Revision Log
Charlotte-Mecklenburg Storm Water Design Manual
October 7, 2013

General

1. Added a Log Sheet to the manual that will document the original date and future revision dates.
2. Deleted all text shading in manual.
3. Throughout manual replaced all references of "Charlotte-Mecklenburg Land Development Standards Manual" with "Charlotte Land Development Standards Manual".
4. Replaced the term urban with "developed" and the term rural with "undeveloped" throughout manual.
5. Replaced SCS with NRCS throughout manual.
6. Deleted Appendix A.
7. Revised example in Appendix B.
8. Reorganized data in Appendix C to make more readable.
9. Replaced all "storm sewer" terms throughout manual with "storm drainage".

Chapter 1

1. Page 1-2, Section 1.1: Revised text to read, "When accompanied by sound engineering judgement, application of the procedures and criteria presented in this manual should contribute toward the effective and economical solutions of local drainage and flooding problems."
2. Page 1-2, Section 1.2: Deleted "Shaded areas occurring throughout the manual represent design criteria that must be satisfied."
3. Page 1-3, Section 1.4: Replaced current text with the following: "The Charlotte-Mecklenburg Storm Water Design Manual is a dynamic document and is available at www.charmeck.org/Departments/StormWater/Contractors/storm+water+design+manual.htm and is updated periodically. It is the responsibility of the user to make sure the most recent standards are being specified. Users may request to receive notification of future revisions. The current manual is available via download only from this website. Hard copies or CDs of the Design Manual are no longer available from the City."
4. Page 1-3, Section 1.5: Deleted section 1.5 in its entirety.
5. Page 1-3, Section 1.6: Added the following bullet, "Discharge leaves site in the same direction and relative location as pre-developed condition."
6. Page 1-3, Section 1.6: Revised the text in bullet 3 to read, "Design and installation of all storm water detention facilities must comply with applicable federal, state and local laws. Attention should be given to the applicable Soil Erosion and Sediment Control Ordinances, Post Construction Stormwater Ordinance, and the North Carolina Dam Safety Law."
7. Page 1-3, Section 1.6: Revised text in bullet 4 to read, "Detention facilities located within code-required automobile parking areas shall not exceed a maximum water depth of 6 inches. Additional criteria are listed in Chapter 6, section 6.2.5."
8. Page 1-3, Section 1.6: Revised text in bullet 5 to read, "With the exception of erosion control facilities, all detention facilities shall be considered permanent."
9. Page 1-3, Section 1.6: Revised text in bullet 6 to read, "Routine maintenance of all detention facilities shall be the responsibility of the property owner or appointed designee."
10. Page 1-3, Section 1.6: Removed bullet 5 in its entirety.
11. Page 1-3, Section 1.6: Revised the text in bullet 9 to read, "Off site detention facilities are acceptable provided the land area involved with the facility is delineated on an acceptable

map and officially recorded at the Mecklenburg County's Register of Deeds Office as a "Permanent Detention Easement". Also, an official commitment to maintenance of the facility will be required."

12. Added new section 1.6 "City and County Storm Water Regulations".
    "It is the responsibility of the user to be fully aware of all applicable federal, state and local code requirements when using the Storm Water Design manual such as, but not limited to:
    - Floodplain Regulations
    - Soil Erosion & Sedimentation Control
    - Stormwater Ordinance
    - Subdivision Ordinance
    - Zoning Ordinance
13. Added new section 1.7 "Concept Definitions". Reviewed and revised all concept definitions throughout the manual and made sure there is consistency with the Floodway Ordinance and Subdivision Ordinance. All concept definitions were moved to under section 1.7 "Concept Definitions". A new definition was added for "Crown".

Chapter 2

1. Deleted Chapter 2 in its entirety (which means the new chapter two will be Hydrology).

Chapter 3

1. Renamed Chapter 2 – Hydrology.
2. Page 3-3, Section 3.1.1: Added "Hydraulic roughness" before Manning's n under Stream Channel Characteristics.
2. Page 3-3, section 3.1.1: Added "Storm Frequency Events" to Meterological Characteristics.
3. Page 3-4, section 3.1.2: Deleted "If other methods are used, they must first be calibrated to local conditions and tested for accuracy and reliability. In addition, complete source documentation must be submitted for approval."
4. Page 3-4, Table 2-1: Comment for Rational Method: Deleted "For storage design, the Rational method may be used to determine the peak discharge rate up to 50 acres. See section 7.7, 7.8, and 3.11"
5. Page 3-4, Table 2-1: Deleted Basin Lag-Time from the table – Method, Size Limitations and Comments.
6. Page 3-4, Table 3-1: Deleted SCS Step Function from the table – Method, Size Limitations and Comments.
7. Page 3-5, Table 3-1: Replaced "HEC-1" with "HEC-1/HEC-HMS". Revised the maximum number of ordinates in the Comments from "300" to "2,000".
8. Page 3-5, Table 3-1: Deleted Graphical Method from the table – Method, Size Limitations and Comments.
9. Page 3-5, Table 3-1: Added the following note to the table, "If other methods are used, they must first be calibrated to local conditions and tested for accuracy and reliability by the user. Third party computer software not identified in this table must be independently verified and calibrated to the recommended methods by the professional prior to its use. If other software is used, it will be compared to HEC-1/HEC-HMS to make sure it reproduces equivalent results. In addition to verifying results, complete source documentation for the software must be submitted for approval."
10. Page 3-5, Section 3.1.3: Revised title to read, "Storm Water Conveyance Design Policy." Replaced current text with: "All storm water conveyances shall be designed based on fully developed land use conditions as shown on current County and City Land Use Plans and Zoning Maps or existing land use, whichever generates the higher runoff rate."
11. Page 3-5, Section 3.1.4: Deleted Section 3.1.4 in its entirety.

12. Page 3-5a, Section 3.1.5: Added the following text to the first bullet, "The computation interval, when multiplied by the number of hydrograph ordinates, must also be greater than the storm duration which is planned to be studied (6 hour, 24 hour, etc.). Not having the program set to allow the storm to run causes hydrographs to be inappropriately peaked due to the lack of necessary time to fit in the needed runoff hydrograph."
13. Page 3-6, Section 3.2: Deleted Section 3.2 in its entirety.
14. Page 3-8, Section 3.4: Deleted Section 3.4 in its entirety.
15. Page 3-10, Section 3.5.1: Revised the section to read:

Description	***Design Storm***
Storm system pipes	10 year
Ditch systems	10 year
Culverts/Cross-drain (subdivision streets)	25 year
Culverts/Cross-drain (thoroughfare roads)	50 year
Culverts (over regulated floodways)	100 year
Culverts/Cross-drain (primary access streets)	No overtopping in 100 year
Usable and functionable part of structure or building (as defined in the Subdivision Ordinance)	100 year + 1 foot

16. Page 3-10, Table 3-3: Added intensity equation and P_{24} (inches) records at bottom of the table.
17. Page 3-11, Section 3.6.1: Revised the first bullet to read, "In determining the C value (land use) for the drainage area, hydrologic analysis should take into account future land use changes. Drainage facilities shall be designed for future land use conditions as specified in the County and City Land Use Plans and Zoning Maps (or existing land use, whichever generates the higher runoff rate)."
18. Page 3-11, Section 3.6.2: Revised equation 3.1 to include the frequency factor (C_f) from Section 3.6.3.
19. Page 3-11, Section 3.6.3: Deleted Section 3.6.3in its entirety.
20. Page 3-12, Table 3-4: Updated table to include the 2 and 10-year recurrence intervals and corresponding frequency factor.
21. Page 3-12, Section 3.6.4: Reworded Time of Concentration section and included the Kirpich Equation.
22. Page 3-13, Figure 3-1: Delete Figure 3-1 Nomograph for Time of Concentration
23. Page 3-14, Table 2-5: Changed "Parks & cemeteries" to "Bare soils". Added "Note: The above runoff coefficients are valid for 2-year to 10-year storm frequencies only. Coefficients must be accompanied with a C_f factor when used for less frequent, higher intensity storms."
24. Page 3-16, Section 3.7: Updated Rational Method Example Problem.
25. Page 3-18, Section 3.8: Deleted Section 3.8 in its entirety.
26. Page 3-20, Section 3.9.2: Deleted Section 3.9.2 in its entirety.
27. Page 3-21, Section 3.9.3, Updated Rainfall section to read, "Rainfall—The NRCS method applicable to the Charlotte-Mecklenburg area is based on a storm event which has a Type II time distribution. Figure 2-1 shows this distribution. To use this distribution for the one year storm event it is necessary for the user to obtain the 24-hour rainfall intensity from Table 2-2 and multiply by the 24-hour duration to obtain the depth(P_{24} in Figure 2-1) from Table 2-5. This depth is then distributed according to Figure 2-1. To use this distribution for other storm events it is necessary for the user to obtain the 6-hour rainfall intensity from Table 2-2 and multiply by the 6-hour duration to obtain the depth (P_6 in Figure 2-1) from Appendix 2B for the frequency of the design storm. This depth is then distributed according to Figure 2-1. Rainfall may also be distributed using a center weighted "balanced" distribution. Tables 2-5 thru 2-10 show a balanced distribution for various storm events."

28. Page 3-22, Table 3-7: Deleted Table 3-7 Ratios for Dimensionless Unit Hydrograph and Mass Curve.
29. Page 3-23, Figure 3-2: Deleted Figure 3-2 Dimensionless Unit Hydrograph and Mass Curve.
30. Page 3-26, Table 3-8: Updated Table 3-8 to include 1-year, 25-year, 50-year and 100-year storm data.
31. Page 3-29, Section 3.9.5: Renamed section "Modifications for Developed Conditions".
32. Page 3-30, Table 3-11: Updated Table 3-11. Removed notes 4 and 5 from the table.
33. Page 3-31, Section 3.9.6.1: Revised travel time equation (3.15).
34. Page 3-32, Section 3.9.6.3: Added the following text, "Also please note, when designing a drainage system, the sheet flow path is not necessarily the same before and after development and grading operations have been completed. Selecting sheet flow paths in excess of 100 feet in developed areas and 300 feet in undeveloped areas should be done only after careful consideration."
35. Page 3-32, Section 3.9.6.3: Adjusted Equation 3.17 to report time of concentration in minutes.
36. Page 3-33, Table 3-12: Updated Manning's *n* value for smooth surfaces (concrete, asphalt, gravel or bare soil).
37. Page 3-34, Section 3.9.6.5: Renamed the section "Channelized Flow".
38. Page 3-34, Section 3.9.6.4: Added the following text, "Flow within pipes and culverts not under pressure is considered closed channel flow" and "Manning's velocity for pipes assumes a fully flowing condition."
39. Page 3-35, Figure 3-5: Deleted Figure 3-5 Average Velocities – Shallow Concentrated Flow.
40. Page 3-36, Section 3.9.6.7: Delete the third bullet.
41. Page 3-37, Section 3.9.7: Remove section 3.9.7 in its entirety.
42. Page 3-38, Table 3-13: Deleted Table 3-13 Hydrograph Spreadsheet.
43. Page 3-42, Figure 3-6: Deleted Figure 3-6 Unit Hydrograph.
44. Page 3-43, Figure 3-7: Deleted Figure 3-7 Resulting Hydrograph.
45. Page 3-44, Section 3.10: Deleted Section 3.10 in its entirety.
46. Page 3-46, Figure 3-8: Deleted Figure 3-8 SCS Type II Unit Peak Discharge Graph.
47. Page 3-47, Table 3-15: Deleted Table 3-15 I_a Values for Runoff Curve Numbers.
48. Page 3-51, Section 3.11: Deleted Section 3.11 in its entirety.
49. Page 3-55, Table 3-16: Deleted Table 3-16 Example Hydrograph Results.
50. Page 3-58, Figure 3-9: Deleted Figure 3-9 Resulting Hydrographs.
51. Page 3-60, Appendix A: Deleted Appendix A in its entirety.
52. Page 3-61, Appendix B: Renamed to Appendix A.
53. Page 3-63, Table B-1: Expanded Table B-1 to include additional data.
54. Page 3-64, Appendix C: Renamed to Appendix B.

Chapter 4

1. Renamed Chapter 3 – Open Channel Hydraulics.
2. Page 4-2, Section 4.1.1: Added the following text, "For information on roadside ditch requirements see Chapter 4."
3. Page 4-2, Section 4.1.2.2: Revised the last sentence to read, "The use of flexible lining may be restricted where space is limited, since the introduction of linings with higher roughness values generally results in the need for greater channel capacity."
4. Page 4-4, Section 4.2: Deleted Section 4.2 in its entirety.
5. Page 4-5, Section 4.3.1: Revised the text to read, "The following criteria shall be used for open channel design:

1. Channel side slopes shall be stable throughout the entire length and slope shall be a maximum of 2:1.
2. Superelevation of the water surface at horizontal curves shall be accounted for by increased freeboard.
3. A minimum freeboard of 6" must be provided in the 10-year design storm.
4. Transition from closed systems to channel sections (or between transitioning channel sections) shall be smooth and gradual, with a minimum of 5:1 taper.
5. Low flow sections shall be considered in the design of channels with large cross-sections
   (Q > 100 cfs). Some channel designs will be required to have increased freeboard (see North Carolina Erosion and Sediment Control Planning and Design Manual, Section 8.05.21)."

6. Page 4-5, Section 4.3.2: Revised the first sentence to read, "Open channel drainage systems shall be designed to convey a 10-year design storm. The peak flow rate for the 100-year storm shall be computed at appropriate points within the drainage system to determine if a 100 + 1 flood study is required as described in section 3.2.3."
7. Page 4-5, Section 4.3.3: Replaced "streams" with "storm water conveyances" in the second sentence.
8. Page 4-5, Section 4.3.3: Revised the bullets to read as follows:
   2. The 100-year storm water surface elevations should be calculated using a method acceptable to the City/County Engineering Department, as further described in Section 3.6.
   3. The peak flow rate used in the 100+1 analysis shall be based on an assumption of full build out of the tributary drainage area. The assumption of full build out shall be defined as either full development per the current zoning of the property, the existing land use, or adopted area land use plans, whichever generates the higher runoff rate.
   4. For drainage systems within development projects subject to the Subdivision Ordinance, the 100+1 elevation and flood limits shall be shown on the recorded maps associated with the subdivision as further described in the Subdivision Ordinance.
   5. For drainage systems within development projects not subject to the Subdivision Ordinance, the City/County Engineering Department may require that the 100+1 elevation be shown on a recorded map if the engineering analysis indicates that one of the following conditions is present:
      - The 100+1 line would exceed the set-back limits.
      - The estimated runoff or proposed modifications to a storm water conveyance would create a hazard for the adjacent properties or residents.
      - The flood limits would be of such magnitude that adjacent property owners should be informed of these limits.

6. Page 4-6, Section 4.3.4: Revised the text to read, "The design of open channels should be consistent with the velocity limitations for the selected channel lining. For design information see section 3.4 Open Channel Design."
7. Page 4-7, Section 4.4: Moved Section 4.4 to Appendix 3A.
8. Page 4-11, Table 4-2: Revised recommended Manning's n values in Table 4-2.
9. Page 4-14, Section 4.6: Moved Section 4.6 to Appendix 3B. Removed the following sentence from Section 4.6.1, "A minimum freeboard of 6" must be provided."
10. Page 4-16, Section 4.7: Moved Section 4.7 to Appendix 3C.
11. Page 4-17, Section 4.7.4: Deleted Section 4.7.4 in its entirety.

12. Page 4-18, Figure 4-4: Deleted Figure 4-4 Nomograph for the Solution for Manning's Equation.
13. Page 4-19, Figure 4-5: Deleted Figure 4-5 Solution of Manning's Equation for Trapezoidal Channels.
14. Page 4-23, Section 4.8: Moved Section 4.8 to Appendix 3D.
15. Page 4-23, Section 4.8.1: Revised Equation 4.13.
16. Page 4-26, Section 4.8.3: Revised Equation 4.15.
17. Page 4-27, Section 4.9: Incorporated text, figures and tables from the North Carolina Erosion and Sediment Control Planning and Design Manual.
18. Page 4-28, Section 4.10.1: Deleted the following text, "The following procedure is based on results and analysis of laboratory and field data (Maynord, 1987; Reese, 1984; Reese, 1988). Also, added the following sentence, "Where riprap is used in ditches/channels that are 2% or less, the design should take into account the potential for sedimentation."
19. Added Figure 3-2 K_b Factor for Maximum Shear Stress on Channel Bends.
20. Added Figure 3-3 Protection Length, $_{LP}$, Downstream from Channel Bend.
21. Page, 4-34, Section 4.11: Deleted Section 4.11 in its entirety.
22. Page 4-35, Table 4-5: Deleted Table 4-5 Water Surface Profile Computation Form for the Direct Step Method.
23. Page 4-38, Table 4-6: Deleted Table 4-6 Water Surface Profile Computation Form for the Standard Step Method.
24. Page 4-40, Section 4.12: Deleted Section 4.12 in its entirety.
25. Page 4-41, Table 4-7: Deleted Table 4-7.
26. Page 4-43, Table 4-8: Deleted Table 4-8.
27. Page 4-45, Section 4.13: Revised last sentence to read, "This requires a backwater analysis to determine the stream flow depth. The HEC-RAS software package is an acceptable method."

Chapter 5

1. Renamed Chapter 4 – Storm Drainage Systems.
2. Updated/Deleted standard numbers or replaced with a description.
3. Page 5-2, Section 5.1.1: Replaced "HEC -12" with "HEC-22 (USDOT, FHWA, 1996)".
4. Page 5-2, Section 5.1.2: Replaced the work "sump" with "sag".
5. Page 5-2, Section 5.1.3: Revised the criteria as follows:
    a. Replaced the word "sump" with "sag".
    b. Moved the Design Frequencies section to Chapter 2, Section 2.3.1 and added a reference for this.
    c. Clarified the design criteria for sag inlets in 25-year event for local roads and added the 50-year event design criteria for thoroughfare roads, based on the NC Division of Highways Standard.
    d. Added criteria for no surcharging of sag inlets in the 25-year event for local roads and 50-year event for thoroughfare roads.
    e. Added criteria to evaluate the need for flanking inlets near sag inlets based on slope check points.
    f. Added criteria for concentrated flow over City sidewalks.
    g. Added design criteria for roadside ditches and driveway culvert sizing for the 25-year event for local roads and the 50-year event for thoroughfare roads.
6. Page 5-3, Section 5.2: Deleted Section 5.2 in its entirety.
7. Page 5-4, Section 5.3: Deleted Section 5.3 in its entirety.
8. Page 5-6, Section 5.4.6: Revised text to read, "Curb and gutter installation shall be designed in accordance with the relevant standards for the jurisdiction."

9. Page 5-7, Section 5.4.8" Revised the text to read, "Roadside ditches (when allowed) will be required behind the shoulder of roadways without curb and gutter to convey storm drainage away from the pavement to a discharge point. The steepest side slope allowed is 3:1 (horizontal to vertical) on the roadside of the ditch and 2:1 on the side closest to the right-of-way line. The ditch shall be graded to a minimum longitudinal slope of 1 percent and a maximum velocity of 4 ft/sec. For grass lined channels with velocities up to 7 ft/sec, permanent matting may be approved on a case by case basis. For velocities greater than 7 ft/sec, a concrete lined ditch may be required. Riprap will not be allowed for stabilization within the street right-of-way (except as outlet protection on culverts).

    In addition to the design of roadside ditches, a design shall be provided for driveway culverts for each individual lot on the plan. The use of a small driveway culvert, 15 inches minimum diameter, in conjunction with overtopping of the driveway itself will be allowed as further described in Section 4.1.3. Sizes for all driveway culverts shall be shown in tabular form on the plans, and each culvert shall be designed for the highest ditch flow applicable for the lot."
10. Page 5-9, Section 5.5.2: Replaced and "Q" with "Q_{cap}" to be consistent.
11. Page 5-11, Section 5.6.11: Clarified to also use "Q_{cap}" consistently.
12. Page 5-16, Section 5.6.2.2: Replaced "drop inlet" with "grated drop inlet"
13. Added open throat (slab top) catch basin design information with an example problem after the Drop Inlet section (Section 5.6.2.2). Named this section 4.4.2.3 Open Throat (Slab Top) Catch Basin.
14. Page 5-23, Section 5.9.2: Added the following design criteria, "The maximum discharge velocity at pipe outlets is 10 fps except for pipes greater than 48 inches in diameter unless velocity is further restricted for energy dissipation."
15. Page 5-24, Section 5.9.4: Deleted Section 5.9.4 in its entirety.
16. Page 5-25, Figure 5-6: Deleted Figure 5-6 Nomograph for Solution of Manning's Formula for Flow in Storm Sewers.
17. Page 5-26, Figure 5-7: Deleted Figure 5-7 Nomograph for Computing Required Size of Circular Drain, Flowing Full – n = 0.013 or 0.015.
18. Page 5-27, Figure 5-8: Deleted Figure 5-8 Concrete Pipe Flow Nomograph.
19. Page 5-28, Figure 5-9: Deleted Figure 5-8 Values of Various Elements of Circular Section for Various Depths of Flow.
20. Page 5-29, Section 5.9.5: Added the following sentence, "If computer models are utilized then results should be consistent with the procedure outlined below. All input data should be supplied, including loss coefficients, and output should be in similar format to Figure 4-6."
21. Page 5-24, Section 5.9.3: Corrected Equation 5.20.
22. Page 5-29, Section 5.9.5.1: Corrected Equation 5.22.
23. Page 5-31, Section 5.9.6: Corrected Equation 5.25.
24. Page 5-36, Section 5.10: Deleted Section 5.10 in its entirety.

Chapter 6

1. Renamed Chapter 5 – Design of Culverts
2. Page 6-4, Section 6.2: Deleted Section 6.2 in its entirety.
3. Page 6-6, Section 6.4: Deleted Section 6.4 in its entirety.
4. Page 6-8, Section 6.5.3: Revised language to read as follows, "The appropriate flood frequency for determining the flood carrying-capacity of a culvert is dependent upon:

- the level of risk associated with failure of the culvert crossing; and
- the level of risk associated with increasing the flood hazard to upstream (backwater) or downstream (redirections of floodwaters or loss of attenuation) properties.

For specific design storm frequencies for culvert crossings, reference Section 2.3.1, Design Frequencies. Also, in compliance with the National Flood Insurance Program, it is necessary to consider the 100-year frequency flood at locations identified as being special flood hazard areas. The design engineer should review the City and County floodway regulations for more information related to floodplain regulations."

5. Page 6-8, Section 6.5.4: Deleted the following text, "The maximum allowable velocity within corrugated metal pipe is 10 fps. There is no specific maximum allowable velocity within reinforced concrete pipe, but outlet protection shall be provided where discharge velocities will cause erosion problems. The maximum discharge velocity at pipe outlets is 10 fps except for pipes > 48 inches in diameter."
6. Page 6-12, Section 6.5.9: Revised the text to read, "The relative efficiency of the inlet depends on the conduit. Headwalls are required for all metal and HDPE culverts. Concrete flared end sections may be utilized in lieu of headwalls upon approval of the City Engineer. The figure below illustrates the use of headwalls and wingwalls. Corrugated metal pipe in a headwall is essentially square-edged with an inlet coefficient of about 0.5."
7. **P**age 6-13, Section 6.5.12: Revised the text to read, "For culvert selection, only reinforced concrete pipe is allowed within the street right-of-way except for culverts equal to or greater than 60 inches. For culverts equal to or greater than 60 inches in diameter, aluminum or aluminized steel pipe is allowed."
8. Page 6-13, Table 6-3: Revised Table 6-3 and moved it to Table 4-3 in Chapter 4.
9. Page 6-14, Section 6.5.14: Revised the text to read, "In addition to controlling erosion, sedimentation and debris at the culvert site, care must be exercised in selecting the location of the culvert site. Environmental considerations are a very important aspect of culvert selection and design.

   This selection must consider the entire site and include provisions for maintaining existing stream cross section at the inlet and outlet while providing passage of aquatic life."
10. Page 6-19, Section 6.7.1: Deleted the following text, "It is recommended that the HYDRAIN (HY8) computer model be used for culvert design since it will allow the engineer to easily develop performance curves rather than only examining one design situation. The personal computer system HYDRAIN uses the theoretical basis for the nomographs to size a culvert. In addition, this system can evaluate improved inlets, route hydrographs, consider road overtopping and evaluate outlet streambed scour. By using water surface profiles, this procedure is more accurate in predicting backwater effects and outlet scours."
11. Page 6-24, Section 6.7.7: Removed Section 6.7.7 in its entirety.
12. Page 6-30, Section 6.10: Moved this section to Appendix 5B.
13. Page 6-35, Section 6.11: Deleted Section 6.11 in its entirety.
14. Page 6-40, Appendix B: Deleted Appendix B in its entirety.

Chapter 7

1. Renamed Chapter 6 - Storage and Detention
2. Page 7-2, Section 7.1.2: Revised Section 7.1.2 to refer to Fee Credit Manual
3. Page 7-3, Section 7.2: Deleted section 7.2 in its entirety.

4. Page 7-4, Section 7.3: Added Section 6.2.1 Introduction and the following text, "If you do not comply with the Post Construction Control Ordinance then you must follow requirements in the zoning ordinance and the control requirements of 6.2.3 and 6.2.4 apply."
5. Page 7-4, Section 7.3.3: Added a new section 6.2.5 Storage within Parking Areas and moved the following text from Section 7.3.3 to Section 6.2.5, "Storage within code-required parking areas are allowed a maximum depth of 6 inches; additional parking areas 10 inches; and 15 inches is allowed in truck storage and loading areas."
6. Page 7-5, Section 7.3.4: Revised the text to read, "A concrete paved low flow or pilot channel (minimum slope of ½ %) constructed across the facility bottom from the inlet to the outlet shall be considered for conveyance of low flows to prevent standing water conditions."
7. Page 7-5, Section 7.3.4: Revised the text to read, "A minimum freeboard of 6 inches above the 50-year design storm high water elevation shall be provided all impoundments. Storage facilities under the jurisdiction of the North Carolina Department of Environment and Natural Resources (NDCENR), Dam Safety Program of Land Quality are in addition subject to the requirements of the Safe Dams Act (see Section 6.2.9)."
8. Page 7-5, Section 7.3.5: Added the following text, "Minimum barrels through embankments are 12 inch pipes with corresponding orifice plates. Any orifice smaller than 4 inches in diameter must be protected to prevent blockage. A 2 foot by 2 foot concrete pad must be placed in front of any orifice plate at the invert of the outlet. If the spillway is in fill material then the spillway must be lined."
9. Page 7-5: Added Section 6.2.8 Off-site Storm Water Detention Facilities and the following text, "When off-site storm water detention facilities (or for storm water release through recorded easements to regulated floodway in lieu of detention) the following requirement must be met:
    - All pipes/channels leading from the subject site to the off-site storm water detention facility (or regulated floodway) must be sized to carry the 10-year storm water runoff.
    - A "Permanent Detention Easement" leading from the subject site to the off-site detention facility (or regulated floodway) must be shown on a map which has been recorded with the Mecklenburg County Register of Deeds Office. This easement should be centered on the pipe or channel and must be at least 15 feet wide for pipes and 20 feet wide for channels (refer to City Std. #20.30 for easement widths). A metes and bounds description is not required for this portion of the easement.
    - A "Permanent Detention Easement" which encompasses the detention facility must be shown on the recorded map. This easement must be described by metes and bounds.
    - The recorded map must have a note which clearly states who is responsible for maintenance of the detention facility, pipes, and/or channels located within the Permanent Detention Easements (these easements will not be maintained by the City).
    - For off-site detention facilities the recorded map must have a note stating, "The purpose of the Permanent Detention Easement is to provide storm water detention for Lot(s) _____. The pipes and/or channels located within the Permanent Detention easement and leading to the detention facility carry unrestricted storm water flow from the developed upstream Lot(s) ___.
    - For storm water released to regulated floodway through an easement, the recorded map must have a note stating "The purpose of the Permanent Detention Easement is to allow storm water release directly to regulated floodway in lieu of on-site storm water detention. The pipes and/or channels located within the Permanent Detention Easement and leading to the regulated floodway carry unrestricted storm water flow from the developed upstream Lot(s) ___."
10. Page 7-5, Section 7.3.6: Updated text to read, "Under the Dam Safety Law regulations, a dam is a structure and appurtenant works erected to impound or divert water that is 25 feet

or greater in height and has a maximum storage volume of 50 acre-feet or more. A number of exemptions are allowed from the Dam Safety Law and any questions concerning a specific design or application should be addressed to the North Carolina Department of Environment and Natural Resources, Dam Safety Program of Land Quality (919-707-9220)."

11. Page 7-7, Section 7.4.2: Add the following language, "Computer based methods, such as HEC-1/HEC-HMS, are widely available to perform these iterations quickly. Other computer programs can provide similar results. For guidelines for using other party software, please refer to Section 2.1.2 – Hydrologic Method."
12. Page 7-8, Section 7.5.2: Updated the equation for a sharp-crested weir with no end contractions (Equation 7.1). Removed formulas for sharp-crested weir with two end contractions (Equation 7.2) and the discharge equation for a sharp-crested submerged weir (Equation 7.3).
13. Page 7-9, Section 6.4.3: Revised Equation 7.4 so L is defined as the horizontal weir length (ft). Removed the following text, "If the upstream edge of a broad-crested weir is so rounded as to prevent contraction and if the slope of the crest is as great as the loss of head due to friction, flow will pass through critical depth at the weir crest; this gives the maximum C value of 3.087. For sharp corners on the broad-crested weir, a minimum C value of 2.6 should be used. Additional information on C values as a function of weir crest breadth and head is given in Table 7.2 on the next page."
14. Page 7-10, Table 7-2: Deleted Table 7-2 Broad-Crested Weir Coefficient C Values as a Function of Weir Crest Breath and Head.
15. Page 7-11, Section 7.5.5: Deleted Section 7.5.5 in its entirety.
16. Page 7-11, Section 7.5.6: Revised Equation 7.8 so that C = 0.60. Removed the following text, "Any orifice smaller than 4 inches in diameter must be protected to prevent blockage."
17. Page 7-12, Section 7.6: Moved Section 7.6 to Appendix A
18. Page 7-15, Section 7.7: Deleted Section 7.7 in its entirety.
19. Page 7-23, Section 7.8: Deleted Section 7.8 in its entirety.
20. Page 7-25, Figure 7-3: Deleted Figure 7-3 Triangular Approximation.
21. Page 7-28, Figure 7-3: Deleted Figure 7-4 Variation in Attenuation Ratio as a Function of N_r and a for Reservoirs with Spillway Outlet.
22. Page 7-28, Figure 7-3: Deleted Figure 7-5 Variation in Attenuation Ratio as a Function of N_r and a for Reservoirs with Orifice Outlet.
23. Page 7-31, Section 7.9: Moved Section 7.9 to Appendix A.
24. Page 7-35, Section 7.10: Revised bullet 6 under proper design to read, "Outlet structures should be selected to minimize the possibility of blockage (i.e., very small pipes tend to become blocked quite easily and should be avoided). Outlets shall be no less than 4 inches in diameter."
25. Page 7-35, Section 7.10: Revised bullet 4 under proper design to read, "Standing water or soggy surfaces must be eliminated…"
26. Page 7-35, Section 7.10: Revised bullet 6 under proper design to read, "Outlet structures should be selected to minimize the possibility of blockage (i.e., very small pipes tend to become blocked quite easily and should be avoided). Outlets shall be no less than 4 inches in diameter."

Chapter 8

1. Renamed Chapter 7 – Energy Dissipation.
2. Page 8-2, Section 8.2: Deleted Section 8.2 in its entirety.
3. Page 8-4, Section 8.4.1: Revised to read as follows "A flat riprap apron can be used to prevent erosion at the transition from a pipe or box culvert outlet to a natural channel, or onto a flat, open surface. Protection is provided primarily by having sufficient length,

roughness, and flare to dissipate the energy by allowing the flow to expand and slow down. Riprap aprons shall be used when the culvert outlet velocity exceeds the erosive velocity of the receiving channel or soil. Riprap aprons are appropriate when the culvert outlet velocity is less than or equal to 10 fps for pipes ≤ 48 inches in diameter. Unincorporated Mecklenburg County and the six Towns require a velocity less than or equal to 5 fps for all pipes."

4. Page 8-8, Section 8.4.3: Added the following text under bullet 2, "After the d_{50}, d_{max} and the rip rap depth have been determined, specify the class of rip rap that will be used for the construction of the apron. Normally, Class 1 or Class 2 rip rap will be specified. Occasionally, Class B stone will be specified. Refer to the NCDOT Standard Specifications for Roads and Structures for stone grading and size information."
5. Page 8-8, Section 8.4.3: Revised bullet 5 to read, "If the ground slope downstream of the apron is steep, channel erosion may occur. Either the apron should be extended as necessary until the slope is gentle enough to prevent erosion, or the pipe should be extended to a drop structure at the toe of slope, and the riprap apron placed on a flat surface or other in-stream drop structure created."
6. Page 8-8, Section 8.4.3: Revised bullet 6 to read, "Keep the apron as straight as possible and align it with the flow in the receiving channel. DO NOT place apron at 90 degrees to the receiving waterway as it will cause erosion of the opposite bank. Discharge at an angle to the stream flow to smoothly combine the flows."
7. Page 8-8, Section 8.4.3: Added the following text for bullet 7, "The approved plans shall accurately depict the limits of the apron as determined from the calculations. Easement widths shall encompass the entire apron."
8. Page 8-8, Section 8.4.3: Added the following text for bullet 8, "The potential for vandalism should be considered if the rock is easy to carry. If vandalism is a possibility, the rock size must be increased or the rocks held in place using concrete grout."
9. Page 8-9, Section 8.4.4: Delete d 8.4.4 in its entirety.
10. Page 8-10, Figure 8-4: Deleted Figure 8-4 Riprap Apron Design Graph
11. Page 8-11, Figure 8-5: Deleted Figure 8-5 Riprap Apron Design Chart
12. Page 8-12, Figure 8-6: Deleted Figure 8-6 Maximum Stone Size for Riprap
13. Page 8-13, Figure 8-7: Deleted Figure 8-7 Gradation of Riprap