Safety on streets and highways is essential to motorists, bicyclists, and pedestrians. Drainage systems that remove storm water run-off from streets and highways are an integral feature of a safe system. Water that remains on the roadway surface can contribute to vehicle hydroplaning. In winter, standing water can freeze and cause skidding.

\footnote{In the context of this RON Update, the roadway includes the travel lanes and shoulders, if any. Streets and highways are considered roadways or roads. The travelled way is that portion of the roadway for vehicle travel.}

The curbs, gutters, channels, and ditches that carry the run-off from the roadway can have a serious effect on an errant motorist or bicyclist when not designed and maintained correctly. Erosion along the roadway can also contribute to the severity of a crash or inundate crashworthy systems such as breakaway sign supports. Even headwalls, pipe ends and grates on drop inlets and pipe openings need to be safety-treated when they are within the area an errant motor vehicle or bicycle can reach.

**Maintaining roadway drainage** is important for safety and for ensuring the long life of the roadway by:
- Preventing erosion of the roadway.
- Preventing saturation of the subbase.
- Preventing damage to roadway structures.

This **RON Update** is intended to help *local road agency maintenance workers* understand the importance of maintaining and upgrading drainage features on their road system to avoid an unsafe condition. Its purpose is to highlight common roadway drainage problems that can cause an unsafe condition and suggest inspection methods and corrective action. *This guide is not intended to be a design guide.* Readers may want to contact their County Engineer, City Engineer, ODOT District Office, or ODOT’s Office of Hydraulic Engineering for more details on drainage design.

**How Storm Run-Off Affects Roadway Safety**

There are many factors affecting safety on local streets and highways, and one of these is how drainage—the run-off of water from the pavement and shoulder—is treated.

The primary objective in treating drainage is to ensure that safe operating conditions exist on the
roadway. This is done by removing storm run-off, providing for snow removal, and reducing the ability for ice to form on roadways and bridges. Additionally, the drainage systems used on the roadway should not be hazardous or reduce the crashworthiness of other systems, such as breakaway signs and guardrail.

Also included as part of this objective is the safe design and maintenance of drainage features, such as travel way and shoulder surfaces, drop inlets, pipe ends, safety grates, and gutters.

**Travelled Way Pavement Surface**

**Drainage factors** that affect safety on the travelled way of streets and highways include:

1. Even a thin layer of water on the travelled way surface can initiate motor vehicle hydroplaning at speeds as low as 35 MPH. When a vehicle tire rides on top of this thin layer of water, the vehicle cannot be steered or stopped easily. A vehicle that is hydroplaning behaves similarly to a vehicle on ice.
2. **Water ponding** in the wheel paths or ruts is also very dangerous, particularly for motorcycles and bicycles. Water ponding at intersections may be especially hazardous as vehicles may require greater distances to stop.
3. Travelled ways are generally designed to provide sufficient cross slope to facilitate storm run-off; however both traffic and maintenance activities can and often do affect the original cross slope of the roadway surface. Traffic, particularly heavy truck traffic, can cause wheel ruts in the pavement surface.

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(2) Ponding refers to water collecting on the pavement or shoulder that is deteriorated. Standing water refers to water collecting on the surface due to insufficient cross slope or backup in the drainage system.

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*Water Ponding in wheel ruts.*
Rutting or surface depression in wheel paths is a pavement distress than can have several causes, including surface wear or vertical deformation of pavement or subgrade layers under traffic loading. Rutting usually runs parallel to the centerline of the roadway. When wheel ruts are noticeable, they are generally deep enough to pond sufficient water to initiate hydroplaning.

Another pavement condition, often referred to as shoving, can occur where vehicles frequently stop, such as at intersections. Shoving is most common at stop locations, particularly on steep downgrades. Shoving results in a series of ridges running across the roadway. The ridges can retain water and are hazardous even when dry because they cause the wheels of a vehicle to bounce, reducing wheel contact with the roadway surface and decreasing braking ability.

Ponding or standing water in the travel way may also cause some drivers, bicyclists, or pedestrians to divert from their desired path. Storm drains or drop inlets that have collected debris, such as leaves, can cause ponding during and after storms. Both motor vehicle and bicycle operators may choose to avoid going through the water by encroaching on the opposing lane, thus endangering themselves and opposing traffic.

In sections of the travelled way where storm water run-off drains directly onto the shoulders (where there are no curb and/or gutters), water may collect along the edge of the travel way. Water on a portion of roadway can result in drivers losing control of their motor vehicle, particularly when braking in an emergency. This can happen when the inside tires are in contact with roadway surface while the braking ability of the outside tires is hindered by the water.
Water can pond on the outside edge of the travel way surface when debris, particularly aggregate and soil on turf shoulders, builds up. As debris accumulates on the shoulder, it raises the level of the edge, and eventually hinders run-off from flowing into side ditches.

Water ponding at the edge of the roadway.

Water ponding on the edge of the pavement contributes to the deterioration of the pavement edge and the rutting of stabilized soil supporting the pavement edge, which can result in additional safety hazards. **Edge drop-offs and shoulder scour** are often caused when water is trapped at the pavement edge by the build-up of debris and vegetation growth.

Deterioration of pavement edge and shoulder due to poor drainage.
Partial overlays and pavement repairs can result in water being trapped and retained on the travel way surface. Partial overlays, either to correct shoulder deterioration or widen the roadway surface, result in a pavement edge where the overlay stops. Depending on the size of aggregate in the overlay mix and the effort taken to feather the lip into the existing pavement, water can be retained on the travel way. When the lip is along the wheel path, the thin layer of retained water can initiate hydroplaning, reduce braking ability or freeze and contribute to skidding.

The edge of this partial pavement overlay is causing water to be retained on the travelled way surface.

The safety of pedestrians and bicyclists can also be jeopardized by poor drainage in the travelled way, shoulder, or paths. While these users are more able to avoid or compensate for standing water or ice in their path, maintenance activities and relatively low-cost improvements can prevent drainage problems and improve the safety for these users.

RECOGNIZING DRAINAGE PROBLEMS

The drainage problems discussed in the previous section can directly cause or contribute to crashes. As an example, drainage features that fail to remove run-off because they are too small or are clogged and pond water on the roadway can cause hydroplaning or force drivers to leave their lane.
It is important to identify these potentially hazardous situations as soon as possible. Some of these conditions may have been in existence for quite some time, while others may have recently developed as a result of a storm or change in weather conditions. For areas of the country that are subject to freezing, the spring thaw frequently reveals pavement, shoulder and roadside deterioration.

A clogged drain can easily be detected during a field survey.

Drainage problem locations can be identified in several ways:

- **Citizen complaints**—Citizens drive the roads every day and are the first to notice problems. You should have an easily identified phone number, e.g. on your web site, where citizens can call in problems and complaints.

- **Local police**—Your local police patrols can also identify drainage problems. Police personnel need to be instructed on what types of drainage problems they should be on the ‘look out’ to report.

- **Crash data**—A periodic review of crash data can reveal some locations where drainage deficiencies may be a contributing factor. Locations that experience a higher than average number of wet weather crashes may have deteriorated pavement surfaces. Also look for crashes with fixed objects, which could include drainage structures that need to be removed or protected by a barrier.
- **Field reviews**—Potentially hazardous drainage features are best identified through field reviews. Drainage features may be reviewed alone or in a combined safety review. An excellent time to review a road or section of highway is when there is other highway work being planned. For example, if a section of road is scheduled for an overlay, the section may be reviewed to determine if there are any safety improvements that can be included. Including drainage improvements on other projects will often reduce the cost of the work and the inconvenience to the public.

**FIELD INSPECTION CHECK LIST (CHECK FOR THE FOLLOWING CONDITIONS)**

1. Rutting or shoving of pavement surface.
2. Discontinuity of surface level between the pavement and shoulder (shoulder drop-off).
3. Accumulation of earth or debris on shoulder.
4. Existence of erosion channels on ditch side slopes.
5. Silt or debris accumulation in ditch.
6. Headwalls and drainage structures that are not flush with the ground.
7. Damage to drainage structures, such as crushed culverts.
8. Grates with wide openings parallel to the roadway that can trap bicyclists.
9. Drains blocked by soil and debris.
10. Side slopes that have steepened due to erosion.
11. Erosion around all roadside structures such as headwalls, sign posts, and guardrail posts.
12. Drainage structures within clear zone that are not traversable or protected by suitable barrier system.

**Maintaining Good Drainage at Intersections and Access Points**

**Access points**, such as road intersections, driveways, pedestrian and bicycle crossings are important areas where drainage features should be reviewed and, where appropriate, improvements made.

At access points, the grade of the highway and the access point have to meet. Consequently, the free flow of run-off is restricted and some drainage feature is usually built to move the water away. Drainage facilities, particularly those for driveways, may have been poorly constructed by developers or property owners and may be potential hazards. Local jurisdictions may have established laws requiring access points to be free of hazards and obstacles that could affect the safety of the traveling public.
In this photo, water is ponding because the outflow ditch has silted up. Ponded water can cause drivers to leave their lane, reduce braking ability or contribute to pavement deterioration.

WORKER SAFETY

The first consideration during any installation or maintenance of drainage features is the safety of both the work crew and the motorist. Therefore, remember to follow these safety procedures:

- Assure workers have proper Personal Protective Equipment.
- Before any excavation begins, contact the Ohio Utilities Protection Service to determine if underground utilities are in the area.
- Follow safe trenching operation techniques.
- Comply with confined space requirements.
- Be aware of crushing hazards and pinch points.
- Be aware of loose materials, excavation drop-offs, tripping hazards, uneven ground.
- Avoid walking and working under suspended loads.
- Determine escape routes in case of emergency.

In addition, before work begins, it is important to set up proper work zone traffic control. Appendix A provides three typical traffic control plans that may be applicable depending upon the type of work being performed -- use layout no. 1 (6H-1) when the work is beyond the shoulder area; use layout no. 2 (6H-6) when the work is being done on the shoulder; and use layout no. 3 (6H-17) if the work is a moving operation such as for cleaning out curb inlets. These are for illustrative purposes; refer to the Ohio Manual of Uniform Traffic Control Devices (OMUTCD) for more detailed guidance.
REFERENCES


**DISCLAIMER:** This RON Technical Update is provided for purposes of general information only. This is not a primary technical or legal authority, and should not be relied upon as such. Interested persons should refer to the source documents referenced herein. Please note also that information contained in this document could become outdated or obsolete over time.

APPENDIX A:

THREE TYPICAL WORK ZONE LAYOUTS FROM THE OMUTCD
1. Typical Traffic Control Layout for Work Beyond the Shoulder

![Diagram](image-url)
2. Typical Traffic Control Layout for Shoulder Work with Minor Encroachment

![Diagram of Shoulder Work with Minor Encroachment](image)

*Figure 6H-6. Shoulder Work with Minor Encroachment (TA-6)*

Note: See Tables 6H-2 and 6H-3 for the meaning of the symbols and/or letter codes used in this figure.
3. **Typical Traffic Control Layout for Mobile Operations on Two-Lane Road**

![Figure 6H-17. Mobile Operations on Two-Lane Road (TA-17)](image)

Note: See Tables 6H-2 and 6H-3 for the meaning of the symbols and/or letter codes used in this figure.

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