downstream riffle shall be replaced with a grade control. See Section 6.04.07 for more information on grade controls.

5) All lateral outfalls shall include a concrete toe wall. Toe wall shall be a minimum of 30" below the channel flowline.

6.02.04 Emergency Relief System

The design components of the drainage system include the inlets, pipe, storm sewers, and improved and unimproved channels that function during typical rainfall events. The Emergency Relief System (ERS) comprises the major overland flow routes such as yard swales, streets, floodplains, detention basins, and natural overflow and ponding areas. The purpose of the emergency relief system is to provide a drainage path to safely pass flows that cannot be accommodated by the piped system without causing flooding of adjacent structures, or street ponding depth that restricts emergency access or property ingress/egress.

1. Provide an ERS that generally begins at the most upstream intake structure to convey flows when the piped system is blocked. The ERS shall be directed to a point of discharge at a detention facility, or as otherwise approved by the City. The ERS may include Critical and Non-Critical Components as defined herein.
   a. Non-Critical Component – A portion of the ERS that is unobstructed downstream and outside the influence of ponding.
   b. Critical Component – A portion of the ERS that is obstructed downstream causing ponding for the design event that, if not properly graded, could cause structural flooding or restrict property ingress/egress.

2. The capacity of the ERS shall be verified with hydraulic calculations using the following criteria:

   a. The ERS shall be designed for the 100-year, 20-minute storm event, assuming the piped system is blocked. The Modified Rational method shall be used to calculate the peak flow rate. See Section 6.01.06 for more information.

   b. The maximum peak flow rate through an ERS for the 100-year, 20-minute storm event, assuming the piped system is blocked, shall be 50 cubic feet per second (CFS) unless otherwise approved by the City.

   c. The maximum water surface elevation for improved open channel flow shall be one (1) foot.

   d. The ERS ponding depth in residential yards shall be 18 inches or less for public safety and nine (9) inches or less in streets and parking areas at the lowest gutter elevation for emergency access and property ingress/egress. Modifications to typical street cross-sections may be considered to achieve conformance with this criterion.

e. Low sill elevation of structures and any openings (i.e. egress windows, window wells, walkouts, etc.) adjacent to the ERS shall be established at a minimum of 6 inches above the 100-year high water elevation.

f. Where the topography will not allow for an emergency relief path or as otherwise approved in lieu of an emergency relief path, pipe and intake capacity of the piped system shall be designed for the 100-year, 20-minute event. Additionally, the minimum pipe size shall be thirty-six (36) inches in diameter.

3. The following is the minimum design information that shall be included on the improvement plans:

   a. The ERS shall be designated on the drainage area map and on the grading plan from the first upstream intake structure to the point of discharge. All critical and non-critical components of the ERS shall be labeled.

   b. Non-Critical Components of the ERS shall be identified on the plans with a general flow path provided.

   c. Critical Components of the ERS shall be identified on the plans with cross-sections and calculations provided demonstrating compliance with the design criteria noted listed in Section 6.02.04.2.

   d. For where an open channel is part of the ERS, provide the following information (table preferred):
      i. Finish grade elevations of property lines
      ii. the highest midpoint in between property corners for side yard ERS
      iii. Minimum low sill elevation for each lot along the ERS

   e. For where a piped system is part of the ERS, provide the following information (table preferred):
      i. 100 year 20 minute flows for each drainage area to the ERS
      ii. Capacity of intake structures for the 100-year 20-minute event
      iii. Capacity of the piped system for the 100-year 20-minute event
      iv. Ponding depths in conformance with Section 6.02.04.2.d.

4. At a minimum, a 10-foot wide drainage easement shall be established over the ERS on the record plat. Provide additional easement width as required to accommodate the ERS.

5. All foundation opening elevations shall be clearly documented on the Building Permit Application Submittal.

6. Temporary and final occupancy permits will not be issued until structures, grading and drainage are verified to be in accordance with this section.

   a. All lots adjacent to Non-Critical Components of the ERS shall be visually verified by the City for conformance with the ERS criteria and improvement plans prior to final occupancy.

b. All lots adjacent to Critical Components of the ERS shall be verified for construction in accordance with the improvement plans by a survey signed and sealed by a Professional Land Surveyor prior to temporary occupancy.

c. If during the verification process it is determined that the ERS component may not be constructed in accordance with the improvement plans, the builder shall either:

   i. Provide an Engineer Certification signed and sealed by the professional engineer. The Engineer Certification shall demonstrate through hydraulic calculations that the ERS has been verified to suffice the criteria in Section 6.02.04.2 as constructed.
   ii. Ensure the grades and elevations follow the improvement plans and provide elevation verification by a Professional Land Survey demonstrating conformance to the improvement plans.

d. The next permit inspection shall not be authorized by the Building Official without verification.

6.02.05 Sinkhole Areas

1. Sinkhole Report

Where improvements are proposed in any area identified as sinkhole areas, a sinkhole report will be required. This report is to be prepared by a Professional Engineer, registered in the State of Missouri, with demonstrated expertise in geotechnical engineering, and shall bear his or her seal.

The sinkhole report shall verify the adaptability of grading and improvements with the soil and geologic conditions available in the sinkhole areas. Sinkhole(s) shall be inspected to determine its functional capabilities with regard to handling drainage.

The report shall contain provisions for the sinkholes to be utilized as follows:

a. All sinkhole crevices shall be located on the plan. Functioning sinkholes may be utilized as a point of drainage discharge by a standard drainage structure with a properly sized outfall pipe provided to an adequate natural discharge point, such as a ditch, creek, river, etc.

b. Non-functioning sinkholes and sinkholes under a proposed building may be capped.

c. If development affects sinkholes, they may be left in their natural state; however they will still require a properly sized outfall pipe to an adequate natural discharge point.

d. An emergency relief path shall be required for all sinkholes assuming the outfall pipe and sinkhole become blocked.

Where the topography will not allow for an emergency relief path:

1) The storm sewer shall be designed for the 100-year, 24-hour storm; and

2) If this storm pipe is smaller than thirty-six (36) inches in diameter, a designated ponding area shall be identified, assuming the pipe is blocked; and

3) Ponding areas shall be based on the 100-year, 24-hour storm; and

4) The low sill of all structures adjacent to the ponding area shall be a minimum of 6 inches above the 100-year high-water elevation and in compliance with Section 6.02.04.

2. Procedure for Utilization of Sinkholes

a. Excavation. Prior to filling operations in the vicinity of a sinkhole, the earth in the bottom of the depression will be excavated to expose the fissure(s) in the bedrock. The length of fissure exposed will vary, but must include all unfilled voids or fissure widths greater than one-half (1/2) inch maximum dimensions which are not filled with plastic clay.

b. Closing Fissures. The fissure or void will be exposed until bedrock in its natural attitude is encountered. The rock will be cleaned of loose material and the fissures will be hand-packed with quarry-run rock of sufficient size to prevent entry of this rock into the fissures, and all the voids between this hand-packed quarry-run rock filled with smaller rock so as to prevent the overlying material's entry into the fissures. For a large opening, a structural (concrete) dome will be constructed with vents to permit the flow of groundwater.

c. Placing Filter Material. Material of various gradations, as approved, will be placed on top of the hand-packed rock with careful attention paid to the minimum thicknesses. The filter material must permit either upward or downward flow without loss of the overlying material.

The fill placed over the granular filter may include granular material consisting of clean (no screenings) crushed limestone with 10 inch maximum size and one inch minimum size or an earth fill compacted to a minimum density of 90 percent modified Proctor as determined by ASTM D-1557.

d. Supervision. Periodic supervision of the cleaning of the rock fissures must be furnished by the Engineer who prepared the Soil Report. Closing of the rock fissures will not begin until the cleaning has been inspected and approved by that Engineer.

During the placement and compaction of earth fill over the filter, supervision by the Engineer shall be continuous. Earth fill densities will be determined during the placement and compaction of the fill in sufficient number to insure compliance with the specification. The

Engineer is responsible for the quality of the work and to verify that the specifications are met.

6.02.06 As-Built Certification for Storm Sewer Facilities

An as-built survey is required for all storm sewer facilities. The design engineer shall submit the Professional Engineer's Construction/As-Built Certification for Sanitary and Storm Sewers as required in Section 11.

The City may require the submittal of revised hydraulic calculations for any sewer reach having an as-built grade flatter than the design grade by more than 0.1 percent. Based on a review of this hydraulic information, the City may require the removal and replacement of any portion of the sewer required to ensure sufficient hydraulic capacity of the system.