrow tyres such as road cycles, which are favoured by most touring and long-distance, multi-day cyclists. Designers should determine what type of bike (and therefore tyre) will be used on the trail and specify materials accordingly.

Gravel is often a cheaper option, especially if rocks excavated on-site can be crushed and used to surface adjacent sections of trail. Another advantage of using naturally occurring surface materials is that the surface looks natural and fits into the environment. However, the low capital cost required for these trails can be offset by high operational costs to maintain them. It is important that compacted gravel paths are cleared of vegetative matter during construction and plants are prevented from growing in them. The aggregate is likely to spread and thus it may be necessary to sweep loose aggregate back onto the path where it spreads onto drainage features, roads, driveways, or other critical locations.

Figure E4: Compacted gravel section of Little River Rail Trail at Catons Bay

E8.4 Compaction

Compaction binds the trail aggregate and removes air gaps that water would otherwise get into. It makes the track strong and impermeable to water. Do not compact more than 200mm thickness of material at a time.

Gravel should be at the optimum moisture content when compacted. If it is too wet it will stick to the plate compactor machinery and hinder the process. If it is too dry it will not bind. Gravel should be of mixed size to facilitate binding into a dense and firm riding surface.

The material beneath the surface is also important. Gap-graded aggregates (like railway ballast used on rail trails) form a good structural base with excellent drainage properties and can provide surplus water storage if there is a known flooding problem in the area. However, too much drainage in dry environments can also cause problems. Experience on the Otago Central Rail Trail (OCRT) shows that a very dry surface can prevent the establishment of a firm, cohesive surface. To counter this, the OCRT operators use a consolidated AP40[9] layer between the railway ballast and surface material (well-graded AP20 with a high clay content).

There is no single formula that provides the solution for all trail surfaces. The appropriate surface for a section of a trail will depend on underlying substrate, topography, trail Grade, proposed use and climate. Solutions that may give the best durability may be prohibitively expensive for the number and type of users on a given trail. Over the length of a trail there is likely to be a variety of substrates so the trail surface and underlying layers will need to vary as well.

E8.5 Natural surface

Low volume farm roads with natural (i.e. uncovered soil) surfaces, where motor vehicles provide compaction and prevent vegetation from growing, may also be appropriate for off-road trails. In most cases, natural soil surfaces are likely to be only applicable to mountain biking paths of higher Grade.

The natural surface may be a more rocky surface, such as gravel or even large rocks. Such surfaces can be appropriate for paths of higher Grade trails where riders are experienced in riding on loose surfaces. Figure E5 shows an example of a path with a natural gravel surface.

Figure E5: Natural surface, Great Lake Trail, Taupō (Photo: Jonathan Kennett)

[9] A specification for medium-sized gravel – 'all passing 40mm' sieve. Will ideally contain a mix of stone sizes, including clay.

Natural surfaces can also include the volcanic soils commonly found in the central North Island. Regardless of the soil type, all organic matter should be removed and only mineral material used. Organic matter decreases a soil's strength, promotes vegetation growth and water retention, and accelerates surface deterioration.

Stabilising products can be used on natural surfaces in critical areas to strengthen the trail and provide higher skid resistance for cycling. Figure E6 shows a 'geomat' applied on a steep track with loose surface in Tongariro National Park; aggregate is then placed on top of this base. Geotextiles are useful at sites with high use, extreme weather conditions and erodible soil.

Figure E6: 'Geomat' surface stabilisers (prior to having aggregate placed on top), Tongariro National Park (Photo: John Bradley)

A more natural alternative to surface stabilisation is to apply 'rock armouring' or 'stone pitching' whereby rocks are used to pave the ground surface. Finer gravel or sand can be applied on top of the rocks to produce a smoother surface, depending on the target skill level of riders. This is, however, generally a labour-intensive treatment. Figure E7 shows an example of a rock armoured path.

Figure E7: Rock armoured path – Nichols Creek Track, Dunedin (Photo: Kennett Brothers)

E8.6 Paving stones

Paving stones provide a high quality, durable and attractive surface for paths. They can be easily removed and reinstated for access to sub-surface services. Maintenance is still required for clearing the path of debris and spraying weeds that may grow between the pavers.

The high cost of this treatment is likely to make it an unsuitable option for most NZCT routes. It may however be appropriate for small sections where aesthetics are particularly important, for example end treatments at urban locations. Some trails may be able to make use of wide, flat stones found locally to serve as paving stones.

E8.7 Recommended surface types for path grades

Table E4 outlines the recommended surface types for Grade 5. The appropriateness of natural surfaces also depends on site and user characteristics; stabilising materials may be required.

Table E4: Recommended surface types for Grade 5 trails

Grade 5	Recommended surface type
EXPERT	Natural surface Compacted gravel/lime-sand

E9 Construction

Here are ten useful guiding principles for track construction.

- Keep water away from the track surface
- Construct sustainable gradients
- Make the track flow

- Provide a suitable surface
- Maintain a good surface
- Maintain when required
- Be environmentally astute
- Protect your investment
- Train staff
- Respect and keep historic values

Cyclists have indicated that they like to feel as if they are exploring the 'wilderness' but not as if they are biking on a country road. It is important to communicate this message to contractors who may be tempted to provide extra but unnecessary width. Contractors normally involved in road construction may not understand the specific requirements of Grade 3 and above trails; whereas roads are built to be smooth, straight, level and consistent, more experienced riders some challenges in the form of curves, grade reversals, slopes and changes in path alignment.

The best way to communicate the trail requirements to a contractor may be to ask them to ride a trail of a similar Grade with a trail designer and then discuss the trail's characteristics and desirable aspects from a design perspective.

E9.1 Vegetation clearance

Trees and shrubs should be assessed for their ecological value, and where possible, exotic species removed rather than native species. Trail alignment should be adjusted to avoid removing rare and/or large native trees, which are valuable to the landscape amenity and ecological values of the trail. At all times, trail alignment should comply with statutory requirements.

All limbs should be cut flush (or to within 10mm) of the trunk or main branch, or ground level. This makes the cut branches less of a danger if people fall onto the cut branches, and it is also healthier for the tree.

The danger of cut branches and stumps on or near trails cannot be overstated. Potential injuries include stab wounds, broken bones, facial lacerations and lost eyes. All trimmed branches near trails should be cut flush with the main branch or tree trunk. Stumps should be dug out of the ground or cut at or below ground level.

All cut woody vegetation should be removed from the track surface and either chipped or moved out of sight of the track (this applies to DOC and council reserves, and other areas where the native vegetation is valued). In pine plantations it is not usually necessary to move cut vegetation out of sight.

E10 Data collection

All Great Rides are required to have automatic counters appropriately placed along the trail to provide the number of Trail users. Trail managers need to encourage users to complete the survey. As part of governance and management of a trail, Great Rides are required to provide an annual target number of completed surveys.

Survey alerts are a useful tool for trail management.

E11 Accessibility

On-road and off-road trails may be used by cyclists with disabilities, using a range of equipment that may differ in size from a bicycle. This includes:

tricycles (recumbent and upright)

- tandem bicycles
- hand cycles (recumbent and upright)
- e-bikes
- wheelchair tandems
- wheelchair clip-ons
- cargo bicycles and tricycles
- cycle trailers
- bicycles with stabiliser wheels.

Further guidance on making cycle trails inclusive can be found in NZTA's Accessible cycling infrastructure: Design guidance note.

E11.1 Trail barrier remediation – least restrictive access

Physical gates and barriers present significant challenges for the accessibility of outdoor tracks and trails. Many people, including those with disabilities, are affected by such barriers.

Gates and barrier structures along trails should not be a barrier to access for trail users. However, preventing motorcycles and other prohibited vehicles from accessing trails is difficult when trying to accommodate possible legitimate trail users. Meeting the needs of those with modified cycles or cycles with child trailers, adaptive equipment, and parents with prams, as well as not creating hazards for people who are Blind or vision-impaired, may be a challenge, but requires consideration.

Recreation Aotearoa is working with the Outdoor Accessibility Working Group, supported by the University of Canterbury's Dept. of Mechanical Engineering, to develop a decision-making matrix to support more effective decision-making about the use of barriers and access control mechanisms on trails.

Here is the most up-to-date guidance relating to improving barrier accessibility.

E11.2 Is the barrier necessary?

Several types of gate and barrier structures have historically been implemented to address motorbike concerns on trails. It's important to **re-consider if historic rationale for barrier use is still valid on your trail**. Read about an example cycle trail in the UK that re-assessed the need for such barriers and implemented a trail period to understand the effect of changing a barrier.

Unless there is a well-documented and informed health and safety concern or issue to address on your trail, barrier removal should be a priority.

E11.3 What other control mechanisms can be used?

Signage discouraging the use of prohibited vehicles and motorcycles (including information on relevant consequences, such as confiscation of prohibited vehicles and equipment).

Partnering with local police and authorities to provide more frequent surveillance of areas identified as problematic with anti-social behaviour.

Bluetooth keypads with changeable pin-codes (with clear, readily available guidance on how users obtain a code for access).

E11.4 The Least Restrictive Access principle

The principle of Least Restrictive Access (LRA) is that all new work and maintenance repairs should aim to achieve the most accessible option. Least Restrictive Access is achieved by identifying the least restrictive option for a specific feature, such as a gate or barrier. This is not just about selecting the type of structure, but also how to make and install the chosen structure in the least obstructive way for trail users, to maximise accessibility for as many people as possible.

The UK Sensory Trust, on behalf of Natural England, has modified the principle of By All Reasonable Means, Least Restrictive Access to the outdoors to the following:

> *A gap, or no barrier, is less restrictive than the modified squeeze gate (specifications below), which is less restrictive than a traditional squeeze gate. So, when a traditional squeeze gate needs repair or removal, the first option is to remove it entirely. If this is not an option, it is replaced by the modified squeeze gate. The last resort is to replace the traditional squeeze gate.*

E11.5 Existing barrier structures

E11.5.1 Bollards and concrete blocks

These mechanisms do not prevent motorcycle access.

If you are using bollards or concrete blocks to prevent 4-wheeled, or car, access, make sure that there is **at least a 1.7m** clear width between adjacent bollards; there is no linking chain or rope of any kind between bollards; the bollard strongly colour contrasts to the background, and there is lighting or a reflector band around the top (visible from any direction).

The bollard should be clearly marked, by painting it in a visible colour, with reflective disks. On paved surfaces, a white diamond should be painted around the bollard, leading at least 10m (greater if the approach speed is likely to be over 30kph) before and after the bollard, and 300mm either side (ideally 450mm). Also, bollards should either be no more than 700mm high, to be below handlebar height, or they should be at least 1.5m high so that they are clearly above handlebar height. The worst height for bollards is around handlebar height, as this means people find it hard to judge if they will miss it or not.

E11.5.2 Chicane gates, croquet hoops and squeeze gates

These can limit access for prams, child bike trailers, larger mobility equipment, like mobility scooters, and many pieces of adaptive equipment such as adaptive mountain bikes, recumbent cycles, tandem cycles, trikes, as well as e-bikes and heavier equipment that users must lift or manoeuvre to navigate the chicane or squeeze gate.

If there is a grass area around the side of the chicane, squeeze gate or croquet hoop, this will not prevent motorcycle access.

If a croquet hoop or squeeze gate **must** be used, traditional specifications have been modified, in consultation with local trail users, to be made more accessible.

Powder coating the barrier (in a high-contrasting colour to the background) also enhances its accessibility for people who have low vision and sight impairments.

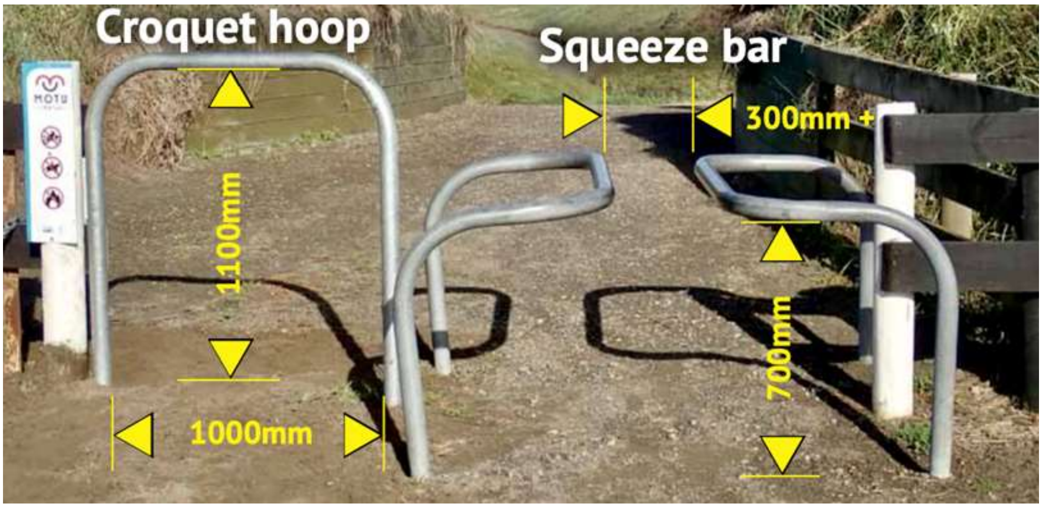


Figure E8: Accessibility modifications for hoop and squeeze barriers

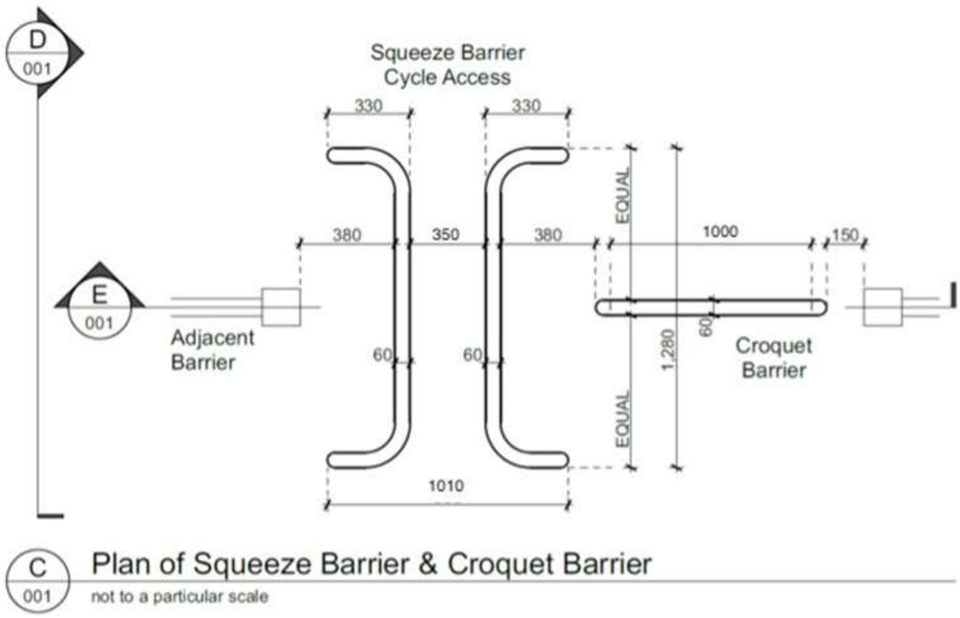


Figure E9: Dimensions for accessibility modifications

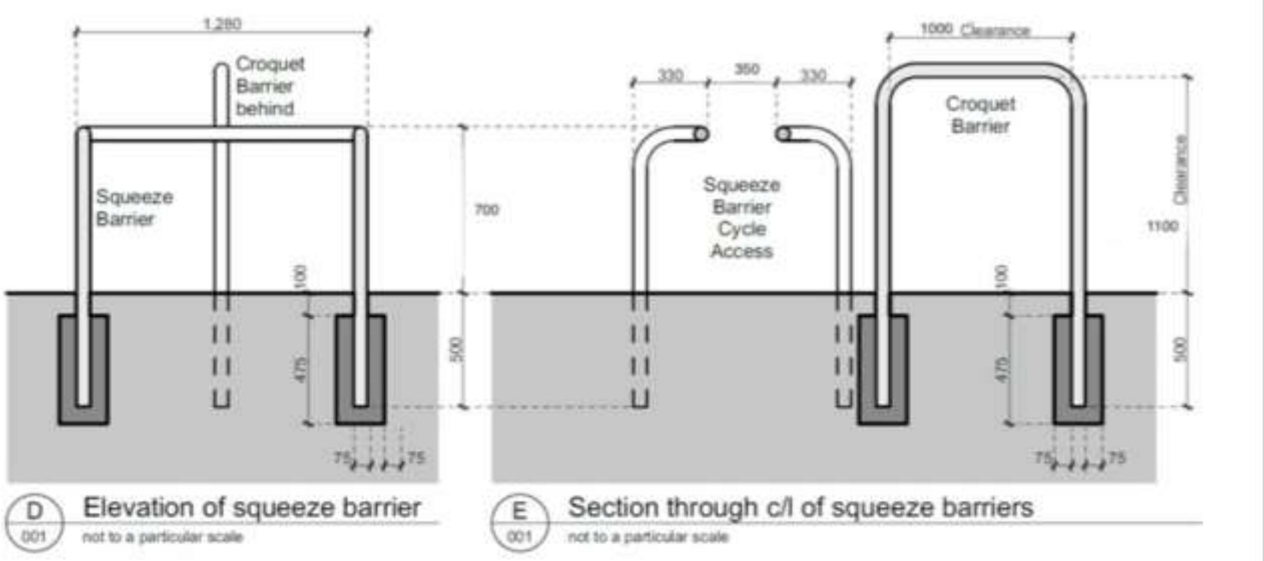


Figure E10: Dimensions for accessibility modifications

Although these specifications are more accessible than traditional squeeze gate and croquet hoop design, **they are not 100% accessible** for all types of mobility devices or adaptive equipment.

Evaluating the absolute necessity of this barrier, including its appropriateness for your type and grade of trail, and its placement on the trail, remain important considerations.

E11.6 Notifying trail users of barriers and limitations

Trail users will want to know ahead of time:

- Where is the barrier on the trail?
- What does it look like? Can a photo or diagram be included in the Trail map or website?
- What are the dimensions of the barrier? What equipment can fit through?
- Are there alternate entrances, such as nearby gates which can be unlocked, that users can arrange ahead of time?
- Who can users contact for more information?

Motu Trails has a great example of displaying this information. Read more about their barrier access on trails, with supporting access information here.

For information specific to urban cycleways and access control mechanisms and barriers, see NZTA's *Accessible cycling infrastructure: design guidance note*.

For further advice on trail accessibility and barriers, or to be kept up to date with the barrier guidance, please contact Katie Owen, Disability and Inclusion Programme Manager.

E11.7 Trail accessibility

Path end or 'terminal' treatments are used at ends of off-road trails (paths) to warn people of the approaching transition to on-road trails (or simply a road, without cycle provisions) and to prevent motor vehicles from accessing the paths. While physical restrictions have been commonly used historically at path ends, they should not be seen as a default treatment, and many trails will operate very well without them.

Path end treatments should not necessarily be designed with the aim of slowing cyclists down and should not provide an obstacle that distracts riders' attention from the impending transition to the roadway. Circumstances where cyclists should be required to dismount are rare, so route end treatments should allow people to comfortably ride through without awkward manoeuvring.

Bollards and staggered fences or U-rails are preferred path end treatments, where necessary. These devices can be designed to prevent access by motor vehicles, including motorbikes. It is recommended that designers seeking further guidance in this area read the NZ-specific guidance on 'Access Control Devices', which will be referenced in the *Cycling Network Guidance* (NZTA, 2019). To support 'safe system' principles, the default position in the new NZTA guidelines is that access control devices should typically ***not*** be used on facilities used by cyclists.

Barriers at path ends that block entry to users of wheelchairs, trikes, etc., should be avoided if possible. They stop some valid users from accessing the trail and will lead to complaints, so consider if they are really needed. Barriers to stop cars do not need to be so narrow that they also stop non-motorised devices. New barrier designs are starting to be developed that allow for a wider range of legitimate users to gain access – e.g. Figure E11.

Figure E11: Example of a wheelchair-accessible barrier, Belmont Regional Park (Photo: Greater Wellington Regional Council)

Bollards are a hazard to users. If they are used then they should be spaced 1.6 to 1.7 metres apart, and not in the centre of the trail. The bollard should be clearly marked, by painting it in a visible colour, with reflective disks.

On paved surfaces, a white diamond should be painted around the bollard, leading at least 10m (greater if the approach speed is likely to be over 30kph) before and after the bollard, and 300mm either side (ideally 450mm). Also, bollards should either be no more than 700mm high, to be below handlebar height (see Figure E12), or they should be at least 1.5m high so that they are clearly above handlebar height. The worst height for bollards is around handlebar height, as this means people find it hard to judge if they will miss it or not.

Figure E12: Path end treatments, West Coast Wilderness Trail, Greymouth

Frangible plastic hold rail could be used at highway crossings where NZTA may not allow a fixed steel hold rail due to risk of highway users hitting it in a crash.

Figure E13: Path end treatment, Hawkes Bay Trails (Photo: Jonathan Kennett)

E11.8 Excluding motorcycles

Motorcycles can be problematic on cycle trails. Various techniques exist to discourage this nuisance, including the positioning of central posts in trails and at gateways or cattle-stops to discourage their use. However, note the discussion above about ascertaining whether the problem is real (and significant) or perceived, particularly where any barrier treatment would severely restrict other legitimate trail users.

One technique, a 'squeeze barrier', is illustrated in Figure E14, with the full design specifications given in Figure E15. Note that if this barrier arrangement is used on trails where cyclists use pannier bags, the horizontal bars should be installed at the maximum stated height of 870mm. Accurate installation is critical. The width and height of these barriers must be consistent throughout a trail. A jig will be needed for installation, and the trail surface should be checked annually, as if it compacts from wear and tear, then the effective bar height will be higher. A sealed surface underneath might be advised, so that the height stays the same. If there is a notable gradient on the trail, then the tops of the barrier should also mirror that gradient, to be parallel with the track surface.

Riders need a straight approach for 10 metres before a squeeze barrier. They cannot be installed on corners as riders cannot ride through them.

Figure E14: 'Squeeze barrier' to discourage motorcycles, Remutaka Cycle Trail (Photo: Jonathan Kennett)

E12 Environmental considerations

Trail designers and builders must consider the environmental impact of the trail construction (for example vegetation clearance, rare plants, wildlife, siltation of streams and wetlands). Efforts should be made to design the trail to get the most out of the environmental beauty of an area by working around trees, passing natural features, and transplanting small seedlings that are in the path of the track.

For a natural surface trail to be sustainable it should incorporate the principles of sustainable gradients (as discussed in Section 2.5), frequent grade reversals (to aid drainage – as discussed in Section 2.4) and weed control (as discussed in Section 8).

Opening a natural surface trail to light can encourage weed growth and degrade the microclimate. The natural tree canopy should not be disturbed if possible. Some invasive weeds (for example African clubmoss and didymo) are easily transferred from one trail to another, even by bicycle tyres. At the design and construction stage, these weeds need to be identified and eradicated or controlled (where possible). If infestations occur after the trail has been built, on-going control techniques will be required. Clean all earthworks machinery, hand tools and PPE before taking onto a new site, to avoid importing weeds. Imported gravel, soil and rocks must be from a weed-free source.

In areas of native forest, the environmental values should be assessed first. An Environmental Impact Assessment (EIA) report from a qualified ecologist may be required. Mitigation of the effects of trail building can enhance a track and the users' experience. For example, at Makara Peak Mountain Bike Park in Wellington a native tree is planted for every metre of track built. This mitigation measure is very popular as it results in a combination of recreation and conservation that people appreciate. Several NZCTs have planted thousands of trees beside their trails.

Tree planting provides shade, bird habitat and wind breaks (which help to prolong the life of the trail surface). Over time, native trees also replace undesirable introduced plants such as gorse and blackberry.

Some trails also have stoat/rat traps set up alongside the trail to improve the environment for native birds.

It is preferable to fill between and over roots rather than digging them out. See Section 8.2 for further guidance about maintenance of trails with roots.

As discussed in Section 2.1.5, the natural landscape is an important factor that should be considered during initial design stages. There are often opportunities to ‘recycle’ local materials (e.g. crushing excavated rocks to be used as base course or surfacing over roots) when building trails. This adds continuity to the trail, decreases environmental impact and can cost less than importing materials.

Councils have rules restricting the amount of earth that can be moved and the maximum cross slope of terrain that a track can be built on. Trail designers and builders need to become familiar with these rules, which make sense from both environmental and track sustainability standpoints.

Check local council plans and rules to be informed of restrictions, as well as Resource Management Act requirements, before design and construction stages.

Culverts may disturb the natural movement of native fauna. Boardwalks and bridges have less impact on watercourses, but are more expensive than culverts.

After construction, undertake a special trip to remove survey tags, construction materials/signs and any general rubbish.

E13 Culture and heritage

Consideration under the Treaty of Waitangi Partnership and the *Heritage New Zealand Pouhere Taonga Act 2014* require trail managers to consider cultural and archaeological factors. Engagement with iwi will help at the trail planning stage, and an archaeology report may need to be written.

Middens, pā and urupā are taonga and there is a legal requirement to treat historical sites (over 100 years old) with respect and have them examined by an archaeologist. These clues to the past can be explained through interpretation panels and will enrich the riding experience by connecting people to the unique environment and stories that contribute to who we are as New Zealanders.

Among solutions to challenges noted in the heritage and archaeological space are the following.

- You may need to identify any existing heritage orders for sites you are developing, as described under Part 8 of the *Resource Management Act 1991*.
- Walking and cycling trails commonly involve earthworks on previously unmodified ground. Archaeological heritage might be missed as it is more invisible and involves a separate consenting process from Heritage NZ.
- Heritage NZ maintains the New Zealand Heritage List and the National Historic Landmarks list where you can identify notable historic and cultural sites around the country.
- It's a small cost to get a high-level archaeological risk assessment for starters – the full Heritage Impact Assessment/AEE can come later if required. Identifying any archaeology early in the process will greatly help forward planning.
- The NZ Archaeological Association's database records are indicative only. Additional information on potential for sites should be sourced from iwi/hapū, Heritage NZ, and an archaeologist with local knowledge.
- Repurposing heritage structures (bridges/tunnels, etc.) has been particularly successful in adding existing infrastructure to walking/cycling trails in a cost-efficient manner.

Build a relationship early in the project life with regional Heritage NZ staff so you can tap their expertise.

Heritage represents an opportunity to enhance sense of place and identity and build community well-being. For more guidance, refer to NZTA's factsheet *Considering historic heritage in walking and cycling projects* (2019), available from the CNG website.

E14 Bridges and boardwalks

Ideally bridge and boardwalk widths should be consistent with the overall path and therefore designed according to the path width requirements outlined in E2 plus additional clearances for 'shy space' due to handrails or walls etc. However, this may not always be feasible, especially for long spans or constrained locations, in which case the minimum bridge widths outlined in Table E5 can be used.

E14.1 Bridges

E14.1.1 Width

It is usually relatively cheap to provide additional width for a cycle bridge. A bridge that is 50% wider than the minimum width will generally be much less than 50% more expensive, yet provide a much more pleasant cycling experience.

Table E5: Bridge and boardwalk widths

Grades	Recommended bridge width	Minimum bridge width *
5	0.8m	0.4m

Note:

- Extra clearance up to 0.8m is necessary on bends, where cyclists will lean into the corner.

E14.1.2 Handrails

It is preferable to slope handrails outwards (17.5–27% from the vertical) to allow more space for handlebars and thus allow more of the bridge deck to be safely ridden on. Flaring the handrails in this manner increases the effective width of the structure at minimal cost and generally improves the appearance of the structure. The minimum bridge width (from Table E5) is required at the surface of the bridge but flaring the handrails allows more clearance at handlebar height (taken as 1.0m) and therefore makes the experience more comfortable for riders.

Handrail barrier height should be at 1.2m high. Any current barriers being replaced, or new barriers, must meet this height requirement. Existing guardrails and barriers should only be replaced at the end of their life where a significant hazard exists. This excludes on-road assets. Handrails for new bridges and replacement bridges on road sections are to comply with Waka Kotahi New Zealand Transport Agency standards.

If a bridge or boardwalk does not have handrails, people will be wary of cycling too close to the edge for fear of falling and suitable clearances for 'shy space' should be provided (see E2 – clearances). Table E5 indicates the recommended bridge width according to path Grade. It may be appropriate to increase this width where possible, especially for bridges of length 20m or longer or on curved sections as cyclists need more space when cornering. Passing/viewing bays should be provided at 50m intervals on bridges (if feasible) and boardwalks; they should be 5m long by 2.5m wide and have handrails. It is not practicable to provide passing bays on suspension bridges and cyclists will need to ride in single file. If cyclists approach such a bridge from opposite ends, one direction will need to give way to the other.

Handrails should be used on significantly curved bridges or bridges 20m or longer if only the minimum width is provided. If the bridge is at least 0.5m wider than the minimum width, handrails are optional (unless the fall height governs). HB 8630 uses an equivalent value of 1.0m but the risk and safety implications of falling off a bridge or boardwalk are likely to be more severe for cyclists than pedestrians. Cyclists travel at faster speeds and fall from a greater height (due to their position on the cycle) than pedestrians. Cycles can also complicate a fall by catching pedals or handlebars on a structure during the fall or hurting the rider on landing. Refer to E14 for decision framework on fall heights.

The guidance provided in this section does not override any legislative requirements.

E14.1.3 Passing/viewing bays

When designing these structures, consideration of the requirements for cyclists passing each other is needed. Similarly, the effects of cross-winds can make cycling unstable and this needs to be addressed when choosing appropriate widths and deciding whether or not to provide handrails.

A typical (although notably narrow) boardwalk is shown in Figure E15 – it would require handrails and passing bays for a Grade 1 or 2 trail.

Figure E15: Boardwalk – Twizel River Trail (Photo: Kennett Brothers)

E14.1.4 Vertical clearance

The vertical clearance of a bridge above a river should take into account the potential river flood height. In some cases, it may be acceptable that a river level will occasionally rise above the bridge deck, but this risks the integrity of the structure.

It is up to the trail owner to specify the appropriate flood design in this circumstance, to erect suitable warning signs and to ensure a suitable inspection and maintenance regime is in place.

E14.1.5 Drainage

NZCT path drainage guidance (Section 2.4) should be used for structures where appropriate rather than HB 8630 track drainage standards, which apply to natural surface walking tracks.

E14.1.6 Skid resistance

UV stable polymer mesh should be used on bridges and boardwalks to increase skid resistance. Wooden surfaces can be dangerously slippery when wet and make corners particularly difficult to negotiate. Wire netting is also a possibility, but it tends to wear out quickly on wooden boardwalks. Boardwalks are very susceptible to frosts and can become hazardous for early morning users. Consideration should be given to surfacing treatments in frost sensitive areas to mitigate the effects of ice on the path surface.

E14.2 Swing and suspension bridges

The terms 'swing bridge' and 'suspension bridge' mean different things to different people. In this design guide, a suspension bridge is a bridge suspended from cables with a fairly rigid deck and may be wide enough for two people to walk across side by side. A swing bridge is a lighter structure, also suspended from cables, but the deck is flexible and often made from steel cables and metal bars, perhaps with wire mesh. They are often used on tramping tracks and are just wide enough to walk across.

In some situations, the type of bridge to be used will be governed by physical features, financial considerations and possibly the logistics of getting construction materials to the site. A swing bridge is often the preferred bridge structure for walking tracks and may also be the most practical alternative for more remote cycle trails, especially when crossing long spans.

Figure E16: Suspension bridge on the Old Ghost Road (Photo: Jonathan Kennett)

Due to their freedom of movement, swing bridges will generally not be suitable for cyclists to ride over. Some cyclists may try to ride over swing bridges, however, which could result in injury from impacts with the bridge sides. Thus, if swing bridges are used, they should be made as rigid as possible with signs to warn cyclists of the dangers of riding across.

Suspension bridges are more stable than swing bridges and can thus be used for all Grades of trail. Suspension bridges are generally a cheaper option than solid timber or metal constructions for longer spans.

Figure E17: Suspension bridge, Ōparara Valley Track

Swing and suspension bridges should comply with the requirements of HB 8630 (unless contrary guidance is provided in this guide).

E14.2.1 Approaches

A bridge or boardwalk narrower than the path will require end treatments to ensure cyclists are channelled onto the structure rather than off the side. This can be achieved by guardrails on either side. A storage space for cyclists to pull over on the approach to the structure (to rest or avoid passing or overtaking inside the structure) would also be appropriate. If provided, this should be on the left side approaching the structure.

E14.2.2 Aesthetics

Bridges provide the opportunity to add to a route's iconic nature.