

**DRAFT****CHAPTER 11. SINKHOLES AND KARST FEATURES****CONTENTS**

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## 1.0 OVERVIEW

### 1.1 General

The Springfield area is located on the Springfield Plateau of the Ozarks physiographic region. The area is underlain by Mississippian Age limestone, which is highly susceptible to solutional weathering. This geology is commonly referred to as “karst” and is characterized by numerous sinkholes, losing streams, springs, caves, and other related features. As a result, a complex and often fragile interaction exists between surface and groundwater, requiring special consideration and protection.

Karst geology can present certain hazards to urban development, such as unstable soil foundation for structures, flood hazards, groundwater contamination, and public safety hazards related to collapses. Requirements, design standards, and methods to address these hazards are contained in this chapter.

The general policy in addressing karst hazards and features is based on the following stepped approach to minimize impacts:

1. **Avoidance** – Avoid disturbance and impacts in and around sinkholes and karst features to the Maximum Extent Practicable.
2. **Minimization** – If disturbance or impacts are necessary, they must be minimized to protect against harm to others or the environment.
3. **Mitigation** – Significant disturbances or impacts that pose a risk of harm to others or the environment must be mitigated to provide protection from harm.

Because karst features can occur in a variety of forms and severity, each feature must be addressed on an individual basis. However, for the purpose of establishing standards for addressing features, sinkholes will be referred to in this chapter as being in one of two broad categories: depression sinkholes or collapse sinkholes.

- Depression sinkholes have a defined drainage area and will generally be shown on the City topographic maps as a closed contour. Development concerns related to depression sinkholes that must be addressed include flood hazards and soil stability within the geologic rim. When runoff from a development is draining to a depression sinkhole, impacts to groundwater quality must be addressed through on-site Best Management Practices (BMPs).
- Collapse sinkholes are areas of karst-related subsidence with no defined drainage area when occurring outside of a depression sinkhole. Collapse sinkholes can occur in the bottom of a depression sinkhole and are commonly referred to as the “eye” of the sinkhole. Stabilization of

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collapse sinkholes requires a permit from the Department of Public Works. A report by a qualified professional may be waived if the feature is a minor feature outside of the geologic rim of a depression sinkhole and no development is proposed in the area. For public health and safety reasons, small collapses outside of a depression sinkhole should generally be filled and stabilized in accordance with the City standard.

Additional information regarding sinkhole permits, report requirements, and stabilization measures is provided in this chapter.

**1.2 Authority**

Chapter 96, Division 2, Sinkholes (Section 96-2) of the Springfield City Code provides the City with regulatory authority to require a permit prior to certain activities in the proximity of sinkholes and addresses the report requirements related to obtaining a permit for such activities. Resolution No. 8648, known as the Water Quality Protection Policy (WQPP), provides regulatory authority to require stormwater BMPs be provided as a part of new developments in sensitive watersheds, such as drinking water supply and sinkhole watersheds.

**2.0 SINKHOLE PERMIT AND REPORT REQUIREMENTS**

A permit from the Department of Public Works is required prior to any filling, grading, or use of motorized equipment within a sinkhole rim, as defined by the most restrictive of the following:

1. Highest closed contour shown on City topographic maps;
2. Sinkhole rim shown on City sinkhole maps; or
3. Other best available data.

Prior to the approval of any development containing a sinkhole or draining to a sinkhole, a sinkhole evaluation must be completed. A sinkhole evaluation includes a geological evaluation and a flooding evaluation. Permits and evaluations shall be completed in accordance with Chapter 96 of the Springfield City Code and the provisions of this chapter. Other city, state or federal permits may be required, depending on the size and nature of the proposed activity. The SF-Sinkholes spreadsheet may be used to assist in calculations needed to complete the sinkhole evaluation.

**2.1 Permit Requirements**

Chapter 96, Division 2, Sinkholes (Section 96-2) of the Springfield City Code addresses the requirements related to disturbances in sinkholes and proposed developments containing a sinkhole or draining to a

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sinkhole. The general information, requirements, and restrictions contained in Section 96-2 are as follows:

1. A permit must be obtained from the Director of Public Works prior to the operation of motorized equipment within a sinkhole. An acceptable plan must be provided containing measures to minimize impacts on the sinkhole.
2. An analysis of the drainage from a development to a sinkhole must be provided.
3. The construction of structures or public streets in sinkholes is generally restricted. Such proposals may be considered on a case-by-case basis and must adhere to other flood protection and water quality criteria in this manual.
4. Dumping in sinkholes is prohibited.
5. Certain plan notes regarding sinkhole protection must be provided on the plan for any proposed development that drains to or contains a sinkhole.
6. Enforcement and appeal processes are provided.

The Public Works Department may require plans for permanent stormwater BMPs to be included as part of the report, depending on the nature of the activity and any proposed developments. Stormwater BMPs must be shown on all development plans such as public improvements plans and site development plans for any development that contains a sinkhole or drains to a sinkhole.

## **2.2 Sinkhole Evaluation**

A sinkhole evaluation includes a geological evaluation and a flooding evaluation. A sinkhole evaluation must be completed by a qualified professional engineer or geologist. A geologic evaluation of an offsite sinkhole will not be required if it is determined by a qualified professional that the sinkhole will not have any geological effect on the site.

Sinkholes receiving an increase in runoff volume from a proposed development require an evaluation with the following components:

1. Drainage area map
2. Details of the drainage path of the discharge from the development to the sinkhole (offsite sinkholes)
3. Sinkhole boundary map based on topography

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#### 4. Flooding evaluation

##### **2.2.1 Geological Evaluation**

A geologic evaluation is required for any sinkhole within a proposed development. The evaluation shall provide the following:

1. Identification of all sinkholes as depression or collapse sinkholes.
2. A map of the topographic rim (highest closed contour) of all depression sinkholes.
3. A map of the geologic rim based on geologic evaluation of all depression and collapse sinkholes.
4. A map showing no-build areas for buildings and other structures based on topographic and geologic rims of depression and collapse sinkholes.
5. Detail of proposed stabilization of collapse sinkholes, if applicable.

The topographic rim shall be based on a 2-foot contour interval or less. The geologic rim shall be determined by a geologic evaluation conducted by a qualified engineer or geologist. If the topographic rim is designated a no-build zone, determination of the geologic rim may not be necessary. The no-build zone, at a minimum, shall cover the geologic rim. The flooding evaluation must also be considered when determining the no-build zone.

##### **2.2.2 Flooding Evaluation**

Sinkhole flood elevations must be determined under both pre-development and post-development conditions for any sinkhole receiving increased runoff. All calculations must be completed assuming no subsurface outflow from the sinkhole. This evaluation may not be necessary for certain collapse sinkholes that do not pose a flood risk.

The calculated flood elevation for a sinkhole shall be determined from the runoff resulting from the 24-hour, 100-year rainfall (Chapter 5, Runoff, Table RO-1). If there is potential for flood damage at lower elevations, the City may require evaluation of higher frequency rainfalls. Runoff shall be calculated using the SCS Curve Number Loss Model (Chapter 5, Runoff, Section 4.1).

If the flood elevation is determined to be higher than the overflow point on the topographic rim (saddle), then the flood elevation shall be determined using reservoir routing methods (Chapter 9, Detention, Section 3.3.3). In this case, additional downstream evaluation is necessary. A flooding evaluation shall be made of the receiving sinkhole, or the flow rate in the receiving stream shall be determined.

**2.2.3 Flooding Elevation Restrictions**

If the post-development flooding area is located entirely on the development property, no additional evaluation is required. A drainage easement restricting structures shall be established covering the area inundated by the 100-year, 24-hour flood under fully developed conditions for the entire watershed. Storm water BMPs must be constructed in accordance with the Water Quality Protection Policy and Chapter 10, Water Quality.

When the post-development sinkhole flooding area is located fully or partially on another property, the following conditions apply:

1. The post-development sinkhole flooding area must be contained within a drainage easement restricting structures.
2. Any flow leaving the proposed development must be contained within a drainage easement until it reaches the receiving sinkhole. This easement must contain the 100-year flood.
3. Where a drainage easement does not contain the sinkhole flooding area, it must be shown that
  - a. The proposed development will not cause a significant rise (<0.1 foot) in the 100-year flood elevation, or
  - b. The proposed development will cause no more than 1 foot of rise in the 100-year flood elevation, taking into consideration, on a proportional basis, all other potential development in the watershed. This rise shall not cause any damage to any building, street or other improvement.

When existing improvements are below the 100-year flood elevation, an evaluation of the impacts during higher frequency rainfalls is required. It must be shown that additional runoff from a proposed development will not increase the flood elevation at the lowest elevation of the existing improvements.

Storm water BMPs must be constructed in accordance with the Water Quality Protection Policy and Chapter 10, Water Quality.

**2.2.4 Mitigation for Increased Post-Development Flood Elevation**

Flood mitigation may be achieved through excavation of compensatory volume within the sinkhole. The area of excavation must be either within the property being developed or within an offsite drainage easement. Excavation is subject to sinkhole eye setbacks given in Section 2.4 and must be completed with special care following the restrictions in Chapter 96, Division 2, Sinkholes (Section 96-2) of the Springfield City Code. If it is shown that adequate easements or access rights cannot be obtained,

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mitigation shall be achieved through further restriction of discharge beyond standard detention discharge criteria based on field investigation and records of the receiving sinkhole intake capacity.

### 2.3 Water Quality Protection

Sinkholes conduits can provide direct recharge routes to groundwater. As a result, these conduits can provide a route for polluted runoff to enter drinking water supplies that are otherwise protected and often being consumed with no treatment. Protection of water quality entering sinkholes protects the quality of area wells, caves, springs and streams. Because the nature of groundwater movement in the Springfield area is complex and not fully known, it is assumed that any conduit could potentially be a source of any of the features mentioned above. Therefore, it is critical to implement water quality protection practices within all developments that drain to sinkholes. Special restrictions may apply to developments within close proximity to private or public wells or in areas that may have an effect on endangered species such as the Ozark cavefish.

#### 2.3.1 Groundwater Contamination Hazard

When determining the level of water quality protection required for a development, the relative level of potential groundwater contamination shall be taken into account. The land use and amount of directly connected impervious area (DCIA) shall be classified as low, moderate, or high in accordance with Table SH-1 in order to determine contamination hazard.

**Table SH-1  
Assessment of Groundwater Contamination Hazards**

<b>Low Hazard</b>	<b>Moderate Hazard</b>	<b>High Hazard</b>
Residential, low density commercial and office developments with DCIA < 1 acre.	Higher density residential, commercial and office developments with DCIA > 1 acre.	High density commercial, industrial and manufacturing areas with concentrated discharge.
Streets, parking lots and buildings with a dispersed discharge into vegetated areas.	Streets, parking lots and buildings with a concentrated discharge and DCIA < 5 acres.	Streets, parking lots and buildings with a concentrated discharge and DCIA > 5 acres. All arterial streets and collector streets in industrial and manufacturing areas.
Land disturbances < 1 acre.	Land disturbances between 1 and 5 acres.	Land disturbances > 5 acres.
Park and recreational areas.		Rail yards, gas stations and other high intensity operations facilities handling fuel or other toxic materials.



**DRAFT****2.3.2 Water Quality Protection Measures**

The most effective protective BMPs are separation from known sinkhole eyes and distribution of runoff into sheet flow as it nears the sinkhole. Required setbacks from sinkhole eyes are provided in Section 2.4. The use of curbs on the low side of the development and a hard-lined drainage system are discouraged. The use of a curbless edge, sheet flow, buffer strips and grass swales is preferred. Where it is necessary to discharge to a sinkhole through a hard-lined drainage system, a higher level of treatment is required such as an extended detention basin or other structural BMP. See Chapter 10, Water Quality, for design criteria for common BMPs. BMPs required for low, medium, and high hazard areas are described in Sections 2.3.2.1 and 2.3.2.2.

**2.3.2.1 BMPs for Low Hazard Areas**

1. During Construction:
  - a. Maintain a 25-foot buffer from any sinkhole eyes where no disturbance can occur.
  - b. No disturbance in the sinkhole flooding area.
  - c. Maintain a silt barrier around the rim of the undisturbed area until all disturbed areas are vegetated.
  - d. Provide a ditch check at all point discharges.
2. Post Construction:
  - a. Sheet flow discharges must maintain a minimum 25-foot grass buffer strip and properly designed grass swales and ditch checks for point discharges.

**2.3.2.2 BMPs for Moderate Hazard Areas**

1. During Construction:
  - a. Maintain a 50-foot buffer from any sinkhole eyes where no disturbance can occur.
  - b. No disturbance in the sinkhole flooding area.
  - c. Maintain a silt barrier around the rim of the undisturbed area until all disturbed areas are vegetated.
  - d. Provide a ditch check at all point discharges with less than 1 acre of drainage area.
  - e. Provide a sedimentation basin at all point discharges with more than 1 acre of drainage area.

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2. Post Construction:
  - a. Sheet flow discharges must maintain a minimum 50-foot grass buffer strip and properly designed grass swales and ditch checks for point discharges.
  - b. Developments greater than 1 acre shall follow requirements of Chapter 10, Water Quality.

**2.3.2.3 BMPs for High Hazard Areas**

1. During Construction:
  - a. Maintain a 100-foot buffer from any sinkholes eyes where no disturbance can occur.
  - b. Maintain a 25-foot buffer from the flooding area where no disturbance can occur.
  - c. Maintain a silt barrier around the rim of the protection area until all disturbed areas are vegetated.
  - d. Provide a sedimentation basin at all point discharges.
2. Post Construction
  - a. Sheet flow discharges must maintain a minimum 100-foot grass buffer strip and properly designed grass swales and ditch checks for point discharges.
  - b. Developments greater than 1 acre shall follow requirements of Chapter 10, Water Quality.
  - c. Developments involving the outdoor handling of toxic materials must provide a containment plan to show what measures will be taken to assure that discharges of toxic materials will be contained and prevented from entering a sinkhole.
  - d. A National Pollutant Discharge Elimination System (NPDES) Stormwater Discharge Permit may be required from the Missouri Department of Natural Resources for industrial facilities or other developments handling toxic materials.

Erosion and sediment control provisions shall be provided in the Storm Water Pollution Prevention Plan (SWPPP) and shall adhere to the City's Erosion and Sediment Control Guidelines.

**2.4 Setback Requirements**

New developments shall maintain setbacks in the form of vegetated buffers as summarized in Table SH-2.

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**Table SH-2  
Minimum Setbacks from Sinkholes**

<b>Hazard Level</b>	<b>Minimum Setback From Flooding Area</b>	<b>Minimum Setback From Any Eye</b>
Low	25 ft	50 ft
Moderate	25 ft	50 ft
High	50 ft	50 ft

### **3.0 OTHER KARST FEATURES**

In addition to sinkholes, other karst features shall be protected including caves, springs, losing streams, and exceptional geologic features.

#### **3.1 Caves**

Any cave feature that may be accepting or discharging water shall be treated as a sinkhole eye with all applicable restrictions and setbacks. Exceptional or significant caves shall be protected from any new development by a minimum 100-foot setback.

No proposed construction shall be within 100 feet of a known cave alignment unless a report prepared by a qualified engineer or geologist is submitted and approved by the City, verifying that:

1. The cave will not be materially altered by the development, and
2. Sound foundations or the support for the development will not be subject to collapse or undue settling.

#### **3.2 Springs**

No new development shall be within 100 feet of a spring unless a report prepared by a qualified engineer or geologist is submitted and approved by the City verifying that the quality and quantity of the spring flow will not be materially altered by the development. In the case of small wet-weather springs that only flow for a short period of time after rainfall, normal sinkhole setbacks apply, and provision must be made to allow the spring to flow unaltered with no damage to structures or other improvements.

**DRAFT****3.3 Other Features**

Developments containing any other significant karst features shall be designed to protect the features to the maximum extent practicable, shall take measures to protect all improvements from potential impacts, and shall take measures to protect the health, safety and welfare of the public.

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