9.2 Design Practices

9.2.1 ConnDOT Design Practices

The following design practices are specific to bridges:

- The final design selection should consider the maximum backwater allowed by the National Flood Insurance Program and Stream Channel Encroachment Lines unless exceedence of the limit can be justified by special hydraulic conditions.
- The final design should not significantly alter the flow distribution in the floodplain.
- The "crest-vertical curve profile" should be considered as the preferred highway crossing profile when allowing for embankment overtopping at a lower discharge.
- A specified clearance should be established to allow for passage of ice and debris. For navigation channels, a vertical clearance conforming to Federal requirements should be established based on normally expected flows during the navigation season.
- Degradation or aggradation of the river shall be estimated and contraction and local scour shall be computed. Appropriate positioning of the foundation, below the total scour depth if practicable, shall be included as part of the final design.

9.2.2 ConnDOT Practice-Substructures for Bridges over Waterways

Substructures for bridges over waterways shall be designed to safely support the structure subjected to the design scour. This policy is based upon the design guidelines contained within the FHWA document entitled “Evaluating Scour at Bridges” (HEC-18), wherein it states that “Bridges should be designed to withstand the effects of scour from a superflood with little risk of failing.”

With regard to abutment or pier foundations, two basic approaches to achieving this goal are available to the designer, listed as follows in order of preference:

1) Design the foundation to resist the effects of scour from a superflood.
   Foundations subjected to scour shall be designed with footings supported on piles, footings founded on rock or deep footings (located below the maximum estimated scour). Structural tremies (concrete poured under water which directly supports the foundation loads) will be allowed in very limited situations, only where no other solution is feasible, and only with the approval of the Department. Preference for foundations adjacent to or within waterways will be for pile supported footings or direct foundations on rock. For pile foundations, the top of pile cap shall be set below the sum of the long term degradation and contraction scour.

2) Protect the substructure units with riprap or similar armoring layers.
   In general, the use of riprap to provide scour protection for **new** bridges is discouraged and should be used only where it has been demonstrated that alternate, preferred means of designing bridges to be safe from scour related failures are not feasible. On bridge rehabilitation projects where the substructure is being repaired and incorporated in the reconstruction of the bridge, riprap scour countermeasures may be an effective solution for protecting the bridge from scour.

   The designer should explore and incorporate into the design all reasonable methods of minimizing local scour, such as the use of embankment or “stub” abutments placed at the top of a protected slope. These types of abutments are much less susceptible to scour than full height

abutments. The use of stub abutments does not relieve the requirement for founding on piles or directly on rock. Piers which may experience local scour should be flow aligned and should have streamlined end sections.

9.2.3 ConnDEP Requirements

The following definitions were taken from Section 25-68h-1 of the Flood Management Statutes and Administrative Regulations.

Sec. 25-68h-1. Connecticut floodplain management regulations for state agencies.

(a) Definitions.
(1) As used in Sections 25-68h-1, 25-68h-2 and 25-68h-3:
"Hurricane wave wash" means the effect of wave action in a coastal flood hazard zone.
"Significant impact" means any activity that would create:
(A) A five percent increase in peak flow rates at any downstream point;
(B) A twenty percent increase in flow velocities or a change that allows a stable condition to become unstable;
(C) An activity that contributes to an unacceptable cumulative impact;
(D) Any activity that causes flooding on developed property not currently subject to flooding;
(E) An activity that could cause a downstream dam to become unsafe.
"Velocity waters" means the effect of moving water in a coastal flood hazard zone.
(2) As used in Sections 25-68h-1, 25-68h-2 and 25-68h-3, the definitions of the following terms shall be the same as the definitions in Section 25-68b of the General Statutes: activity; base flood; base flood for a critical activity; Commissioner; critical activity, floodplain; flood-proofing; freeboard.

The following requirements for culverts and bridges taken from Section 25-68h-2 and Section 25-68h-3e(1) through (8) of the Flood Management Statutes and Administrative Regulations shall be incorporated into all ConnDOT projects.

- All state activities shall conform to the Federal Emergency Management Agency National Flood Insurance Program requirements, specifically Part 60 – Criteria For Land Management and Use, Subpart A Sections 60.3, 60.4 and 60.5. (See Chapter 2, Section 2.3.)
- The following restrictions shall pertain to all new and substantially improved structures located within the floodplain.
  1. Structures shall not be designed for human habitation unless elevated with the lowest floor one foot above the level of the base flood.
  2. Structures and all stored materials which may result in damage to other structures, restriction of bridge openings or other narrow sections of the stream or river shall be anchored or restrained to prevent them from floating away.
  3. Service facilities such as electrical and heating equipment shall be constructed at or above the elevation of the base flood or flood-proofed with a passive system.
  4. Structures located within a “coastal high hazard area” as defined in 44 CFR Part 59 shall be elevated on adequately anchored pilings or columns and securely anchored to such piles or columns such that the lowest portion of the structural members of the lowest flood (excluding the pilings or columns) is elevated to one foot above the base flood and certified

by a registered professional engineer or architect that the structure is securely anchored to piling or columns in order to withstand velocity waters and hurricane wave wash.

5. No new structures shall be permitted on undeveloped coastal barrier beaches as designated by the Federal Emergency Management Agency (FEMA).
6. All water supply equipment shall be designed to prevent flood waters from entering and contaminating the system.
7. All sanitary sewer collection systems located in the floodplain must have watertight manhole covers and if equipped with vents, shall extend above the elevation of the base flood.

- The following restrictions shall pertain to all filling, dumping, construction, excavating, and other activities which change the topography within the floodplain.
  1. No filling, dumping or construction or other activity shall be allowed which would increase the elevation of the base flood by more than one foot or adversely affect the hydraulic characteristics of the floodplain unless the proposed filling is fully compensated for by excavation in or contiguous to the filled area.
  2. No filling, dumping, construction or excavation will be allowed if these changes will result in a concentration of the natural flow of water such as to cause or increase drainage, erosion or sediment problems.
  3. Any fill placed in the floodplain shall not be greater than that which is necessary to achieve the intended purpose as demonstrated by a plan showing the uses to which the filled land will be put and the final dimensions of the proposed fill or other materials.
  4. Such fill or other material shall be protected against erosion as discussed in the Connecticut Guidelines for Soil Erosion and Sediment Control (1985), as may be amended.
  5. Any activity within a floodway designated by FEMA which would result in an increase of the elevation of the base flood or ten year flood profile is prohibited.
  6. The placement of fill in areas of high velocity flow or at the outside edge of a migrating river bend is discouraged.
- The following restrictions shall pertain to the storage of materials and equipment within the floodplain.
  1. The storage of materials that are buoyant, hazardous, flammable, explosive, soluble, expansive radioactive or which could be injurious to human, animal or plant life is prohibited below the elevation of the base flood for a critical activity.
  2. Other material or equipment may be stored below the elevation of the base flood for a critical activity provided that such material or equipment is not subject to major damage by floods, and provided that such material or equipment is firmly anchored, restrained or enclosed to prevent it from floating away.

- Culverts and bridges will be designed for flood frequencies and underclearances stipulated in this manual, except that on local (not state highways) roads and driveways with low traffic volumes and where alternate routes are available, lower design criteria is acceptable when:
  (A) Flood discharges may be allowed to cross over roads that are at or close to the floodplain grade.
  (B) Water surface elevations shall not be increased by more than one foot, nor allowed to cause damage to upstream properties.
  (C) Provisions are made to barricade the road when overtopped.
  (D) The road or driveway is posted as being subject to flooding.
- Bridges and culverts along stocked watercourses and watercourses which may support fish shall be designed to allow passage of fish as may be recommended by the Department of Environmental Protection Fisheries and Wildlife Units.

- The location of new bridges and culverts shall minimize the relocation of watercourses.
- Where applicable, rigid structural floors at bridges and culverts should be depressed below the normal streambed, to allow an alluvial streambed to form over them, and shall anticipate if the streambed is degrading.
- The use of solid parapet walls at bridges and culverts located in the sag part of vertical curves is discouraged. *
- Debris barriers shall be used upstream of structures prone to blockage by debris.
- The use of a single large culvert or bridge opening is preferred over use of multiple small openings.
- The underclearances and maximum headwaters stipulated in this manual may be waived when decreasing the headwater depth at existing structures could increase downstream peak flows or when it can be demonstrated that satisfying these criteria would be impractical due to site conditions and other factors.

* This applies to locations where there is roadway overtopping.

- **Stream Channel Encroachment Lines (SCEL) [*Repealed October 1, 2013*]**

1. Established - On any stream where channel encroachment lines have been established by the Department of Environmental Protection, authorization shall be obtained from the ConnDEP for the proposed structure in accordance with Section 22a-342 through 22a-349 and 25-68b through 25-68h, Connecticut General Statutes. The encroachment line study discharge shall be used for analysis; however, the design discharge may vary from this quantity.

2. Not established - On streams for which channel encroachment lines have not been established Section 25-68b through 25-68h and Section 13a-94 of the Connecticut General Statutes apply. The structures shall be designed using the appropriate storm frequency as stated previously and as indicated in Table 9-2.

9.2.4 Flood Management Definitions

Sec.25-68b. Definitions. As used in sections 25-68b to 25-68h, inclusive:

(1) "Activity" means any proposed state action in a floodplain or that impacts natural or man-made storm drainage facilities, including, but not limited to, the following: (a) Any structure, obstruction or encroachment proposed for emplacement within the floodplain area; (b) any proposal for site development which increases peak runoff rates; (c) any grant or loan which affects land use, land use planning or the disposal of state properties in floodplains, or (d) any program regulating flood flows within the floodplain;

(2) "Base flood" means that flood which has a one per cent chance of being equaled or exceeded in any year, as defined in regulations of the National Flood Insurance Program (44 CFR 59 et seq.) or that flood designated by the commissioner pursuant to section 25-68c. Any flood so designated by the commissioner shall have at least a one per cent chance of being equaled or exceeded in any year. Such flood may be designated as the A or V zones on maps published by the National Flood Insurance Program. The "base flood for a critical activity" means the flood that has at least a .2 per cent chance of being equaled or exceeded in any year. Such flood may be designated as the B zone on maps published for the National Flood Insurance Program;

(3) "Commissioner" means the commissioner of environmental protection;

(4) "Critical activity" means any activity, including, but not limited to, the treatment, storage and disposal of hazardous waste and the siting of hospitals, housing for the elderly, schools, or residences, in the .2 per cent floodplain in which the commissioner determines that a slight chance of flooding is too great;

(5) "Floodplain" means that area located within the real or theoretical limits of the base flood or base flood for a critical activity;

(6) "Flood-proofing" means any combination of structural or nonstructural additions, changes or adjustments which reduce or eliminate flood damage to real estate or improved real property, to water and sanitary facilities, and to structures and their contents;

(7) "Freeboard" means a safety factor, expressed in feet above a calculated flood level, that compensates for unknown factors contributing to flood heights greater than the calculated height, including, but not limited to, ice jams, debris accumulations, wave actions, obstructions or bridge openings and floodways, the effects of urbanization on the hydrology of a watershed, loss of flood storage due to the development and sedimentation of a watercourse bed.