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ORDINANCE FOR THE CONTROL OF URBAN DEVELOPMENT IN SINKHOLE AREAS IN THE BLUE GRASS KARST REGION, LEXINGTON, KENTUCKY

James S. Dinger[a] and James R. Rebmann[D]

ABSTRACT

Uncontrolled urban development on sinkhole fill and areas adjacent to sinkholes can lead to significant economic loss to developers, local government, and property owners. Funds may have to be provided for remedial engineering construction for foundation stability, flooding, or sinkhole collapse. Off -site problems may be intensified because of development in sinkhole areas. In a recent Fayette County study of storm-water projects for a 6-year period (1985-1990), the expenditure of over $1.5 million could be attributed, either directly or indirectly, to problems caused by urban development in sinkhole areas. Many other areas, designated as having potential sinkhole problems, were not considered in the calculation of cost estimates because of the present boundary of urban development and the limited time frame addressed in the study.

Recently, it has become increasingly apparent that the Lexington- Fayette Urban-County Government, developers, and builders responsible for development in sinkhole areas may be liable for damages if it can be shown that development took place in an area where sinkhole problems could be expected to occur. For this reason, a sinkhole ordinance was created and adopted in 1985 by the Lexington-Fayette Urban-County Government. This ordinance defines sinkhole-drainage areas, development-plan requirements, non-buildable areas, and required hydrogeologic studies that must be submitted for governmental review in order to request approval for urban development.

The ordinance prohibits the filling of sinkholes and limits development within their boundaries as well as the discharge of storm water into sinkholes. Sinkhole boundaries are defined on topographic maps with 5-foot contours. The designated boundaries of sinkholes may be reduced if the developer submits a hydrologic study of the sinkhole system that indicates the proposed urban development will not have an adverse effect. Non-developable areas maybe set aside for open space, parks, or green belts. An increase in development density is allowed to off set the cost of land that is determined to be non-developable.

INTRODUCTION

Lexington is located in Fayette County (283 square miles) in north-central Kentucky, an area generally referred to as the Blue Grass region of the State (Fig. 1). More specifically, Lexington is located in the Inner Blue Grass region, where carbonate rocks of Middle to Late Ordovician age crop out along the crest of the Cincinnati Arch. Published U.S. Geological Survey 7.5-minute geologic maps indicate the distribution of rock types and provide detailed lithologic descriptions of the units, which include the Lexington Limestone and the Clays Ferry Formation. These units attain a thickness of approximately 500 feet in the study area (Cressman, 1973; Weir and others, 1984).

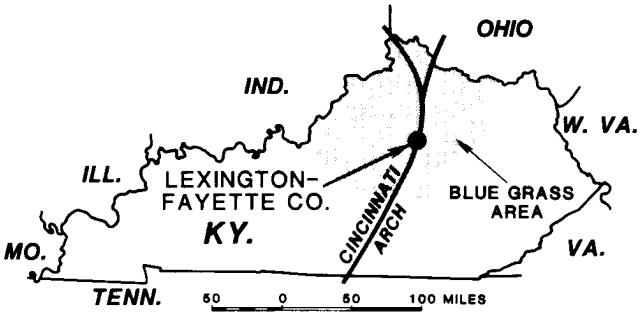

Figure 1. Map showing location of Lexington and Fayette County.

[a]Kentucky Geological Survey, University of Kentucky, Lexington, KY 40506
[b]Lexington-Fayette Urban-County Government, Lexington, KY 40507

From a hydrogeologic perspective, members composing these two formations are described as limestone, limestone and shale, argillaceous limestone, or calcareous shale. These lithologies have allowed the development of a gently rolling terrain characterized by moderate karst development. Karst features include sinkholes, sinking streams, and springs, which in several instances are, or were, the source of drinking-water supplies for small communities. Although a few large caverns are present, they are not numerous. Thrailkill and others (1982) have published the most detailed study of ground-water occurrence and movement in the region.

This paper has two main purposes. One is to present the general types of urban-development problems associated with karst features in the Lexington area. The other purpose is to discuss the basis for and the content of an ordinance adopted in 1985 by the Lexington-Fayette Urban-County Government to regulate development with respect to the presence of sinkholes and their associated flow systems.

HISTORICAL PERSPECTIVE

In 1928 the Lexington City Charter authorized the creation of the Fayette County Planning and Zoning Commission, and in 1931 Lexington's first comprehensive growth plan was adopted. Since that time the growth of Lexington has been guided by comprehensive planning and zoning of land use. In 1958 the Urban Service Area (USA) concept was devised to protect prime agricultural lands and the internationally known horse farms against uncontrolled urban development. At present the USA is an area of 76 square miles with Lexington at its center (Fig. 2). In general terms, large-scale development will only occur within the 76 square miles of the USA. The 207 square miles of Rural Service Area (RSA) should remain rural (Fig. 2). Residential development in the RSA requires a minimum lot size of 10 acres, and with current land costs of $10,000 or more per acre, it is anticipated that urban-type development in the RSA will be minimal.

In 1974, Lexington and Fayette County merged to form a city-county government, one of approximately a dozen such communities in the United States. The creation of merged government brought about many changes in the governmental infrastructure for development planning. The concept of a growth management system was developed, technical staff was expanded, and, in part, planning designs considered environmental concerns. A new policy was initiated that provided for a sequential timing of urban growth in accordance with provision and adequacy of public services and facilities. The combined effect of these changes insures that any area to be developed goes through an environmental analysis.

In 1985 the estimated population for Fayette County was 222,800. This reflects a growth rate of approximately 28 percent since 1970. In terms of land use for the past 15 years, approximately 350 acres per year have been converted from agricultural land for residential purposes, and about 40 acres per year of agricultural land have been converted to non-residential land use (business/commercial).

The growth rate and direction of growth were significant in developing sinkhole policies. Early development through the 1960's took place primarily on relatively flat land (2 to 6 percent slope) and avoided the drainage ways of the six watersheds within the USA (Fig. 2) and the major areas of sinkhole activity and flooding. Subsequent development has taken place on steeper slopes along drainages (6 to 15 percent slope) and has encroached directly into sinkhole areas (Fig. 2).

This shortsightedness has created problems for the Urban-County Government. The cost of correcting major environmental problems is usually beyond an individual's financial means, and gets passed on to the taxpayers of the Urban-County Government. A 1983 Storm Water Plan (Kennoy, 1983a, 1983b) illustrates that many storm-water problems were caused by development in and around sinkhole areas. Table 1 shows the projected cost based upon figures generated by the 1983 storm-water report. In some cases the cost figure indicates the amount of money necessary to remedy a problem directly related to a particular sinkhole, and in others a sinkhole is an indirect cause associated with a flooding problem.

The minimum cost to alleviate urban sinkhole-related flooding problems totals over $1.5 million. This cost represents 1.7 percent of the 1986 Urban-County Government annual budget of approximately $90 million, and does not account for those areas that do not have an estimated cost (Table 1). Also, the cost does not reflect structural damage to buildings due to differential subsidence and general surface collapse, both of which have occurred in the area. The issue of karst is, therefore, monetarily significant to Fayette County.

As a rule, problems are not widespread in every neighborhood, but many hundreds of sinkholes have been mapped on detailed base maps and on the Comprehensive Plan maps (Fig. 2). Past development in Lexington has often ignored the consequences of building in sinkholes and has used sinkholes for many urban purposes: disposal of storm water, refuse disposal, water supplies, and sinkhole filling for development. The following two case histories illustrate sinkhole-related

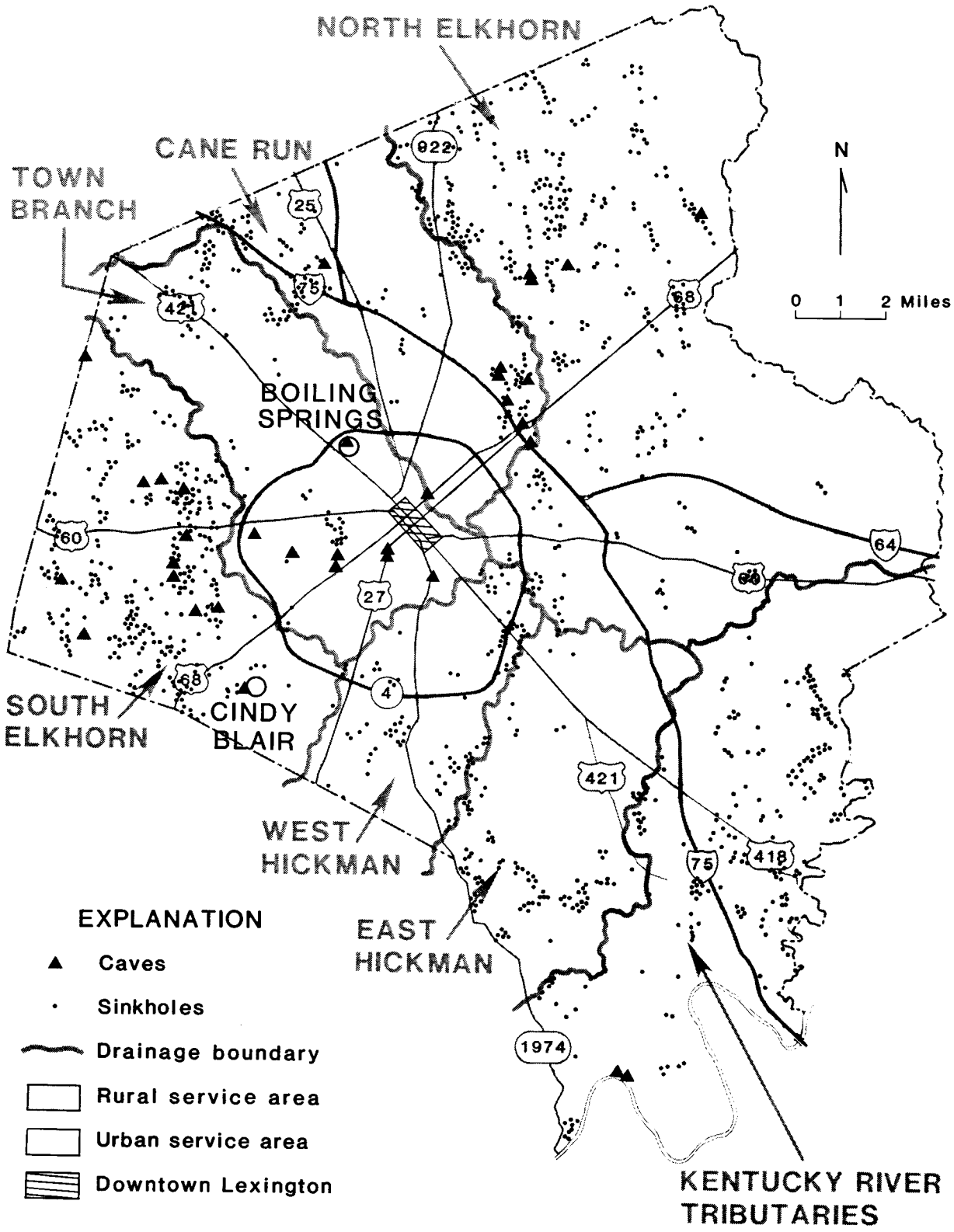

Figure 2. Map showing location of environmental features in Fayette County.

problems. These examples are but two of numerous types of hazards created by karst features in the Lexington-Fayette County area. Associated problems include land subsidence, sinkhole collapse, flooding, and ground-water transport of hazardous materials such as gasoline from improperly placed or failed facilities or from surface spills.

Table 1.—Projected Cost for Drainage Improvements, 1985-1990 (Modified from Kennoy, 1983a, 1983b).

Stream Drainage Area	*Project Number*	*Costs*
West Hickman	WH-36	$ 250,000
South Elkhorn	SE-4	18,000
	SE-12	85,000
	SE-2	30,000
Cane Run	CR-4	355,000
	CR-5	90,000
Town Branch Wolf Run	TB-15	350,000
	WR-29	45,000
	WR-5	8,000
North Elkhorn	NE-2	17,000
	NE-5	2,000
		$1,250,000
Other sinkhole areas that require remedial action but not included in the 6-year drainage project:		
Stream Drainage Area	*Project Number*	*Costs*
West Hickman	WH-15	$ 20,000
	WH-37	3,500
	WH-40	Not determined
South Elkhorn	SE-1	Not determined
	SE-10	5,000
	SE-13	Not determined
Cane Run	CR-16	7,000
	CR-17	Not determined
Town Branch Wolf Run	TB-21	12,000
	WR-1F	205,000
	WR-14	7,000
	WR-15	40,000
		$ 299,500

Boiling Springs Sinkhole

In the 1930's several sinkholes were filled with dirt to provide for development on Boiling Springs Drive (Fig. 2). In addition, the cavern system was utilized for storm-water drainage by placing a manhole cover over a small-diameter swallet that had a 28-foot vertical drop to the natural underground drainage system. Storm water was diverted into the swallet for approximately 40 years until June 1974, when the backyard at 300 Boiling Springs Drive collapsed. At that time some remedial work was done by placing a caisson into the sinkhole to shore up the walls. Two years later subsidence recurred, and an intensive effort was initiated by the Urban-County Government to correct the problem (Fig. 3). An important point is that the government did not acknowledge liability, but did feel culpable because storm-water drainage plans were approved by the municipal engineer when the subdivision was developed. The case was settled out of court in 1976 at an accumulated cost of approximately $140,000. At the time, the market value of the property was $42,000.

Cindy Blair Sinkhole System

The Cindy Blair development (Fig. 2) is an example of sinkhole flooding. Figure 4 is a map indicating the hydrogeologic setting of the area that is underlain by three members of the Lexington Limestone: the Grier Limestone, Brannon Member, and Tanglewood Limestone, in ascending order. In this area the Grier Limestone is prone to solution, and characteristic karst features such as individual sinkholes, clustered sinkholes, swallets, and resurgent points (springs) are common.

The developer recognized potential drainage problems and consequently designed larger than normal lots, placed many of the homes outside the boundary of individual sinkholes, and allowed open space along lineaments defined by sinkholes. However, storm sewers were designed to discharge into sinkholes, and several lots were developed in resurgent areas. Figure 5 is a photograph of a resurgence and subsequent flooding in the development. Water has been as high as 4 feet within a house at 665 Cindy Blair Way, and temporary remedial action consisted of the erection of a wooden dike to hold back floodwaters (Fig. 6). In the past few years some slumping and subsidence have also been noticed in sinkhole bottoms in the area.

UNIFIED MAPPING PROGRAM AND ENVIRONMENTAL PLANNING

With the advent of merged government in 1974, the Division of Planning became responsible for community-wide planning. The planning staff was increased to include environmental-planning personnel. In reviewing available environmental data, it became apparent that a good base-map system was needed. Soil maps of varying scales and U.S. Geological Survey topographic maps at a scale of 1:24,000 with 1 0-foot contour intervals were available. However, up-to-date, larger scale maps necessary for environmental planning were generally lacking. In 1976, a mapping program was initiated to produce maps at a scale of 1:2,400 with a 5-foot contour interval for the USA, and a scale of 1:4,800 with a

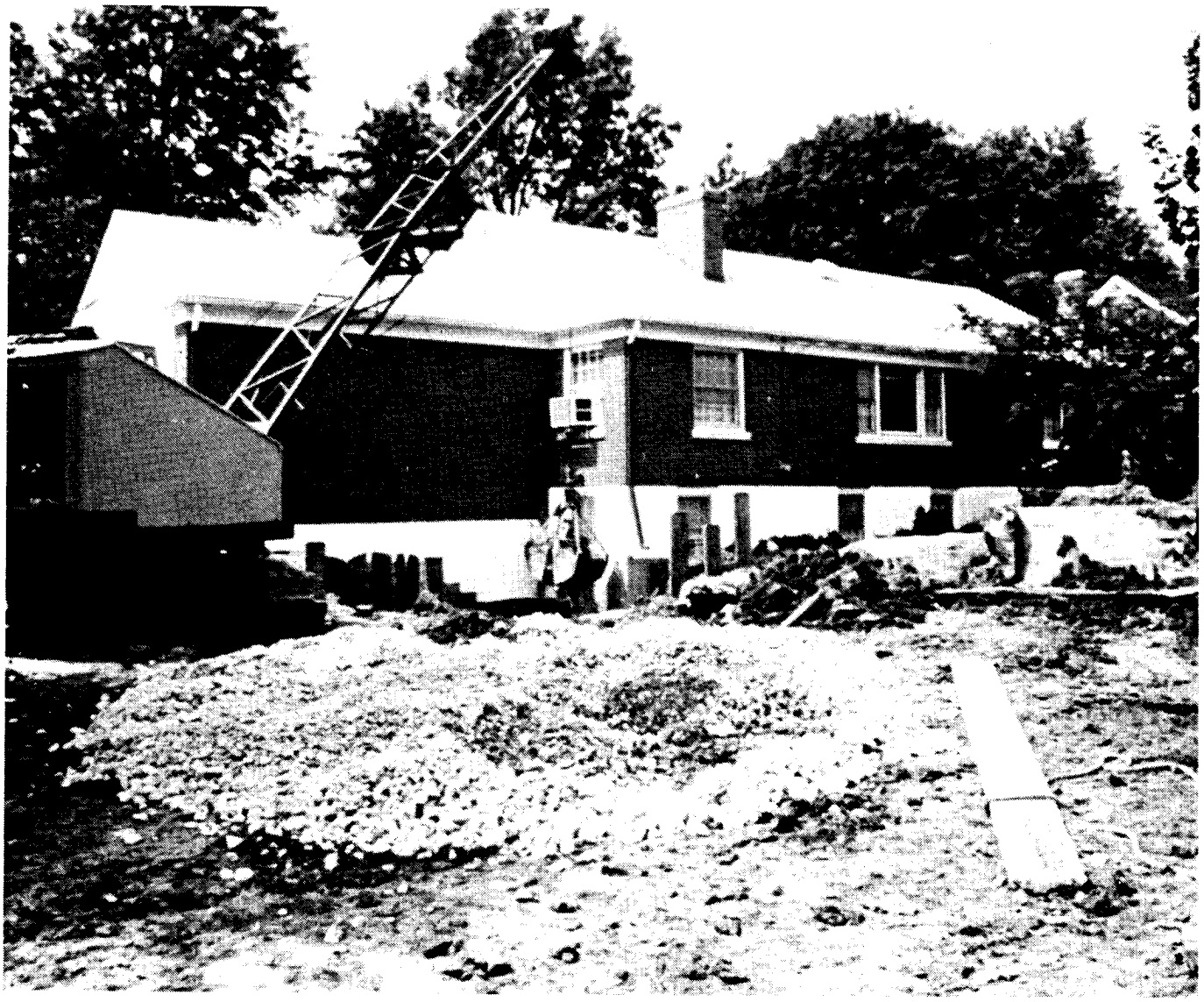

Figure 3. Photograph of remedial work to stabilize ground collapse at 300 Boiling Springs Drive, Lexington, Kentucky.

10-foot contour interval for the RSA. The maps were compiled by aerial photogrammetric methods with ground control to conform to National Map Accuracy Standards. At the time of compilation, the 100-year floodplain data were generated by hydrologic calculation for most streams. In areas lacking hydrologic data, soil maps and reports were used to delineate flood-prone areas.

The newer maps with a 5-foot contour interval reveal more sinkholes than do the older topographic maps (1:24,000 scale, 1 0-foot contour interval). On the other hand, study of the older topographic maps provides the locations of sinkholes filled in 30 or 40 years ago during urban development. It is not surprising to note that drainage problems occur in areas of filled sinkholes or in areas developed in and around sinkholes that were not defined on the older, smaller scale maps. In addition, soil maps developed by the Soil Conservation Service indicate sinkhole-problem areas by both soil type and by actual site location of sinkholes via map symbol.

In preparing guidelines for long-range planning in areas of new development, a series of environmental overlays (1:7,200 scale) have been produced from the 1:2,400-scale maps for the entire USA using aerial photography and field reconnaissance. Separate overlays have been developed for floodplains, sinkholes, areas of steep slope (over 15 percent), and tree stands, the latter two features having been discovered to be good indirect indicators of sinkhole locations in Fayette County.

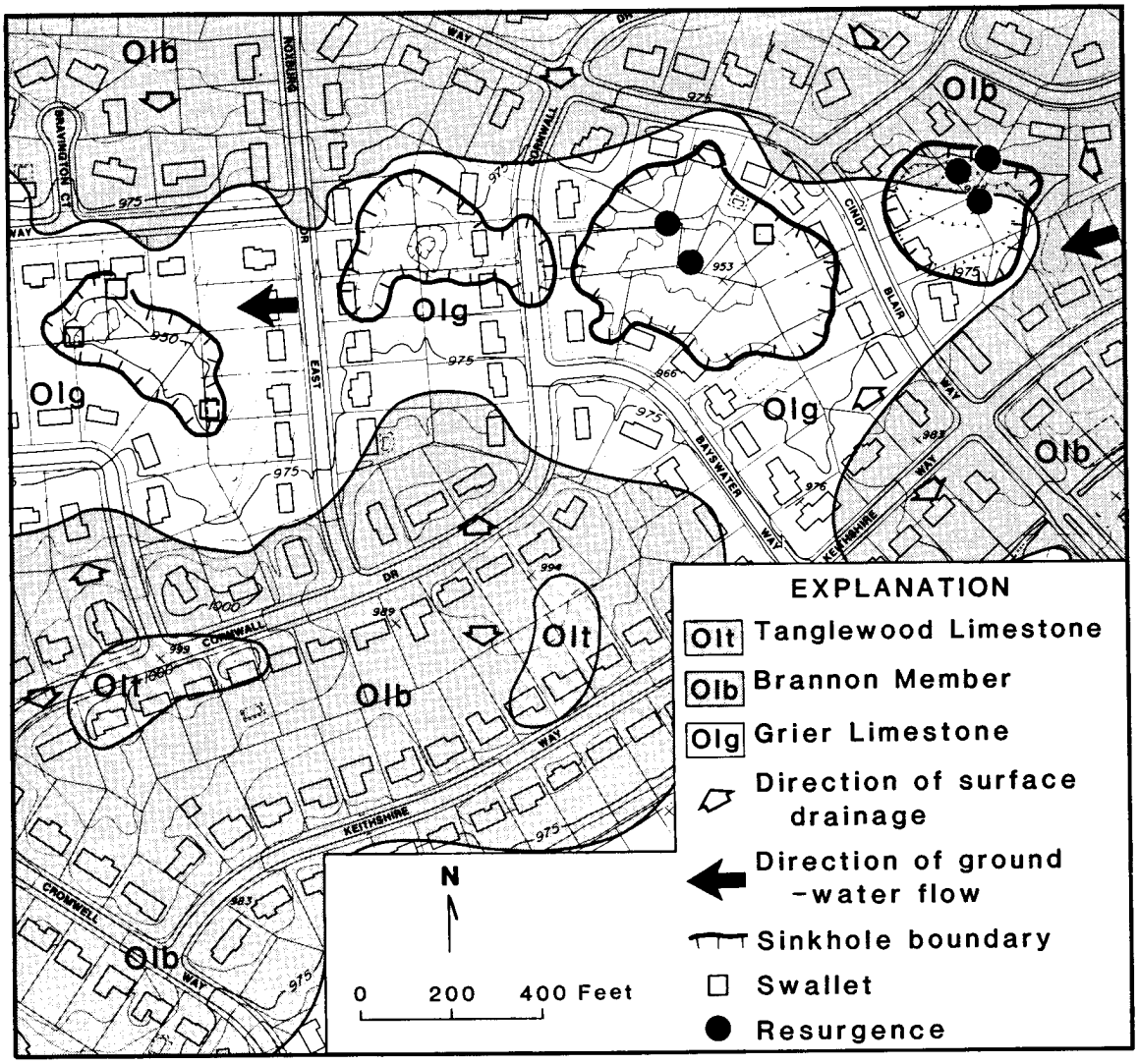

Figure 4. Map showing the hydrogeologic setting in the Cindy Blair development.

The aforementioned series of environmental maps constitutes the Unified Mapping Program. Before the Urban-County sinkhole ordinance was adopted, other guidelines were put into effect to regulate development based, in part, on the maps created by the Unified Mapping Program. The 1980 Comprehensive Plan (Lexington-Fayette Urban-County Planning Commission, 1980) dealing with Zoning Ordinance and Subdivision Regulations includes two "special area" designations: (1) Environmentally Sensitive Areas and (2) Geologic-Hazard Areas. An environmentally sensitive area is any land that, due to its natural or physical setting, may have environmental problems with regard to development. This is not to say that the land cannot be developed; but if it is determined that development can occur, then some safeguards such as detailed site planning are necessary to overcome the physical limitations of the land. These limitations include (but are not limited to) areas of steep slope (over 15 percent), floodplains, sinkholes, areas of poor soils, improper fill, wetlands, significant areas of tree stands, and aquifer-recharge areas.

A geologic-hazards area differs from an environmentally sensitive area in that environmental problems are so numerous that development, even with severe design limitations, would pose a serious problem to the immediate or surrounding areas. Examples of this classification include excessive floodplains, cliffs, and areas that have potential collapse problems due to caves within the rock strata that are close to land surface

Locations of recognized environmentally sensitive and geologic-hazard areas are shown in the 1980 Comprehensive Plan. Additional maps and information regarding site-specific descriptions are

Figure 5. Photograph showing resurgence and subsequent flooding in Cindy Blair development.

on file with the Division of Planning. Whenever a subdivision is proposed on land containing such areas, special restrictions apply that require the developer to identify the hazards and propose a design to mitigate their effects. The proposed design is then presented to the Division of Planning for review before its comments and recommendation are passed on to the Planning Commission for final action.

SINKHOLE ORDINANCE

Although the Unified Mapping Program and designation of Environmentally Sensitive and Geologic-Hazard Areas recognized the potential hazards associated with sinkhole areas, the past 5 years have proved them to be too general for proper planning. Recognition that severe problems still existed, the expense necessary to rectify these problems, and a question concerning liability for damages created by karst features led to the development of a separate ordinance dealing with sinkholes. The ordinance, which was developed over a period of 18 months, received input from various divisions in the Urban-County Government, developers, and the Kentucky Geological Survey.

Varied support for the ordinance came from most parties with a stake in development including lending institutions, developers, and the Urban-County Government. Much of this support stemmed from questions concerning liability and insurance for sinkhole-related damage, both personal and property.

Figure 6. Photograph of flooding and wooden dike at 665 Cindy Blair Way, Lexington, Kentucky.

Ouinlan (1986) published an extensive article on the legal aspects concerning sinkhole activity and flooding in karst terrains. He noted in his abstract that

> insurance compensation for damages that result from sinkhole collapse or subsidence in a karst terraine are covered by statute only in Florida and by voluntary agreement of companies operating in Tennessee. Liability or insurance compensation for damages resulting from sinkhole flooding is not specifically covered by any state or federal statute.

Because insurance is not generally available in Kentucky to cover damage caused by sinkhole subsidence, lending institutions are interested in supporting an ordinance that would help protect against loan defaults that might occur when such damage to a building is significant but not insurable. Furthermore, many communities and governments are now subject to self-insurance, which may place compensation for structural damage and personal-injury claims solely in their hands should the courts find them liable for permitting development on karst terrain. Likewise, support for the ordinance also came from developers and builders who could imagine themselves faced with lawsuits to recover damages incurred from construction on such lands.

The ordinance (see Appendix 1) defines sinkholes, refers to specific planning maps for field determination (Unified Mapping Program), specifies what types of studies must be done and by whom before land development takes place, and specifies the manner in which development can proceed where karst features are present on a given property. In so doing, the

ordinance covers three areas of basic concern: (1) regulation of development near sinkholes so as to minimize the potential damage that might occur with future subsidence on the property proposed for development, (2) regulation of storm-water disposal from the property, as it might cause downstream subsidence or flooding via surface or subsurface flow, and (3) notice to a potential purchaser or lender that a given property may be subject to future karst problems.

In general, the contents of the ordinance are based on the definitions of a sinkhole, immediate sinkhole drainage area, and sinkhole cluster area (Appendix 1). Adoption of these definitions, particularly with regard to their areal extent as defined by the Unified Mapping Program, was highly debated because the maps with a 5-foot contour interval reveal the existence of many more sinkholes than maps used in the past. For this reason, more land has come under increased review by the Planning Commission.

Several aspects of the ordinance are worth noting. Provisions are made to decrease or increase the non-buildable area around sinkholes and allow for sinkholes to be used for surface runoff drainage in a proposed development (Appendix 1, subsections 2 and 4). However, the burden of proof that such activity will not create additional environmental hazards is left to the developer, who must submit appropriate investigative reports. These reports must contain the recommendations from a consulting engineer *and* hydrogeologist, based on site-specific information obtained by substantial, state-of-the-art field studies. The inclusion of a hydrogeologist lends a necessary level of expertise to these types of studies, and the requirement for site-specific information prohibits the use of generalities that could be misleading at a particular site. The studies themselves would probably, by necessity, involve flow measurements both of drainage to the sinkhole and within the subsurface drainage system. Tracing would most likely be necessary to establish the path of the water once it entered the subsurface.

One of the key provisions of the ordinance is to provide methods to compensate the developer for the presence of sinkholes that render a portion of his land non-developable. In any development, certain zoning must be conformed to, and open-space requirements have to be met. On property with small, individual sinkholes, the open-space requirement can be met by designing the subdivision around the sinkholes, thereby utilizing them as open space. In developing areas with larger sinkholes, a more complex problem exists. If an extensive area of sinkholes cannot be developed and is to be left as open space, then an increase in overall building density maybe allowed. For example, if an area of 45 acres were to be developed, this might result in 280 lots of 7,000 square feet each. If it were determined that 5 acres could not be developed because of sinkholes, then an increase in density might be allowed. This would result in the same number of lots, but each lot would be smaller (6,222 square feet each). Unfortunately, these options do not work well for sites zoned as industrial. These sites are already designed for the maximum development density, so no compensation can be made.

Planning-design problems are often compounded by site location and property lines. Two types of problems occur with respect to sinkholes: those involving original property boundaries, and those dealing with internal subdivision design of property boundaries. In the first case, a sinkhole might be bisected by a property line, with one side to be developed and the other side to remain in its natural state until development is undertaken at some future time. Caution must be used in development plans to assure that the undeveloped property is not adversely affected by adjacent development. In the second case, individual lot boundaries within a subdivision should not cross a sinkhole. This is to prevent one lot owner from leveling out one side of a sinkhole without regard for adjacent property owners and the ordinance; i.e., it would be difficult for the government to police unauthorized "remedial" work on sinkholes on a lot-by-lot basis.

Because this ordinance is relatively new, only a few areas have actually been affected by the regulation. One example is an area that was being planned for development during the adoption process of the ordinance. The developers elected to follow the ordinance due to a clustering of sinkholes on the development site. Core drilling in the sinkholes provided data on depth and extent of sinkhole features. An innocuous-appearing depression, 75 feet in diameter and having only a 5- to 9-foot depth as shown on the United Mapping Program topographic maps, was found to have 27 feet of soil overlying bedrock, whereas general soil thickness is less than 2 feet. In the past, this sinkhole would probably have been filled in and developed because its presence would not have been identified on the older topographic maps.

SUMMARY

Sinkholes have historically been used in the Lexington area as storm drains and sites for dumping construction debris and trash, or have been deliberately filled to produce level land for development. In some areas subsequent urban development has been subject

to subsidence problems. Failure to recognize swallets and springs as parts of an integrated subsurface drainage system has also resulted in flooding problems. Most of the cost to rectify the damage has been borne by individual property owners and the local government.

Development of the Unified Mapping Program in the past decade by the Lexington-Fayette Urban-County Government has greatly aided environmental planning. This planning effort has included the designation of environmentally sensitive and geologically hazardous areas, and has resulted in the codification of a specific ordinance to control urban development in sinkhole areas.

Support for this ordinance has come not only from local government but also from lending institutions and the developers themselves. The nonavailability of insurance to cover damage created by karst features makes the ordinance important to lending institutions that want to protect themselves against loan defaults that might occur when such damage to a building is significant but not insurable. Responsible developers also want specific guidelines to follow, as provided in the ordinance, regarding development on karst terrain to minimize their liability. Likewise, the local planning agency supports the ordinance, which provides a means to define sinkholes and regulate their use and development of surrounding areas, while allowing urban development to continue in Lexington.

REFERENCES

Cressman, E. R., 1973, Lithostratigraphy and depositional environments of the Lexington Limestone (Ordovician) of central Kentucky: U.S. Geological Survey Professional Paper 768, 61 p.

Kennoy Engineers, Inc., 1983a, Watershed drainage survey, vol. I-North Elkhorn Creek, East Hickman Creek, Cane Run; vol. II-West Hickman Creek; vol. III-Wolf Run; Vol. IV-Town Branch; Vol. V-South Elkhorn Creek: Unpublished report prepared for the Department of Public Works, Lexington- Fayette Urban-County Government, Lexington, Kentucky.

Kennoy Engineers, Inc., 1983b, Storm drainage master plan, Lexington-Fayette Urban-County Government: Unpublished report prepared for the Department of Public Works, Lexington- Fayette Urban-County Government, Lexington, Kentucky, 159 p.

Lexington-Fayette Urban-County Planning Commission, 1980, 1980 comprehensive plan: Division of Planning, Lexington- Fayette Urban-County Government, Lexington, Kentucky, 156 p.

Quinlan, J. F., 1986, Legal aspects of sinkhole development and flooding in karst terraines; 1. Review and synthesis: Environmental Geology and Water Science, v. 8, nos. 1/2, p. 41-61.

Thrailkill, J., Spangler, L. E., Hopper, W. M., McCann, M. R., Troester, J. W., and Gouzie, D. R., 1982, Groundwater in the Inner Bluegrass karst region, Kentucky: Water Resources Research Institute, University of Kentucky, Research Report 136,126 p.

Weir, G. W., Peterson, W. L., Swadley, W C, and Pojeta, J., 1984, Lithostratigraphy of Upper Ordovician strata exposed in Kentucky: U.S. Geological Survey Professional Paper 1151 -E, 121 p.

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BIOGRAPHICAL SKETCHES

Jim Dinger holds the B.S. and M.S. degrees in geology from Juniata College and the University of Vermont, respectively, and received the Ph.D. in hydrology in 1977 from the Desert Research Institute, University of Nevada-Reno. He has worked as a hydrogeologic consultant, principally in New England, Nevada, and Alabama, and served on university faculty for8 years. At present he is the head of the Water Resources Section of the Kentucky Geological Survey, University of Kentucky, Lexington, Kentucky 40506 (606/257-5863).

Jim Rebmann holds the B.S. and M.S. degrees in physical geography from Eastern Kentucky University. He is currently the Senior Environmental Planner with the Division of Planning for Lexington- Fayette Urban-County Government, 200 East Main Street, Lexington, Kentucky 40507 (606/258-3160). Prior work in caves and karst areas includes Kentucky, Mexico, Honduras, England, and Ireland.

QUESTIONS AND ANSWERS

Q. The ordinance requires that a study and recommendations be made by a consulting engineer and hydrogeologist in order to obtain a variance concerning development in sinkhole areas. What constitutes a hydrogeologist, does Kentucky have an approved list of such persons, and does the hydrogeologist have to be an employee of a government agency?

A. There is no approved list of hydrogeologists in Kentucky. A person submitting a recommendation to the local Division of Planning as a hydrogeologist would have his credentials reviewed by the Division to ascertain his qualifications. This person would not be an employee of the government, as the intent of the ordinance is to put the burden of proof upon the developer who wants to obtain a variance to the ordinance.

Q. Does the local government assume liability for damage if Division of Planning accepts a plan for development that later suffers from damage due to sinkhole activity?

A. To date the government has not accepted liability in a legal sense and no court cases have yet materialized from this newly enacted ordinance. The Division of Planning will place a disclaimer of liability on future plats for developments in which sinkholes are known to occur. The city has, in the past, paid for the repair of damages to personal property due to sinkhole activity, but has not legally accepted nor has it been forced by any court action to accept liability for such damage, as the issue has never gone to the court.

Q. Royal Springs in Scott County is the Georgetown water supply. However, a large portion of the recharge basin forthis spring is in neighboring Fayette County. Has the recharge basin been mapped in detail and designated as an environmentally sensitive area in Fayette County? Could this sinkhole ordinance (Fayette County) be used to protect this municipal water supply in Scott County?

A. The recharge basin for Royal Springs has not been officially mapped and designated as an environmentally sensitive area by the Division of Planning (Lexington-Fayette Urban County Government). However, Dr. John Thrailkill, Geological Sciences Department, University of Kentucky, Lexington, has conducted and published the results of dye tracing studies in the area. Therefore, the drainage basin is at least generally defined and the Division of Planning would certainly consider this information in ruling on a proposed development within the confines of the basin. The sinkhole ordinance could be used to protect this recharge area in that it controls development within a "sinkhole, sinkhole cluster area, or immediate sinkhole drainage area" as defined by the ordinance.

APPENDIX 1:

Sinkhole Ordinance, Lexington-Fayette Urban-County Government, Lexington, Kentucky

SRA 85-2: Article 6-7(l): SINKHOLES

For purposes of this section, the following definitions shall apply:

Sinkhole: Any closed depression formed by removal (typically underground) of water, surficial soil, rock, or other material. The existence of a sinkhole shall be as indicated by the closed depression contour lines on the Unified Mapping Program topographic maps or other documents as approved by the Urban County Engineer. Its actual limits may, however, be determined by field measurements with concurrence of the Urban County Engineer. Sinkholes may be either circular in plan or irregular, depending upon structural control.

Immediate Sinkhole Drainage Area: Any area that contributes surface water directly to the sinkhole(s); this does not include areas which contribute surface water indirectly to a sinkhole (via streams).

Sinkhole Cluster Area: Any area that contributes surface water other than by way of a stream to a sinkhole which is located in a group of two or more sinkholes clustering together.

1. Plan Requirements

A sinkhole, the immediate sinkhole drainage area, a sinkhole cluster area, or portions of such items shall be shown on any development or preliminary subdivision plan for land where they exist. Sinkhole-related non-buildable areas and restricted fill areas shall be shown on final subdivision plans and development plans.

2. Sinkhole-Related Non-Buildable Areas

Based upon the topography, geology, soils, and known history of the sinkhole (such as past filling) and the developer's engineer's storm-water analysis and plan, the Planning Commission shall establish sinkhole-related non-buildable areas. No buildings, parking areas, or other structures shall be permitted within the sinkhole-related non-buildable area.

This non-buildable area shall follow the limits of the sinkhole in most cases. However, the non-buildable area may be expanded or contracted by action of the Planning Commission where warranted due to the nature of the specific sinkhole, the underlying geology, soils, drainage, and any related information such as depth to bedrock. In sinkhole cluster areas, the Division of Engineering may require the developer to provide recommendations from a consulting engineer and a consulting hydrogeologist based upon substantial and state-of-the-art field studies and evaluation of the specific sinkhole system. Such studies shall be submitted to the Divisions of Engineering and Planning, which shall review said studies and make recommendations to the Planning Commission.

3. Development in Sinkhole Drainage Areas

Development may occur in the immediate sinkhole drainage area if the developer provides alternative surface drainage away from the sinkhole, while keeping the water in the same surface drainage basin, and provided further that the water shall not go into another sinkhole drainage area off the petitioner's property, nor into another stream of known flooding problems. The immediate sinkhole drainage area (or

portion thereof) which cannot be provided with an alternative drainage system can be deleted from the development area and can be used to meet the normal open space requirements. The developer may request that the Planning Commission increase the density on the remainder of the developable area, with the total resulting density no greater than if the entire area were developed to the permitted density. For portions of the immediate sinkhole drainage area where alternative surface drainage methods cannot be provided, as determined by the Division of Engineering, the developer may choose one of the options described in Section 4 herein below.

4. Sinkhole Surface Drainage Analyses

The sinkhole can be used for surface runoff drainage of a proposed development if the conditions of either of the following alternatives are met:

a. Alternative 1: A sinkhole can be used for surface runoff of a proposed development with or without retention or detention facilities as recommended by a consulting engineer and a consulting hydrogeologist, provided that any increase in the quantity of surface runoff due to development of the entire sinkhole drainage area in question will not aggravate flooding on the proposed development, adjacent existing development, or connected/adjacent sinkhole subsurface systems. Such engineering and geological reports must be substantive and based on state-of-the-art field studies and evaluation of the specific sinkhole system. The Planning Commission shall not approve development proposals subject to Alternative 1 provisions unless the study findings meet the requirements of this subsection and the Division of Engineering concurs with those findings and recommendations.

b. Alternative 2: A sinkhole can be used for surface drainage of a proposed development if all of the following conditions and provisions are met:

1 . That the runoff from the development area is either completely retained in a retention basin or detained in a detention basin. The flow rate out of the above basins shall be regulated so that it is no greater than the flow rate into the sinkhole of the development area prior to development for each of the following storms: 10 year/1 hour, 25 year/24 hour storm or a 100 year/1 hour storm. The outflow rate shall not aggravate flooding on downstream properties for any of these storms.

2. As previously noted in subsection 3, the developer may elect to divert enough of the sinkhole drainage area so that the development of the remaining area does not increase the total quantity of runoff into the sinkhole. Where additional runoff is anticipated, a consulting engineer and hydrogeologist shall evaluate and show the effect of any additional quantity of runoff to the sinkhole and sinkhole system. For approval, the study must show the development will not aggravate flooding on the proposed development, adjacent lands, or connected/adjacent sinkhole systems. The Division of Engineering shall review the study findings and make recommendations to the Planning Commission for alternative 2 to be acceptable.

3. Where the sinkhole outlet is off site, either the runoff leaving the subject property must be shown to be no greater in f low or in quantity than that which existed before development or written approvals must be submitted from owners of property where any increase in flow or quantity of water must go to reach the sinkhole outlet. Easement areas shall be approved by the Division of Engineering, based upon the developer's engineer's calculations of proposed ponding elevation.

5. Filling in Sinkholes and Sinkhole Drainage Areas

Development may involve some filling of the sinkhole drainage area or sinkhole upon approval by the Urban County Engineer. However, no principal or accessory buildings with soil-bearing foundations shall be permitted to be constructed on fill within the limits of any sinkhole.

6. Required Plan Notes

For any land which includes a sinkhole-related non-buildable area, or restricted fill area, the developer shall place the following notes on the final subdivision plan or development plan:

a. Based upon the evidence presented to them, the Planning Commission had identified sinkhole-related non-buildable areas on this plan. However, approval of this plan is not to be interpreted as any guarantee that future sinkhole problems will not occur due to either nature or human activities.

b. Any sinkhole-related non-buildable area identified here has been determined to be unsuitable for any construction activity, and no buildings, parking areas or other structures shall be permitted within this area.

Any sinkhole or restricted fill area identified here has been determined to be unsuitable for soil bearing foundation, and the entire structure of any building (including the floor system) constructed therein must be founded on solid rock.

No basement or first floor elevations shall be lower than elevation USGS datum, said elevation being at least 1 foot above the 100 year six hour storm assuming no outflow from the sinkhole.

Based upon the facts of each case additional notes may be required by the Planning Commission.