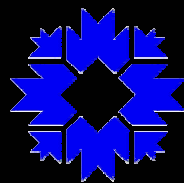




CITY OF BLOOMINGTON ENVIRONMENTAL RESOURCE INVENTORY

November 2003



CITY OF BLOOMINGTON
PLANNING DEPARTMENT

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EXECUTIVE SUMMARY

This report is an interpretive summary of the results from the City of Bloomington Environmental Resource Inventory (COBERI). The primary purpose of this report is to collect and analyze information on Bloomington's natural environment in an effort to help prioritize areas for future management and/or preservation. This summary is part of a larger, on-going project that provides the factual foundation to further develop sustainable land-use and land development strategies for the City of Bloomington. The COBERI project was initiated by the City of Bloomington Planning Department in cooperation with many local, state, and federal groups and agencies.

There is sound scientific evidence showing that preserving natural areas provides immeasurable benefits to society. These benefits include many different types of ecological, economic and social opportunities. The City of Bloomington's Growth Policies Plan recognizes the importance of preserving high quality natural areas and promotes the use of sound conservation planning principles.

The approach used for this analysis involved a series of four steps. Those steps included identifying primary research categories, collecting data, performing quality control activities, and data analyses and interpretation. Based on generally recognized fields of research suitable for this type of analysis, a total of seven categories were identified. The seven categories were soils, wetlands, floodplains and water resources, karst geology, topography, sensitive habitat and vegetative cover. Once data collection and quality control examination was completed, a series of environmental overlays were created for the City's Geographical Information System database.

While studying natural resources individually is useful in determining their type and extent, to better understand their roles and functions they must be studied as an interconnected system. As part of this project, the City of Bloomington's Planning Department evaluated and ranked natural areas in Bloomington using an environmentally sensitive areas (ESA) analysis.

In order to clearly identify more diverse natural areas from less diverse ones the use of GIS technology and spatial analysis was required. The spatial analysis technique used for this study was a simple numeric point-based ranking model. In general, the model aggregated data collected for the environmental overlays and ranked areas based on the diversity of features in the vicinity. Although further investigation into the quality, functions and cumulative impacts of features is required, this analysis provided sound results useful for providing the factual foundation to further develop sustainable land-use and land development strategies.

The analysis revealed that highly sensitive and diverse areas were mainly located along the periphery of the City - most notably in the northeastern, southeastern and southern portions of the City. In general, the highest sensitivity ratings were located in the vicinity of the Twin Lakes, Lake Wapehani, Clear Creek, Jackson Creek, University Lake, Griffy Reservoir and Cascade Creek areas. These areas included a diversity of environmental features such as clusters of sinkholes and springs, wooded ridges and hilltops, streams and lakes, sensitive soils and steep slopes, as well as wetlands and floodplains.

In the past, some of these diverse environmental areas have been targeted for preservation as parks or nature preserves such as the Griffy Nature Preserves, Wapehani Mountain Bike Park, Clear Creek Trail, Winslow Woods Park, and Cascades Parks. Results from this analysis are meant to provide a resource for future preservation efforts. In order to do this, various administrative and management tools such as zoning, land acquisition and public-private partnerships may be used.

Overall, the COBERI project identified several themes present in the natural resources found throughout Bloomington. Those included:

- **Bloomington is shaped by several major environmental features that harbor diverse and sensitive natural areas.**
- **Bloomington is home to many unique and sensitive ecological communities that also extend beyond its political boundaries.**
- **The natural resources in Bloomington are interconnected in a complex network of systems that requires constant monitoring.**

This report is meant to help guide and assist future decisions for land-use and land development strategies for the City of Bloomington. However, while Bloomington contains many diverse natural areas, it is a small piece of a much larger environmental system. Activities that take place in Bloomington have a profound effect and influence on surrounding cities, counties and states. By evaluating natural resources, monitoring and updating the data, as well as considering the myriad of other factors involved, sound conservation planning decisions may be made.

INTRODUCTION

This report is an interpretive summary of the results from the City of Bloomington Environmental Resource Inventory (COBERI). The summary is part of a larger, on-going project that provides the factual foundation to further develop sustainable land-use and land development strategies for the City of Bloomington. The COBERI project was initiated by the City of Bloomington Planning Department in cooperation with many local, state, and federal groups and agencies.



Wetland at Griffy Lake Nature Preserve

This report is divided into five sections. This first section outlines the purpose, goals and objectives for the report. The second section provides the context and basis for the study. The third section reviews the process used for data collection and analyses, and the fourth section gives a brief synopsis of the findings – those include overviews on: soils, wetlands, floodplains and water resources, karst geology, topography, special habitat, and vegetative cover. The final section reviews the environmentally sensitive areas (ESA) analysis using a simple, numeric point-based ranking model to generate results.

Purpose

The primary purpose of the COBERI project was to collect and analyze information on Bloomington's natural environment in an effort to help prioritize areas for future management and/or preservation activities.

Goals

The City of Bloomington's Planning Department identified four key goals for this project. They were as follows:

- 1) To provide the factual foundation to better integrate natural resource data into the City's Comprehensive Plan, ordinances, and development review process;
- 2) To provide the analytical tools to help prioritize land for management and preservation efforts, and to plan land-use and design strategies that respect and enhance Bloomington's environment;
- 3) To serve as a model in an effort to promote the sustainable development of Bloomington and its surroundings; and
- 4) To foster and advance community awareness and appreciation for the relationships between the natural, cultural and built environments.

Objectives

The four goals were then used to help formulate a series of objectives that served to further meet the project's intended purpose. They were as follows:

- i. Create a geographical information system (GIS) database that encompasses a wide breadth of natural resource data for the City of Bloomington and surrounding areas.
- ii. Utilize existing, readily available data and ensure its integrity through rigorous quality control methods in order to provide robust results.
- iii. Enlist best management practices and sound scientific methods throughout all stages of the project.
- iv. Develop an analytical tool or application that ranks land based on the presence of environmentally sensitive features.
- v. Provide a framework from which future studies can be based on.
- vi. Provide technical assistance for data interpretation as well as the data's relationships to land-use and design strategies.
- vii. Publish pertinent findings and make them readily available to the community and relevant stakeholders.
- viii. Create a long term maintenance plan that includes providing a centralized, easily updatable database.



Trees at Winslow Woods Park

REPORT CONTEXT

There is sound scientific evidence showing that preserving natural areas provides immeasurable benefits to society – termed ‘ecosystem goods and services’. Some of the goods and services provided by natural areas include:



West Fork of Clear Creek near the Clear Creek Trail

- Timber and natural fibers
- Biomass and fuel
- Fish and wild game
- Water and air purification
- Flood and drought mitigation
- Climate stabilization and moderation of weather
- Detoxification and decomposition of wastes
- Provisions for aesthetics, intellectual stimulation and recreational opportunities

Above all, preserving highly diverse natural areas contributes to the framework needed for environmental, social and economic sustainability. Generally, the flow of natural goods and services is determined by type, extent and location. Due to this, preservation of non-native, small, sporadically placed spaces and populations generally does not maintain an efficient and sustainable ecosystem.

The City of Bloomington’s 2002 Growth Policies Plan provides a vision for Bloomington in which one of the core goals is to ensure “...a respect for, and adherence to, environmental quality in Bloomington and [its] surrounding environs”. The City of Bloomington’s Growth Policies Plan recognizes the importance of preserving high quality natural areas and promotes the use of sound conservation planning principles.

This report is the first step in identifying and prioritizing Bloomington’s natural areas through a series of analyses. The basis for pursuing this is to preserve high quality natural areas in Bloomington in an effort to maintain the valuable ecosystem goods and services they provide.



Spring found near Twin Lakes Sports Park

COBERI PROCESS

The approach used for this project involved a series of four steps. Those included:

- 1) Identification of primary data research categories
- 2) Data collection
- 3) Data quality control
- 4) Data analyses and Interpretation

Identification of Primary Data Research Categories

The first step of the project determined the key research categories in which data concerning natural resources were to be collected. A total of seven categories were identified. The seven categories were soils, wetlands, floodplains and water resources, karst geology, topography, sensitive habitat and vegetative cover.



Lake Wapehani shoreline at Wapehani Mountain Bike Park

The categories identified above for evaluation were based on generally recognized fields of research suitable for natural and physical environmental analyses of this type.

Data Collection

Once the primary data research categories were identified, likely sources of information were pursued. This included reviews of in-house information already part of existing GIS databases and reports such as soil, water resource, topographic, geological and vegetative cover data, as well as searching readily available public information databases.

The most notable public data sources outside of existing City sources were:

- US Fish and Wildlife Service – wetland and land cover data
- US Department of Agriculture – soil and land use data
- US Geological Survey – soil, topographic and geological data
- Indiana Department of Natural Resources – waterway, wildlife and land cover data
- Indiana Geological Survey – geological and vegetative cover data

Once all potential data sources were searched and site visits were completed, information was catalogued and a preliminary determination on its applicability and integrity was made.

Data Quality Control

The third step included identifying data deficiencies, revealing information gaps, and enhancing the data. All of the information gathered in earlier stages was available in varying degrees of quality, scale and detail and required varying levels of quality control.

First, several of the data sets required some form of manipulation to prepare them for translation into a more common, readable format for the City's GIS program. Some examples of data manipulation used for this stage included extracting selected features from single sources, combining data from multiple sources, creating buffers around selected features, and simplifying feature identities to remove complex attributes not needed for the analyses. In certain instances data were outdated, inadequately detailed, or were unavailable in digital formats.



Field left for fallow near the Thomson Community Park

Where more recent information was available, outdated data were discarded from further use. When possible, inadequately detailed data were combined with other source data to produce more detailed, useable information. Data not available in digital format were either digitized into the City's GIS program, or entered into attribute tables as simple point locations. Once these quality control measures were exhausted and the data were successfully translated into the City's GIS, the data were analyzed for patterns and trends.

Data Analyses and Interpretation

The fourth step of the project used the information gathered in previous steps to create seven individual GIS overlays - soils; wetlands; floodplains and water resources; karst geology; topography; special habitats; and vegetative cover. Once the overlays were completed and inputted into the City's GIS database, they were analyzed for patterns and trends. After individual analyses were completed, a sensitivity analysis was performed.

The sensitivity analysis consisted of using a numeric point-based ranking model that aggregated the information contained in the seven overlays. Once data were aggregated, the model ranked areas based on the number of overlaying features – in general, the more overlapping features in an area, the more sensitive and diverse it was. Using a color coding scheme, an environmentally sensitive areas (ESA) map was then generated. A more detailed description of each of the seven GIS overlays including map preparation, map characteristics, data sources, patterns and perspectives is contained in the following section. Further sections provide an interpretive summary of the ESA analysis, as well as provide a detailed description of the model and methods used to generate results.

ENVIRONMENTAL OVERLAYS

The City of Bloomington has a wide range of natural features making it a unique place. As discussed earlier, those features can be placed into seven general categories: soils, wetlands, floodplains and water resources, karst geology, topography, special habitat, and vegetative cover. This section provides a brief synopsis of those categories.

Soils

Soils provide the basis for many different types of ecological functions. Some of those include supplying nutrients for plants and animals, supporting critical habitat for wildlife, and controlling flooding and mass wasting processes. Soils also have a profound impact on the built environment. Based on their productivity and physical characteristics, soils can be a useful tool in determining where growth occurs and what type of land uses may be suitable.

The soils present in Bloomington have a range of properties varying widely in physical, chemical and biological makeup. In 1977, the United States Soil Conservation Service (now the National Resource Conservation Service) conducted a soil survey of Monroe County that contained detailed information on soil unit locations, properties, as well as predictions of soil behaviors for selected land use activities. Conclusions drawn in this category were based primarily from information contained in that report.

Perspectives and Patterns

Soils in Bloomington are predominately moderately deep (2-4 ft) to deep (> 4 ft), well drained, formed in limestone, and on upland formations - with the exception of the northeast portion of the City. In the northeast, soils are typically shallow (< 2 ft) and formed in sandstone, siltstone and shales providing for steeper slopes and a higher erosion potential.

The analysis done for this category identified areas within the City that contained sensitive soils. For the purposes of this study, sensitive soils were identified as having the following 5 characteristics:

1. Poor for crops and pasture
2. Poor for woodland management and productivity
3. Poor for urban uses such as landscaping, building site development, sanitary facilities, construction materials, and water management
4. Poor for intensive recreation development
5. Poor wildlife habitat potential

In general, Bloomington's sensitive soils had the following physical properties: high shrink swell potentials; poor permeability rates; susceptible to frost heave action; prone to flooding; and highly susceptible to mass wasting processes (based on National Resource Conservation Service's guidelines). Figure 1 illustrates the sensitive soils in Bloomington and surrounding areas.

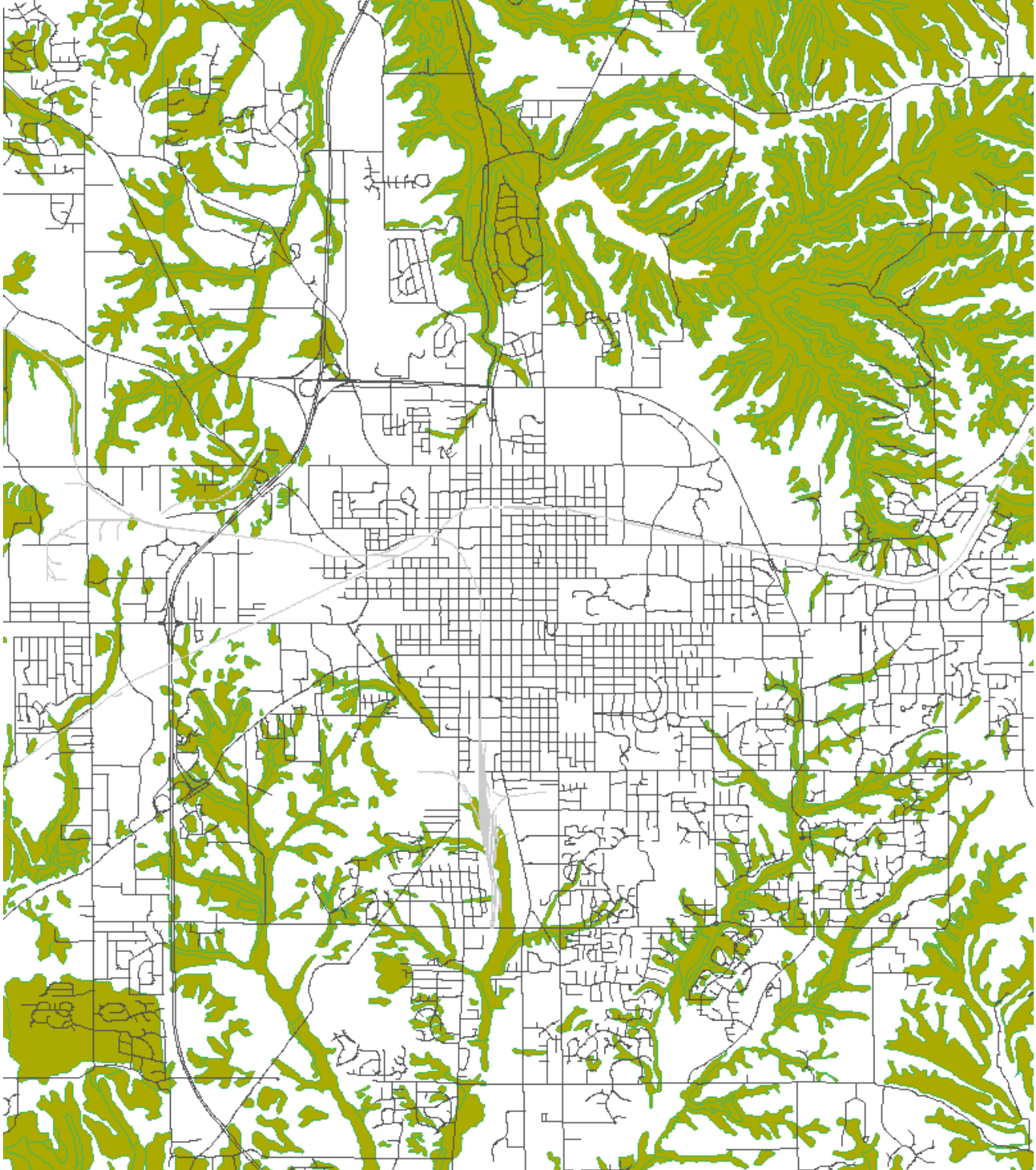


FIGURE 1. Map of sensitive soils in Bloomington and surrounding areas

The shaded areas above depict sensitive soils. In Bloomington, sensitive soils were generally found along steep slopes, ridges, floodplains and riparian corridors. Sensitive soils accounted for approximately 25% of Bloomington's overall land area.

Wetlands

Wetlands are areas inundated or saturated by water at a frequency and duration sufficient to support vegetation typically adapted for life in wet conditions (hydric soils). There are five main types of wetlands referred to as wetland 'systems'. Those are:

1. Marine systems – nourished only by ocean waters (reefs and ocean beds)
2. Estuarine systems – nourished by both fresh and ocean waters (salt marshes, tidal flats, and mangroves)
3. Lacustrine systems – nourished and closely associated with lakes (freshwater marshes and aquatic beds)
4. Riverine systems – nourished and associate with water running through a channel (river banks, streams, freshwater marshes and aquatic beds)
5. Palustrine systems – lack running water or ocean salts in concentrations more than 0.5% (isolated marshes, swamps, bogs and floodplains)

All of these wetlands provide different types of ecological functions including critical habitat for wildlife, supplying water for recharge, controlling flooding and erosion, improving water quality, and offering recreational and educational opportunities. Depending on the type and extent of wetland, these critical habitats may be protected under federal, state and/or local laws.

The successful maintenance and improvement of wetlands depends heavily on watershed management and planning activities. Due to their ecological importance and sensitivity to development, wetlands must be considered for preservation and management when determining land uses and growth patterns. Information for this category came mainly from the United States Fish and Wildlife Service's National Wetland Inventory. Other sources included the United States Environmental Protection Agency and the City of Bloomington Planning Department.

Perspectives and Patterns

Wetlands in Bloomington are categorized primarily as isolated marshes, swamps, bogs, and floodplains (palustrine systems). However, several freshwater marshes, aquatic beds as well as wetlands closely associated with creeks and streams were also found (riverine systems). Initial analysis revealed that wetland features in Bloomington ranged in size from approximately 0.01 acres to 110 acres, but averaged 1.4 acres in size. In general, wetlands identified in Bloomington were created through natural succession in diked, impounded, or excavated land.

All of the wetlands in Bloomington are freshwater wetlands. Further analyses revealed that these areas are scattered throughout Bloomington, with the largest concentrations located near floodplains and close to major creeks and streambeds. Figure 2 illustrates the extent and location of wetlands throughout Bloomington and surrounding areas.

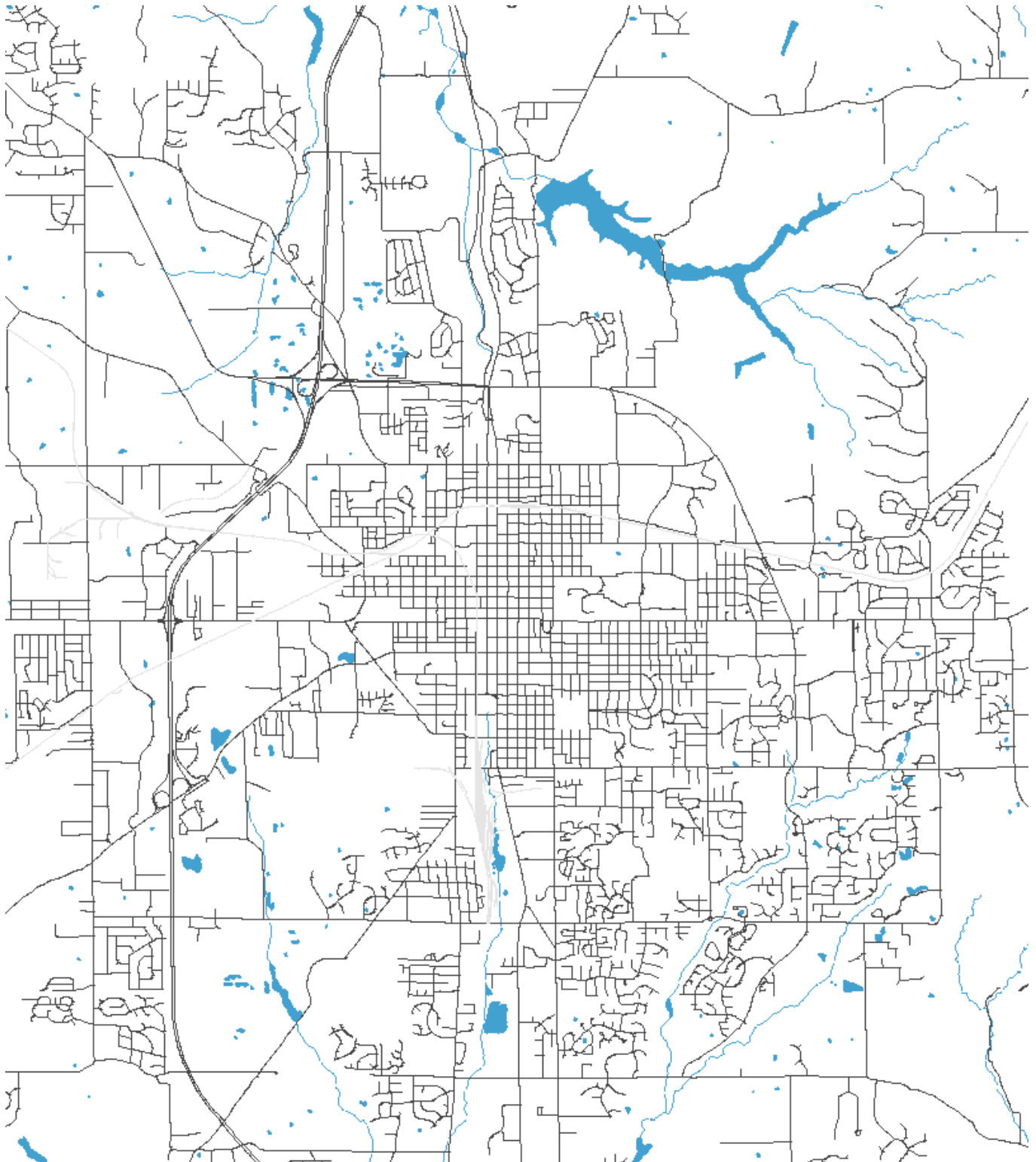


Figure 2. Map of wetland areas in Bloomington and surrounding areas

The shaded areas above represent potential wetland areas. In Bloomington, the majority of wetlands were found near lakes, reservoirs or major creeks. Wetlands accounted for approximately 2% of Bloomington's overall land area.

Floodplains and Water Resources

Floodplains and water resources play an integral role by circulating and distributing surface water. Some examples of water resources include rivers, streams, creeks, ponds, wetlands, lakes and reservoirs. Water resources also provide important ecological functions such as:

- Providing critical terrestrial and aquatic habitat
- Providing surface water recharge and supply
- Controlling flooding and erosion
- Stabilization and moderation of climate
- Educational and recreational opportunities.

Many different types of water resources are contained in floodplains. Floodplains play an important role by containing excess stream flows and providing spawning and foraging habitat for aquatic animals. They are defined as the land adjacent to waterways susceptible to inundation by floodwaters. Depending on the size and extent of a waterway and its floodplain, these features may or may not be regulated by local, state and/or federal regulations.

Issues pertaining to management of floodplains and water resources become more critical as land becomes more urbanized. Developing sound watershed management and planning activities that implement best management practices can help mitigate negative impacts. Information for this category came primarily from the Indiana Department of Natural Resources and the Federal Emergency Management Agency.

Perspectives and Patterns

Bloomington contains many different types of water resources including lakes, reservoirs, creeks and their tributaries. Due to the challenging topography, Bloomington has an extensive network of watersheds that contribute to its waterways. Figure 3 illustrates the locations and extent of watersheds for Bloomington and surrounding areas.

Bloomington has two main waterbodies – Griffy Reservoir and Lake Wapehani. Griffy Reservoir is the larger of the two covering an area of approximately 109 acres. Both of these are former municipal water supplies and were constructed through a series of dams and levees. Bloomington also contains two major waterways - Jackson Creek and Clear Creek. Both of these creeks have wide-spread tributary systems containing floodplains. Figure 4 illustrates water resources as well as their 100 year floodplains for Bloomington and surrounding areas.

Past industrial activities have significantly degraded some of Bloomington's water resources. The Indiana Department of Natural Resources has issued fish consumption advisories for Griffy Reservoir, Lake Wapehani and Clear Creek. Furthermore, Clear Creek has been listed by the Indiana Department of Environmental Management as one of Indiana's impaired waterways based on its current pollutant loads and poor habitat potential.

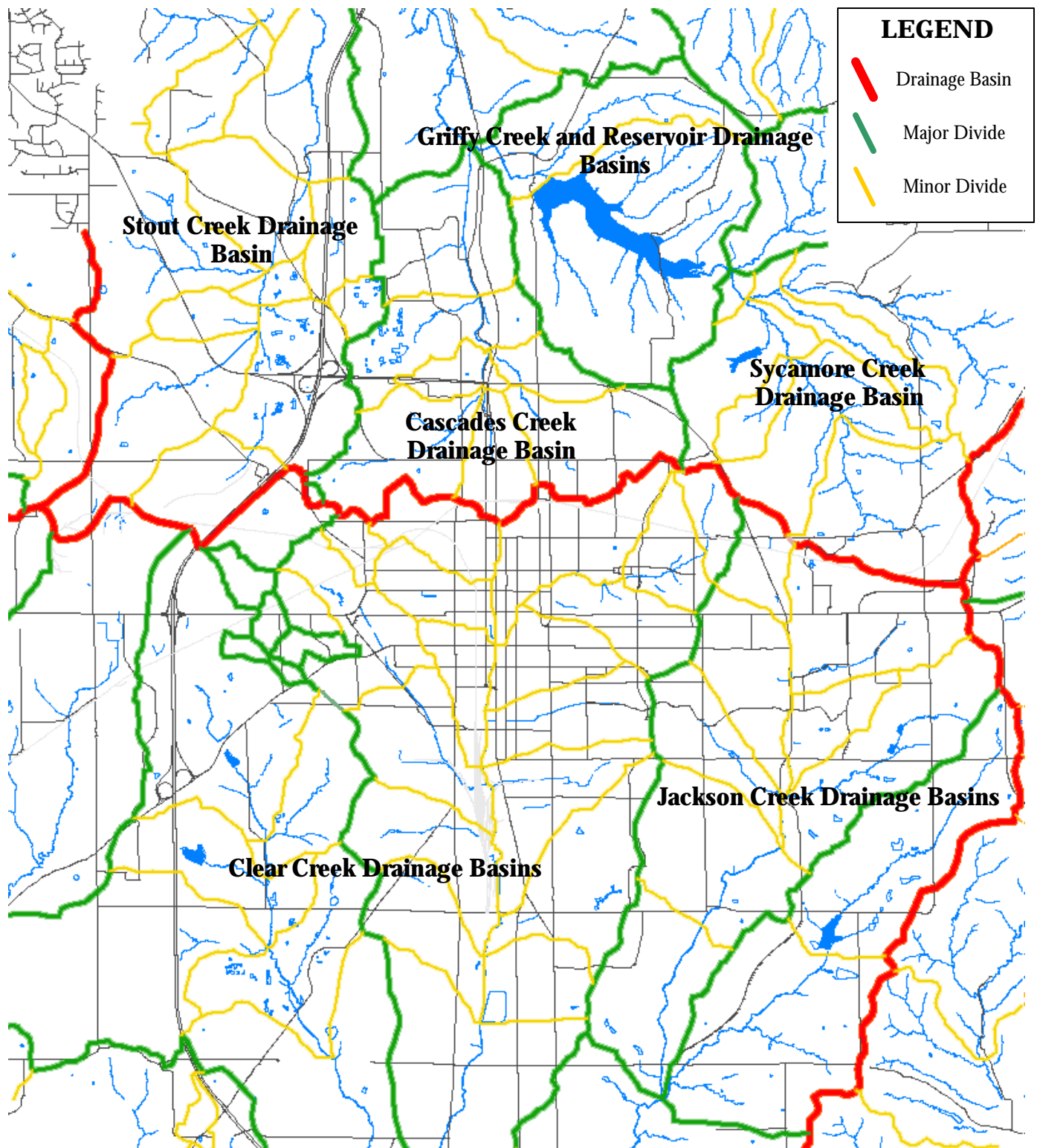


Figure 3. Map of watersheds in Bloomington and surrounding areas

The map above illustrates Bloomington's water resources, as well as its major and minor drainage basins. The 6 main drainage basins in Bloomington are the Stout Creek, Cascades Creek, Griffy Reservoir and Griffy Creek, Sycamore Creek, Clear Creek (and west fork), and Jackson Creek (and east fork) basins.

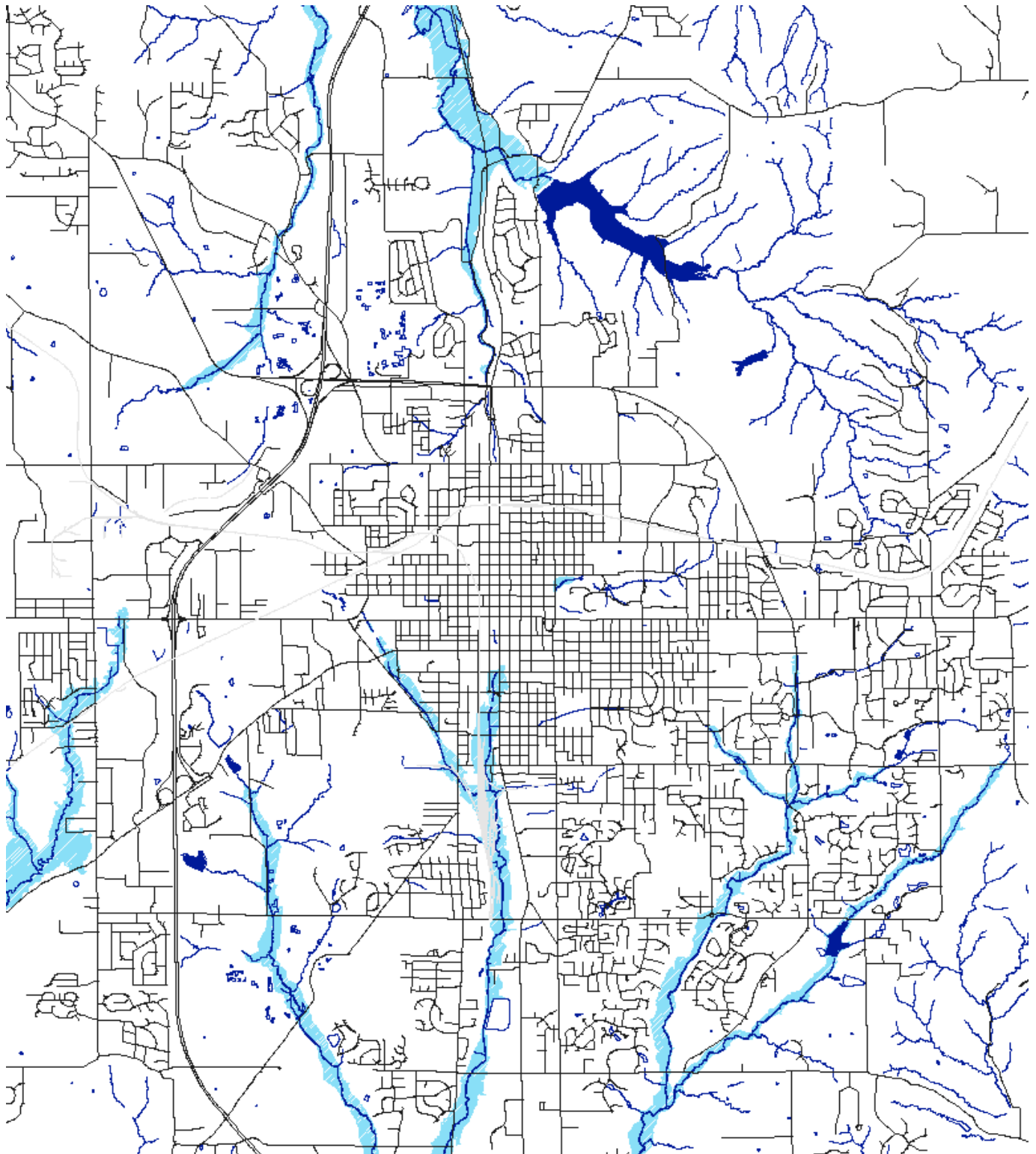


Figure 4. Map of water resources and floodplains in Bloomington and surrounding areas

The map above further illustrates the extent of Bloomington's water systems - the dark areas are water resources, and the lightly shaded areas represent their floodplains. Overall, 10% of Bloomington's land is water contained in creeks, lakes or reservoirs. Floodplains (100 year) cover 3% of Bloomington's land area, and are all regulated under local and state law.

Karst Geology

Karst is a term describing regions characterized by irregular topography developed by the dissolution of carbonate rock - largely by underground water. In general, karst features form in the presence of limestone and include surface features such as sinkholes, swallow holes, soil slumps, sinking streams, blind valleys, springs, and caves. Some subterranean karst features include vertical shafts, solution chimneys, fissures, corridors and canyons.

Karst terrains are extremely sensitive to development and changes in land uses. Some common characteristics that influence the use of water resources and land uses in karst regions include:

- ground subsidence and bedrock instability
- groundwater contamination and unpredictability
- karst feature size and habitat potential.

Often, areas containing karst features offer unique habitats for a variety of rare organisms such as blind cave fish, the Indiana bat and other obligate cave dwelling species. It is important to properly manage all types of karst systems to protect their inherent geological, biological and ecological importance. Typically, karst features are protected by state and local laws, however, the degree of protection varies widely across the country.

Information for this category was obtained primarily from the Indiana Geological Survey, as well as the City of Bloomington Utilities and Planning Departments.

Perspectives and Patterns

Bloomington's karst topography was created by surface and ground water dissolving the underlying limestone bedrock. The most prominent surface karst features found in Bloomington include sinkholes, swallow holes, soil slumps and springs. Bloomington also contains extensive and complex underground water systems that have not been extensively mapped or studied. For that reason, this analysis will focus entirely on surface features, however, subterranean features should be considered for subsequent investigations.

Surface karst features were found to be scattered throughout Bloomington. Initial analysis revealed the highest concentration of features was found in the west and southwest portions of the City, followed by the south and southeast. There were limited features discovered in the highly urbanized downtown areas, however, lower concentrations of surface features were also found in the eastern and northern quadrants.

Karst geology has a profound influence on land uses and development in Bloomington. In the past, Bloomington's karstic landscape has influenced the location of municipal water supplies, public infrastructure, as well as building and development locations. Figure 5 illustrates the general locations of large karst areas in Bloomington and surrounding areas.

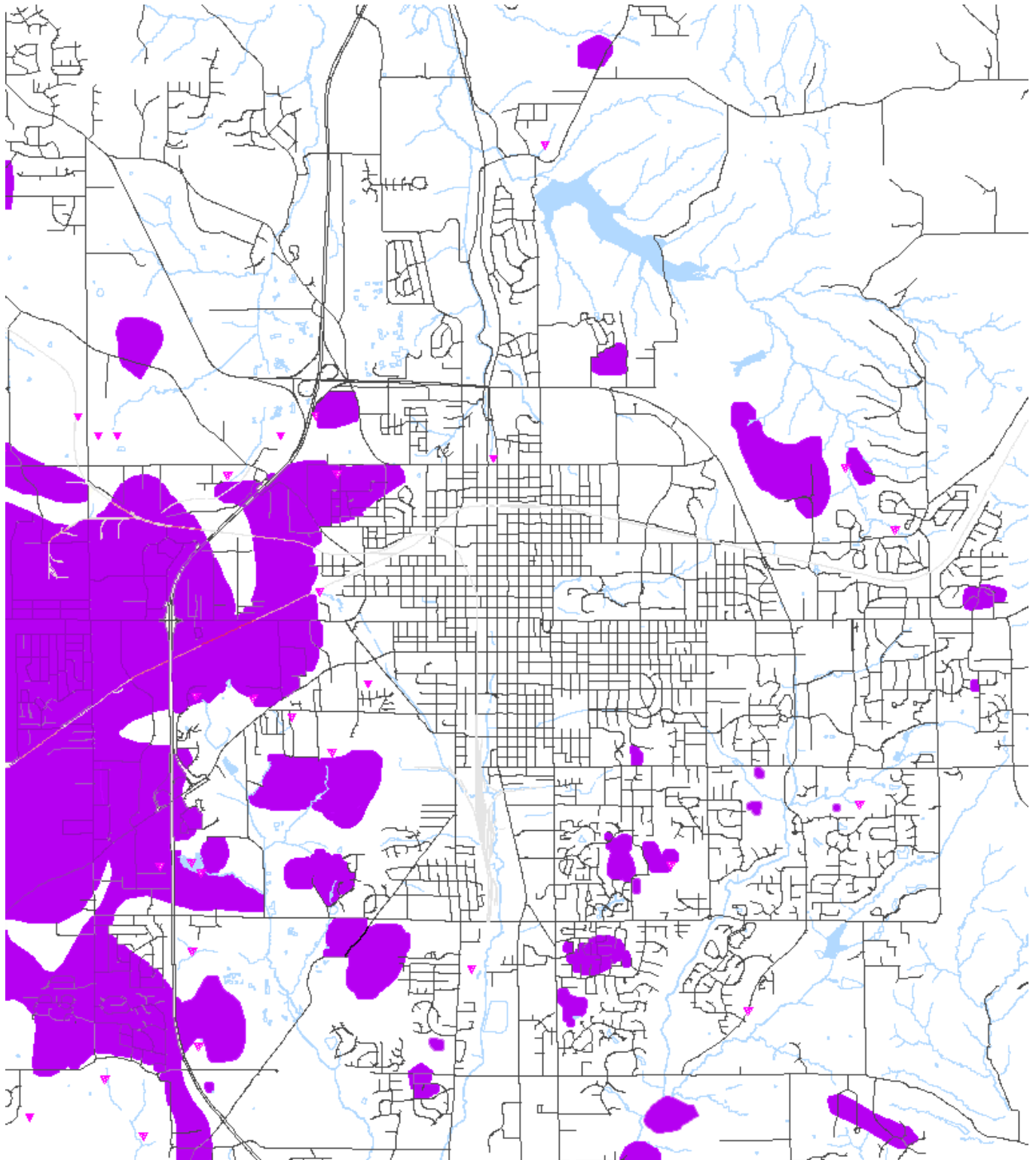


Figure 5. Map of karst areas and springs in Bloomington and surrounding areas
The dark shaded areas above represent the larger karst areas in Bloomington. The shaded triangles represent approximate spring locations. Overall, surficial karst features cover 3% of Bloomington's land area, and there are over 20 perennial springs currently inventoried.

Topography

Topography has a profound impact on how a region develops. Both settlement patterns as well as land uses are influenced by the location of features such as steep slopes, hillsides, valleys, plains, flat lands and uplands. The natural topography of a region is heavily influenced on its geology. Unique and distinctive landforms are created by areas subjected to processes such as glacial, volcanic, surface water, groundwater, and tectonic activity.

In general, a region's topography is expressed by the physical characteristics found on the surface. The topography of Bloomington ranges moderately in relief, and has many unique surface anomalies due to its karstic landscape. Because geological formations in Bloomington (karst geology) were discussed earlier, this portion of the report will focus only on the general relief and elevations of Bloomington.

The United States Geological Survey (USGS) supplies detailed topographic information across the United States. Information for this category came mainly from the USGS, with some supplemental data provided by the City of Bloomington Planning, Engineering Services, and Utilities Departments.

Perspectives and Patterns

Bloomington's topography is composed mainly of gentle (<6%) to moderate (6% to 12%) slopes characterized by flatlands to gently rolling hills. Bloomington also contains some areas with steep slopes (>12%) in the form of hillsides, gullies, and draws. Steep slopes were found primarily in the lower density residential areas along the periphery of the City, however, some steep slopes and hillsides were also found near the interior.

In general, Bloomington's landscape was created by soil erosion and bedrock weathering caused by water. Therefore, the majority of Bloomington's most challenging topography was found in close proximity to water resources such as Lake Wapehani, Griffy Reservoir, Clear Creek, Jackson Creek and their tributaries. Figure 6 illustrates the general topographic patterns in Bloomington and surrounding areas.

Bloomington contains very moderate range of elevations. Bloomington's average elevation is 784 feet above sea level. The lowest point in Bloomington is located just west of the Griffy Reservoir - 590 feet above mean sea level. The highest elevation in Bloomington is located on the north side of the Bell Tower near East Lingleback Lane - 932 feet above mean sea level. Figure 6 also depicts the locations of these points.

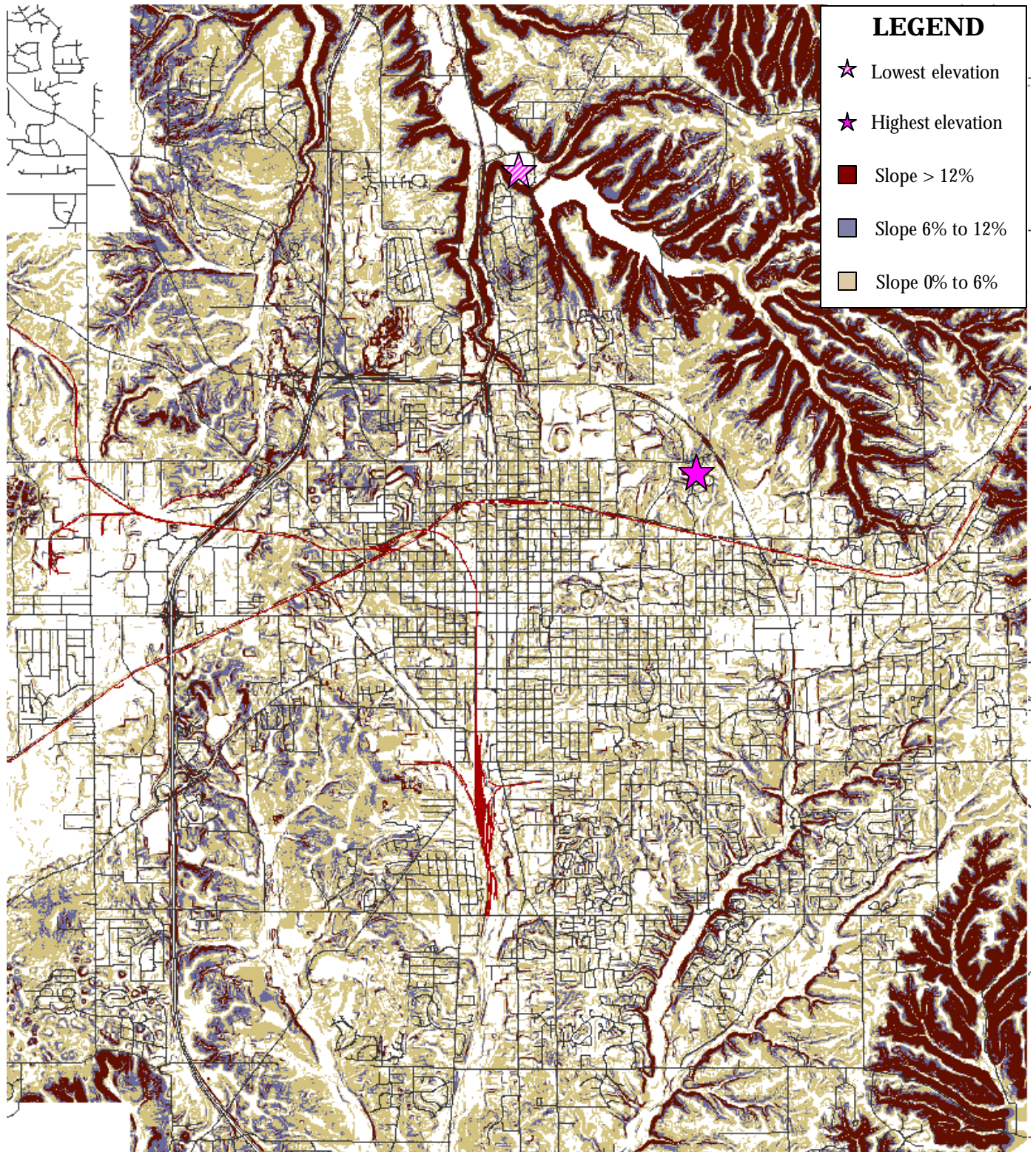


Figure 6. Map of general topography in Bloomington and surrounding area
 The shaded areas above show the location of different degrees of slopes in Bloomington. In general, steep slopes (> 12%) covered 17% of Bloomington's overall land area.

Special Habitats

For the purpose of this report, special habitats are areas observed as supporting species and/or communities of national or state-wide concern. Those include species or communities found on one or more of the following lists:

- Federally and/or state endangered species list
- State extirpated species list
- Federally and/or state threatened species list
- State rare species list
- Species listed as being of special concern (state)
- Species on the state watch list
- Species listed as being significant (state)
- High quality natural communities list (state)

It is important to identify and conserve all species and natural communities to preserve the earth's natural biodiversity. However, those identified on the lists above have been recognized as being endangered, threatened or of special concern. In order to prevent further decline of these species, listed species and communities receive special consideration for management and preservation efforts.

Generally, species and communities identified as special resources are targeted for preservation efforts under federal, state, and/or local laws. Because of their sensitivity to human activities, the surrounding supporting habitat is typically targeted for protection as well. Depending on the extent of their habitat requirements, preservation areas may be as large as tens of thousands of acres, to as small as less than one acre in size. Information for this category was obtained from the Indiana Department of Natural Resources' Natural Heritage Data Center. Other sources included the United States Fish and Wildlife Service, and the United States Environmental Protection Agency.

Perspectives and Patterns

Bloomington contains several areas having special habitats. Those include recorded observations of 1 state endangered species (Bobcat), 1 state threatened species (Troglobitic Crayfish), 1 species of state special concern (Sharp-Shinned Hawk), and 2 natural communities of state-wide significance (Dry-Mesic Upland Forest and Mesic Upland Forest). In general, areas confirmed as having these species and/or natural communities in Bloomington are managed locally as parks, nature preserves and/or conservation areas.

Based on initial analysis, most special habitats in Bloomington are found close to densely wooded areas containing steep slopes, sensitive soils, and water resources - including wetlands. Investigations into the locations of species and natural communities identified as special habitats, including the effects of human activities, are on-going. Figure 7 illustrates the general locations of recorded special habitats in Bloomington and surrounding areas.

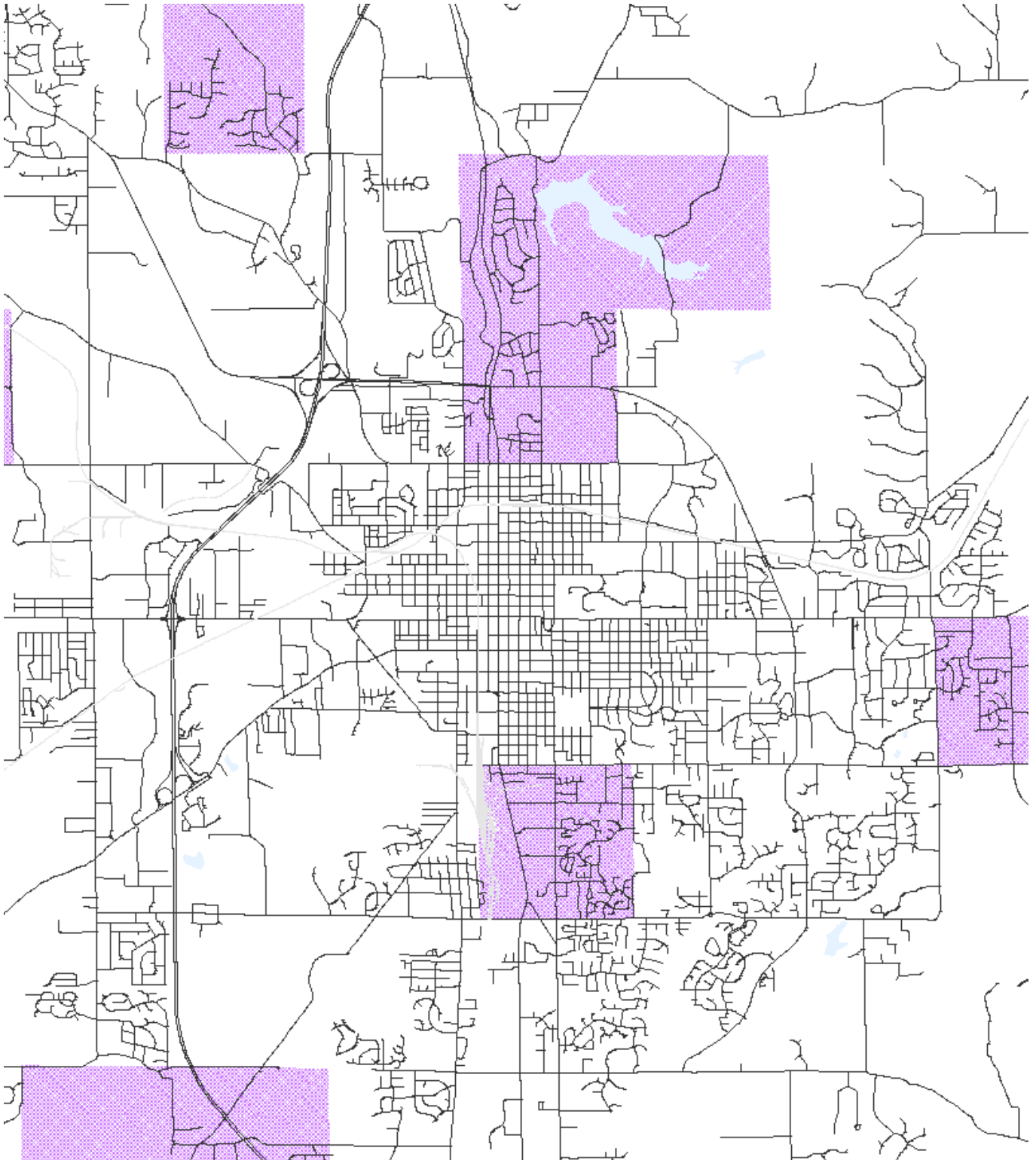


Figure 7. Map of special habitats in Bloomington and surrounding areas

The shaded areas above represent square mile buffers that contain special habitats observed in Bloomington. Overall, there were 5 different species and natural communities on 4 different state lists.

Vegetative Cover

Vegetation provides a wide range of ecological services depending on its type and extent. Some of those services include providing habitat for wildlife, slope and soil stabilization, air and water purification, flood mitigation, maintenance of biodiversity, as well as educational and recreational opportunities. In general, native plant communities are more beneficial than exotic and invasive species because native vegetation is better adapted to local conditions and requires less maintenance.

Bloomington has a diversity of vegetative cover ranging from open fields to densely wooded forests. High quality vegetation may be permanently preserved in a variety of ways for a variety of different reasons. Some of the ways vegetation may be preserved include creating parks, conservation easements, greenways, as well as common open spaces and backyards for private residences.

The successful maintenance and preservation of vegetation depends heavily on conservation planning and management activities. The USGS conducts studies that provide detailed information on vegetative cover and land uses across the country. Various departments at the City of Bloomington have recently undertaken studies to further develop the USGS's land cover database for Bloomington. Information contained in this category was obtained primarily from the USGS databases along with supplemental information generated by the City of Bloomington.

Perspectives and Patterns

The most predominant types of vegetative cover in Bloomington included urban and recreational grasslands, shrublands and forests. The majority of high quality vegetated land in Bloomington was found to be located along the periphery of the City outside the urban core – most notably the northeast and southwest portions of the City. In general, 78% of Bloomington's overall land area was classified as containing some form of vegetation including grassy areas and open fields in backyards, common open spaces, urban parks, as well as other public and private lands.

However, further analysis (excluding land classified as urban residential or commercial) revealed that 43% of Bloomington's land area could be classified as forest, sparsely wooded or shrubland/grassland. The majority of land classified as forest or sparsely wooded contained native deciduous species such as maples, oaks, elms, ashes, and hickories. The majority of land classified as shrubland/grassland was generally open fields left for fallow, abandoned quarry land and manicured fields containing some native grasses, forbs and shrubs. Figure 8 illustrates the general types, extent and location of vegetated cover in Bloomington excluding vegetated areas less than 1 acre in size.

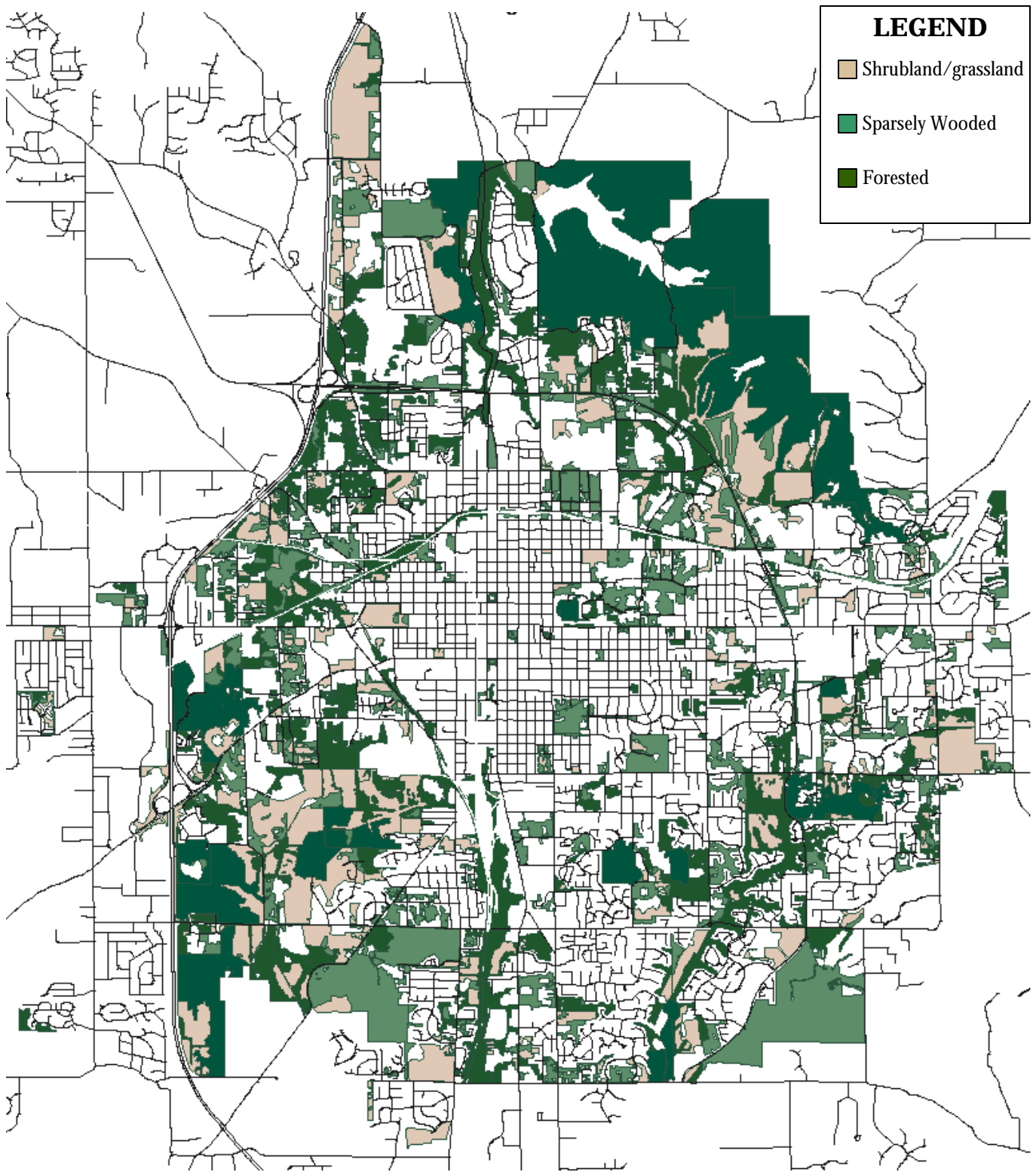


Figure 8. Map of vegetative cover in Bloomington

The shaded areas above represent vegetated areas in Bloomington excluding vegetated areas less than 1 acre in size. Overall, 11% of Bloomington's land area was shrubland/grassland, 10% was sparsely wooded, and 22% was forested.

ENVIRONMENTALLY SENSITIVE AREAS ANALYSIS

Studying natural resources individually is useful in determining their type and extent. However, to better understand their roles and functions they must be studied as an interconnected system. Bloomington has many unique and sensitive ecological communities that interact with one another such as wetlands, native woods, riparian corridors, karstic landscapes, and wildlife. As part of this project, the City of Bloomington's Planning Department evaluated and ranked natural resources in Bloomington using an environmentally sensitive areas (ESA) analysis.

This ESA analysis was based on the information collected for the environmental overlays described in the previous sections. The following three steps were used in this analysis to help further prepare data and interpret results from the analysis:

- i. Data preparation
- ii. Data aggregation and spatial analysis
- iii. Interpretation of results



Limestone cliff at Lower Cascades Park

Data Preparation

In order to begin the ESA analysis, some environmental overlays required further data preparation. To implement a conservative approach and ensure robust results, some overlays required additional preparation such as attribute removal, attribute addition, or feature buffering. Both the sensitive soils and wetland overlays were based on detailed surveys requiring no further preparation. The special habitat overlay was based on point feature data already consisting of a square mile buffer as explained in the previous section.

Overlays requiring further data preparation included the floodplain and water resources, karst geology, topography, and vegetative cover overlays.

Floodplain and Water Resources Overlay

To further consider the sensitive nature of Bloomington's waterways, a riparian buffer zone was created. Based on generally accepted scientific practices, it was determined that a minimum 100 foot riparian buffer was most suitable. To incorporate this, a 50 foot buffer was placed on both sides of all creeks and streams, and a 100 foot buffer was placed around all water bodies.

The new 'riparian buffer' dataset was then overlaid with the floodplain data shown in Figure 4. Where the floodplain exceeded beyond the 100 foot riparian buffer, it was expanded to

include the entire floodplain. The resultant overlay included all of Bloomington's water resources with a minimum 100 foot buffer zone, depending on the extent of the floodplain.

Karst Geology

To consider the various functions of karst in Bloomington, a buffer around all individual features was used. Including a buffer helped to better address features such as compound sinkholes, as well as better represents critical drainage areas. In general, research indicated that buffers as small as 25 feet, to buffers larger than 500 feet were required for effective resource management. After careful consideration, it was determined that a 100 foot buffer was most suitable. Using the surface karst feature data collected earlier (Figure 5), a 100 foot buffer was placed around all sinkholes, swallow holes, blind valleys and springs.



Fungus growing on a fallen log at the Griffy Nature Preserve

Topography

In general, further investigation revealed that slopes over 12% were considered to be most sensitive to human activities. Therefore, it was determined that only slopes over 12% would be included in this ESA analysis.

All slopes under 12% were extracted from the steep slope overlay illustrated in Figure 6. The resultant overlay was then included for further analysis.

Vegetative Cover

The vegetative cover overlay separated land into 3 distinct components – wooded, sparsely wooded and shrubland/grassland (see Figure 8). As discussed in the previous section, the majority of shrubland/grassland in Bloomington consisted of abandoned quarry land, old farm lots, and manicured grass fields. Because of the lower ecological value and to help simplify the analysis, these shrubland/grassland areas were discarded from further consideration. To better consider the functions and value of large tracts of native woods, a fourth component was created – high quality vegetation. For an area to be deemed high quality, it had to have the following characteristics:

- Be larger than 20 contiguous acres
- More than 80% of the vegetation must be native to the area (canopy and under-story)
- More than 80% of the canopy must be considered mature (older than 35 years)

Once the location of high quality areas was determined, the new attributes were included in the ESA analysis.

Data Aggregation and Spatial Analysis

This step required the data to be aggregated into a single map – the ESA map. To do this, spatial analysis techniques were used. In general, spatial analysis is a simple method used to evaluate habitat conditions and land use patterns for regions containing multiple features. Spatial analysis typically uses basic and applied research in physical geography, ecology, mathematics and information management technology to measure, describe and illustrate results.

For this project, the technique used was a numeric point-based ranking model. First, individual features (including buffers) were assigned a numeric value. To keep the model relatively simple, each feature was weighted evenly and assigned a value of 1. The features used for this analysis included: sensitive soils, wetlands, waterways, floodplains, karst features, steep slopes (>12%), special habitats, vegetative cover (sparsely wooded or wooded areas only), and high quality vegetation. Once assignment of the value was completed, the resultant datasets were aggregated, and overlapping feature values were added together. The minimum point total for an area was 0, and the maximum was 9.

Each individual score was then assigned a color for illustrative purposes as shown in Figure 9. For example, areas containing no features received a sensitivity rating of 0 - shown on the ESA map as white. Areas containing the maximum number of overlapping features were assigned a sensitivity rating of 9. However, in Bloomington the highest sensitivity rating was 8, therefore the sensitivity rating scheme ended at 8 – shown on the ESA map as dark purple. Areas containing only a few overlapping features were rated accordingly and corresponding colors were assigned as shown in the ESA map's legend.

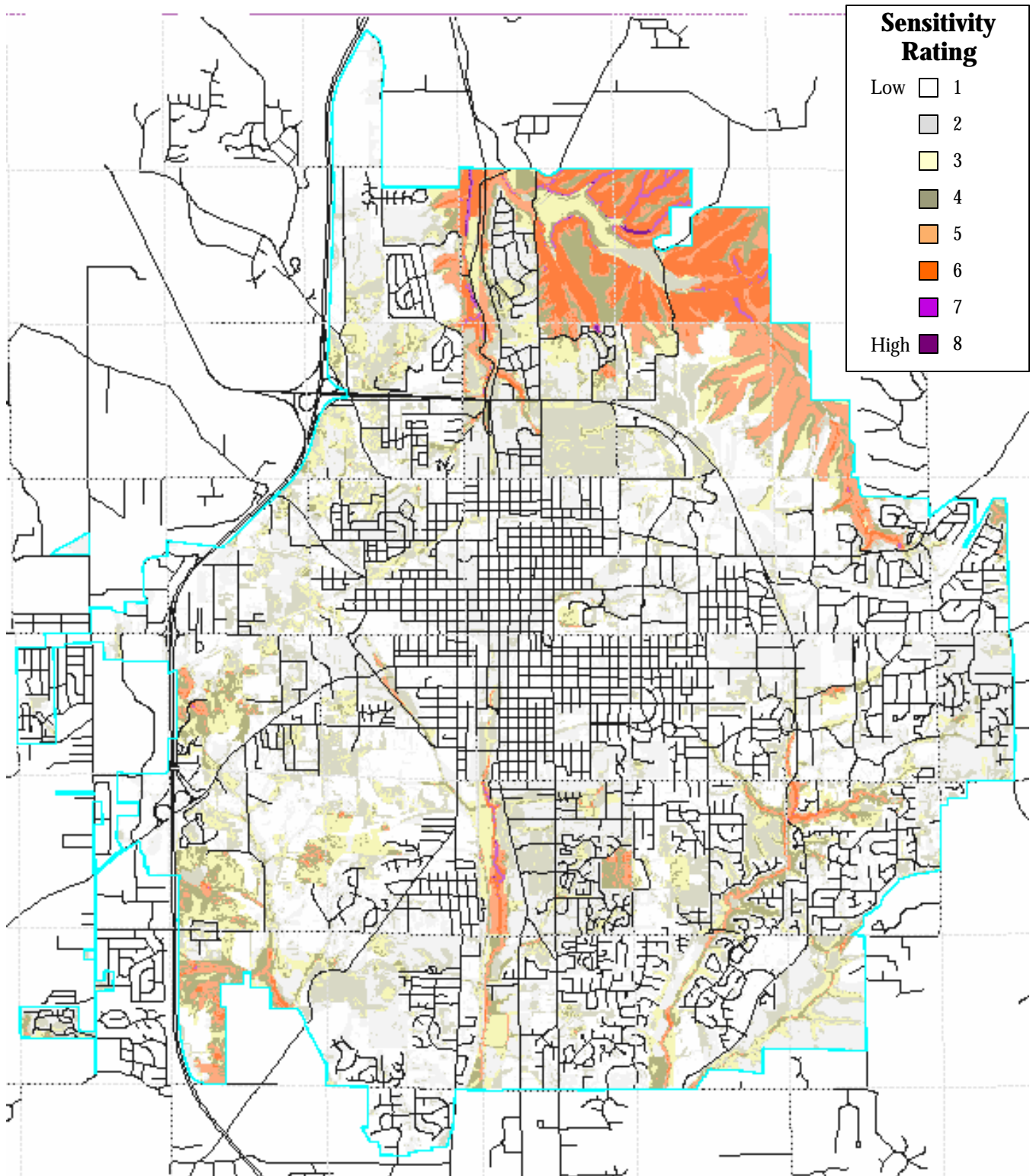


Figure 9. Environmentally Sensitive Areas Map of Bloomington

The map above illustrates the results generated by the environmentally sensitivity analysis. The different shades on the map correspond to the sensitivity rating shown in the legend. Overall, 13% of Bloomington's land area had sensitivity rating of 4 or greater.

Interpretation of Results

As described earlier, Figure 9 illustrates the results from the ESA analysis for the City of Bloomington. Each color on the map corresponds to a different sensitivity rating considering all 9 environmental features. White, grey and yellow areas represent portions of the City with a low sensitivity rating. Brown, orange and purple areas represent portions of the City with a higher sensitivity rating. In order to better illustrate the results, more detailed, larger scale quadrant maps for Bloomington were produced and may be found in Appendix A.

In general, the sensitivity rating is directly proportional to the complexity and diversity of environmental features in the area. Table 1 shows the extent of coverage for each sensitivity rating in Bloomington.

Table 1. Extent of sensitivity ratings for Bloomington

| Sensitivity Rating | Total City Acreage | Total City Coverage (%) |
|---------------------------|---------------------------|--------------------------------|
| 0 | 7184 | 42.99 |
| 1 | 3987 | 23.86 |
| 2 | 2024 | 12.11 |
| 3 | 1320 | 7.90 |
| 4 | 833 | 4.98 |
| 5 | 719 | 4.30 |
| 6 | 584 | 3.49 |
| 7 | 54 | 0.33 |
| 8 | 5 | 0.03 |

As Figure 9 illustrates, the most sensitive and diverse areas were found to be located along the periphery of the City - most notably in the northeastern, southeastern and southern portions of the City (see Appendix A ESA Quadrant Maps 2, 4, 7, 8 and 9). In general, the highest sensitivity ratings were located in the vicinity of the Twin Lakes, Lake Wapehani, Clear Creek, Jackson Creek, University Lake, Griffy Reservoir and Cascade Creek areas.

In the past, some of these diverse environmental areas have been targeted for preservation as parks or nature preserves (e.g. Griffy Woods/Lake Nature Preserves, Wapehani Mountain Bike Park, Clear Creek Trail, Winslow Woods Park, and Lower/Upper Cascades Park). Results from this analysis are meant to provide a resource for future preservation efforts. In order to do this, various administrative and management tools such as zoning, land acquisition and public-private partnerships may be used.

THEMES

As part of the COBERI project, GIS technology has been used to create maps of the natural resources in Bloomington. These maps include information on soils, wetlands, floodplains and water resources, karst geology, topography, special habitats and vegetative cover. In addition to this, an ESA analysis was performed to help rank land based on the presence and diversity of environmental features.

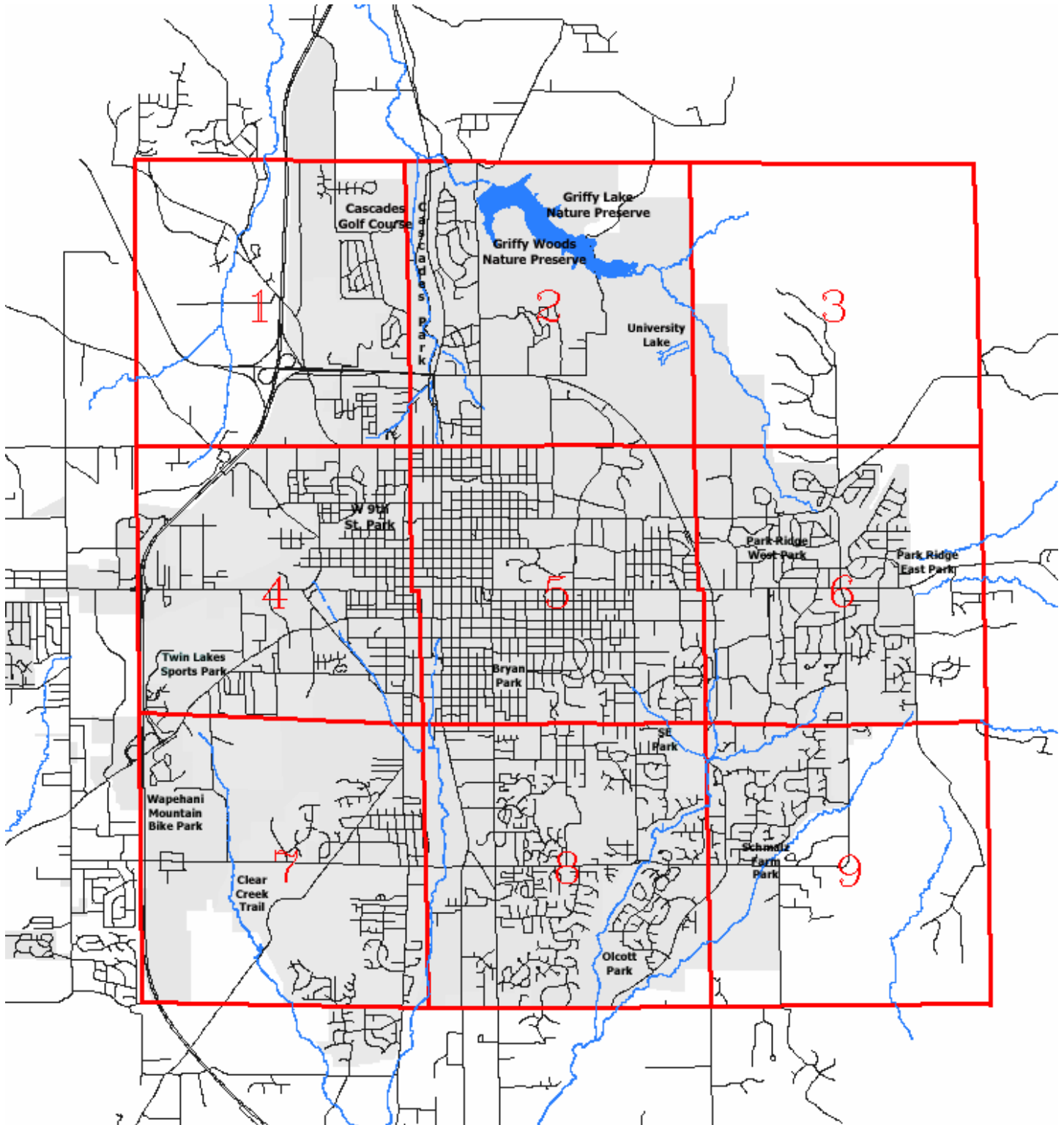
Overall, the COBERI project identified several themes present in the natural resources found throughout Bloomington. However, while Bloomington contains many diverse natural areas, it is a small piece of a much larger system. Activities that take place in Bloomington have a profound effect and influence on surrounding cities, counties and states. Keeping this in mind, some of the major themes raised by this report include:

- **Bloomington is shaped by several major environmental features that harbor many diverse and sensitive natural areas.**
In general, the ESA map illustrated the highest sensitivity ratings were located in close proximity to major water resources. Those included the major creeks (and their tributaries), lakes, and reservoirs found in Bloomington. Areas such as these provide unique habitats for wildlife as well as create corridors for wildlife migration. In order to best protect these areas, future land use policies and strategies should be based on sound watershed management principles.
- **Bloomington is home to many unique and sensitive ecological communities that also extend beyond its political boundaries.** In general, the analysis revealed the City of Bloomington has many unique and highly sensitive areas already preserved as parks or preserves. Future land use policies should consider these valuable natural resources and use the myriad of administrative and management tools available to protect them. Also, many of the most environmentally sensitive areas in Bloomington extend well beyond the City's political boundaries. Coordination of management and preservation efforts with adjoining jurisdictions must also be a priority.
- **The natural resources in Bloomington are interconnected in a complex network of systems that requires constant monitoring.**
Prior to drawing final conclusions, on-going investigation and monitoring of the quality and value of individual features and their cumulative functions is required. Subsequent studies must also consider cultural resources, geographic patterns and socio-economic factors.

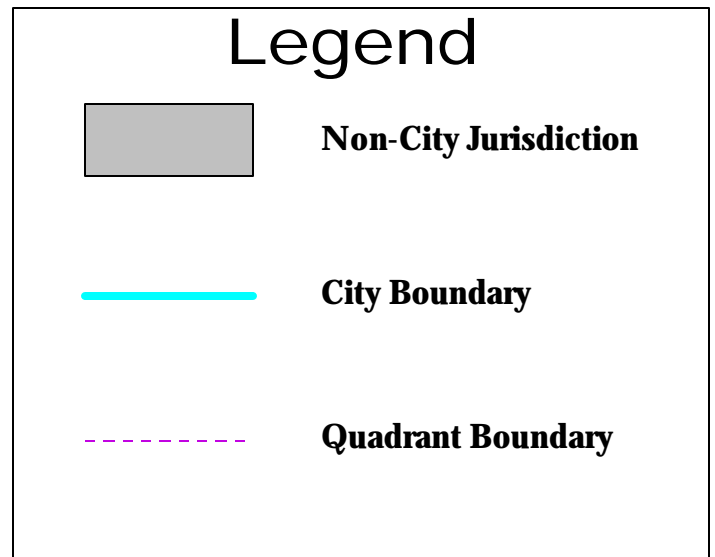
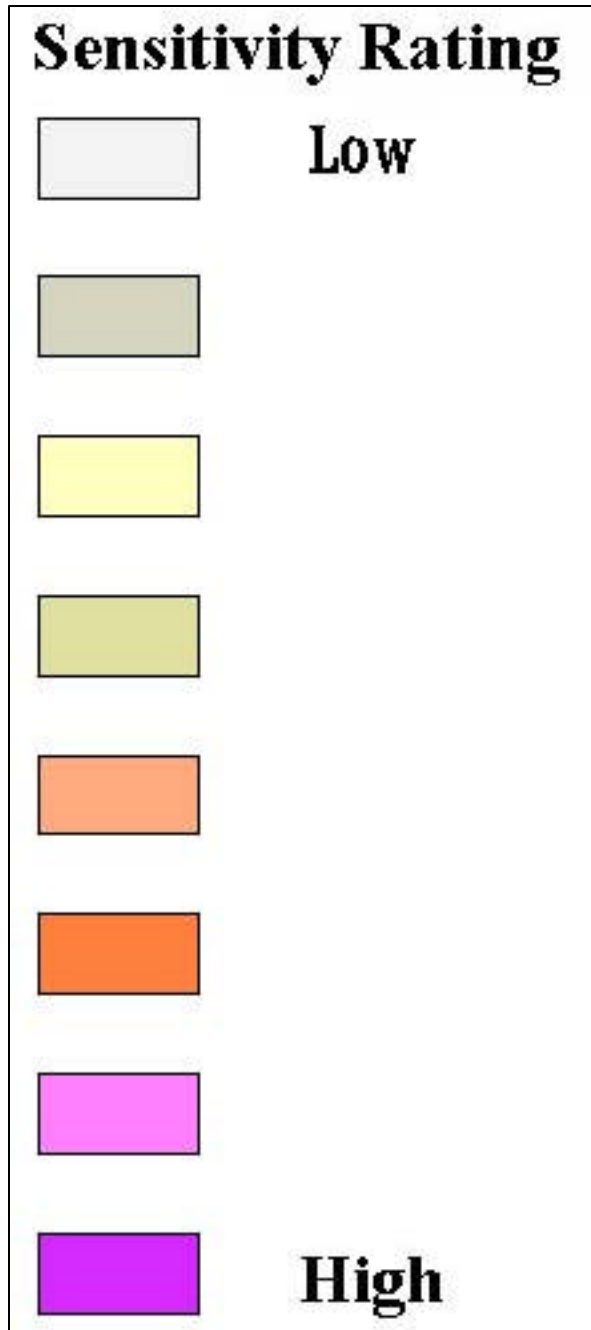
This report is meant to help guide and assist future decision for land-use and land development strategies for the City of Bloomington. By evaluating natural resources, as well as considering the myriad of other factors involved, sound conservation planning decisions may be made.

APPENDIX A

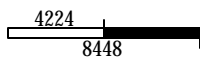
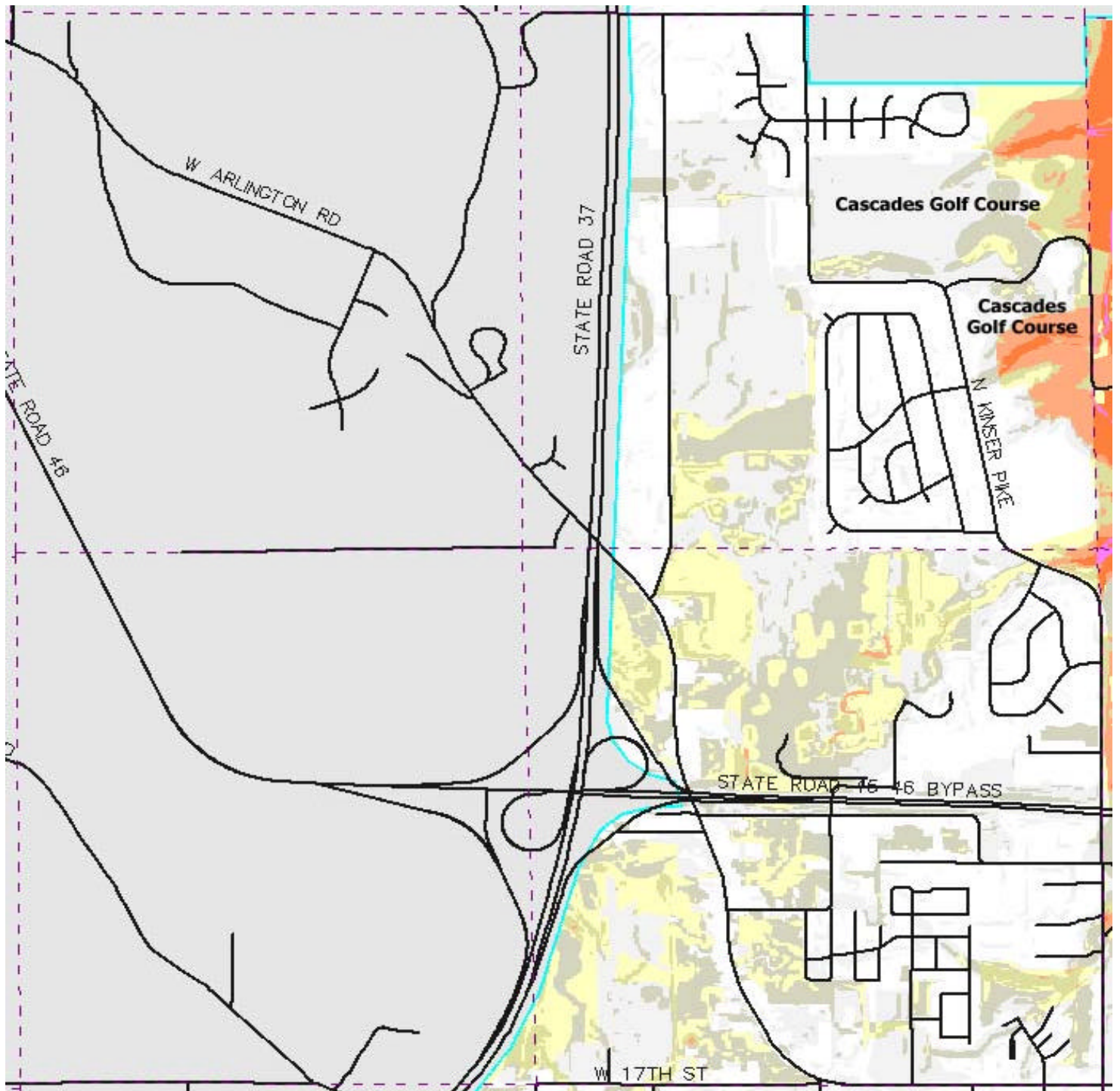
Environmentally Sensitive Areas Quadrant Map Index



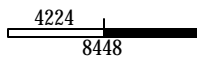
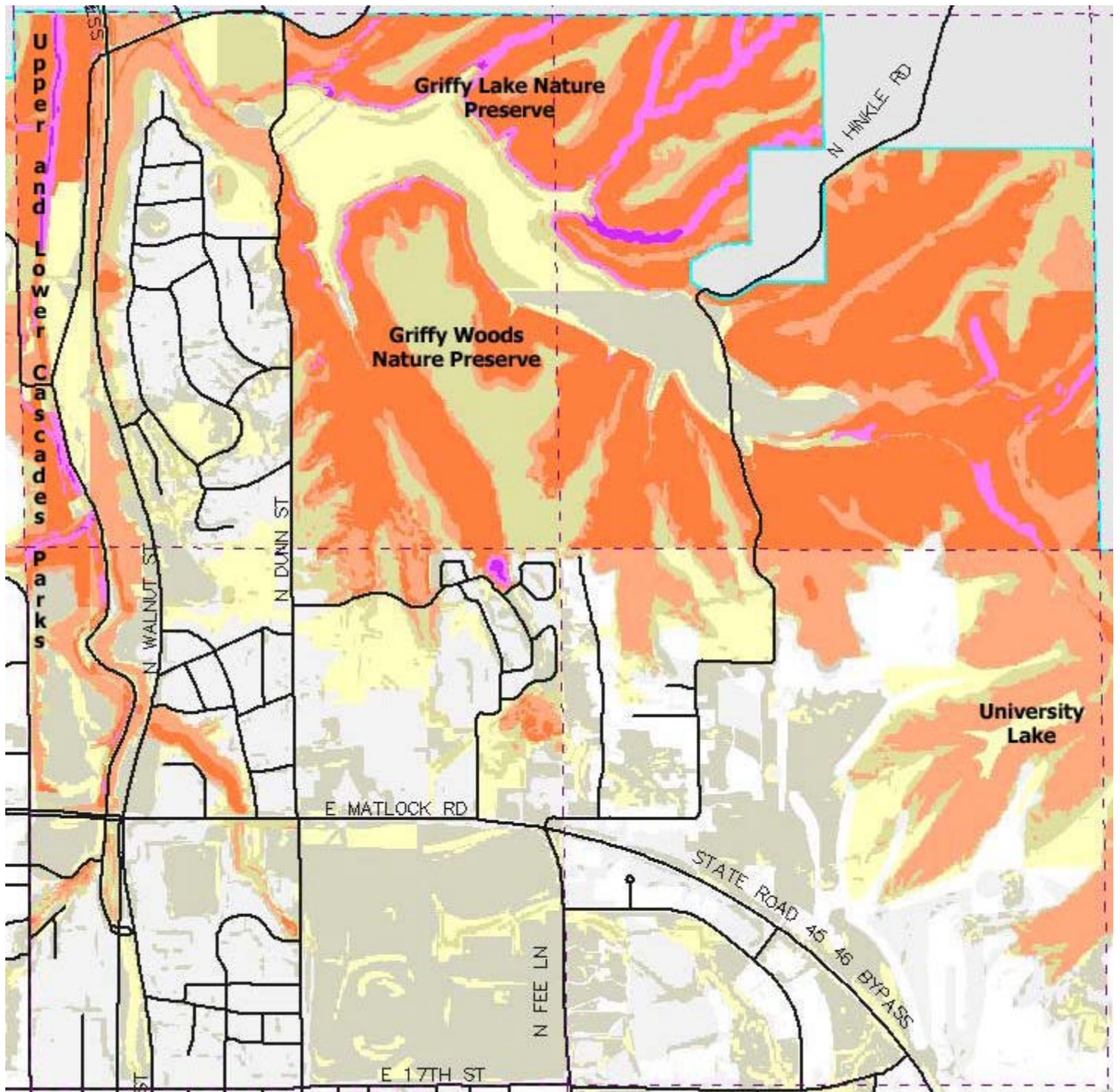
Environmentally Sensitive Areas Quadrant Map Sensitivity Rating and Legend



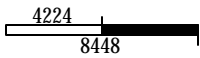
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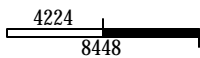
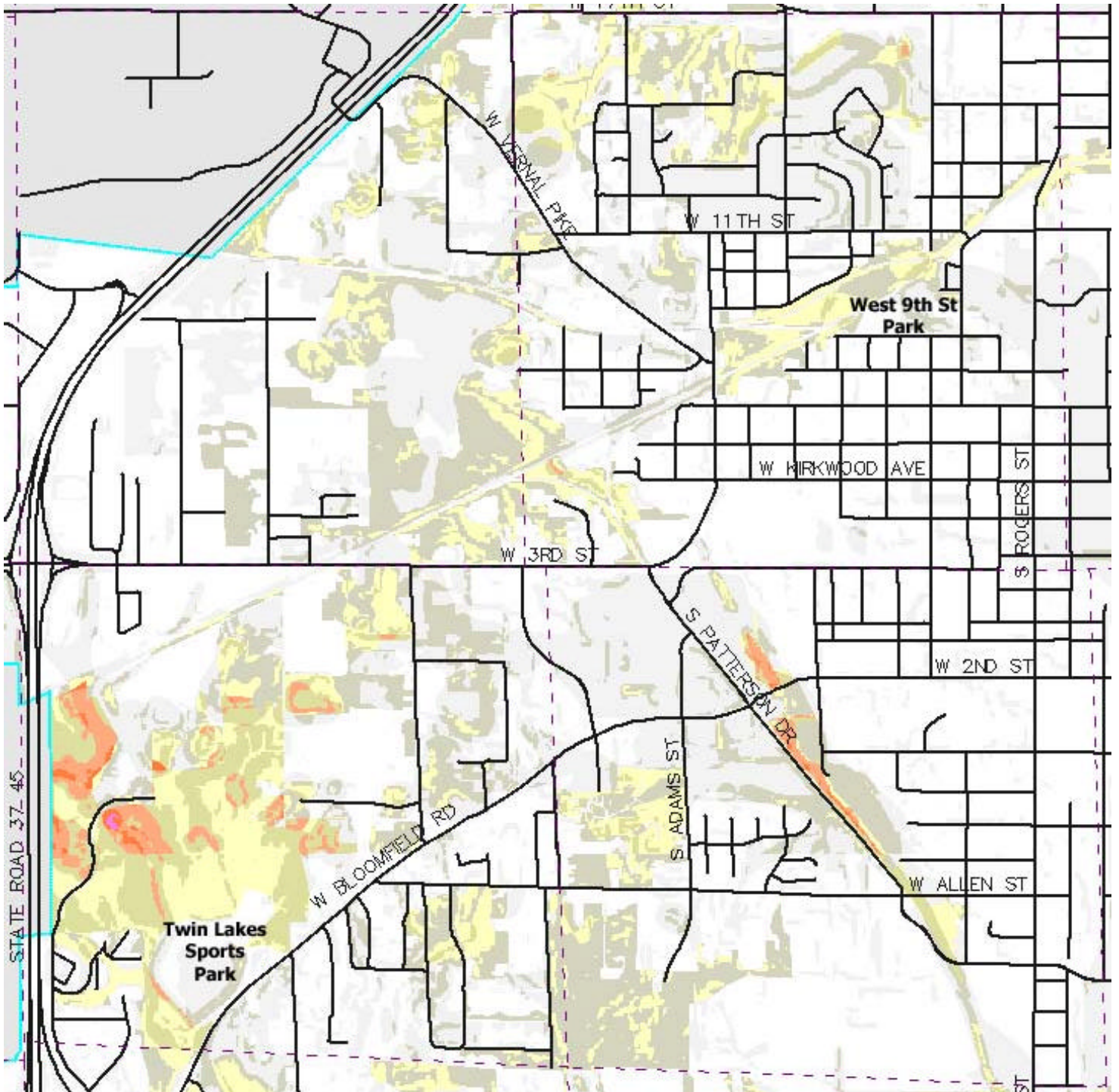
Environmentally Sensitive Areas Quadrant Map 2



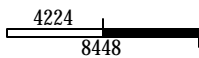
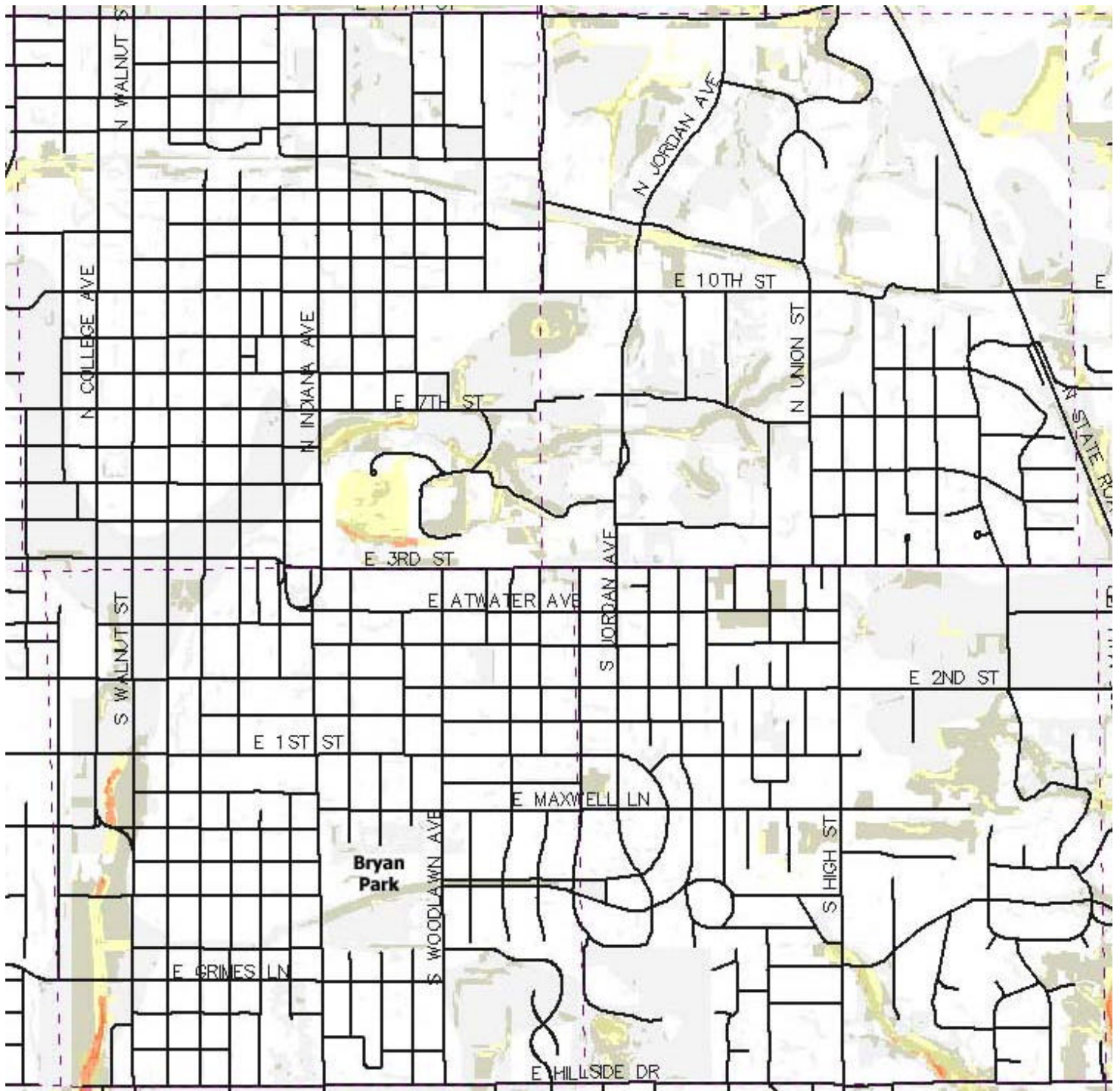
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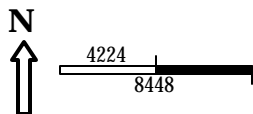
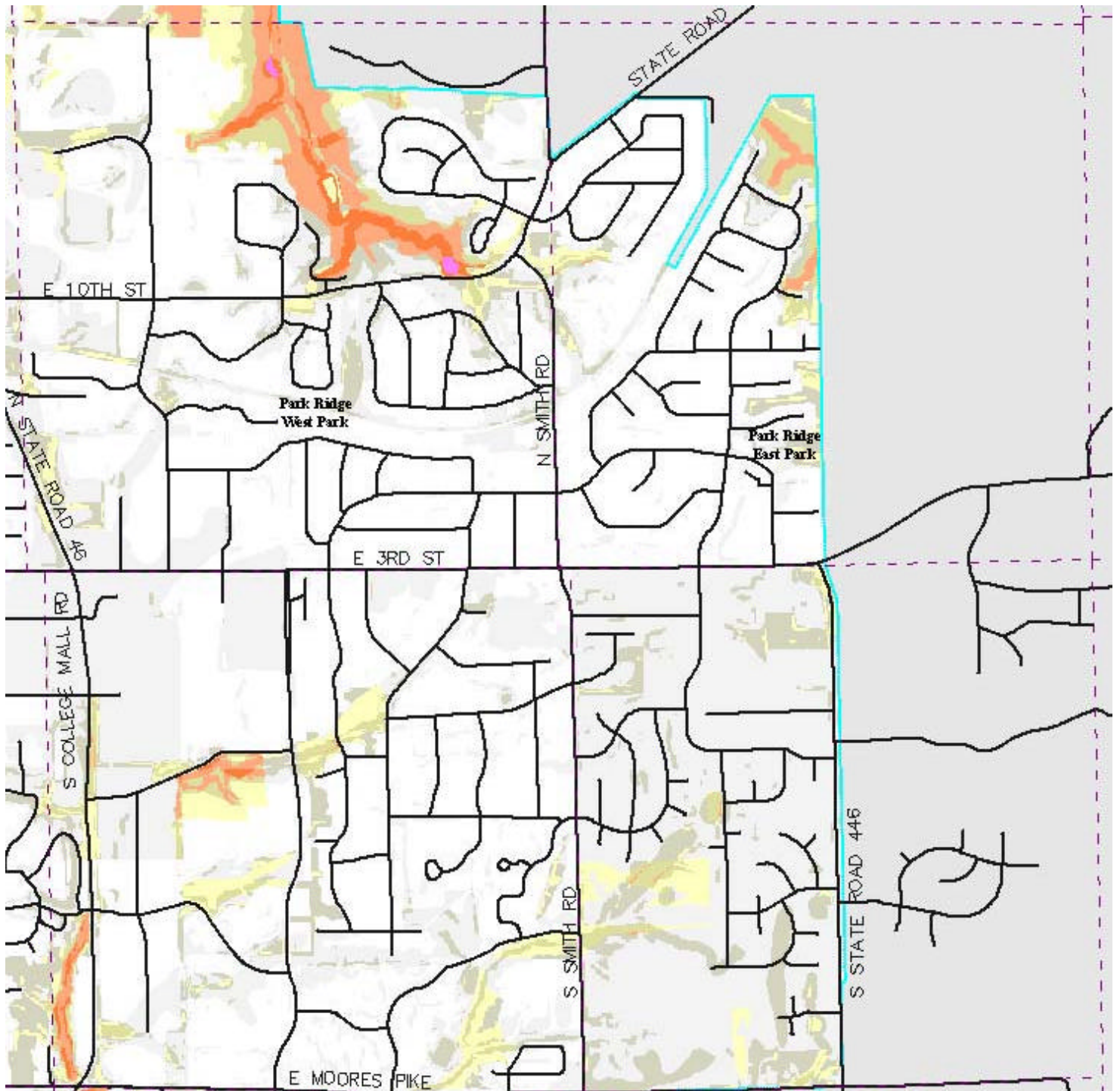
Environmentally Sensitive Areas Quadrant Map 4



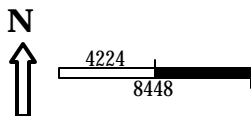
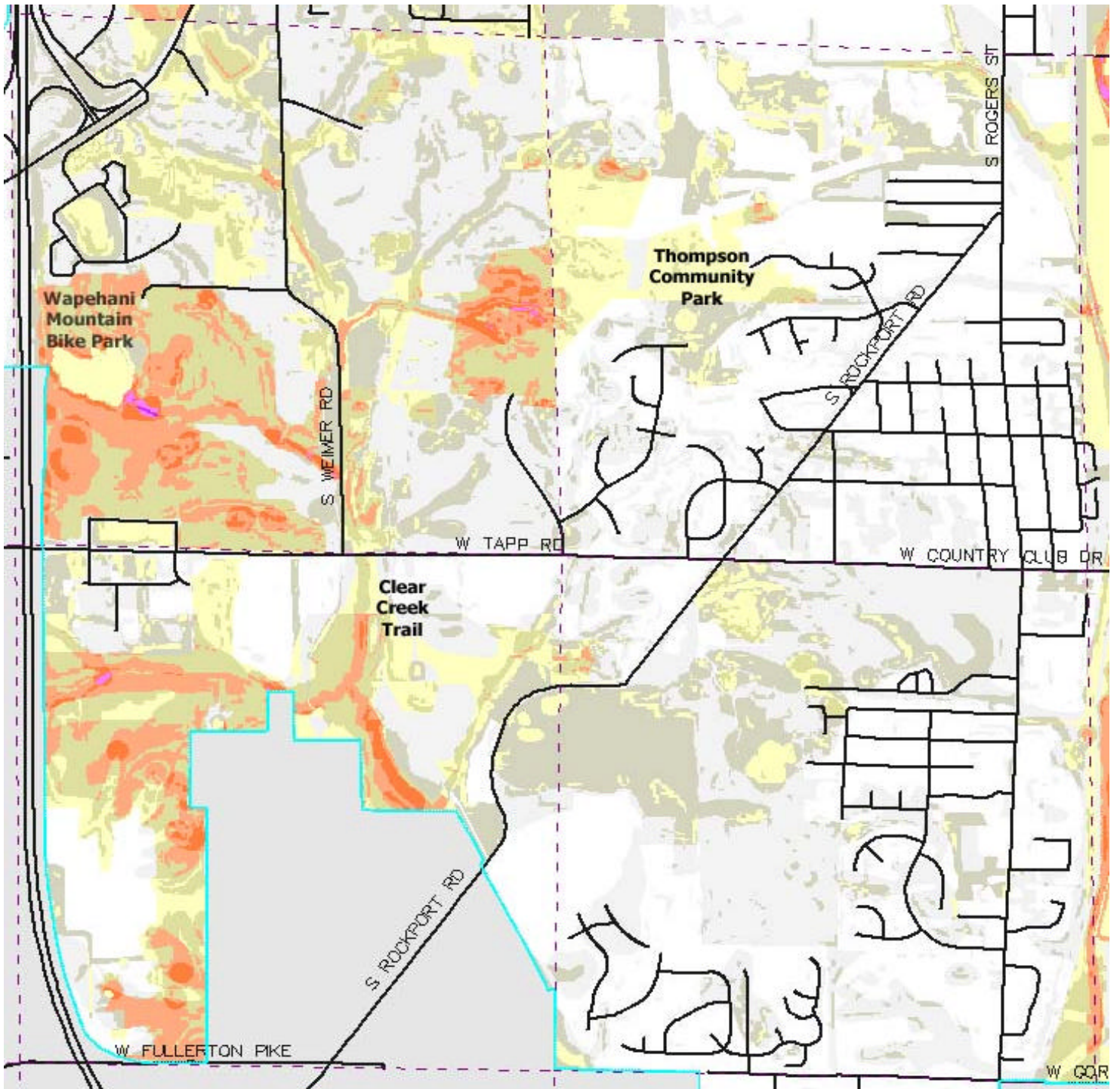
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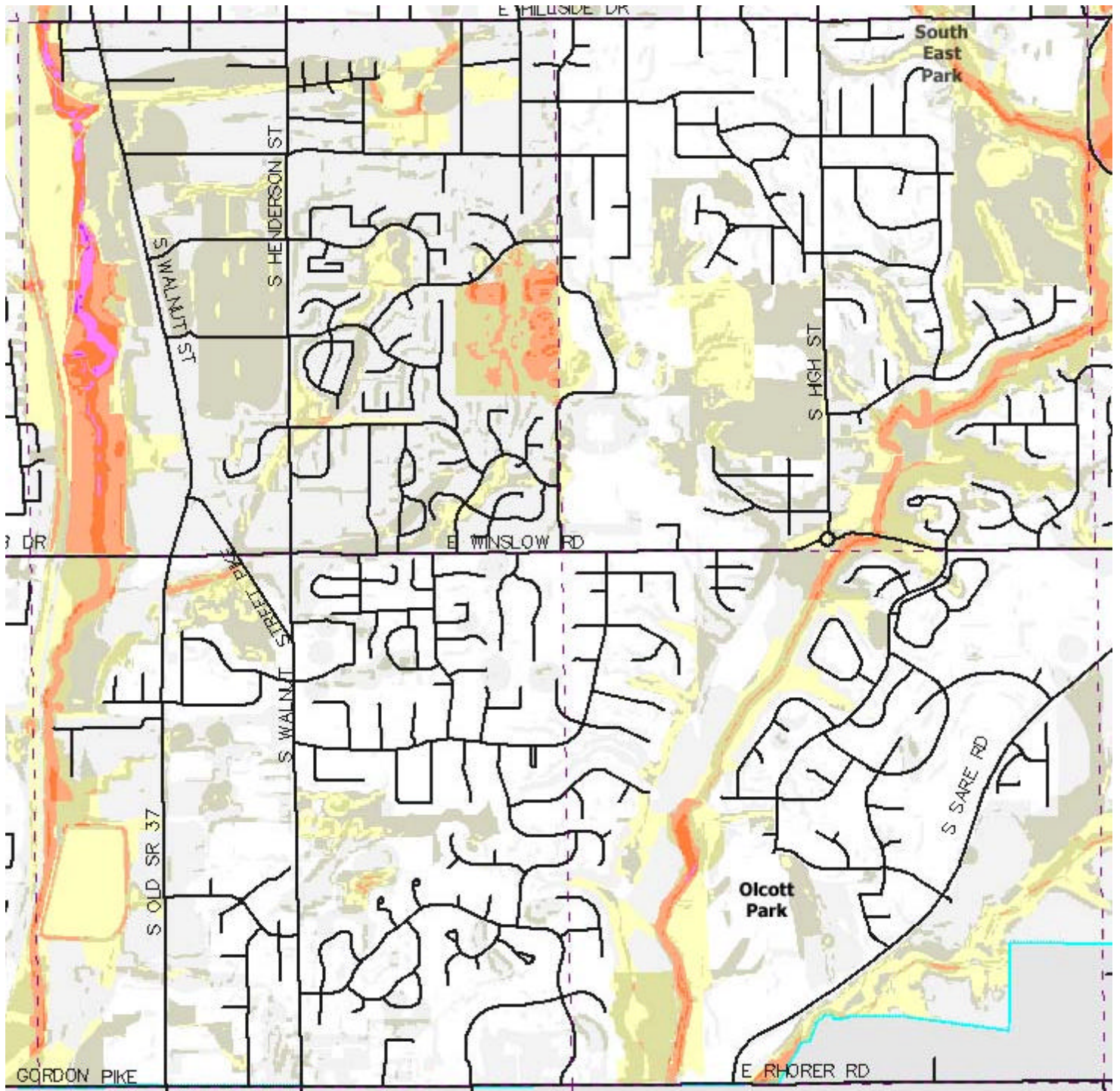
Environmentally Sensitive Areas Quadrant Map 6



Environmentally Sensitive Areas Quadrant Map 7



Environmentally Sensitive Areas Quadrant Map 8



Environmentally Sensitive Areas Quadrant Map 9

