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800.01 General

Hydraulic design factors can significantly influence the corridor, horizontal alignment, grade, location of interchanges, and necessary appurtenances required to convey water across, along, away from, or to a highway or highway facility. An effective hydraulic design conveys water in the most economical, efficient, and practical manner to ensure reasonable public safety without incurring excessive maintenance costs or appreciably damaging the highway or highway facility, adjacent property, or the total environment.

This chapter is intended to serve as a guide to highway designers so they can identify and consider hydraulic-related factors that impact design. Detailed criteria and methods that govern highway hydraulic design are in the Washington State Department of Transportation (WSDOT) *Hydraulics Manual* and *Highway Runoff Manual*.

Some drainage, flood, and water quality problems can be easily recognized and resolved; others might require extensive investigation before a solution is developed. Specialists experienced in hydrology and hydraulics can contribute substantially to the planning and project definition phases of a highway project by recognizing potentially troublesome locations, making investigations, and recommending practical solutions. Regions may request that the Headquarters (HQ) Hydraulics Section provide assistance regarding hydraulic problems.

Since hydraulic factors can affect the design of a proposed highway or highway facility from its inception, consider these factors at the earliest possible time during the planning phase.

In the project definition phase, begin coordination with all state and local governments and Indian tribes that issue or approve permits for the project.

800.02 References

(1) Design Guidance

Highway Runoff Manual, M 31-16, WSDOT

Hydraulics Manual, M 23-03, WSDOT

Standard Plans for Road, Bridge, and Municipal Construction (Standard Plans), M 21-01, WSDOT

Standard Specifications for Road, Bridge, and Municipal Construction (Standard Specifications), (Amendments and General Special Provisions), M 41-10, WSDOT

Utilities Manual, M 22-87, WSDOT

(2) *Special Criteria*

Special criteria for unique projects are available by request from the HQ Hydraulics Section.

800.03 Hydraulic Considerations

(1) *The Flood Plain*

Encroachment of a highway or highway facility into a flood plain might present significant problems. A thorough investigation includes the following:

- The effect of the design flood on the highway or highway facility and the required protective measures.
- The effect of the highway or highway facility on the upstream and downstream reaches of the stream and the adjacent property.
- Compliance with hydraulic-related environmental concerns and hydraulic aspects of permits from other governmental agencies per Chapter [225](#).

Studies and reports published by the Federal Emergency Management Agency (FEMA) and the U.S. Army Corps of Engineers are very useful for flood plain analyses. The HQ Hydraulics Section has access to all available reports and can provide any necessary information to the region.

(2) *Stream Crossings*

When rivers, streams, or surface waters (wetland) are crossed with bridges or culverts (including open-bottom arches and three-sided box culverts), consider:

- Locating the crossing where the stream is most stable.
- Effectively conveying the design flow(s) at the crossing.
- Providing for passage of material transported by the stream.
- The effects of backwater on adjacent property.
- Avoiding large skews at the crossing.
- The effects on the channel and embankment stability upstream and downstream from the crossing.
- Location of confluences with other streams or rivers.
- Fish and wildlife migration.
- Minimizing disturbance to the original streambed.
- Minimizing wetland impact.

For further design details, see the [Hydraulics Manual](#).

(3) Channel Changes

It is generally desirable to minimize the use of channel changes because ongoing liability and negative environmental impacts might result. Channel changes are permissible when the designer determines that a reasonable, practicable alternative does not exist. Consult the HQ Hydraulics Section for the best guidance when channel changes are considered.

When channel changes are used, consider the following:

- (a) Restoration of the original stream characteristics as nearly as practicable.
This includes:
 - Meandering the channel change to retain its sinuosity.
 - Maintaining existing stream slope and geometry (including meanders) so stream velocity and aesthetics do not change in undisturbed areas.
 - Excavation, selection, and placement of bed material to promote formation of a natural pattern and prevent bed erosion.
 - Retention of streambank slopes.
 - Retention or replacement of streamside vegetation.
- (b) The ability to pass the design flood.
- (c) The effects on adjacent property.
- (d) The effects on the channel and embankment upstream and downstream from the channel change.
- (e) Erosion protection for the channel change.
- (f) Environmental requirements such as wetlands, fish migration, and vegetation reestablishment.
- (g) The drainage pattern. Do not redirect flow from one drainage basin to another; follow the historical drainage pattern.

(4) Roadway Drainage

Effective collection and conveyance of stormwater is critical. Incorporate the most efficient collection and conveyance system considering initial highway costs, maintenance costs, and legal and environmental considerations.

Of particular concern are:

- Combinations of vertical grade and transverse roadway slopes that might inhibit drainage.
- Plugging of drains on bridges as the result of construction projects. This creates maintenance problems and might cause ponding on the structure. The use of drains on structures can be minimized by placing sag vertical curves and crossovers in superelevation outside the limits of the structure.

For discussion of the relationship of roadway profiles to drainage profiles, see [Chapter 1220](#).

(5) Subsurface Drainage

Subsurface drainage installations control groundwater encountered at highway locations. Groundwater, as distinguished from capillary water, is free water occurring in a zone of saturation below the ground surface. The subsurface discharge depends on the effective hydraulic head and on the permeability, depth, slope, thickness, and extent of the aquifer.

The solution of subsurface drainage problems often calls for specialized knowledge of geology and the application of soil mechanics. The Region Materials Engineer evaluates the subsurface conditions and includes findings and recommendations for design in the geotechnical report.

Typical subdrain installations control seepage in cuts or hillsides, control base and shallow subgrade drainage, or lower the groundwater table (in swampy areas, for example).

Design a system that will keep the stormwater out of the subsurface system when stormwater and subsurface drainage systems are combined.

(6) Subsurface Discharge of Highway Drainage

Consider subsurface discharge of highway drainage when it is a requirement of the local government or when existing ground conditions are favorable for this type of discharge system. Criteria for the design of drywells or subsurface drainage pipe for this type of application are described in the *Hydraulics Manual*. The criteria for the design of infiltration ponds are described in the *Highway Runoff Manual*.

(7) Treatment of Runoff

On certain projects, effective quantity control of runoff rates and removal of pollutants from pavement are intended to address flooding and water quality impacts downstream. (See the *Highway Runoff Manual* for specific criteria on quantity and quality control of runoff.)

800.04 Safety Considerations

Locate culvert ends outside the Design Clear Zone when feasible. (See [Chapter 1600](#) for culvert end treatments when this is infeasible.)

For detention ponds and wetland mitigation sites, see [Chapter 560](#) regarding fencing.

800.05 Design Responsibility

The *Hydraulics Manual* describes the responsibilities of the regions and the HQ Hydraulics Section regarding hydraulic design issues.

800.06 Documentation

For the list of documents required to be preserved in the Design Documentation Package and the Project File, see the Design Documentation Checklist:

🔗 www.wsdot.wa.gov/design/projectdev