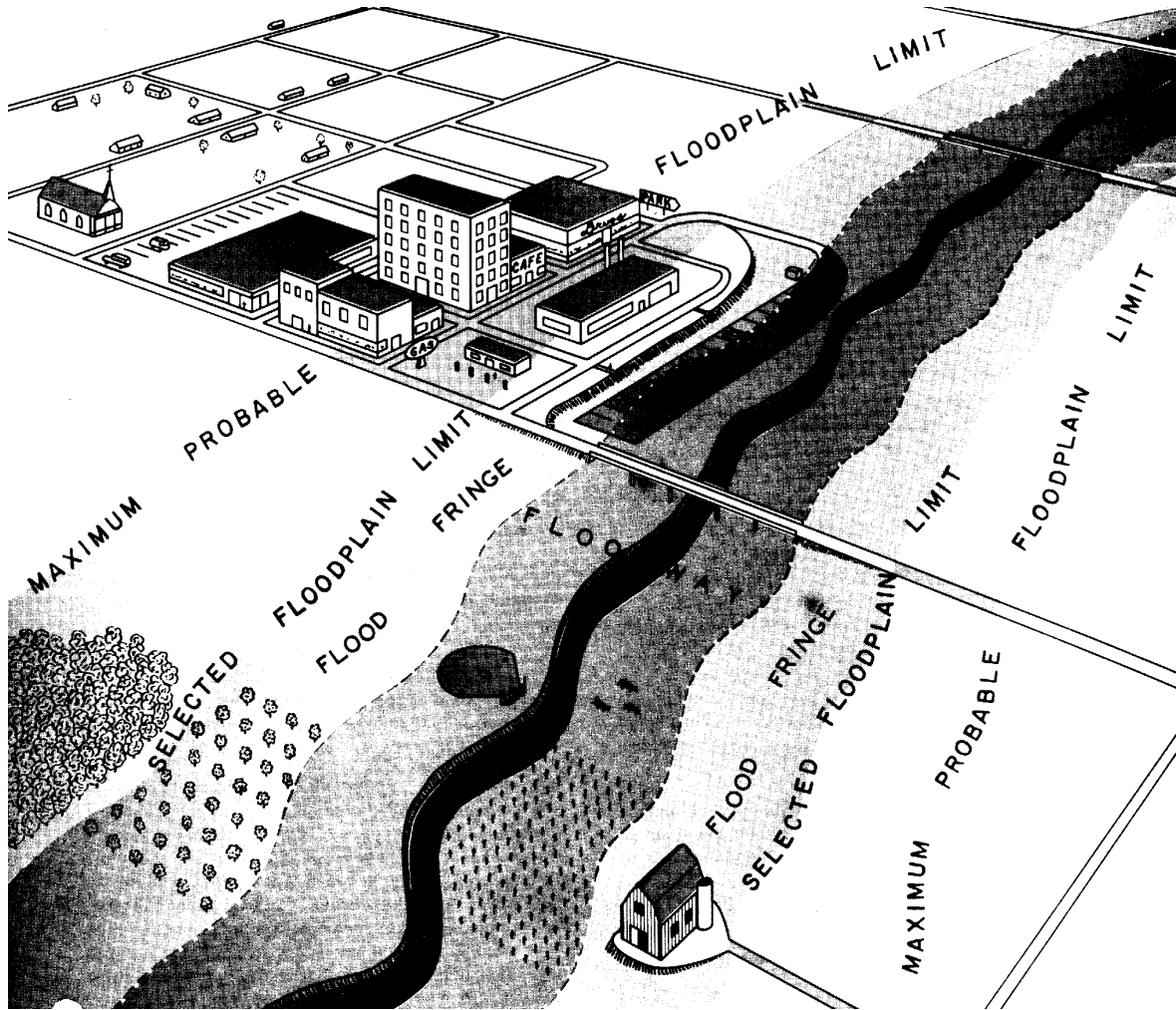


Appendix I

TOWN OF CARRBORO



STORM DRAINAGE DESIGN MANUAL

by:

SUNGATE DESIGN GROUP, P.A.

GENERAL DESIGN STANDARDS AND POLICIES

1. STREET AND LOCAL DRAINAGE

Discharge estimates for specified design storms shall be calculated assuming full development of the contributing watershed based on current zoning or on existing development whichever is greater. Routing of discharges through lakes, ponds, or other impoundments is not acceptable unless the impoundment is publicly owned and operated as a permanent discharge control structure. Diversions of stormwater flow are not acceptable. The Town Engineer must approve any diversion of stormwater, which cannot be avoided.

For review, copies of topographic maps or the equivalent, clearly showing the limits of the site, shall be submitted with the plans. These maps shall extend a minimum of 1000 feet beyond the site boundaries. All off-site drainage areas shall be shown on the topographic maps. All calculations used to compute runoff and storm drainage systems, culvert and detention designs shall be submitted for review.

2. STORM DRAINAGE SYSTEM

All street and local drainage systems, which collect and transport stormwater runoff from the street to an outlet should be designed to pass the 10-year design storm unless more stringent requirements apply. Catch basins in streets shall be designed for spread using the 2-year storm provided a 5-minute time of concentration is used and the remainder of the system is designed for the 10-year storm. For computation of spread, a 4-inch per hour intensity (as allowed by NCDOT) may be used in lieu of the 2-year storm with minimum 5-minute intensity. Inlet capacity at sags shall allow for potential debris blockage by providing twice the required computed opening.

All storm drainage systems shall be analyzed to establish the hydraulic grade line. The hydraulic grade line shall be at least 0.5' below the top of the inlet grate. Each storm drainage structure shall also be checked for inlet control. The recommended HW/D ratio is 1.5 or less. The occurrence of pressure flow in storm drainage systems is not recommended. If pressure flow in the system is proposed, a thorough analysis of pressure flow in the system will be required. In addition the joints in the system will be constructed to withstand the projected pressure without leaking.

No more than 3 cubic feet per second (cfs) shall be discharged over the curb and into the street at any one point and spread shall be checked at that point.

No concentrated flow shall be discharged across walkways. Provisions are to be made to pipe the flow under the walkway.

No pipe shall should be longer than 400 feet without some type structure providing access.

All structures shall allow for access to the storm drainage system with a grate, manhole ring and cover, or lid capable of being removed without mechanical equipment. No “blind boxes” are permitted.

Curb inlets in the roadway should be placed in such a way that the spread of water in the 2-year storm does not exceed one half of a lane width. When the typical section includes a full shoulder or parking lane, no spread encroachment into the travel lane will be allowed.

Inlets should be provided at sags, up-grade of intersections, up-grade of super-elevation crossovers, and where driveways would discharge more than 3 cfs into a street.

A minimum gutter gradient of 0.3 percent shall be utilized. When lesser gutter slopes are encountered (such as at sags), the gutter shall be warped to provide the minimum slope.

NCDOT type E, F, and G (bicycle) grate inlets are allowed in streets. Grates shall be oriented to capture flow.

When development of an area changes the flow regime from sheet flow to concentrated flow, the drainage system should be designed to minimize impacts of the concentrated flow on adjacent properties by tying into existing systems, providing detention, using multiple outlets through agreements with adjacent owners, or other appropriate means.

Minimum drops in inlets, junction boxes and other structures shall be designed and constructed to NCDOT standards.

Where storm drainage lines cross or parallel other utility lines, appropriate clearances shall be provided as required by the appropriate utility or local, state or federal agencies.

A manhole, inlet junction box or other structure allowing for access shall be required at all changes in grade or direction or at any pipe junction. Details shall be provided on the plans for all such structures.

3. CULVERTS

All culverts (conduits which convey flow through the roadway embankment) shall be designed to pass the 25-year storm with HW/D less than or equal to 1.2. Effects of the 100-year storm shall also be analyzed to ensure that:

- 1) No flooding will occur on upstream off-site properties due to backwater from the culvert.
- 2) The stability of the roadway embankment will not be compromised due to overtopping.
- 3) Proposed or existing structures and utilities will not be inundated due to backup of stormwater created by installation of a culvert or other drainage structure.
- 4) No structures will be constructed on lots within the 100-year flood limits created by backup of stormwater from culverts or other stormwater structures.

Storm drainage pipes in the public or private right-of-way shall be reinforced concrete with a minimum diameter of 15 inches. Pipes utilizing other materials with a service life equal to or greater than reinforced concrete (as determined by an independent testing agent) may be approved by the Town Engineer.

Headwalls plus an appropriate velocity dissipater will be required at the end of all culvert systems (excluding driveway pipes) based on the following table;

END TREATMENT FOR CULVERTS	
18" - 30"	NO END TREATMENT.
>36"	HEADWALL ON UPSTREAM END

Headwalls are also required if the skew of the pipe is less than 75 degrees or greater than 105 degrees. Skew is defined as the angle from the centerline road line ahead of the end of the pipe on the right-hand side of the road.

All reinforced concrete pipe shall be Class III or higher.

The maximum fill height for Class III RCP with standard bedding is 23 feet. Loading conditions should be evaluated where deep fills or other high loads are expected and the appropriate combination of pipe material, class of pipe, and bedding selected.

Minimum slopes for pipes and open ditches is 0.5%.

Maximum slopes for concrete pipes are 10.0%.

Minimum cover for reinforced concrete culverts is one foot to top of sub grade. Pipes of materials other than reinforced concrete shall have minimum cover conforming to manufacturer's recommendation.

For cross drainage serving 10 acres or more, the maximum depth of the water impounded during the 100-year flood shall not exceed fifteen (15) feet as measured from the upstream invert of the culvert beneath the roadway section to the water surface elevation unless appropriate engineering calculations are submitted verifying the stability of the embankment against slope failure and seepage effects. Any detention facility designed and construction in compliance with the North Carolina Dam Safety Regulations shall be acceptable to the city.

Roads, which cross or parallel creeks serving more than 25 acres of drainage area must have at least 2 feet of freeboard in the 10-year storm and 6 inches in the 100-year storm. If this is impractical, the street may be designed to flood in the 100-year event provided the flooding depth does not exceed 1 foot and substantial erosion protection is provided on the downstream side of the roadway. In "regulated discharge floodplain areas", streets shall be constructed at or above the 100-year flood elevation.

No public roads are to be constructed on dams.

4. OPEN CHANNELS

For open channels, gradual changes in alignment, not to exceed a minimum radius of 4 times the top width of channel is recommend. Where no other options are available, sharper changes in alignment may be allowed under the following conditions.

20 - 45 DEGREES	Bank stabilization must be provided according to tractive force analysis.
GREATER THAN 45 DEGREES	Same as for above but in addition, freeboard equal to or greater than 1/2 of the Q10 depth of flow must be provided utilizing berms or other appropriate means to increase depth of the channel.

Side slopes for vegetated open channels in residential areas should be no greater than 3 to 1 for stability, safety, and ease of maintenance. Where the channel width must be limited, side slope may be increased if suitable structural stabilization techniques are employed according to following the table and safety measures are utilized. A tractive

force analysis of the channel is also required. Aesthetics and ease of maintenance should also be considered in the design.

MAXIMUM SLOPES FOR COMMON STABILIZATION TECHNIQUES	
STONE	1.5:1
GRID PAVERS	2:1
PAVING *	1:1
GABIONS	VERTICAL
RETAINING WALLS	VERTICAL

*** Note: asphalt channel linings are not allowed.**

5. EASEMENTS

Private drainage easements shall be provided outside of the public right-of-way:

- * for all culverts; except private driveway pipes,
- * for all new or existing open channels or watercourses,
- * below all new or existing pipes and other points of concentrated flow;
- * for primary and emergency dam spillways; or
- * at other locations deemed appropriate by the Town engineer.

Normally, the easements shall be centered, but offset easements may be permitted by the Town Engineer.

Easements widths may differ from the nominal width below if an engineering study is performed, to the satisfaction of the Town Engineer, which demonstrates that the pipe or channel can be excavated and maintained, meeting all OSHA sloping and other safety regulations, within a different easement width.

Combined easements, with widths as approved by the Town Engineer, are permitted with other utilities.

Private drainage easements containing only storm drainage facilities shall be of sufficient width to provide for access and maintenance and shall be centered over the culvert or watercourse with recommended widths based on the following table

FOR CULVERTS	
0 TO 35 INCHES	20 FEET
36 TO 72 INCHES	40 FEET
72 INCHES AND ABOVE	THE DIAMETER OR WIDTH PLUS 40 FEET
MULTIPLE CULVERTS	THE SUM OF THE DIAMETERS PLUS 40 FEET

FOR OPEN CHANNELS	
0 TO 25 ACRES	15 FEET ON EACH SIDE
25 TO 100 ACRES	25 FEET ON EACH SIDE
= 100 ACRES	DETERMINE FLOOD BOUNDARIES

Widths shall be determined from the top of the bank or centerline if no banks are discernible

All drainage easements shall be recorded based on field surveys, following construction, to insure that the drainage structure or watercourse is centered within the easement.

All drainage easements shall be designed to tie into existing easements, existing watercourses, or to other appropriate locations when possible.

6. DETENTION

Detention of stormwater shall be provided in each development so that the peak flow up to and including the post development 25-year storm leaving the site does not exceed up to and including the pre-development 25-year storm peak. This requirement may be varied by the Town Engineer based on existing conditions downstream and the impact, which increased flow in the receiving watercourse, could have on flooding levels. It is recommended that a pre-design meeting with the Town Engineer and the Town Planning Director be held to discuss detention requirements.

