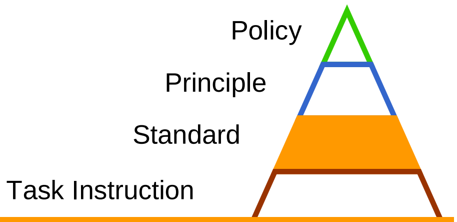

Civil Standard

Formation

Purpose

This Standard establishes the design requirements for track formations (rail pavement layers) to be installed on KiwiRail network.

Document Control

Document No.	C-ST-FO-4110	**Issue No.**	Issue 1.0
Date Effective	31/03/2019	**Author**	Daniel Rodriguez
Prepared (P) **Reviewed (R)** **Amended (A)**	Daniel Rodriguez (P) Brad Adams (R)	**Checked and Approved By**	Civil Engineering – Technical Committee
		Authorised for Release By	Professional Head – Civil Engineering

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1. Revision Procedure and History

This is a 'living' document, that will be up dated every five years or whenever KiwiRail determines that changes to it and processing requirements documented herein are appropriate.

If changes arise from the review this document will be reissued, however, if no changes arise from the review, the current version of this document will remain in force.

Refer to the **Briefing Note(s) for C-ST-FO-4110 Formation**

and **Document History** (at the end of this document) for full document changes.

1.1 Changes in this issue

Issue No	Description	Page(s)

1.2 Withdrawn, closed and superseded

Old Reference	Title	Replaced by
GENZCHRI14775	Formation Design and Maintenance Guidelines – Field Guide	C-ST-FO-4110

2. Associated Documents

Level	Number	Title
	CE 100862	Drainage and Formation Standard Details
3	C-SP-GE-64000	Earthworks
3	C-ST-CD-4102	Corridor Drainage
3	C-ST-GE-4105	Ground Engineering and Earthworks
3	G-ST-AL-9103	Departure from Standard
3	G-ST-AL-9112	Engineering Drawing Issue and Control
3	T-SP-MM-60140	Supply of Crushed and Screen Stone Ballast
3	T-ST-DE-5200	Track Design
4	C-TI-FO-4206	Formation Investigation
4	C-TI-FO-4207	Formation Construction

2.1 New Zealand and International Standards

The design of track formations (rail pavement layers) shall comply with this standard and relevant New Zealand Standards and codes. Other international standards may be referred to for guidance where specific information is not available in the referenced standards.

Where any discrepancy exists between the different standards referenced, the Professional Head Civil Engineering, shall be consulted to provide a ruling on applicability.

The principal design standards are listed below. Refer on line for the latest editions.

New Zealand Standards

TNZ F 1 (1997) Specification for Earthworks Construction

NZTA SP/M/022 (version 3) New Zealand Transport Authority Bridge Manual

NZS 4402:1986 Methods of Testing Soils for Civil Engineering Purposes

TNZ F 2 (2000) Specification for Pipe sub-soil drain construction

TNZ F 5 (2000) Specification for corrugated plastic pipe in sub-soil drain construction

TNZ F6 (2006) Specification for geotextile wrapped aggregate subsoil drain construction.

TNZ F 7 (2003) Specification for geotextiles

Australian Standards

AS 7638:2013 Railway Earthworks

Other Standards and Guidelines

AREMA (American Railway Engineering and Maintenance-of-Way Association)

UIC (International Union of Railways)

2.2 Statutory Requirements

Statutory documents which should be referred to include, but are not limited to the following New Zealand Statutory Requirements:

The Railway Act 2005

The Building Act

National Environmental Standards

The Building Regulations and Building Codes

Health and Safety at Work Act 2015 and Regulations

Excavation Safety – Good Practice Guidelines

Resource Management Act 1991

Territorial and regional authority policy and bylaw documents as appropriate.

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3. Acronyms and Definitions

Name	Description
BOL	Block of Line
Batter Slope	Inclination of the outer surface of a cut and/or fill surface profile
Borrow Pit	Excavation made for the procurement of material
Bulk Fill	This is all the material placed in the fill, from the ground surface after clearing and removing of top soil
CBR	California Bearing Ratio: Penetration test used for the evaluation of the strength of natural ground, subgrades and base courses. Commonly determined via correlation with Dynamic Cone Penetrometer test results. However, it can also be measured directly in accordance with test method NZS4402 Test 6.1.1, 6.1.2 or 6.1.3 on remoulded or undisturbed samples, or in-situ, respectively.
Compaction	The process whereby the density of soil is increased by mechanical means. This typically involves, rolling, impact or vibration, or a combination of these actions.
Contaminated Material	Material that may contain toxic substances or soluble compounds harmful to environment, water supply or agriculture
Cutting	An earth or rock excavation that is made to create the railway formation/corridor
DCP	Dynamic Cone Penetrometer
Dump Area/Dump Site	Location within or out of the work site for permanent disposal of unsuitable material. Also referred to as 'spoil area/spoil site'
Earth/Soil	All materials including soils and weathered or loose rock which could normally be removed by ripping using an excavator or dozer
Embankment	An earth or rock filled structure above an existing and/or excavated surface to create the rail track formation
Engineered Fill	Fill that has been placed and compacted in a controlled manner and verified to meet set requirements such as placed layer thickness, percentage of maximum density and soil moisture
Formation	The upper load bearing layers comprising selected materials. Earthworks structure including all foundation and capping layers on which Ballast is laid
Formation Width	Railroad width at formation level
GAP	General All Passing
General Fill Zone	The zone below the formation zone of the embankment
Geosynthetics	Generally polymeric products. Geotextiles and geogrids are often used as filter drainage or foundation reinforcement
NZGS	New Zealand Geotechnical Society
NZTA	New Zealand Transport Agency
NZS	Standards New Zealand
Rail Level	Theoretical level of the running surface of the rails (top of rail). In the

Name	Description
	case of canted track, it is the low rail
Relative Compaction	The per cent ratio of the compacted field density of the materials and the optimum density obtained in laboratory testing
Structural Zone	The upper zone of the embankment. Its thickness varies depending on the CBR of the general fill
Sub-grade	In situ material retained below the General Fill Zone or Structural Zone for construction of the embankment and/or formation
Tolerance	Range between the limits which a dimension or position lies
Topsoil	A natural surface soil that may contain organic matter
TNZ	Transit New Zealand
UIC	International Union of Railways
Undercut	Removal of material beneath required depths for replacement with new selected materials
Unsuitable Material	Materials which cannot be used in construction fill due to one or more of its inherent properties making it unsuitable
USCS	Unified Soil Classification System

3.1 Notes, caution and warnings

Icon	Definition
	Note(s) to point out something of special importance
	Caution or warning – drawing special attention to anything of important reminder or a safety message

No table of figures entries found.

4. Scope

This Standard sets the requirements for all design of track formations. These are the principal load bearing Formation layers.

It also covers design requirements for any formation work that may be undertaken during projects, repairs, maintenance or upgrades to existing lines.

This Standard needs to be read in conjunction with documents C-ST-CD-4102 Corridor Drainage, for drainage requirements and C-ST-GE-4105 Ground Engineering for associated earthworks.

4.1 Use in the field

This document has been designed to be used in the field. It is expected that this document will be opened on an iPad via 'Briefcase' and used as reference to complete the task. Note as written on the front cover the controlled version is held on iKon. Printed copies of this document are uncontrolled.

5. General Requirements

5.1 Controlling specifications

The general specification, document C-SP-GE-64000 Earthworks, for earthworks shall be supplemented by the TNZ F1 (1997) and, when applicable, a project-specific earthworks specification where the characteristics or intervals requiring testing differs for a designated project.

5.2 Safety-in design

A Safety-in-Design (SiD) register shall be recorded and submitted to KiwiRail for all designs. The designers are accountable for a 'safe design' for all formation works. This means the implementation of control measures early in the design process to eliminate or, if this is not reasonably practicable, minimise risk to health and safety throughout the life of the track formation works that are being designed.

A safe design includes the refurbishment, demolition and replacement of existing structures. The designer must take into account safety considerations for construction (including haulage of materials) and maintenance personnel, and the future users of the asset.

5.3 Existing track formation

Over sections of the network, the geometric standards that prevailed for cuttings, embankments and drainage provisions at the time of construction are now substandard when compared with the requirements described in the KiwiRail drawings CE 100862 Drainage and Formation Standard Detail.

Therefore, when track and/or drainage improvements or maintenance requirements affect an existing cutting or embankment, any geometric changes must be fully evaluated by a geotechnical engineer to undertake an adequate assessment of the ground stability.

Should there be opportunity to do so, such embankments, cuttings and general formation on grade will be modified to match the current standard requirements.

5.4 Protection of the environment

The design of cuttings, embankments and other civil infrastructures, including the formation works, must consider environmental impacts during construction and maintenance activities, with a view to minimising any such impacts.

In some circumstances, erosion and sediment control plan and/or a Resource Consent may be required. Advice should be sought from KiwiRail's Resource Management advisors.

Guidance on techniques for minimising erosion and managing sediment runoff from construction activities are outlined in the NZTA Erosion and Sediment Control Guidelines – Construction Stormwater Management (2014). Local Authorities also have guidelines that should be reviewed and adopted as required.

5.5 Heritage

Heritage considerations and classifications must be observed in all earthworks designs. This may have particular application in circumstances where an existing historically site is planned to be refurbished or modified, or where earthworks are designed in the vicinity of existing heritage items.

In all instances, safety is the main priority and unsafe structures/components should be replaced if they do not satisfy KiwiRail requirements for the safe running of trains.

Where required, advice on heritage and archaeological values can be sought from KiwiRail's Resource Management specialists.

5.6 Documentation and records

All earthworks activities shall be documented. Appropriate documents must be prepared at the following stages:

- Investigation and planning
- Design and specification
- Construction
- Commission/delivery.

5.6.1 Design and specification

The functional requirements of the design must be documented in the specification and Issued for Construction drawings. The documentation must be sufficiently complete to allow the constructor to unambiguously carry out the works, and for those supervising to be able to interpret the design and administer the works.

5.6.2 Drawing standards

Issued for Construction and As-Built drawings must comply with document G-ST-AL-9112 Engineering Drawing Issue and Control and must detail the design criteria including loading, horizontal and vertical clearances, and any other relevant information to ensure that the new structure is constructed and maintained in accordance with the design.

Drawings shall include details of:

- Site survey
- Track alignments and levels. Any offsets should be referenced horizontally from Track Centre Line and vertically from top of rail level.
- Drainage and Formation Standard Detail layout and details.
- Location of structures, services and natural features.
- Appropriate number of cross sections according to the possible relevant differences in the section affected with a minimum of one detailed cross section each 50 metres of longitudinal track

Drawings CE 100862 Drainage and Formation Standard Detail should be used as guideline for the details and appropriate scale of drawing references.

Document T-ST-DE-5200 Track Design should be referenced for track geometric design.

5.6.3 Construction

Adequate records need to be kept during the construction, including conditions encountered, works as executed, As-Built drawings, testing records and any alterations to the specification and drawings.

Site records, such as daily diaries and detailed drawings of works as executed, should be maintained by site staff to a level of detail appropriate for the scale of the works.

6. Planning, Investigation and Assessment Requirements

6.1 General

Document C-TI-FO-4206 Formation Investigation shall be the reference document.

When approaching investigations for large scale projects, such as major realignments or new sections of track, the investigation should also follow the guidelines of the Task Instruction referenced, although it is understood that additional requirements must be considered within the holistic approach involved in such projects.

6.2 Site specific safety plan

Prior to any investigation works commencing on site, a Site Specific Safety Plan must be submitted for KiwiRail approval. This shall include a description of the proposed activities and how safety risks will be managed, timing of the activities and proposed track protection.

6.3 Adjoining property

An assessment must be completed prior to works commencing to establish whether there is a potential for damage due to excavation, compaction, vibration, noise, run-off, dust or other effects from any KiwiRail earthworks. If there is the potential for any such issues affecting adjoining property owners there must be direct liaison with them prior to works commencing. Maintaining good relationships with neighbours is important to KiwiRail, therefore adjoining property owners must be informed of upcoming works irrespective of whether damage is not likely or otherwise.

6.4 Consenting requirements

During the planning phase, affected Authorities (Regional, District and or City Councils) must be identified, consenting requirements established including, but not limited to, water and earthworks consents. Whether the works are within the KiwiRail designation or extend into other properties or non-rail-designated areas must be established. In addition, Building Consent and Heritage requirements must be determined and complied with.

6.5 Work areas and rehabilitation

All zones impacted by the work must be identified. This includes areas needed or affected by different construction activities such as stockpiles, spoil disposal areas, haul routes, storm water control, and site office/facilities locations.

General arrangement drawings must show these impacts and the planned works and specifications covering the detailed works prepared. Rehabilitation of these areas must be included in planning so that materials such as topsoil, mulched native vegetation (which can contain useful seed stock and nutrients) and bulk fill materials used for such rehabilitation are identified and preserved for re-use. Rehabilitation works must be completed before the constructor vacates the site.

7. Design Criteria

7.1 Formation design – general

Document C-ST-GE-4105 Ground Engineering and Earthworks, shall be referenced for the design of all earth structures (cuts and embankments) and for general fill placement. Drainage requirements shall comply with document C-ST-CD-4102 Corridor Drainage and must be based on the drawings CE100 862 Drainage and Formation Standard Detail.

7.1.1 New works

KiwiRail currently runs an 18 tonne axle load network with selected lines operating at lower levels, and the future operating parameters are 20 tonne axle loads for locomotives and 22.5 tonnes for wagons.

Based on these requirements, for new lines, the formation should be designed to carry the imposed loads from 25 tonnes axle load trains.

All factors impacting the formation life such as service objectives, line category (traffic), design strategy, traffic variability, available materials and environment must be taken into account. Values selected must be confirmed by KiwiRail Professional Head – Civil Engineering prior to detail design.

7.1.2 Repairs and upgrades

The majority of the New Zealand Railways original and current rail formation is still as originally constructed, and was typically designed for relatively low axle loads of 8-14 tonnes. The current maximum axle loads of 18 tonnes (on principal lines), has placed a significant stress on the original rail formation, leading to an accelerated deterioration of track condition in some areas characterised by unfavourable in situ ground conditions.

Although the aim for a 25 tonnes axle load standard formation design shall prevail for all new works, an appropriate site specific business case will be undertaken to decide if is economically justified to undertake the repair or upgrade of a small section of a line to a 25 tonnes axle load standards.

This concept is illustrated in the diagram below extracted from the current KiwiRail Asset Management Plan. In Case 1, there is a hypothetical section of formation that is carrying 18 tonne axle loads but is need of rehabilitation. The long term axle load parameters mentioned before suggest that upgrading to 22.5 tonnes is the upgrade we should consider. However, there is an opportunity to create a consistent axle-load environment at a low incremental cost, and a 25 tonnes design should be the aim, despite KiwiRail having no immediate plans to operate at the higher axle load. For Case 2, there is no clear advantage in rehabilitating the formation to an axle load greater than 18 tonnes

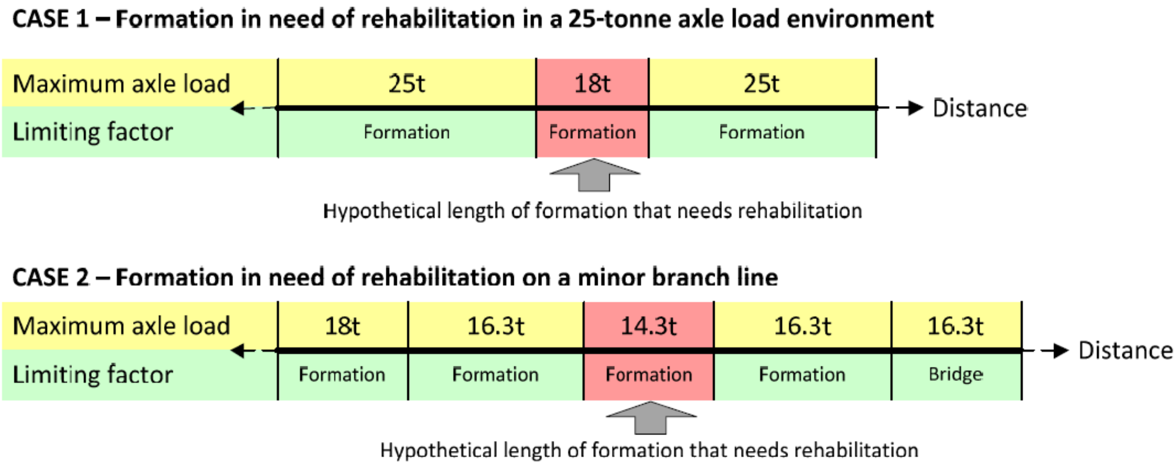


Figure 7.1 Case 1 and 2 formation

In many situations, due to this analysis, the repair / upgrade will not meet the formation standard for new 25 tonnes axle load lines set out in this document for new formation construction. It is therefore imperative that the Professional Head, Civil Engineering is in agreement with the planned work.

The investigation of problematic track is set out in document C-TI-FO-4206 Formation Investigation (Investigation of Track Formation). That document, together with document C-TI-FO-4207 Formation Construction, provide the basis for studying problematic sites and processes to be followed to select and implement an appropriate solution and its construction.

7.1.3 Design life

The rail formation is designed to withstand certain loads. The formation failure may be defined as reaching a 'limit condition' where the formation cannot any longer support the required functional service level (line and level).

New rail routes, because the alignment is fixed and any potential remediation would be very high cost and disruptive to traffic, require an analysis period (design life) of no less than 30 years. The life cycle strategy must be for preventative maintenance and also for high initial standards, followed by very low maintenance needs.

Soil structures such as side drains, v-drains, catch drains as well as subsoil drains must be designed with a target life of no less than 20 years. It must be noted that such soil structures require periodic maintenance on a regular basis.

7.2 Formation design – materials

The ballast, sub-ballast and structural layers required for the track formation design are described in this section.

Reference should also be made to drawings CE 100862 Drainage and Formation Standard Detail for further definition of these layers.

7.2.1 Ballast layer

The Ballast is an intermediate layer that is integral to both the track structure and the formation structure - the ballast can readily be reworked and is instrumental in retaining the line and level of the track while it simultaneously transfers load to the formation, while providing a free draining layer.

Ballast comprises crushed rock which complies with a specified grading envelope and material properties. Ballast material shall meet the requirements stated in document T-SP-MM-60140 Supply of Crushed and Screened Stone Ballast.

7.2.2 Sub-ballast layer

The Sub-ballast is defined as the top formation layer for the purpose of this document. In other rail and pavement documents this layer also receives names such as capping, binding, or blanket layer.

The sub-ballast layer has an important function which is achieved through strict material characteristics and requirements as defined below.

Functions:

- **Bearing capacity/stress reduction**: Improving the bearing capacity and reducing the traffic induced stress over the sub-grade layers. This is the key performing function of this layer, in order to avoid foundation failures.
- Separation layer:
    - It prevents migration of fine particles from the sub-grade and /or structural layers into ballast. This prevents mud pumping and fouling of ballast.
    - Prevents penetration of ballast into the structural layers.
- **Drainage/filtration**: Ballast is a highly permeable layer and an appropriate sub-ballast layer is significantly less permeable. This allows to intercept water and, with the required 3% fall at the top and base of the sub-ballast layer, diverts the flow away from the structural layers.

Sub-ballast material characteristics and requirements:

- **Composition**: Material source should be classified as either soil quality SQ3, subgroups SW (well graded sands) or GW (well graded gravels), as per Table 7.3 or as an aggregate obtained from rock quality RQ3 as per Table 7.4.
- Although GAP40 (general, all passing) is the most common material used as sub-ballast, it is recommended to confirm adherence to the specifications before approving the supply of the material. It is quite common that GAP40 commercial aggregates have fines content higher than the values required, and this might affect their performance.

	While GAP65 has been included in previous KiwiRail documents, there are significant long term benefits for the use of well grade GAP40 vs GAP65. GAP65 is generally an adequate material for **structural layers** beneath the sub-ballast, it is not recommended for its use immediately below the ballast (regardless of the thickness of sub-ballast needed)

- **Mechanical characteristics**: Grading, obtained from laboratory tests as per NZS 4402, With a coefficient of uniformity (Cu) = D60/D10 ≥ 10,

Table 7.1 Grading required for sub-ballast material

Sieve Size (mm)	Percentage by Mass Passing Each Sieve (%)
40	100
20	85-95
10	65-85
4.75	45-65
2	30-50
0.425	10-30
0.075	3-10

- **Strength**: Generally, a LAA ≤ 30 (Los Angeles Abrasion coefficient, as per NZS 4407.3.12) is required for Sub-ballast materials. Values up to LAA ≤ 40 could be accepted depending on the characteristics of the subgrade layers.
- **Permeability**: Optimum permeability for a sub-ballast layer would meet a k (permeability coefficient) of 10-6 m/s = 10-4 cm/s, for a sample tested at 100% of the PMM density. When structural layers or natural ground subgrade are not susceptible to water ingress, the permeability requirement for the Sub-ballast could be withdraw.

Sub-ballast layer design thickness:

- A minimum provision of 75 mm layer thickness shall be provided for the sub-ballast layer, although the required thickness would be obtained from the combined analysis of the original sub-grade (in situ) conditions; the required strength of the formation (current 18 tonnes axle loads or targeted 25 tonnes axle loads) and available ground improvement design options (such as geogrid composite layers).
- Note that a new formation design for 25 tonnes axle loads requires a minimum of 150 mm thickness of sub-ballast, depending on the strength characteristics of the material underlying the formation.
- The appropriate layer thickness required in each case is discussed in the Section 7.4 Formation design – dimensions of this document.

7.2.3 Structural layers

For the purpose of this document, the structural layers are those comprised of adequately selected and compacted material placed between the sub-ballast and the in situ sub-grade or the bulk earthworks for larger embankment construction.

Function:

- Improving the bearing capacity and reducing the traffic induced stress over the in situ sub-grade.

Structural layers composition:

- The granular material to be used in the structural fill layers shall be hard, sound, of uniform quality and free of organics. Generally, the material commercially known as GAP65 would meet the general requirements summarised in the following table.

Table 7.2 General requirements of structural fill

Property	Standard	Test Method	Number of Tests[1]	General Requirements
Particle Size Distribution	NZS 4407:2015	Test 3.8.1	Two representative samples every 5,000 m^3	Clean and permeable: <7% passing 0.075 mm sieve Well graded: 20% < Passing 4.75 mm Sieve < 60% 5% < Passing 0.6 mm Sieve < 25% Coefficient of uniformity (Cu) > 4 1 < Coefficient of Curvature (Cc) < 3 Size: 100% passing 65 mm sieve
Crushing Resistance	NZS 4407:2015	Test 3.10	One per source	< 10% Fines Passing 2.36 mm Sieve under 130 kN load
Weathering Quality Index	NZS 4407:2015	Test 3.11	One per source	Quality Index > CA
Broken Face Content	NZS 4407:1991	Test 3.14	Two representative samples every 5,000 m^3	50% for >37.5 mm fraction and 19 mm-37.5 mm fraction
Maximum Dry Density and Optimum Moisture Content	NZS 4402:1986	Test 4.1.1	Two representative samples every 5,000 m^3	Parameters to be used in verification of compaction

(1) Minimum number of tests per type of soil when used in formation layers
(2) Coefficient of Uniformity (Cu) = D_{60}/D_{10}; Coefficient of Curvature (Cc) = $D_{30}^2/(D_{10}xD_{60})$

Structural layers design thickness:

- This would be defined by the combined analysis of the following factors:
  - In situ/sub grade characteristics.
  - Expected strength requirements of the track infrastructure
    - Tonnes per axle load required
    - Traffic volume

- A minimum provision of 300 mm layer thickness shall be provided for the structural layers in any case, although unfavourable in situ ground conditions could require more than one metre of ground improvement.
- As such, the appropriate layer thickness required in each case is discussed in section 7.4 Formation design – dimensions.

7.2.4 Geosynthetic materials

There are beneficial applications for geosynthetics in the track formation, although their use will be determined by the site specific characteristics and expected outcome of the formation design. The two principal applications where their use may be advantageous are:

- As a reinforcing element, subgrade support and/or improvement.
- As a filtration/drainage or separation layer.

Geogrids are mainly used as a reinforcing element, although they also provide a separation layer; while geotextiles are mainly chosen based on their filtration/drainage characteristics, although they can also improve the subgrade support.

Geotextiles and geogrids should be used where problem identification has been conclusive and beneficial and durable outcomes can be identified. When there is doubt, the Professional Head – Civil Engineering should be approached for assistance.

The characteristics and requirements for geotextiles relevant to the scope of this document are based on the 'in-track' use of them (within the rail formation layers); hence the use of geotextiles in situations such as slope erosion protection or subsoil drainages is not part of the scope of this document.

The geogrid selection needs to consider these two parameters which will drive the performance and durability of the geogrid used:

- Grading of the material in contact with the geogrid. The maximum grid opening size should be the maximum size of the aggregate in contact with the geogrid. This should be the primary selection criteria to follow when selecting the adequate geogrid.
- **Strength required**: While this would be driven by the specific formation design, the recommended minimum strength of the geogrid is 20 kN/m, both longitudinal and transversal, to the track.

The selection of a geotextile for in-track purposes is also dependent upon many factors such as:

- existing track structure.
- existing in situ subgrade.
- existing drainage conditions.
- previous maintenance and/or upgrade works in the area.
- expected performance required.

When used for formation strengthening purposes, geogrids are slightly more efficient when placed higher within the formation structural layers or immediately below the sub-ballast layer.

When significant ground improvements are required, configurations with two geogrid layers; one at the ballast/sub-ballast interface and another one below the sub-ballast; can achieve significant improvements in bearing capacity, which would reduce significantly the additional undercut depth required at situations with poor in situ ground conditions.

On these specific site conditions:

- Geogrids need to be adequate for its use under ballast (heavy duty geogrids).
- Ballast stone size to geogrids aperture size ratio needs to be incorporated in the design (larger aperture geogrids for coarse aggregate grades).
- There could be impacts of the geogrids placement on track maintenance tasks.

7.3 Formation design – parameters

The railway formation design is typically driven by combined analysis of the following parameters:

- In situ sub-grade characteristics
- Axle load requirements

7.3.1 In situ sub-grade characteristics – soil and rock quality index

The track formation is going to be supported by the natural ground, hence the importance of identifying the quality of the in situ materials in the area before any formation design is completed.

It is common practice at infrastructure projects to use the material available on site for the structural layers needed.

The following tables provide quality classifications of soils and rocks. These classifications shall be used for the characterization of the materials present in the area of study, and it will be the guideline for the suitability of its use as structural layers within the formation.

- The classification of soils is based on the UIC (International Union of Railways) and it has been slightly modified to adjust the group's classifications to the New Zealand Geotechnical Society (NZGS) guidelines for soil descriptions and the Unified Soil Classification System (USCS), reference system for laboratory soil classification.
- The classification of rocks is based on the NZGS field description of rocks, adjusted to the expected strength parameters when these materials are adequately treated for their use as aggregates.
- Colours have been used to provide a visual reference linked to the formation designs in following sections of this document.

Table 7.3 Soil quality categories

Soil Quality Category	Soils included	USCS[2] Soil classification
SQ0	0.1. Organic soils[1]: topsoils, organic clays, silts or sands, peat 0.2. Saturated or highly wet soils 0.3. Contaminated soils 0.4. Expansible soils 0.5. Collapsible soils	**OL, OH, PT (Highly organic soils)**
SQ1	1.1 All soils containing fines > 50% not included in the SQ0 Category	**CL, ML, CL+ML, CH, MH (Inorganic silts and clays)**
SQ2	2.1 All soils containing fines from 12 to 50% and not included in the SQ0 Category	**GM, GC, SM, SC (Gravels with fines and sands with fines)**
SQ3	3.1. Soils containing fines <12%	**GW, GP, SW, SP (Clean gravels and clean sands)**

(1) As described in NZGS Field Description of Soil
(2) Unified Soil Classification System
(3) % of fines is the % of material that passes the N⁰ 200 sieve size in a granulometry test NZS4402

Table 7.4 Rock quality categories

Rock Quality Category	Rock Strength [1]	Typical abrasion characteristics when transformed in aggregate MDV: Micro-Deval and LAA: Los Angeles Abrasion Test
RQ1	1.1. Very weak to extremely weak 1.2. Weak rock	**NA**
RQ2	Moderately strong rocks	**25 < MDV ≤ 40** **30 < LAA ≤ 40**
RQ3	Strong to extremely strong rocks	**MDV ≤ 25** **LAA ≤ 30**

(1) As described in NZGS Field Description of Rock

Inferred measures needed as support for a railway formation:

These groups are a generalization of the typical in situ materials which that may be found in any infrastructure project. According to this classification, the potential requirements can be inferred for the formation design on top of them, as per the following Table 7.5.

California Bearing Ratio Test (CBR) is a common test value used for appraising the in situ strength of aggregates when they are being used for construction of pavement layers. The laboratory CBR test (laboratory soaked CBR) is carried out on a sample that has been compacted to maximum density at optimum moisture content (Maximum Dry Density), followed by a five-day immersion in water. Details can be found in NZS 4402:1986 (Test 6.1.1) and NZS 4407:1991 (Test 3.15).

Scala Penetrometer Test is the scala penetrometer is a colloquial name in New Zealand for the Dynamic Cone Penetrometer (DCP). It is based on the number of blows a falling weight requires to drive a steel cone a set distance into the ground.

The test is carried out to New Zealand Standard NZS 4402 Test 6.5.2. The number of blows required to penetrate a fixed distance, usually 50mm or 100mm, is recorded.

Scala Penetrometer tests should be carried out in conjunction with test pitting to confirm the nature of the soils being evaluated as per document C-TI-FO-4206 Formation Investigation.

The inferred values included in the following table are just a reference of the typical CBR values observed in these materials.

Table 7.5 Inferred formation design requirements based on in situ/subgrade characteristics

In situ/Sub grade	Sub grade	Inferred CBR* of the subgrade	Summary of inferred measures needed as support for a railway formation[(1)]
SQ0	Poor	<1% When completely saturated 1% ≤ CBR ≤ 3% Moderately saturated	• Subgrade removal and replacement to suitable depth • Major strengthening works (additional structural layers and/or geogrids) • Separation/filtration layers to avoid migration of fines
SQ1 & RQ1	Weak	3% ≤ CBR ≤ 8%	• Strengthening works (additional structural layers and/or geogrids) • Separation/filtration layers to avoid migration of fines
	Moderate	8% ≤ CBR ≤ 15%	
SQ2	Moderate	8% ≤ CBR ≤ 15%	• Strengthening works (additional structural layers and/or geogrids) • Separation/filtration layers to avoid migration of fines
	Strong	15% ≤ CBR ≤ 25%	• Separation/filtration layers to avoid migration of fines
SQ3, RQ2 and RQ3	Moderate	SQ3 with 8% ≤ CBR ≤ 15%	• Requires rework/additional compaction • Adequate Sub-ballast layer
	Strong	SQ3 with 15% ≤ CBR ≤ 25%	• Adequate Sub-ballast layer
	Strong rock	RQ2 & RQ3 (CBR not applicable)	• Adequate Sub-ballast layer

[(1)]Note that these inferred measures are only referred to the grading and strength characteristics of the in situ soils/rock. The following parameters need to be incorporated in the design of the formation:

- Adequate slope stability analysis for embankments higher than 6 m and/or affecting bridge abutments or retaining structures.
- Adequate catchment assessments when formation design affects existing or new culverts.
- Adequate drainage, erosion and scouring protection assessments at locations where watercourses are close to the formation.
- Reinforced earth construction or retention structures may be needed wherever steep or vertical slopes are required due to space constraints.

Soil/Rock inferred suitability for its use within formation structural layers

Similar to section 7.2.3, it can also be inferred infer the adequacy of the use of these materials within structural layers when required to build up the track formation.

Table 7.6 Soil/rock suitability for its use as structural layers

In situ/Sub grade	Suitability for its use in structural layers (formation)	Additional requirements
SQ0	**Never to be used**	**NA**
SQ1 & RQ1	Limited use	Not to be used in the layer immediately below Sub-ballast Adequate separation and reinforcement layers (aggregates and/or Geosynthetics) need to be incorporated into the design
SQ2	Limited use	Adequate separation and reinforcement layers (aggregates and/or Geosynthetics) may need to be incorporated into the design
SQ3, RQ2 & RQ3	Suitable materials	NA

This inferred adequacy of the materials needs to be complemented with the verification of the material characteristics as per the Table 7.2 General requirements of structural fill.

7.3.2 Axle load design requirements

The current KiwiRail future operating parameters are 20 tonnes axle loads for locomotives and 22.5 tonnes for wagons. Based on these requirements, for new works, the formation should be designed to carry the imposed loads from 25 tonnes axle load trains.

An appropriate site specific business case will be undertaken to decide if is economically justified to undertake the repairs or upgrades for small sections of a lines for a 25T axle load standards.

In many situations, due to this analysis, the repair / upgrade will not meet the formation standard for new 25 tonnes axle load lines set out in this document for new formation construction. It is therefore imperative that the Professional Head – Civil Engineering is in agreement with the planned work.

7.4 Formation design – dimensions

7.4.1 Geometry

The geometrical design of the KiwiRail formation is as per the associated document CE 100 862 Drainage and Formation Standard Detail Standard Details, which has been obtained in order to provide the adequate support for document T-ST-DE-5200 Track Design.

The typical minimum width of six metres for the top of the formation layers needs to be adjusted to the geometry of the section and overall geotechnical characteristics.

Key exceptions to the dimensions included in drawings CE 100862 Drainage and Formation Standard Detail would be:

- Additional width of formation shall be provided as a contingency to cope with increase in extra ballast at the outside of curves.
- At embankments with both banks ≥ 6 m and no access track, formation width shall be extended to a minimum of eight metres (four metres from Track Centre Line on each sides)
- At sidling cut environments, with bank side ≥ 6 m, formation width shall be extended a minimum of one additional meter in the bank side
- At embankments with one or both banks ≥ 6 m and an adequate access track at one or both sides, formation width can be limited to the 6 m minimum.
- Formations on top of retaining structures or reinforced earth embankments can be reduced accordingly to site constrains, although further strengthening or the formation layers could be required to reduce load dissipation.

7.4.2 Formation drainage

Specific drainage requirements are included in the associated with document C-ST-CD-4102 Corridor Drainage.

The general requirement is for a cross fall of 3% for the top of the formation (bottom of ballast layer) towards both sides in single track scenario and central crown design (between the two lines) for double track cases, as per drawings CE 100862 Drainage and Formation Standard Detail.

Sections with more than two tracks (loops, sidings, yards, stations and certain metro areas) will require site specific analysis for the most adequate drainage design.

7.4.3 Formation thickness

As introduced in previous sections of this Standard, the required thickness of the formation layers would be obtained from the combined analysis of the original in situ Sub-grade conditions; the characteristics of the structural layers used; ground improvement options (such as geotextile composite layers) and the required strength of the formation (current 18 tonnes axle loads or targeted 25 tonnes axle loads).

The following Table 7.7 summarise general formation configurations in different scenarios, including approximate layer thickness of Sub-ballast and structural layers.

The formation thickness configurations included are based on UIC Code 719 for axle loads in range of 20 to 25 tonnes. The 75 mm minimum thickness for sub-ballast layer in an 18 tonnes axle load scenario has proved its efficiency in several KiwiRail upgrades when properly implemented.

The key limitations of the designed thickness configurations for the formation layers included in Table 7.7 are:

- The assumption of uniform characteristics along a three-dimensional section of track, when ground characteristics are typically variable in longitudinal, section and width.
- Thickness configurations have been grouped in order to simplify design outcomes, hence the variable structural fill thickness included in some groups. An in situ subgrade characterised by a CBR of 4 would require slightly different structural fill layer thickness required for a sub-grade with CBR of 8.
- The configuration of the formation layers, with variable thickness layers and geosynthetics materials intends to provide the adequate flexibility for site specific conditions and achieve reductions in depth of undercuts required.

Summarising, the formation design thickness layers included at Table 7.7 intend to provide flexibility to achieve a bespoke design in major formation sites while setting the minimum design requirements for all formation sites on the rail corridor.

Table 7.7 Typical formation thickness requirements based on in situ/subgrade characteristics and design load

In situ/sub grade	Sub grade	Inferred CBR* of the subgrade	Summary of inferred measures needed as support for a railway formation(1)	18 tonnes axle load formation thickness requirements	25 tonnes axle load formation thickness requirements	
SQ0	Poor	<1% When completely saturated 1% ≤ CBR ≤ 3% Moderately saturated	• Subgrade removal and replacement to suitable depth • Major strengthening works (additional structural layers and/or geogrids) • Separation/filtration layers to avoid migration of fines	• Geogrid[1] layer between ballast and sub-ballast • 150 mm sub-ballast GAP40[2] • Geogrid[1] and geotextile[3] layer below sub-ballast • 600 mm to 900 mm of structural fill[4] • Geogrid[1] and geotextile layer below structural layers Total thickness of ground improvement will need to be confirmed following a detailed settlement and bearing capacity analysis.	• Geogrid[1] layer between ballast and sub-ballast • 300 mm sub-ballast GAP40[2] • Geogrid[1] and geotextile[3] layer below sub-ballast • > 900 mm of structural fill[4] • Geogrid[1] and geotextile[3] layer below structural layers Total thickness of ground improvement will need to be confirmed following a detailed settlement and bearing capacity analysis.	**Geogrid[1] : Geogrid to be selected based on grading of materials and strength required.** **GAP40[2] : GAP40 referred as most common material, alternative aggregates can be used if Sub-ballast requirements are fulfilled** **Geotextile[3] : Geotextile to be selected based on grading of materials and permeability required.** **Structural fill[4] : Thickness of ground improvements are indicative only, based on the use of aggregate materials. Thickness can be adjusted with the combined used of geosynthetic materials or improved selected aggregates.**
SQ1 & RQ1	Weak	3% ≤ CBR ≤ 8%	• Strengthening works (additional structural layers and/or geogrids) • Separation/filtration layers to avoid migration of fines • If Geotextile layers are used, allow up to 30% thickness reduction.	• Geogrid[1] layer between ballast and sub-ballast • 150 mm thickness of sub-ballast layer GAP40[2] • Geogrid[1] and geotextile[3] layer below sub-ballast • 300 mm to 600 mm of structural fill[4] • Geogrid[1] and geotextile[3] layer below structural layers: preference for bonded product.	• Geogrid[1] layer between ballast and sub-ballast • 150 mm thickness of sub-ballast layer GAP40[2] • Geogrid[1] and geotextile[3] layer below sub-ballast • 600 mm to 900 mm of structural fill[4] • Geogrid[1] and geotextile[3] layer below structural layers: preference for bonded product.	
	Moderate	8% ≤ CBR ≤ 15%		• Same as above, with structural fill[4] limited to 300 mm to 600 mm thickness and sub-ballast layer reduced to 75 mm.	• Same as above, with structural fill[4] limited to 300 mm to 600 mm thickness	
SQ2	Moderate	8% ≤ CBR ≤ 15%	• Strengthening works (additional structural layers and/or geogrids) • Separation/filtration layers to avoid migration of fines	• 75 mm thickness of sub-ballast layer GAP40[2] • Geogrid[1] and geotextile[3] layer below structural layers: preference for bonded product. • 300 mm of structural fill[4]	• 150 mm thickness of sub-ballast layer GAP40[2] • Geogrid[1] and geotextile[3] layer below structural layers: preference for bonded product. • 300 mm to 600 mm of structural fill[4]	
	Strong	15% ≤ CBR ≤ 25%	• Separation/filtration layers to avoid migration of fines	• 75 mm thickness of sub-ballast layer GAP40[2] • Non-woven geotextile[3] may be required below sub-ballast	• 150 mm thickness of sub-ballast layer GAP40[2] • Non-woven geotextile[3] may be required below Sub-ballast	
SQ3, RQ2 & RQ3	Moderate	SQ3 with 8% ≤ CBR ≤ 15%	• Requires rework/additional compaction • Adequate Sub-ballast layer	• 75 mm thickness of sub-ballast layer GAP40[2] • Geogrid[1] and geotextile[3] layer below sub-ballast • 300 mm of structural fill[4]	• 150 mm thickness of sub-ballast layer GAP40[2] • Geogrid[1] and geotextile[3] layer below sub-ballast • 300 mm of structural fill[4]	
	Strong	SQ3 with 15% ≤ CBR	• Adequate Sub-ballast layer	• 75 mm thickness of sub-ballast layer GAP40[2] • Non-woven geotextile[3] may be required below sub-ballast	• 150 mm thickness of sub-ballast layer GAP40[2] • Non-woven geotextile[3] may be required below Sub-ballast	
	Strong rock	RQ2 & RQ3 (CBR not applicable)	• Adequate sub-ballast layer	• 75 mm thickness of sub-ballast layer • Non-woven geotextile[3] and geogrid[1] may be required below sub-ballast layer.	• 150 mm thickness of sub-ballast layer • Non-woven geotextile[3] and geogrid[1] may be required below sub-ballast layer.	

7.5 Formation design – repairs

The assessment of the root causes of the formation failure need to follow the methodology set out in KiwiRail's Task Instruction C-TI-FO-4206 Formation Investigation.

Once the investigation is completed, the design approach for repairs and upgrades shall combine the guidelines for typical formation issues included in the referred Task Instruction, with the standard design requirements included here.

Sections 7.1.1 and 7.2.2 of this Standard shall be referred for the adequate design approach when planning works repairs/upgrades.

Standard Repair methods for typical formation issues such as mudspots, Ballast contamination or weak subgrade are included in the associated document C-TI-FO-4206 Formation Construction (Repairs and Upgrades).

7.6 Formation design – bridge transition zones

Transition zones at bridges are a vulnerable section of the track formation due to the abrupt change in track stiffness. For new bridge constructions or bridge replacement projects, ground characteristics of the embankments at bridge approaches must need to be confirmed in order to assure an adequate transition between the planned structure and the formation is achieved.

The different stiffness characteristics between a bridge structure and a more flexible formation is the key factor in these transition zones and an increased stiffness requirements by the means of additional ground strengthening works in the top layers of the formation, designing a gradual transition towards a standard formation strength.

For KiwiRail bridges, a transition zone of minimum 12 metres length three subsequent steps has proved to provide an adequate transition zone, with variable depths of structural fill according to the ground conditions at the abutments.

For existing bridge transitions requiring repairs, refer to KiwiRail drawings CE 100912 Bridge Transition sheets 1 to 3. The limitation of the applicability of the proposed investigation method and design requirements in those drawings is the assumption of a formation failure due to weak formation/structural fill. Hence it needs to be verified that:

- There are no slope stability concerns at the bridge approach embankment.
- There are no deep seated settlement concerns at the bridge approach embankment.

If…	then…
these issues are identified during the assessment	a specific geotechnical investigation would be required and advice must be sought from Professional Head – Civil Engineering.

7.7 Formation design – level crossings

The Drainage and Formation Standard Detail design for the installation or repair/upgrade of level crossings are included in the KiwiRail Standard drawing CE 300 182 sheets 1 and 2.

Reference shall be made to the following documents when approaching the design of formation works on level crossings:

- G-ST-LC-9120 Level Crossing Management
- T-ST-AM-5360 Level Crossing Management
- T-TI-WO-5957 Level Crossing Installation

8. Construction

The reference document C-TI-FO-4207 Formation Construction is the Task Instruction which details typical methodologies of undertaking formation repairs and upgrades.

For materials specifications, compaction and testing requirements and formation construction tolerances, reference shall be made to specification document C-SP-GE-64000 Earthworks.

Specific requirements for works in the rail corridor are also included in the relevant Task Instruction.

9. Drawings

9.1 Drawings list

Table 9.1 includes the standard drawing list for approved formation works, including repairs and interaction with utilities and services in the rail corridor.

The reference document C-TI-FO-4207 Formation Construction shall be the Task Instruction which details typical methodologies of undertaking formation repairs and upgrades.

Table 9.1 Standard drawing list for approved formation works

Document Number	Title
CE 100795	Culvert Renewal Standard Details
CE 100862	Standard Drainage and Formation Drawings
CE 100890	Points Machine – Drainage and Formation Interaction
CE 100892	Exclusion Zones for Cables and Ducting
CE 100910	Moderate Subsidence Damage
CE 100911	Over-Steepened Embankment
CE 100912	Bride Transition

Document Number	Title
CE 120535	Sand Blanket Separation Layer Standard
CE 300182	Level Crossing Drainage and Formation

9.2 General requirements

All design drawings shall be produced in accordance with KiwiRail's Network Services G-ST-AL-9112 Engineering Drawing Issue and Control.

Drawings issued at different stages of the design shall have the following status stamped on the bottom right corner of the drawing:

- Work in progress drawings shall be marked as 'preliminary'.
- Final design drawings shall be marked 'for approval'.
- Approved final design drawings shall be marked 'for construction'.
- Drawings created from survey carried out after construction shall be marked 'As-Built'.

Names of the people responsible for the design, checking and approval of the design shall be shown in printed form on the title block.

9.3 Control of drawings

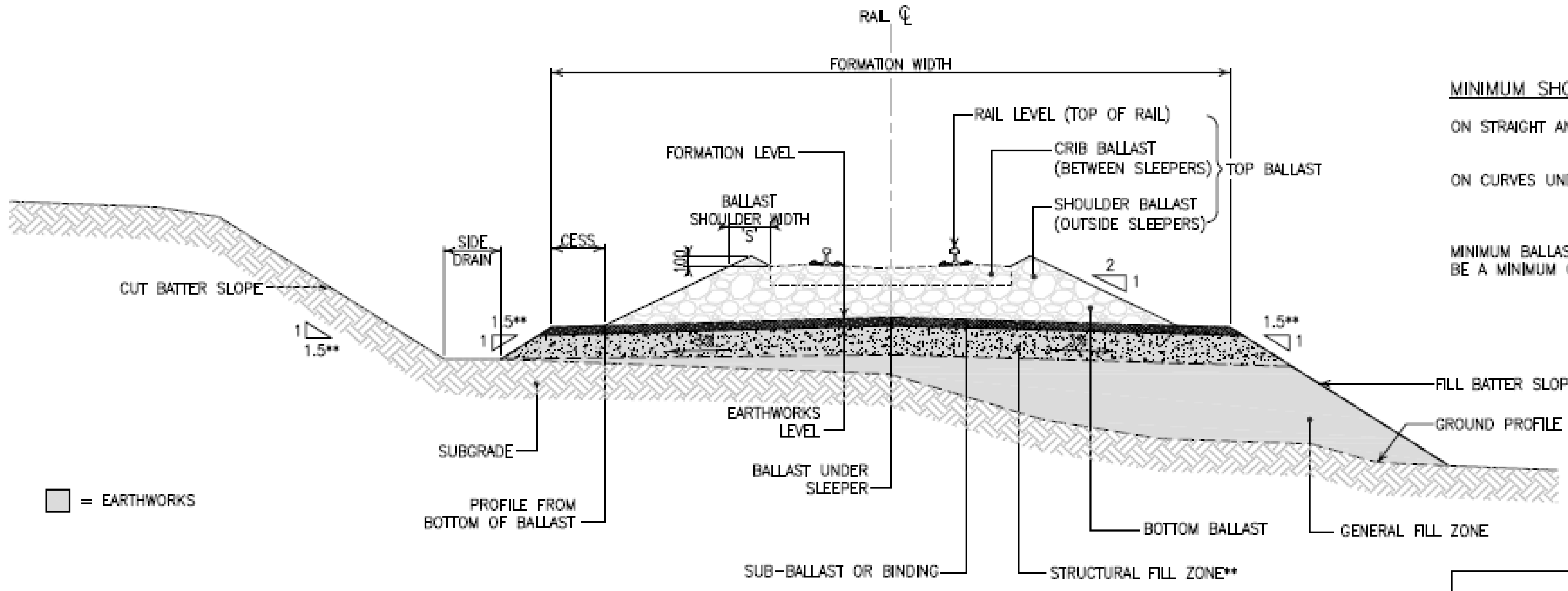
The issue and revision of design drawings shall be controlled so that the status of all copies of drawings can be identified and all the work is carried out using the latest version of the drawings.

All the design drawings shall be issued in .pdf format.

All drawings shall be submitted to Civil Engineering to enable records and asset data are appropriately updated.

Appendix 1 Drainage and Formation Standard Detail Drawings

A3



STANDARD TERMINOLOGY

MINIMUM SHOULDER WIDTH 'S'

ON STRAIGHT AND CURVES 540m RADIUS AND OVER, JOINTED AND CWR TRACK: S = 350mm

ON CURVES UNDER 540m RADIUS:
JOINTED TRACK: S = 350mm
CWR TRACK: S = 450mm

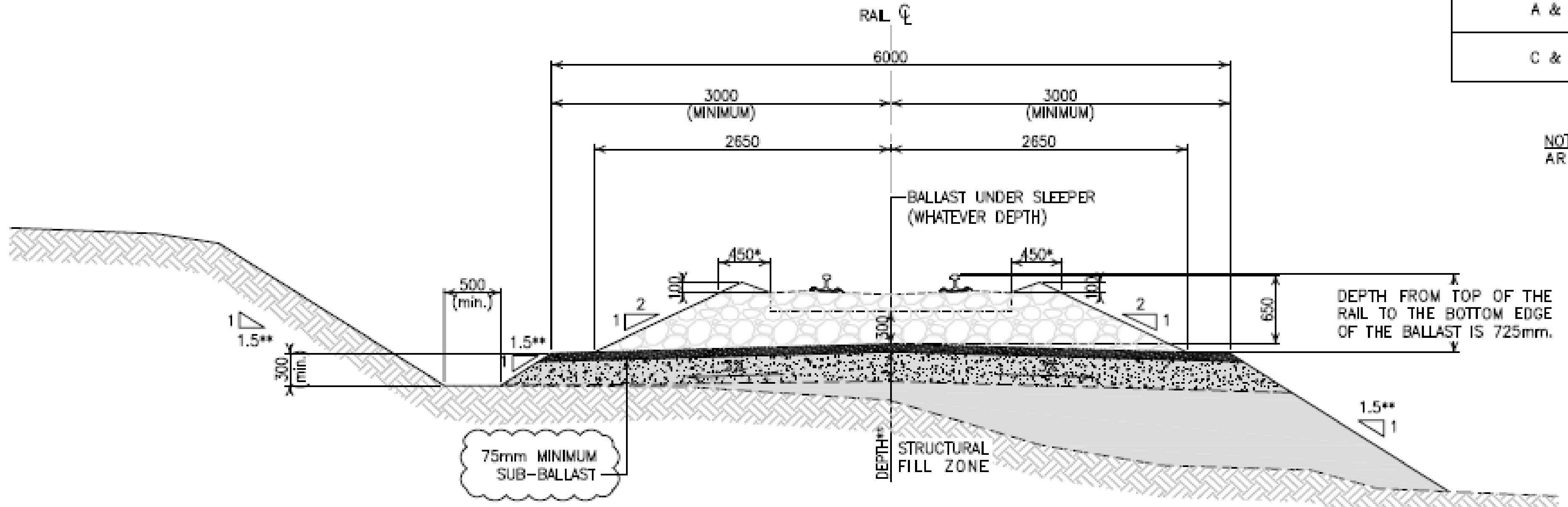
MINIMUM BALLAST SHOULDER HEIGHT AT ENDS OF THE SLEEPERS TO BE A MINIMUM OF 100mm

BALLAST UNDER SLEEPER FOR DIFFERENT CLASS LINES

CLASS OF LINE	MINIMUM	MAXIMUM
A & B	300 mm	450 mm
C & D	200 mm	300 mm

TABLE 1

NOTE: FOR CANTED TRACK, ALL VERTICAL MEASUREMENTS ARE WITH RESPECT TO TOP OF LOW LEG RAIL.



STANDARD DIMENSIONS

** = SUBJECT TO GEOTECHNICAL DESIGN CONFIRMATION

EXTENT OF 300mm BALLAST UNDER THE SLEEPER IN RELATION TO SHOULDER WIDTH 'S'

SHOULDER WIDTH 'S'	DISTANCE FROM TRACK ℄ TO BOTTOM EDGE OF BALLAST	DISTANCE FROM TOP OF RAIL TO BOTTOM EDGE OF BALLAST
350 mm	2550 mm	725 mm
450* mm	2650 mm	725 mm

TABLE 2

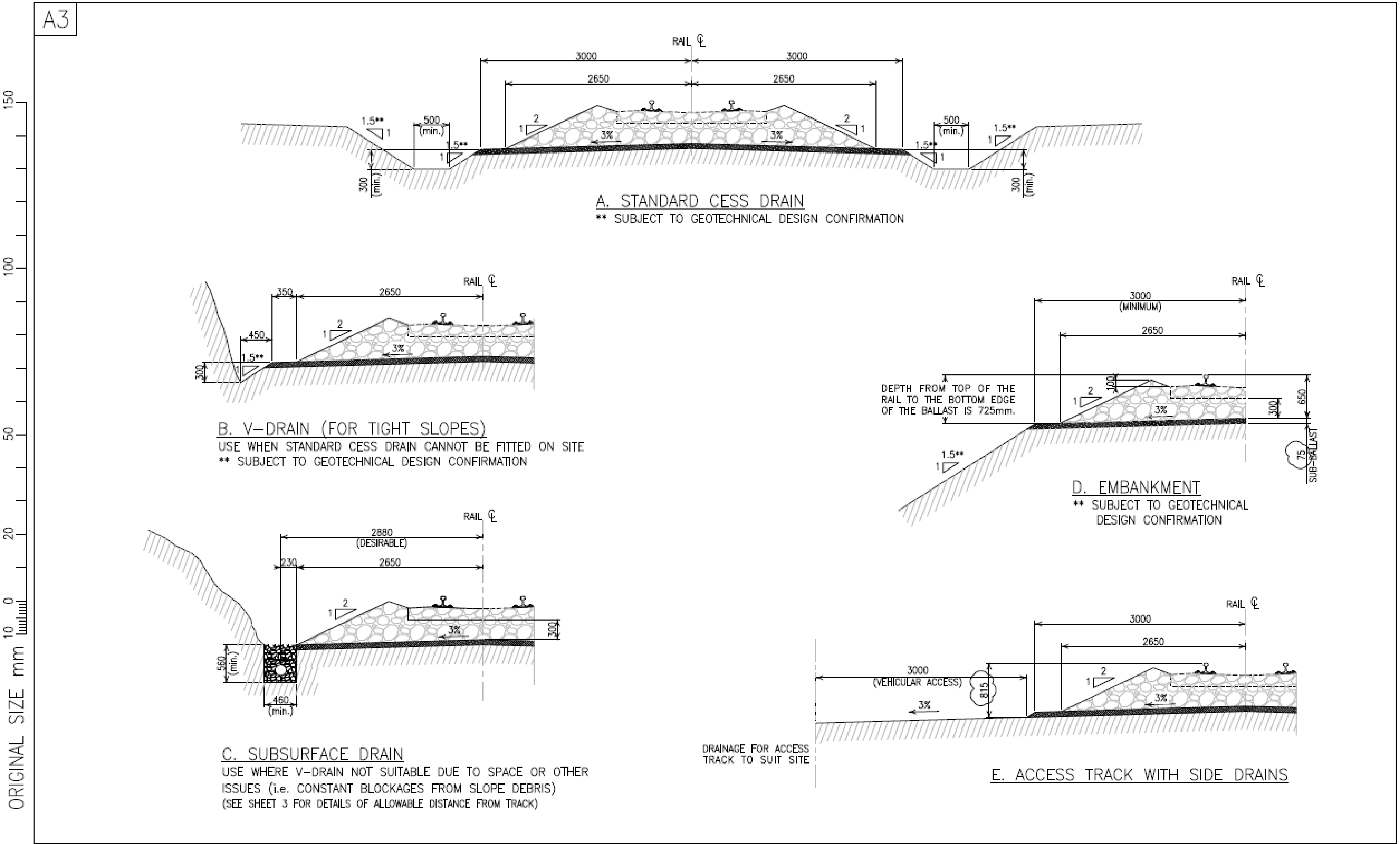
NOTE: DATA PROVIDED ON TABLE 2 IS FOR 50Kg RAIL ON 25T CONCRETE SLEEPER.

ORIGINAL SIZE mm

KiwiRail, Backbone of integrated transport networks, CIVIL ENGINEERING, PO Box 593, Wellington 6140, Tel: (04) 495 3000	DSN	DH	OCT '13	SCALE 1:50 @ A3	ALL DIMENSIONS IN (mm) UNLESS OTHERWISE STATED	AMENDMENTS	BY	APP	DATE
	DRN	ES	OCT '13			A FOR DISCUSSION	ES	DH	11.12.2013
	CHK	DH	FEB '14		TOLERANCE (+/-1.0mm) UNLESS OTHERWISE STATED	B FOR DISTRIBUTION	ES	DH	11.02.2014
	APR	DH	FEB '14			C DETAILS AMENDED BY KRN.	ES	DH	20.07.2015

FORMATION AND DRAINAGE DETAILS
STANDARD DETAILS
SINGLE TRACK

SHEET No. 1 | REV C
SHEETS IN SET 6
CE No. 100 862



KiwiRail CIVIL ENGINEERING PO Box 593, Wellington 6140 Tel: (04) 495 3000	DSN	BP	OCT '14	SCALE	ALL DIMENSIONS IN (mm) UNLESS OTHERWISE STATED	AMENDMENTS		BY	APP	DATE	FORMATION AND DRAINAGE DETAILS TRACK SIDE DRAIN OPTIONS	SHEET No. 2	REV E
	DRN	JM	OCT '14	1:50		B	FOR DISTRIBUTION	ES	DH	11.02.2014		SHEETS IN SET 6	
	CHK	SH	OCT '14	@ A3	TOLERANCE (+/–1.0mm) UNLESS OTHERWISE STATED	C	DETAIL CHANGES BY MWH	JM	DAH	23.04.2015		CE No. 100 862	
						D	DETAILS AMENDED BY KRN	ES	DH	14.05.2015			
	APR	DAH	OCT '14			E	DETAILS AMENDED BY KRN	ES	DH	20.07.2015			

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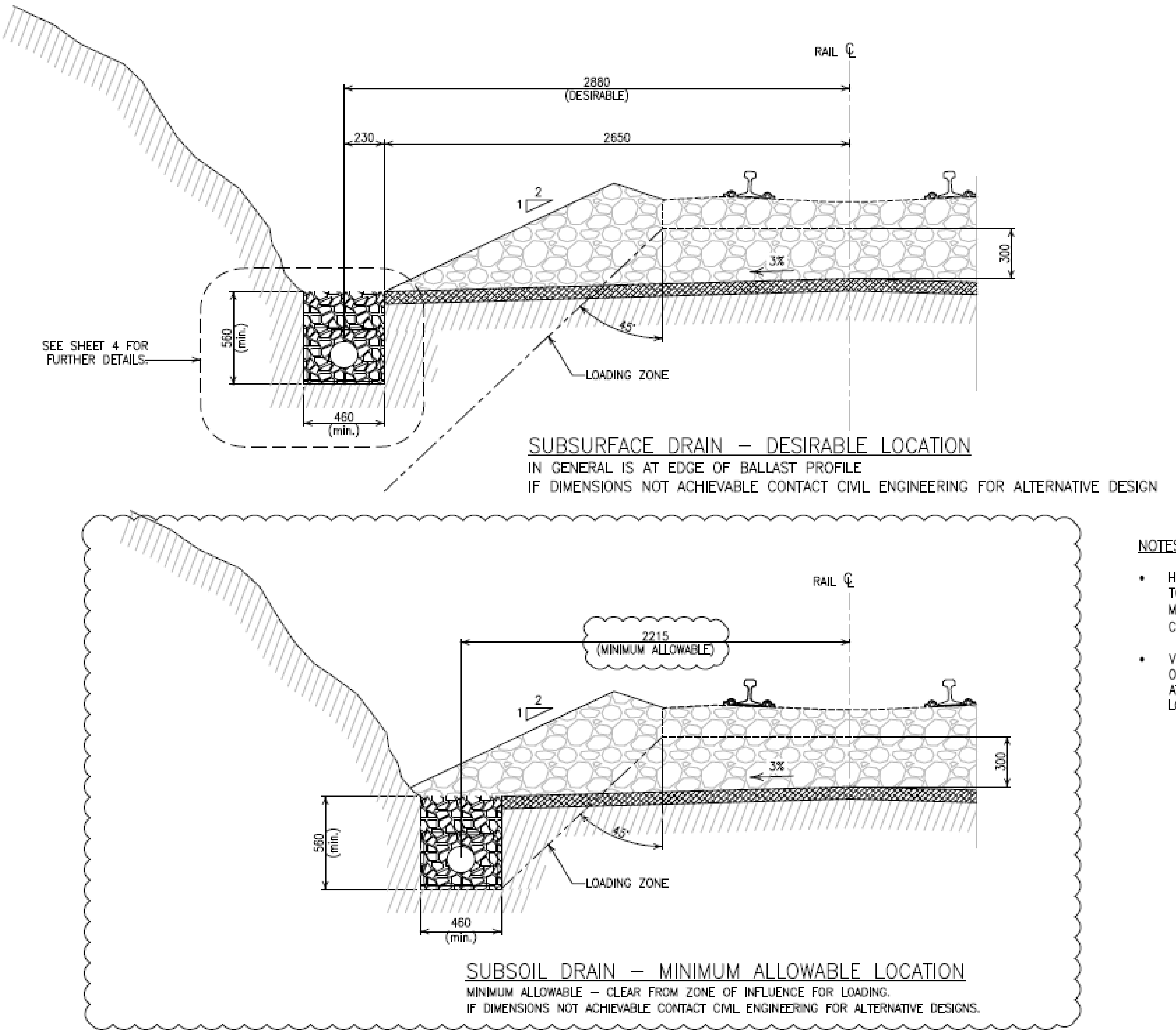


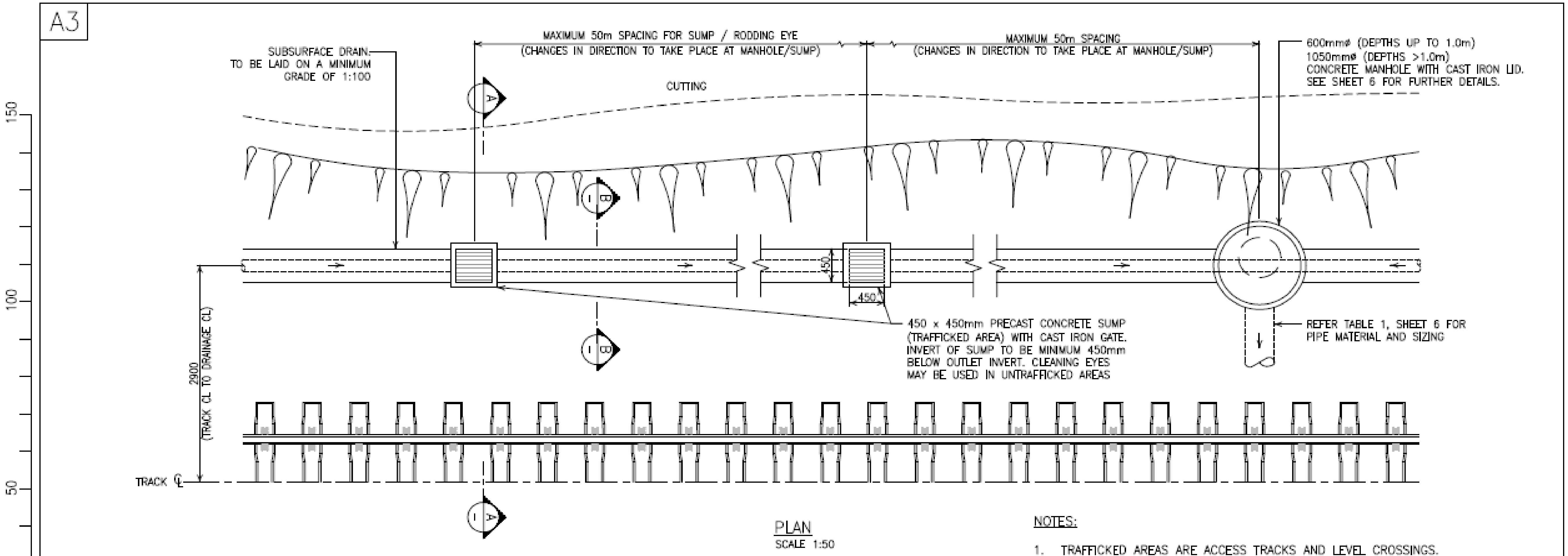
NOTES:

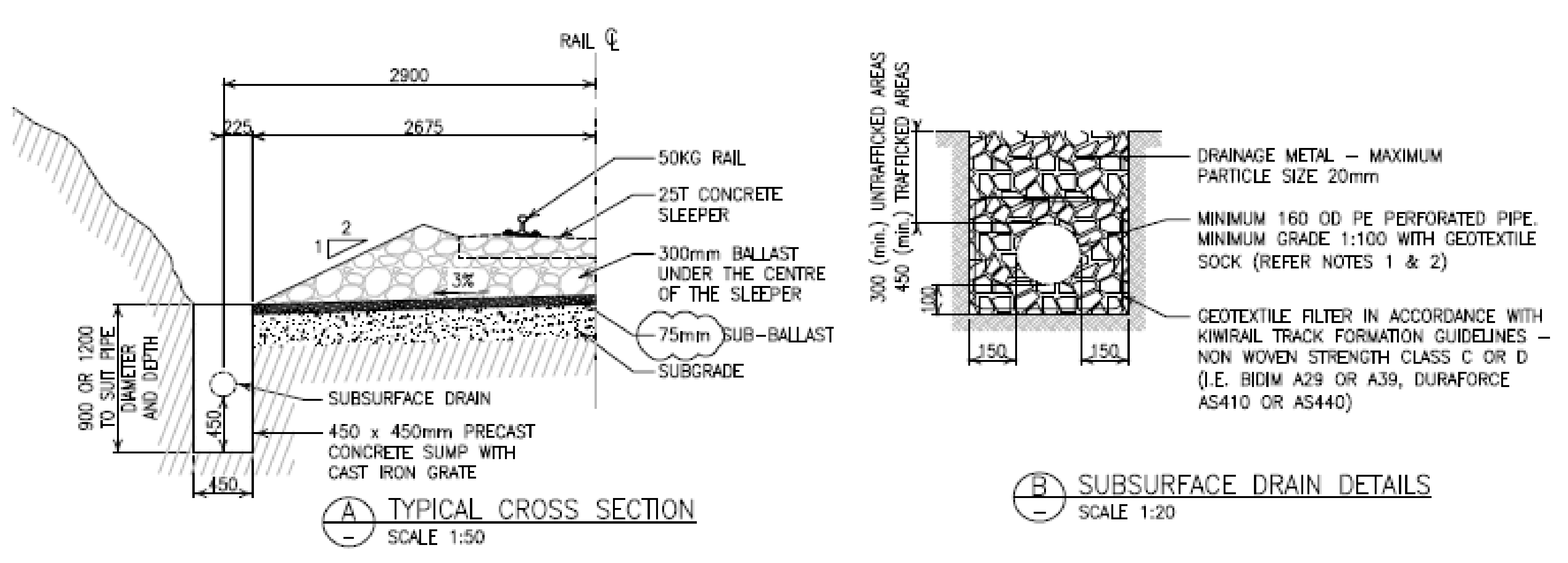
- HORIZONTAL OFFSET FROM TRACK CENTRE LINE TO SUBSOIL PIPE CENTRE TO BE RECORDED IN MAXIMO DATABASE (AT 50M INTERVALS IF ANY CHANGES).
- VERTICAL OFFSET TO PIPE INVERT FROM TOP OF RAIL TO BE RECORDED IN MAXIMO DATABASE AT INLET AND OUTLET POINTS AND MANHOLE LOCATIONS.

ORIGINAL SIZE mm 0 10 20 50 100 150

KiwiRail Backbone of integrated transport networks CIVIL ENGINEERING PO Box 593, Wellington 6140 Tel: (04) 495 3000	DSN	BP	OCT '14	SCALE	ALL DIMENSIONS IN (mm) UNLESS OTHERWISE STATED		AMENDMENTS	BY	APP	DATE	FORMATION AND DRAINAGE DETAILS SUBSURFACE DRAIN – CROSS SECTIONS	SHEET No. 3 / REV E
	DRN	JM	OCT '14	1:25		B	FOR DISTRIBUTION	ES	DH	11.02.2014		SHEETS IN SET 6
	CHK	SH	OCT '14	@ A3	TOLERANCE (+/-1.0mm) UNLESS OTHERWISE STATED	C	DETAIL CHANGES BY MWH	JM	DAH	23.04.2015		CE No. 100 862
						D	DETAILS AMENDED BY KRN	ES	DH	14.05.2015		
	APR	DAH	OCT '14			E	DETAILS AMENDED BY KRN	ES	DH	03.07.2015		

A3

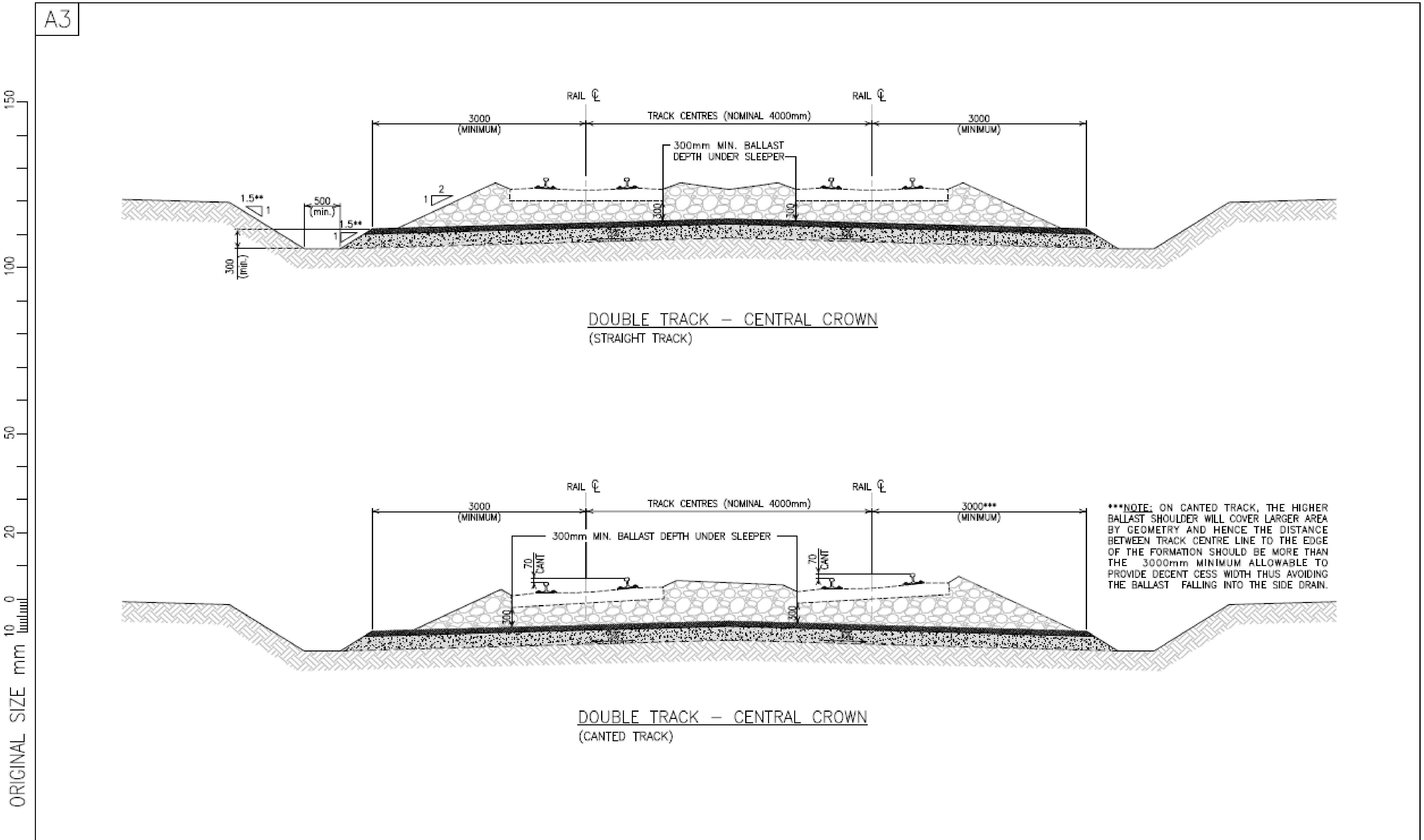




NOTES:

1. TRAFFICKED AREAS ARE ACCESS TRACKS AND LEVEL CROSSINGS.
2. IN NON-TRAFFICKED AREAS, SUBSOIL PIPE TO BE MINIMUM 160 OD PE PERFORATED TESTED TO AS2439 "CLASS 200" (E.G. IPLEX NEXUS). MINIMUM 200 OD TO BE USED WHEN INLET SUMPS ARE INSTALLLED.
3. IN TRAFFICKED AREAS, USE AS2439 "CLASS 500 PIPE" (E.G. IPLEX NEXUS HI-WAY), AND 450mm COVER OVER TOP OF PIPE.
4. TRENCH DEPTH / PIPE DEPTH TO TIE INTO DISCHARGE POINT WITH A SUITABLE LONGITUDINAL GRADE (MINIMUM IS 1 IN 100).
5. FOR HIGH INTENSITY RAINFALL AREAS SUCH AS THE WEST COAST, NEW PLYMOUTH, BAY OF PLENTY, AUCKLAND, AND NORTHLAND, TAKE EXTRA CARE IN CATCHMENT AREA CALCULATION AND PIPE SIZING. CONTACT CIVIL ENGINEERING IN WELLINGTON FOR ADVICE.
6. WHERE LENGTHS OF SUBSOIL PIPE ARE GREATER THAN 100m, CALCULATE CATCHMENT SIZE AND CONFIRM PIPE SIZING WITH CIVIL ENGINEERING IN WELLINGTON.
7. IF CATCHMENT EXTENDS GREATER THAN 20m FROM TRACK FOR LENGTHS OF PIPE GREATER THAN 50m CALCULATE CATCHMENT SIZE AND CONFIRM PIPE SIZE WITH CIVIL ENGINEERING IN WELLINGTON.
8. IF GROUND WATER CONTROL IS REQUIRED, DEEPER TRENCHES OR LARGER PIPES MAY BE REQUIRED. CONFIRM WITH CIVIL ENGINEERING IN WELLINGTON.

						AMENDMENTS	BY	APP	DATE			
KiwiRail Backbone of integrated transport networks CIVIL ENGINEERING PO Box 593, Wellington 6140 Tel: (04) 495 3000	DSN	BP	OCT '14	SCALE (AS SHOWN) @ A3	ALL DIMENSIONS IN (mm) UNLESS OTHERWISE STATED	B	FOR DISTRIBUTION	ES	DH	11.02.2014	FORMATION AND DRAINAGE DETAILS TYPICAL SUBSURFACE DRAINAGE DETAILS	SHEET No. 4 / REV E
	DRN	JM	OCT '14			C	DETAIL CHANGES BY MWH	JM	DAH	23.04.2015		SHEETS IN SET 6
	CHK	SH	OCT '14		TOLERANCE (+/-1.0mm) UNLESS OTHERWISE STATED	D	DETAILS AMENDED BY KRN	ES	DH	14.05.2015		CE No. 100 862
	APR	DAH	OCT '14			E	DETAILS AMENDED BY KRN	ES	DH	03.07.2015		



KiwiRail CIVIL ENGINEERING PO Box 593, Wellington 6140 Tel: (04) 495 3000	DSN	DH	OCT '13	SCALE 1:50 @ A3	ALL DIMENSIONS IN (mm) UNLESS OTHERWISE STATED		AMENDMENTS	BY	APP	DATE	FORMATION AND DRAINAGE DETAILS SPECIAL DETAILS DOUBLE TRACK	SHEET No. 5	REV B
	DRN	ES	OCT '13			A	FOR DISCUSSION	ES	DH	11.12.2013		SHEETS IN SET 6	
	CHK	DH	FEB '14		TOLERANCE (+/-1.0mm) UNLESS OTHERWISE STATED	B	FOR DISTRIBUTION	ES	DH	11.02.2014		CE No. 100 862	
	APR	DH	FEB '14										

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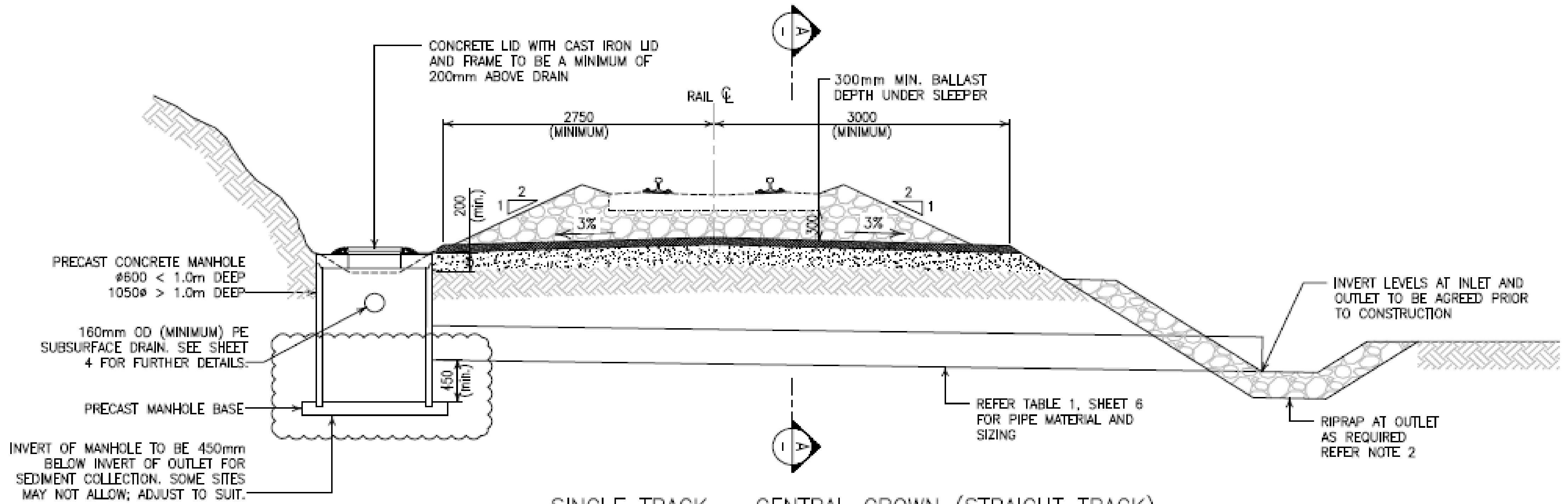
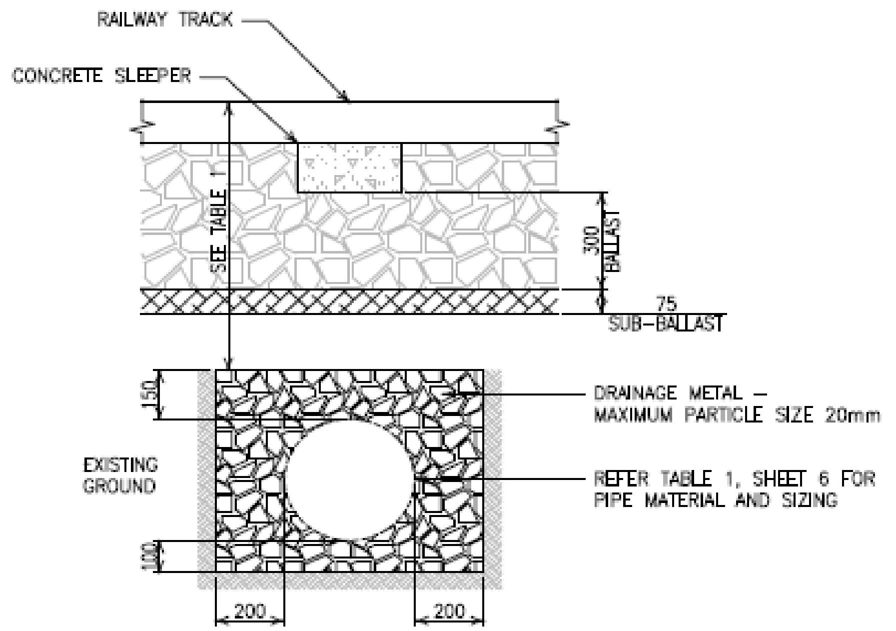


SINGLE TRACK – CENTRAL CROWN (STRAIGHT TRACK)

SCALE: 1:50



(A) TRACK CROSSING – CROSS DRAINAGE PIPE TRENCH DETAIL

SCALE 1:20

PIPE MATERIAL & CLASS	MINIMUM NOMINAL PIPE DIAMETER (mm)	MINIMUM DEPTH BELOW TOP OF RAIL TO TOP OF PIPE (mm)	MINIMUM GRADE
PVC U PN16 *	375 NB	800	1:100
PE100 PN16 (SERIES 1) *	400 OD	800	1:100
PVC–U DWV SN8	375 NB	950	1:100
PE100 PN10 (SDR17)	400 OD	950	1:100
RCRRJ CLASS 4	300 NB	1200	1:100

* LEAD TIME FOR THESE PIPE MATERIALS MAY BE SIGNIFICANT. CHECK WITH SUPPLIER (IPLEX/HYNDS) OR CONTACT CIVIL ENGINEERING IN WELLINGTON.

TABLE 1

NOTES:

1. THIS DETAIL IS FOR CARRIER PIPE INSTALLATION IN GOOD GROUND CONDITIONS. SURROUNDING SOIL TO HAVE A CBR ≥ 15%. IF CBR < 15% OR IN PEAT/ORGANIC SOILS, SURROUNDING MATERIAL, (2 x PIPE DIAMETER ON EITHER SIDE OF PIPE) IS TO BE REMOVED AND REPLACED IN ACCORDANCE WITH KIWIRAIL TRACK FORMATION GUIDELINES. TEST TO BE UNDERTAKEN IN WINTER CONDITIONS.
2. OUTLET PROTECTION DETAIL MAY DIFFER FROM SITE TO SITE AND IS TO BE CONFIRMED WITH CIVIL ENGINEERING, ENGINEERING SERVICES, IN WELLINGTON. REFER TO SHEET 1 OF SET 100-795 FOR OUTLET DETAILS.
3. THESE PIPE SIZES ARE NOT INTENDED FOR CULVERT CROSSINGS, ONLY FOR CLOSED DRAINAGE SYSTEMS.

ORIGINAL SIZE mm 0 10 20 50 100 150

KiwiRail
Backbone of integrated transport networks
CIVIL ENGINEERING
PO Box 593, Wellington 6140
Tel: (04) 495 3000

DSN	BP	OCT '14	SCALE (AS SHOWN) @ A3	ALL DIMENSIONS IN (mm) UNLESS OTHERWISE STATED
DRN	JM	OCT '14		
CHK	SH	OCT '14		TOLERANCE (+/-1.0mm) UNLESS OTHERWISE STATED
APR	DAH	OCT '14		

	AMENDMENTS	BY	APP	DATE
A	NEW DETAIL SHEET BY MWH	JM	DAH	23.04.2015
B	DETAILS AMENDED BY KRN	ES	DH	14.05.2015
C	DETAILS AMENDED BY KRN	ES	DH	03.07.2015

FORMATION AND DRAINAGE DETAILS
SINGLE TRACK CROSSING
SUBSURFACE DRAIN DETAILS

SHEET No. 6 | REV C
SHEETS IN SET 6
CE No. 100 862

Briefing Note(s) for C-ST-FO-4110 Formation

Date Effective 31/03/2019 **Issue No.** Issue 1.0

Background

This document establishes the design requirements for track formations (rail pavement layers) to be installed on KiwiRail network. This Standard needs to be read in conjunction with documents C-ST-CD-4102 Corridor Drainage and C-ST-GE-4105 Ground Engineering and Earthwork.

Key changes / compliance

This is the first issue of a new document.

Implementation

This document should be cascaded to all staff impacted by this Task Instruction in the field. The changes contained in this document will become effective as soon as a 'Tool Box' briefing has been conducted for effected staff but no later than 31st March 2019.

Applicability (Select relevant boxes)	**General**	**Civil**	**Signals and Telecommunications**	**Structures**	**Track**	**Traction and Electrical**
Zero Harm	☒	☐	☐	☐	☐	☐
Learning and Development	☒	☐	☐	☐	☐	☐
Project Management Office	☒	☐	☐	☐	☐	☐
Manager Property Revenue and Grants	☒	☐	☐	☐	☐	☐
National Train Control Centre	☐	☐	☐	☐	☐	☐
Professional Head		☒	☐	☒	☒	☐
Engineering Manager		☐	☐	☐	☐	☐
Network Services Managers		☐	☐	☐	☐	☐
Region Operations Managers		☒	☒	☒	☒	☒
STTE Managers		☐	☐	☐	☐	☒
Production Managers		☒	☒	☒	☒	☒
Asset Engineers		☒	☒	☒	☒	☒

Document History

Note page numbers relate to the document at the time of amendment and may not match page numbers in current document.

Issue No.	Section	Description	Page(s)
1.0		First publication	