CHAPTER 10    DRAINAGE

10.1 INTRODUCTION

The drainage system manages both surface and subsurface water coming off the road surface and from the surrounding countryside. The purpose of the system is to ensure that the road and its surrounds are free from standing water at all times and to have sufficient capacity to prevent the road from being overtopped. The principal elements of the system are:

- Crossfall on the road and shoulders to permit free flow off the road. Main problems are slacks, ruts, flat or obstructed shoulders, or shoulders with edge build up.
- Side drains, parallel to the road, which collect run-off from both the road and countryside. Main problems are standing water often caused by silting up, lack of capacity and erosion.
- Bridges and culverts which permit crossflow of water under the road and provide outlets for the side drains. Main problems are blockage, lack of capacity and poor discharge.
- Mitre drains which lead water out of side drains onto lands sloping away from the road. Main problems are blockage or ponding at the entrance of the drain.
- Berms which channelise water flow particularly into culverts. Main problems are erosion, breaching and poor positioning.
- Cut off/catchwater drains situated along the crests of cuttings to reduce sheet flow down cut faces from higher lying ground and prevent cut erosion. Main problems are blocking, shallow drains, lack of continuous fall and erosion.
- Subsurface drains which collect water below ground level where there is seepage, springs or saturated conditions. Main problems are poor construction, incorrect material specifications, particularly with regard to the geofabric, subsurface drain too shallow to cut off the water table and an inefficient drain outlet.
Asphalt berms on the road edge particularly on fills. Main problems are damaged or broken berms which result in concentrated water flow from the road onto fills.

In general many road failures are caused by failure in the drainage system in combination with heavy wheel loads. Even the best foundation material will fail if subjected to poor drainage. On national roads the foundation layers have, in most cases, been well designed and construction carefully supervised. It follows therefore that when road failures are repaired, care must be taken to investigate whether the drainage system is functioning properly.

On road maintenance contracts, sufficient funds must be made available for the cleaning of drainage structures. The following sections describe the drainage aspects that must be attended to on an annual basis. If efficiently carried out, the work will become easier and more economical to do as the years pass.

Heavy rain presents an ideal opportunity to make sure that the drainage system is working correctly. So don't stay in the office, go out on the road and observe. Where flooding of the road occurs detailed notes should be made of the location and SANRAL informed. This is particularly important where this occurs regularly and there is a likelihood that the drainage structure has insufficient capacity. The detailed inspection in loco of cut catchwater drains (ie. climb up and inspect) is essential to ensure that failures in the early stages are rectified before major damage occurs.

Where new developments take place adjacent to the road reserve, it is essential that stormwater management is appropriate. SANRAL must be informed immediately the Route Manager notices problems in this regard.

### 10.2 DRAINAGE MAINTENANCE

#### STANDING WATER (ON ROAD SURFACE)

**Description**

Water stands on the road surface or road shoulder and does not drain away.

**Causes**

- Slacks due to settlement/subsidence.
- Rutting in wheel tracks on flat grades.
- Flat or high gravel shoulders and/or windrows or vegetation on the gravel shoulder preventing drainage.
- Blocked weepholes/scuppers on structures.
- Flat grades, particularly at superelevation transitions.
**Extent**
Can be either isolated (slacks) or extensive (ruts, high shoulders and vegetation).

**Response Time**
Standing water on the road surface is dangerous to traffic (aquaplaning and loss of control) and can also result in wetting up of the pavement layers which normally leads to pavement failures. As a result all areas of standing water should be treated as soon as possible and especially before the start of the next wet season. Where the areas are extensive this cannot be handled under routine maintenance and SANRAL should be informed immediately and warning signs erected.

**Repairs**
Correctly identify the cause of the standing water. Repairs should then be carried out as described in the various sections on Road Pavement and Gravel Shoulders.

**Caution**
Standing water is a cause of pavement distress and aquaplaning. Localised problems must be addressed immediately.

**KERBS AND CHUTES**

**Description**
Kerbing and chutes are mainly used to control sheetflow on the road and to ensure safe discharge into the side drainage system. Problems are associated with mechanical damage, inadequate capacity, poorly placed chutes, fill settlement or obstructions in chutes.

**Causes**
- Kerbs are damaged by vehicle impact.
- Lack of capacity is often due to outlets being spaced too far apart.
- Chutes perform poorly because they are badly aligned, have gaps because of fill settlement or carry too much water and overtop because the inlets are spaced too far apart.
- Debris in kerbs and chutes causes water to jump out of channel resulting in erosion of the road prism.
- Settlement on high fills resulting in chutes not being positioned at low points.
**Extent**
Isolated problem.

**Response Time**
Should be dealt with routinely. If left too long can cause erosion, settlement and failure of the fill.

**Repairs**
Replace damaged kerbs. Check inlet spacing and where necessary place extra chutes. Check alignment and nesting of chutes and relocate where necessary.

**SIDE DRAINS**

**Description**
Side drains are important links in the road drainage system. The most common problems associated with side drains are standing water, lack of capacity and erosion.

**Causes**
- Standing water on flat gradients
- Blockage due to loose material (often from eroding cut faces), vegetation and blocked culverts. This is a particular problem with V-shaped earth sidedrains.
- Lack of capacity caused by silting up with material from surrounding land or very flat/shallow drains particularly in cuts where the underlying material may be hard rock.
- Erosion on steep grades and where the drain floor is in fine erodible material.
- Cracked lined sidedrains resulting in the ingress of water into the pavement layers.
- Mole activities next to or under the drains.

**Extent**
The problems can be either isolated or extensive. Wet weather inspection of the road reserve will facilitate the identification of the problem areas.
**Response Time**

Lack of attention to problems can lead to flooding, washaways, wetting up of the pavement structure and consequent pavement failure. Problems should be remedied before the start of the next wet season.

**Repairs**

Most of the problems can be handled routinely by cleaning drains, cutting vegetation and removing blockages on a regular basis. Shallow drains (where water often stands or flows onto the road) should be deepened. This may require the removal of rock. In a number of cases shallow drains are associated with flat terrain and flat gradients where deepening of the drain won't help. In such cases concrete lining of the drain increases the rate of flow and also prevents saturation of the road prism. It is important always to have a continuous fall even if it is small.

V-shaped earth drains are prone to blockages resulting in erosion of the road prism. Where these occur they should be reshaped to form a trapezoidal (table) drain profile.

Where erosion is a problem this can be treated by concrete lining (expensive), grouted stone pitching, packing of stones in the drain, grassing of the drain, soil stabilization or putting in transverse gabion bars/bolsters (the steeper the grade the closer the spacing). The local conditions should be examined to determine which materials are available, which measures are suitable, and the costs involved before selecting the best option.

Where inlet grids have been removed or stolen, these should be replaced immediately so that large objects do not block the drainage system and for road safety. Replacement grids should be welded or chained to the frame, or made with material which has no resale value like concrete.

**Caution**

- Remove all debris off site. Do not dump on the side of the drain as this material is likely to be
washed back into the drain during heavy rain.
- Total removal of vegetation particularly in soils may start erosion.
- Construction of gabion bars/bolsters requires detailed attention to design and spacing - erosion around the outside edges can cause further problems.

**BRIDGES AND CULVERTS (REFER ALSO TO CHAPTER 13)**

**Description**
Bridge and culvert structures are constructed to allow stormwater to pass beneath the road. Most common problems relating to bridges and culverts are blockage, flooding, overtopping, collapsing of culverts through erosion and cavities formed at prefabricated culvert joints.

**Causes**
- Blockage is caused by debris transported during large storms, vegetation in the water course, poor drainage downstream, incorrect location of the structures’ invert level and collapse of culverts.
- Flooding/overtopping if the opening size is too small or where rainfall exceeds the drainage design criteria.

**Extent**
Normally isolated problems but can be extensive in areas of fine-grained erodible soils and farming activity or at times of high rainfall. All structures should be regularly checked including over and underpasses.

**Response Time**
Problems should be identified as they occur and quickly dealt with especially during the wet season. Blockages at drainage structures can result in standing water on the road, alongside the road (wetting up of, pavement structure) and in heavy rain overtopping and washaways.

**Repairs**
Clear out the blockage material making sure that this is removed from the road reserve to a suitable spoil site (otherwise it could well get...
washed back into the structure or its drainage path). Poor discharge downstream requires careful checking of the levels, including the structure's invert levels. If action is needed outside the road reserve the landowner must be consulted. In some instances the floor of the structure may be so low that there is not adequate fall downstream and the structure may have to be allowed to silt up to an even gradient. In this case check the capacity of the structure. This should also be done where water regularly dams up at the structure or overtops the road. Insufficient capacity requires enlarging of the structure or the construction of extra drainage structures. Normally this work will not be done under routine maintenance and the Route Manager must inform SANRAL so that appropriate action can be taken.

**MITRE DRAINS**

**Description**
Mitre drains provide a means for the water in the side drain to be shed away from the road into the adjacent property. The most common problems are blockage and water not flowing in the mitre drain.

**Causes**
- Blockage caused by vegetation, too sharp a change in direction of the water from the side drain to the mitre drain and too flat a gradient on the mitre drain.
- The mouth/entrance to the mitre drain in a flat area constructed too deep and the water does not flow. Where this occurs there is often associated cracking in the adjacent pavement surface.
- Fenceline debris or soil where the drain extends outside the reserve.

**Extent**
General problems with mitre drains are isolated.

**Response Time**
If mitre drains do not function correctly water will continue to run in the side drain and overload its capacity. These drains should be maintained on a routine basis but particularly just before the wet season.

**Repairs**
Identify the cause of the blockage eg. vegetation in the mitre drain, loose material deposited due to poor alignment of the mitre drain or loose material from the side drain due to other problems, and then take appropriate action. Check the levels at the entrance and in the mitre drain. It may be better to close the mitre and have a general gentle slope away from the road prism.

For cases where the drain extends beyond the reserve fence, the adjacent landowner will need to be contacted for assistance in resolving the problem.
BERMS

Description
Berms consist of shallow embankments or mounds usually placed transversely to the side drain to deflect the flow of water. Most common problems are breeching or erosion.

Causes
Erosion and breeching of the berm occurs when the berm material is too fine or there is no protection to the berm in the form of vegetation or stone pitching. Lack of maintenance to the protected face can also result in failure.
Berms may be incorrectly positioned resulting in water bypassing the culvert or damming up without reaching a culvert inlet.

Extent
Usually an isolated problem.

Response Time
Failure of berms can lead to the downstream culverts being overloaded or silted up. The condition of berms should be routinely checked and repairs should be effected before the next wet season.

Repairs
Depending on the problem either select less erodible material, protect with grassing, stone pitch the berm or reposition it.

CATCHWATER DRAINS (SUMMIT/CUTOFF DRAINS)

Description
Catchwater drains are usually positioned on the upslope side above the cut face and parallel to the road. The purpose of the catchwater drain is to intercept sheet flow and prevent erosion of the cut face. Most common problems are blockage, lack of fall in the drain and erosion.

Causes
- Blockage caused by debris washed downslope, or vegetation growth.
- Unevenness in hillside or hardness of underlying rock resulting in a drain that is shallow in places and may not have adequate fall. During heavy rain the drain overtops at these places and water runs down the cut face causing severe erosion.
- Erosion in sandy materials.

Extent
Isolated or intermittent problems but in similar countryside may occur in many of the cuttings.

Response Time
Blockages should be routinely cleaned.
Repairs
Where drains are shallow they should be deepened. Where this is not practical (say hard rock and undulating hillside) a channel or down chute should be constructed at problem points. Where erosion occurs in the catchwater drain, particularly on steep downgrades, the drain should be protected by lining (grass, pitching, concrete, etc). An earth berm or stone masonry wall could be constructed on the downside of the drain, rather than deepening the drain which could then erode in soft material. Loose material spilled onto the road should be broomed off and the side drain cleaned.

Caution
Because of the location of catchwater drains (i.e. Generally above high cut slopes) they are often not inspected until a failure occurs.

SUBSURFACE DRAINS
Descriptions
Subsurface drains are installed below ground levels in areas where the subsurface water could be problematic. The purpose of the drain is to provide a medium which is more permeable than the surrounding soil so that the water will drain away in the subsurface drain. Main problems with subsurface drains are incorrect selection of materials, poor installation and inadequate outlet. Subsurface drainage is often a problem at the start and end of cuts and in weathered granite.

The locations of subsurface drains, particularly the outlets should be identified and marked appropriately so that maintenance teams can inspect regularly. Where it is evident that subsurface water is a problem (fountains in road after rain, pavement distress etc) and no drains have been constructed, SANRAL should be informed and actions to correct the situation agreed on.

Causes
- Incorrect materials used in construction of subsurface drains resulting in blocking/non performance.
- Drains not properly installed with adequate fall and contaminated or not continuous not performing.
- The drain not working where either the outlet is blocked or situated below the water table.
**Extent**
Isolated problem

**Response Time**
Saturated areas result in wetting up of the adjacent pavement layers and often lead to structural pavement failure. Repairs should be carried out as soon as possible especially before the next wet season.

**Repairs**
Where a rodding eye has been installed, this should be used to clean or flush out the drain as much as possible. Cleaning or flushing from the outlet may also be effective.

However it is often difficult to identify the reason for non-performance. Investigate by opening up the obviously saturated area and inspecting the drainage materials, continuity and gradient. If the reason is not obvious seek specialist advice. Subsurface drain materials should be used in accordance with the supplier's specifications. Where the drain traverses soft material such as clay it may be advisable to line the invert with suitable material. This prevents contamination and also sagging of the drain pipe.

Formal outlet structures should be constructed for all subsurface drains. Rodding eyes, where these have been installed, should also be formally protected and identifiable.

**Caution**
The subsurface drain must have an outlet point that is free draining.

### 10.3 EROSION CONTROL

In the preceding paragraphs, erosion is often mentioned as a problem in drainage management. Erosion can occur widely in the road reserve, at structures, in drainage paths and on fills or cuts.

Before protection measures are installed, the reason for the erosion should be established (e.g. fill slope next to culvert too steep). Certain measures such as the provision of catchwater drains, or raising headwalls, may cure the problem without resorting to protection measures such as grassing, stone pitching, concrete paving or gabions/mattresses. Should protection measures be required existing measures used
in the region should be inspected to establish whether they work. Often several remedial treatment options are identified and a decision should then be made based on relative costs and competency of the Contractor.

Erosion at the abutments and on the approach fills can be a problem, particularly on older bridges. Check all structures carefully and take appropriate measures in conjunction with SANRAL.

The concentration of water over long lengths of side drain without adequate cross drainage structures is often the cause of excessive erosion in the side drain. Where the earth sidedrain is V-shaped, erosion often results, particularly on medium to steep grades in erodable material.

Thunderstorm

Gabion baskets to prevent erosion at drain outlet