An Roinn Iompair
Department of Transport

Guidelines for Road Drainage

Second Edition

March 2022

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Guidelines for Road Drainage

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DOCUMENT CONTROL

Title				
Guidelines for Road Drainage				
Edition	**Prepared By**	**Checked By**	**Approved By**	**Date**
Second Edition	Working Group	Working Group	DoT	March 2022
Description	This document is a revision and update to “Guidelines for Road Drainage” Document History: First Edition April 2004			

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Acknowledgements

The Department of Transport (DoT) wishes to acknowledge the role played by the Working Group involved in preparing and drafting this document. The members of the group are listed hereunder:

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The DoT also acknowledges the assistance of the Support Office Kildare County Council in drafting this document.

Contents

Section B

1. Introduction

1.1 Background

This document supersedes the *"Guidelines for Road Drainage"* published by the (then) Department of the Environment, Heritage, and Local Government in 2004. This document is to provide guidance to all Local Authorities (LA) Engineers, Supervisors and other relevant bodies on the current best practice guidance in respect of Road Drainage.

1.2 Objectives

This document provides guidance to those involved in the design, rehabilitation, maintenance and rating of Road Drainage elements. The purpose of the document is to:

- Provide means of standardising the practices used in the maintenance of the road drainage network;
- Provide a consistent and uniform approach to the construction methods associated with road drainage;
- Provide a mechanism for recording and rating the road drainage network;
- Provide robust guidance to future proof the road drainage network to cater for the effects of climate change.

This document is not intended to be a comprehensive design manual for the drainage of new roads but concentrates on the design, rehabilitation and maintenance of the drainage network on Regional and Local roads.

1.3 Road Drainage

Road drainage is a process of removing and controlling surface water and sub-surface water. This includes the interception and diversion of water from the roadway and sub-surface levels. The surface water from the roadway should be drained off without allowing it to percolate to sub-surface formation. Surface water from adjoining land should be prevented from entering the roadway. The drainage type used should have sufficient capacity and longitudinal slope to cater for the movement of the surface water.

The main objectives of Road Drainage systems are:

- The removal of surface water from the roadway to ensure safety and minimum nuisance for the road user.
- The provision of effective surface and sub-surface drainage to maximise longevity of the pavement and road edges.

It is essential all LA provide adequate road drainage to ensure that a road pavement performs satisfactorily.

1.4 Document Structure

This document is structured in two sections.

- Section A, contains information in relation to:
  - Legal Frameworks;
  - Drainage Types;
  - Drainage Assessment; and
  - Drainage Design.
- Section B, contains information in relation to:
  - Drainage Rehabilitation; and
  - Maintenance of Drainage systems.

1.5 Glossary of Terms

DoT	Department of Transport
Road Authority	Any Local Authority in charge of a public road
LA	Local Authority
OPW	Office of Public Works
IFI	Inland Fisheries Ireland
NPWS	National Parks and Wildlife Service
DSCI	Drainage Survey Condition Index
TII	Transport Infrastructure Ireland
VRU	Vulnerable Road Users

Section A

2. Legal Frameworks

2.1 Roads Act 1993

Legislation

- **Roads Act 1993, Section 76 (No 14 of 1993)**

Section 76 of the 1993 Roads Act re-enacts, in an updated and strengthened form the powers dealing with drainage of public roads and related matters which were previously contained in the Summary Jurisdiction (Ireland) Act, 1851 and the Local Government Act, 1925.

The 1993 Roads Act gives wide powers to road authorities to ensure adequate drainage of public roads.

The full text associated with Section 76 of the Roads Act can be reviewed at the following link.

http://www.irishstatutebook.ie/eli/1993/act/14/section/76/enacted/en/html

Section 76 includes several sub-sections which are summarised as follows:

Subsection 1: Temporary usage of Land, Construction and Maintenance of drains

- Permits Roads Authorities to maintain and construct drains either to remove or prevent water from flowing on a road surface and deals with usage of land whilst doing so.

Subsection 2: Serving Procedure Notices

- Roads Authorities must allow 1 months' notice prior to works on or storage of materials on landowner's land. Objections and representations by the landowner must be considered if made.

Subsection 3: Emergency Works

- This subsection gives Authorities the power to carry out immediate works to a road without due notice if such emergency is deemed to be hazardous to road users or the road itself.

Subsection 4: Compensation

- Gives right to compensation from relevant authorities where the carrying out of drainage works, the storage and preparation of materials and the carrying out of emergency works has caused damage to land.

Subsection 5: Landowners' Responsibilities

- Requires landowners to take responsibility to ensure that water is not prevented from running off the road into their land and also to ensure that their soil or water does not escape onto the roads' surface.

Subsection 6: Landowners Works' Notice

- Allows the Roads Authority to serve a written notice to a landowner stating specific work that need to be carried out to allow sufficient drainage from the road surface to the land in question or to ensure water/soil do not escape to the road surface.

Subsection 7: Landowners Right of Appeal.

- Gives a person the right to appeal a notice within 14 days of it being received.

Subsection 8: Powers of Court

- Allows for the District Court to reject, amend or affirm a notice by the Roads Authority under subsection 6.

Subsection 9: District Court Appeal

- The District Court has the jurisdiction to hear an appeal on any notice. Any appeal on a matter of fact from the District Court is deemed to be precluded.

Subsection 10: Effective Notice

- A notice will not have effect until 14 days after service. This date can be decided upon by a District court if an appeal is submitted regarding the notice.

Subsection 11: Non-Compliance with a Notice

- Concludes that it is an offence for a landowner to not comply with a served notice and may be subject to a fine or imprisonment if they do so.

Subsection 12: Road Authority Action

- Allows the Roads Authority to act upon a served notice where a landowner has failed to comply with the issued notice. The works must be reasonable and governed by notice served prior.

Subsection 13: Immediate Road Authority Works.

- Roads Authority can undertake immediate works where seen fit as a prevention to hazards to road surfaces and road users without due notice being required.

Subsection 14: Cost Recovery by Roads Authority

- Gives the Roads Authority discretion to recover its costs from the landowner where immediate or emergency works are required.

Subsection 15: Consent of Roads Authority

- Ensures appropriate consent is given to a landowner regarding works within 15m of a public road and or works that interfere with any element or structure that provides support to the public road

Subsection 16: Advance & Retrospective Serving of Notices

- The Road Authority must serve notice prior to entering the landowners land and must also give notice at their earliest convenience upon entering land without due notice for emergency works.

Subsection 17: Defines Drains

- Gives a descriptive analysis of a drain and the entailments of such feature.

Figure 2.1 Summary of Section 76 of the Roads Act.

2.1.1 LA Process Flow chart

An integral part of consultation with landowners is the initial correspondence ahead of the enforcement of the roads act. Fig 2.2 provides a flow chart to give an indication of the benefit of communication with the landowner with a view to resolving a drainage issue. LA should ensure that all avenues have been attempted with the landowner prior to proceeding with applying Section 76 of the Roads Act.

LA can issue notifications to the landowner to inform them of their responsibilities under Section 76 or any sub-section of the road act if they deem them not in compliance. See template of notice in Appendix 1.

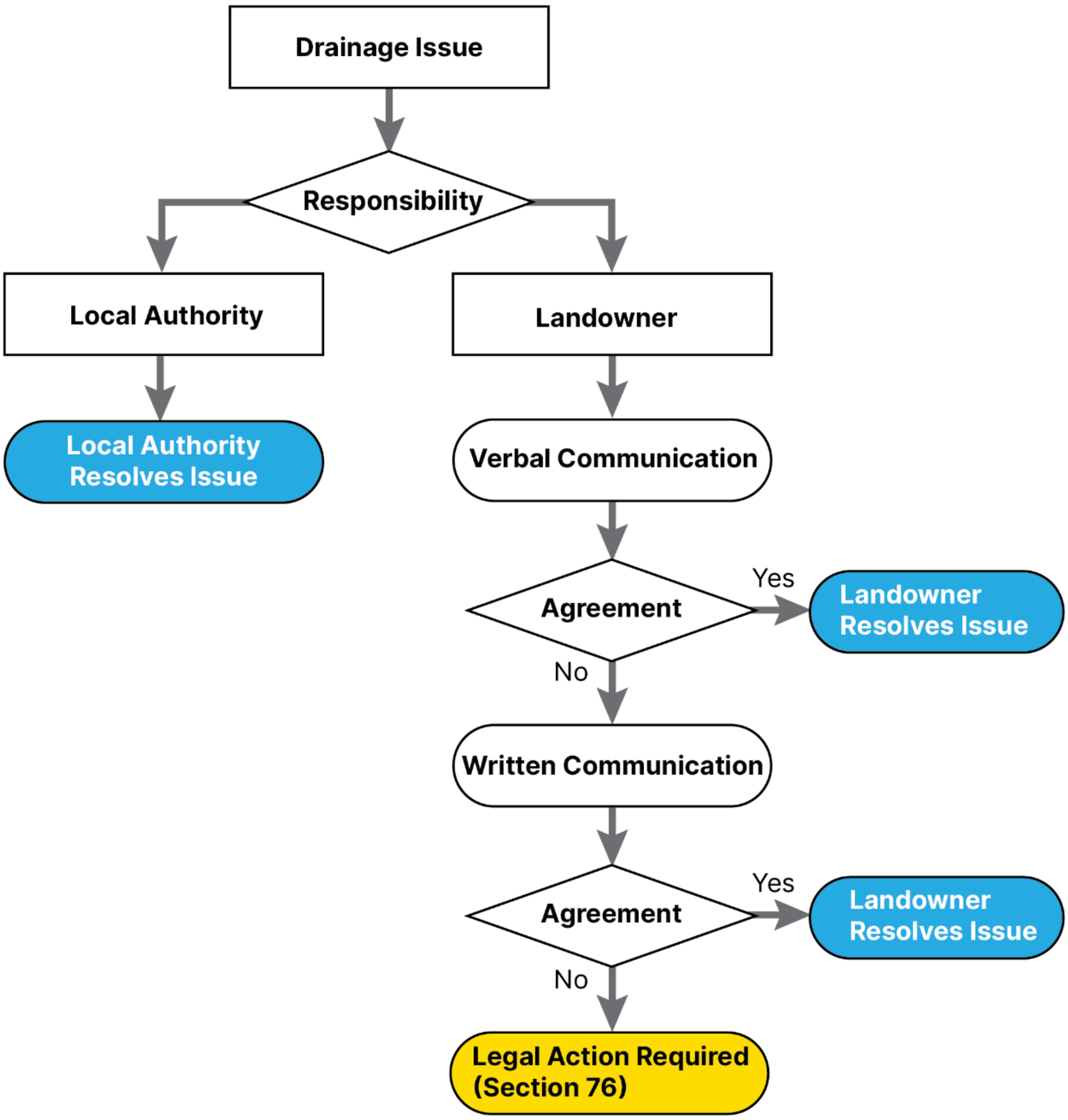


Figure 2.2 Process Flow Chart for Communication

2.1.2 Riparian Landowners Requirements

Owners of property where there is a watercourse within or adjacent to the boundaries of their property are a riparian landowner. A watercourse includes a river, stream or ditch. A riparian landowner is also responsible for watercourses or culverted watercourses passing through their land.

A riparian landowner has a number of rights and responsibilities. The following sets out elements of those requirements:

Rights of a Riparian Landowner include:

- **Consult and agree with your LA the most suitable course of action prior to undertaking any maintenance works.**
- **Protect your property from flooding, and your land from erosion.**
- **Consult with your local Inland Fisheries Ireland (IFI) office to check what your rights are and if a fishing licence is required.**
- **Water should flow onto or under your land in its natural quantity and quality.**
- **Water should not be taken out of a watercourse if it could lead to a lack of water downstream.**

Responsibilities of a Riparian Landowner include:

- **Passing on water flow without obstruction, pollution or diversion affecting the rights of others.**
- **Managing the channel for the purposes of flood risk and having due regard for the needs of wildlife and giving space for nature.**
- **Maintaining the bed and banks of the watercourse (including trees and shrubs growing on the banks).**
- **Taking appropriate steps to prevent erosion of the banks, clearing any debris, including litter whether or not it originated from your land.**
- **Protecting waters against pollution from agricultural sources.**
- **Maintaining free passage for fish.**
- **Keeping clear any structures that you own such as culverts and weirs.**
- **Not building new structures that encroach on the watercourse or alter the flow of water.**

2.2 Arterial Drainage Act 1945 and EU Assessment and Management of Flood Risks Regulations SI 122 of 2010

Legislation

- **Arterial Drainage Act 1945, Section 29, 37 and Section 50**

Section 29

Under Section 29 of the Act, if the Commissioner of Public Works are of the opinion that any existing drainage works which are for the time being maintained by the council of a county are not being properly maintained and that maintenance or repair work is immediately necessary in respect of the said existing drainage works, it can serve by post on such council notice of disrepair.

Section 37

Under Section 37 of the Act, the Commissioner of Public Works are statutorily obliged to maintain all rivers, embankments and urban flood defences on which it has executed works since the 1945 Act in "proper repair and effective condition".

Maintenance referred to under the Arterial Drainage Act 1945 includes:

- The maintenance of river channels in a condition that ensures they are free flowing, thus reducing flood risk and providing adequate outfall for land drainage.

An interactive map of the current watercourse which are impacted by this section of the legalisation can be located at the following link.

https://www.floodinfo.ie/map/drainage_map/

Section 50

Under Section 50 (1) of the Act, a LA shall not construct any new bridge/culvert or alter, reconstruct, or restore any existing bridge/culvert over any watercourses without the consent of the Commissioners of Public Works. The Act states that watercourse includes rivers, streams, and other natural watercourses, and also canals, drains, and other artificial watercourses.
Where consent is given by the Commissioners then the works should be carried out in accordance with any plans which have been approved of by the Commissioners.

The Office of Public Works (OPW) has produced guidance documents which can be found at the following links.

- https://www.gov.ie/en/publication/957aa7-consent-requirements-constructionalteration-of-watercourse-infrastru/ and
- https://www.gov.ie/en/collection/4ef661-examples-of-section-50-applications/

These documents set out the OPW assessment criteria for bridges and culverts. It is primarily concerned with bridges and culverts on rivers and streams which have associated catchment areas. In such cases, it recommends a minimum culvert diameter of 900mm to ensure accessibility for future maintenance and to reduce the risk of blockages. The OPW is also concerned with any effects that a bridge/culvert will have both upstream and downstream of its location. The OPW is not concerned with the detailed drainage design (longitudinal drainage, manhole details etc.) for a road scheme.

Legislation

- **S.I. No. 122 of 2010 EU Assessment and Management of Flood Risks Regulations**

Section 42

Under this section the powers of the Commissioner of Public Works in relation to the maintenance on any flood risk management works are outlined and include the following:

- Enter on any land and there do all such things as shall be necessary for or incidental to such maintenance;
- Take from any land all sods and other material required for the purpose of such maintenance;
- Deposit on any land all spoil and other material produced in the course of such maintenance;
- Utilise for the purpose of such maintenance all or any spoil, gravel, stone, rock, or other material removed in the course of such maintenance; and
- Do all such other acts and things as shall, in the opinion of the Commissioners, be necessary or proper for the efficient carrying out of such maintenance.

2.3 Additional Legislation

Legislation

- **Planning and Development Act 2000, Section 182, 213, 202/203**

Section 182

Revolves around powers to lay pipes through land rather than the acquisition of way-leaves for this purpose. In addition to this simplified approach, the section also shifts the prerogative on to the LA, in the face of refusal by a landowner or occupier to provide a definite response, to initiate proceedings to have the position of the landowner or occupier determined.

Under Section 182 (1) of the Act, a LA may with the consent of the owner and occupier of any land not forming part of a public road, place, construct or lay, as may be appropriate pipelines (including water pipes, sewers or drains), under or over the land, and may, from time to time, inspect, repair, alter, renew or remove any such pipelines.

Section 182 (4) provides that a consent "shall not be unreasonably withheld", and, at the initiative of the LA where it considers that consent is being unreasonably withheld, enables it to appeal to An Bord Pleanála for a determination. If the Board subsequently determines that consent has been unreasonably withheld, it is deemed that the consent has been given, and the LA is accordingly empowered to proceed with the works.

It should be noted that section 182 of Act does not confer on a LA any power to acquire a way-leave or land. Section 182 confers only the power to run a pipe and any ancillary apparatus through a stretch of land, and accordingly, its operation would not result in a burden being registered on the landowner's title. Where a section 182 procedure is used, it is essential to avoid reference to acquisition of way-leaves in any related documentation or notification. Such a purpose is beyond the scope of the section.

Section 199 of the Act, provides the basis for compensation which may be payable which provides for restitution where it is shown that the value of an interest in the land is reduced or that a person has suffered damage by being disturbed in his or her enjoyment of the land.

Section 213

Procedures for obtaining consent to lay pipes under private lands involve acquisition of "way-leaves" in the traditional manner, either under the Public Health (Ireland) Act 1878 or using updated acquisition powers under Section 213 of the Planning and Development Act, 2000 **(preferred method)**

Section 213 (1) power conferred on a LA under any enactment to acquire land shall be construed in accordance with this section.

This section can be used by LA to lay water main and sewers through land, it is provided for in sections 18 and 64 of the Public Health (Ireland) Act 1878.

Section 202/203

This 202/203 of the Act also enable sanitary authorities to acquire land (by agreement or compulsory purchase).

In addition to the acquisition of land per se, the provisions of sections 202/203 have traditionally been applied in the water services sector to the acquisition of "easements" (usually known as "way-leaves") for the purpose of running pipes through land. Such interpretation arises from the inclusion of "easements" in the definition of land under section 2 of the 1878 Act.

Legislation

- **Inland Fisheries Act 2010**

Section 7

Under this section it states the principle function of Inland Fisheries Ireland is the protection, management and conservation of the Inland Fisheries resources. It outlines the requirement to consult with, and involve the LA in developing Inland Fisheries catchment management plans

Local Authority Consultation

In Ireland road discharge is not regulated and does not require a discharge licence to either discharge to surface water or groundwater. Consultation from LA should take place with IFI, OPW and the NPWS in relation to road drainage design and discharge.

3. Drainage Types

3.1 Piped Systems

3.1.1 Kerb and Gullies

Kerbs and gullies have been for many years one of the most commonly used forms of road drainage in urban areas. Surface water flows over the pavement to a kerb at the edge of the road and is collected in gullies which are connected to longitudinal carrier drains set within the road verge. Although the main functions of kerbs are to protect pedestrians and provide support for the carriageway, they are often also an essential part of a drainage system. They form a channel at the carriageway edge directing surface water to gullies from where it is removed through a system of pipes. The gulley can be located at the edge or the road pavement, or can be inset into the verge. The carrier drain may be a sealed pipe for the collection of surface water only, or a perforated or open jointed pipe may be used in order to convey both surface water and sub-surface water to the outfall.

Gullies can have both beneficial and negative impacts on water quality for receiving watercourses. The main benefit for gulley pots is their ability to capture potentially contaminated sediments during normal rainfall events at their base prior to discharge into a receiving watercourse. They are more effective at trapping the course sediments than finer ones. They can also provide a good first line of defence in the event of an actual spillage.

However high inflow rates can cause re-suspension of sediments within the gulley pot and subsequent discharge of the suspended sediments from the gulley pot can result in a pollutant flush into the receiving drainage network or watercourse.

3.1.2 Rural Gullies

Gullies can also be used in rural settings. The gullies may be placed along the edge of the carriageway or may be placed adjacent to the carriageway. Ensure a suitable surround is provided to channel the surface water from the carriageway into the gullies. For rural areas the gullies used may be larger chambers to cater for higher surface water levels. In most cases space will not be a limiting factor and 600mm diameter gullies / chambers can be used.

3.1.3 Drainage Kerbs

Combined kerb and drainage systems are precast concrete units either in one piece or comprising separate top and bottom sections. A continuous closed internal channel section is formed when contiguous blocks are laid. The part of a unit projecting above road level looks similar to a conventional kerb unit though the face has a series of preformed holes that admits water into the internal cavity. They are especially useful where kerbs are necessary at locations of little or no longitudinal gradient. They can be useful where there are a number of public utility services, especially in urban areas.

3.1.4 Kerb Inlet Gullies

Kerb Inlet Gullies is a side entry drainage item. These inlet gullies are placed within the kerb line of the road and the road surface is then laid to ensure the surface water flows to the location of the inlet gullies. The carrier pipe for these inlet gullies can be located beneath the kerb area or within the carriageway. The use of this drainage type ensures a smoother and safer road surface for cyclists as the drainage device is not placed within the road surface.

3.1.5 Aco Drains

Aco drains are particularly used in the urban areas. They are designed for removal and conveyance of surface water. They are a modular trench drain manufactured from either stainless steel, corrosion resistant polymer concrete, or fiberglass, together with grates from a variety of materials for all loading applications. The correct loading class must be chosen for the gratings to ensure suitability for the installation location, whether it be pedestrian loading or vehicular loadings.

Aco drains collect rainwater through the grating, the collected water then flows along the length of the channel. The channel is then connected into the storm water network. When choosing the location of Aco drains care should be taken to provide safe and suitable access to maintenance.

3.1.6 Slot Drains

Slot drains are particularly used in the urban environment. The surface area of the slot drains is small and can be aesthetic pleasing in a paved or pedestrian heavy environment. They are set flush with the surface and contain a drainage conduit beneath the surface into which the surface water enters through slots or gratings.

When used on shallow gradients they are prone to maintenance difficulties. The slot drains can be made from a number of material types. Care needs to be taken to ensure the materials chosen is suitable for the loading levels required for the drain. If vehicular loading is to be considered, then slot drainage channels can be precast or formed of in situ concrete. Slot drains used in locations where pedestrians and cyclists are present need to ensure the slot width does not cause a hazard for the users. When choosing slot drains care should be taken to provide safe and suitable access to routine maintenance.

3.2 Filter Drains

Filter drains are particularly useful in draining the road network and used throughout the country. They are frequently employed in Ireland because groundwater levels tend to be high and sub-surface drainage systems such as filter drains are needed to control water levels under the sub base of the road which would compromise the pavement structure. These systems are used independently or in combination with kerb systems or concrete channels and piped systems.

A filter drain is a gravel filled trench, topped with crushed rock as a surface layer to minimise the likelihood of stones being scattered on the carriageway. Generally filter drains have a perforated pipe at the base. It is important to ensure that filter drains are not used in a trafficked area as the perforated pipe may be crushed by the vehicle weight.

Runoff flows slowly through the granular material, trapping sediments and providing attenuation. Flow is then directed to the perforated pipe, which conveys run-off into a waterbody. A geotextile material should be used to control the flow of sediments. Drainage networks which incorporate filter drains can provide a degree of control over pollution.

Monitoring results suggest that filter drains have a finite lifespan. A maintenance cycle for filter drains needs to incorporate replacement of the top section of filter material.

3.3 Open Drains

Open drains are used to drain surface water and to act as interceptors for seepage water, including sub-soil water. The use of open drains may be restricted for reasons of safety and of maintenance. They are often used, however, at the bottom of embankments and as intercepting channels at the tops of cuttings. Open drains should be located a reasonable distance from the edge of the road pavement to ensure that water does not seep back into the road structure.

A lot of rural roads are drained by inlets which comprise of shallow channels excavated across verges to allow drainage from road edges to open drains. Inlets require regular maintenance as they are prone to rapid build-up of silt and blockage by debris or vegetation growth. An inlet can be formed with a concrete base to reduce maintenance and improve serviceability.

3.4 Verge Removal

Road verge removal is common in rural locations along much of the road network. It ensures surface water can flow from the carriageway into the receiving grass verge. Verge removal can be in the form or a continuous removal of the verge material 300mm to 500mm from the road edge.

It may also be the removal of sections of the verge at recurring distances which suit the road geometry. This will allow surface water to flow to the grassed area and away from the road structure.

3.5 Concrete Channels

Concrete channels are normally rounded or triangular concrete sections, either slip-formed, cast-in-situ or precast and set at the edge of the road pavement, flush with the road surface. Benefits of the channel would include ease of maintenance and the fact that long lengths can be constructed quickly and relatively inexpensively. Channel outlets can be located at significant spacings and possibly coincident with existing watercourses. However, roads with flat longitudinal gradients may necessitate discharge of channels fairly frequently into outfalls or parallel longitudinal carrier pipes in order to minimise the size of the channels.

3.6 Over the Edge Drainage

This method of drainage is applicable to embankment conditions where the embankment is constructed of free draining material. It is not appropriate on embankments constructed of silty or clayey, moisture susceptible soils.

Over the edge drainage occurs on several roads on the network where the road elevation when constructed was higher than the area on one or both sides of the carriageway. This drainage can be very effective once the maintenance of the carriageway edge is undertaken to ensure surface water can flow over the edge.

3.7 Soakaway & Infiltration Trench

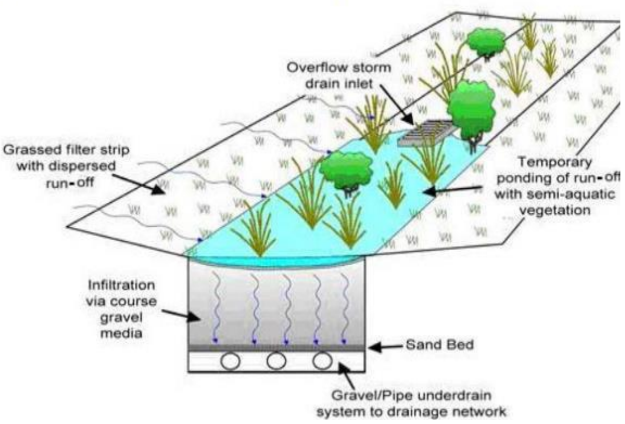
Soakaways are sub-surface structures into which surface water is conveyed, designed to promote infiltration. An infiltration trench is a gravel/crushed rock filled trench designed to infiltrate run-off to the ground. Infiltration trenches are essentially long thin soakaways rock filled pits or large tank structures. Soakaways are generally large square or circular excavations, filled in with aggregate, or precast storage structures surrounded by granular backfill. Run-off is stored in the voids allowing it to slowly infiltrate through the bottom into the soil. This reduces the volume of water that is discharged into receiving watercourses thereby reducing some of the impacts caused by excess flows and pollutants.

Ring soakaways comprise of a cylindrical chamber into which the surface run-off from the catchment area is collected. The space between the rings and the excavation is backfilled with coarse aggregate.

Soakaways must not allow direct discharge to groundwater, for example via boreholes. Soakaways should not be placed within 5m of a building. Soakaways shall not lead to a risk of instability, either by washing out of fines, or of saturation of road foundations due to inadequate capacity. Soakaways must not increase the risk of groundwater flooding. The soil conditions must be suitable for infiltration if choosing to use soakaways or infiltration trenches.

3.8 Bio – Retention

Bio retention areas are storm water controls that collect and treat storm water runoff. They are designed as depressions backfilled with a sand/soil mixture and planted with native vegetation. As the surface water passes through the vegetation it provides filtration and settlement as well as allowing for infiltration. Bio-retention facilities are typically under-drained, and the filtered run-off is returned to the drainage network or to watercourses. They are most commonly used in high density urban areas, traffic islands or within small pockets in residential areas.



The runoff is treated using soils and vegetation in shallow landscaped basins to remove pollutants.

There is considerable variability in the effectiveness of bio-retention areas, detailed design and regular maintenance are essential to maximise performance.

Best applied to relatively shallow slopes. However, sufficient slope is needed at the site to ensure that water that enters the bio-retention area can be connected with the wider storm network. Bio-retention systems are most effective, when they are placed as close to the source of run-off as possible.

3.9 Attenuation Basins

Attenuation Basins are dry basins that attenuate storm water runoff by providing temporary storage with flow control of the attenuated runoff.

Attenuation basins are normally dry and in certain situations the land may also function as a recreational facility. Basins tend to be found towards the end of the SuDS management train.

3.10 Attenuation Tanks

Attenuation Tanks are tanks that provide a storage system for rainwater and surface water. Storm water attenuation tanks provide a cost-effective solution to control the water flow of a drainage system or watercourse. Attenuation tanks are commonly used for larger application of controlling water which are suitable for new roads and upgrades. The stored water inside the attenuation tank is released via a flow-control chamber and is either pumped via a pumping chamber or run-off through a gravity stormwater pipe system. The surface water run-off is slowed down before it is discharged into the local watercourse, effectively reducing the risk of localised flooding.

3.11 Swales

Swales are channels lined with grass, which are used to convey run-off to infiltration and in the process trap pollutants and reduce runoff velocity. Swales are particularly suitable for controlling run-off from small residential developments, parking areas and roads. They can be used in both urban and rural locations. They can replace conventional pipework, and in some cases should remove the need for kerbs and gullies.

They are typically provided along roads in grass verges. Swales can be designed for infiltration to subsoil or detention and conveyance. The vegetation acts as a sediment filter. Swales are recommended to cater for runoff from access roads, providing water treatment and reduction in peak flow. There are three main types of swale, standard conveyance swale, Dry Swale and Wet Swale.

Conveyance swales are broad, shallow vegetated channels. The dry swale is a vegetated conveyance channel, designed to include a filter bed of prepared soil that overlays an underdrain system. The wet swale is equivalent to the conveyance swale, but designed to encourage wet and marshy conditions in the base to enhance treatment processes.

3.12 Wetlands

Wetlands provide both stormwater attenuation and treatment. They comprise shallow ponds and marshy areas, covered almost entirely in aquatic vegetation. Wetlands detain flows for an extended period to allow sediments to settle, and to remove contaminants by facilitating adhesion to vegetation and aerobic decomposition.

Well designed and maintained wetlands can offer significant aesthetic, amenity and biodiversity opportunities. The area required for wetlands is large and care should be undertaken to ensure the correct placement of a wetlands area. Access for maintenance is one factor that needs to be taken into account when designing wetlands.

3.13 Drainage Type Effectiveness

Table 3.1 shows the effectiveness of the drainage types using different sub-headings. The classification used for each sub-heading is

- **Green:** Rated high under the sub-heading
- **Amber:** Rated medium under the sub-heading
- **Red:** Rated poor under the sub-heading.

Drainage Type	Drainage Type Effectiveness								
	Ease of Construction	Cost of Construction	Rural Location Suitability	Urban Location Suitability	Maintenance Requirements	Life Span	Road User Safety	Traffic Loading	Sediment Capture
Kerb & Gullies									
Drainage Kerbs									
Kerb Inlet Gullies									
Aco Drains									
Slot Drains									
Filter Drains									
Open Drains									
Verge Removal									
Concrete Channels									
Over the Edge Drainage									
Soakaway and Infiltration Trench									
Bio-retention								NA	
Attenuation Basins								NA	
Attenuation Tanks									
Swales								NA	
Wetlands								NA	

Table 3.1 Drainage Type Effectiveness

3.14 Drainage Type Selection Assistance

The following flow charts provide assistance in the selection of the drainage type whether the location is in an Urban or Rural context.

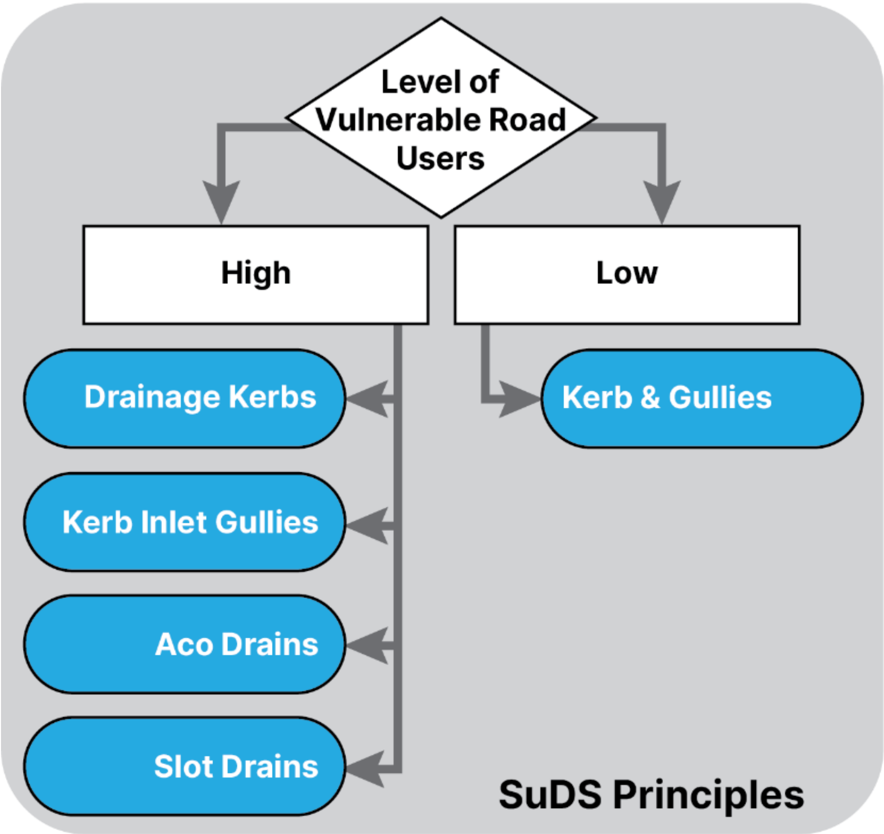


Figure 3.1 Urban Drainage Type Selection

Note: Sustainable Urban Drainage Principles should be adhered to when selecting the drainage type.

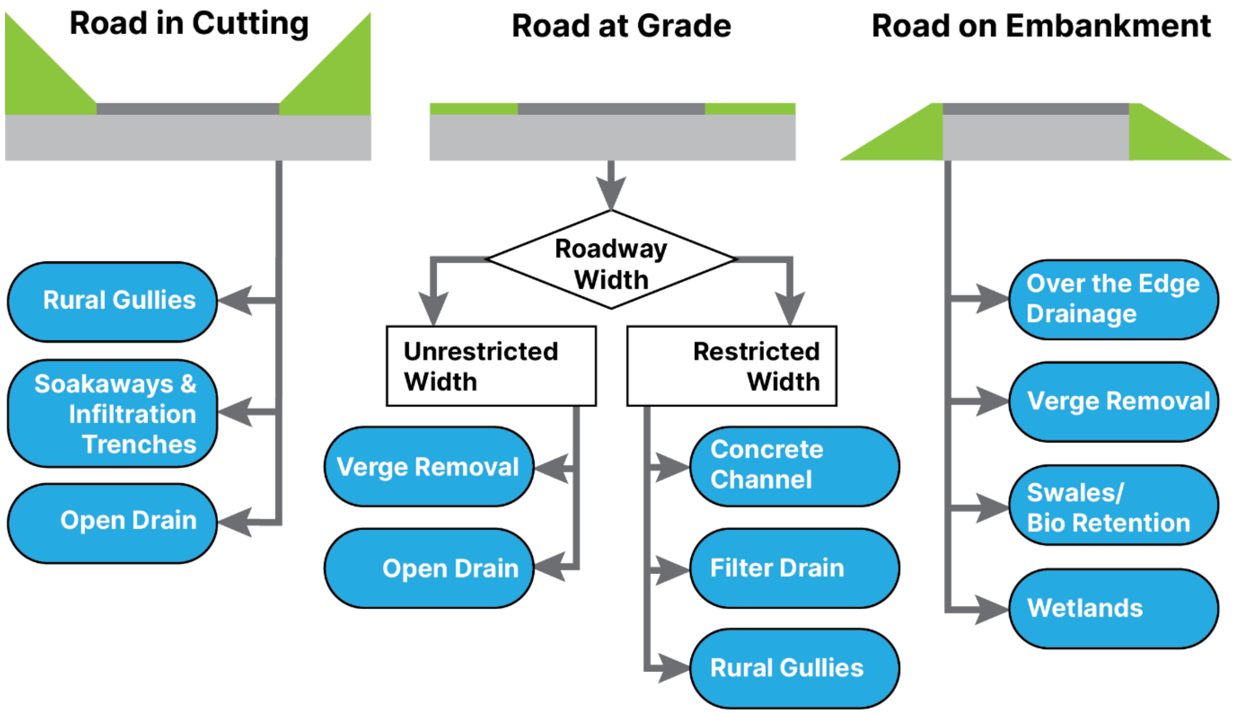


Figure 3.2 Rural Drainage Types Selection

Site constraints should be taken into account when selecting the correct drainage type. A number of drainage types can be chosen for a given stretch of roadway if required.

If the selection of an Open Drain is chosen as the preferred drainage type, there is further guidance that should be considered. The distance from the edge of the carriageway to the open drain should be determined. The following guidance can be used to determine additional options for a drainage type dependent on the distance from the carriageway.

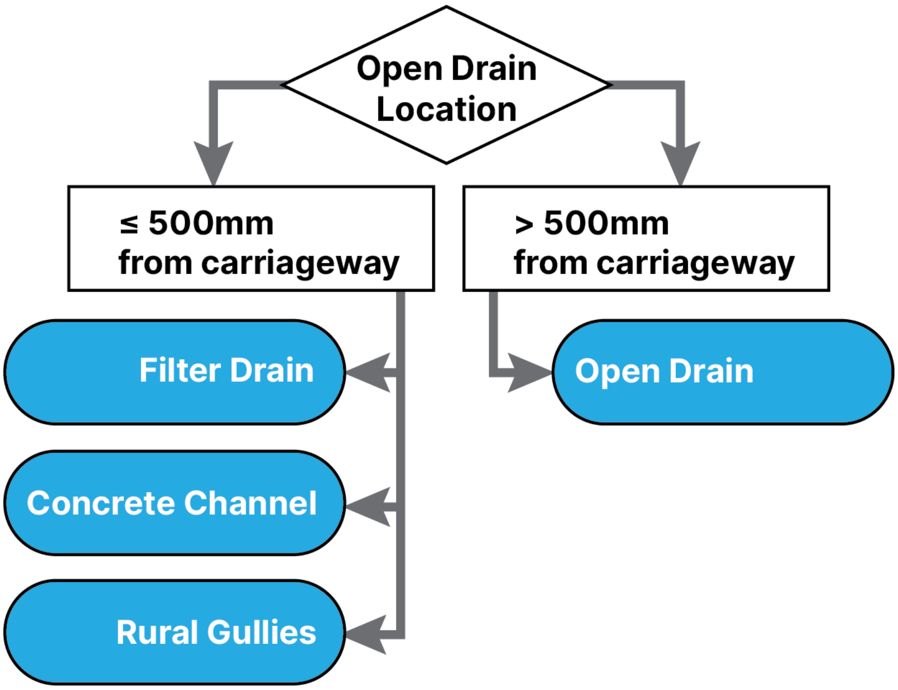


Figure 3.3 Open Drain Guidance

4. Drainage Assessment

An appropriate assessment of drainage infrastructure is essential to establish how existing drainage is, or is not, operating. It will also then provide the necessary information central to determining an appropriate intervention. This section demonstrates a collection of analysis and activities that together aims to ensure a consistency of approach with respect to determining the appropriate drainage intervention for a specific site location.

4.1 Intervention

An intervention in the context of drainage is defined as the action taken that results in a drainage system functioning adequately. See Table 4.1

Intervention Category	Description
Routine Maintenance	Refers to any maintenance task that is done on a planned and ongoing basis aimed to prevent problems before they result in drainage operational issues.
Reactive Maintenance	Refers to repairs or actions carried out to drainage that is non-functional, to restore the drainage to its normal operating condition.
Rehabilitation	Refers to the action of restoring drainage that has been damaged to its former normal operating condition.
Improvement	Refers to new drainage infrastructure or the enhancement of existing drainage infrastructure.

Table 4.1 Intervention Categories

4.2 Site Assessment

An site assessment is designed to provide an overall evaluation of the drainage condition and potentially identify areas that require a more detailed assessment.

4.2.1 Drainage Survey Condition Index

As a mechanism to aid the management of drainage routine maintenance programmes and project works cycles, a Drainage Survey Condition Index (DSCI) can be assigned to sections of the network.

The DSCI rating should be captured via MapRoad Pavement Management System Field Apps to then be displayed spatially on the MapRoad browser interface.

The DSCI allows the road drainage condition to be systematically identified and then re-rated post intervention. It is important to appreciate, that a drainage condition survey may only be the first assessment stage to why an element of road drainage is not functioning to the required service level. Table 4.2. provides four ratings associated with the drainage performance and the effect on the road.

DSCI Rating	Description:	Action:	Intervention(s)
Functional Drainage	Drainage adequately facilitating the displacement of surface water from the road pavement	Monitor	None
DSCI Rating	**Description:**	**Action:**	**Intervention(s)**
Functional Drainage	Initial indicators that drainage may not facilitate the adequate displacement of surface water from road pavement	Intervention	Routine Maintenance
DSCI Rating	**Description:**	**Action:**	**Intervention(s)**
Non - Functional (Pre Road Damage)	Drainage **not** facilitating the displacement of surface water from the road pavement AND has NOT yet affected the road structure	Intervention	Reactive Maintenance
		Project Level Assessment	Rehabilitation, Improvement
DSCI Rating	**Description:**	**Action:**	**Intervention(s)**
Non - Functional (Post Road Damage)	Drainage **not** facilitating the displacement of surface water from the road pavement AND HAS affected the road structure	Intervention	Reactive Maintenance
		Project Level Assessment	Rehabilitation, Improvement

Table 4.2 Drainage Performance Index

4.3 Project Level Assessment

The aim in the first instance of the DSCI rating is to establish the operational capacity of the drainage with the aim to determine the appropriate intervention required to return it to a functional operational level i.e. DSCI.

For example, a section of the network may fall into DSCI where under initial assessment it has been concluded that the correct intervention is Reactive Maintenance to fix an isolated problem. Therefore, the drainage does not require further assessment.

However, if a location has been determined to be considered at a project level i.e. outside routine or reactive maintenance, then a project level assessment exercise is required to gather information about the 'Site' to ensure accuracy in decision making. See Figure 4.2

Figure 4.1 DSCI Performance Index Examples Rural and Urban

4.3.1 Desktop Study

A detailed analysis of the surrounding environment with the aim to establish how it may be affecting the operational capacity of the drainage is vital. A desktop study is a valuable source of information on the nature and characteristics of the surrounding area or 'Site', where site refers to the geographical setting where data collection takes place.

It is important to utilise relevant 3rd party data sets to aid in the identification of factors which contribute to the operation or functionality requirements of the specific road drainage. For example, knowledge of an areas soil type will provide an indication of drainage properties in the area. If a road is traversing an area of heavy clay soil with hard bedrock beneath, road drainage will be more restrictive than in an area of sandy soil or a karst region.

MapRoad currently displays a suite of 3rd party data sets and provides the functionality to view them as mapped layers on a single mapped interface. MapRoad also has a specific Web Map Service Loader tool which enables further data sets to be imported into the system as additional layers as required, making the platform a valuable and convenient tool in carrying out a desktop study.

Listed in Table 4.3 are some of the 3rd party data sets that are beneficial in carrying out an extensive desktop study.

Organisation	Identify Mapped Areas
Geological Survey Ireland	Bedrock, Groundwater, Geotechnical, Geological heritage, Marine, Geophysics Geochemistry etc.
Teagasc	Soil Classification Maps
Met Eireann	Rainfall frequency
OPW Flood Studies Update Web Portal	Rainfall frequency Flood estimation (Gauged) Flood estimation (Ungauged)
DATA.GOV.IE	Environment Section

Table 4.3 Relevant 3rd Party Data Sets

4.3.2 Visual Site Inspection

The overall objective of the visual site inspection is to collect data from the road pavement, drainage infrastructure and surrounding area in question. Information gathered about the site is used to inform decision making and be incorporated into any drainage assessment in tandem with the desktop study.

For a comprehensive set of results the visual site inspection should be undertaken in two conditions. An inspection undertaken after a period of dry weather enables a safe and unperturbed inspection allowing better visual exposure to establish the physical condition of the drainage network. A wet weather inspection is undertaken during or after a period of rainfall and will help to establish the sources, patterns, obstructions, and the effects of flowing water.

The site should be thoroughly photographed and/or video recorded so that it can be reviewed post inspection, to minimise additional site visits and inform possible maintenance or design solutions.

4.4 Projects, Data Collection, and Inventory

Once through the project level assessment, it shall be determined if a project shall be placed in the yearly drainage programme and scheduled for works. The projects current DSCI rating (DSCI or DSCI) will aid in the prioritisation of projects.

Projects with a DSCI rating has not affected the road structure where DSCI rating has affected the road structure. An intervention when the drainage is rated as DSCI will ensure that the road structure will not deteriorate further, and the longevity of the carriageway can be maintained. In most cases the drainage rated as DSCI will require a greater level of intervention in parallel with works being undertaken to the carriageway.

MapRoad and its associated Apps with GIS capabilities will facilitate the capture of all associated drainage data and information. The MapRoad platform will provide the functionality to manage all aspects of drainage projects including but not limited to inventory capture, planned and as built works records, estimated and actual expenditure and cross analysis of drainage data with all other available MapRoad data sets, Road Schedule, Pavement Projects etc. Figure 4.2 outlines the project process.

The Road Management Office provides centralised supports to LA with respect to MapRoad and the asset management of road pavement and associated infrastructure (drainage).

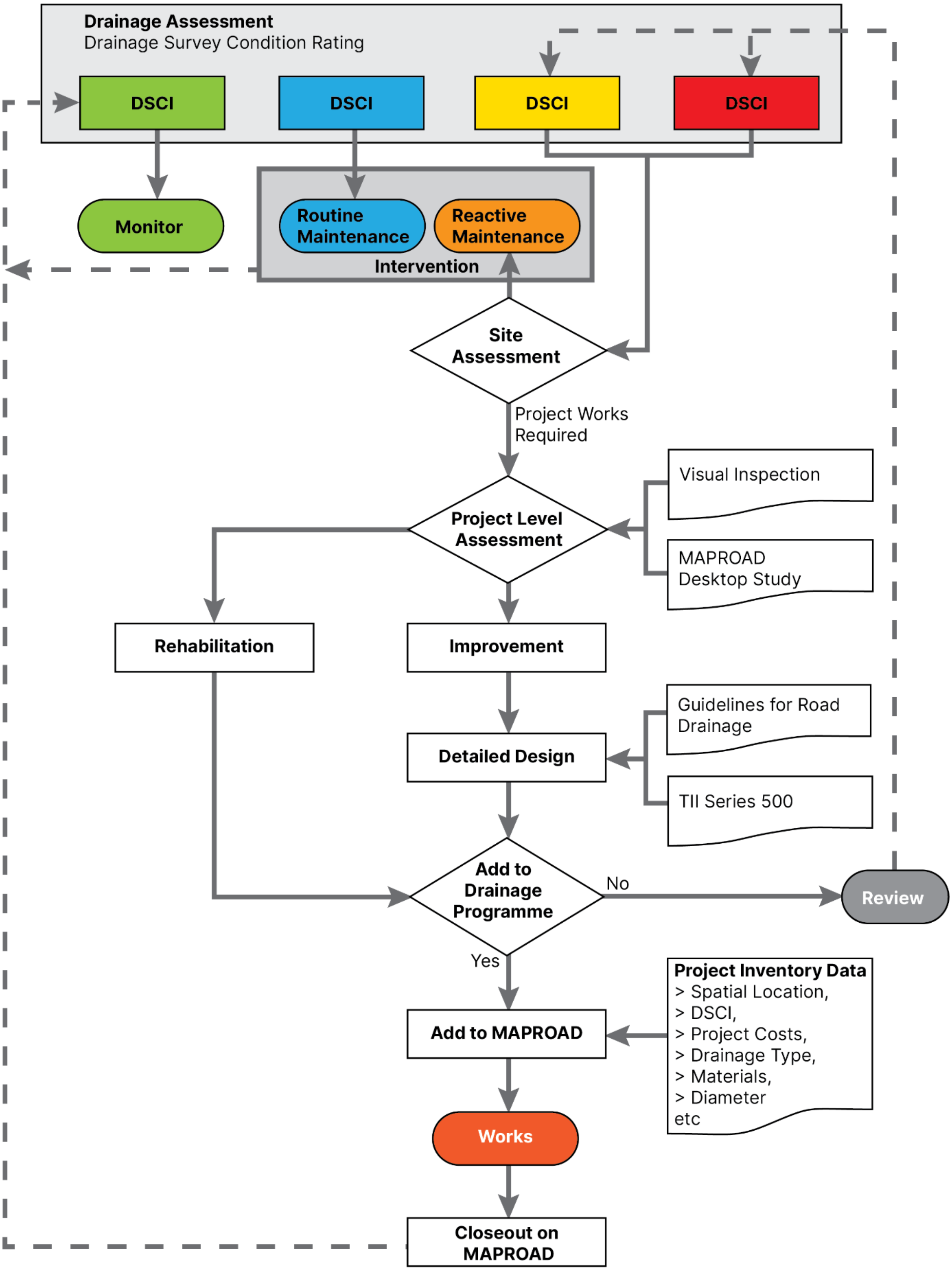


Figure 4.2 Drainage Assessment and Project Level Process Flow Chart

5. Drainage Design

5.1 Design Principles

There are three major objectives in the drainage of roads:

- The speedy removal of surface water to ensure safety for road users;
- Provision of effective sub-surface drainage to maximise longevity of the pavement and its associated earthworks; and
- Provide for drainage of earthworks and structures associated with the road.

It is important that the drainage designer ensures that:

- All drainage systems are accessible for inspection and maintenance;
- All impermeable and semi impermeable surfaces are adequately drained;
- Drainage systems do not have an adverse impact on existing ecology, surface-water hydrology or groundwater hydrogeology;
- All drainage designs have adequate consideration for climate change; and
- In the interest of pollution control and containment the road drainage shall, wherever possible, be kept separate from other catchment drainage.

The designer should ensure that sufficient information is known in relation to the existing road section when undertaking a detailed design for a given drainage type. The elements may include:

- Crossfalls;
- Longitudinal Gradients;
- Outfall locations; and
- Outfall levels.

If the designer is undertaking a design for a new road section or a restoration project then the road geometry criteria as set out in the TII Publications should be utilised.

The quantity of water to be drained will depend on a number of variables, the intensity, duration and frequency of the rainfall, together with the size and type of the area contributing to the run-off.

Design is normally based on the rainfall intensity of short intense storms occurring during summer, which usually overloads the drainage system more than the steady but less intense rainfall which occurs during the winter. The less intense rainfall is important however, where the unpaved area drained is much greater than the paved area.

Care should also be taken if adjacent fields have the potential to contribute runoff to the road drainage network. This will result in potentially higher flows during winter when land is saturated.

5.2 Return Periods

Longitudinal carrier drains must be designed to accommodate a 1 in 1 year storm. The design must be checked against a 1 in 5 year storm intensity to ensure that surcharge levels do not exceed the levels of chamber covers.

Transverse sealed drains, including gully connections, crossing beneath the carriageway, shall be designed to accommodate a 1 in 50 year storm without surcharge or be a minimum of 300mm, whichever is greater.

Section 50 applications require capacity of the structure to cater for 1 in 100 year storm event.

5.3 Minimum Pipe sizes

The minimum pipe size chosen to be installed as part of a road project should be 225mm for longitudinal drains.

The minimum transverse pipe diameter should generally not be less than 600mm unless there are site specific constraints. The standard details included in Section 6 outlines a detail that should be used if a transverse pipe may have very low cover due to outfall levels.

5.4 Pipe Design Sizing

5.4.1 Colebrook White

Initial sizing of pipework can be undertaken using the HR Wallingford developed hydraulic capacity tables.

These capacity tables consist of discharge, velocity, gradient and pipe size. The generated tables are based on a friction loss equation known as the Colebrook-White equation. The assumption here is the pipes are flowing full, unpressurised flow conditions.

Colebrook White Formula	$$V = -2\sqrt{2gDS}\log\left(\frac{K_s}{3.7D} + \frac{2.51v}{D\sqrt{2gDS}}\right)$$	V = Average velocity flow (m/s) g = Acceleration due to gravity (9.81 m/s^2) D = Pipe diameter (m) S = hydraulic gradient (pipe slope) (m/m) Ks = Pipe effective roughness (mm) Taken as 0.6 for carrier drains and 1.5 for filter drains v = Kinematic viscosity (m^2/s) Taken as 1.41 x 10-6 may be used for water @ 15 degrees.

When the gradient, effective roughness and flow are known then the size off the pipe required can be determined from the hydraulic flow chart.

Table 5.1 is generated using the above formula and the graphic in Fig 5.1. The effective roughness used is 0.6mm. This table can be used for preliminary sizing.

Preliminary Sizing charts (Capacity in l/s at the various slopes) Ks = 0.6mm										
Slope		**Pipe Diameter (mm)**								
Gradient	**%**	**225**	**300**	**375**	**450**	**525**	**600**	**675**	**750**	**900**
1 in 200	**0.5**	36.6	78.2	141	227.9	341.8	485.5	661.5	872.1	1406.5
1 in 150	**0.667**	42.3	90.4	163.0	263.3	395.0	561.0	764.3	1007.7	1624.9
1 in 125	**0.8**	46.4	99.2	178.7	288.8	433.2	615.2	838.1	1104.9	1781.6
1 in 100	**1**	51.9	111.1	200	323.2	484.7	688.3	937.6	1236	1993
1 in 80	**1.25**	57.5	123.0	221.5	357.9	536.7	762.2	1038.2	1368.5	2206.5
1 in 50	**2**	73.7	157.5	283.5	458	686.8	975.1	1328.2	1750.7	2822.4
1 in 40	**2.5**	82.4	176.2	317.2	512.3	768.2	1090.7	1485.6	1958.1	3156.7
1 in 33	**3**	90.4	193.1	347.6	561.5	841.8	1195.2	1627.9	2145.7	3458.9
1 in 28.57	**3.5**	97.7	208.7	375.6	606.7	909.5	1291.3	1758.7	2318.1	3736.8
1 in 25	**4**	104.4	223.1	401.6	648.7	972.6	1380.8	1880.5	2478.6	3995.5
1 in 22.22	**4.5**	110.8	236.7	426.1	688.2	1031.8	1464.8	1994.9	2629.4	4238.4

Table 5.1 Preliminary Pipe Sizing

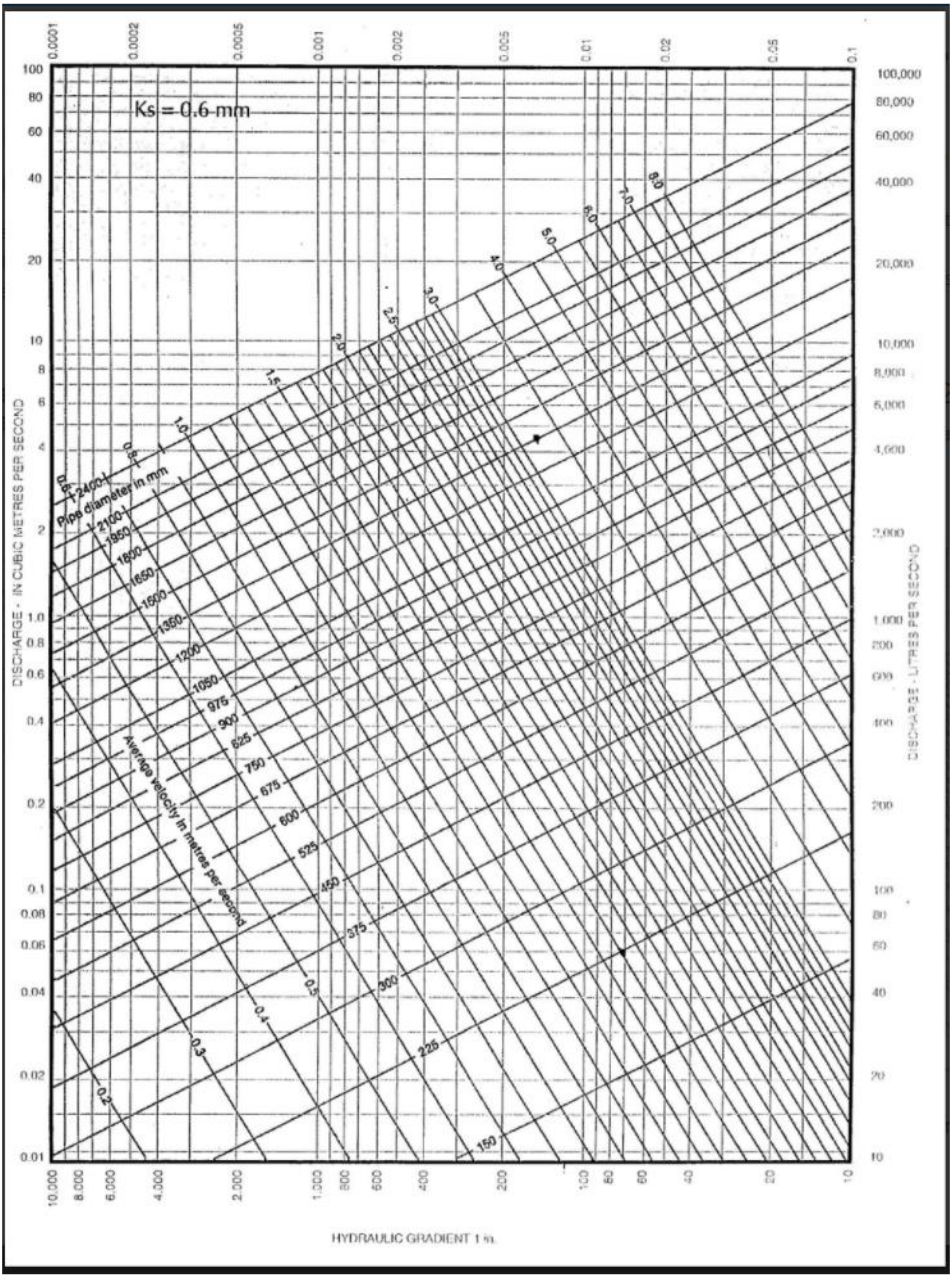


Figure 5.1 HR Wallingford hydraulic capacity table for Ks 0.6mm

5.4.2 Manning's Equation

Manning's equation can also be used for sizing of pipe conduits assumed to be flowing full and not under pressure.

Mannings Equation	$V = \dfrac{R^{2/3}\ x\ S^{0.5}}{n}$	V = Velocity (m/s) R = Hydraulic radius (m) S = Energy slope (m/m) n = Manning's roughness coefficient.
Hydraulic Radius	$R = \dfrac{A}{P}$	A = Cross-sectional area (C.S.A) of flow. (m^2) P =Wetted perimeter (m)
Discharge Flow	$Q = AV$	V = Velocity A = C.S.A (m^2)

Manning's roughness coefficient "n" is required for the equation. Table 5.2 provides a range of values.

Material	***Manning's Roughness Coefficient n***
Concrete	0.012 - 0.016
Polyvinyl Chloride PVC - with smooth inner walls	0.09 - 0.011
Polyethylene PE - Corrugated with corrugated inner walls	0.018 - 0.025
Grassed Channel	0.035 – 0.050

Table 5.2 Roughness Coefficient

The following example shows how Manning's equation can be used for pipeline design.

Design Calculation

Calculation of Pipe Sizes Required to Cater for Run-Off from a typical length of road.

Site Information

The road runs on a low embankment at a gradient of 2% and then enters a cutting where the gradient changes to 1% and finally to 0.5%. The Road width is 8.0m, which includes the carriageway width of 7.0m and two hard strips of 0.5m either side. The site information layout is provided in Figure 5.2 below.

The pipe chosen in this example is Concrete with a Manning's Roughness Coefficient *n* of 0.014. If a different pipe material is chosen, then the value for *n* will also change.

Design Procedure

- Divide the pipeline into 100m lengths (assumed distance between manholes). Give each length a classification number starting at the beginning, 1.1, 1.2,1.3,1.4 etc. See column 1 of Table 5.3.
- The smallest pipe size as recommended in this document is 225mm so this is adopted as the minimum size to avoid silting up of the pipe.
- Assuming the size of the pipe (column 5) and knowing the gradient (column 4), calculate the flow area (column 6), perimeter (column 7) and hydraulic radius (column 8)

- Calculate velocity using Manning's Equation (column 9). For simplicity the velocity of flow in the pipe is assumed to be the velocity corresponding to pipe flowing full.
- You can then calculate the discharge flow (column 10) for that pipe section once you have the velocity calculated

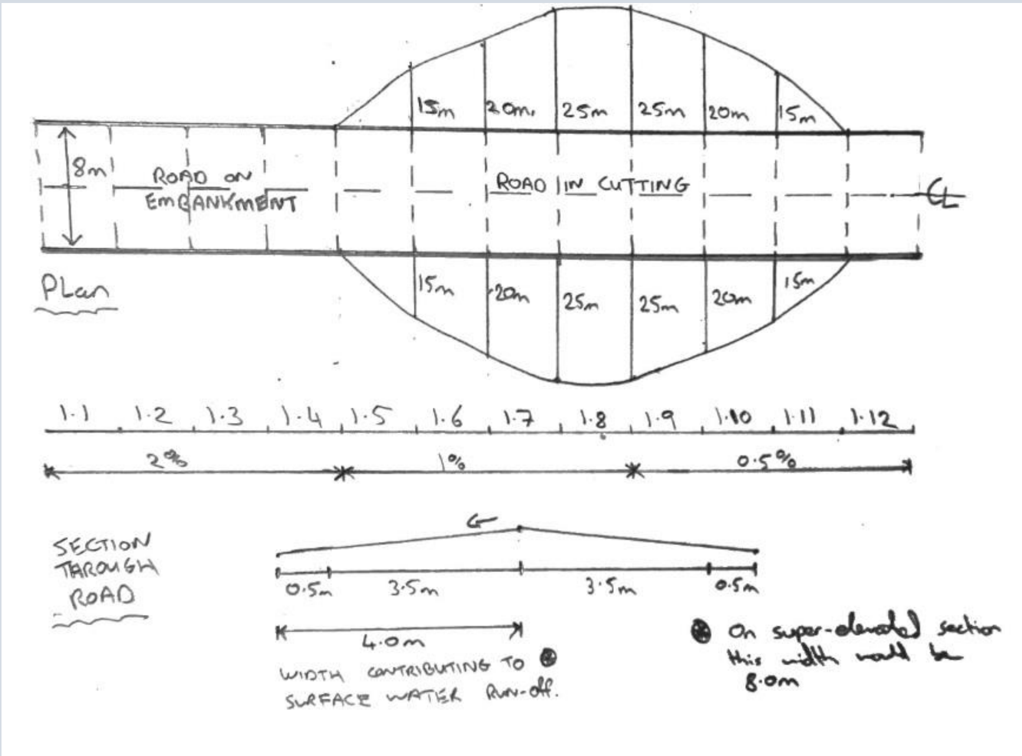


Figure 5.2 Site Information Layout for Pipe Sizing.

1. Length No.	2. Difference in Level (m)	3. Pipe Length (m)	4. Pipe Gradient (%)	5. Assumed Diameter (m)	6. Flow Area of pipe (m^2)	7. Perimeter (m)	8. Hyd. Radius (m)	9. Velocity (m/s)	10. Discharge Flow (l/s)
1.1	2.0	100.00	0.020	0.225	0.040	0.707	0.056	1.512	60.11
1.2	2.0	100.00	0.020	0.225	0.040	0.707	0.056	1.512	60.11
1.3	2.0	100.00	0.020	0.225	0.040	0.707	0.056	1.512	60.11
1.4	2.0	100.00	0.020	0.225	0.040	0.707	0.056	1.512	60.11
1.5	1.0	100.00	0.010	0.225	0.040	0.707	0.056	1.069	42.51
1.6	1.0	100.00	0.010	0.225	0.040	0.707	0.056	1.069	42.51
1.7	1.0	100.00	0.010	0.300	0.071	0.943	0.075	1.292	91.37
1.8	1.0	100.00	0.010	0.300	0.071	0.943	0.075	1.292	91.37
1.9	0.5	100.00	0.005	0.375	0.110	1.178	0.094	1.059	116.97
1.1	0.5	100.00	0.005	0.375	0.110	1.178	0.094	1.059	116.97
1.11	0.5	100.00	0.005	0.375	0.110	1.178	0.094	1.059	116.97
1.12	0.5	100.00	0.005	0.375	0.110	1.178	0.094	1.059	116.97

Table 5.3 Design Table for Pipe Sizing.

5.5 Green field Runoff Rate

Initial estimates of runoff rates from an area can be made using the Wallingford Procedures 'Modified Rational' approach.

To determine the quantity of run-off to be disposed of, the Rational formula is used.

Determined the Green field run off is an important part in the design of any of the drainage types. In this document we concentrate on three different methods:

- Rational
- IH124
- ADAS

The following section explains each of the formula.

5.5.1 Rational Method.

The rational method is a simple empirical procedure to determine runoffs from small catchments.

Rational Method	$Q = C\ i\ A$	Q = runoff in l/s C = runoff coefficient is regarded as a combination of two separate coefficients C = CvCr i = rainfall intensity (mm/hr) during the design storm of duration A = area of catchment upstream of the point being considered (hectares)
Simplified Rational Method	$Qp = \frac{Ap\ x\ i}{360} = 2.78Ap\ x\ i$	Qp = runoff in m^3/s Ap = impermeable area to be drained (hectares) i = rainfall intensity (mm/hr) during the design storm of duration
Time of Concentration Tc	$T_c = T_e + T_t$	Te = time of entry - time taken for runoff to travel overland from properties, roofs, down pipes, etc, to the 'point of entry' at the road channels Tt = time of flow - length of time to travel in the pipe length under consideration.

This formula can be used for pipe sizes up to but not exceeding 600mm diameter to determine the peak run-off. An advantage of this method is it does not require computer software and it remains a valid procedure for design sizing of small pipe drainage systems.

This approach to rainfall intensity is applicable where sufficient data in the form of rainfall records, giving frequencies and intensities of storms over varying return periods are available at a particular location.

The rainfall intensity is available for download from Flood Studies Update portal and also from Met Éireann website as outlined in Section 5.7

An effective approach to determine the rainfall intensity for a given location in this country can be based on the graphic representation of the intensity segments of Ireland as included in Section 5.7

The coefficient C is equal to $Cv.Cr$ where:

- Cv is the volumetric runoff coefficient; and
- Cr is a dimensionless routing coefficient.

The value of Cv ranges from 0.6 on catchments with rapidly draining soils to about 0.9 on catchment with heavy soils. We use the value of 0.9 in our design example.

The coefficient of Cr is recommended to be a constant value of 1.3.

The time of concentration T_c is obtained by adding together the time of entry T_e and the time of flow T_t for a particular length of pipe. The time of entry for Ireland is taken as 3 minutes which would appear to be adequate.

The time of flow will depend on the velocity of flow and this in turn depends on the size, gradient and roughness of the pipe. The time of flow (length of time to travel in the pipe length under consideration) is calculated from full pipe velocity.

Using the example in section 5.4.2 we can develop the following:

Design Calculation

Calculate the pipe segment run-off in l/s using the Rational Method for the site information in Figure 5.2

Design Procedure

- Use the information already calculated in Table 5.3. From that table we will use the length no. (column 1) assumed diameter (column 5), the calculated discharge flow (column 10)
- In this example we are using the Rational Method Q= Cv.Cr.i A.
- The intensity for the site can be determined from the map provided in Section 5.7or via the OPW Hydronet Portal. The rainfall intensity from the chosen site was 40mm/hr (column 11). We increased the intensity by the 20% factor for climate change (column 12).
- Calculate the areas drained by each of the pipeline lengths. In this example the paved area contributing consists of half the carriageway plus the hard strip. Where the road runs in the cutting, 70% of the plan area is deemed to contribute to the flow in the pipe. Ensure the cumulative total area in recorded. (columns 13 i to iv))
- Calculate the run-off by Q = 0.9.1.3.(column 12).(column13(iv))
- The calculated Q in column 14 can then be checked against the Q value in column 10. The pipe sizes chosen, have sufficient capacity to cater for the run-off.

1. Length No.	5. Assumed Diameter (m)	10. Discharge Flow (l/s)	11. Rain Intensity (mm/hr)	12. Rain Intensity * Climate Change %	13. Impermeable Area (m^2)				14. Rational Formula (l/s)
					(i) Area Paved	(ii) .Area Cuttings	(iii). Total	(iv) Cumulative	
1.1	0.225	60.11	40.00	48.00	400.00	0.00	400.00	400.00	2.25
1.2	0.225	60.11	40.00	48.00	400.00	0.00	400.00	800.00	4.49
1.3	0.225	60.11	40.00	48.00	400.00	0.00	400.00	1200.00	6.74
1.4	0.225	60.11	40.00	48.00	400.00	0.00	400.00	1600.00	8.99
1.5	0.225	42.51	40.00	48.00	400.00	525.00	925.00	2525.00	14.18
1.6	0.225	42.51	40.00	48.00	400.00	1225.00	1625.00	4150.00	23.31
1.7	0.300	91.37	40.00	48.00	400.00	1575.00	1975.00	6125.00	34.40
1.8	0.300	91.37	40.00	48.00	400.00	1750.00	2150.00	8275.00	46.47
1.9	0.400	138.87	40.00	48.00	400.00	1575.00	1975.00	10250.00	57.56
1.1	0.375	116.97	40.00	48.00	400.00	1225.00	1625.00	11875.00	66.69
1.11	0.375	116.97	40.00	48.00	400.00	525.00	925.00	12800.00	71.88
1.12	0.375	116.97	40.00	48.00	400.00	0.00	400.00	13200.00	74.13

Table 5.4 Run-Off calculation for pipe segments Design Table for Pipe Sizing.

5.5.2 IH124 Method

The IH124 formula can also be used to determine the greenfield run off. For bigger catchments this would be the most common formula used. It is important to note that this method is most suited to catchments of 50 hectares or more.

IH124 Method	$QBAR = 0.00108 Area^{0.89} x SAAR^{1.17} x\ SOIL^{2.17}$	QBAR = mean annual flood m^3/s Area = Catchment area km^2 SAAR = standard average annual rainfall in mm) SOIL = Soil index
SOIL	$SOIL = \frac{(0.10S1 + 0.30S2 + 0.37S3 + 0.4S4 + 0.53S5)}{(S1 + S2 + S3 + S4 + S5)}$	S1 to S5 = Proportion of the catchment covered by each soil class.

The following table provide the soil index values for each of the five soil classes.

Soil Class	S1	S2	S3	S4	S5
Soil Index	0.1	0.3	0.37	0.47	0.53
Note: S1 to S5 is the soil type based on the runoff potential. S1 has a low runoff value and S5 has a very high runoff potential					

Table 5.5 Soil Class and Index values

The value of QBAR mean annual flood can then be multiplied by an appropriate regional flood frequency growth factor to give the appropriate discharge rates for various return periods. See table 5.6.

Return Period	1	2	5	10	25	50	100	200
Growth Factor	0.87	0.96	1.20	1.37	1.60	1.77	1.96	2.14

Table 5.6 Growth Curve Factors applied to QBAR for various Return Periods

To use this method for smaller catchments the recommended procedure is to adopt a catchment area of 50 ha and then apply a factorial correction for catchment sizes e.g. if the catchment size is 10 ha then the QBAR is then divided by 5. In order to calculate the permitted discharge rate from a particular point or catchment area, the QBAR is calculated and then factored for the appropriate storm return period.

5.5.3 ADAS Method

The ADAS (Ministry of Agriculture and Food) method was developed for small scale catchments and the design of field drainage pipe systems and as such could be suitable for road scale. There are many variations of the formula, but the most suitable method is the ADAS 1982 publication (MAAF Ref 345 1982). The procedure is described in detail in the publication.

The information required for the calculation includes:

- Area of the catchment in Ha.;
- Max length of catchment in metres;
- Average slope (1:100 flat, 1:20 average);
- Average Annual Rainfall;
- Crop type (grass);
- Soil factor (based on permeability);

ADAS Method	$Q = S_T F A$	Q = 1 yr peak flow l/s S_T = soil factor, values between 0.1 and 1.3 F = function of catchment characteristics such as slope, drainage length, rainfall. A = Area (ha)

Similar modified growth curve factors as used for IH 124 are used to take account of the fact that the peak flow value Q generated are for an return period of 1 year. These growth curve values as per Table 5.6 when applied achieve the design return period, e.g 1:50, 1:100.

5.6 Drainage Types Design Principles

5.6.1 Piped System

The spacing of the collection points as part of a piped system is a critical element to the success of the drainage type. This is generally dictated by the longitudinal road gradient, cross sectional profile and the road width.

The following items for consideration when designing piped system:

- Longitudinal gradient;
- The cross-fall;
- The Manning roughness coefficient;
- The grating type for the drainage type, or the size and angle of kerb inlet;
- No flow shall bypass a terminal collection point;
- The overall hydraulic capacity of a system of road gratings and kerb inlets shall capture any water that by-passes any single grating in the system.
- Gratings shall comply with the requirements outlined in BS EN 124.

5.6.2 Filter Drains

Filter drains are a drainage type that deal with surface and sub-surface water ingress. Filter drains will remove any water which may penetrate the road pavement layers in both the cut and fill situations.

It is important that an assessment is undertaken to determine if the need for sub-surface drainage is required. The first step in analysing if sub-surface drainage is required is a site survey. Data from the site investigation for the road improvement or road design scheme would be sufficient to develop the detailed design.

Filter drains offer temporary storage of surface runoff prior to infiltration to groundwater or conveyance via a perforated pipe.

If these systems are to be used for infiltration, the base of the drain must be above the groundwater table. These filter drains are not designed to function as sediment traps. The top layer will have to be regularly removed as the filter drain will become clogged. his can be achieved using a geotextile separator. This enables the top layer to be removed for cleaning or replacement.

The storage volume is determined on voids ratio of the filler material. Infiltration rate of the surrounding soils must be determined if infiltration is required.

The following items for consideration when designing filter drains:

- Location on the roadside edge or median strip;
- Allow for maintenance and repair situations;
- Classify the soil type and thickness of strata;
- Determine the water table level;
- Determine the catchment area, natural drainage of adjoining lands, existing drainage ditches and land drains;
- Trench dimensions shall be determined by the level of reduction and attenuation of flows required;
- A pre-treatment device such as a filter strip should be included to increase the longevity of the system;
- Constructed above groundwater levels and where groundwater classification allows;
- Designed for 1:30 year storm event;
- Minimum distance from property should be 3 times depth of trench;
- Crushed rock as a surface layer will minimise the likelihood of stones being scattered on the carriageway in the event of a vehicle leaving the road; and
- Can be used in the base of swales to provide additional attenuation.

5.6.3 Soakaways

In some locations, difficulties can sometimes be experienced in finding a convenient outfall to which a roadway can be drained. In such circumstances it may be possible, if the subsoil conditions are appropriate, to dispose of run-off water to a soakaway. Soakaways collect all surface water run-off into one point before allowing it to percolate in a controlled manner into the surrounding ground/earth in the area where it falls. The ability of a soakaway to perform satisfactorily depends on its size and the nature of the soil in which it is built.

Soakaways should only be used in free-draining granular soils such as gravel or sand. Soakaway design is covered in BRE Digest 365. The Digest also describes detailed design and construction procedures and gives design examples.

The use of soakaways to drain large paved areas are not an attractive option and it is recommended that all efforts should be made to dispose of surface water to the nearest watercourse rather than to use soakaways.

The following items for consideration when designing soakaways and infiltration trenches:

- Ensure ground strata is suitable for a soakaway by carrying out a percolation test;
- Recommended to be located a minimum of 5m from buildings or roads;
- The soakaway should store the required runoff for the allowable storm duration;
- The inclusion of an overflow or outlet for storm events should be assessed;
- Existing ground water levels of the area should be known;
- Site constraints need to be known to ensure sufficient surface area;
- Granular fill material used shall be free of fine particles;
- Suitable geo-textile material to prevent contamination of the fill material;
- The required storage volume is inflow minus outflow can be checked for a range of return periods to determine maximum storage required; and
- The slope of area to be drained will determine the speed of water flow into the soakaway.

5.6.4 Drainage Materials

The drainage materials when specified in the standard details in section 6 relate to Series 500 of the TII publications. LA should use materials that are in compliance with the TII standards when undertaking drainage works.

5.7 Rainfall Intensities

The intensity of rainfall can be determined from rainfall records or by assuming values found to be adequate from experience. The Rational approach to rainfall intensity has been applicable where sufficient data in the form of rainfall records, giving frequencies and intensities of storms are available for a particular location.

Rainfall intensity for a given location can be determined from a point location on the FSU portal at the link below. This information is developed using a Depth Duration Frequency Model (DDF Model)

https://opw.hydronet.com/

The process for obtaining this information is explained in Figure 5.4.

Met Éireann provides a facility where information will be circulated to the designer once a submission has been made with the required co-ordinates. The submission of point data can be done on the following link.

https://www.met.ie/climate/services/rainfall-return-periods

In the Rational approach to drainage design the rainfall intensity value is required. The graphic in figure 5.3 provides a map of Ireland for the return period of 1:100 and for a 1 hour duration. This data is based on a study conducted for Flood Studies Update (FSU) Programme and Met Éireann, using funding provided by the Office of Public Works (OPW), developed a DDF model, allowing the estimation of point rainfall intensities for a range of durations for any location in Ireland. This information was correlated back to 2021 Met Eireann recorded information from all their weather stations.

These rainfall intensity values can be used for the design of drainage types. The rainfall intensity can be seen to vary depending on your location within Ireland.

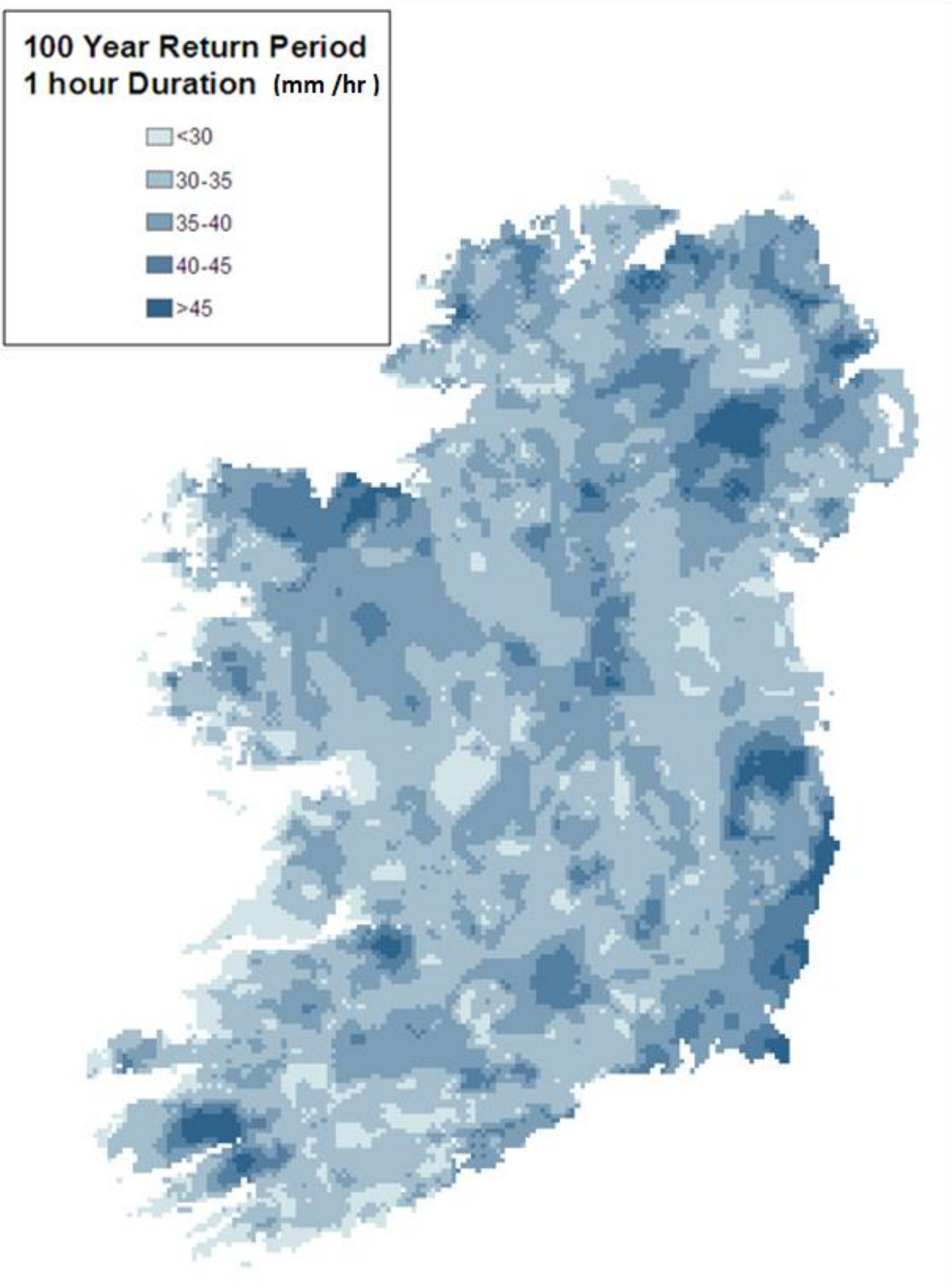


Figure 5.3 100 year Return Period, 1 hour duration

Flood Studies Update (FSU) Process Flow

Step 1

Log onto website https://opw.hydronet.com/ and register an email address and password.

Step 2

Select “Rainfall and Flood Estimation Applications”

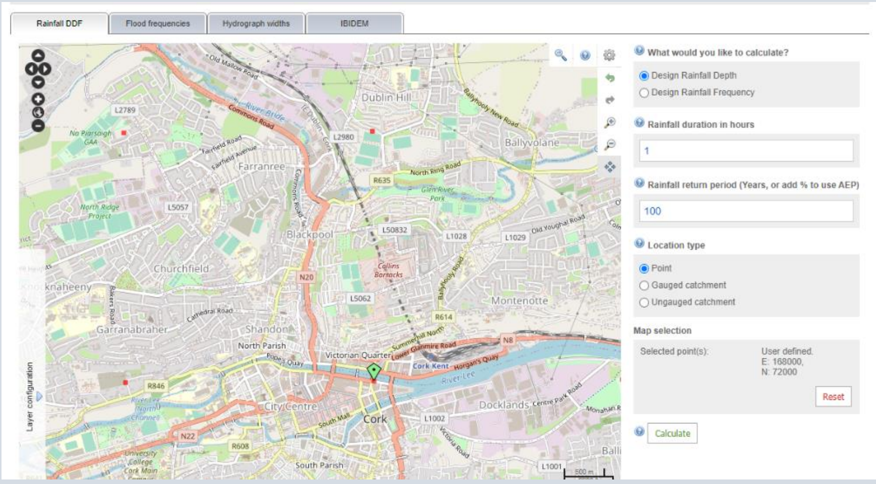
Step 3

Select “Rainfall DDF”

Step 4

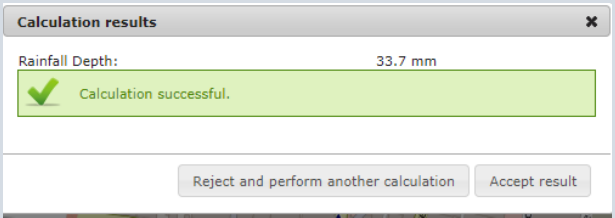
Pick the location on the map of Ireland where you need the data.
For this example, we have selected Cork City Centre. (See image for reference)
Populate the following required information

- Select Design Rainfall Depth
- Rainfall duration of 60 minutes which is 1 hour duration
- Rainfall return period of 1:100 years.
- Location Type Point



Step 5

Press “Calculate” to determine the rainfall depth



Step 6

Convert the rainfall depth to intensity(mm/hr) for use in the design formula. In this example choosing the rainfall duration as 1 hour (60mins) the result in step 5 is equal to the mm/hr. If you had chosen 0.5 hr (30mins) duration, then you would need to convert that value from mm/30mins to mm/hr.

Note

This method can be used for numerous Rainfall Durations and Return Periods

Figure 5.4 FSU Process for Determining Intensities

5.8 Climate Change

Climate change is set to impact greatly on the usage and design of road drainage now and in the future. The main impacts related to climate change vary across the country but include, heavier and more intense rainfall events, flooding and increase in runoff and erosion.

It is predicted that future rainfall events will increase in both intensity and duration. The probability of extreme precipitation is likely, even in areas with projected less mean precipitation.

The key implications of climate change for road maintenance were identified in the report “The Changing Climate”. They are as follows:

- Increased risk of flooding from rivers, seas and inadequate drainage;
- Deterioration and damage to road structures from subsidence, heave and high temperatures;
- Damages to structures from high winds;
- Increased road safety problems as a result of adverse driving conditions and deterioration of infrastructure;
- Effects of management of trees, landscapes and biodiversity;
- Carriageway rutting;
- Embankment subsidence;
- Deterioration of concrete; and
- Reduction in skid resistance.

The trends in climate change indicate increased rainfall in the autumn and winter months will have a significant increase in rainfall and the winter months will have an increase in peak rainfall intensity and frequency in Ireland. The “Climate Status Report for Ireland 2020” published in 2021 provides evidence that the average annual rainfall in Ireland from 1990 to 2019 has increase in the order of 7%

To ensure allowance for the changing climate the design storm rainfall intensities used in the design of the drainage types by designers must be increased by 20%. This increase will allow for the future effects of climate change.

Section B

6. Drainage Rehabilitations

Drainage details used on Regional and Local roads vary across LA. This section aims to provide standard details that can be used to assist LA in the development of their drainage networks.

These details can be used in the improvement of drainage infrastructure and they can also be utilised in the rehabilitation of existing drainage infrastructure.

6.1 Standard Details

General Notes

1. Road Authorities may use these details in the course of the rehabilitation and improvement of their drainage network
2. Road Authorities must ensure that when using these details, that they are sufficient to meet the intended requirement.
3. Site Specific Elements must also be addressed when these details are being used.

6.1.1 GA 1 Over the Edge Drainage

6.1.2 GA 2 Open Drain

6.1.3 GA 3 Verge Removal

6.1.4 GA 4 Filter Drain

6.1.5 GA 5 Urban Swale

6.1.6 GA 6 Rural Swale

6.1.7 GA 7 Precast Concrete Soakaway

6.1.8 GA 8 Granular Soakaway

6.1.9 GA 9 Piped Crossing Shallow

6.1.10 GA 10 Headwall Details

6.1.11 GA 11 Road Crossing Closed system

6.1.12 GA 12 Residential Entrance Detail

6.1.13 GA 13 Agricultural Entrance Detail

6.1.14 GA 14 Field Inlet

6.1.15 GA 15 Gulley Detail

6.1.16 GA 16 Rural Road Gulley Detail

6.1.17 GA 17 Concrete Channel Detail

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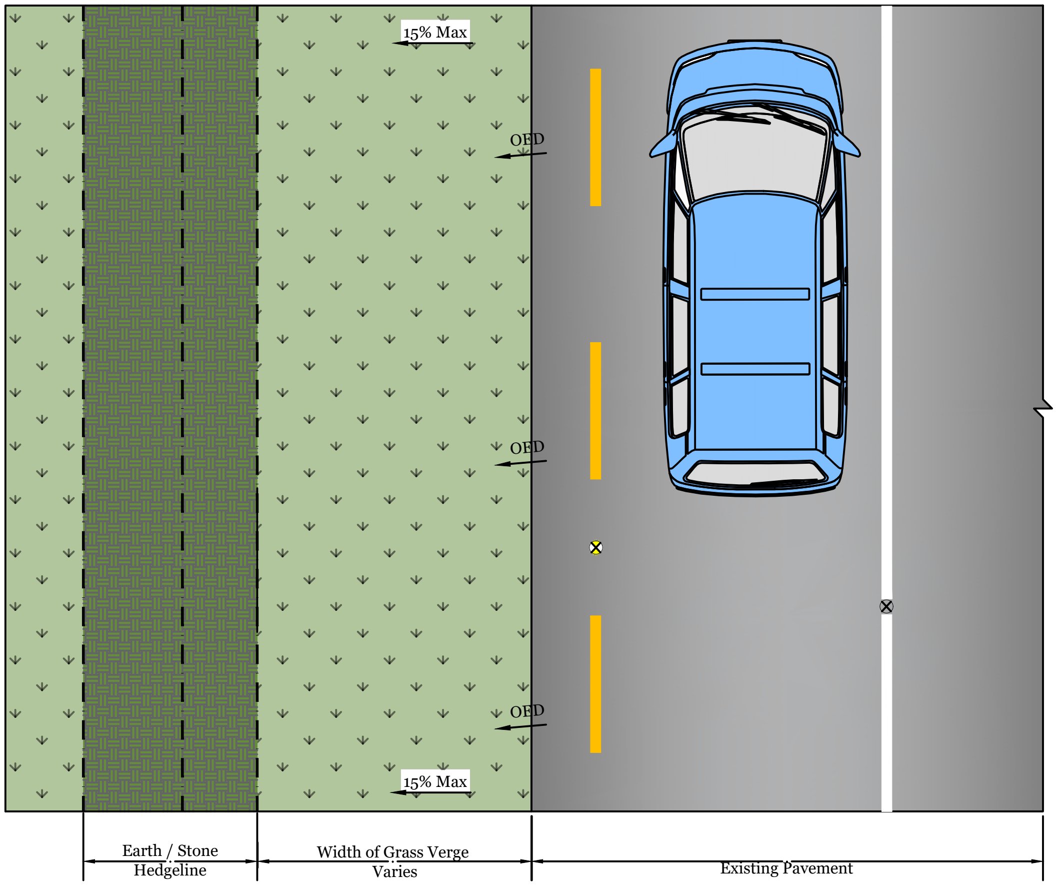
GENERAL ARRANGEMENT DRAWING GA 1

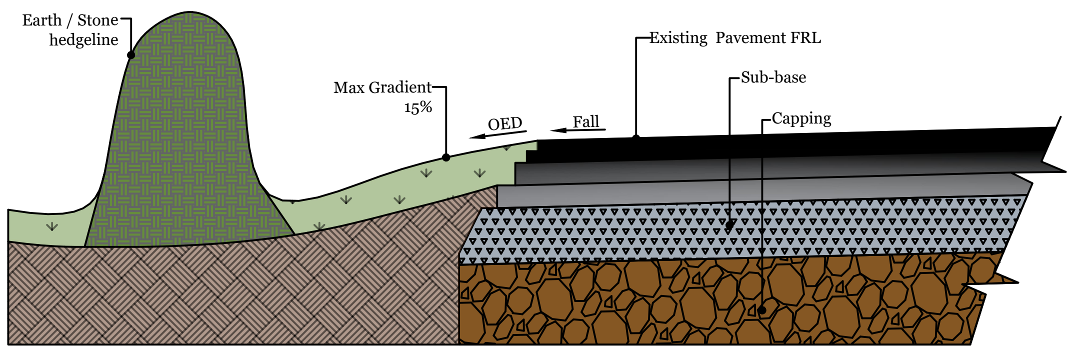
Description Over the Edge Drainage - Verge Reinstatement

NOTES:
1. Do not scale from drawings.
2. Drawings are indicative only.

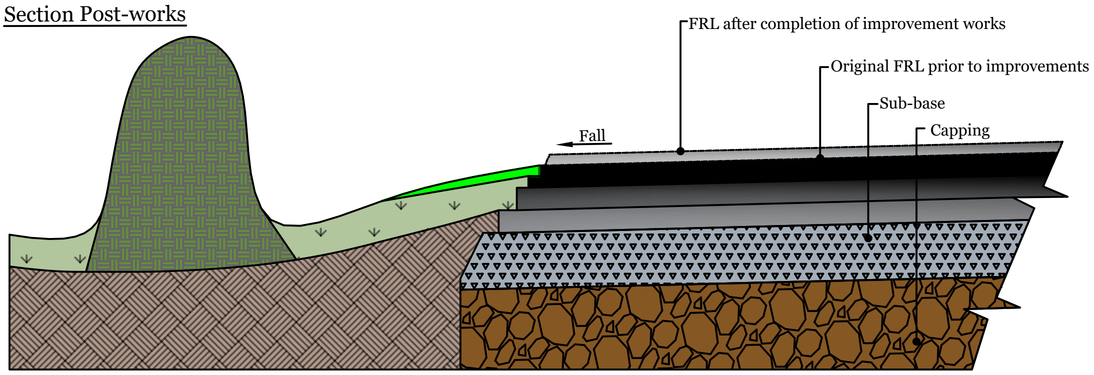
Plan



Section - Pre-works



Section Post-works



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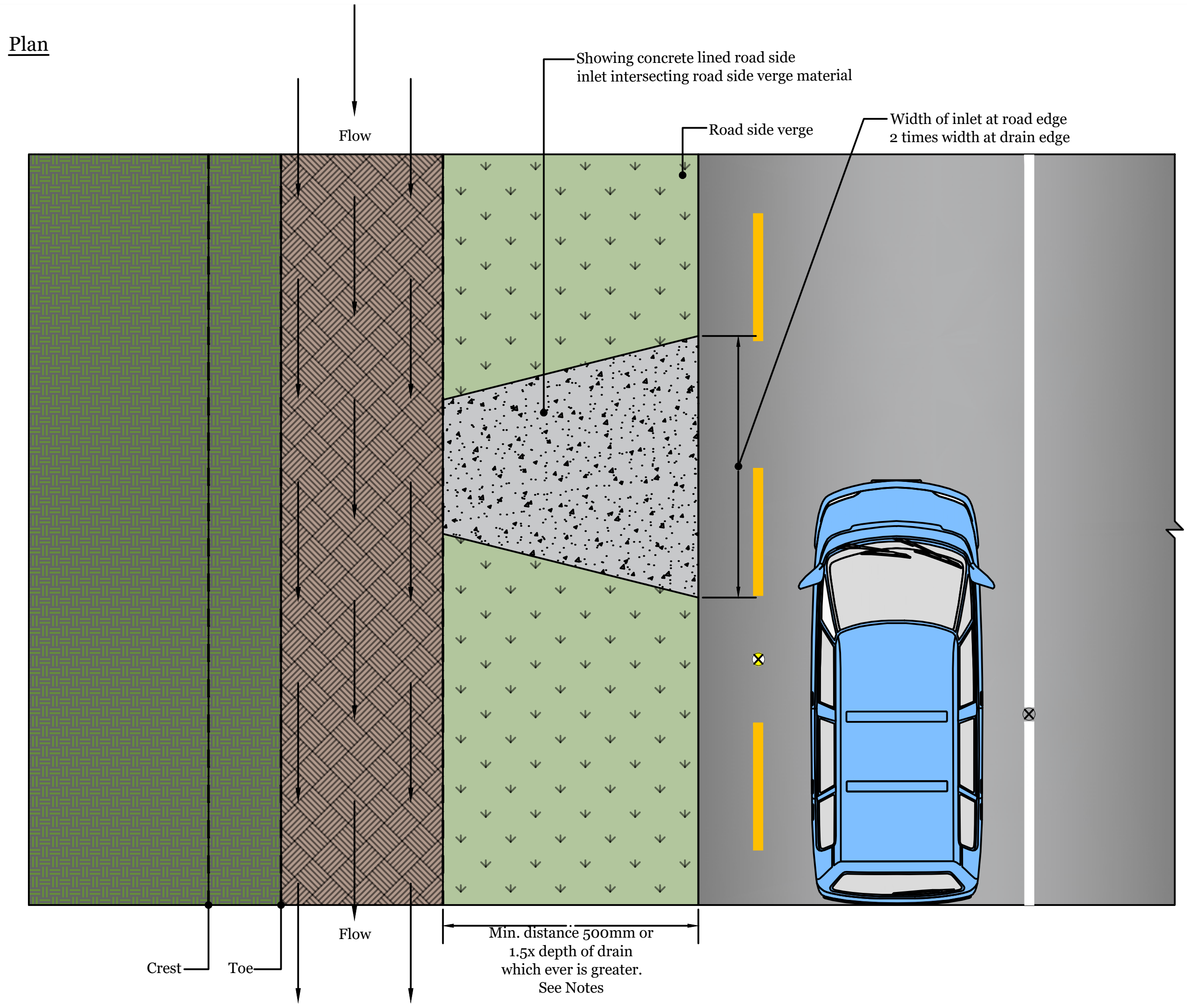
GENERAL ARRANGEMENT DRAWING GA 2

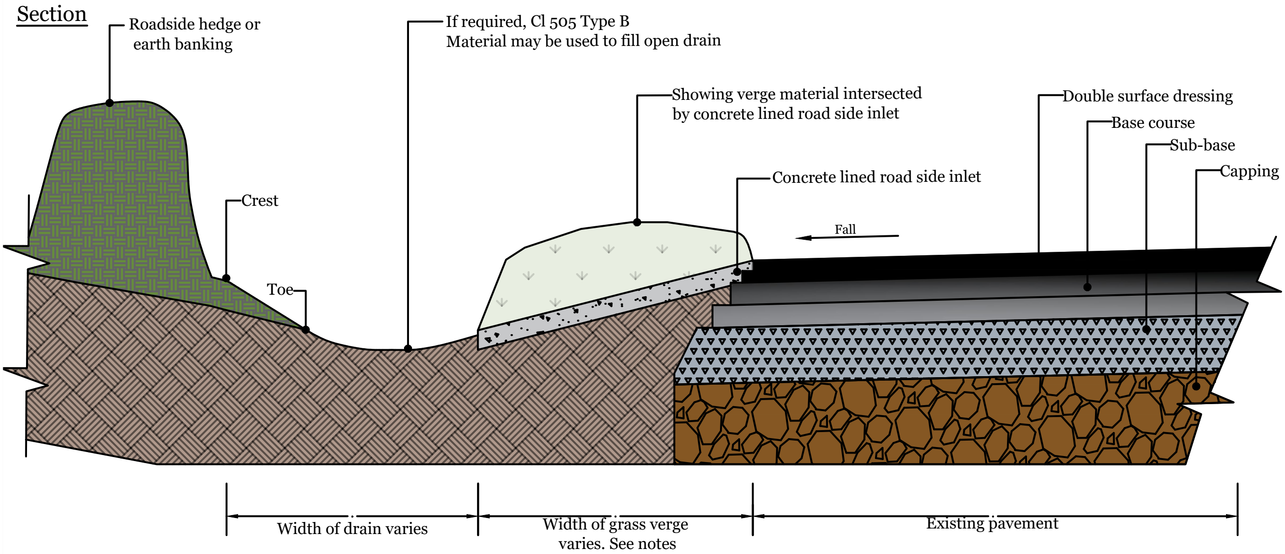
Description Open Drain with inlets at Edge of Carriageway

NOTES:
1. Do not scale from drawings.
2. Drawings are indicative only.
3. Minimum inlet spacing to be 30m.
4. Minimum distance to open drain from pavement edge to be 500mm or 1.5 x ditch depth, whichever is greater.
5. 500mm maybe reduced to 300mm where space is restricted.

Plan



Section



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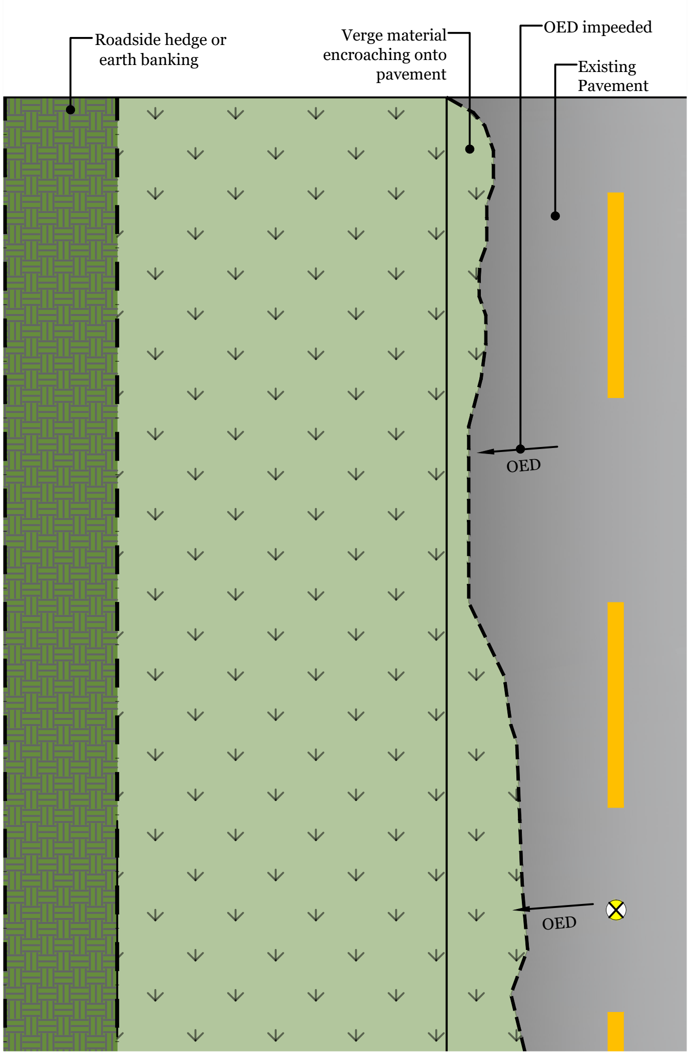
GENERAL ARRANGEMENT DRAWING GA 3

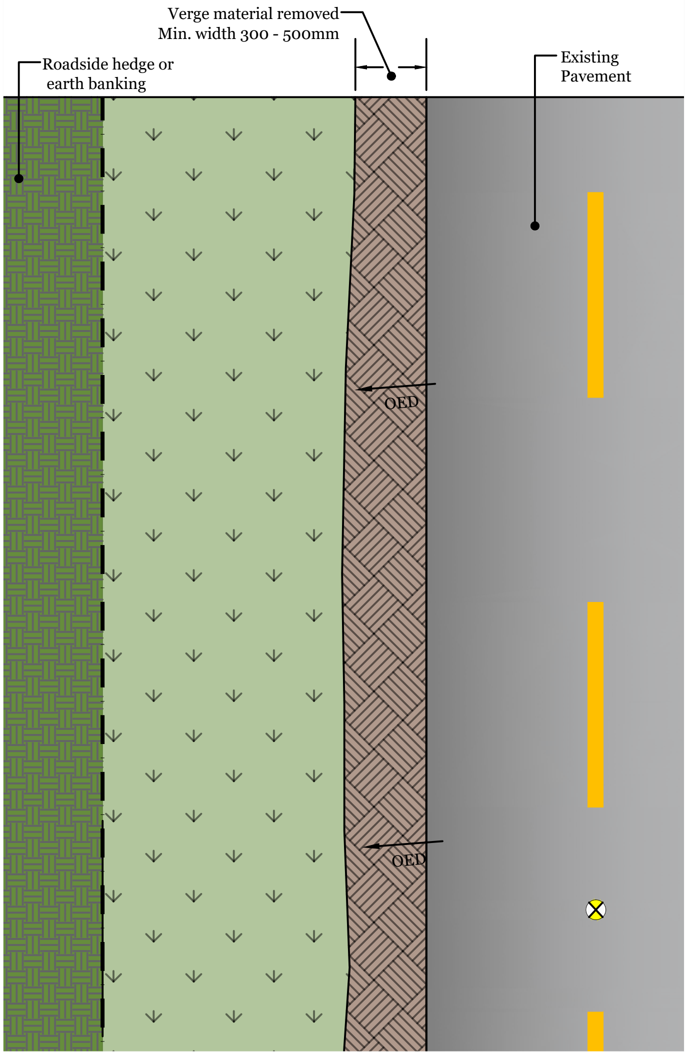
Description Road Verge Removal

NOTES:
1. Do not scale from drawings.
2. Drawings are indicative only.
3. Inlets can be placed at the required intervals along with verge removal.
4. Ensure the verge removal does not damage the road edge material.

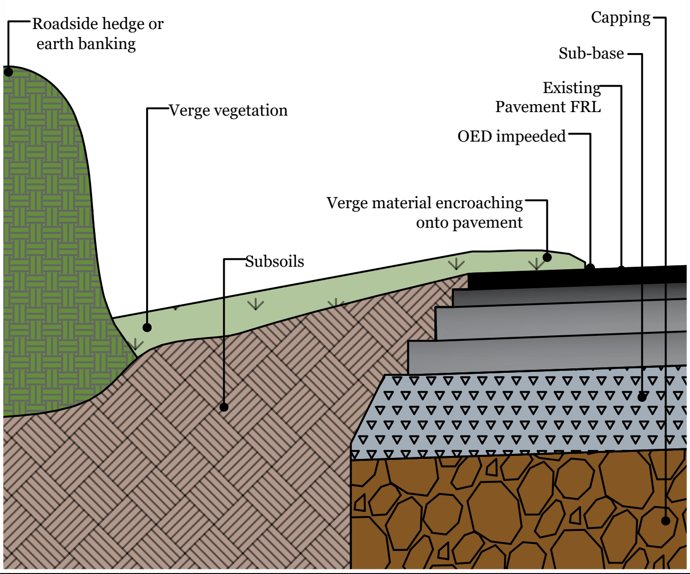
Plan - Showing pre-maintenance works verge condition



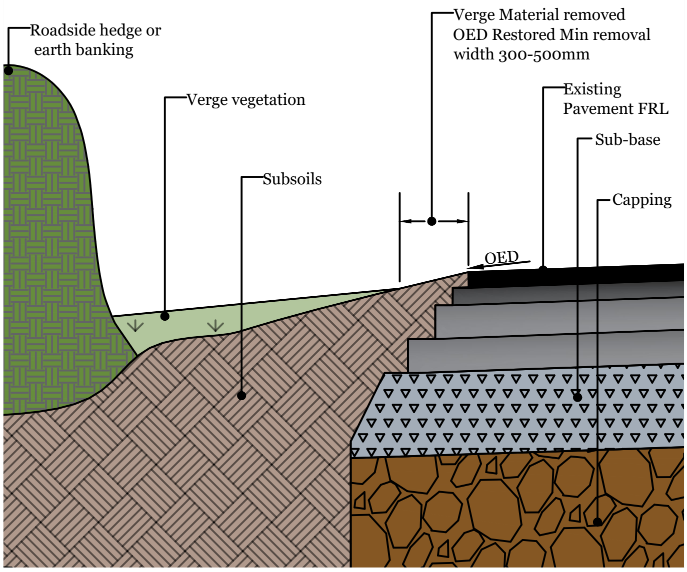
Plan - Showing post-maintenance works verge condition



Section - Showing pre-maintenance works verge condition



Section - Showing post-maintenance works verge condition



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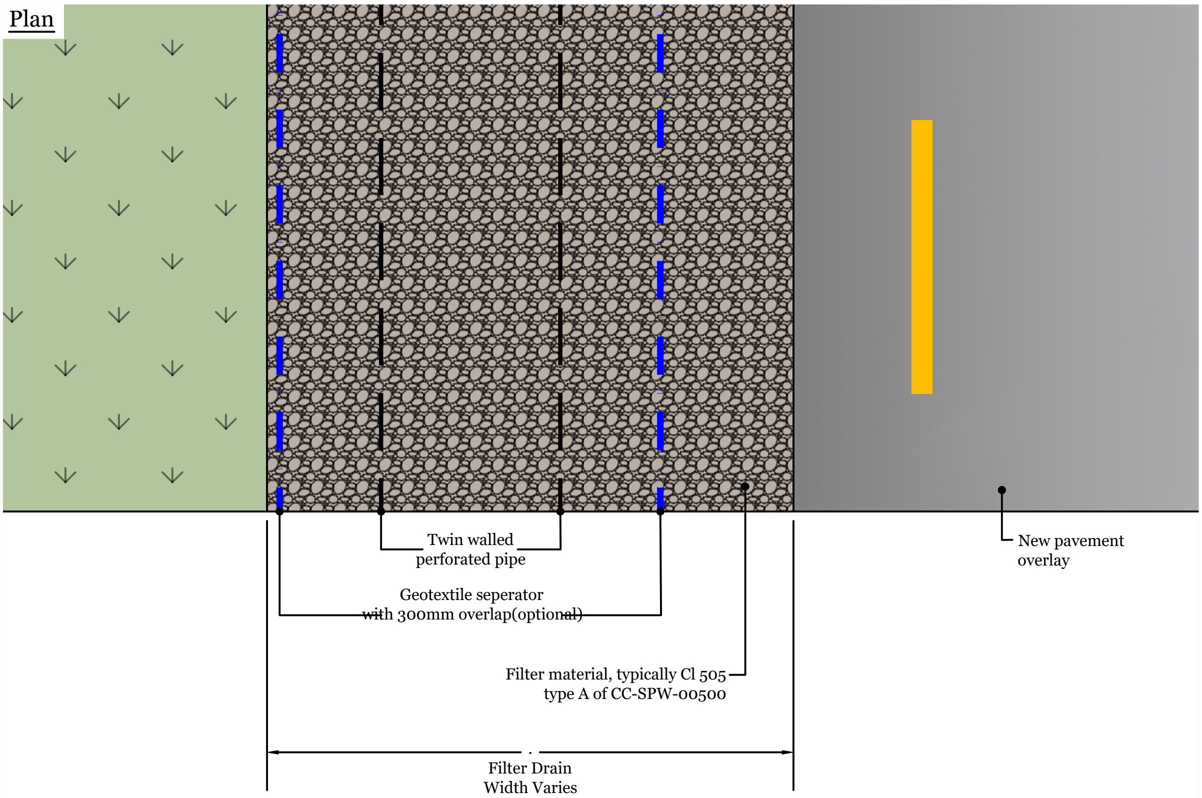
GENERAL ARRANGEMENT DRAWING GA 4

Description Filter drain showing geotextile seperator

NOTES:
1. Do not scale from drawings.
2. Drawings are indicative only.
3. Perforated pipes are to be laid with slots or perforations facing upwards.
4. Filter drains require higher level of maintenance involving surface regeneration.

Plan



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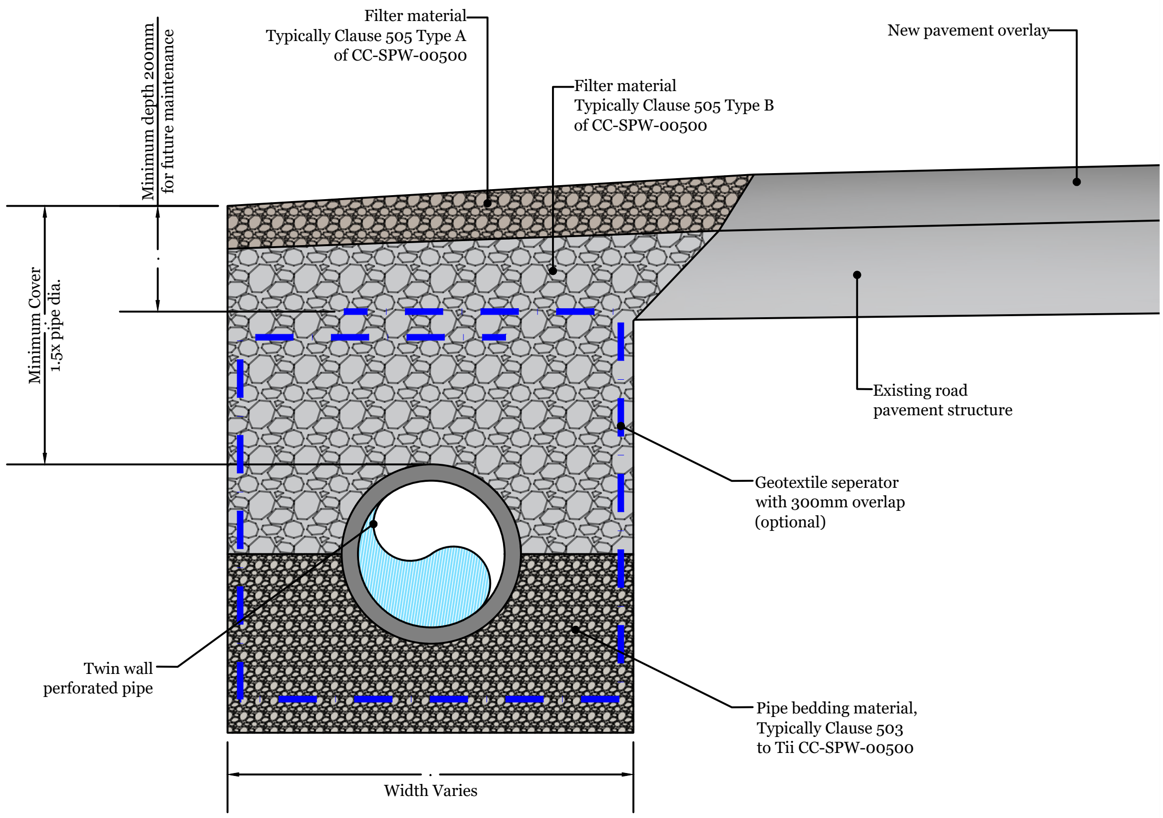

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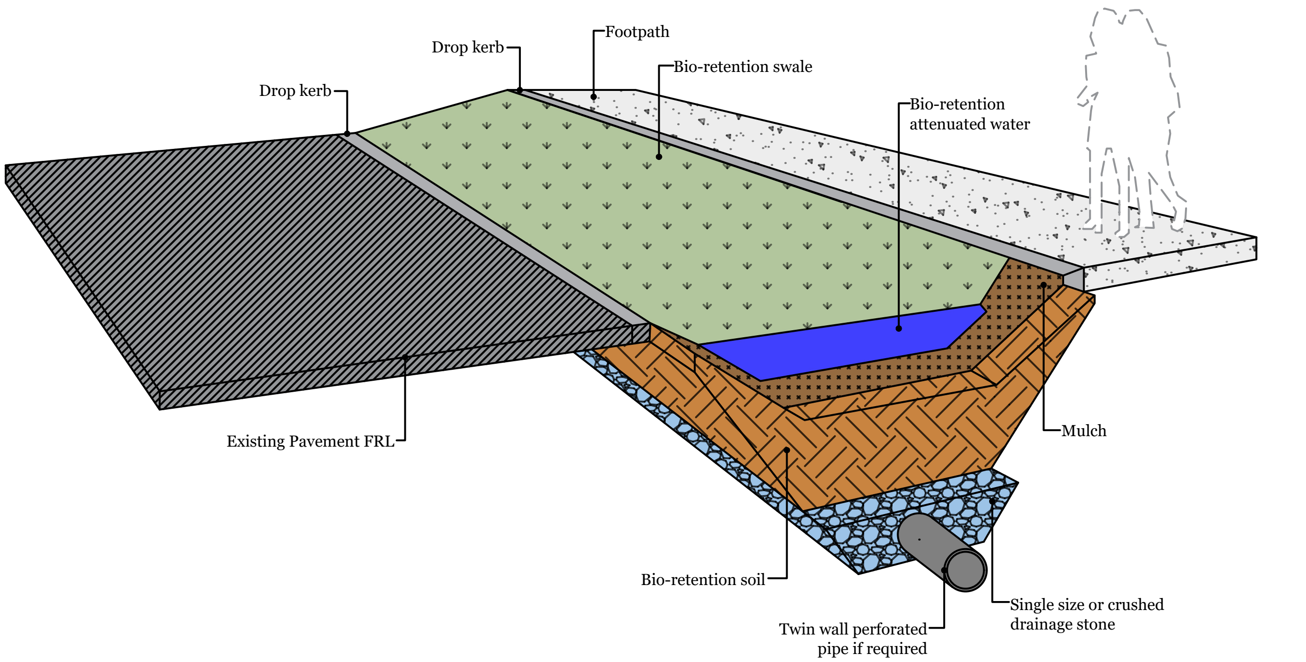
GENERAL ARRANGEMENT DRAWING GA 5

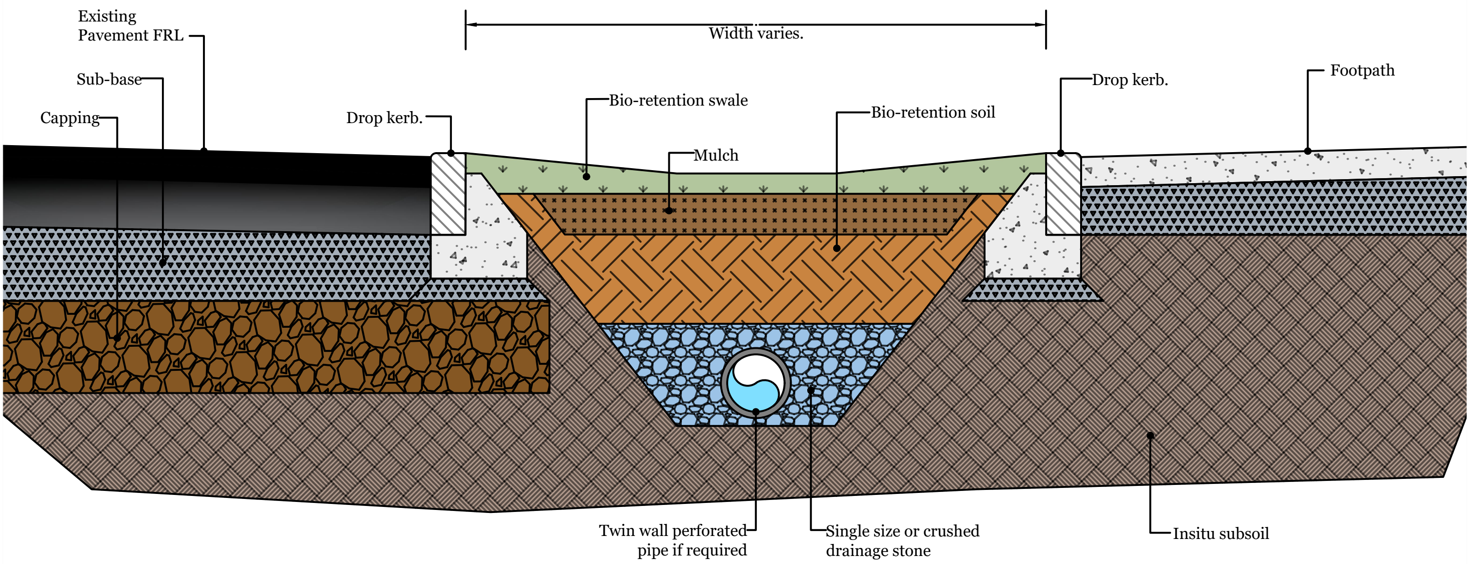
Description Bio-retention Urban Swale

NOTES:
1. Do not scale from drawings.
2. Drawings are indicative only.
3. Perforated pipes are to be laid with slots or perforations facing upwards
4. Approved planting to be undertaken within swale area
5. Regular & annual maintenance required

Plan Isometric View Showing Typical Urban Swale



Section Showing Typical Urban Swale



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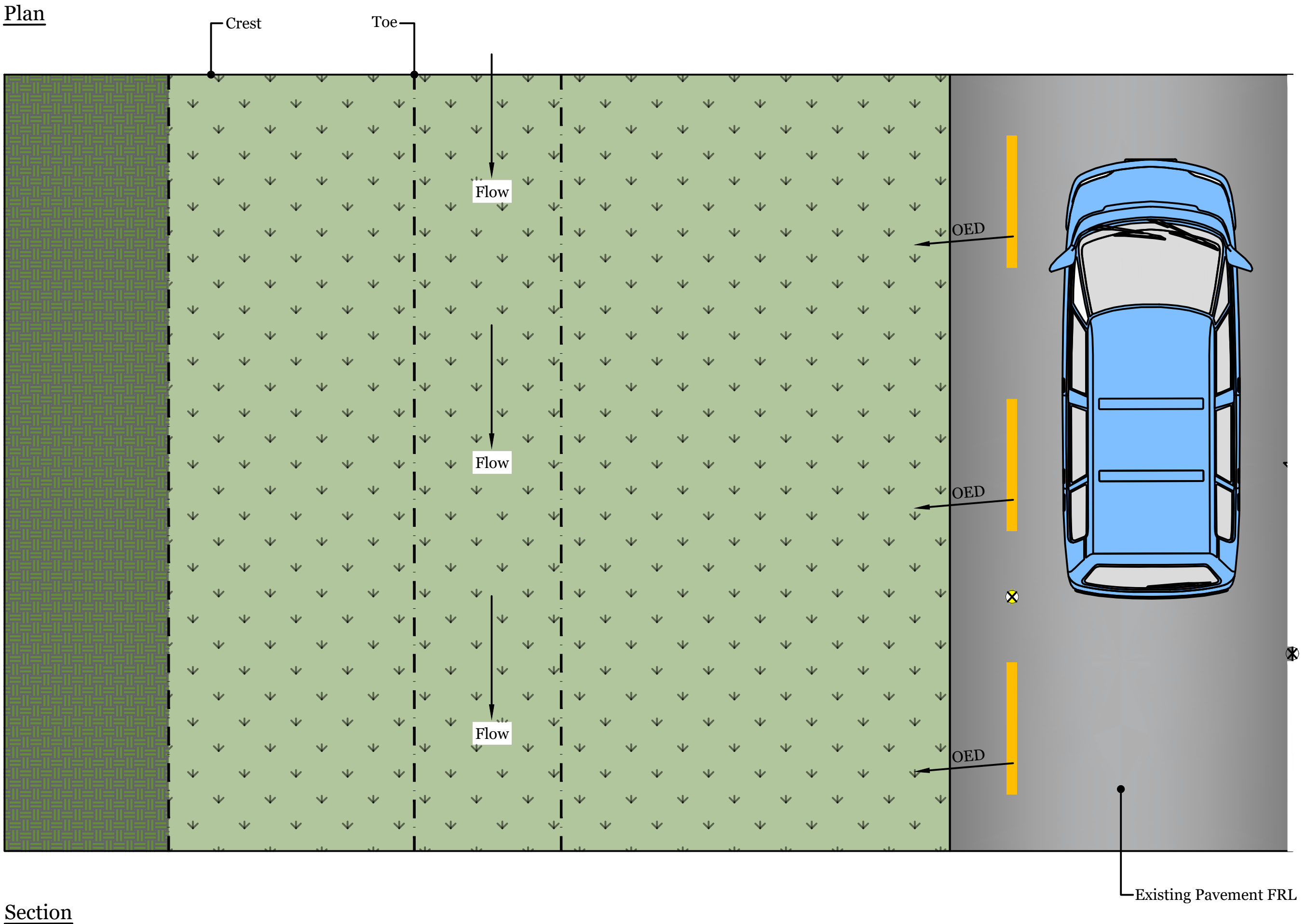
GENERAL ARRANGEMENT DRAWING GA 6

Description Rural Swale

NOTES:
1. Do not scale from drawings.
2. Drawings are indicative only.
3. Edge protection may be provided.
4. Ensure road surface water can flow into swale area via over the edge drainage (OED).

Plan



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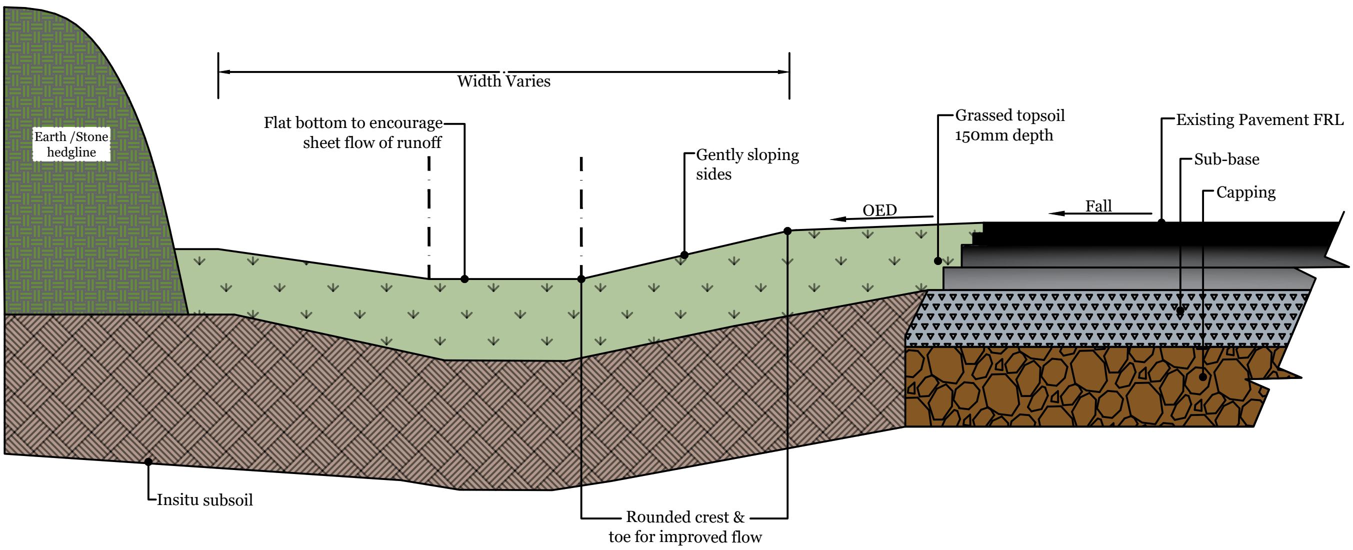

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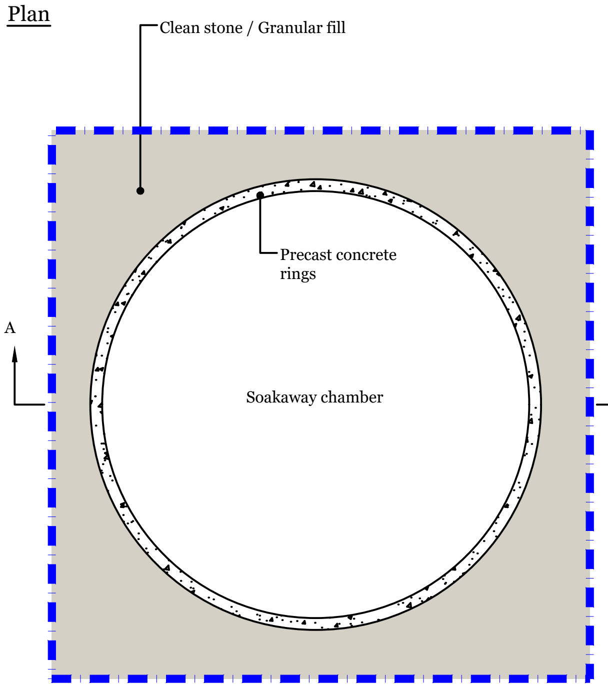
GENERAL ARRANGEMENT DRAWING GA 7

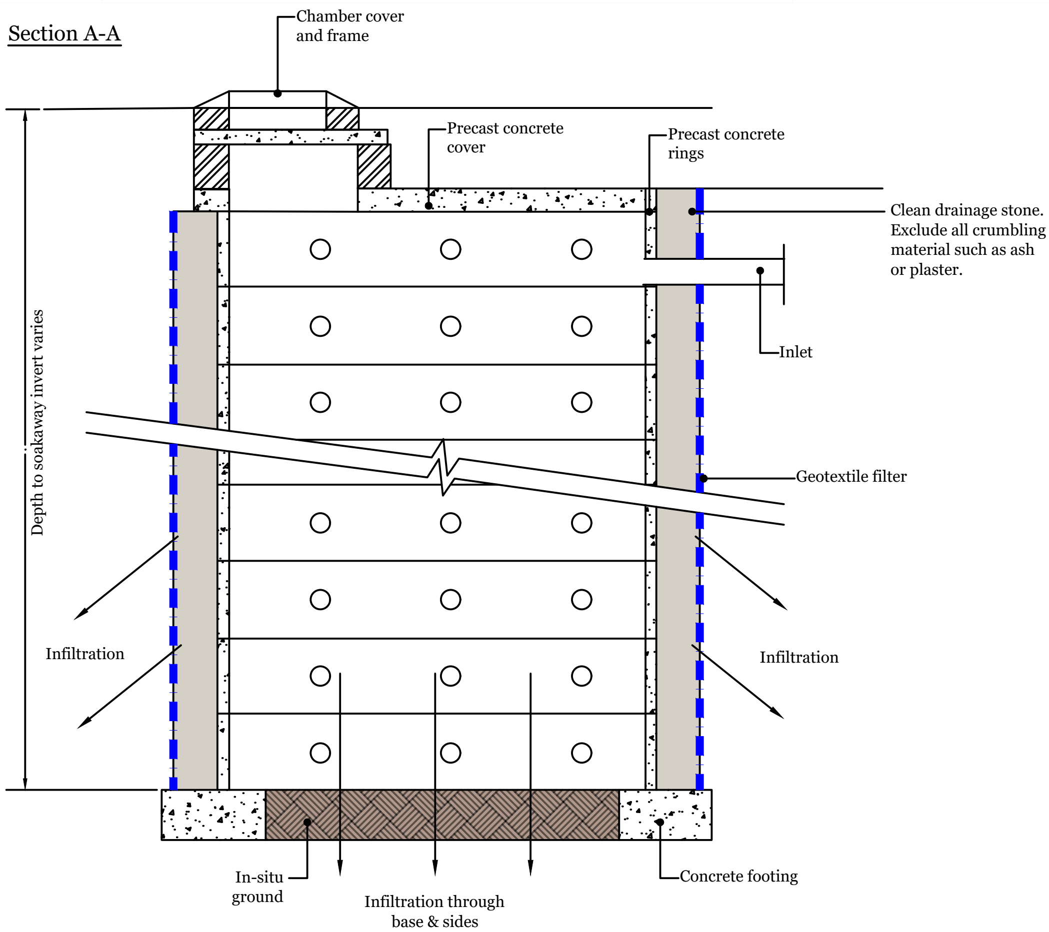
Description Vertical Precast Concrete Ring Soakaway

NOTES:
1. Do not scale from drawings.
2. Drawings are indicative only.
3. Concrete footing may be omitted where constructed in non-live loaded areas and at a minimum a compacted stone base is required.
4. Site specific requirements may require an overflow pipe
5. Ensure site & soil suitability for soakaways, reference BRE Digest - Soakaway Design.

Plan



Section A-A



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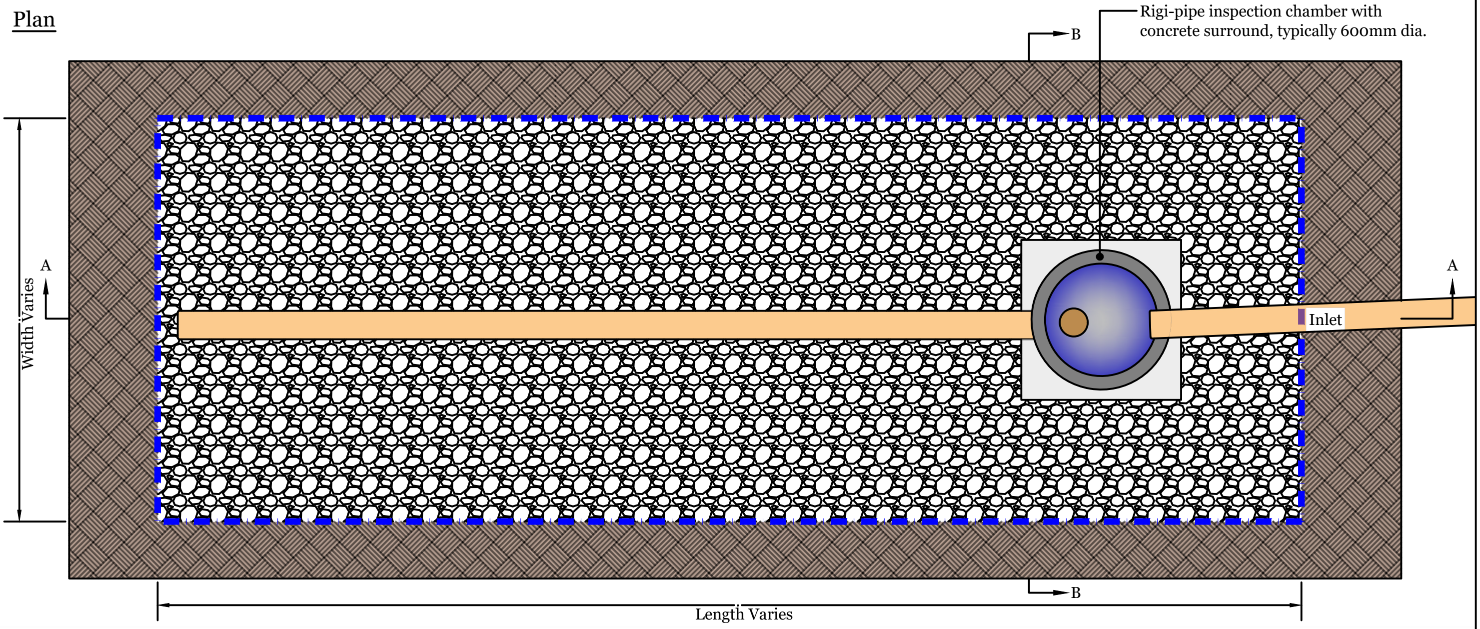
GENERAL ARRANGEMENT DRAWING GA 8

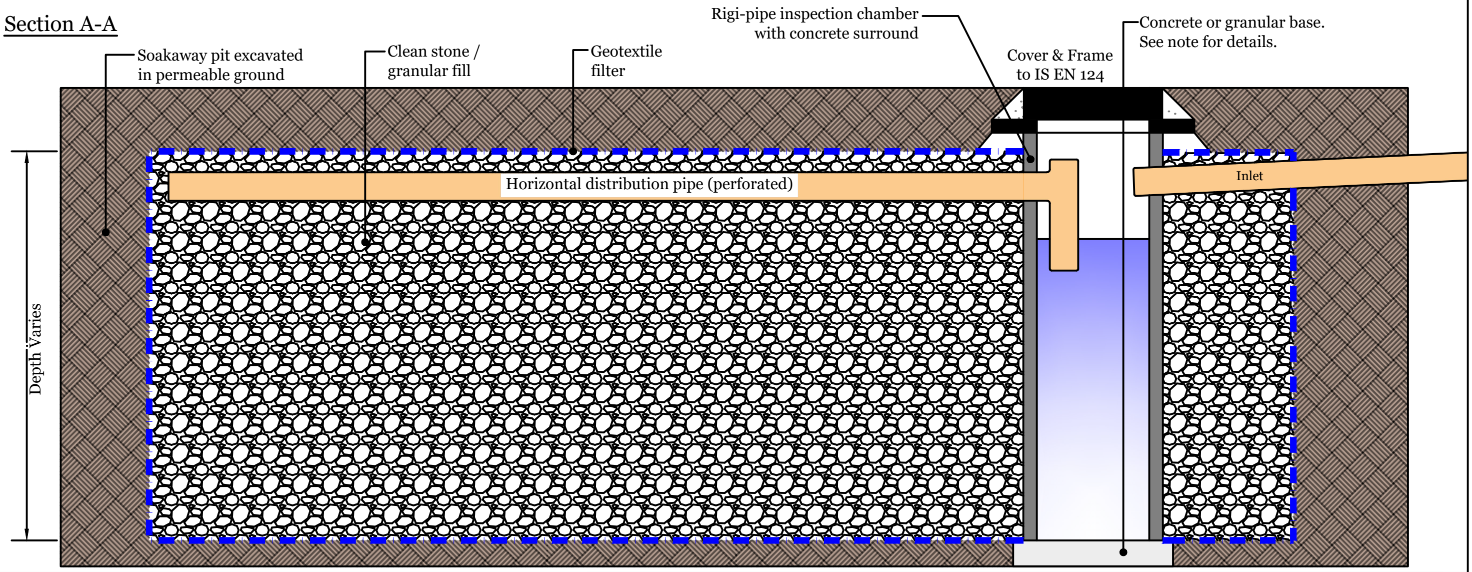
Description Granular Soakaway with Inspection Chamber

NOTES:
1. Do not scale from drawings.
2. Drawings are indicative only.
3. Site specific requirement may require an overflow pipe
4. Inspection chamber typically 600mm twin walled pipe with concrete surround.
5. Ensure site & soil suitability for soakaways, reference BRE Digest 365 - Soakaway Design.
6. Where the inspection chamber will encounter live loading ensure concrete footings, otherwise granular fill material is acceptable.

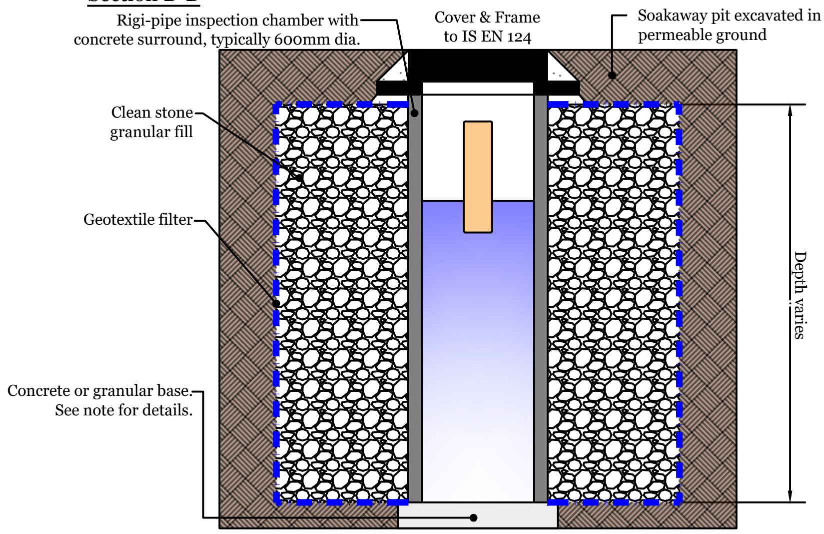
Plan



Section A-A



Section B-B



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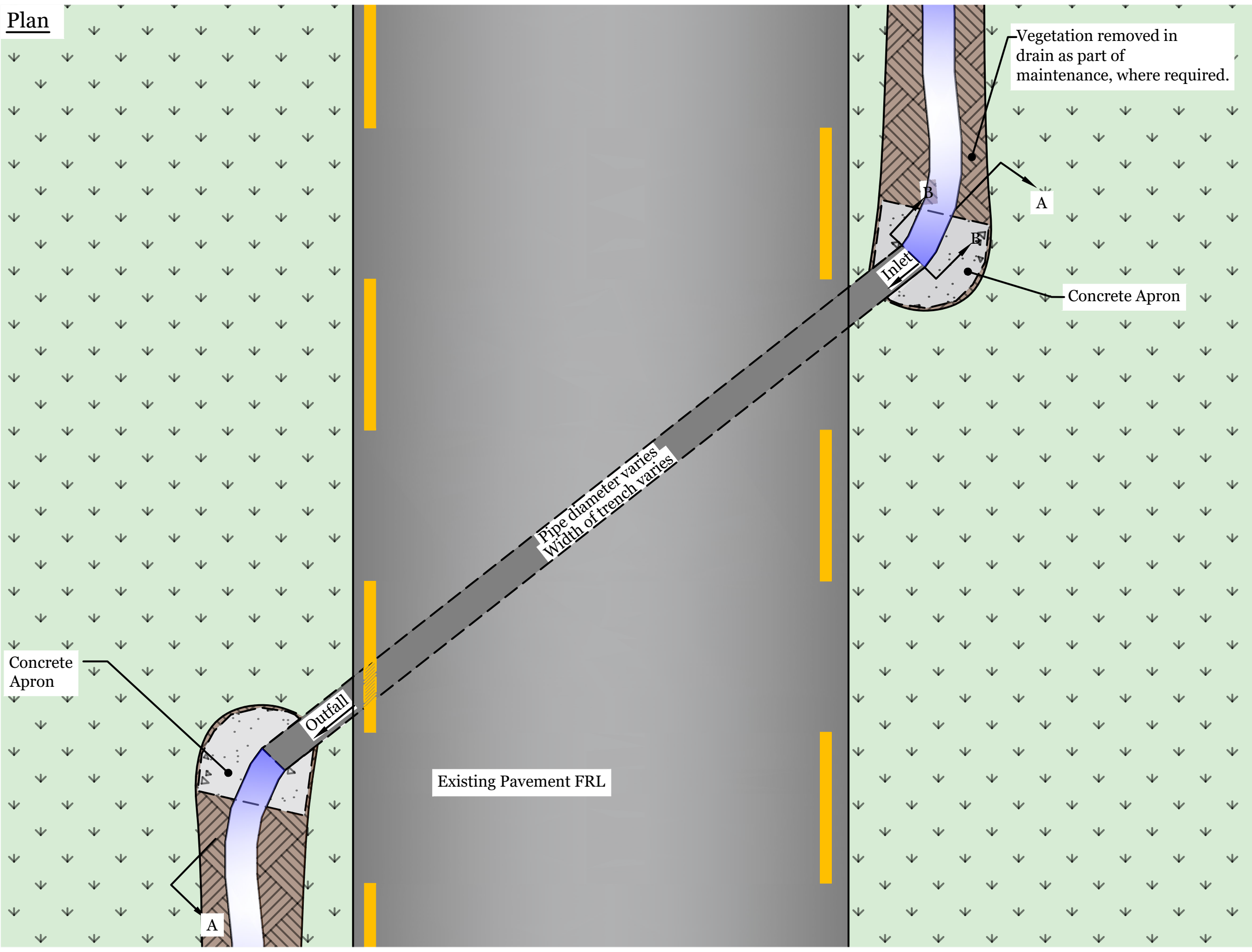
GENERAL ARRANGEMENT DRAWING GA 9

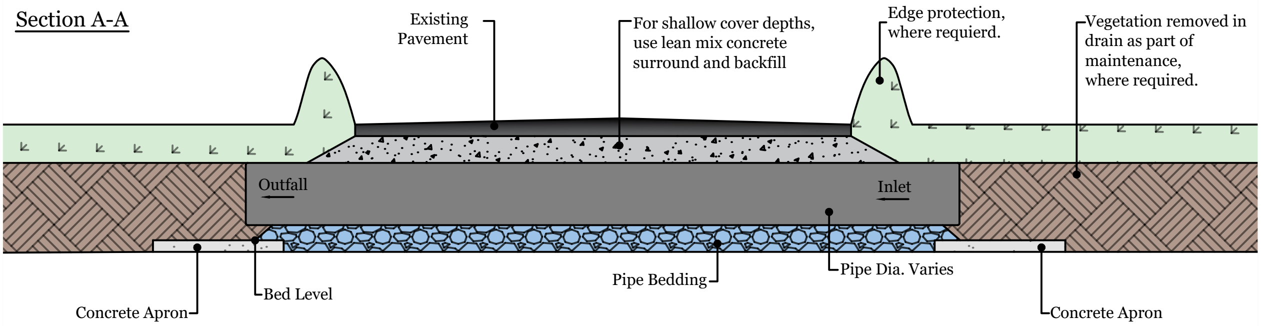
Description Diagonal piped road crossing detail at shallow depth

NOTES:
1. Do not scale from drawings.
2. Drawings are indicative only.
3. For shallow crossing depth, use lean mix concrete surround as backfill.
4. Maximum un-compacted layer depths to be 150mm
5. Ensure that pipe inlet and outlets are protected from vehicular traffic. The use of a bund, covering or delineation devices are options.
6. If required, Rip Rap can be placed to side of ditch at the inlet and outlet.

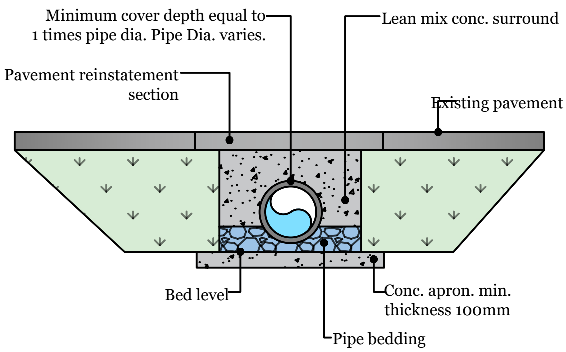
Plan



Section A-A



Section B-B



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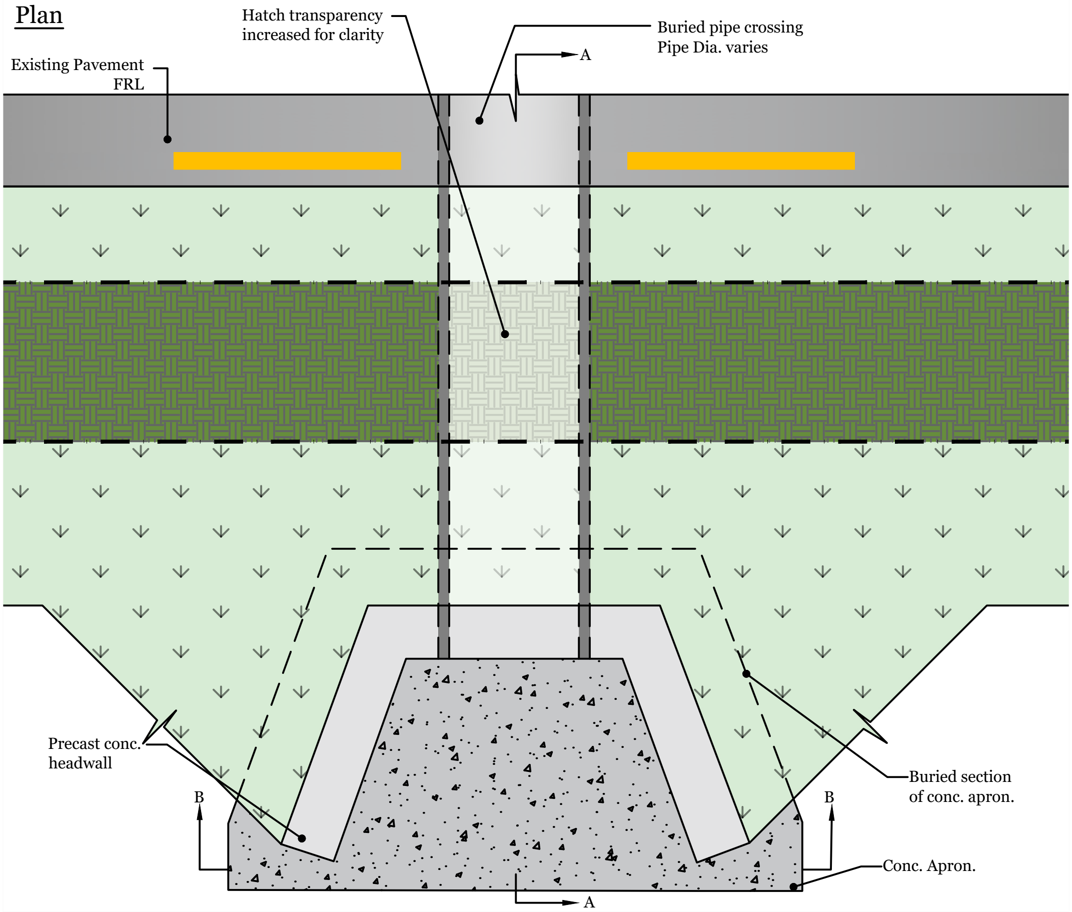
GENERAL ARRANGEMENT DRAWING GA 10

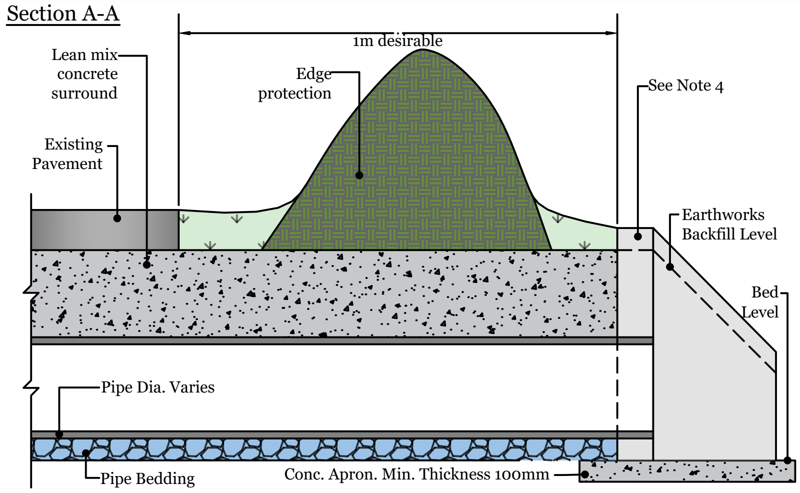
Description Headwall Details

NOTES:
1. Do not scale from drawings.
2. Drawings are indicative only.
3. Where space is restricted ensure the pipe inlet and outlet is delineated.
4. Headwall detail can be precast concrete or be developed from insitu concrete, block and plaster or existing stone masonry with cementitious material to fix in place.

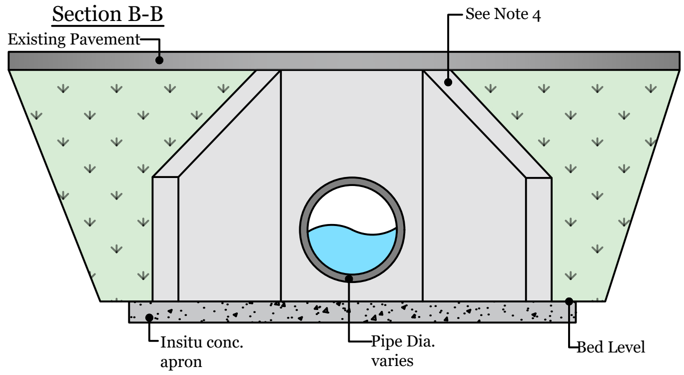
Plan



Section A-A



Section B-B



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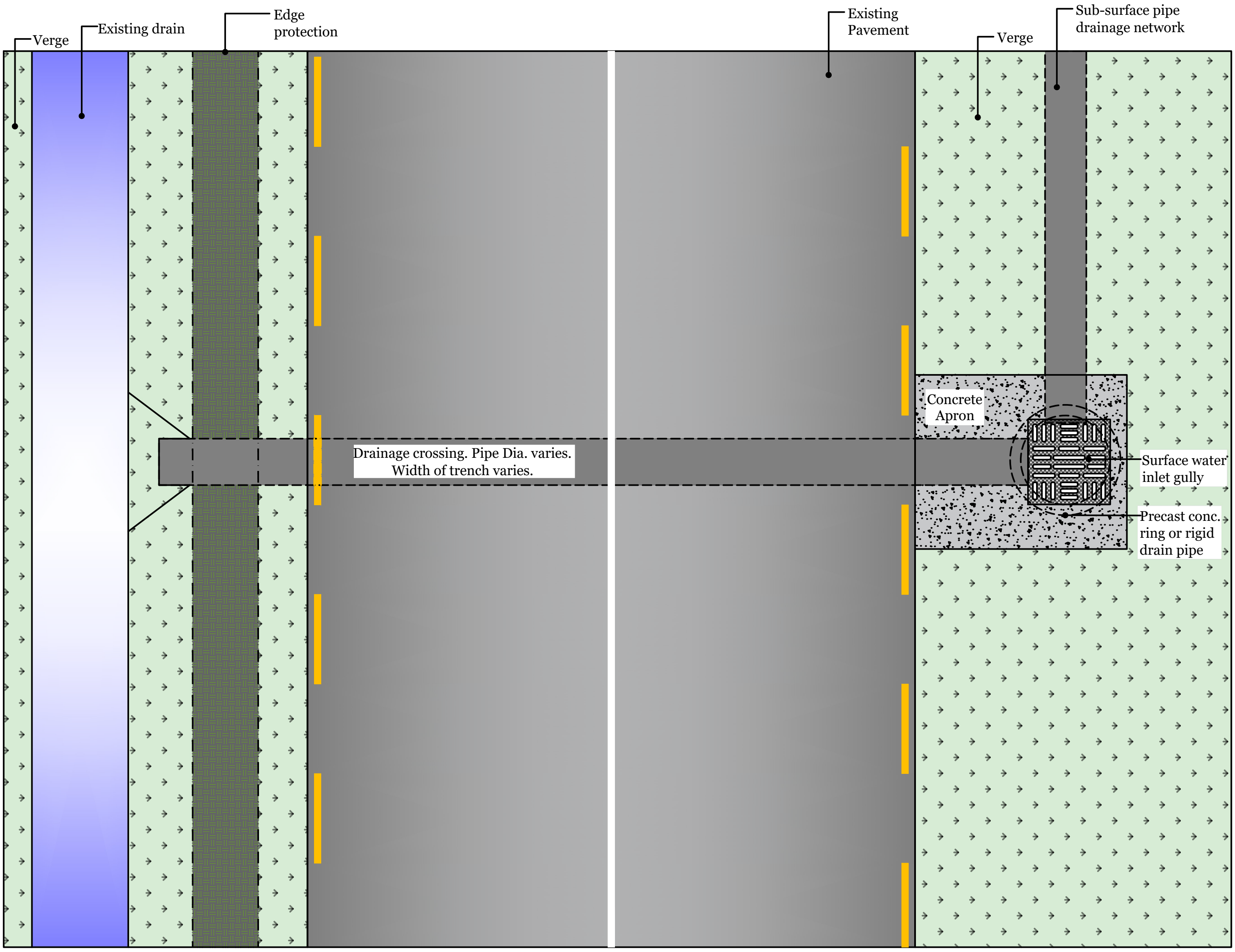
GENERAL ARRANGEMENT DRAWING GA 11

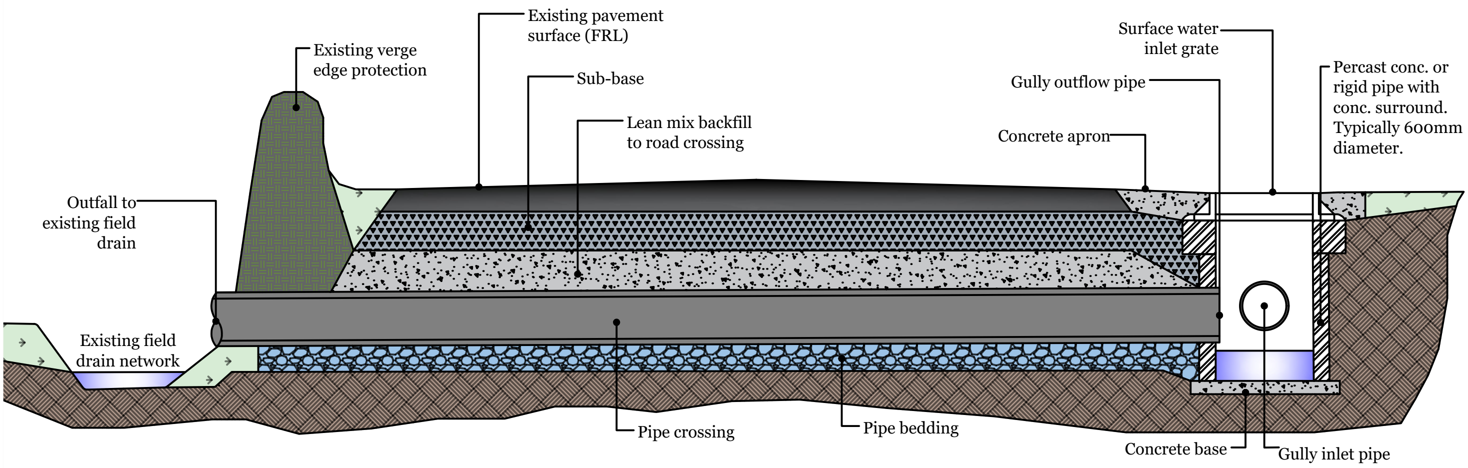
Description Road Crossing Closed System

NOTES:
1. Do not scale from drawings.
2. Drawings are indicative only.
3. For shallow crossing depth, use lean mix concrete surround.
4. Maximum un-compacted layer depths to be 150mm

Plan



Section



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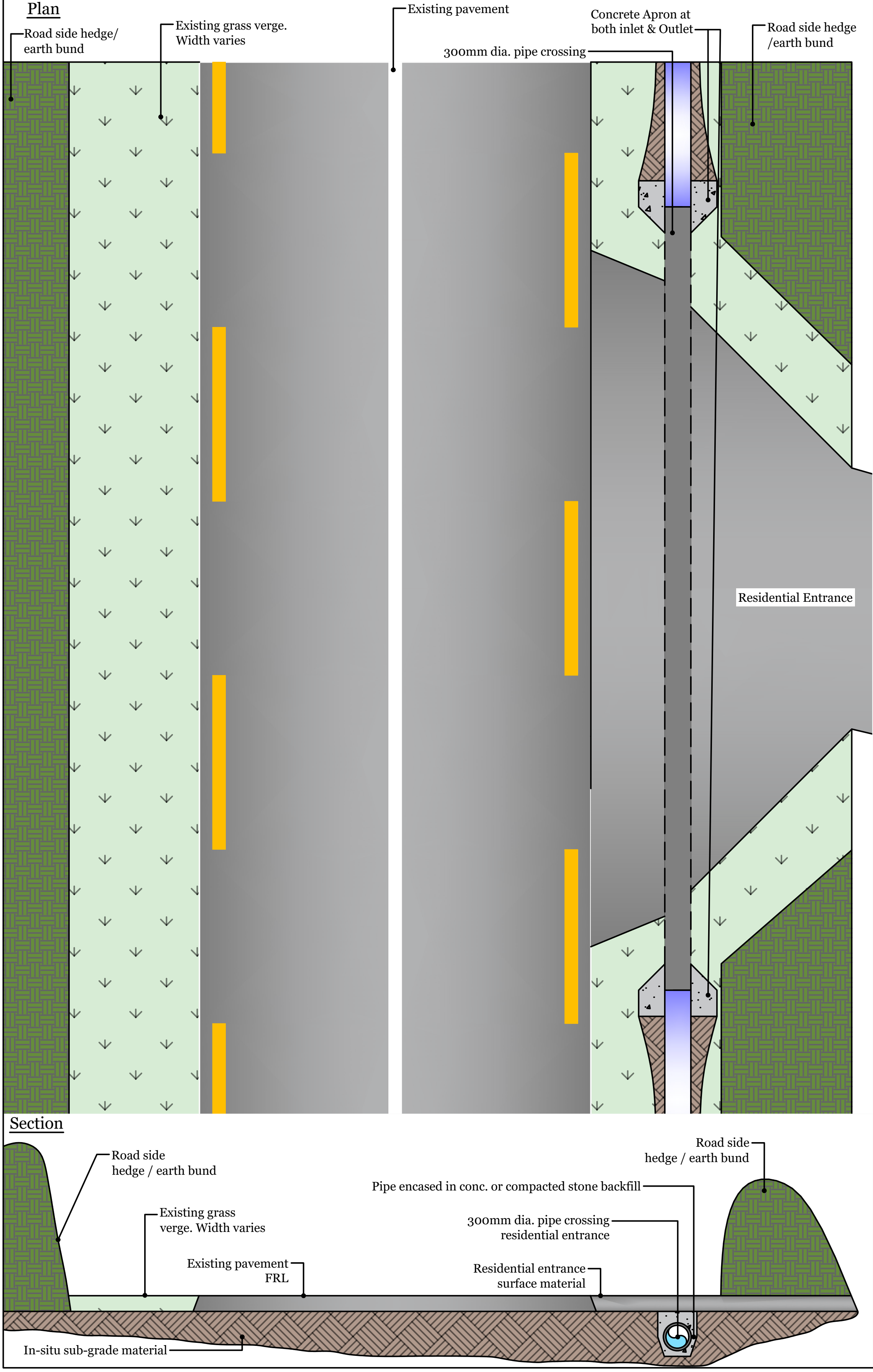
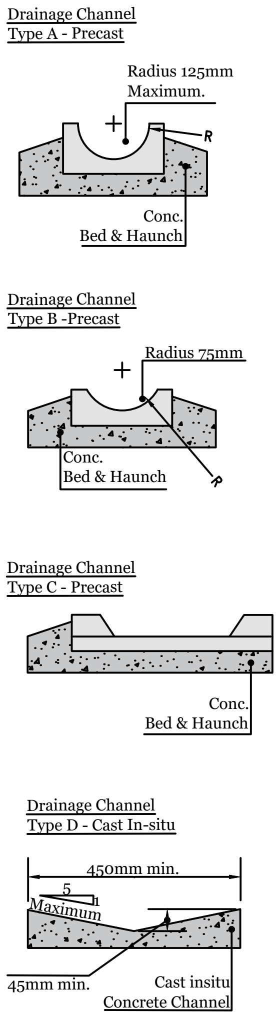
GENERAL ARRANGEMENT DRAWING GA 12

Description Rural Residential Entrance Detail

NOTES:
1. Do not scale from drawings.
2. Drawings are indicative only.
3. Ensure surface water from residential entrance does not flow onto the carriageway
4. Residential entrance detail, can be developed from pipework, precast channels, or insitu concrete as per the details in the drawing





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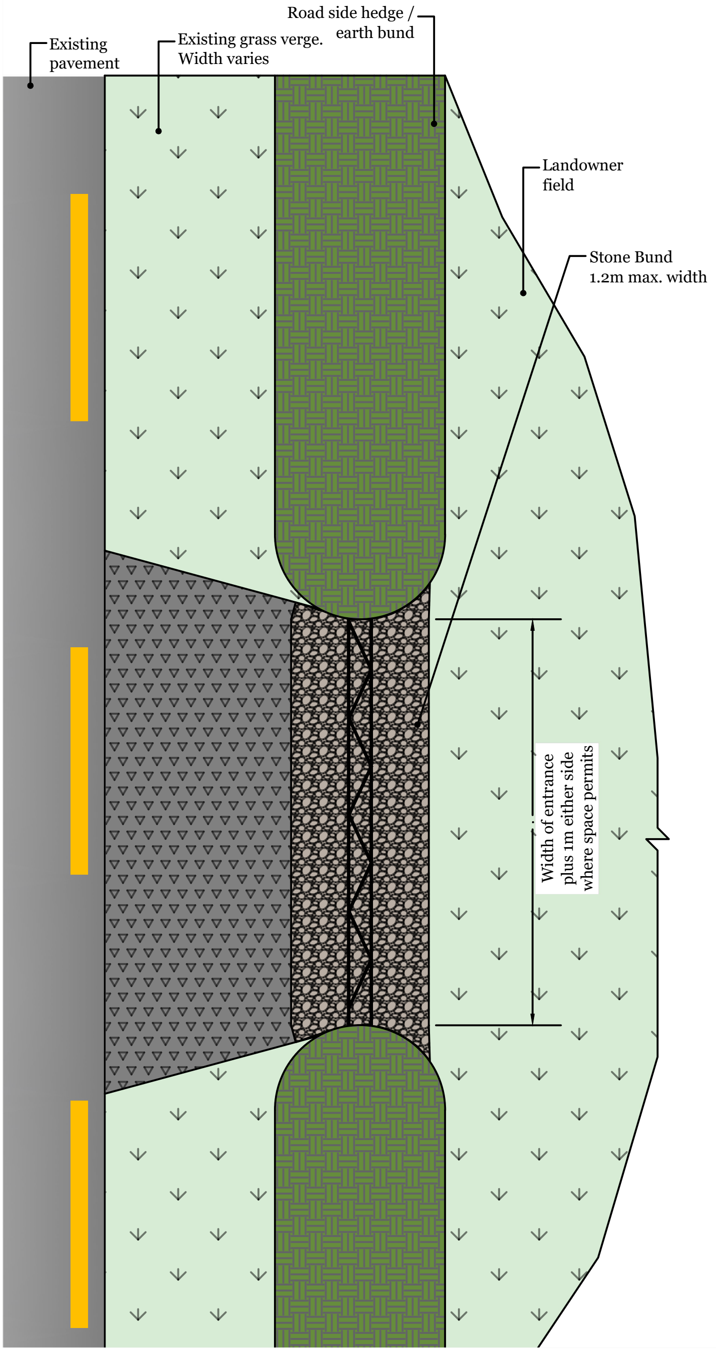
GENERAL ARRANGEMENT DRAWING GA 13

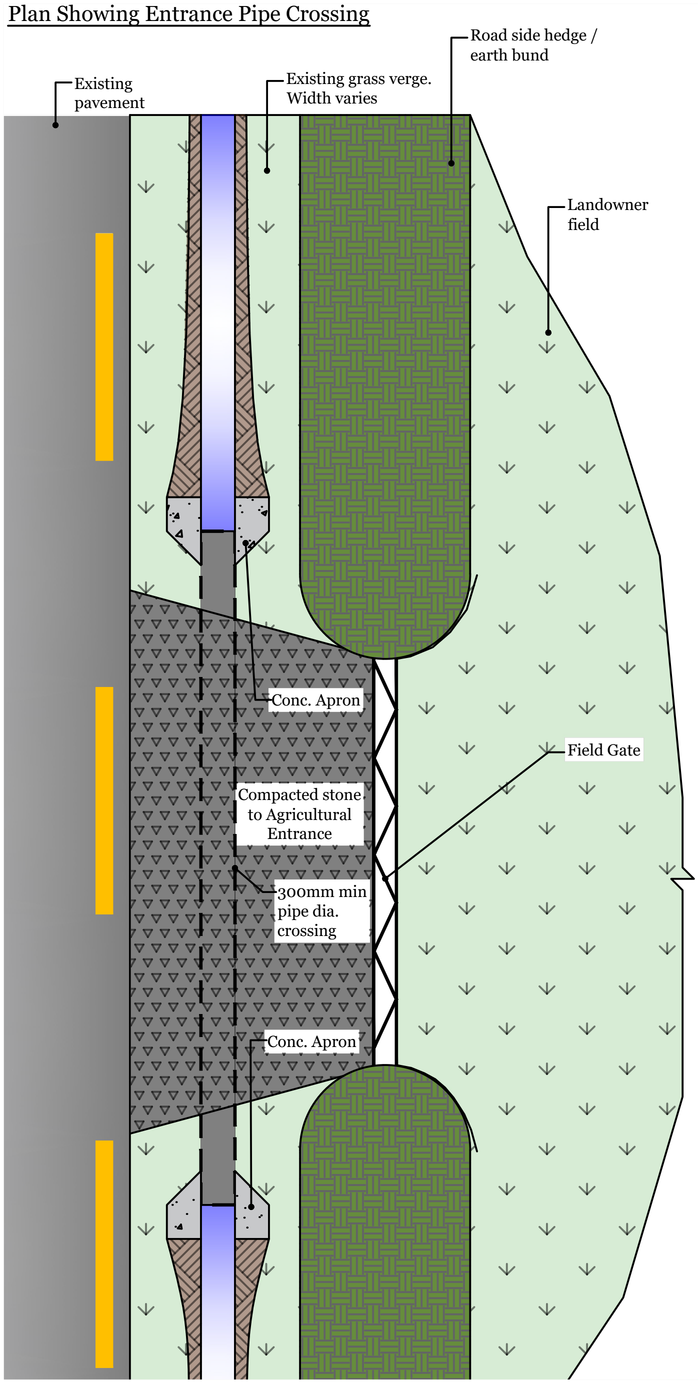
Description Agricultural Entrance Detail

NOTES:
1. Do not scale from drawings.
2. Drawings are indicative only.
3. Ensure surface water can flow off the carriageway.
4. Adjacent land gradient must be taken into account when choosing the detail to be used.
5. Stone bund should be used when adjacent land is higher than carriageway
6. Provide 75mm drainage dip, graded to inlet/outlet to prevent water entering public road

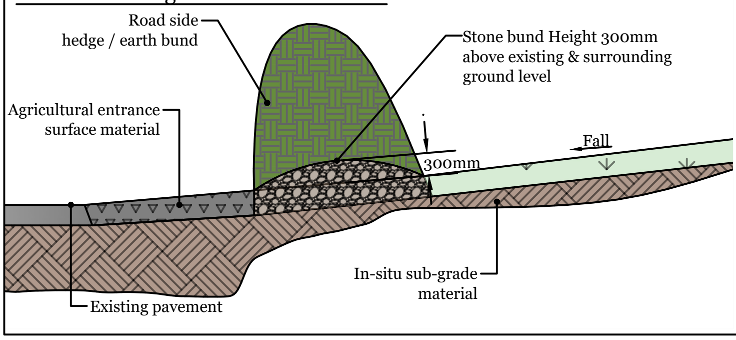
Plan Showing Entrance Stone Bund



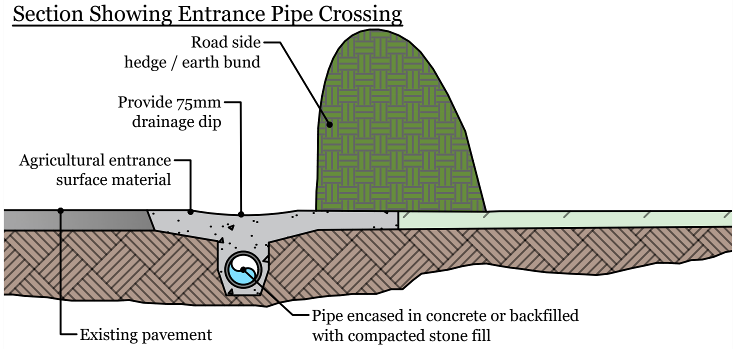
Plan Showing Entrance Pipe Crossing



Section Showing Entrance Stone Bund



Section Showing Entrance Pipe Crossing



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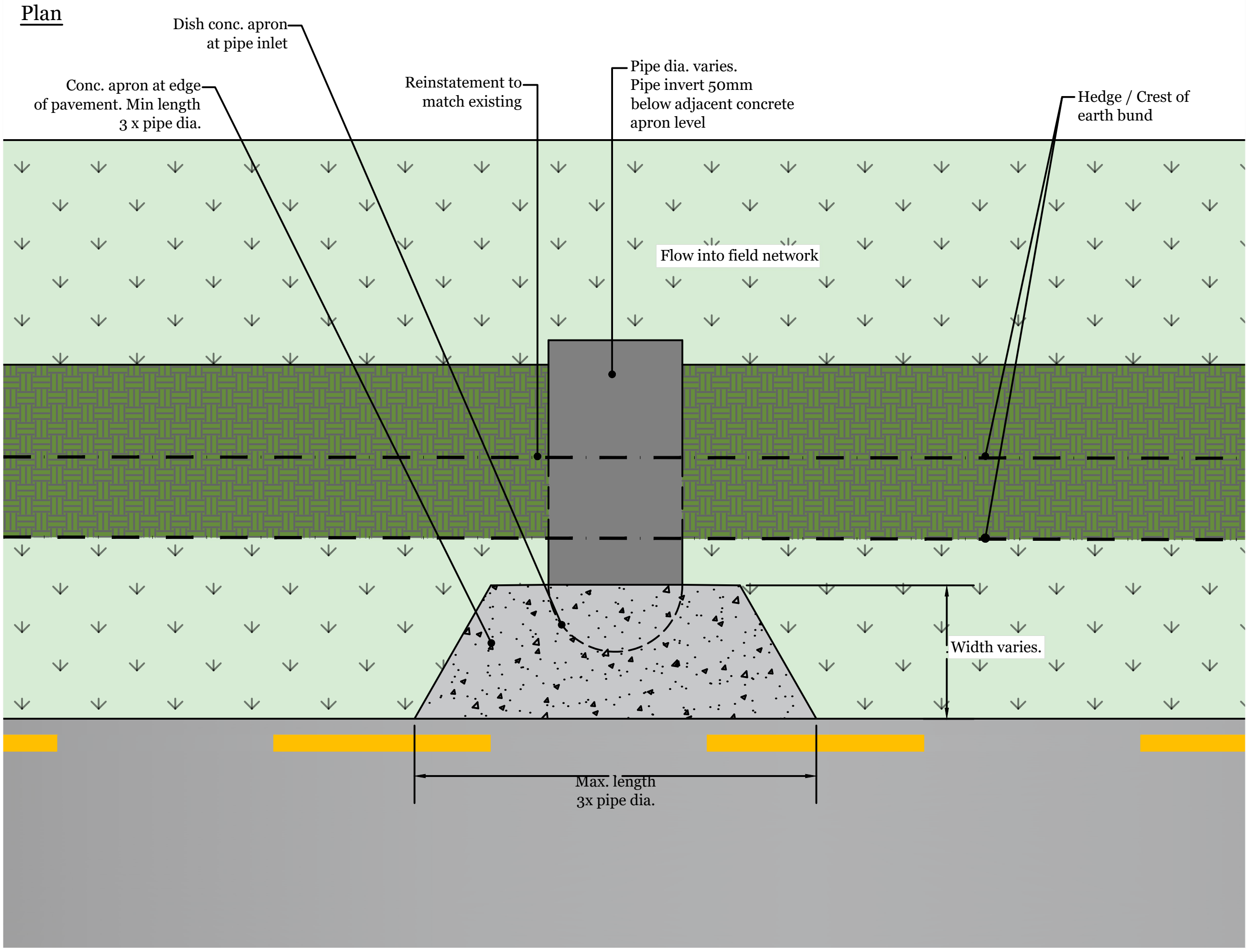
GENERAL ARRANGEMENT DRAWING GA 14

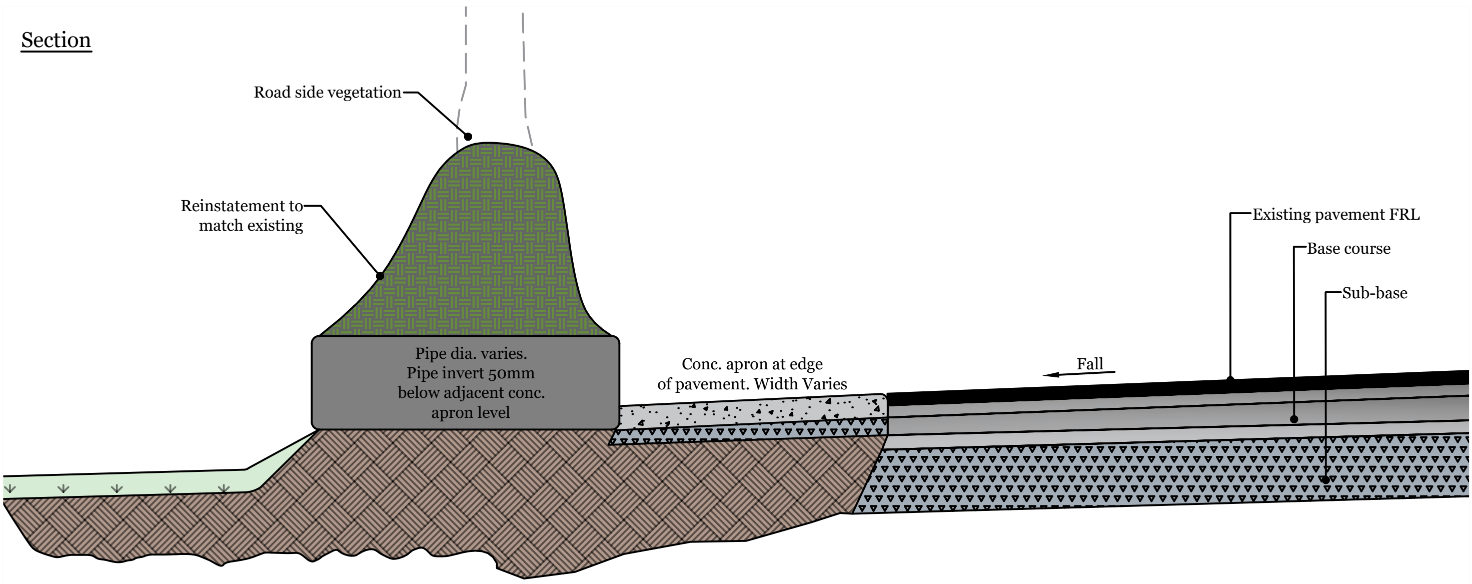
Description Piped Field Inlet

NOTES:
1. Do not scale from drawings.
2. Drawings are indicative only.
3. Rip rap scour protection can be installed on the field side of inlet to prevent scour erosion, where required.

Plan



Section



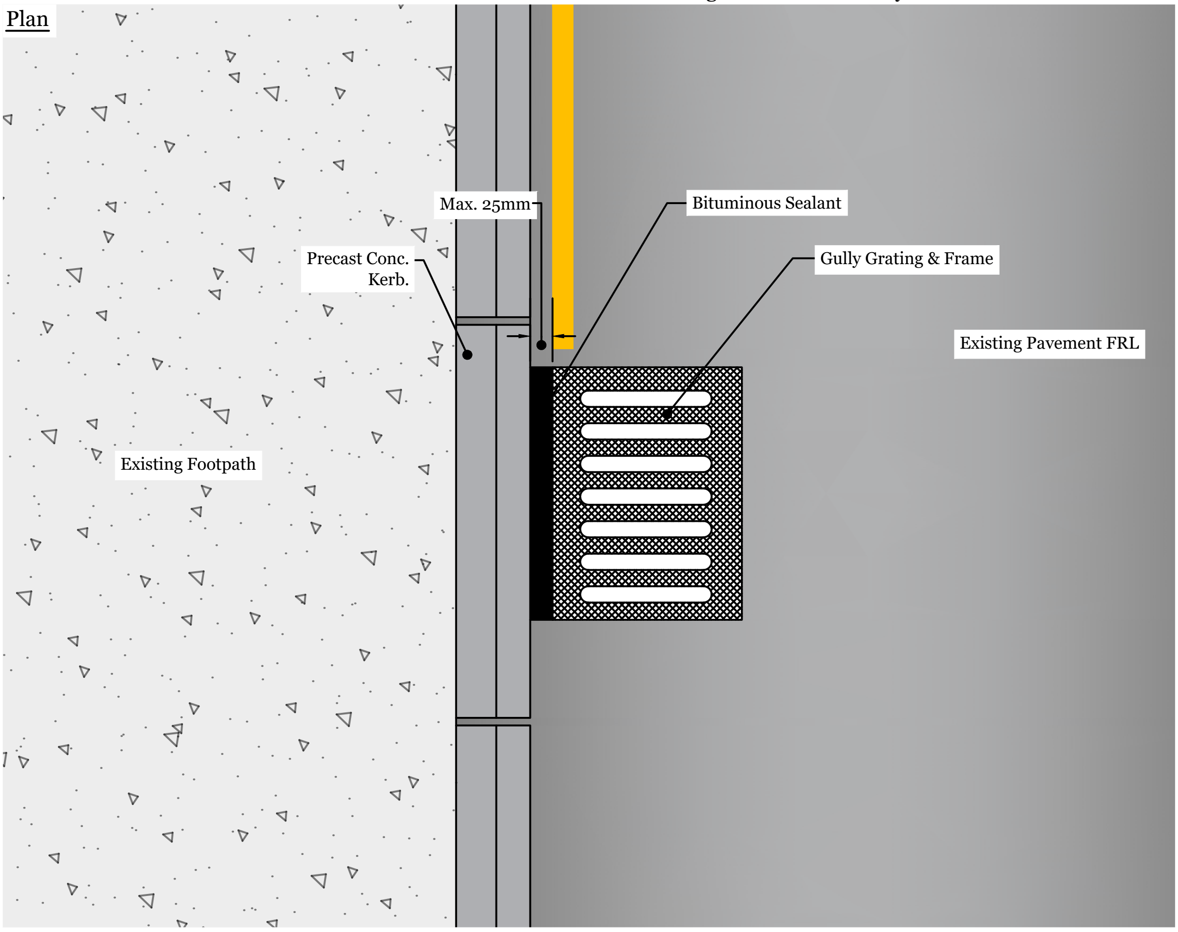
An Roinn Iompair.
Department of Transport.

GENERAL ARRANGEMENT DRAWING GA 15

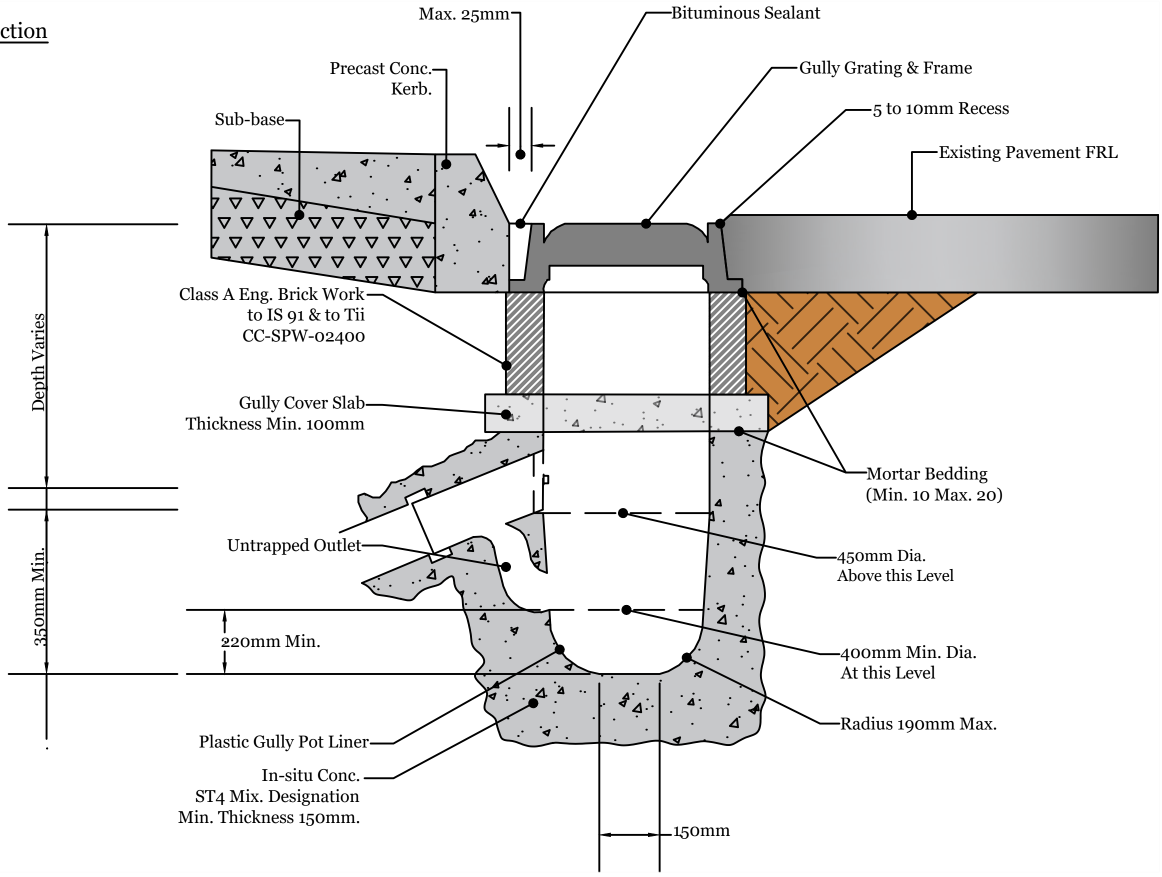
Description Urban Gully Detail

NOTES:
1. Do not scale from drawings.
2. Drawings are indicative only.

Plan



Section

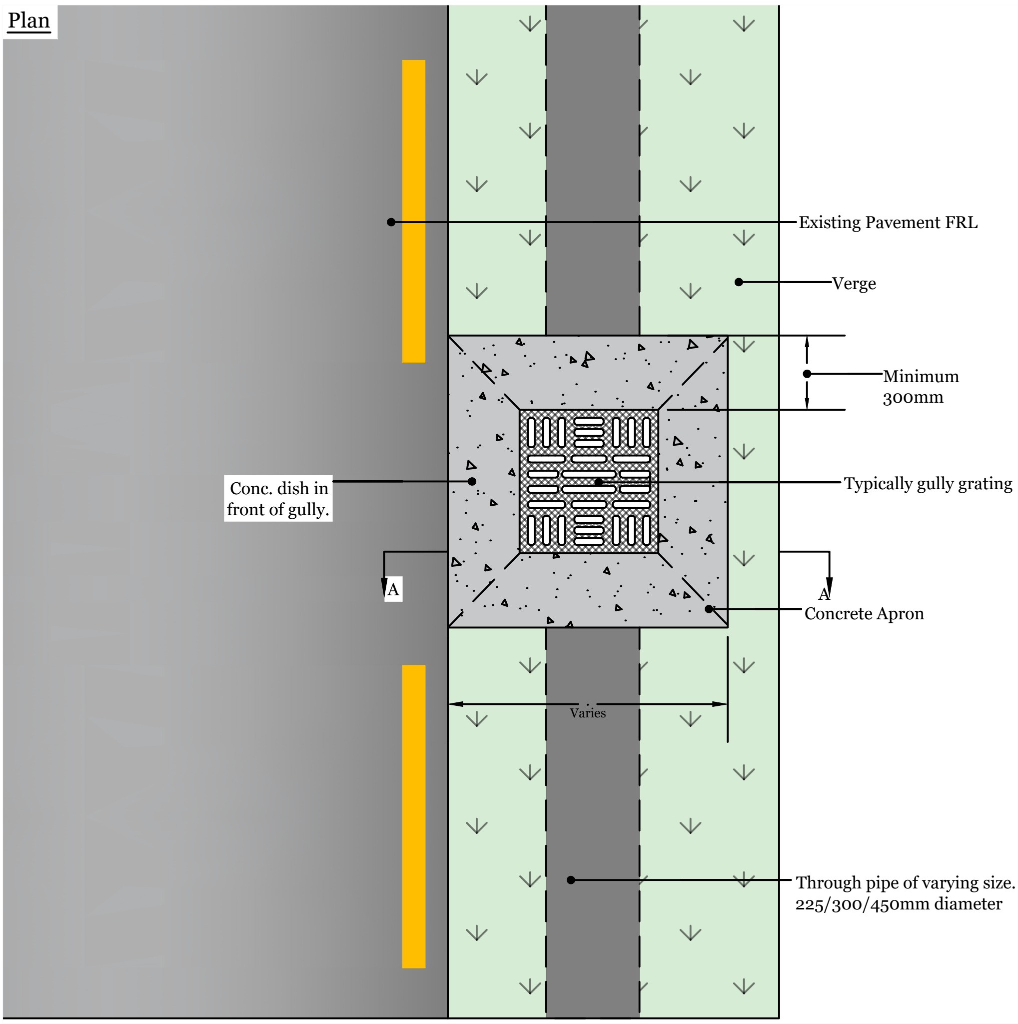


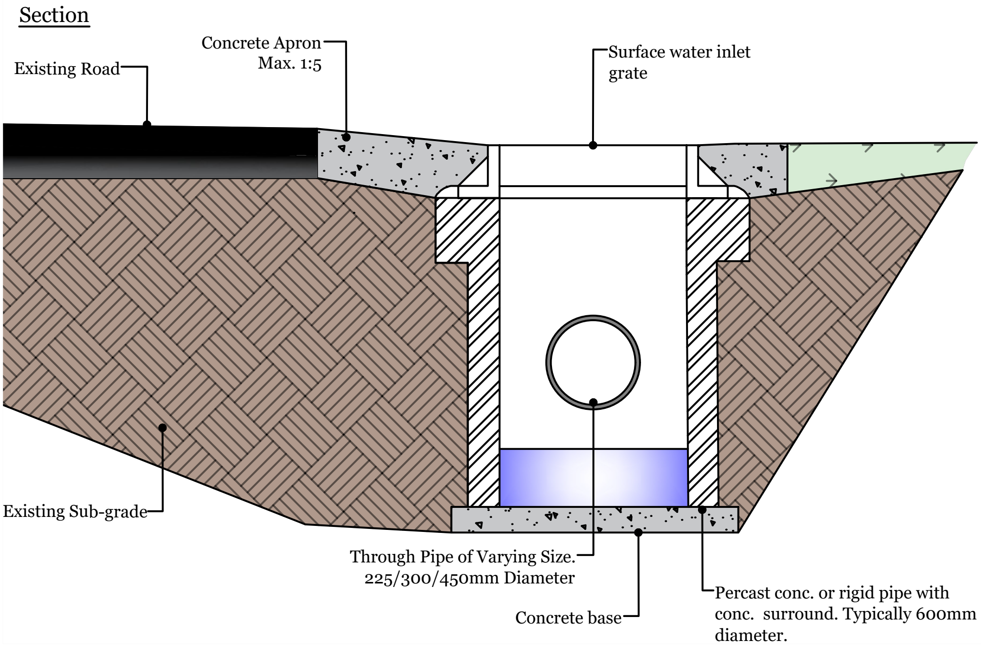
An Roinn Iompair.
Department of Transport.

GENERAL ARRANGEMENT DRAWING GA 16

Description Rural Road Gully Detail

NOTES:
1. Do not scale from drawings.
2. Drawings are indicative only.





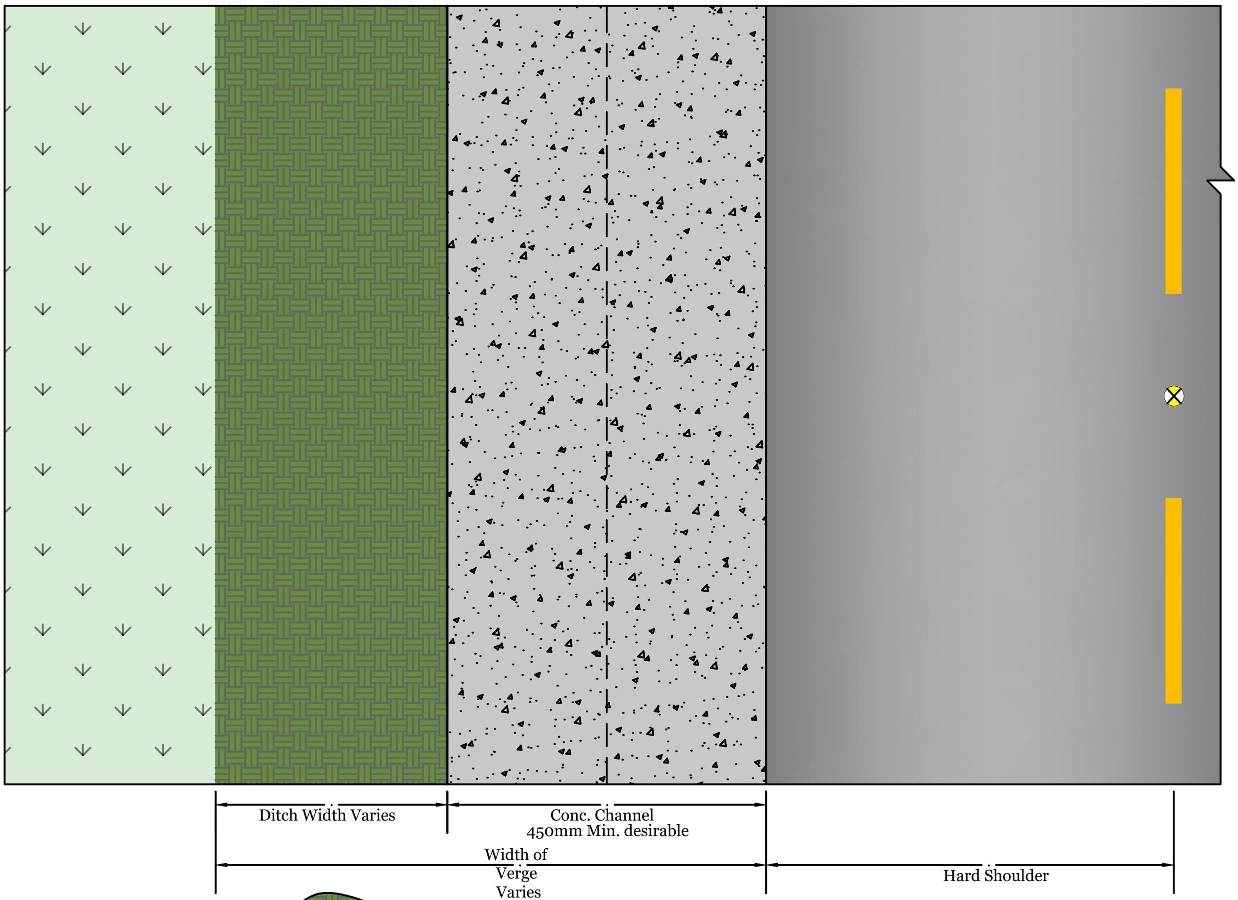
An Roinn Iompair.
Department of Transport.

GENERAL ARRANGEMENT DRAWING GA 17

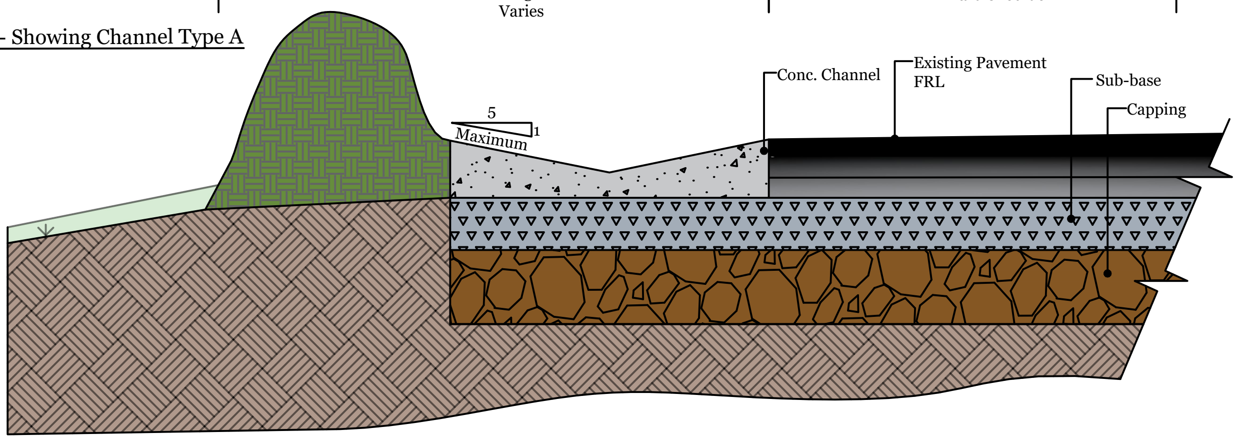
Description Rural Edge Concrete Channel

NOTES:
1. Do not scale from drawings.
2. Drawings are indicative only.

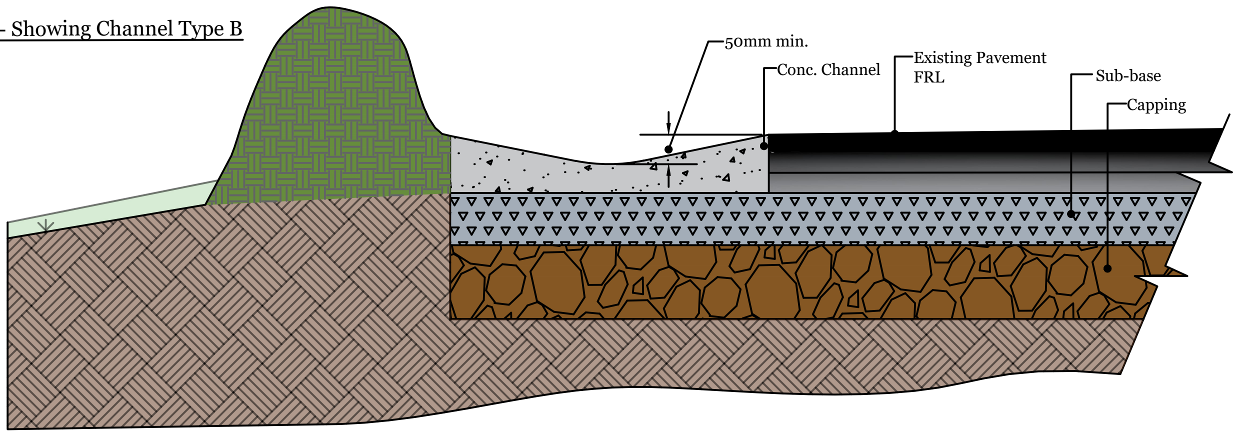
Plan



Section - Showing Channel Type A



Section - Showing Channel Type B



6.2 Pipe Systems

6.2.1 Gradient

The principles for pipe gradient are outlined as follows:

- Pipes must be at least 225 mm in diameter, and these should not be laid flatter than 1 in 150;
- As larger pipes are required, pipes can be laid at minimum gradients using the inverse of the pipe diameter, so a 300 mm pipe can be laid at 1 in 300 or steeper; and
- For pipes larger than 500mm, gradients should not generally be laid flatter than 1 in 500.

6.2.2 Trench Dimensions

The width of the trench is dependent on the diameter of the pipe to be placed into the trench. The general principle for the width of the trench should be twice the diameter of the pipe.

The depth of the bedding beneath the pipe should be a minimum of 100mm for pipe diameters up to and including 450mm. For pipe diameters in excess of 450mm the minimum depth of bedding should be 150mm

6.3 Drainage Gratings

It is important to ensure the correct grate is chosen to cover gullies. All grating used should be certified to the European Standard IS EN 124-2. There is a mandatory requirement for the following markings to be a permanent, integral part of the grating and frame:

- Name of the European Standard-EN 124-2;
- Appropriate class (e.g. D400);
- Name and/or identification mark of the manufacturer;
- Factory of manufacturer which may be in code; and
- Date or week and year of manufacture (coded or not coded).

Gratings have an impact on the end user of the carriageway, it can impact on the frequency of the maintenance required and it can also impact on the functionality of the gulley. The following items need to be considered in choosing the correct grating:

- Location of grating, urban or rural;
- Ensure slots don't place VRU at risk;
- Ensure the correct load capacity for the carriageway type;
- Ensure correct material chosen and finish;
- The slot area provided for water to drain;
- Fixed grating or hinged;
- Ease of access and safe access for maintenance; and
- Position relative to the wheel track.

6.3.1 Rural Gratings

Rural gratings can be provided off the carriageway where sufficient space is available, alternatively rural gratings can be provided on the carriageway, but care should be taken to ensure the location of the grating is not within the wheel track. The following principles should be adhered to when selecting rural gratings:

- 600mm x 600mm opening;
- A minimum weight load class of D400;
- A minimum waterway area of 0.2m^2;
- Ensure a surround of either concrete or mastic asphalt is provided;
- If providing a grating in conjunction with a concrete channel, then a shaped grate may be more appropriate; and
- If using a flat grating, ensure the surround provided allows for the surface water to reach the grating.

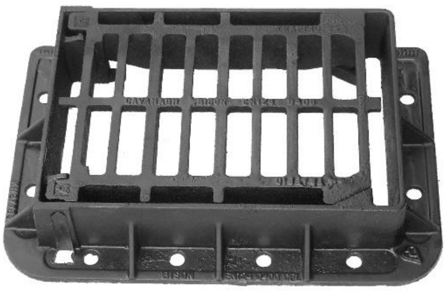
6.3.2 Urban Gratings

There are number of considerations which should be addressed when choosing the correct urban gratings. The gratings will dependent on the drainage type installed. The grating chosen should take cognizance for the level of VRUs. The greater the waterway area provided in the grating selection will reduce the likelihood of blockages.

<u>Urban Gullies</u>

Dependent on the carriageway space available will determine the appropriate size for the grating. Selected smaller grating sizes will require a greater volume of gullies to cater for the surface water volumes. The selection of a wider grating will reduce the risk of the surface water bypassing the grating. The following principles should be noted for urban gullies gratings:

- Approximate grating size of 350mm x 500mm to be provided;
- An approximate minimum waterway area of $0.1m^2$;
- Larger Grating size of 450mm x 450mm can be provided if sufficient space is available;
- A minimum weight load class of D400;
- Ensure a surround of either concrete or mastic asphalt is provided;
- Where space is restricted smaller opening area can be provided; and
- Smaller grating size provided, reduce the waterway area and are more likely to demand a high level of maintenance.



<u>Kerb Inlet Gullies</u>

The selection of kerb Inlet gullies may be due to restricted space. The use of kerb inlet gullies has added benefits for VRU especially cyclists. Due to the large waterway area they are less likely to suffer blockages. Care must be taken on the installation of the kerb inlet gullies that sufficient falls are provided for the surface water to flow into the opening. Kerb Inlet gullies are unsuitable for roads with steep gradients where surface water may pass the opening.

<u>Aco Drains</u>

The aco drains can be placed flush with the surrounding finished surfaces which reduce the risk of slips, trips and falls. The choice of grating used for these drains is important. There is a high level of maintenance required so that needs to be addressed at grating selection stage. The weight load classification should also be an important decision, this is dependent on where the aco drains are being placed. The following principles should be noted for aco drain gratings:

- Suitable for intended purpose, if trafficked then minimum weight load class of D400;
- Ensure the grating can be securely fixed to the base of the unit;
- Ensure ease of access for maintenance; and
- Slip resistance of the chosen grating should be determined.

7. Drainage Maintenance

Road drainage infrastructure is designed for a certain discharge and/or capability and needs to be properly maintained to ensure continued performance. Failure of the drainage may be attribute to a one-off event such as an extreme weather event or vehicle accident. Maintenance work is intended to ensure the drainage system functions as intended and to its original capability.

Poor maintenance reduces the performance of the drainage systems and can increase the risk of the following:

- Unsafe driving conditions;
- Pavement deterioration;
- Sub-grade deterioration;
- Embankment failure;
- Erosion;
- Silting;
- Flooding; and
- Structural Damage.

7.1 Maintenance Scenarios and Requirements

In order to ensure efficient and optimal long-term operation of the drainage system it is important that the drainage system be regularly maintained. Some key components are as follows:

- Regular street sweeping and catch basin cleaning;
- Regular inspection of storm system including inlet grates and periodic flushing as required; and
- Regular inspections of overland drainage system including ditches, culverts and the removal of the accumulated sediment and debris as required.

The following tables outlines typical examples of the maintenance scenarios associated with the drainage types.

Kerb and Gullies	
Misplaced gulley, gulley is not at low point of the road causing ponding.	
Lack of gullies/drainage at pedestrian crossing. Can lead to pedestrians being splashed.	

Rural Gullies	
Installation of 600mm diameter gullies and carrier pipe to remove water from roads with high verges.	

Surface water pooling caused by building a new wall without considering drainage.	

Kerb Inlet Gullies	
Vegetation growing at entry point, causing reduced hydraulic capacity.	

Aco Drains	
Vegetation growing in Aco drain, causing reduced hydraulic capacity.	

Aco grating dislodged and drain full of sediment.	

Filter Drains	
Permeable performance reaching critically low levels.	
Surface has localised vegetation growth, surface water removal reduced, maintenance required.	

Open Drains	
Vegetation has been maintained in the open drain, inlets required to allow surface water to reach the drain	
Surface water flow unable to enter open drain due to high bank at road edge and no inlets.	

Vege Removal	
Road newly resurfaced and no inlets have been opened along edge of carriageway.	

Inlets not maintained and has caused ponding along road edge.	

Concrete Channels	
Sediment build up at grating in concrete channel, which will reduce the hydraulic capacity of the channel and gulley.	
Concrete channel present but poorly maintained, filled with vegetation.	

Over the Edge Drainage	
Pipe used in ditch to facilitate over the edge drainage in the area of a high ditch. Pipe location is critical to ensure the flow path of surface water can reach the pipe.	
Pipe used to facilitate over the edge drainage but requires maintenance.	

Swales	
Rural swale along carriageway edge, no inlet provided for surface water to enter.	

7.2 Inspections

All drainage types will require inspections to be undertaken by LA personnel. When carrying out inspections, it is important to understand the elements of the drainage type that needs to be inspected. Each drainage system can be broken into sections:

- Section 1 - Collection Points;
- Section 2 - Transmission Network; and
- Section 3 - Discharge Element.

If problems are evident in any part of the sections of the drainage system, it will cause a risk of flooding or excessive surface water ponding during periods of rainfall. Inspections on the drainage types should ensure that the three sections of the drainage system are checked. Any defects that are determined can then be included in the maintenance regime of the network.

Guidance on the inspection frequency for each of the drainage types is outlined in Table 7.1 The inspections should begin in early autumn when drainage systems begin to be filled with debris and foliage. Maintenance can then be scheduled to take place ahead of the winter period.

Drainage types should be inspected after a storm period to ensure that the capacity or functionality has not been impacted by the storm.

Inspection Guidance	
Drainage Types	**Inspections**
Kerb & Gullies	Twice Annually or After a Storm
Drainage Kerbs	
Kerb Inlet Gullies	
Aco Drains	
Slot Drains	
Filter Drains	Annually or After a Storm
Open Drains	
Verge Removal	
Concrete Channels	
Over the Edge Drainage	
Soakaway & Infiltration Trench's	
Bio- Retention	
Attenuation Basins & Tanks	
Swales	
Wetlands	

Table 7.1 Inspection Guidance for Drainage Types

7.3 Plant and Equipment

LA throughout the country use a varied array of plant and machinery to undertake maintenance works on their drainage network. The following is the various type of plant being utilised.

Plant and Equipment	
180 degree rubber wheeled excavator for maintenance of opened drains	
360 degree wheeled 6 Tonne excavators are being used due to their compact nature.	
360 degree rubber track, 3 Tonne excavators are being used due to their compact nature for rural roads.	

Plant and Equipment	
Wheeled dumpers for removing the excess material during the maintenance	
Verge treatment machinery has been developed which removes road edge earthen material, crumbles the material and sweeps the area.	
Hydraulic tilt grading bucket for maintaining the opening drain network. This can be fitted to an 180 degree of 360 degree excavator.	
Hydraulic tilt and rotate excavator hitches provide flexibility in restricted locations.	

Plant and Equipment	
Gulley Suckers are used to remove silt and debris for the closed systems.	
Sweepers are provided in all sizes to cater for both the urban and rural location.	
Jetting and Vacuum Trucks are used in maintenance of drainage systems.	
CCTV equipment are used for a number of reasons in the maintenance and rehabilitation of piped networks e.g. tracing networks, condition surveys and blockage locators.	

APPENDIX 1 – Letters to Landowners

Roads Authority – Notice to Landowner

Road Act 1993 – Section 76

Mr John Smith.

....

Co. ....

Date:

Re: Water Flowing from lands onto Public Road at ....

It has come to my attention that a large amount of surface water is flowing onto the public road at .... from lands in your ownership. This is resulting in damage to the public road and a hazard for the road user.

This letter is to inform you this is an offence under Section 76, Paragraph 5 of the Roads Act 1993. You are hereby instructed to remedy this situation immediately or the roads authority will initiate proceedings against you under the above section of the Act.

Should any further damage be caused to the public road as a result of this runoff, the Roads Authority is empowered by the Act to recoup the cost of repair works from the landowner responsible.

Yours Sincerely,

Name

Organisation

Grade