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DR-11.100 FUNDAMENTALS

DR-11.110 General

A substantial part of highway expenditures is for the purpose of improving existing highways. The type of improvements can include improvements in geometrics, level of service, safety, and/or repair and rehabilitation of various highway elements. These improvements may involve highway drainage.

DR-11.120 Planning Phase

The hydraulic consequences of a highway improvement need to be addressed during the planning phase of the project. Failure to assess the hydraulic aspects of the improvement could result in an increase in damages to adjacent property and the highway facility.

DR-11.130 Coordination and Cooperation

Opportunities for coordination, cooperation and input from utilities, individual property owners or with other agencies are sometimes present in highway improvement projects. Cost sharing, maintenance, and other responsibilities for cooperative projects need to be addressed when planning the improvement. Coordination with other agencies and the public must be initiated early in the project location phase and continued as necessary through subsequent stages of project development.

DR-11.140 Other Agencies

Several Federal, State or local agencies could have an interest in the drainage aspects of a particular improvement project. The modification or replacement of a drainage structure could:

- affect an existing or planned project by another agency;
- render an action feasible that may not have been practical with existing conditions;
- afford a flexibility in the channel bed elevation; effect the size and/or conveyance characteristics at the crossing;
- involve preserving existing vertical and horizontal clearances in navigable or recreational waters;

- present the opportunity for a cooperative storm drain project with a city or county; and

- expedite the development of another project.

DR-11.150 Utilities

It is important that every effort be made to identify all utilities that may impact a highway improvement project because they can be a major consideration both in the design and cost of the improvement project.

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DR-11.200 PERMITS AND APPROVALS

DR-11.210 General

Highway improvement projects are subject to the same permit requirements as highways on new alignments. Applications for permits and approvals required by Federal, State, local, and other agencies should be made early in the project development.

DR-11.220 National Flood Insurance Program

Under the National Flood Insurance Program, flood profiles, are published as part of a flood insurance study, should include the effects of existing highway facilities that are located in the study area. Improvements to highways within the limits of flood insurance studies can usually be accomplished without objection, as long as they do not increase the elevation of the base flood water surface computed for the regulatory floodway. Formal approval of such projects from the Federal Emergency Management Agency may, however, still be required.

DR-11.230 Federal Water Pollution Control Act

If the highway improvement project is on the same alignment, a 404 permit is easier to obtain than it would be for a highway on a new alignment, because the impact on the stream and floodplain is usually less. In environmentally sensitive areas, stay on the existing highway alignment. A Section 404 permit may be required for detours constructed with the highway project.

The Corps of Engineers has issued general permits for certain minor works. Projects that meet the conditions for general permits can be constructed without an individual project permit. Federal-aid projects that are determined to be categorical exclusions can be processed using the nationwide general 404 permit under an agreement between FHWA and the Corps of Engineers.

DR-11.240 Navigation

Highway improvement projects that involve navigable waters of the United States require the same permits in connection with navigation as do new projects, and coordination with navigational interests should be initiated early in the project development stage.

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DR-11.250 State and Local Permits

State, Metropolitan Sewer District, and Lexington Fayette County Urban Government Storm Water Permits are pending.

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DR-11.300 TYPES OF RESTORATION

DR-11.310 Improvement Needs

There are many kinds of highway improvement projects ranging from minor pavement patching to complete reconstruction of several miles or more of existing highway. Whenever these projects are undertaken, drainage facilities should be analyzed to determine if existing or proposed facilities are adequate.

DR-11.320 Horizonal or Vertical Adjustments

Adjustments to the horizontal or vertical alignment of a highway are actually changes in the location of the highway. The highway is reconstructed except where a part of the old embankment is used. Reconstruction can:

- result in changes in roadside ditch drainage,
- require either the replacement or the modification of existing drainage structures,
- change the hydraulic performance of the structure, and
- cause increased headwater that affects adjacent property.

DR-11.330 Cross Section Changes

The roadway cross section is significantly changed in many highway improvement projects. When a change to the roadway cross section is proposed, the effects of the change on highway drainage facilities must be recognized and dealt with, including:

- increase in runoff due to a greater impervious area or more direct ditching;
- changes in roadside drainage from open to closed systems;
- changes in the hydraulic performance of drainage structures;
- adjustment of existing storm drains and utilities.

DR-11.340 Widening Roadway

Pavement may be widened without any significant change in the highway cross-section and consequently no significant effect

on drainage results. Other widening may affect drainage. The hydraulic characteristics of the drainage system should be analyzed for these projects.

DR-11.350 Flattening Foreslopes

Whenever foreslopes are flattened the culverts need to be extended, and the effects of the project on existing roadside ditches must be determined. This type of project also can affect the backslopes and right-of-way.

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DR-11.400 SURVEYS

DR-11.410 Data Needs

The survey items required for highway improvement projects are substantially the same as for a highway on a new alignment. In addition information on the condition of the structure being improved is required, as is specific information about the past hydraulic performance of structures, and identification of any other problems with the existing structure.

DR-11.420 Existing Structures

Most highway improvement projects require some modification to the existing structures or to the roadway over the structures. Necessary structural repairs to the bridges, culverts, and storm drains that lie within the limits of the improvement project should be included with the other project work. Culverts in particular should be inspected throughout their length, before they are extended. The condition survey should provide information about:

- scour, settlement, joint separation and piping;
- alignment with the stream;
- susceptibility to plugging;
- corrosion and/or abrasion damage;
- inlet blockage damage, crushed inlets, etc.;
- recent levees, fills, or other man-made features that affect the hydraulics;
- vegetative growth; and
- high water information.

Information about the hydraulic performance of existing culverts and bridges is not always available but an effort to obtain this type of information should always be made because it is extremely valuable input into the hydraulic design of an improvement.

A side-tapered improved inlet should be routinely considered for all inlet control culverts in urbanizing areas with attendant discharge increases. Incorporating this type of inlet improvement within the expanded highway template will increase the hydraulic capacity of inlet control culverts, negating the additional culvert size in some instances.

DR-11.430 Existing Conditions

There are a number of other hydraulic related conditions which may affect the drainage requirements including:

- stream stability or the rate and amount of aggradation, degradation, or bank (meander) movement;
- debris problems;
- changes in land use, either past or proposed;
- pier scour and bank scour at bridges, or outlet scour at culverts;
- upstream or downstream structures that have caused or could cause difficulties to an existing structure; and
- channel improvements that have been made or are planned.

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DR-11.500 HYDROLOGY

DR-11.510 General

Hydrologic studies for a replacement bridge or culvert are in many respects the same as those required for structures on a new alignment. There are, however, important differences in the information available at replacement structure sites which can provide valuable input into the hydrologic analysis.

DR-11.520 Observed Flood Discharge

Knowledge of how an existing bridge or culvert performs during high runoff events is an important addition to the design of drainage facilities. Survey data collection will normally provide information about past flood events. This survey information should include high water data. The designer can relate this historical high water data to a discharge. At those sites where discharge information can be obtained from a gaging station, the task of determining a discharge for the historical flood is simplified.

It is important, when evaluating past floods, that the designer is aware of conditions at the structure site which could affect the evaluation such as the following:

- changes in hydrologic techniques;
- flow obstructions;
- stream stability;
- levees or spoil banks;
- dams, reservoirs, ponding;
- downstream controls;
- land use changes;
- backwater conditions;
- changes in vegetation density;
- upstream storage; and
- changes in stream confluences.

DR-11.530 Hydrologic and Hydraulic Investigations

The hydrologic/hydraulic investigation for any highway drainage structure should be commensurate with the importance of the structure. This should apply to structures on new highways and existing structures that are being improved. Problem structures include locations where:

- frequent maintenance of the structures is required;
- complaints regarding the structure's performance have been received;
- the highway is frequently overtopped;
- the replacement cost is very high;
- river meanders threaten the highway;
- aggradation or degradation is evident;
- there is high offsite flood damage potential;
- environmentally sensitive areas are present;
- there is evidence of damage to the structure (wash out, scour, corrosion, abrasion, etc.); and
- plugging with debris often occurs.

It is also important to be aware of the possibility that replacement structures could cause new problems, such as drift and scour. This may be due to added piers and/or less freeboard because of deeper superstructures, changes in flow distribution, and changes in downstream peak flows.

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DR-11.600 HYDRAULIC CONSIDERATIONS

DR-11.610 Changes in Performance

Most highway improvement projects will require some modification of the existing drainage structures. This modification can vary from extension of small culverts to complete replacement of bridges. The effects on the hydraulic performance of the existing drainage structures can be significant or they can be negligible. If the hydraulic performance of a drainage structure is changed, the change should be investigated. The investigation should include both upstream and downstream effects. Some types of structure modifications and the consequences of change in hydraulic performance are discussed in the following subsections.

DR-11.620 Culvert Replacement and Rehabilitation

The following sections discuss the advantages and disadvantages of culvert replacement versus culvert rehabilitation.

CULVERT REPLACEMENT

When an existing culvert is to be replaced, an analysis should be made to see if the size of the existing culvert is either smaller or larger than necessary.

- Where an existing culvert is larger than needed for hydraulic purposes, but adequate structurally, it may be more economical to extend the length of culvert than replace it.

- When a culvert must be replaced for structural purposes, and a culvert with less hydraulic capacity is considered, one possible consequence is a significantly higher headwater at the culvert inlet.

- If enough water is ponded, the peak discharge from that drainage area may be lowered downstream.

- The consequences of replacing a hydraulically small culvert with a larger one could be:

  - reduced inlet headwater,
  - increase in the downstream flood flow, and
  - under very limited conditions, change pressure flow to open channel flow.

CULVERT REHABILITATION

Any proposed culvert rehabilitation scheme should be analyzed for hydraulic adequacy and outlet protection. If the cross-sectional area resulting from culvert rehabilitation is reduced, this could lead to higher headwater elevations; however, this effect may be insignificant if there is storage upstream or if the potential for damage is minimal. Routing of flood hydrographs for the proposed design is a good way of assessing increased risks where the upstream channel and floodplain contain significant storage. Corrugated metal culverts greater than 48-inches in vertical dimension should have at least a concrete anchor to minimize potential failure.

DR-11.630 Culvert Extensions

The extension of an existing culvert can result in significant changes to the hydraulic performance.

- Extending the inlet of a culvert operating in inlet control will raise the water elevation of the inlet by an amount equal to the difference in invert elevation between the original and reconstructed culvert, all other inlet conditions being equal.

- Extending a culvert which operates under outlet control will increase the headwater.

- Long culvert extensions can cause culverts to switch from inlet control to outlet control.

DR-11.640 Bridge Replacement

Where a proposed new bridge is larger than the existing bridge, there are rarely any significant detrimental consequences because of the change in size. An exception to this would be where the highway profile is raised, eliminating highway overflow. This may increase bridge backwater. If the grade is lowered, the flow pattern and the amount of flow directed over the road and onto downstream property could be increased, possibly decreasing the resultant backwater. When replacement bridges have shorter spans than the existing bridge, the resulting increase in the number of piers could add to debris and scour problems or increase backwater.

Where a proposed bridge is smaller than an existing bridge there may be some increase in backwater and in velocities in the bridge opening.

DR-11.650 Type of Structure

At most sites, the replacement structure will be of the same type as the existing structure; that is, bridges will replace bridges and culverts will replace culverts. Although, at some locations the hydraulic requirements of the site can be satisfied by either a bridge or by a large culvert.

BRIDGE REPLACING CULVERT

Locations where it may be advantageous to replace a culvert with a bridge would include sites where:

- a larger structure is needed;
- maintenance problems are serious;
- construction costs would be less;
- there may be a physical obstacle to a culvert;
- future channel improvements can be better accommodated by a bridge;
- clearance for boats and recreation is needed;
- abrasive sediment could make a bridge a better choice; and
- environmental considerations, foundation conditions, and channel configuration favor a bridge.

CULVERT REPLACING BRIDGE

Locations where it may be advantageous to replace a bridge with a culvert would include sites where:

- maintaining traffic through a construction site is made easier;
- bridges would create safety problems near intersections;
- a culvert could stop stream degradation by providing a fixed bottom;
- a culvert would take less time to construct;
- freeboard requirements are not as critical;

- a long bridge was originally built because of available construction methods;
- foundation conditions favor a culvert; and
- culverts provide more flexibility with horizontal and vertical alignments and have lower maintenance costs.

DR-11.660 Existing Structures

The following sections will discuss the influence that existing structures might have on the highway drainage structures.

UPSTREAM STRUCTURES

Structures that have been built immediately upstream from a highway, since the original highway construction, can influence the design for reconstructing a drainage structure. Upstream culverts that are undersized and small dams could detain a large enough volume of water during peak runoff events to reduce peak flows at the highway site. On the other hand, an inadequate structure may wash out and increase flows to the downstream structure. Accordingly, the highway culvert should be designed, considering the permanence and stability of upstream structures, any overtopping floods, and the potential risks involved.

The replacement structures also can affect existing structures upstream and downstream. If the grade of the highway is raised and an upstream facility is not raised, flooding of the upstream facility could result. This could be avoided by sizing the highway structure considering its effect on the upstream facility.

DOWNSTREAM STRUCTURES

Structures located downstream from a structure being designed can influence tailwater elevations at that drainage structure, causing it to operate under outlet control. Downstream structures also influence the position of the highway structures. Thus, the effects of all downstream structures should be analyzed.

DR-11.670 Improvements in Hydraulic Performance

Methods of improving hydraulic performance include:

- improved inlets on culverts,
- local channel modifications at bridges to reduce backwater,
- bridge structure modifications,
- debris control measures to prevent blockage of waterways,
- spur dikes at bridge sites to improve flow alignment and reduce scour,
- superstructure modifications to increase freeboard, and
- removal of obsolete structures.

DR-11.680 Added Structures

When improving an existing highway, there is sometimes a need for adding drainage structures or multiple-use structures. Additional drainage structures could be required for one or more of the following reasons:

- a need to provide more waterway opening,
- anticipated future drainage needs,
- a multiple-use structure may not be functioning well and an additional drainage structure may be warranted,
- a drainage improvement may require a lower flow line and an additional small structure to carry the smaller flow,
- elimination of roadway overflow,
- need to redistribute flood flows,
- need to equalize flow such as the flow in roadside ditches, and
- need to add storm drain systems in urban areas where widening projects eliminate roadside ditches.

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DR-11.700 EROSION AND SEDIMENTATION CONTROL

DR-11.710 General

The control of erosion and sedimentation is as important on highway improvement projects as it is on the original construction. Erosion problems on an existing highway indicate obvious areas where corrective measures are necessary when the improvement is being designed and constructed.

See Chapter 10 for erosion and sediment control methods.

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