CITY OF GASTONIA STORMWATER DESIGN AND SYSTEM MANUAL

Purpose: This Manual is intended as a supplement to the City of Gastonia Code of Ordinances, and the Standards & Specifications and Details. In the case of conflict, the text of the Ordinance shall prevail. In other conflicts, the most environmentally stringent standard shall prevail. The determination of "most environmentally stringent standard" shall be at the sole discretion of the Stormwater Administrator, subject to appeal.

This Manual is intended to provide guidelines and standards for the development of lands in the City of Gastonia's Stormwater jurisdiction. These guidelines are intended to serve the development community and the City in securing the requirements of the City's Stormwater Phase II Permit.

Definitions (with examples):

Built Upon Area (BUA): Within the limits and boundaries of a development, any surface that by its nature significantly inhibits infiltration, or increases the total runoff or the rate of runoff. Gravel roads, gravel parking areas, concrete surfaces, roofs, asphalt paved roads, the tops of enclosed tanks or silos, bridge decks or other elevated impervious surfaces including the tops of freight trailers, and secured or unsecured mobile homes, athletic or recreational tracks unless exempted, and any other surface identified by the Stormwater Administrator. The following are specifically exempted: *planted islands, specifically designed permeable parking or roadway surfaces, specifically designed draining "clay" tennis courts, athletic or recreational tracks or paths with friable surfaces, the water surface of swimming pools, and smokestacks.*

High Density Project: Any project, plan, development, construction, or other significant improvement to a property that:

- Increases the impervious surface by 10,000 sq. ft. or more or;
- Has a housing density greater than 2 dwelling units per acre of the total development. That is, any fraction greater than two shall be considered greater than two. Or,
- Has a total BUA greater than 24% of the total development area. That is any fraction greater than 0.24 shall be considered greater than 24%.

Pre-Developed Condition: The state or condition of the site with regard to imperviousness at the time of the submittal of the proposed development. Unless the development will raze 50% or more of the building's first floor area, or increase the total impervious surface by 50% or more; then, the entire site will be taken as having been either woodland or meadow.Note: *The City of Gastonia uses the Rational Method for sites less than 150 acres; the City uses a Rational C factor of 0.25 for meadows and woodlands.*

Example: Todd is going to build a new stereo repair shop on the corner of East and Maple streets. There is currently an old gas station there. The site is only about half an acre, and the gas station is all pavement. Todd plans to tear down the old station to build his 5,000 square foot shop with 15 parking spaces (total

12,378sf IS). Even though Todd's new shop will have about 20% less impervious surface than the old gas station, Todd will need to put in a detention system to accommodate his site because he razed 100% of the old building.

Return Period: The inverse of the statistical probability of a storm of given duration and intensity occurring in any given year.

The 2 year storm has a 50% chance of occurring in any given year, the 5 year storm a 20% chance, and the 100 year storm only a 1% chance.

Operation: New development or re-development in the City of Gastonia must be performed under a Stormwater Post Construction Permit. This permit is issued after completion of the general review process for the type of development.

Example: A site plan for a gas station is submitted to the Land Development Division. In addition to reviewing the proposed plan for appropriateness regarding utilities, site layout, street improvements, and the like, there will also be a review for the post-construction requirements of Stormwater Phase II. Once the site plan is approved, it will be stamped approved by the Stormwater Administrator, and a permit will be issued.

Requirements: There are three basic levels of requirement in response to Stormwater Phase II. The simplest level is exemption from action.

If a proposal is sited on a tract less than one acre, **and** the tract is not part of a larger development that encompasses more than one acre, **and** (if residential) there will only be one dwelling unit on the site, **and** there will be less than 10,000 square feet imperviousness on the completed project, **and** the total impervious area is less than 24% of the total site area, **and** the site is to be served by public wastewater service; **then** the need for the post construction permit will be waived.

Example: Mrs. Jones wants to build a home closer in to town. There's a nice piece of land she inherited from her uncle on S. North St. Since the land is only **¾ of an acre**, and since Mrs. Jones is only constructing **one residence**, and since Mrs. Jones is only planning on building a modest little **cottage with a driveway and a deck**, and she's already got **water and sewer in S. North St**.; Mrs. Jones' house will receive a waiver when her builder or she pulls her building permit.

The next simplest level is the phase II low density threshold.

If for some reason, or combination of reasons, an exemption is not possible, an applicant may still be able to secure a permit and avoid most post-construction BMPs if: the proposal keeps the BUA below 24% of the total site **and** less than 10,000 square feet of impervious surface, **and** if residential, the dwelling density does not exceed 2 dwelling units per acre.

If a Low-Density plan is pursued, a concept plan and consultation meeting under § 14-735 of the ordinance will be required.

Example: Mrs. Jones wants to help out her three children. She wants to split the old home place into three parcels, one each for Robert, Susan, and Peter. The old home place sits on 1.7 acres, which she will divide equally. The old house and the two new ones will average about 2650 square feet of impervious surface each. Since the subdivision won't require any infrastructure improvements, and the land was old pasture, the concept plan is waived in this case. After a preliminary review of the subdivision, as described, Mrs. Jones will be issued a Stormwater Permit (Low Density).

Example: Mike the developer has bought a 40 acre tract at an auction. It straddles the City limit line, but is zoned R-1. Mike considers himself an old fashioned kind of guy, and decides to build under the R-1 controls. In fact Mike is looking to put in 60 estate lots with what he calls "Contemporary Classic" houses. The Stormwater Administrator will probably ask Mike to meet to discuss his plans. They will review the topography of his site, the land cover, proximity of streams and flood plains or other wetlands, steep ravines and other features of the land that may impact Mike's paper plans for the development. Mike will proceed with his plans being sure to minimize his use of pipe, work with the lay of the land to avoid conflicts between lots and drainage, and generally take into account the impact of his development on the pre-existing hydrology. After Mike's plans are reviewed for overall density and imperviousness, he will receive a low density permit, and be on his way. *Note:* Mike will still need to put in deed restrictions that prevent excessive over construction and prohibit the conversion of swales to pipe systems without approval of the Stormwater Administrator.

The third option, phase II high density, requires the installation of BMPs to manage the Stormwater runoff from the completed project. BMPs for high density must meet three main standards: Water Quality, High Frequency Peak Runoff Mitigation, and Intermediate Frequency Peak Runoff Mitigation. It is expected that one basin, or set of basins will control all three issues.

The ordinance says the BMP must capture an equivalent volume of runoff as is calculated according to the difference in pre-and post-construction conditions. This means that if we draw a big circle around the site, the total runoff leaving the circle after construction **must not exceed** the total rate of runoff that left the same circle before construction.

For sites smaller than 150 acres, runoff will be calculated according to the Rational Method, weighted C factors will be indicated on calculations. This means that the City will use this method to check the designs. Any different methods must meet our calculations or be considered invalid.
When re-development exceeds those thresholds indicated to require **full** site detention, a C factor of **0.25** will be used for pre-construction conditions. The

Ordinance indicates these thresholds, but in essence, once these limits are reached, the detention will have to restore the discharges to the "natural" conditions such as meadow or forest.

In order to uniformly determine rainfall intensity, the City will use the following excerpted **R**eturn **D**uration **D**epth table from the National Oceanographic and Atmospheric Administration (NOAA)[a]:

RDD (inches)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr
1 yr	0.44	0.71	0.90	1.18	1.36	1.50	1.47
2 yr	0.47	0.74	0.94	1.29	1.62	1.89	2.02
5 yr	0.55	0.87	1.1	1.57	2.01	2.36	2.52
10yr	0.6	0.96	1.22	1.76	2.3	2.72	2.93
25 yr	0.67	1.07	1.35	2.01	2.67	3.2	3.48
50 yr	0.72	1.15	1.45	2.19	2.96	3.58	3.92
100 yr	0.77	1.22	1.54	2.36	3.25	3.95	4.38

Note: The 1 year 24 hour rainfall totals 2.55".

All systems must have overflows that are capable of discharging the remainder of the 50 year event without damage to the overflow, or the downstream areas that will receive this flow.

The **intermediate** frequency system correlates to the 10 year detention that has been with the City since the 1970s. These systems must be configured so that the total runoff from the site does not exceed the pre-developed (see above) runoff rate for the 10 year storm. This rate is based on the calculated rate for the time of concentration for the post-construction condition. The discharge rate will be calculated on the combination, if necessary, of the other outlets with the ten year control structure. *Note:* This references back to the runoff leaving the circle that was discussed before. In addition, there will probably be a Water Quality orifice and a 2yr orifice below this control. It is the sum of all three discharges that must not be too great.

These basins must be sized so that the maximum storage volume will be accommodated for the range of 10 year design storms. That is, the various durations must be routed to determine the maximum volume for different intensity/duration storms. The time of concentration volume will not necessarily be sufficient.

This means that occasionally (arguably once every ten years **on average**) it rains very hard for some amount of time. These storms are usually short, between 5 and 30 minutes. For each site, there is a particular 10% chance storm that may not be the hardest or the longest, but when this storm hits this site more runoff is generated than any other 10% chance storm combination.

The **high** frequency system correlates to the 2 year detention that has been with the City since December of 2000. These systems must be configured so that the total runoff from the site does not exceed the pre-developed (see above) runoff rate for the 2 year storm. This rate is based on the calculated rate for the time of concentration for the post-construction condition. The discharge rate will be calculated on the combination, if necessary, of the other outlets with the two year control structure.

These basins must be sized so that the maximum storage volume will be accommodated for the range of 2 year design storms. That is, the various durations must be routed to determine the maximum volume for different intensity/duration storms. The time of concentration volume will not necessarily be sufficient.

Note: The same analyses apply to the two year storm as did for the ten.

The **Water Quality (WQ)** system is new with phase II. These systems must do several things in addition to controlling the peak runoff.

- They must capture and treat the difference in runoff from the pre- and post-developed condition for the first inch of rainfall (**the treatment volume**). *Note:* There is no allowance for "un-balanced" detention. There is no big circle to calculate runoff from. All the water in the first inch of rain onto the site must go through the **WQ** system.
- They must remove 85% of the annual Total Suspended Solids (TSS) load from runoff for the post construction condition.
- They must release the treatment volume at a rate not greater than the pre-developed rate for the 1 year 24 hour storm (linearization of the rate is acceptable).
- They must not drain faster than 48 hours, but may not drain slower than 96 hours to dry bottom surface.
- Finally they must be constructed according to the guidance of NCAC 02H .1008(c), which is a technical repetition of the details indicated here.

The City has developed adaptations from the NCDENR BMP design manual of 1998. City Detail 71-C 26 pages a-d, and pages e-h will be accepted as meeting the above requirements when proposed with supporting calculations. The modified sand filter of a-d can serve larger areas such as commercial developments or multiple lots in a residential development. The bio-retention area or rain garden of e-h is intended to serve very small commercial sites, or single family units.

Example: Don wants to develop a fifteen acre tract with fifty really nice little brick cottages. He's got a marketing idea for folks who want nice houses without all that yard work, but want a cozy neighborhood feel. Don has set aside two areas at the lower ends of the land to put his BMPs on and his engineer is going to submit the plans next week. Don is on the right track.

Maintenance: The permit is essentially a permit to construct. The ongoing protection of the waters of Gastonia is ensured through the proper care and maintenance for the systems as designed. Two of the most important parts of the permit application are the Operation and Maintenance (O&M) manual, and the O&M agreement. Before building permits will be issued by the City an O&M manual and agreement must be approved. Before COs will be issued, the BMP serving the site must be complete or bonded, and the O&M agreement executed.

O&M manual: For each structural BMP that is designed submitted and approved to manage the water quality and quantity leaving a site, there must be an O&M manual signed and sealed by the designing professional. This manual must contain at a **minimum**, a narrative description of the basic function of the BMP, the estimated life of each component of the BMP, a timetable for cleaning, testing and replacement for each component of the BMP, and a brief troubleshooting table for the various functions of the BMP. Designers are encouraged to use common terms, and sufficient drawings or details that their concepts are readily communicated to the general population of Gastonia.

O&M agreement: As indicated in § 14-740 of the ordinance, BMPs must be maintained, and cared for. They must continue to provide the level of service they were originally designed to provide, and they may not be allowed to become a nuisance. The O&M agreement will be a binding contract between the owners of property served by a BMP and the City. The agreement will guarantee performance on the part of the owner, and grant relief and compensation to the City in the event of failure. The intent of the agreement is the protection of the City in the event of failure to maintain on the part of the owner(s). The O&M agreement must include a statement granting the City the right to enter and maintain the BMP if necessary, and a statement releasing the City from any responsibility to maintain the BMP.

Escrow: In many cases, an Escrow account will be necessary for the preservation and control of appropriate funds to ensure proper maintenance of the BMPs. The escrow account shall be established so that the City will approve the withdrawal of funds, and if necessary, the City may unilaterally withdraw funds to make repairs as necessary. The account shall maintain sufficient funds (as determined by the Stormwater Administrator) to provide for major repairs. 75% of the cost of re-construction will be considered as a standard. The development of the Escrow can be pro-rated concurrent with a fixed build out schedule.

Records: The entity responsible for the maintenance of the BMP shall maintain the records of the maintenance for a period of five years after the maintenance is performed. These records shall be made available for inspection by the City after due notice.

Annual maintenance and inspection: Annually, not more than 30 days before the anniversary of the O&M agreement, the owner / responsible party shall submit an

inspection report to the City on the form provided by the City. This report must be compiled by a person qualified (as listed in the ordinance) to perform these inspections.

Notice to Owners: Any property that is to be served by a runoff control BMP under the ordinance, must have deed restrictions that clearly indicate the location and nature of the BMP, reference to the O&M manual, and strict prohibitions against alteration of the BMP without approval from the City.

Execution:

1. Determine existing condition area:
    a. 50/50 threshold? If so, use entire site area. *(see §14-738 (a) (3) of the ordinance)*
    b. Greenfield development? Use entire site area.
    c. Redevelopment or Expansion < 50/50? Use only area to be converted to impervious. (Net new impervious.)
2. Determine one (1) inch (WQ) volume: Divide existing condition area (square feet) by 12. This will be the effective WQ volume. For very large sites, routing may be desired.
3. Determine WQ depth in control structure.
4. Determine permissible WQ discharge rate: City of Gastonia 1yr/24hr storm has a rate of 0.10625 in/hr. The City uses a Rational C of 0.25 for pre-developed. Therefore: $\mathbf{Q}_{WQ} = \mathbf{A}_{\text{existing condition}}$ x **0.0265625.**
5. Determine appropriate WQ outlet size.
    a. City of Gastonia uses 0.62 as the orifice constant for round sharp edged orifices.
    b. WQ volume must not draw down quicker than 48 hrs.
6. Determine maximum 2 year and 10 year detention (not discharge) as functions of $C_{\text{post developed}}$, and $T_{c\ \text{predeveloped}}$.: Considering the IDF chart included in this document, each recurrence/duration combination will produce a predictable detention requirement. The City of Gastonia requires that the 2 and 10 year storms be controlled to the peak pre-developed runoff condition. Unmodified, the peak runoff would be expected as the occurrence of the storm of duration equal to the pre developed T_c. This discharge then becomes the allowable discharge for all storms of that frequency. It is therefore necessary to analyze the series of durations for a frequency, applied to the post-construction condition and allowing for the pre-set discharge, to ensure that the design volume is sufficient to contain any and all storms of that frequency. In other words, a chart or graph must be produced that calculates the total volume detained for each duration (5 minute steps are recommended) until a peak volume is determined. This volume should then be analyzed with the proposed geometry of the detention structure to site the outlet control for the 2 and/or 10 year storms. *(Remember to take credit for the WQ volume, as this will necessarily be at the bottom of the system.)*

Example: Lineberger Park Renovations (SE sector) (2008)

1. Determine Existing Condition Area: Total Area = 1.80 Ac, Impervious Area = 0.37 Ac, $T_{c\ pre}$ = 5min, C_{pre} = 0.25, CA_{pre} = 0.45, CA_{post} = 0.709.

2. Determine WQ volume: Vwq = 0.37Ac x 1in / 12(in/ft) x 43,560 (ft^2/Ac) = 1,343 ft^3.
3. Determine WQ depth in control structure: Given: 3:1 side slopes and bottom dimensions of 2ft x 94ft, D_{WQ} = 21.24 inches (1.83ft).
4. Determine permissible WQ discharge rate: QWQ = 0.25 x 0.0265625 in/hr x 1.80Ac. = 0.0478cfs.
5. Determine appropriate WQ outlet size: $Q = 0.62 \times A_o \times (2gh)^{1/2}$ $A_o = Q/\{0.62 \times (2gh)^{1/2}\}$. Ao = 0.0478cfs / {0.62 x (2 x 32.2ft/s^2 x 2.5ft) $^{1/2}$} = 0.0003ft^2 , $d_o = 1\,1/16$", after routing, this orifice will not detain the V_{WQ} long enough, the orifice must be reduced to 19/32" to hold for 48 hrs. The new Q_{WQmax} is 0.0149cfs.
6. Determine 10 year peak volume:
   $Q_{10allow}$ = 0.25 x 1.80Ac x 7.2in/hr = 3.24cfs,
   $Q_{5min\ post}$ = 0.709(Ac/1) x 7.2 = 5.1048cfs
   $V_{5min\ post}$ = (5.1048cfs – 3.24cfs) x 5 min x 60(s/min) = 559 cf
   $Q_{5min\ post}$ = 0.709(Ac/1) x 5.76= 4.0838cfs
   $V_{5min\ post}$ = (4.0838cfs – 3.24cfs) x 10 min x 60(s/min) = 506 cf
   Since the WQ volume is greater than the 10yr volume, we must check without the discharge based on the max load storm, in this case the 5 minute storm. Q_{5post} = 5.1048cfs: V_{5post} = (5.1048cfs x 300s) – 1343 = 188 additional ft^3 which brings the depth in the given geometry to 1.9 feet. Use 2 feet for the construction design.

Notes: While these calculations represent an appropriate path, they are not the only acceptable method.

This example was converted to an infiltration system for actual construction at Lineberger Park.

Footnote:

a: POINT PRECIPITATION FREQUENCY ESTIMATES
FROM NOAA ATLAS 14
North Carolina 35.316 N 81.182 W 800 feet
from "Precipitation-Frequency Atlas of the United States" NOAA Atlas 14, Volume 2, Version 2
G.M. Bonnin, D. Todd, B. Lin, T. Parzybok, M.Yekta, and D. Riley
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