Chapter 5: Drainage, Ditches, and Culverts

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Safety Tips for Maintaining Drainage, Ditches, and Culverts

Always check with your supervisor and follow your agency’s safety policies and procedures.

Suggested personal safety equipment

- Hard hat
- Safety glasses
- Heavy gloves
- Hard-toed boots
- Highly visible apparel

Advance preparations

- Be properly trained in principles of excavation safety and be thoroughly familiar with equipment.
- Make sure an up-to-date first-aid kit, emergency contact information, and hand-held radios or cell phones are available at the work site.

During operations

- If road is open to traffic use proper temporary traffic control, including flagger(s) if needed, as described in the Iowa Traffic Control Devices and Pavement Markings: A Manual for Cities and Counties; in the MUTCD, part 6; and in your agency’s policies and procedures.
- Wear highly visible apparel when out of your vehicle.
- When excavating, make sure a competent person trained in excavation safety is available at the work site.
- Do not enter a trench or excavation over four feet deep without proper shoring and/or sloping.
- Remove all temporary traffic control immediately when no longer needed.
There’s an old saying that the three most important elements in road maintenance are drainage, drainage, and drainage.

**Water on or under the roadway is the single most significant cause of damage to the roadway.** Problems related to water include rutting, cracking, potholes, erosion, washouts, heaving, flooding, and premature failure of the roadway.

To prevent these problems and help ensure a roadway achieves its designed service life, you need to do three things:

- Get water off the road.
- Get water out of the road.
- Get water away from the road.

The solution: a good drainage system. Such a system includes several elements, all of which must function properly and be well maintained:

1. Surface drainage (crown, shoulders, foreslope and backslope, and ditches). See figure 5–1.
2. Subsurface drainage (pavement drainage layer, under drains/edge drains).
3. Inlet drainage structures (primarily in urban areas).
4. Culverts (primarily in rural areas).

![Figure 5–1. Ditch with good drainage](image-url)
Characteristics of Good Drainage

A successful drainage system will drain water away from the road in an adequate amount of time, as shown in table 5-1.

Elements of Good Surface Drainage

Crown

A road’s crown should have sufficient slope from the pavement centerline to the edge to make sure water will effectively drain off the roadway surface. When the slope is too flat, water can pond on the surface and migrate through joints and cracks into the pavement or under the surface. This can lead to pavement cracking and potholes. Water that doesn’t drain off the roadway can also present a safety hazard to motorists by introducing the possibility of hydroplaning.

Maintenance workers can affect the crown on gravel roads only. In general, a crown between four and six percent is adequate for gravel roads. See chapter 3.

Shoulders

To aid in drainage, shoulders should be flush with the adjacent roadway, slope slightly away from the roadway, and have no erosion problems or secondary ditches. Earth shoulders should be mowed in accordance with local agency policies and procedures. See chapter 4.

Slope

Slopes are normally referred to by the ratio of the run to the rise. For example a 4:1 slope is four feet horizontal distance to one foot vertical distance (run to the rise).

The degree of foreslope and backslope is determined by design standards (e.g., AASHTO’s Green Book and Iowa DOT’s design guide) and local conditions (e.g., cohesive soils, or rights of way). Local conditions may require that slopes be designed and constructed steeper or flatter than the design guides suggest.

Whatever slope has been designed and constructed should be maintained at the same ratio of run to the rise.

<table>
<thead>
<tr>
<th>Drainage Quality</th>
<th>Time for 50% Dissipation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>2 hours</td>
</tr>
<tr>
<td>Good</td>
<td>1 day</td>
</tr>
<tr>
<td>Fair</td>
<td>1 week</td>
</tr>
<tr>
<td>Poor</td>
<td>1 month</td>
</tr>
<tr>
<td>Very poor</td>
<td>(Water will not drain)</td>
</tr>
</tbody>
</table>
Ditches
Ditches collect runoff from the road surface. A well-maintained, smooth-flowing ditch will be free of heavy vegetation (tall grass, trees, cattails, etc.) and standing water, with enough grade to ensure self-cleaning and continuous flow. (Ditches with flat percent-of-grade allow residue or debris to settle and fill in the ditch. If sediment accumulates, water may erode a new path outside of the ditch area.)

Culverts
Culverts are well maintained when the flow line and the design slope from inlet to outlet still exist. No sections have settled, and all joints are tight and not separated. The curtain walls are not exposed, and the downstream channel has not started to erode.

Inlets
In well-maintained inlets, the inlet structures are straight and true, marking devices are in place and visible, and the surrounding pavement and joints are sound and water tight. The inlets are free of debris and silting, and the adjacent vegetation is not impeding the ditch drainage flow.

Elements of Good Subsurface Drainage
A subsurface drainage system carries water from beneath the pavement to appropriate drainage features, like ditches or storm drains. An excellent sign that this system is well maintained and in good working order is the absence of “frost heaves” in the winter months.

The elements of subsurface drainage include a granular drainage layer and subdrains (under drains and edge drains).

Granular Drainage Layer
A well-maintained granular drainage layer is uniform in thickness, the width detailed in the plans and specifications, and of the proper material gradation.

Under Drains/Edge Drains
A well-maintained system of transverse and longitudinal drainage pipes effectively intercepts and carries water out of the granular layer. Under drains carry water from the granular drainage layer to edge drains. Edge drains are installed under shoulders, longitudinally adjacent to the pavement. See figure 5–2.

Edge drains are constructed during roadway construction. Perforated pipe is installed in a trench parallel to the roadway, which is then backfilled with an open-graded aggregate. Caps of impervious soil are placed on top of edge drains to prevent surface water from draining into them. Filters may be used to prevent fine-grained soil from clogging the open-graded aggregate or the pipe itself.

Water from the under drains is collected in a non-perforated edge drain pipe that discharges into a roadside ditch or a storm sewer system.
All subdrains should maintain the flow lines and the design slopes. The outlet water flow should be clear and uniform, indicating that erosion is not occurring and the system is not clogged.

**Optimal Timing/Conditions for Maintenance**

The drainage system should be closely observed after a major storm event, when the effectiveness of the system will be most evident. In addition, culverts and other drainage features should be inspected on a routine schedule as directed by the policies and procedures of your agency. The results of these inspections should be recorded in a database.

Maintenance activities are generally scheduled when there will be the least damage to these features. For example, ditch cleaning will be scheduled when water in the ditch has dissipated (if possible) and there is some stability in the soil to support the weight of equipment. In addition, your supervisor will likely schedule regular drainage system maintenance, perhaps semiannually or in conjunction with drainage or roadway improvements.

**Drainage Maintenance Activities**

Maintenance operations include activities that focus on the road surface and then move out to the roadway edge and subsurface. Several activities related to surface and subsurface drainage are common to both rural and urban environments. (Activities specific to urban or rural environments are discussed separately later in this chapter.)

**Iowa One Call: It’s the Law**

Iowa law requires that anyone planning any form of excavation must contact the Iowa One Call notification system (1-800-292-8989) at least 48 hours in advance so that utilities can be located and marked. Always consult your supervisor before conducting any excavation, which may include ditch-cleaning operations or other activities related to maintaining drainage systems.

![Figure 5-2. Edge drain](image)
**Surface Drainage Maintenance Activities**

For information about maintaining crowns (on gravel roads) and shoulders, see chapters 3 and 4.

**Maintaining Ditches**

Motor graders and excavators are commonly used to clean ditches. Be careful when creating a steeper ditch grade. A too-steep grade may accelerate runoff enough to seriously erode the ditch. A too-flat grade will not drain properly, as shown in figure 5–3.

**Beware of Methamphetamine Trash**

When maintaining ditches, be alert for abandoned materials from methamphetamine-manufacturing labs. These hazardous materials require special handling. Consult your supervisor, and follow your agency’s policy.

Figure 5–3. A flat ditch may not drain properly (Lee Co.)
Subsurface Drainage Maintenance Activities

The granular subsurface layer, under drains, and edge drains must be maintained.

Maintaining Granular Drainage Layer

Few routine maintenance activities are generally necessary for the granular drainage layer. As long as it stays clean and undisturbed, it will function as intended.

However, maintenance crews do need to be careful of the granular drainage layer when performing other maintenance activities. One of the best examples is full-depth pavement patching. When the deteriorated pavement is removed, the granular drainage layer is exposed. It is very important that this layer is not disturbed and or contaminated with dirt, etc., that would reduce its effectiveness.

Maintaining Subdrains

Few routine maintenance activities are generally associated with under drains and edge drains. As long as drains are clean and undisturbed, they will function as intended.

However, maintenance crews do need to be careful of these drains when performing other maintenance activities, like repairing shoulder edge drop-offs, foreslopes, and backslopes, and ditch-cleaning operations. Be aware of the location of drains and outlets and be careful not to damage them.

Urban Drainage Systems

Drainage issues unique to urban situations include water running from the pavement to a curb and gutter (shoulder) and then into a storm sewer system (ditch). (Curb and gutter inlets and storm sewers are also used in rural areas where shoulders and foreslopes on roads are easily eroded or backslopes are too steep to cut in a ditch. Sometimes a curb and gutter system will be used on the low side of horizontal curves to control erosion of the shoulder material and to manage edge drop-offs.)

Paved Curbs and Gutters

Curbs and gutters collect runoff water from the pavement and direct it to inlets. Maintenance activities include keeping curbs and gutters clear of debris and silt so that water can run freely to the inlets.

Inlets, Storm Drains, and Manholes

In enclosed drainage systems, water is collected from the curb and gutter by inlets and funneled through storm drains into an underground storm sewer. Storm sewer runs are connected by inlets (one storm drain) and manholes (where two or more storm drains meet) which, in addition to funneling water into the storm sewers, allow personnel to access the storm sewer.
Maintenance activities include the following:

- Remove debris and silt from inlets so that water can freely enter the storm sewer.
- Make sure the pavement around inlets and manholes is sound and has water-tight joints, which prevents deterioration of the structure. See figure 5–4.
- If the storm sewer lines are too flat, clean and flush them regularly.
- Clean drains regularly. If they are too flat, you may have to excavate and realign them to a grade that promotes good water flow.

Figure 5–4. Water-tight joints at an inlet
Rural Culverts

Culverts provide drainage under driveways, roads, slopes, and adjacent areas. Their grade and direction should conform as closely as possible to that of the water they are carrying. See figures 5–5, 5–6, and 5–7.

Figure 5–5. Culvert (profile view)

Figure 5–6. Culvert (section view)

Figure 5–7. Culvert (plan view)
**Culvert Observation Activities**

Culverts are major drainage structures. Culvert failure can be catastrophic, causing serious injury or death, and costly restoration or reconstruction.

City and county road maintenance workers are generally not responsible for extensive culvert inspection and repair. However, as you drive over culverts in your jurisdiction or work in their vicinity, you can and should be aware of the signs of culvert stresses or other problems and report them immediately to your supervisor.

Signs of potential problems could include the following:

- A dip in the pavement over a culvert (could indicate settlement or a structural problem).
- High water lines (may indicate a drainage problem).
- Accumulated debris and/or signs of bank erosion upstream of the channel (may indicate a drainage problem).
- Debris on fence lines or backslopes.
- Erosion around the headwall.
- Wet ditches or vegetation (may indicate standing water).

**Maintenance Issues for Culverts**

You may also need to perform some basic housekeeping/maintenance activities as directed by your supervisor.

**Clogs and Siltion**

Culverts get clogged because debris accumulates at the culvert inlet. They become silted when the grade is too flat and the flow is restricted.

To solve the debris/silt problem, conduct these maintenance activities:

- Stop debris upstream by using a barrier.
- Clean the culvert frequently, making sure debris can pass through the culvert.
- Steepen the culvert grade to promote self-cleaning.

**Scour**

Scour is erosion from water in a roadway ditch or a stream channel.

Scour may occur at culvert inlets if the inlet is choked with debris. Remove the debris to restore water movement. Another possibility is that the inlet capacity is simply inadequate. The makeup of the drainage area may have changed since the culvert’s construction. In this case, the culvert will have to be reconstructed to provide a larger opening/capacity.

At outlets, scour occurs when a large volume of water is discharged at a high velocity. See figure 5–8. When scour occurs at outlets, curtain walls may be undermined. Repair the scour by backfilling the eroded area with suitable material, then placing riprap, concrete, or bituminous material to protect the outlet from further damage.
Abrasion
Culvert floors and sidewalls gradually deteriorate as a result of debris and sediment passing through the culvert. Inspect culverts at regular intervals for abrasive wear. Consider forming and paving a new invert or inserting a culvert liner, as directed by your supervisor.

Corrosion (Rust)
Metal pipe culverts experience corrosion when the protective coating is worn away by abrasion. Common maintenance is to replace the culvert or to insert a culvert liner. Consult your supervisor.

In concrete culverts, reinforced steel can be subject to corrosion in locations with very acidic water. There is no routine maintenance activity for this problem. When the deterioration becomes severe, a major repair of the culvert will be required.

Leakage
Leakage occurs when culvert sections separate at the joints. This is caused by movement of the embankment material or by faulty construction joints. Water leaking out of joints will erode the surrounding material, causing the joints to separate more and, eventually, undermining the structure itself. Regularly inspect culverts for leaks and repair the joints.

Cracks
Cracks may occur in culvert collars, cut-offs, and wing walls. Repair these defects using a sand-cement mortar containing an anti-shrinking additive.

Damaged Culvert Ends
Metal culvert ends are susceptible to damage. Remove the damaged sections by excavating the backfill and cutting off and replacing them.

Acidic water conditions (e.g., near a feedlot) may require plastic pipes or specially coated pipes instead of corrugated metal.
Drainage Laws

A drainage district is a quasi-governmental agency that administers drainage issues within an established area. Drainage districts are generally responsible for maintaining tile lines within the districts. Street and road agencies, however, are responsible for responding to problems and coordinating repairs where tile lines outlet into or cross the right of way.

Before starting any work on tile lines, check with your supervisor and follow your local policy. Find and mark all tile lines in the area so you don’t accidentally damage them. Any tile lines that are damaged must be repaired.

If you’re going to divert drainage, make sure affected property owners have signed a release and that there’s minimal likelihood that the diversion will cause any property damage.

The Iowa Drainage Law Manual is available from the Local Technical Assistance Program. The manual answers questions frequently asked by local road agencies. For a copy of the manual, contact the librarian, 515-294-2981, hoganj@iastate.edu. You can also download it, www.cte.iastate.edu/pubs/drainage_law/index.htm. Development of the manual was sponsored by the Iowa Highway Research Board, TR-497.

RULE OF THUMB

The primary concept behind all drainage law: “Do no harm.” Don’t flood anyone, and don’t cause erosion by sending water rushing downstream.
BIBLIOGRAPHY


