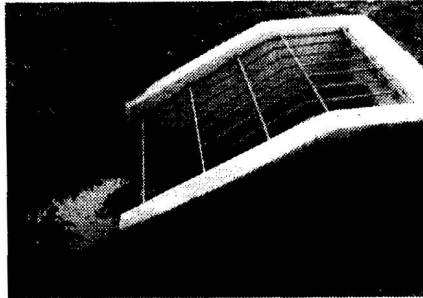


MAINTENANCE OF DRAINAGE FEATURES FOR SAFETY

A Guide for
Street and Highway Maintenance Personnel



U. S. Department
of Transportation

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I. Introduction

Drainage of streets and highways is a broad subject. It includes water flow in street gutters, the flow of water in roadside ditches, and the flow of water across the pavement. Some ways of maintaining the street or roadway to control the water flows will increase safety and other ways will not.

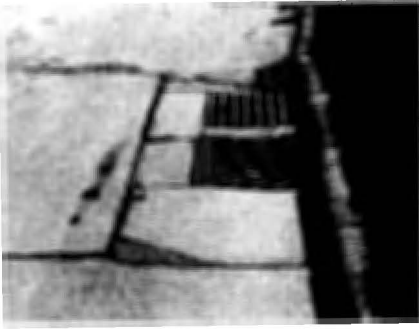
For example, some grates can be very good at draining water but at the same time may be hazardous to bicycles or pedestrians. Driveways may have culverts that work for carrying water, but are hazardous to vehicles that miss the driveway or run off the main road.

Pictures and drawings in this handbook show some points about road drainage features that are important to safety. If you pay attention to details like these on your everyday maintenance work, you can make a big difference in safety.

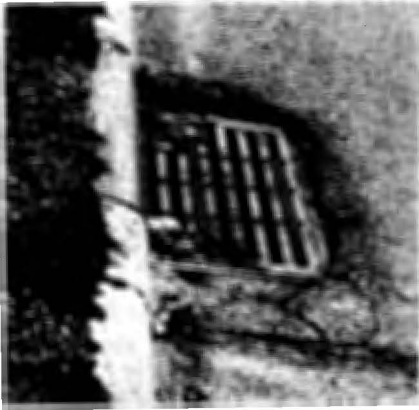
This handbook is organized by roadway features:

- Streets and gutters
- Shoulders and roadway cross slope
- Culverts and small drainage structures
- Roadway entrances
- Traffic control
- Maintenance tips.

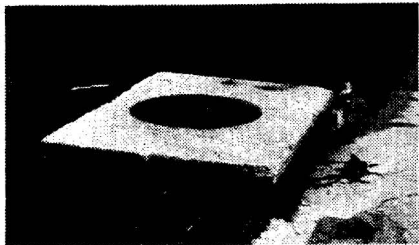
II. Streets and Gutters



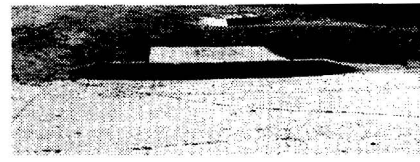
This photograph shows an inlet with two different grate designs. The one grate has slots at an angle, and the other grate has slots running parallel to the street. The grate with slots at an angle is much safer for bicyclists or anything with narrow wheels. Check with your supervisor to see if you can replace parallel grates with a safer design.



This inlet has been modified by adding small reinforcing bars across the slots. The bars are to stop bicycles from falling into the slots. But, notice the bars trap stones and litter on top of the inlet. This reduces the amount of water the inlet can handle and will increase ponding. Be sure your "improvement" doesn't cause another problem.



Here is a curb inlet on a residential street. This inlet should be changed so it has the edge flush with the gutter line. A vehicle or bicycle getting too close to the edge of the street is in danger of snagging the raised top on the inlet. Broken concrete on the corners of an inlet suggests that it has been hit more than once in the past.



The inlet shown in this photograph has a raised concrete top like the one in the previous photograph. In this case, a curb ties into the raised top of the inlet. But, the curb is only a few feet long. Long driveway entrances on each side of the inlet have turned down curbs. The inlet still sticks out from the traveled lane as an obstacle and reduces safety. Report the location of such inlets to your supervisor.



This curb inlet was built with a metal cover over the inlet that matched the shape of the concrete curb. Exposed bolts, broken metal edges, and the open holes over part of the inlet are hazards to all traffic. Report inlet conditions like this to your supervisor.



There may be a low area (sump or swale) beyond the curb or edge of the pavement where drainage is collected. This photograph shows a well-maintained roadside swale where the drain inlet is clear of debris and the gentle slopes prevent erosion. Avoid raised structures like this. Flat grates would be safe and effective.



This photograph shows a sump that is poorly maintained. The swale and the ditch area have not been cleaned or regraded. Water can pond over this sump during a rain, which may reduce soil support at the edge of the pavement. Check sump inlets after a rain. Report any conditions which require cleaning or other maintenance.



Suburban street drainage often gets changed because of adjacent construction. This photograph shows a sump inlet that has been almost covered up by a grading contractor. Your agency might have an inventory of minor drainage structures (inlets, culverts, location of storm sewer pipe lines). Use it to keep track of what is happening to the drainage system.



Drainage structures on private property can create problems on the road. In this photograph, a paved channel carries water from a private parking lot to a sump inlet which leads to a storm drain. Debris is collecting in the sump, which will allow water to run over the sidewalk into the street. This could cause a problem on the public road. Look for trash and sediment that might clog a drainage channel.



This photograph shows where storm water has washed the soil out under a paved channel. A small hole has started at the edge of the pavement where the water goes under the channel. This will gradually wash out under the pavement and become a hazard for motorists. Inspect drainage structures and repair them while damage is small.



In strip commercial areas, traffic can often drive over the edge of the curb for a long distance. Watch for water at the edge of the pavement as shown in this photograph. Since these low spots are on the street right-of-way, they should be repaired as soon as the area is dry.



The raised cover for the inlet in this picture is a hazard for a vehicle leaving the roadway. Since this inlet is about 6 m (20 ft) from the edge of the roadway lane and there is a low speed limit, it is not urgent that this inlet be replaced immediately. However, if you notice any of these on high-speed roads [75 km/h (45 mph) or more] or close to the edge of the road, report them to your supervisor.



Sometimes large stones are dumped in a washout as a quick fix until a full repair can be made. Never leave large or loose stones on the edge of the roadway as shown in this photograph. Level the stones and mark the area with warning devices such as vertical panels.



As you go about your regular maintenance work, look for streets where pavement overlays have filled up the gutters, such as shown in this picture. When very little gutter is left, a heavy rain storm can cause water to spread over the entire pavement. Flooded pavement is very dangerous, especially for high-speed traffic. Report any areas like this to your supervisor.

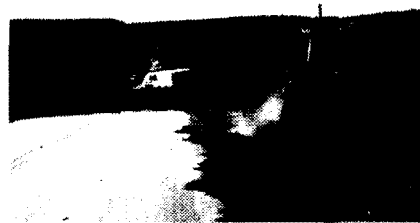


Maintaining good street drainage may require you to work with other agencies. This photograph shows a local street intersection that is flooded when adjacent streets are dry and no rain has fallen for some time. In this case, the ponding is on a town road, but is caused by a clogged drain on the adjacent interstate highway. If you see a problem caused by something outside your right-of-way, report it to your supervisor so an agreement can be worked out with the other agency or landowner.

III. Shoulders and Roadway Cross Slope



Good maintenance is needed to prevent a drop off at the edge of the pavement. This photograph shows a deep rut that was left when a truck ran off the pavement onto a soft shoulder. The shoulder needs to be regraded so the rut will not wash. Even in this condition it is a danger to cars and bicycles. If the drop off is more than three inches and you cannot do the work immediately, place warning devices such as vertical panels or barricades with flashing lights to warn motorists.



A deep rut at the edge of the pavement can usually be corrected by reshaping the shoulder and foreslope with a motor grader. As a final step, blade or sweep the loose material off the road.



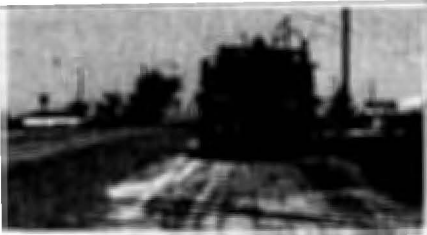
The shoulder in this photograph needs to be brought up flush with the pavement. This type of drop off can be repaired by placing gravel along the edge of the shoulder and building it up to the existing pavement. Sweep loose gravel off the pavement onto the unpaved areas.



A safe and efficient shoulder maintenance operation includes care in reshaping the shoulder and positioning the equipment. A motor grader blades the shoulder and drags the material toward the edge of the pavement. This fills any ruts and restores a shoulder slope to drain water away from the pavement.

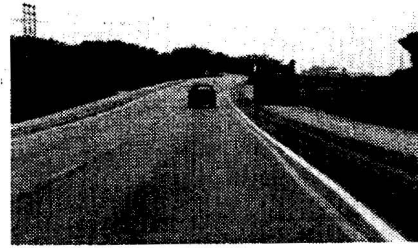


Behind the motor grader is a utility tractor with a light blade set to scrape any loose material off the pavement. The tractor blade is set so the material is spread on the shoulder at or near the edge of the pavement. Do not leave a ridge of material at the edge of the pavement.



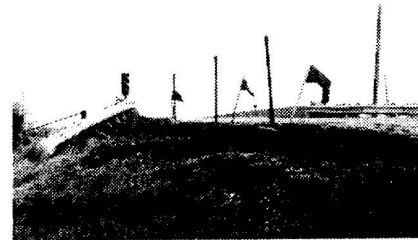
A dump truck towing a rubber-tired roller follows to compact the reshaped material. Packing the shoulder helps hold the drainage slope and prevent more rutting from traffic.

A warning sign such as **ROAD WORK AHEAD** [1200-mm x 1200-mm (48" x 48")] is mounted on the back of the roller. Each piece of equipment has a rotating beacon.



If you are adding aggregate to a high-speed road, try using a team of three dump trucks with spreader boxes. The lead truck distributes stone in a smooth even swath several feet wide at the edge of the shoulder. The second loaded dump truck (also equipped with a spreader) follows using the outer rear dual wheels to compact the aggregate. When the lead truck is empty, the second truck begins spreading. The third truck becomes the compaction unit. In this way three or more trucks can provide a continuous operation.

ROAD WORK AHEAD signs should be set on the shoulder at the beginning of the work area. See the chapter on work zone traffic control for details.



When you blade and reshape a gravel road, do not cut into the shoulder or leave a roll of gravel. Either one can form a channel for water to run along the road instead of draining off to the side. This photograph shows a gravel road approaching a bridge over Interstate 80. Trapped water soaked into the embankment and caused it to slide, pulling the guardrail over with it. After you shape a shoulder, some shovel work may be necessary to make the shoulder drain.



Watch out for erosion around culverts. Water leaking (piping) along the culvert can wash out the compacted roadway material leaving a large hole under the roadway surface. This photograph shows a hole that has been washed several feet from the end of the culvert. The next time a vehicle drives over this pipe, the hole will probably cave in. Warning signs or barricades should be placed immediately to keep people off this part of the road. As soon as the work can be arranged, inspect the culvert for breaks and leaks. If there is a serious break in the culvert, you may have to replace the pipe. If there are no breaks or leaks, then excavate enough to replace and tamp the backfill next to the culvert. Then replace the aggregate surface.

Be alert for erosion of the foreslope and shoulder at

- the ends of culverts
- the breaks in a gravel windrow along the shoulder of an aggregate-surfaced road
- the bottom of a sag vertical curve,

This photograph shows a small washout that needs to be filled in to reduce the hazard and stop erosion.



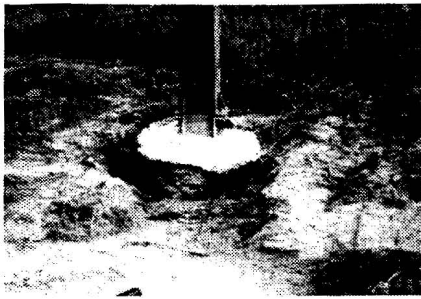
These two photographs show a condition to watch for where steep cuts limit the shoulder and drainage ditch width. Surface drainage is collected in drop inlets and erosion around an inlet can cause it to cave in. Replace such an inlet with a grate in the sump of the inlet, with a slope no steeper than a 1 foot drop in 10 feet of horizontal run from all directions. This should provide a safe and workable drain. Always follow your agency's guidelines.



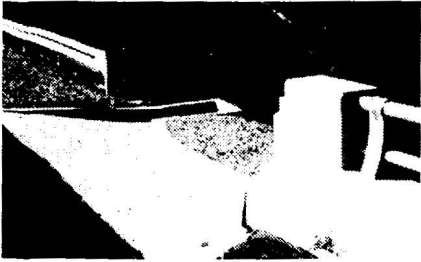
A curb section is often added at the low point of a sag vertical curve to catch water and direct it into a small flume, which drops it into the drainage ditch.



Watch for broken curbs when doing routine maintenance work. A broken curb allows erosion to start. In some cases, several cubic feet of rubble or large stone maintained at the bottom of the drainage flume can reduce erosion.



Watch for erosion around the base of sign supports. The soil around this breakaway sign base has washed out. Place and compact soil around the footing so the soil is within 10 cm (4 in.) of the slip base. Also check the ditch, it may need to be cleaned to prevent this condition from happening again.

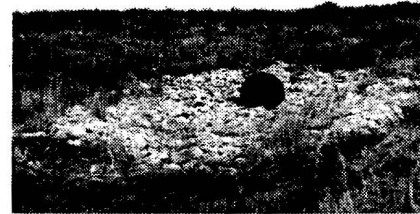


This photograph shows a well-maintained curb and flume at the end of a bridge. However, the guardrail ends before it ties to the bridge. If you find a gap in a guardrail or a sharp curb in the shoulder area, mark it with a vertical panel or warning barricade to show drivers they should stay away from it. Report the location and condition to your supervisor.

IV. Culverts and Small Drainage Structures



This photograph shows a road intersection with a reinforced concrete box culvert and two corrugated metal pipe culverts all combining water from different directions into the roadside ditch. The combined flows have caused deep erosion in the ditch and made the foreslope of the ditch much steeper than needed. Report any condition similar to this to your supervisor for an engineering evaluation.



Large stones have been placed around this culvert end. This holds soil around the end of the culvert so it is not a hazard to vehicles that run off the road.



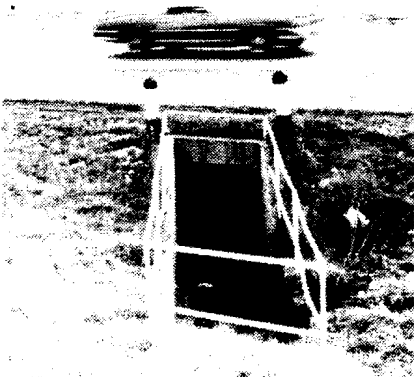
This photograph shows a culvert end that does not extend much beyond the edge of the gravel road entrance to a paved highway. The end of the culvert is bent out of shape and no longer carries water efficiently, causing erosion around it. Replace the culvert with a longer one and regrade the intersection so the water drains toward the ditch and not along the top of the culvert.



This photograph shows a ditch that needs cleaning so it will drain. Ponding will cause silt to fill in and eventually reduce the ditch flow capacity.



This photograph shows the result of a ditch not draining. The ditch is filled with sediment, and the culvert can no longer drain water from the other side of the road. A recent rain overtopped the road and washed out a big section of the shoulder. Inspect and clean ditches and culverts regularly to prevent this or similar problems.



This photograph shows a headwall opening with two painted posts and a light gauge pipe railing to mark the opening. But this isn't a good way to protect motorists. A safety grate can be constructed from large diameter pipe that will allow water to flow freely into the culvert and will allow a vehicle to drive over the culvert opening. Report any culvert opening that you think is unsafe to your supervisor.



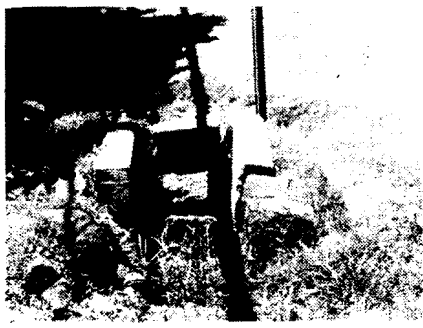
A pipe grate has been added to this culvert. A vehicle running off the road can pass over the end of the culvert without overturning. Grates over culverts do require periodic inspection to make certain the grate is in place and to clear debris if needed. An annual inspection is suggested if your agency does not have a policy.



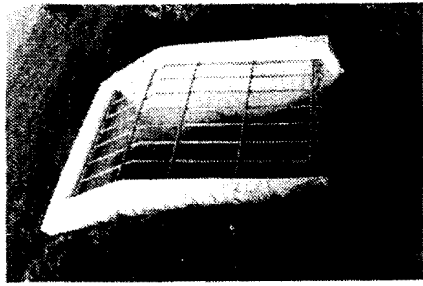
This photograph shows a new culvert end section with a grate. It will work very well for both safety and drainage if little debris is present.



This shows a culvert end section that is old, has broken edges, and a loose grate. Grass and litter have collected in the end and will prevent good drainage. Replace the end section to make it drain well and to be safe for vehicles to cross.



This photograph shows an inlet with a masonry wall that is badly broken. Inlets like this at the edge of the shoulder or in the foreslope are hazardous. Report them to your supervisor. Such inlets should be replaced with inlets similar to the one shown in the next picture.

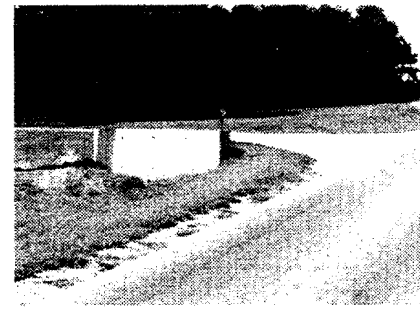


This inlet has vertical walls that have been shaped to the slopes of the roadway foreslope and has a grate of welded reinforcing bars.

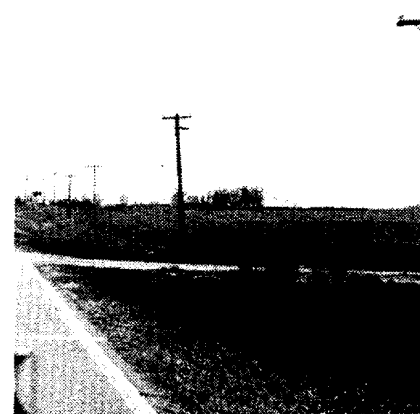


Small bridges and culverts on rural roads often catch large debris, such as trees and brush after storms. Here a farmer had cut small trees in a field drainage ditch upstream from this culvert. The local road crew had to clear the trees and brush from the culvert. Check culverts and bridges, especially after storms, for debris on the upstream side. Missing a clogged culvert or bridge might cause a washout in the next storm.

V. Roadway Entrances



This driveway is located where the public road has a steep grade. A concrete retaining wall was built on the downhill side of the driveway probably to let the driveway have a flat cross section and avoid a long culvert. To protect vehicles from the drop-off, the retaining wall sticks up about a foot above the driveway. This creates a serious hazard to any vehicle running off the road. Report such situations to your supervisor.



This driveway entrance has loose stone walls for retaining the driveway embankment. A second wall has been added to form a flower planter. While this may be attractive, it is a hazard to vehicles running off the road. Check with your supervisor before taking any action. Also, find out where the right-of-way line is. Your agency may decide to flatten the slope to 10:1 and extend the culvert as part of a safety improvement to that section of the road.



The driveway entrance in this picture is at a commercial property at the edge of town. Even though it is a potential hazard, it is beyond a simple maintenance operation to fix. Report it to your supervisor.



This field entrance has been graded with a flat slope facing traffic. The additional soil to flatten the slope was excavated from the ditch during routine cleaning operations. Look for ways to combine operations like this to increase safety and your efficiency.



The driveway in this picture has very flat slopes (about 10:1). The ditch line is away from the edge of road so the culvert under the driveway is near the right-of-way line. This makes it less likely that someone will hit the culvert end. These improvements will also reduce long-term maintenance.

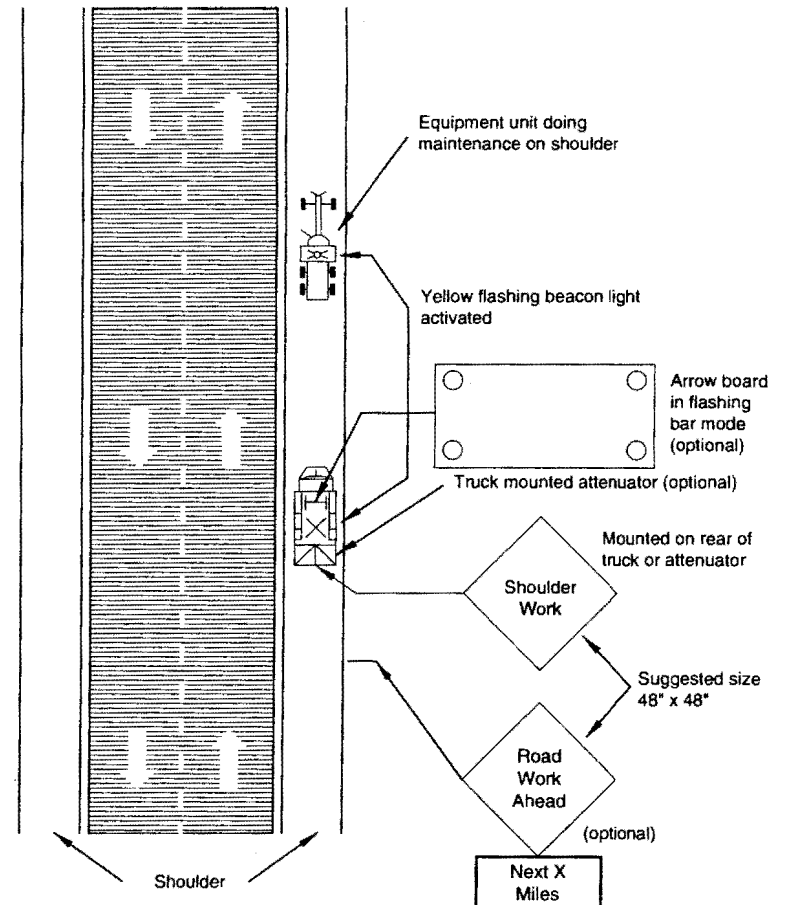


A mailbox on a large post is a hazard. Reshaping the shoulder and driveway entrance during maintenance can provide room for mail carriers to pull off the road. Check with your supervisor before doing the work.

VI. Traffic Control

Some of the drainage-related maintenance suggested in this handbook is a moving maintenance operation, such as blading and compacting an aggregate shoulder. Other activities such as installing or repairing a grate to a culvert end section or ditch cleaning may require closing a shoulder or a lane to traffic. The following are suggested guidelines for minimum traffic control to advise street and highway traffic.

Typical Traffic Control for Mobile Operation on Shoulder



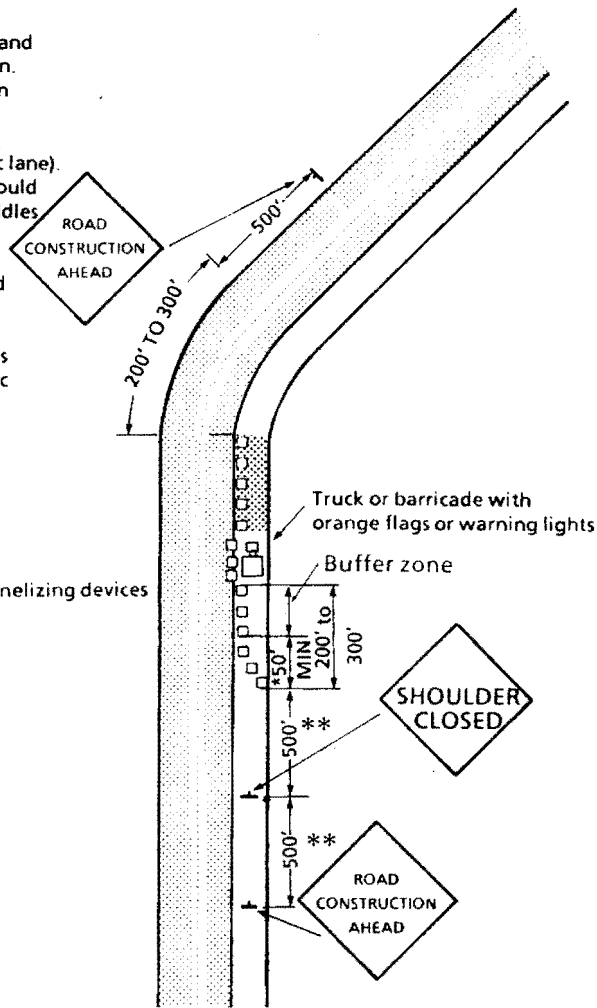
Typical Traffic Control Layout for Shoulder Closure

NOTES:

1. Daytime operation and short repair duration.
2. Use this layout when repair work is on or within 2 feet of the traveled way (traffic lane).
3. Flaggers, if used, should use STOP/SLOW paddles instead of red flags.
4. Buffer zone may be reduced or extended depending on available sight distance.
5. Keep parked vehicles away from the traffic as much as possible.
6. Keep buffer zone free of obstacles or hazards.

KEY:

□ Channelizing devices



* See taper cone spacing table
 ** 200' in urban areas

Equipment Check List—Shoulder Closure Work Zone Traffic Control Devices

1. Cones:		
Taper, see table below for spacing of five cones		5
Buffer zone (minimum of five spaced at 2 times speed in MPH)		—
Work area (minimum of five spaced at 2 times speed in MPH)		—
		—
	TOTAL	—
2. Signs:		
ROAD CONSTRUCTION AHEAD		2
SHOULDER CLOSED		1

Spacing Guideline for Suggested 5-cone Shoulder Taper

Road speed limit (MPH)	Cone spacing (ft)
20	10
25	10
30	15
35	20
40	30
45	45
50	50
55	55

NOTES:

1. You will need at least 15 cones. Depending on where the work is, the kind of road, and other conditions, more devices might be needed. When in doubt, use more cones. **YOUR SAFETY IS AT STAKE.**
2. Any of several delineation devices may be used: cones, type 1 or type 2 barricades, drums, tubular markers, or vertical panels. Check with your supervisor for local policy.
3. Maximum spacing between devices is approximately equal in feet to the speed limit in MPH.

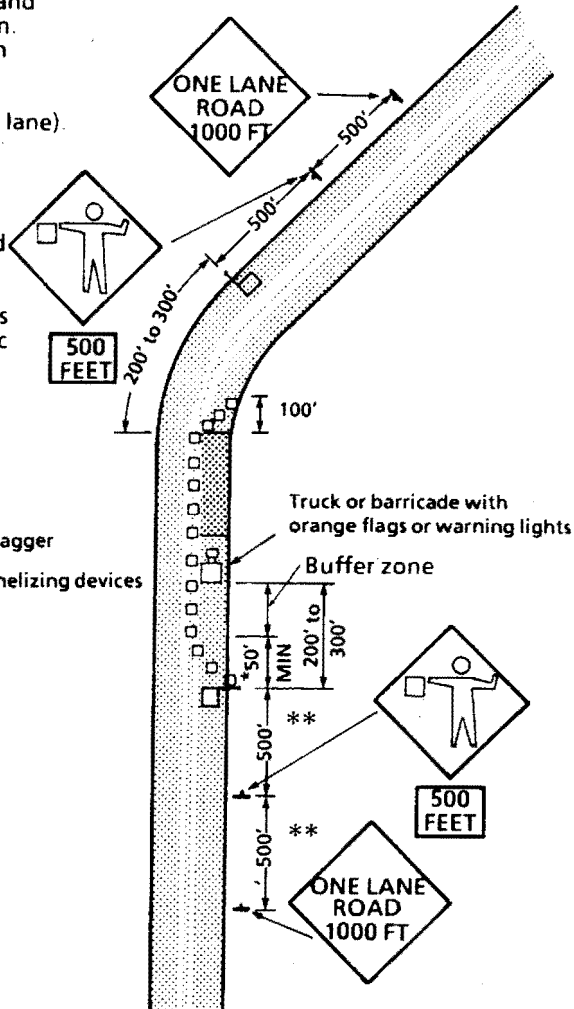
Typical Traffic Control Layout for Lane Closure

NOTES:

1. Daytime operation and short repair duration.
2. Use this layout when repair work is on or within 2 feet of the traveled way (traffic lane).
3. Flaggers should use STOP/SLOW paddles instead of red flags.
4. Buffer zone may be reduced or extended depending on available sight distance.
5. Keep parked vehicles away from the traffic as much as possible.
6. Keep buffer zone free of obstacles or hazards.

KEY:

- Flagger
- Channelizing devices



* See taper cone spacing table
 ** 200' in urban areas

Equipment Check List—Lane Closure Work Zone Traffic Control Devices

1.	Cones: Taper, see table below for spacing of cones (minimum of five) Buffer zone (minimum of five spaced at 2 times speed in MPH) Work area (minimum of five spaced at 2 times speed in MPH) End section	5	
	TOTAL		
2.	STOP/SLOW paddles	2	
3.	Signs: ONE LANE ROAD AHEAD FLAGGER AHEAD, with distance plate	2 2	

Suggested Spacing for Cones in a Taper

Road speed limit (MPH)	No. of cones	Lane Width		
		10'	11'	12'
20	6	18	19	20
25	6	21	23	25
30	7	25	27	30
35	8	29	32	35
40	9	34	37	40
45	13	38	42	45
50	13	42	46	50
55	13	46	51	55

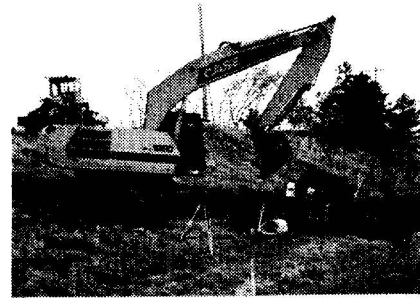
NOTES:

1. You will need at least 20 cones. Depending on where the work is, the kind of road, and other conditions, more devices might be needed. When in doubt, use more cones. **YOUR SAFETY IS AT STAKE.**
2. Any of several delineation devices may be used: cones, type 1 or type 2 barricades, drums, tubular markers, or vertical panels. Check with your supervisor for local policy.
3. Maximum spacing between devices is approximately equal in feet to the speed limit in MPH.

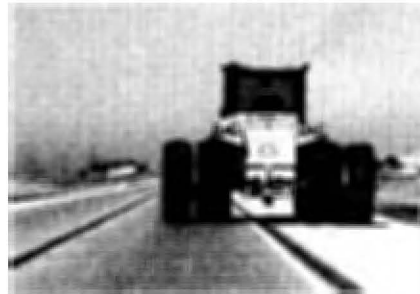
VII. Maintenance Tips



After floods, check bridges for scour around footings and for debris collected around piers. Failure to repair scour can lead to collapse of the bridge during the next storm. Collected debris can plug the waterway and cause the structure to be washed out. Either failure would cause financial loss and be a major safety hazard.



When using a dragline, backhoe, or similar equipment close to overhead or underground power lines, take extra care. Crew chiefs should call MISS UTILITY before digging (or the underground utility clearing house for your area). When laying a culvert, always check it with a surveyor's level to be sure it will drain in the right direction. If you have excess material to be hauled away, try to have enough trucks so that one empty truck is always waiting to be loaded.



In areas where very large farm equipment or large, heavy trucks will be using the road, patrol your routes about once a month for low or rutted shoulders. If your agency has a different policy, follow it.



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