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Railway Drainage Systems Manual

Part 2B: Hydraulic design of new Drainage Systems

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1 Purpose

The purpose of this Part of the Manual is to provide guidance on the hydraulic design of Drainage Systems.

2 Scope

This Part of the Manual applies to new Drainage Systems.

3 Terms used in equations

The terms used in this Part of the Manual are as follows:

AREA	area of the Catchment
D	internal diameter of a pipe
ΔH	difference between the undrained and drained groundwater table levels
ΔH_a	excess artesian head
F	growth factor used to derive the run off with a given annual probability
K	permeability of the aquifer
k	hydraulic roughness coefficient of a pipe
L	maximum distance of the Outfall from the Catchment boundary
n	hydraulic roughness coefficient
P	wetted perimeter
Q	water discharge
Q_C	water discharge from connecting systems
Q_{MAF}	mean annual flood
Q_R	run off
Q_S	sub-surface water
q_s	sub-surface flow from one side of the track
R	hydraulic radius
SAAR	standard annual average rainfall
S	slope or hydraulic gradient
SOIL	index to classify soils according to potential run off
T	time of concentration
Z	average height of the Catchment above the level of the Outfall; for Cuttings, the value of Z should be taken to be the height of the highest part of the Cutting relative to the Outfall.

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4 Design process

4.1 Overview

The steps in the development of a design of a Drainage System are shown in Figure 2B.1.

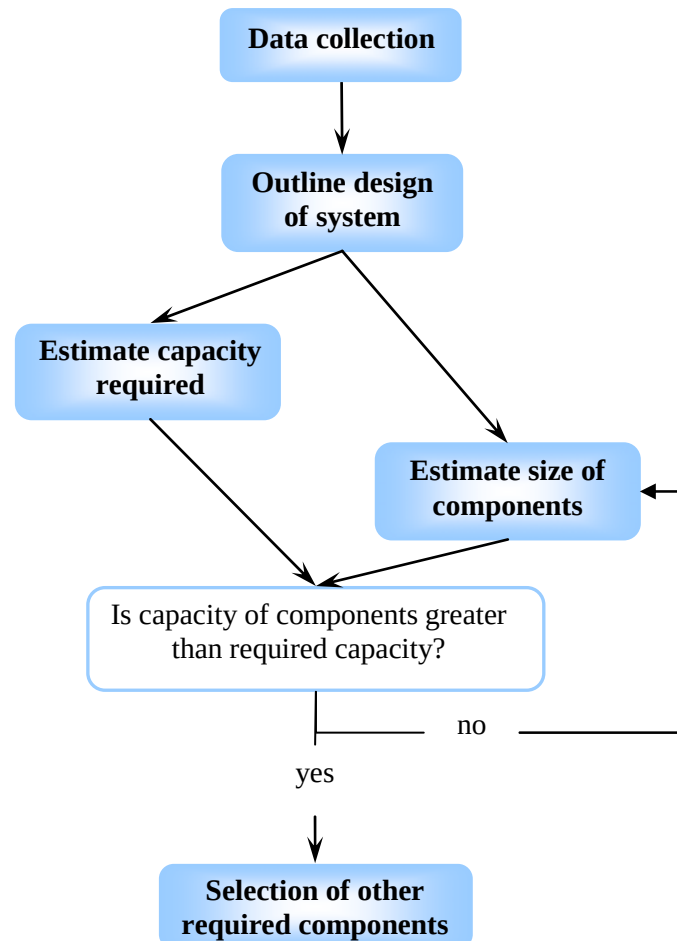


Figure 2B.1: Drainage System design process

4.2 Step 1: Data collection

Information should be collated to establish the requirements for the Drainage System and any constraints that need to be taken into account, such as space restrictions at overline Bridges, Cuttings and Tunnels. Likely changes in land use should be considered as these can substantially affect the volumes of water that need to be carried by the Drainage System.

The following data should be assembled:

1. Geometric characteristics of the track to be drained; such as length, width and levels (including longitudinal and cross slopes).

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2. Topographic information to determine the area of the Catchment, the ground levels adjacent to track (including Cuttings and off-track Catchments that could drain to the track), and the level of suitable Outfalls for the Drainage System.
3. Information on the types of soil in the Catchment.
4. Rainfall data for the location, including rainfall intensities for different probabilities and durations for the event return periods defined in Part 2A.
5. Groundwater levels, including seasonal variations.
6. Expected water levels for any Watercourse or body of water into which the Drainage System will discharge.

Local knowledge should be taken into account.

4.3 Step 2: Outline design

An outline design of the Drainage System should be prepared. In preparing this outline a number of general principles should be considered, although particular circumstances might mean that not all these can be followed.

- a) Separate Off-track Drainage from Track Drainage. Thus, where possible, Crest Drains and Toe Drains should be provided to collect water from off-track Catchments. Similarly, and where practicable, a separate Drainage System should be provided to lower a high groundwater level where it would otherwise be a problem.
- b) The preferred option is to use open Channel Drains as these are easy to inspect and to maintain. In many cases, however, limitations of space or safety considerations lead to the use of piped Systems.
- c) Track Drainage is likely to be provided by Collector Drains installed longitudinally to the track with lateral drainage provided by the cross fall on the formation. However, on wide formations it might be necessary to provide transverse Collector Drains to drain the full width of the track, but such drains can promote sub-grade erosion.
- d) The impact of the proposed Drainage System should be assessed because, for example, lowering the groundwater table could affect nearby designated conservation sites and the construction of an Outfall can increase the risk of flooding of other areas.
- e) Environmental concerns can promote the use of SUDS either to reduce the quantity or improve the quality of the water discharged to the receiving body of water.

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- f) Where Collector and Carrier Drains have to be buried deeply to achieve the required gradient, it might be necessary to install a combination of Collector Drains linked to a deeper Carrier Drain.

4.4 Step 3: Estimating the discharge capacity required

The discharge capacity of the Drainage System should be calculated using the methodology given in **5** for its Catchment and the appropriate design event specified in Part **2A**.

4.5 Step 4: Sizing the components

The capacity of the components of the Drainage System should be estimated in accordance with **5** and Part **2C**. Capacity is a function of the shape, dimensions and roughness coefficients of the components.

4.6 Step 5: Checking the capacity of the system

An iterative methodology should be used to compare the capacity of the drainage components (from **4.5**) with the estimated required capacity (from **4.4**).

1. Determine the water level in the receiving water body for the same annual probability of exceedence as the design event of the Drainage System (Part **2A**).
2. Set the invert of the Outfall to be no lower than the water level in the receiving water body (Part **2C**).
3. Design the component adjacent to the Outfall.
4. Compare the capacity of the Outfall with the required capacity, and modify the geometric characteristics of the components (such as the cross-section of a Channel Drain or pipe) to give the required discharge capacity.

If this is not possible, the longitudinal gradient of the component or the material of construction should be modified.

If it is still not possible to provide the required capacity, a different type of component should be considered or the layout of the Drainage System modified to provide the required capacity.

5. Check the velocity at the Outfall and determine whether an energy dissipation device is required. If so, design a suitable device (Part **2C**).
6. Design the next upstream component.