Raymore Watershed Management Plan

City of Raymore,
Missouri

100 Municipal Circle
Raymore, Mo 64083

May 22, 2006

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Introduction

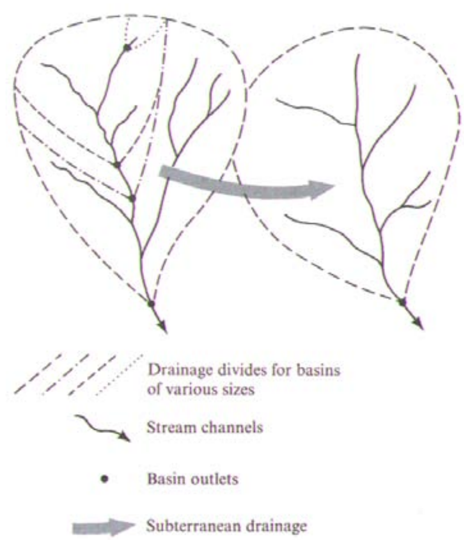
In foresight of the impending development within the current city limits, the City of Raymore hired BNIM Architects and Tetra Tech EMI to develop a Watershed Management Plan (WMP) for the City to help preserve the existing hydrologic conditions, enhance riparian habitat and protect water quality for future generations of Raymore citizens. The Raymore WMP is a supplement to the APWA 5600 guidelines and an outgrowth of the Raymore Growth Management Plan. This plan is written specifically for the City of Raymore with the intent of developing a natural resources framework aimed toward the better management of water resources.

The plan provides a stream setback recommendation developed specifically for the City of Raymore, in the Osage Plains natural division, in northern Cass County. Field observations used to develop the stream setback recommendation were taken by the planning team. The plan recommends a palette of Best Management Practices (BMP's) for urban, suburban, commercial, agricultural and retail situations and provides an abbreviated appendix of the recommended BMP's. A detailed planting palette has been recommended to assist the development of native grass, shrub, and tree seed banks in the Raymore area for application toward BMP's and native landscaping. Individuals who desire more detail for BMP installation or statistics are directed to the extensive literature included in the APWA 5600 guidelines. The Planning Team provides all the map data illustrated in the WMP for the city in geospatial format to assist the City with future planning efforts.

The WMP provides a strategy for future development of the project area focused on water quality, quality of life for Raymore's residents and protection of property. We believe that the WMP is one piece in a critical system of green infrastructure which includes parks and recreation, infrastructure, zoning and ordinances, and transportation. The WMP embodies and reflects the a community who is willing to take responsibility for their watershed and the impacts of development.

WATERSHED

To clearly define watershed, the planning team has provided the following quote from Dunne and Leopold: "A drainage basin is the area of land that drains water, sediment, and dissolved materials to a common outlet at some point along a stream channel. The term is synonymous with watershed in American usage and with catchment in most other countries. The boundary of a drainage basin is known as the drainage divide in the United States and as the watershed in other countries. Thus the term watershed can mean an area or a line. The drainage basin can vary in size from that of the Amazon River to one of few square meters draining the head of a gully. Any number of drainage basins can be defined in a landscape depending on the location of the drainage outlet of some watercourse. Because the hydrologic and geomorphic effects of natural and human processes within a catchment is focused at its outlet, the drainage basin of interest to planners is often defined as the area draining to some critical point at which they intended to install something. Planners should be equally aware, however, that the drainage basin they have defined in order to make some design calculation is a portion of some larger drainage basin whose downstream portion may suffer from the effects of the design unless they are careful (Dunne and Leopold, 1998; pg. 495)."



Drainage Basins and Drainage Networks (Dunne and Leopold, 1999)

Vision and Mission

City staff and the planning team developed a project vision and mission statement as a way to guide the WMP and remind future planning efforts the purpose and outcomes of this study. The vision and mission are critical path items which continually remind the consultant team, client and public as to the purpose of the WMP.

VISION STATEMENT

The vision for Raymore's WMP is to develop an interconnected watershed based flood control and innovative water filtering system that reduces dependence on concrete infrastructure and chemical water treatment. The plan is focused on using sound ecological planning and engineering principles to increase water quality and ultimately encourage increased economic and community vitality.

MISSION STATEMENT

To develop stream corridor and floodplain buffers which align with the Kansas City Metropolitian Chapter of the American Public Works Association Section 5600 guidelines.

To create a guide for resolving and alleviating future storm water management issues through preservation and enhancement of urban and rural waterways, vegetated storm water control, urban retrofitting, and community education. The system is based on soft-engineering, ecological restoration, identification and preservation of important quality biological corridors, urban, suburban, and rural Best Management Practices (BMP), stream setbacks and conservation buffers.

To educate citizens, visitors and the community about ecologically based approaches to improve water quality and handle significant wet-weather flows. The plan will be a living document and geodatabase that serves as a guide for implementation of these strategies. The plan will develop and foster cooperative relationships with local, regional, or state government agencies land management program agencies that are adjacent to the City or share their resources.

Project Objectives

The planning team recommends the City of Raymore consider two basic goals for the WMP:

RUNOFF QUANTITY REDUCTION: Capture and manage, through on-site BMP's, storm water from the water quality event (1.37 inches per hour). The captured water shall be allowed to infiltrate into the groundwater system or stored for beneficial purposes (e.g., landscape watering, car washing). Captured water that is not stored for future use should be released within 24 hours.

KEEP WATER QUALITY: Control and filter pollutants which will be carried by storm water. Particular attention should be given to roadway contaminants (petrocarbons), fertilizers and other nutrients, organic sediment, and existing contaminates within the substrate from previous site impacts.

The water quantity and quality goals can be further subdivided into the guiding principles below:

1. Preserve existing significant natural features.

2. Maximize infiltration and minimize imperviousness

3. Select BMP's that favor sheet flow and on-site infiltration of storm water versus piping or channelizing.

4. Apply "soft-engineered" solutions of plants, swales, and topographic depressions versus "hard-engineered" solutions of concrete channels, curb inlets and storm sewers

5. Utilize native plant species that are adapted to the microclimate of their proposed site placement.

6. Incorporate BMP's into the proposed architecture (e.g., water cisterns, pervious parking, roof water collection, grey water systems, low flow plumbing, energy star appliances, wind and solar collection)

MASTER PLAN DELIVERABLES

The above sections detailed the stakeholders and project drivers for the plan, which are summarized in a list of expected deliverables. These deliverable are 1) A detailed bound report to include data collection, public participation process, existing natural resources analysis, stream setback recommendations and a buffer map, and regional detention suggestions, 2) a BMP manual and ecological design templates for commercial and residential development 3) an executive summary, 4) all GIS data organized and delivered in a geodatabase format for integration into future plans.

Background

Conversion of rural land to urban land typically increases the volume, rate and erosive capacity of storm runoff in a watershed. An urban or urbanizing watershed is one in which impervious surfaces cover or will soon cover a considerable area. Impervious surfaces include roads, sidewalks, parking lots and buildings. Typically, the natural drainage pattern of an urbanized watershed is replaced by paved gutters, storm sewers, drain tiles and other elements of artificial drainage. (SCS, 1985)

Conversion of rural land to urban land changes a the reaction a watershed has to precipitation. The most common effects of increased impervious surface are decreased infiltration and decreased runoff travel time, which significantly increases peak stormwater discharge quantity and velocity through a watersheds tributaries. In turn, increased discharge quantity and velocity lead to stream bank erosion and stream degradation. (SCS, 1985)

How is runoff determined?

"Runoff is determined primarily by the amount of precipitation and by infiltration characteristics related to surface cover type, soil type, soil moisture, antecedent rainfall, impervious surfaces and surface retention (SCS National Engineering Handbook, Section 4-Hydrology (NEH-4) (SCS 1985)."

What is Travel Time?

"Travel time is determined primarily by slope, length of flow path, depth of flow and roughness of flow surfaces (SCS National Engineering Handbook, Section 4-Hydrology (NEH-4) (SCS 1985)."

What is Peak Discharge?

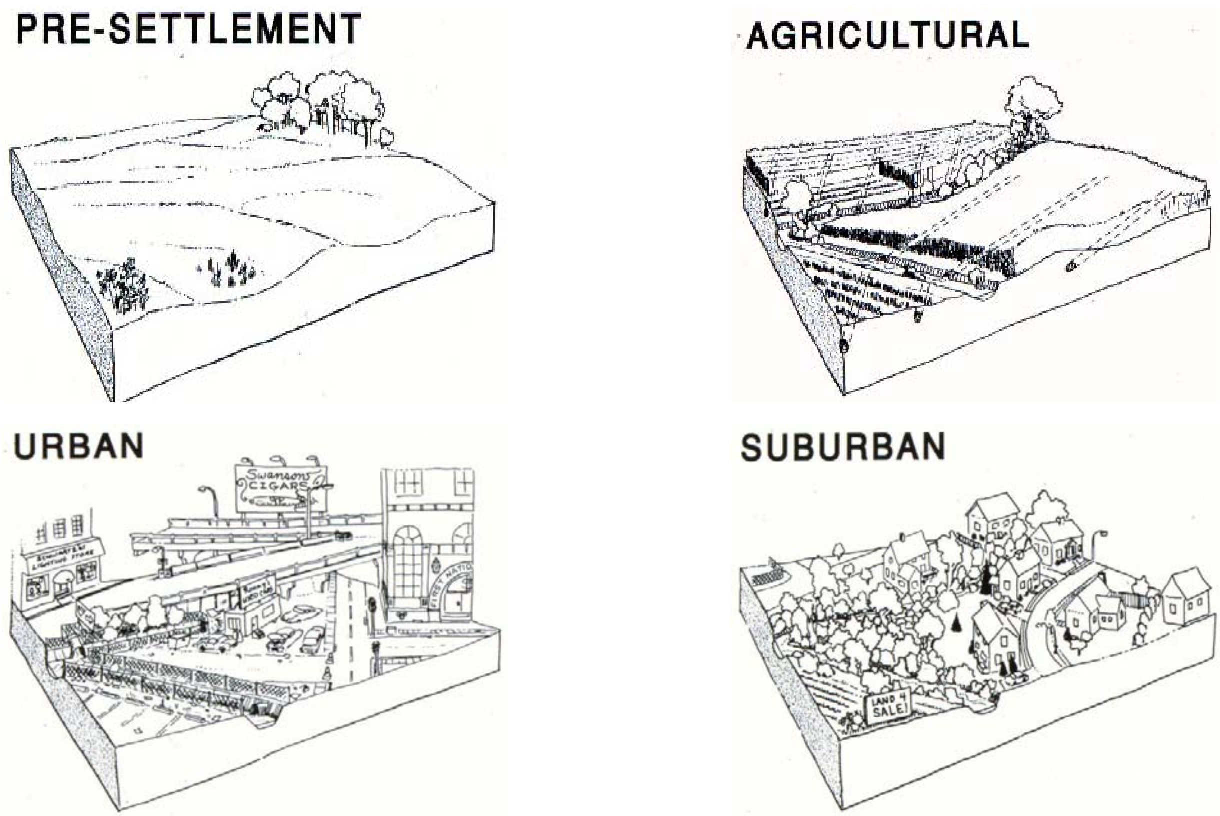
Peak discharge is the peak quantity of flow distributed through a watershed's tributaries during a rainfall event. Rural watersheds often have coarse surface cover and in-tact stream corridors, resulting in smaller peak flows through tributaries during rainfall events and increased stream base flow. Urbanized watersheds have smooth impervious cover and smooth water conveyance elements, resulting in reduced infiltration and greater frequency of larger peak flows through tributaries (SCS, 1985)





Raymore Images

As rural watersheds become urbanized, the resulting increase in peak discharge volume and frequency can have adverse downstream impacts on floodplains, riparian corridors and areas adjacent to riparian corridors. Typical adverse effects include increased sediment load, accelerated stream bank erosion adjacent or encroaching upon existing infrastructure and loss of riparian habitat. Efforts to reduce the volume and frequency of peak flows in urbanized watersheds can be diverse and creative. Effective measures for reducing peak flow volume and frequency are typically called best management practices (BMP's), and include bioswales, retention and detention basins, pervious pavement, rain gardens, rooftop gardens, rain barrels and cisterns. (SCS, 1985)



Typical Patterns of Pre-settlement, Agricultural, Urban and Suburban Landscapes

Detention basins are the most widely applied BMP for reduction of peak runoff quantity and frequency and is generally the least expensive alternative. However, single depressions in every development plat, neighborhood, or commercial development can be viewed as a nuisance, and if designed with concrete and rock, can actually add to the pattern of impervious surface cover. Bio-retention is detention designed to hold water for a short period while water is soaking into the earth feeding plants and leaving behind roadway contaminants for plant uptake. The bioretention principle can be applied to large or small basins, as well as to bioswales and rain gardens.

Diversifying on-site BMPs will reduce the number of residential detention basins, however, BMPs alone will not maintain present condition runoff. Regional wet detention is an effective measure for controlling increased runoff. A regional detention facility provides storage for storm water runoff and treats the runoff volume (Doll 1983). Regional detention facilities can be designed for current runoff conditions or future runoff expectations. Section 5608 contains requirements and design guidelines for these facilities (APWA 2006). To maximize the longevity and effectiveness of regional detention facilities, BMPs are needed to promote infiltration and minimize the sediment delivery into the facility. Regional detention facilities can also act as a multi-use facility by providing a community with parks and recreation areas and link potential linear trail infrastructures.

The City of Raymore is a rapidly suburbanizing post-agricultural landscape

Raymore Images

Truman Lake Reservoir

Missouri Valley Agricultural Village

East Kansas City Missouri

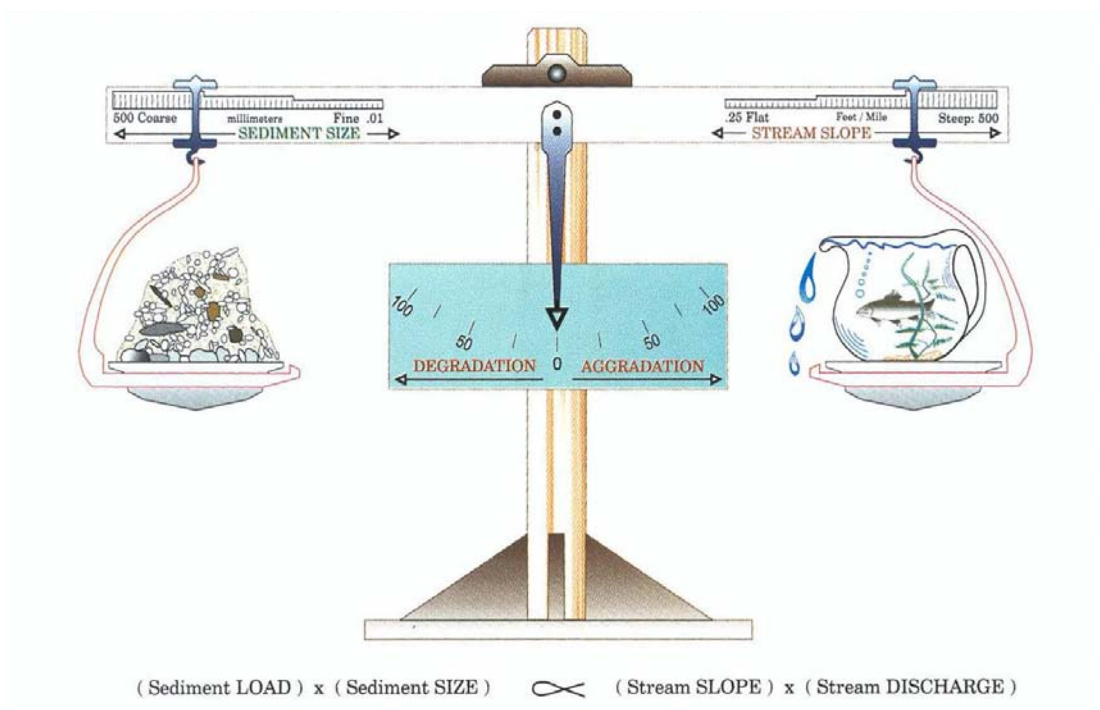
City of Raymore

Stream Characteristics

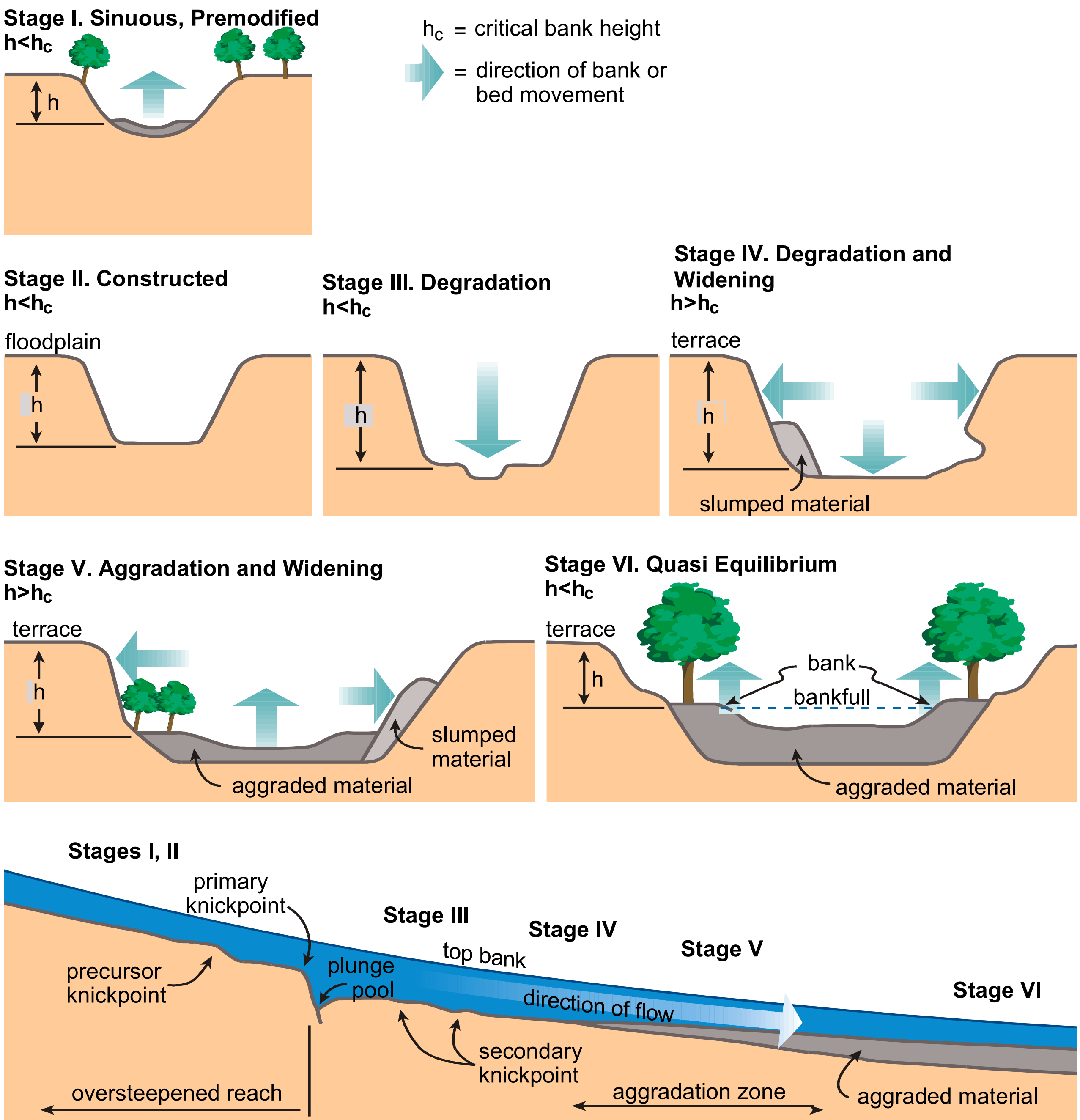
Streams perform two functions (independent variables) within a given watershed. First, streams drain the water delivered by its watershed. Second, streams transport sediment and detritus that is also delivered by its watershed. Streams strive to a state of equilibrium or stability. Rosgen (1996) defines stream stability as, "...the ability of the stream to maintain, over time, its dimension, pattern, and profile, in such a manner that it is neither aggrading nor degrading and is able to transport without adverse consequence the flows and detritus of its watershed." When one of the two independent variables change, it may cause channel instability. These dependent variables included flow resistance, velocity, channel width, channel depth, and stream slope (Leopold, Wolman, and Miller 1964).

Urbanization has shown to change the runoff and sediment characteristics of streams. Most importantly, urbanization can cause adjustments in the frequency and magnitude of the bankfull discharge or channel forming flow. The bankfull discharge is most effective at moving sediment, forming or removing bars, forming or changing bend and meanders, and doing the work that results in the average morphologic characteristics of channels over time (Dunne and Leopold, 1978). The bankfull discharge, on average, had a recurrence interval of 1-2 years. In urbanized settings, the bankfull discharge is normally at or close to the 1-year flow event.

Large flow events can cause significant channel changes but are too infrequent to govern channel morphology (Wolman and Miller 1960). In a stable environment, large flow events spread out on a stream's floodplain. The floodplain is the natural storage area for flood runoff volume. The floodplain slows the water down by spreading it over a wider area and by the vegetative roughness of the stream corridor or buffer. This reduces flooding impacts downstream and promotes infiltration into the alluvial groundwater system.



Healthy streams balance sediment, channel slope and water quantity (Rosgen, 1996)



Simon, A. 1989. A model of channel response in disturbed alluvial channels. Earth Surface Processes and Landforms. Volume 14. Pages 11-26.

BENEFITS OF HEALTHY STREAMS WITH BUFFERS

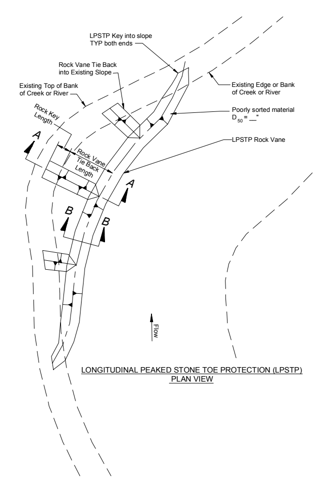
1. Increased storm water infiltration
2. Reduced impervious storm water infrastructure
3. Decreased risk of flooding
4. Healthy patch corridor matrix for wildlife and community connectivity
5. Built-in multi-use corridors for trails

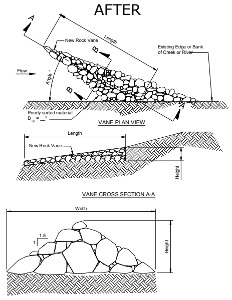
RESULTS OF POOR STREAM MANAGEMENT

1. Increased velocity
2. Decreased infiltration
3. Flash flooding
4. Stream bank erosion
5. Increased siltation
6. Decreased water quality
7. Decreased wildlife habitat
8. No multi-use corridor

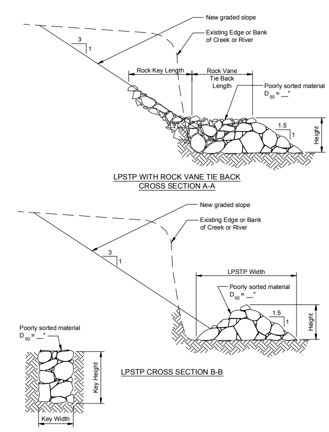
Stream restoration is a costly and intensive process that is difficult to implement in post-urbanized communities

AFTER





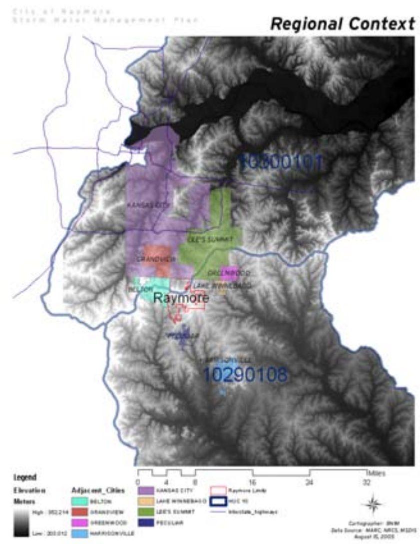
BEFORE



Raymore Background

HISTORIC CONTEXT

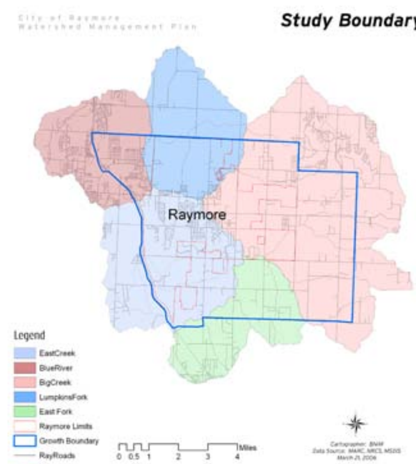
The City of Raymore, located in northwest Cass County, Missouri, was founded as a Fourth Class City of 80 acres on March 5, 1888. Raymore is a southern suburb of Kansas City located on a regional upland, and covers approximately 16.7 square miles. The recorded population of 11,000 plus citizens in 2000 (www.raymore.com) was more than double from the 1990 census and city leaders are expecting this trend to continue as developers discover the abundance of suitable land for development and families discover the quality schools and proximity to the greater Kansas City Metro area. To accommodate the expected growth, the city is hoping to extend its legal boundaries from 16.7 square miles to upwards of 40 square miles, annexing surrounding agriculture land for future suburban development. Current land-use in Raymore is approximately 50% single family residential and approximately 25% land under construction, with the remaining 25% a mix of multi-family residential, school land, park land, private land, agricultural land, religious assembly land, and public building land.



REGIONAL CONTEXT

The study area, as defined by the City at the onset of the project, reflects the previous Growth Management Plan (Transystems / Banks, 2004) and is defined by 291 Highway on the east, 155th street on the north, 71 hwy on the west, and 203rd street on the south. City staff and City Council agreed upon this boundary as their perceived growth objective.

Raymore, as the high point in the region, drains out through several sub-basins in all directions. The outflows of Raymore streams flow into other cities, and if not managed correctly, Raymore could produce an increased flood hazard or decreased water quality situation for downstream cities and towns. As shown in the above diagram, stormwater from Raymore flows northward through Lee's Summit, Kansas City, and Independence and discharges into the Missouri River. Eastward runoff flows through Lake Winnebego and Harrisonville City Lake, then through Pleasant Hill. Southern and Southwestern runoff flow into tributaries of the Grand River which flows through Harrisonville, Cass County, and discharges into Truman Lake Reservoir. The majority of the land to the north and west of Raymore is developed urban or suburban land, whereas the majority of the land to the east and south is undeveloped, privately held agricultural and ranching land.

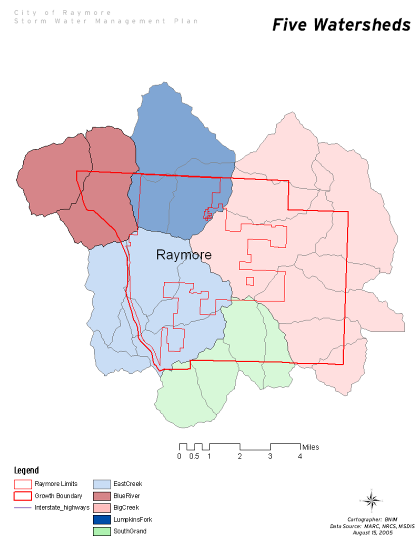


Based upon the objectives of the WMP, the planning team developed a watershed based study area boundary of drainage sub-basins that encompass all runoff from the future development boundary as defined above, and serves as the framework for natural resources inventory. The planning team derived the watershed boundary by overlaying the growth management plan on the sub-watershed boundary layer. The resulting layer encompasses all areas where stream buffers and BMP's should be applied to clean and control runoff that will occur from development within the future growth boundary.

" There is much to be gained from examining the drainage basin as a convenient unit for understanding the action of hydrologic and geomorphic processes and for appreciating the spatial linkages between different areas that can affect both regional and site planning (McHarg, 1969)."

Inventory and Analysis

This section is a summary of the natural resources inventory and analysis conducted for the City of Raymore WMP, including hydrologic, topographic, soil and land cover information. All inventory and analysis of natural resources was done in GIS format using ArcGIS and ArcHydro geospatial modeling software (ESRI, University of Texas, Austin, Geography Department, 2005). A full catalogue of map inventory factors is included in the Map Appendix and is provided in digital geodatabase format for the City for use in future planning projects.



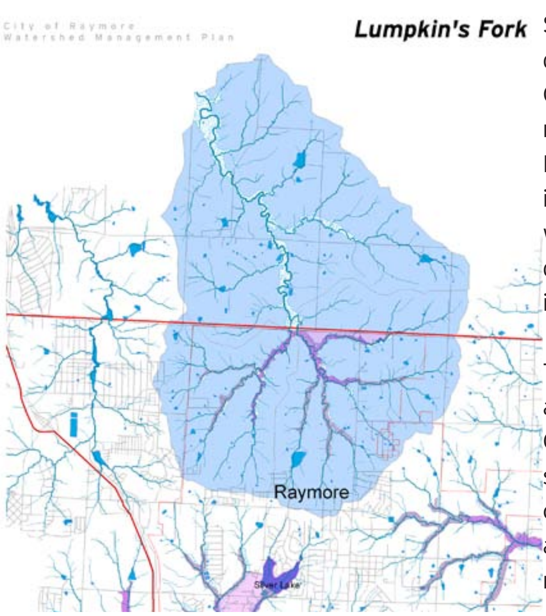
Hydrology

SUB BASINS

The regional importance of the buffer and storm water management system in Raymore is illustrated by the Five Watersheds diagram. Raymore is at the top of five watersheds which drain several sub-basins into populated centers. These sub-basins are: Lumpkin's Fork, Big Creek, East Fork of the Grand River, East Creek of the Grand River, and the Blue River. All names of sub-basins are taken from the USGS topoquads Belton, Raymore, Pleasant Hill, Peculuar, and Westline, which date from 1973 to 1993.

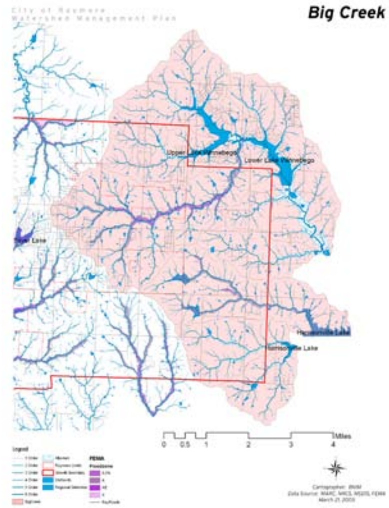
LUMPKIN'S FORK

Lumpkin's Fork, with a drainage area of 12.77 square miles, drains to the north directly into Longview Lake then down through Lee's Summit, Kansas City and into the east-flowing Missouri River at Independence. The future development of CreekMoor, will impound the flow of Lumpkin's Fork at 155th street to store surface runoff expected from the 1000 acre residential and golf course development. Attention will need to be paid to implementing BMP strategies to the existing and future developments above CreekMoor to encourage groundwater infiltration and reduce storm event peak flows.



Since the future growth boundary of Raymore is not intended to go further north than 155th street, the northward base flow from CreekMoor Lake spillway will be the lasting legacy of Raymore's runoff for northern neighbors Lee's Summit, Kansas City and Independence. Hopefully through application of the buffer system in the upper reaches of Lumpkin's Fork, BMP's, and extensive wetland vegetation in the shallow reaches of CreekMoor lake, good water quality will be achieved for CreekMoor lake which will in turn minimize pollutants and siltation of Longview

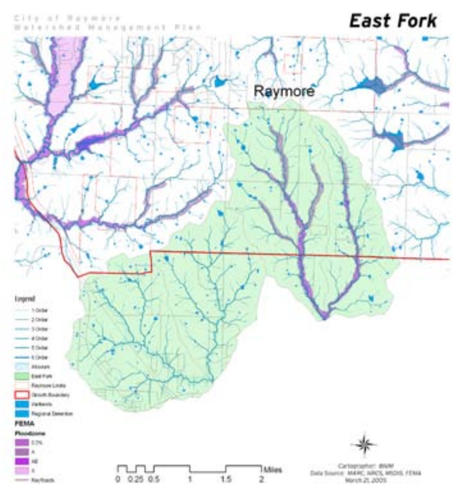
To reduce water quality impacts on CreekMoor Lake, fertilizers and herbicides/pesticides should be applied minimally on the Creekmoor golf course and on adjacent residential lots. BMP's such as bio-retention, rain gardens, bio-swales, or constructed on littoral wetlands, as presented in the BMP appendix, should be associated with each hole on the golf course to capture surface runoff, utilize excess nutrients and reduce sediment load before discharging into Creekmoor Lake. Future linkage to Creekmoor lake through the proposed greenway trail system would offer northern Raymore residents a passive recreation area.



BIG CREEK

Big Creek, the largest sub-basin in Raymore, drains the eastern half of the City. It drains 36.16 square miles and is divided into two main branches, Alexander Creek and Harrisonville City Lake tributaries. The largest tributary, Alexander Creek, drains the North East portion of Raymore into Lake Winnebego. Areas of Raymore included in this sub-basin are the historic 80-acre downtown, single family residential, and a significant amount of private agricultural land. Thus, BMP's applied to this sub-basin should be focused on filtration of agricultural runoff to maintain or improve the water quality of Lake Winnebego. As a large regional wet detention basin, Lake Winnebego is an ideal terminus for a greenway trail, as proposed by the 2004 transportation plan (Transystems / Banks, 2005). The outflow of Lake Winnebego flows into Middle Big Creek then meets Pleasant Hill at the confluence of Big Creek and Middle Big Creek.

The southern half of the Big Creek Basin flows through unnamed tributaries into Harrisonville City Lake (Lake Harrisonville). A portion of Harrisonville gets its water from this lake.



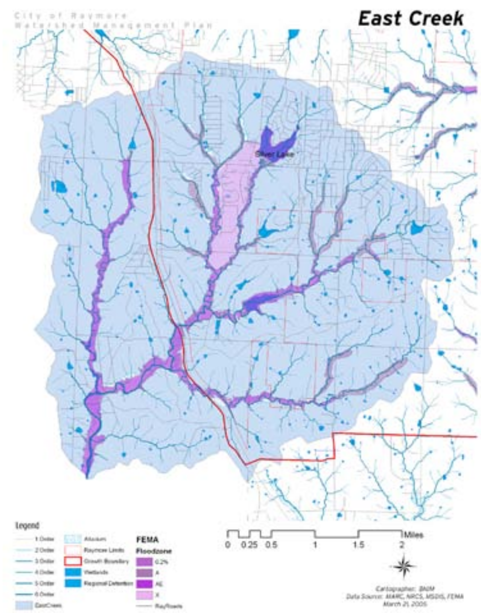
EAST FORK OF THE GRAND RIVER

The south central portion of Raymore lies within the East Fork of the Grand River. The East Fork basin is 9.98 square miles and is predominantly composed of first order upper reach streams. Currently this sub-basin is platted for single family development but is not under construction. Cover within the East Fork sub-basin is 95 percent cool season grass land and row crops (Missouri GAP Land Cover Analysis).

EAST CREEK OF THE GRAND RIVER

The southwest portion of Raymore, a basin of 17.55 square miles, is drained by the East Creek of the Grand River which confluences with the East Fork of the Grand River about 4.5 miles south of Harrisonville. Much like the other 4 sub-basins, 66% of the tributaries are first order streams and 20% of the tributaries are 2nd order streams. These streams are vulnerable to development because they are not protected by FEMA floodplain regulations and are often channelized or piped by developers to accommodate more development plats. Although engineering calculations and sub-surface piping may sufficiently accomidate peak flow quantities, they reduce the impervious cover and infiltration capacity of hydrologic networks, thus making a negative cumulative impact on watershed health, aquifer recharge, native vegetation stands and habitat, and visual aesthetics.   The land-use within the East Creek Sub-basin drains a large portion of the developed urban and suburban land in southwest Raymore. A majority of the developed land in this sub-basin is single family residential, with approximately half of the undeveloped grassland and woodland slated for development within the next 5 years.

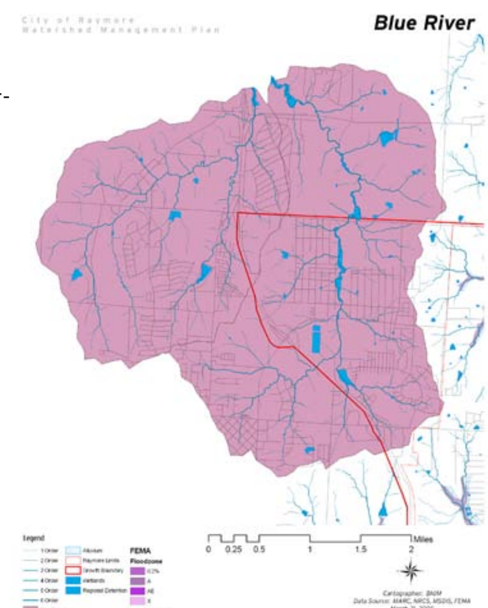
Currently a significant amount of construction is underway in the East Creek sub-basin and the consultant team's field observations showed active stream degradation and sedimentation, possibly a result of development. Thus, this sub-basin faces multiple challenges: 1) urban and suburban BMP should be retrofitted to control water quantity and quality from existing built-out conditions, 2) active enforcement and management of construction sites to minimize impacts and encroachment on riparian systems such as sedimentation and vegetation removal common in construction sites, and 3) resistance from land-owners and developers to apply the stream setback and buffer ordinance presented in this report. Developers often feel that setting aside un-buildable areas adjacent to streams as vegetated buffers will decrease the profitability of their development. It is the purpose of this guidance to provide alternative practices for the city and for developers to help maximize profitability while maintaining riparian health. It is important for land-owners and developers to understand that while the financial impacts of land development are short term and affect few people, the environmental impacts of insensitive development are long term and affect many people.



Part of the urgency of instigating a stream buffer system in the East Fork lies in understanding that much upland development did not address runoff, thus it has created downstream impacts in the lower reaches of the East Creek. When development occurs in the East Creek, the land cover will change from herbaceous vegetation to impervious surfaces such as, roofs, drives and roadways of suburban development. This change will also decrease the surface roughness of a sub-basin already exhibiting active stream bank erosion and periodic flooding, flash flooding and bank erosion. By recognizing and setting a buffer ordinance, the impacts of development can be minimized by "building in" passive storm water detention or other water quality/control BMPs.

BLUE RIVER

The upper reaches of the Blue River drains a very small portion of northwest Raymore about 11.29 square miles. Blue River sub-basin tributaries are primarily first and second order streams, but a higher percentage of 4th and 5th order streams occur here than in any other sub-basin within Raymore. Much of this is due to the past single family residential development of this area using engineered trapezoidal channels to convey stormwater. The existing undeveloped land is cool season grassland, forbs, and lowland forest. This branch joins Lumpkin's Fork at Longview Lake and flows through Kansas City



and Independence where it confluences with the Missouri River.

DETAILED STREAM LAYER CREATION

In order for a citywide buffer map to be valid, an accurate stream GIS layer is necessary to identify stream order classification, and position in the landscape. During the initial field survey it was discovered that the accuracy of the City's GIS streams layer was not sufficient and that a detailed GIS streams layer would need to be created. To develop an accurate detailed streams layer in a timely manner and without extensive stream surveys, the consultant team developed a computer model with the GIS software extension ArcHydro (UT Austin, 2004).

ArcHydro is a hydrologic modeling tool which uses satellite sensed elevation data available from the USGS to accurately delineate stream channels based upon a raster layer of surface topography. The raster layer or Digital Elevation Model (DEM) is a mosaic of 10 meter x 10 meter "tiles" or squares with each square representing a single elevation value on the surface of the earth. ArcHydro interpolates flow direction and accumulation then allows the user to set a threshold for stream definition. The stream definition threshold process is a critical part of the detailed streams layer creation as it allows the user to define the level of detail that will be reflected from the DEM; too low of a threshold will result in an unrealistic stream layer too high a threshold will result in omission of critical upland first order streams. A two-step method was developed by the consultant team to determine an appropriate threshold level.

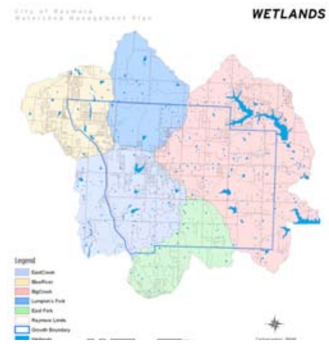
The GPS points of observed 1st order streams taken during a 2-day field data collection event and were overlaid upon sample threshold layers. The threshold layer was visually analyzed to determine if first order points taken in the field coincided with first order streams defined by the threshold layer. If the threshold level was too low, our 1st order observations on the map overlay were identified as 2nd or 3rd order streams, and the threshold level was increased. Conversely, if the threshold level was too high, our 1st order observations in the field were not identified as a stream in the threshold layer and the threshold was decreased. This process was repeated until a threshold layer was created which identified all 1st order stream field observations on the map overlay as 1st order streams.

The final threshold layer with coinciding 1st order identifications was overlaid upon a 2003 aerial image (MSDIS, 2004) to verify the accuracy of the coinciding layer within the entire study area limits. This was an important step to eliminate computer generated errors that were not confirmed as streams and to remove delineated streams in areas that clearly had been developed or experienced a change in land use. Considerable visual analysis was spent by the consultant team during this step to compare the aerial image, the threshold layer, the field collected GPS points, and the DEM to ensure that any line defined by a stream was 1) a visually identifiable riparian corridor on the 2003 aerial image, 2) a defined topographic drainage identified by the DEM, and 3) accurately intersected all of our GPS points taken in stream corridors during the 2-day field observation. If one of these conditions did not match the line was redefined or eliminated.

Using this method, the consultant team determined that there were six identifiable stream orders within the study area.

To accurately define stream orders and develop a stream setback recommendation, the above streams layer methodology is widely accepted and is considered accurate and appropriate for the purposes of this study. Should the City desire additional fluvial information about the physical and biological condition of particular reaches of streams or stream banks, the consultant team recommends conducting a detailed stream survey with a 1 ft x .5 ft x .5 ft accuracy GPS backpack, or a with a GPS linked total station survey tool.

WETLANDS

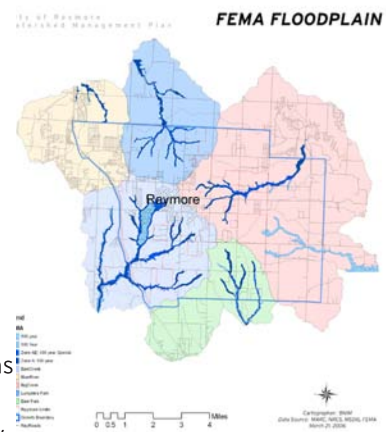


"Wetlands are areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas." —Definition of wetlands as used by the U.S. Army Corps of Engineers (USACE) and the U.S. Environmental Protection Agency (USEPA) since the 1970's for regulatory purposes.

In more common language, wetlands are areas where the frequent and prolonged presence of water at or near the soil surface drives the natural system in respects of soils, vegetation, and the fish and/or wildlife communities. Swamps, marshes, and bogs are well-recognized types of wetlands. However, many important specific wetland types have drier or more variable water systems than those familiar to the general public.

for more information contact the EPA @
http://www.epa.gov/owow/wetlands/facts/fact11.html

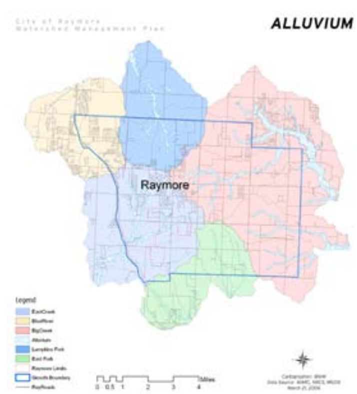
FLOODPLAIN



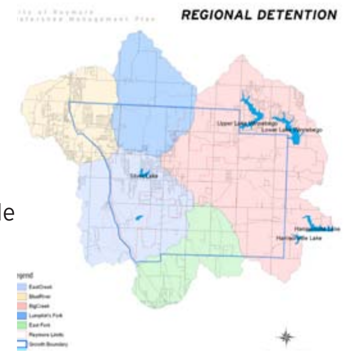
Floodplains are smooth, flat physiographic features located adjacent to streams. Floodplains are inundated during high stream flow events and act as natural storage areas for flood water. Floodplains contain areas of unique plant and wildlife communities or riparian corridors due to the close proximity of streams and their associated alluvial aquifer. Floodplains in and around the City of Raymore contain a variety of southwestern plants and animals, some northern species, but generally a well diverse vegetative riparian corridor. More than 70 percent of the area was prairie in pre-settlement times with small areas of savanna, upland and bottomland deciduous forest and marsh. Streams commonly had shallow valleys and broad floodplains with many sloughs and marshes. Today, floodplains in much of the undeveloped portions of Raymore and adjacent regions, is used for agriculture. Narrow woody riparian corridors are generally located along the streams. The widths vary, but typically extend to the first natural terrace or abandoned floodplain. The Federal Emergency Management Agency (FEMA) is responsible for determining floodplain extents to limit damage from flood events.

More information on FEMA regulations can be found at the website listed below.
http://www.fema.gov/nfip/19def2.shtm#F

ALLUVIUM



Clay, silt, sand, gravel, or similar soil material deposited in a common location by running water. The fluvially deposited sediment is typically more porous than the surrounding soil, acting as an aquifer below the stream channel. Raymore has alluvium underlain streams in Lumpkin's Fork, Big Creek, East Fork, and East Creek.



REGIONAL DETENTION

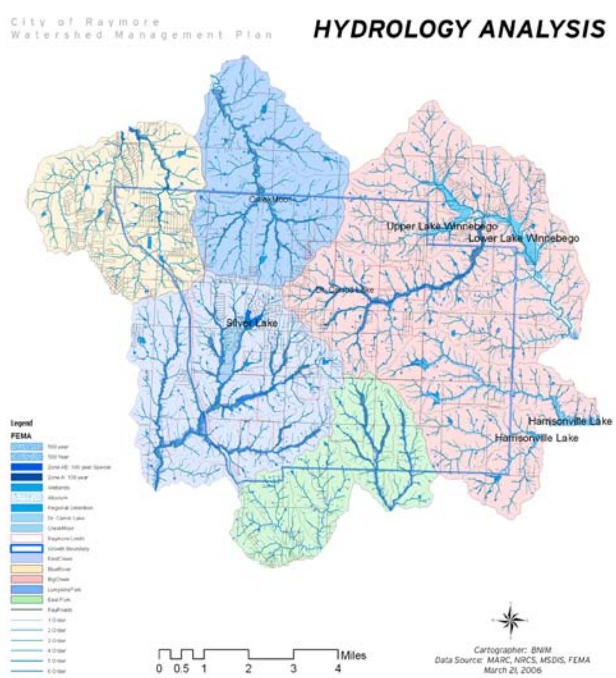
Regional detention is a way to manage stormwater runoff at a large scale. This is accomplished by wet or dry stream impoundments. There are three major wet regional detention basins located near Raymore; Lake Winnebego, Harrisonville Lake, and Silver Lake. An additional Two basins are in the planning phases; CreekMoor and a proposed development made by Dr. Carroll (a local developer), however they will not be designed for large scale regional detention.

WATER QUALITY REPORT - 2004

City of Raymore Water Source): KANSAS CITY

The Department of Natural Resources conducted an assessment of our source water to determine its susceptibility to contamination. All surface water sources are vulnerable to land use activities within their watershed. This is why all surface water in Missouri must be treated in dual treatment trains with barriers in place for potential microbiological and chemical contaminants. The assessment is a delineation of our watersheds) and an inventory of the potential contaminants found within the watersheds). The assessment of ground water sources is a three-step process of identifying an area around our wellheads), inventorying potential sources of contaminants within that area (a one-half mile radius around the wellheads)) and a look at the adequacy of well construction. The ground water assessment can be used to develop a wellhead protection program to protect this valuable resource. If you want to know more about the assessment or wish to participate on a watershed protection team to protect this valuable resource, then please call 816-513-7000 or visit:

http://www.raymore.com/index.asp?Type=B_BASIC&SEC=%7BF27BEA36-85F5-4D11-8BB1-3E76973FBD18%7D



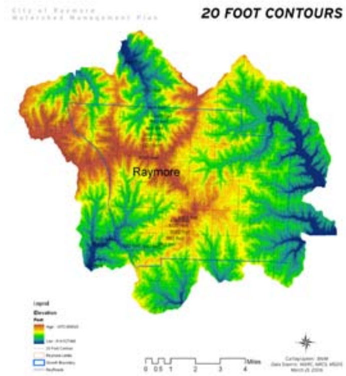
HYDROLOGY ANALYSIS

The hydrology analysis is an overlay of the FEMA designated areas, the detailed streams layer, alluvium, wetlands, and regional detention. The map graphically delineates areas that should be considered the hydrologic network of watershed drainage.

Topography

ELEVATION AND SLOPE

The City of Raymore is located within the Osage Plains Natural Division, which occupies about 8 percent of the state. The Osage Plains Natural Division is an unglaciated region in central western Missouri with an open, grassland aspect and gently rolling topography. Elevations typically range from 860 feet to 1040 feet. Slopes generally range from 0% to 78% with more than 60% of slopes below 6% and 95% of slopes below 18%..



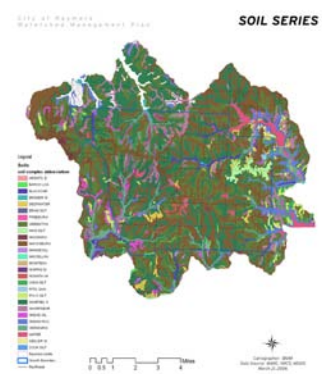
Soils

SOIL SERIES

There are twenty-seven mapped soils types that exist in Raymore. More than seventy percent of all soils in the study area are in the Greenton and Macksburg series. The Greenton series is a deep somewhat poorly drained silty loam located on uplands (US Department of Agriculture [USDA] Natural Resource Conservation Service [NRCS] 1984). The Greenton series is commonly found in areas below limestone outcrops (USDA NRCS). It is also found in areas with a slope ranging from 5 to 9 percent (USDA NRCS 1984) The Greenton series has slow permeability and is listed as a Missouri hydric soil (see Hydric Soils below). The Macksburg series is also a deep, somewhat poorly drained soil located on moderately wide to wide ridgetops (USDA NRCS 1984). It is a silt loam with slopes ranging from 2 to 5 percent (USDA NRCS 1984). Macksburg series has a moderately low permeability (USDA NRCS 1984).

SOIL TYPE

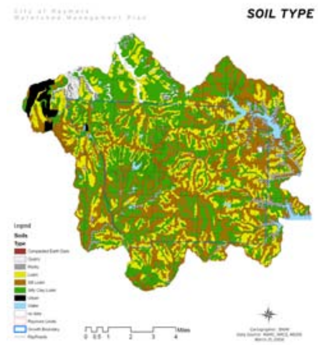
Most of the mapped soils in and around Raymore are loam, clay loam, and silty clay loam soils. Other soil types include quarry, earthen dam, urban land, and rock outcroppings. Most of these soils are well suited for row crop agriculture and pasture.



HYDRIC SOILS

Hydric soils are typically poorly drained soils that are frequently ponded or frequently flooded.. Hydric soil indicators include hisols, histic epipedons, sulfidic odor, aquatic moisture regime, reducing conditions, gleyed or low chroma colors, concretions, high organic content in the surface layer of sandy soils, organic streaking in sandy soils, and listed on the local or national hydric soils list (US Army Corps of Engineers [USCOE] 1987). Raymore has a significant percentage of potential hydric soils, mostly characterized by the Macksburg and Greenton silt loam and silty clay loams. For more information regarding hydric soils, please reference the web addresses below.

http://www.wetlands.com/regs/tlpge02e.htm
http://soils.usda.gov/use/hydric/

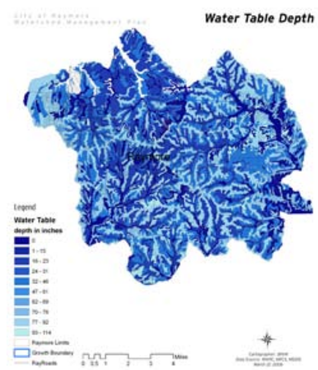


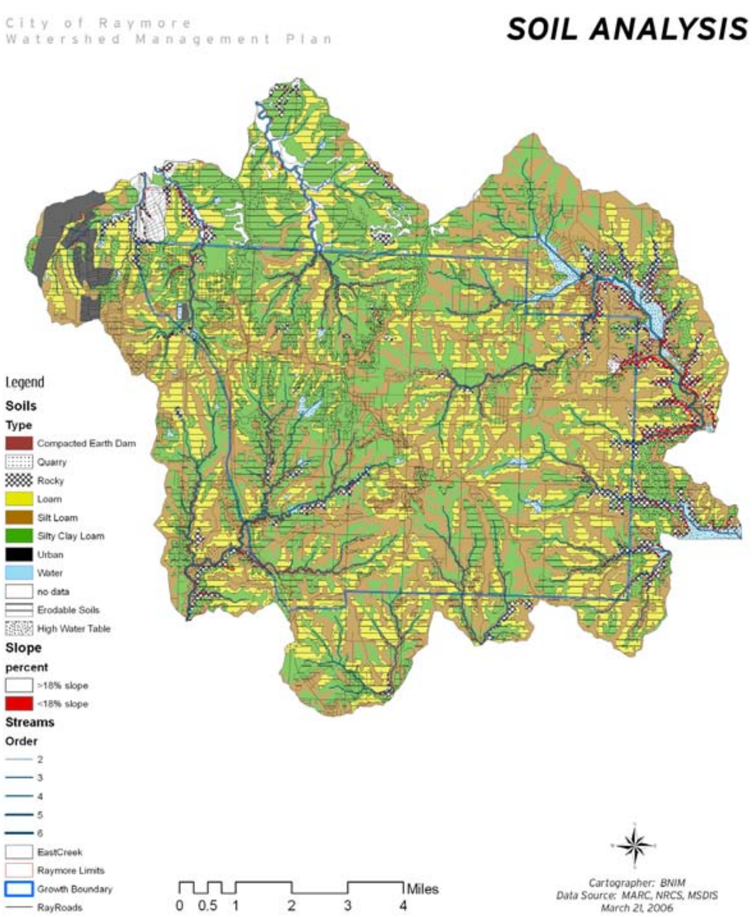
DEPTH TO WATER TABLE

The depth to water table is the depth from surface to groundwater in inches of depth. Water table depth in the study area range from 0 to 145 inches below the surface, with a majority of the low water tables being in the Greenton and Sharpsburg associations .

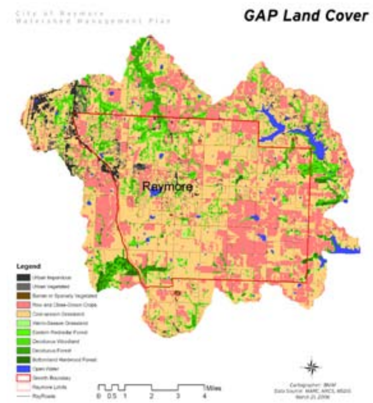
SOIL ANALYSIS

The soil analysis is an overlay of the soil types, exposed bedrock, high slopes and erodable soils to graphically delineate sensitive soils or soils which may limit development potential. Areas where the slope is greater than 18%, has a water table is close to the surface and soils are susceptible to erosion should be developed with caution.





Gap Land Cover

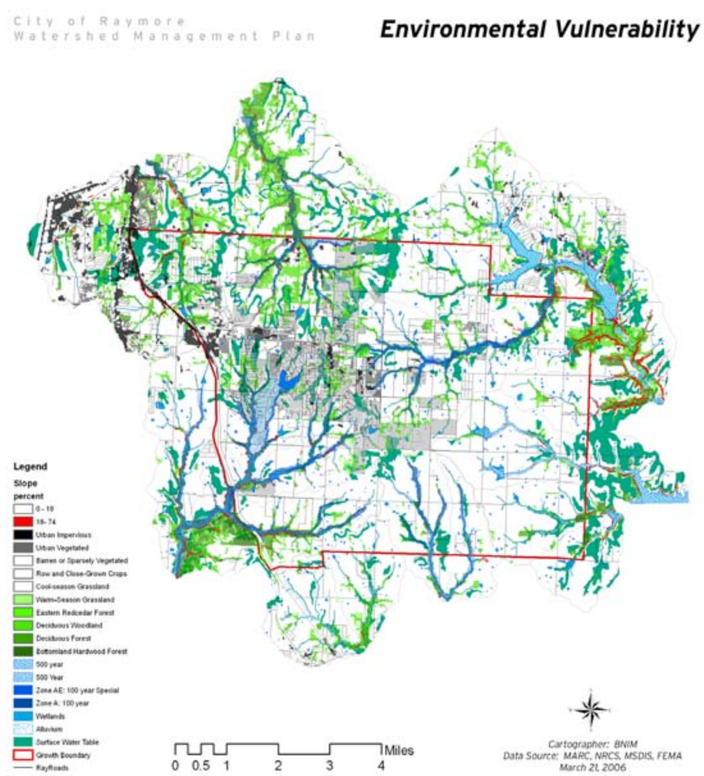


Gap analysis is a U.S. Geological Survey/Biological Resources Division (BRD) research effort being implemented across the U.S. with the help of the U.S. Fish and Wildlife Service and over 140 cooperating organizations including private business corporations, non-profit groups, universities and other government agencies. The effort seeks to identify the degree to which all native plant and animal species and natural communities are or are not represented in our present-day mix of conservation lands. Species-rich areas that are not adequately managed for the long-term maintenance of native species and natural ecosystems constitute conservation "gaps."

for more information contact the USGS @
http://gapanalysis.nbii.gov/portal/server.pt

Environmental Vulnerability Model

The composite overlay of existing native woodlands and grasslands, steep slopes, wetlands, soils with annual water table less than 12" below surface, existing development, FEMA hazard areas, streams, alluvium and open water are combined to create an environmental vulnerability model showing area where sensitive hydrologic, topographic and biologic areas overlap. The environmental vulnerable map is a composite index of vulnerable natural resources which act as an ecological matrix supporting plant and animal life and the hydrologic cycle. Preservation and integration of the ecological matrix into the built environment with riparian buffers, BMP's and high design is the fundament to ecological design or sustainable design. The environmental vulnerability map can be used as a framework to monitor and record ecological enhancement or restoration as the City grows. The environmental vulnerability map should not be limited to the shown factors, and can be used to help site future parks and to identify urban areas where BMP applications such as bioswales, pervious paving, or bioretention would be most beneficial and cost effective, site trails and roadways and they can be applied by City staff and community planners to quickly analyze land for potential improvements.



Planning Process

The planning process of developing stream buffer setbacks and a malleable BMP toolbox began in early August 2005, with a city staff meeting; continued through two educational sessions with the stakeholders and city staff in October and November; and followed up with individual stakeholder group charettes in December. This interactive planning process allowed the stakeholders and city staff to voice their concerns and identify potential problem areas within Raymore, which in turn, helped direct field data collection in December and January. The field results were tabulated and a draft setback recommendation was presented to the stakeholder group and City staff in January. To ensure appropriate format and sufficient content, the report review process benefited from a revolving peer review process of the consultant group and City staff during Feburary and March 2006.

Project Visioning

The visioning stage (or project kick-off) evaluated combinations of existing limitations and future opportunities to establish a critical foundation for the primary ideas and expectations that guided the WMP. The visioning process was conducted at Raymore City Hall August 8th, 2005, with the planning team and a handful of city staff members.

KEY STAKEHOLDERS

The primary task in the visioning process was to establish a list of key stakeholders who could aid in the development of the WMP and who would be directly affected by the plan itself. The stakeholder groups formed during this meeting were the Raymore City Council, Parks and Recreation, Planning and Zoning, South Grand River Watershed Alliance, a northern Raymore resident group, and a developer/land owner group. Each stakeholder group had at least two representatives assigned to attend regular stakeholder meetings, and in-turn were in charge of debriefing other members in the group. The City of Raymore is several steps ahead of Cass County as a whole, in developing a stream setback ordinance. Therefore, this report is considered a public document and can be provided to residents, developers, and Cass County stormwater management for their use and planning.

PROJECT DRIVERS

The visioning group discussed lessons learned from past projects, current concerns, and is attempting to anticipate future problems that the WMP would need to address. These items included: current site scale drainage issues, local retention strategies, regional detention locations and strategies, retrofitting strategies of urban areas to help minimize urban flash flooding during rain events and increase quality of urban runoff, comparing the values and function of hard engineering systems (concrete curb and gutter, piped discharge directly into streams) versus soft engineering (pervious paving, roof water collection, bio-swales, bio-retention, and use of native plantings), and increasing community awareness and education about perceived good and bad storm water practices. All of the above drivers were categorized into the four main categories of: 1. Stormwater control, 2. Urban Retrofitting, 3. Ecological Quality, 4. Education

GROWTH MANAGEMENT PLAN

The growth management plan (GMP) was the driving factor for the City in pursuing a WMP, and it is expected that the WMP will be an "appendix" to the GMP. This will supplement the direction given to storm water management in the GMP and it was expected that the WMP will consider an open space network plan and parks linkage plan and be combined with regional detention and future annexation.

Digital Data collection

Digital data collection began directly after the project visioning workshop with the City staff. All of the previous written reports, such as the Growth Management Plan, Transportation Plan, Open Space and Linkage Plan, and GIS data was gathered from the City. Once the planning team had interpreted existing City data, new research was conducted to obtain all the necessary GIS and paper map data necessary to conduct field reconnaissance and build a storm water related database. The mapping and GIS data resulting from this research is documented in the map atlas attached in this master plan appendix.

After collecting data and developing a preliminary base map, the planning team conducted an initial field survey to get familiar with the study area, to see first hand the current status of development, and verify the accuracy of geospatial base map data. Photos of riparian conditions, comments of observations, and GPS points were recorded. The notes, photos and GPS points were loaded into the geospatial database and are also documented in the appendix of this report.

Initial Stakeholder Meeting

After field verification of the geospatial data and developing a photo montage of initial field conditions for the study area, the planning team developed an educational Power Point presentation and handout for stakeholders. The presentation was given on December 16th, 2005, and the issues addressed in this power point were issues identified during the project visioning session with the City staff.

As a first step in the initial stakeholder meeting, individual stakeholders were allowed to introduce themselves and their concerns in regards to the individual groups they represented. This process resulted in an outline of broad concerns at the site, watershed, city, basin and regional scale.

The second part of the presentation was an educational session focused on the following 4 concepts:

1. Educating stakeholders about the philosophy of natural channel solutions and why the city should implement a stream buffer ordinance,

2. Values associated with traditional stormwater infrastructure and hard engineering versus bioengineering and natural channel solutions for stormwater management,

3. BMP's associated with a stream buffer ordinance and the purpose of treating riparian systems as a system or matrix, and

4. The aesthetics of buffer systems with select native vegetation.

Lastly, photo montages of our initial field reconnaisance were presented to give stakeholders a synopsis of current conditions of the study area. The photo montages were a way to convey to the citizens an overall status of their city and to present to the stakeholders images of healthy and not so healthy riparian ecosystems in a context that they would recognize. The educational session followed by local field examples proved successful, and was followed by an impromptu question and answer period.

This portion of the public participation process provided a forum for the consultant group to meet the stakeholder groups, provide some initial education about stream buffers and the benefits of native ecosystems, and paved the way for the planning team to conduct a future series of individual stakeholder charettes, in which concerns could be raised by individual groups and addressed by the planning team.

Individual Stakeholder Charettes

In order to understand the stakeholders concerns fully and to guide the planning team's two day field survey, individual meetings were held with each stakeholder group to map out their area of concern. To illustrate areas of concern in the meetings, a storm water atlas was created. The storm water atlas is a gis overlay of hydrology, topography, soils, and land cover at a 1:24000 scale that was drawn on by the stakeholders to illustrate problem areas. The six stakeholder meetings conducted were with 1) Raymore Parks and Recreation 2) Planning and Zoning 3) South Grand River Watershed Committee 4) Developers/Land-Owners 5) North Raymore Watershed Committee, and 6) Raymore City Council Representatives

The individual stakeholder interviews were conducted for one-hour sessions on Dec. 16th and 17th, 2005 at the Raymore City Hall, and were held as round table discussions. It was decided to conduct individual stakeholder group interviews to help focus discussion on specific topics important to each stakeholder group. The following lists provide a synopsis of the discussions with each stakeholder group, and is the base data that the planning team used to guide the 2-day field survey.

PARKS AND RECREATION

1. Where can new park infrastructure be located?
2. Current recreation infrastructure needs: Baseball, soccer, shelters, picnic, paved trails
3. Can recreation infrastructure successfully be installed on the proposed Goodranch park property? Is this property wet all the time?
4. Please create layers showing proposed neighborhood parks which are out of the floodway and appropriate for infrastructure.
5. Two to three more parks the size of Recreation Park are needed
6. A large park is needed in the north half of Raymore.
7. A parks master plan is needed.
8. A native grass seed bank should be part of a newly acquired park lands that cannot support recreation infrastructure.

PLANNING AND ZONING

1. Buffers are simply the price of doing business.
2. What is the dollar range of houses we REALLY want in Raymore?
3. How do we make affordable homes for young people?
4. Raymore needs an area of high density.
5. There is much emphasis on the number of building permits given each year, not on the placing and quality of those per mits.
6. The new development occurring is too expensive for current residents to afford.
7. There is a perceived desire for more single family units at a lower cost.
8. The Growth Management Plan should preserve natural features, and in P&Z' s mind, the stormwater master plan should create a natural features preservation plan as well.
9. Planned Unit Developments and Urban BMP Retrofits are a good idea if they can be economically instigated.
10. Build uplands first, protect the floodplains
11. Smart development upstream is important in protecting downstream development.
12. BMP's
    a. They are ok if done right
    b. Who maintains a BMP? – Park easement? Public? Homes association? Developers?
    c. What are the implications of BMP retrofitting (ie, if I cannot maintain my lawn which is adjacent to or within a floodplain to keep out the snakes my wife is going to get mad)
    d. There seems to be a new industry for rain gardens
    e. Can rain barrels be written into a deed?
    f. Don't just replant with grasses. Even though trees may not be historic, they are important sound and visual buf fers for those who live in smaller lot subdivisions.
    g. Short: maintenance, legality, options, cost, palette.
13. Currently by ordinance no development can occur in a floodplain.
14. City would consider smaller lots.

SOUTH GRAND RIVER WATERSHED ALLIANCE (SGRWA)

1. Purpose of South Grand
    a. Educational focus for general public
    b. Know your watershed
    c. Field trips
    d. Ideally, to educate developers and owners about water
2. Can the Raymore stormwater plan provide SGRWA with handouts educating citizens about what types of streams are here and what a healthy stream looks like versus an impacted stream?
3. Perhaps the Americore stream survey from the Soil Conservations Service (SCS) office can be of assistance with ranking priority streams.
4. Advice to give to developers / city:
    a. Consider small tributaries as streams instead of ditches when evaluating future development.
    b. All land is not flat
5. 1871 historical public record can guide land restoration
6. SGRWA is also concerned with identifying wetland s and keeping them healthy.

DEVELOPERS/LAND-OWNERS

1. Where is the line between marketability and environmental health?
2. Developers consider buffers and setback as a potential loss of project instead of selling opportunity
3. What is the middle ground for system health and development?
4. There must be caution not to create restrictions so heavy that the development in Raymore is shut down.
5. "Owning property vests one with certain rights"
6. The Good Ranch has a memorandum of understanding growth the city and several properties underway.
7. Dr. Carroll representatives desires a mechanism to measure economic impact of stream buffers

NORTH RAYMORE WATERSHED GROUP

1. 1% cent tax for parks needed
2. Propose a connection to Creekmore along riparian corridor
3. Where is regional park linkage with Cass County?..There may be a potential partner for park grant
4. What is the long term strategy for maintenance of streamway trails in a buffer? Who maintains this?

RAYMORE CITY COUNCIL REPRESENTATIVE

1. Reaction to Stormwater Mission Plan
    a. Raymore has lots of runoff
    b. "not much natural water in Raymore."
    c. Council can provide access to the 1871 land cover research from the historical society
    d. Quality of runoff a concern
2. What is the adoption process?
    a. City council will ratify the plan
    b. Many public meetings and subsequent plan refinements will be necessary for a stream buffer ordinance to be adopted.
    c. The city should not recommend, rather, they should adopt this plan.
    d. We should consider a public meeting to present the masterplan and answer questions
    e. Present the plan to the public in quadrants so not everyone has to show up at once.
    f. Voters must have a chance to review the masterplan prior to adoption...any unknown will blow down plan.
3. The east side of Raymore is where the next big boom will be.
4. What is the council's perception of smaller lots?
    a. There is a perception in Raymore that homeowners have "entitlement to acreage."
    b. The council leans toward smaller lots
    c. The city council votes for preserved buffers and cluster housing
7. Put an education survey in the water bills
    a. Simple reply survey
    b. Graphic
    c. BMP examples
    d. How important is this to the citizens (response requested)
    e. "Name the streams in Raymore."
8. All city council members voting for adoption should be required to take a tour of good vs. bad streams practices and BMP's

Stakeholder Conclusions

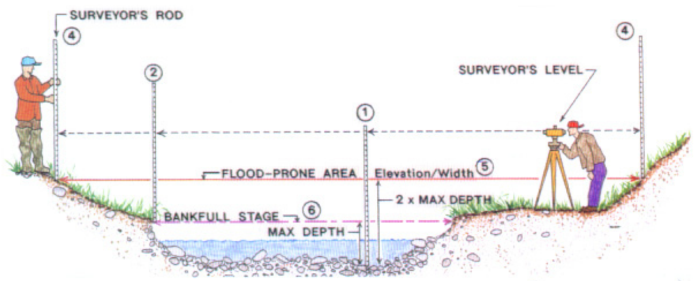
At the conclusion of the two-day stakeholder interviews, the planning team had a significant list of concerns from each stakeholder group, which in many cases overlapped programmatically and spatially. The items of community concern which were common in all groups were 1) The balance of creating sufficient buffers that didn't hinder economic development 2) Retrofitting existing infrastructure 3) Buffer ownership 4) Buffer maintenance 5) Community acceptance 6) Community education 7) "Lost land" that developers will face with instigation of a buffer plan 8) Infringement upon personal property rights of land owners 9) Local flooding related to stakeholder neighborhoods 10) Creating affordable housing price points on lots that respected the buffer and 11) Creation of park space for further recreation and infrastructure 12) Protection of small upland tributaries.

Associated with the individual stakeholder lists presented above was a field atlas in which each stakeholder had the opportunity to mark down areas where they had observed flooding and stream degradation, had concern about development, were planning development to occur, saw a need for BMP retrofit, etc. With the field atlas and the individual stakeholder concerns, the planning team was prepared to conduct a 2-day field survey aimed at inventorying buffer widths in the areas of stakeholder concern.

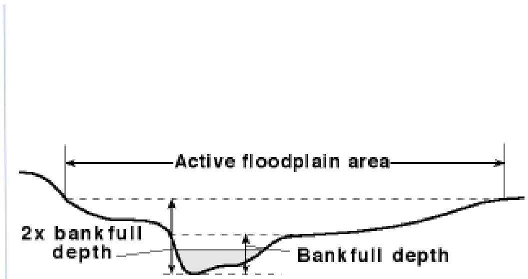
Field Data Collection

FLOOD-ZONE MEASUREMENT METHODOLOGY

As part of the WMP, a stream buffer map was created from field observations from which a setback ordinance could be developed. In the case of the Raymore WMP, the purpose of field data collection is to produce a data set of observed widths which encompass the flood-zone area and associated riparian vegetation on all stream orders, which in turn, would be representative of the entire study area.



Bankful and Flood-Prone Area (Rosgen, 1996)

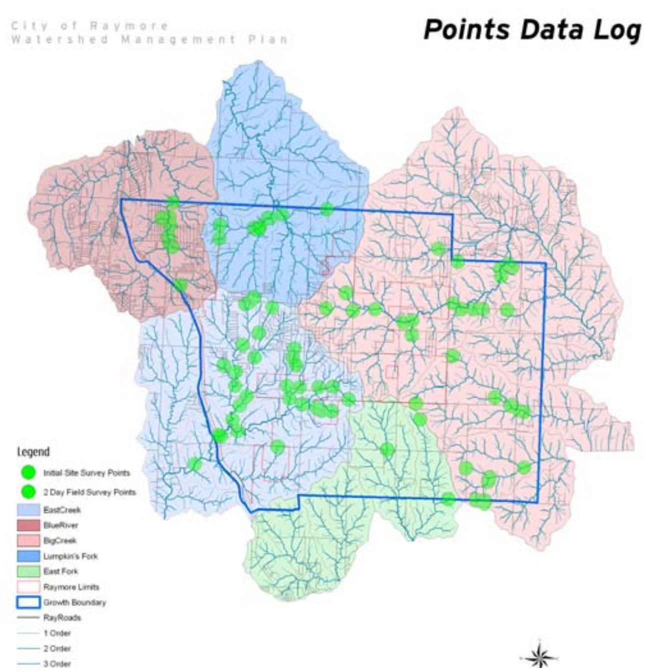


Active Floodplain Area (Rosgen, 1996)

POINTS DATA LOG

On the first day of data collection, the planning team assessed the entire study area by visually observing all the reaches in the study area. The planning team identified that much of the areas of community concern were centered around the developed suburban upland areas of Lumpkin's Fork, Big Creek, and East Creek sub-basins. However, the lowland reaches of Lumpkin's Fork, Big Creek and East Creek sub-basins, and the upland and lowland reaches of the Blue River and Grand River sub-basins would also need to be observed to develop a data set of representative upper and lower reaches of all five sub-basins. Thus, a random array of data collection points were marked on the field atlas in the lowland areas of Lumpkin's Fork, Big Creek, East Creek sub-basins, and in the upland and lowland areas of Blue River and Grand River sub-basins.

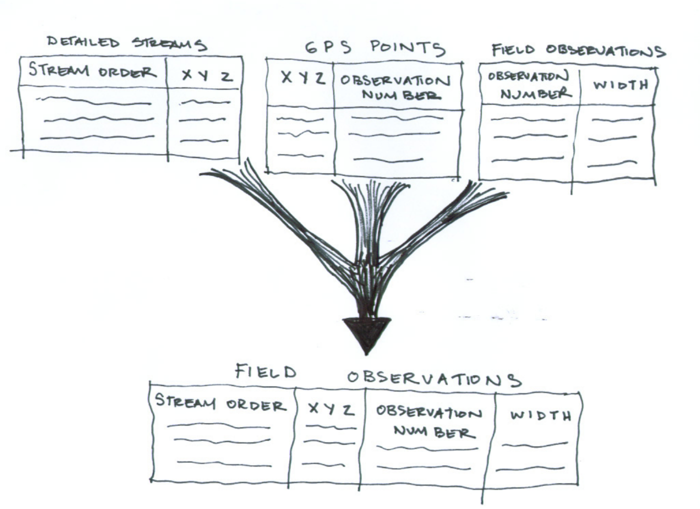
The planning team assessed the study area and collected measurements at random points. The GPS, field data log, laser range finder, and camera were utilized at each sampling location. The planning team identified an existing channel and the bankful width, then measured to the first topographic terrace on each side. A laser range finder was used to measure the distance between terraces. The measured distance was recorded as width of flood-prone area for that reach, representing the area which fills with water on an annual or bi-annual cycle during seasonal rainfalls. A GPS point was taken at each location where data was collected. Photos were taken of upstream and downstream conditions at each observation point.



FIELD OBSERVATIONS

After significant observations were recorded, the planning team transferred the stream width observations into Excel and loaded the GPS points into a GIS database. The next step was to combine the detailed streams layer (containing latitude, longitude, and elevation (X,Y,Z) and stream order information) with the GPS points (containing X, ,Y, Z and observation number information) with the field width observations (containing observation number and width information). This step was done by linking database tables in GIS and is illustrated by the below diagram. The resulting GIS point layer contained all observations of flood-prone area width, stream order classification, and the number of the observation.

The observation points layer is a very useful GIS layer, as it allows the planning team to organize all observations by stream order classification to produce a list of flood-prone area widths of 1st through 6th order streams. In turn, this layer was also used to determine the appropriate buffer width per stream order.



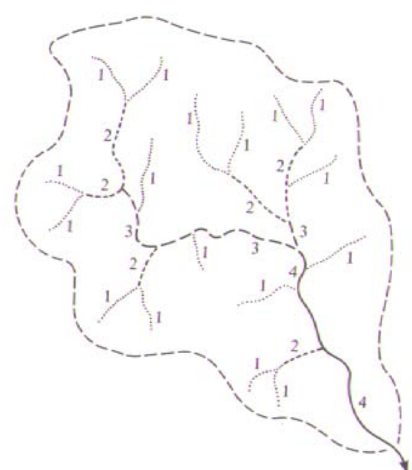
GIS Field Observations Layer Creation

FIELD OBSERVATION RESULTS

As stated above in the field measurement methods, the purpose of field data collection is to produce a representative data set of observed widths which encompass the flood-zone area and associated riparian vegetation on each stream order. Field data was collected and downloaded into a final GPS points layer with an observation ID, and flood-prone area width linked to the stream order classification where the GPS point was taken. This section presents the raw field data organized by stream order.

STREAM ORDER

The Strahler (1964) stream ordering system was used to compare size and capacity of different streams within Raymore's sub-basin systems. The smallest streams of a network, which have no tributaries, are called first-order streams. When two first order streams come together they form a second order, when two second order streams come together they form a third and so on. A low order rank stream joining a higher order stream does not change the ranking of the higher order stream. Generally, as streams increase in rank, the width, drainage area, and floodprone areas increase in size proportionally. The below adjacent diagram illustrates this concept. (Dunne and Leopold, 1999)



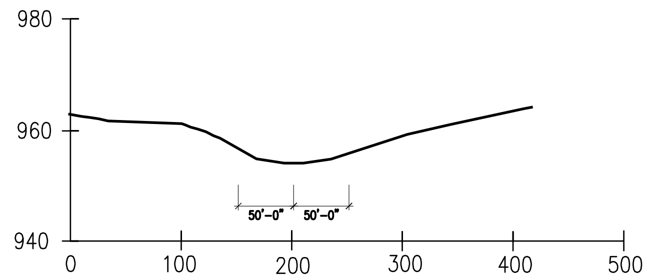
Stream Orders as proposed by Strahler 1964
(Dunne and Leopold, 1999)

First Order

The observed first order stream widths ranged from 39 to 114 feet, with the mean value of 102 feet. Seven first order stream observations were made. Typical first order stream morphology has a shallow channel with low stream banks ranging from a few inches to a few feet and may be an intermittent or ephemeral stream, meaning that the channel only flows when ground-water is charged from rainfall or during rainfall events. Typical first order vegetation consists of grasses with disbursed trees. Many of the observed first order reaches in Raymore have adjacent grazed land or agriculture.

First Order Observations

IDENT	ELEVATION	Width	order_
079	1031.00	42	1
080	981.00	81	1
087	991.00	78	1
111	0.00	60	1
112	0.00	114	1
113	0.00	39	1



First Order Stream Cross Section from Digital Elevation Model

Wooded First Order Stream Near Ward Rd and 58 Highway

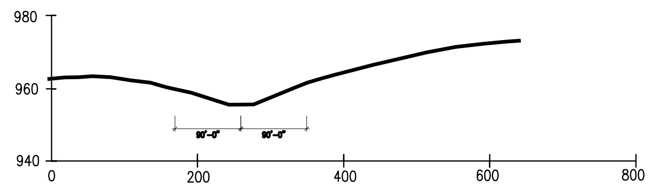
First Order Stream at Lakeshore Meadows (F)

Second Order

The observed second order stream widths ranged from 87 to 180 feet, with the mean value of 134 feet. Eight second order observations were made. Typical second order stream morphology is similar to first order morphology, with a shallow channel and lightly sloped side slopes. Many second order streams have continual base flow but may be intermittent depending on surrounding conditions and land uses. Second order streams differed from first order streams in that they typically had a small visible floodplain and more trees and vegetation than first order streams.

Second Order Observations

IDENT	ELEVATION	Width	order_
070	984.00	99	2
071	929.00	150	2
072	982.00	180	2
074	954.00	147	2
075	952.00	141	2
081	966.00	105	2
092	975.00	114	2
096	1029.00	87	2



Second Order Stream Cross Section from Digital Elevation Model

Impacted Second Order Stream in Canter Ridge with Bank Erosion (H)

Natural Form of Wooded Second Order Stream

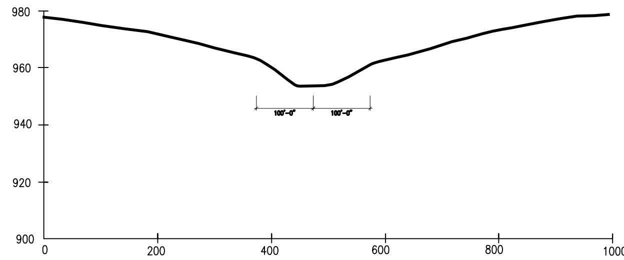
Second Order Stream At Park at Municipal Park (G)

Third Order

The observed third order stream widths ranged from 126 to 189 feet, with the mean value of 158 feet. Six third order stream observations were made. Typical third order streams have continual base flow and the morphology has a defined channel and floodplain with forested vegetation in the floodplain and on the stream banks. In some cases third order streams are wide enough to be protected under FEMA regulations.

Third Order Observations

IDENT	ELEVATION	Width	order_
073	980.00	189	3
076	995.00	126	3
078	978.00	147	3
085	970.00	168	3
100	995.00	153	3
102	1026.00	168	3



Third Order Stream Cross Section from Digital Elevation Model

Channelized Third Order Stream in Foxhaven (A)

Natural Form of Wooded Third Order Stream

Channelized Third Order Stream at Eagle Glenn. Complete Loss of Aquatic and Terrestrial Habitat. Could be Improved With Native Grasses. (C)

Pipe Outlet at Eagle Glen Without a BMP Has Caused Downcutting and Sedementation. Fescue Grass Facilitates Surface Erosion and Provides Minimal Habitat

Impacted Third Order Stream at South End of Eagle Glenn (D)

Excellent Wooded Lot Setback on Third Order Stream at Eagle Glenn. Habitat, Shade Provided. Could Be Improved With Native Grasses. (D)

Channelized Third Order Stream at Foxhaven (B)

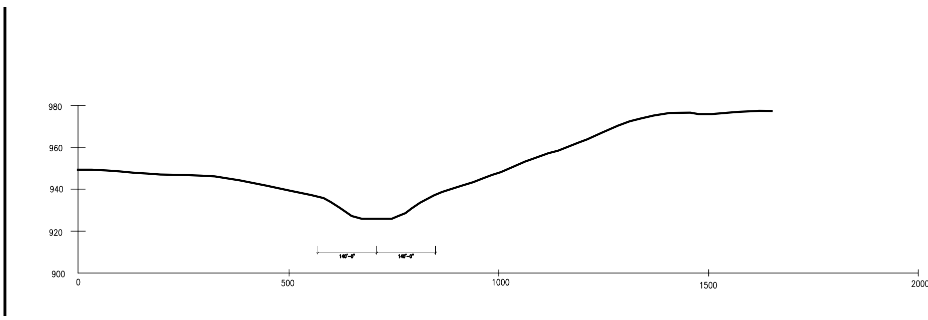
Healthy Third Order Stream at Brookside (E)

Fourth Order

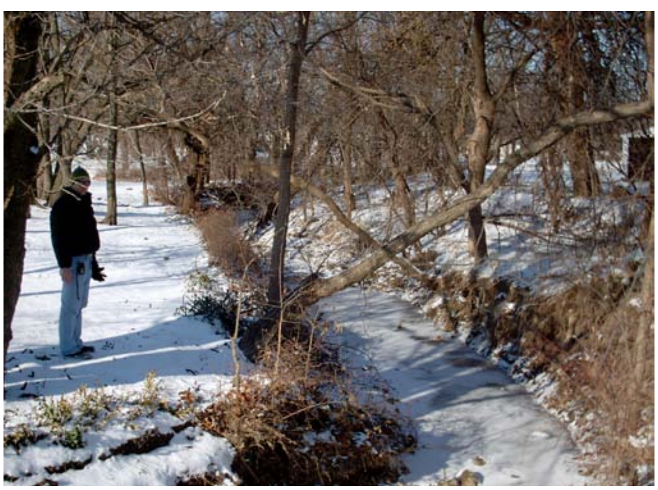
The observed fourth order stream widths ranged from 109 ft to 285 feet, with a mean value of 197 feet. Six fourth order stream observations were made. Typical fourth order streams have continual base flow, have a defined vegetated flood-plain and sideslopes, and have flood level terraces representing recurring flood stage water height. Fourth order streams are typically protected under FEMA.

Fourth Order Observations

IDENT	ALTITUDE	Width	order_
090	954.00	174	4
095	926.00	285	4
104	999.00	117	4
110	994.00	162	4
123	0.00	187	4
129	0.00	109	4



Fourth Order Stream Cross Section from Digital Elevation Model



Channelized Fourth Order Stream at 163rd and Eastern Avenue

Natural Form of Cut Bank and Point Bar of Wooded Fourth Order Stream

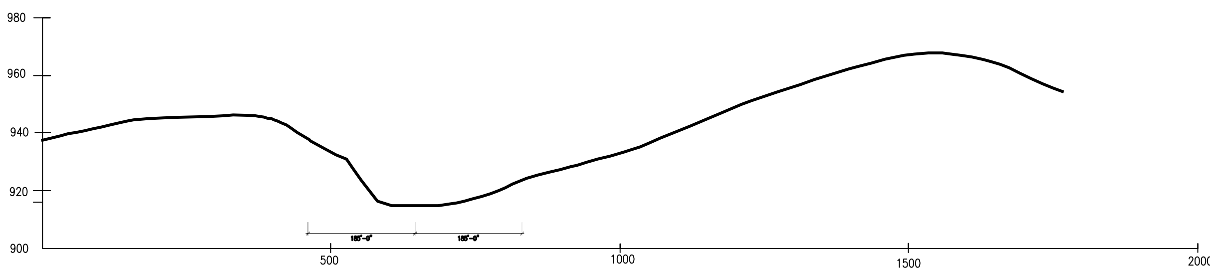
Fifth Order

The observed fifth order streams widths ranged from 139 feet to 373 feet, with a mean value of 256 feet. There were twelve fifth order observations made. Fifth order streams have continual base flow, defined vegetated floodplains, have pools and riffles, vegetated side slopes and defined multiple flood terraces. All 5th order streams observed in Raymore are protected under FEMA regulations.

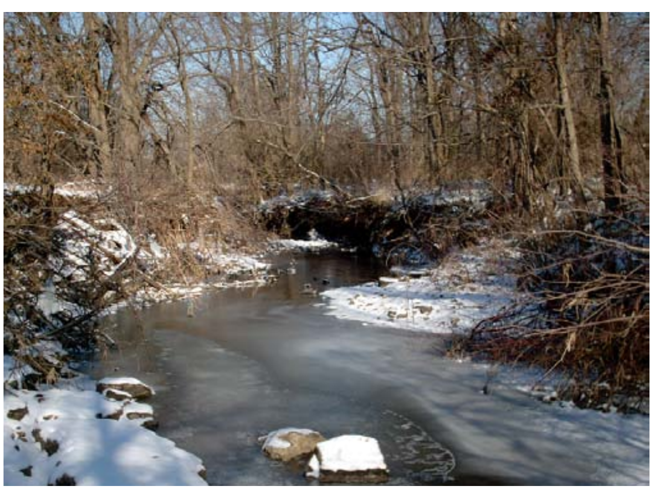
Fifth Order Observations

IDENT	ELEVATION	Width	order_
077	925.00	231	5
088	904.00	216	5
117	0.00	205	5
118	0.00	246	5
119	0.00	194	5
120	0.00	373	5
121	0.00	154	5
122	0.00	267	5
124	0.00	246	5
125	0.00	204	5
126	0.00	139	5
127	0.00	215	5

Channelized Trapezoidal Fifth Order Stream at 162nd and Valentine Rd



Fifth Order Stream Cross Section from Digital Elevation Model



Wooded Fifth Order Stream

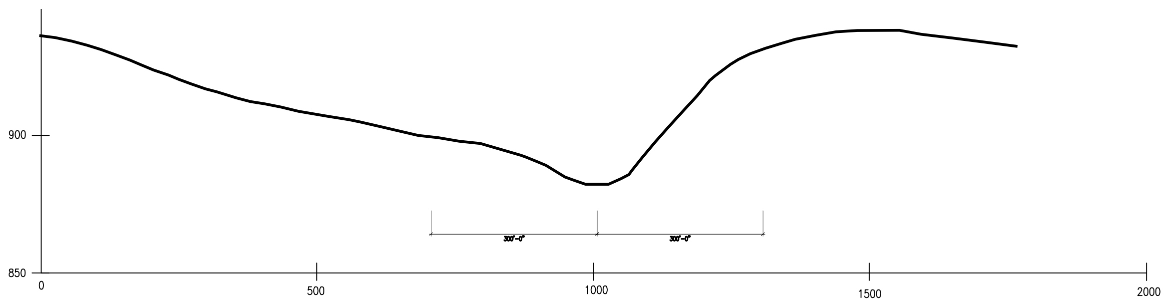
Natural Fifth Order Floodplain Form of Alexander Creek

Sixth Order

The observed 6th order stream widths ranged from 65 feet to 633 feet, with a mean value of 350 feet. Observed streams of 6th order magnitude with widths of 99 and 65 feet were culverted channels, or grassed trapezoidal channels which ran through an existing development and had been channelized to facilitate development. Widths of 633 feet or 346 feet were natural floodplain widths of channels of this magnitude. Typical 6th order streams have wide ribbons of standing water with pools and riffles, have vegetated floodplains that are well defined and wide, have defined multiple flood terraces, and are protected by FEMA.

Sixth Order Observations

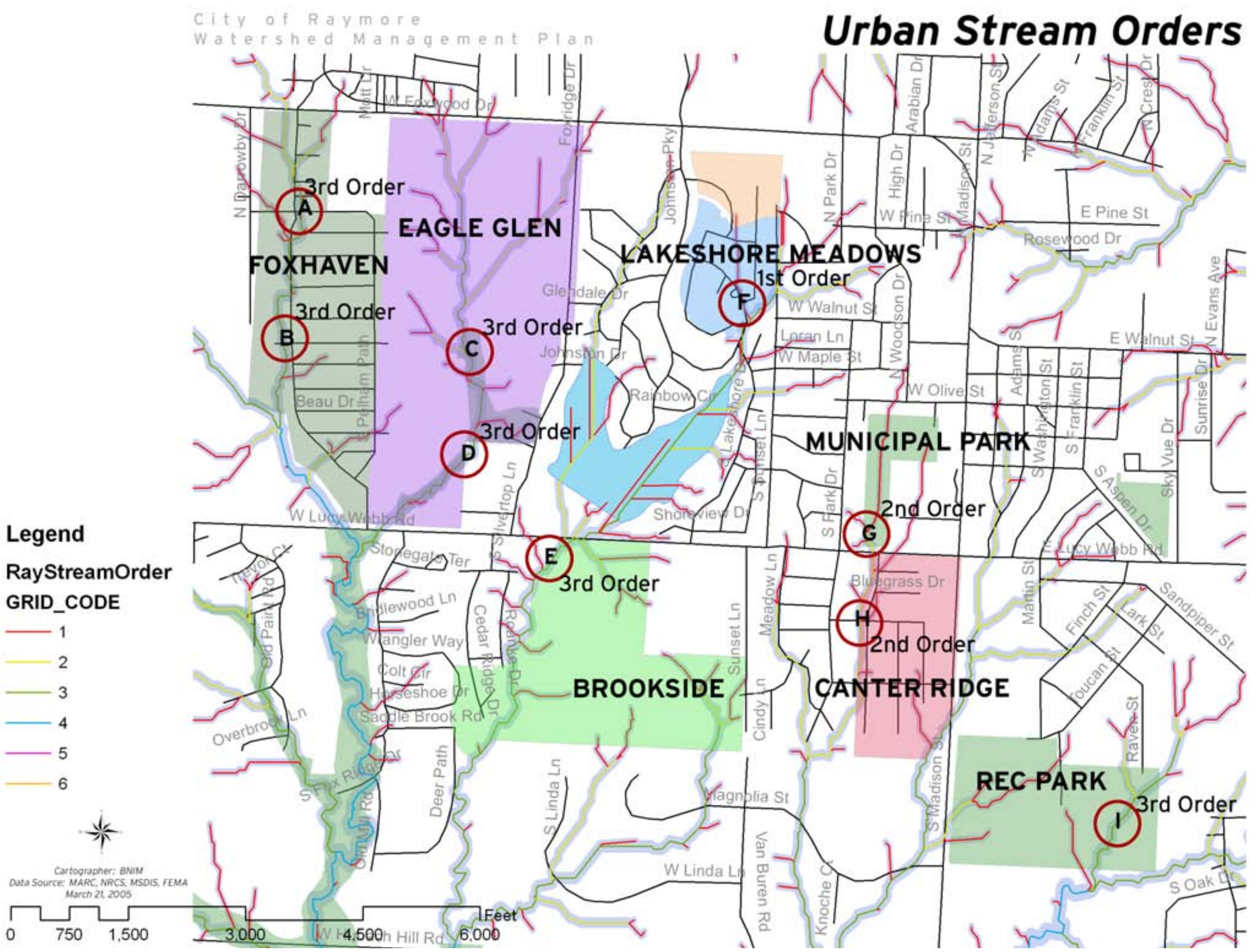
IDENT	ELEVATION	Width	order_
098	995.00	99	6
101	958.00	65	6
114	0.00	346	6
115	0.00	302	6
116	0.00	217	6
131	0.00	187	6



Sixth Order Stream Cross Section from Digital Elevation Model

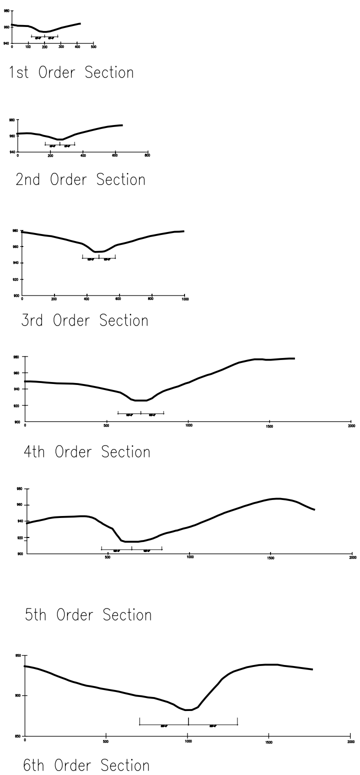
URBAN STREAM IDENTIFICATION

Based upon response from stakeholders and city staff requesting identification of several notable streams in the suburban community, the below diagram was developed. Within the subdivisions of Foxhaven, Eagle Glen, Lakehsore Meadows, Canter Ridge, Brookside and in Municipal Park and Rec Park, residents have repeatedly queried city staff about how their backyard streams would be classified under the stream order classification presented by this study. The planning team addressed this request by spending an additional day in the field and it was found that all streams in the suburbanized areas under question were 2nd or 3rd order streams, and they exhibited varying degrees of impact ranging from active stream bak erosion, as in Canter Ridge, to increased sedementation and agradation, as in Eagle Glen.

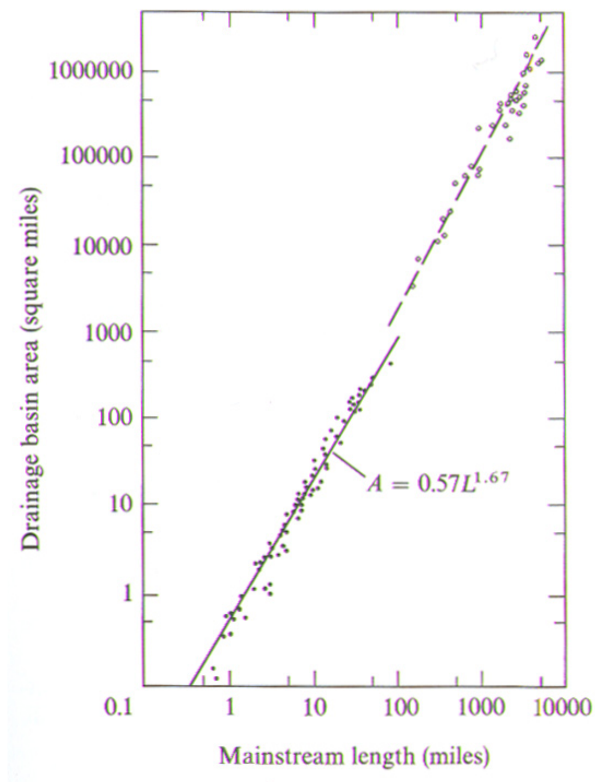


RAYMORE STREAM ORDER OBSERVATION SUMMARY

In looking at the successive width of stream order observations, an increasing linear pattern of flood-zone width was recorded. This pattern reflects other observations made by Dunne and Leopold and is shown by the below diagram representing the drainage basin size on the vertical axes and length of stream on the horizontal axis. The diagram shows that as total length of stream from headwaters to delta is observed drainage basin area increases. Increase in drainage basin area constitutes channels and flood-zone areas to handle greater water volumes, thus wider flood-zone widths and greater channel depths.



Cross Section Comparison of First to Fifth Order Streams Observed in Raymore



Graph Showing Strong Relationship Between Size of Drainga Basin Area and Stream Order, Where HIgher Values of Mainstream Length From Headwater Indicate Larger Order Streams (Dunne and Leopold, 1999)

Stream Buffer Recommendations

The following stream buffer recommendations represent observations of healthy stream corridors connected to adjacent floodplains and stable stream banks with diverse riparian vegetation. The Raymore stream buffer recommendations are widths that preserve the flood-zone area from flood terrace to flood terrace, allow sufficient filtration of surface runoff, allow development of high quality vegetation communities and trails, and provide wildlife cover and transition areas. These stream buffer recommendations are:

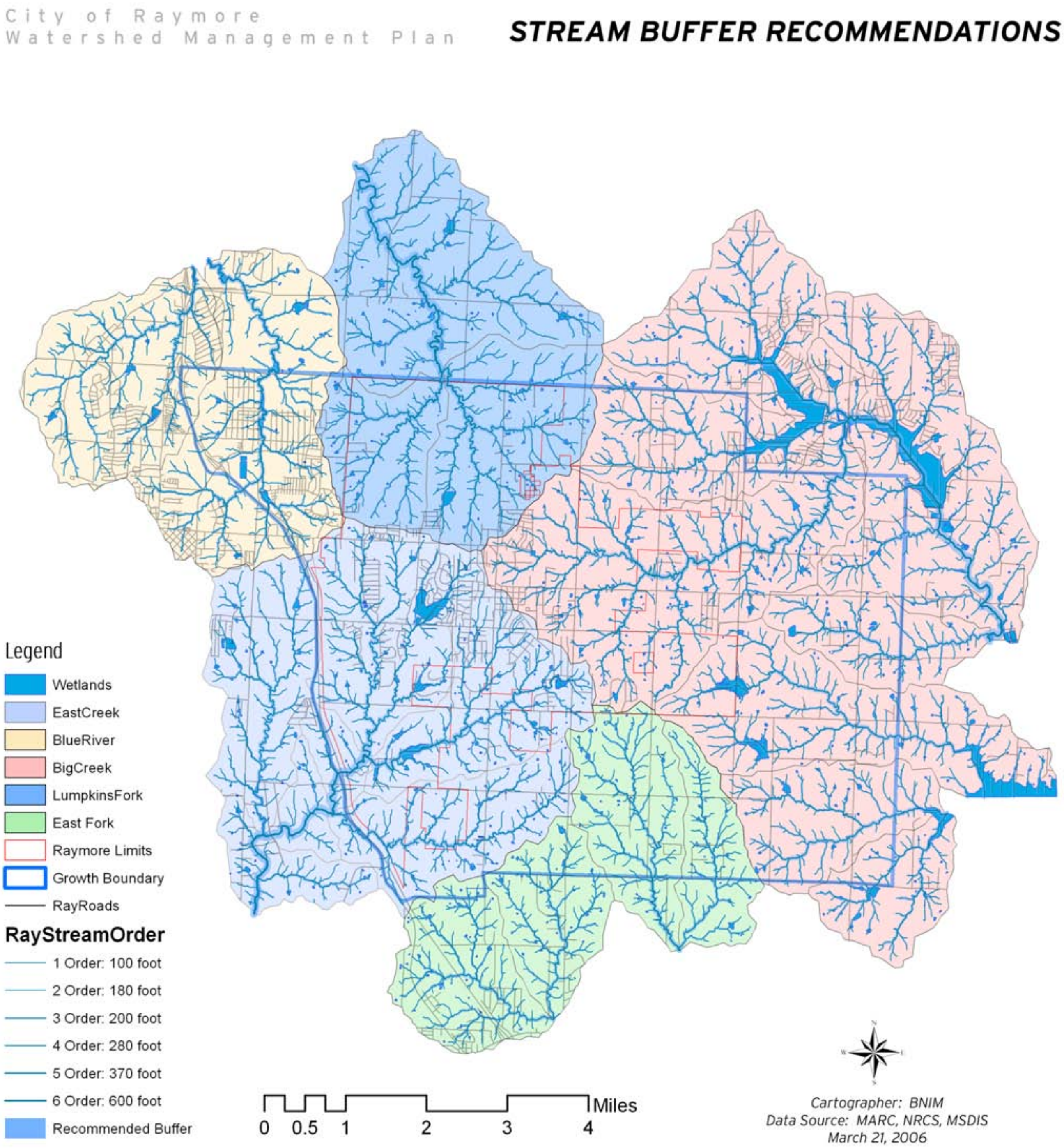
1. 1st Order: 100 foot - 50 foot per side from stream centerline
2. 2nd Order: 180 foot - 90 foot per side from stream centerline
3. 3rd Order: 200 foot or FEMA - 100 foot per side from stream centerline
4. 4th Order: 280 foot or FEMA - 140 foot per side from stream centerline
5. 5th Order: 370 foot or FEMA - 185 foot per side from stream centerline
6. 6th Order: 600 foot or FEMA - 300 foot per side from stream centerline

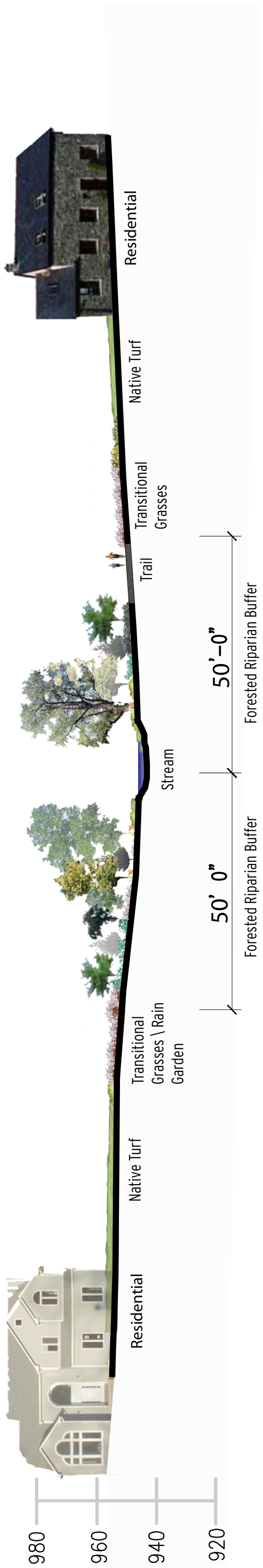
The 1st to 3rd order buffer recommendations do not significantly differ whereas the 4th to 6th order stream vary greatly. Typically our observations showed that 1st order streams with a 100 foot existing buffer had a small channel with a healthy diverse woodland and a 3rd order stream with a 200 foot existing buffer had a defined wooded floodplain with vegetated slopes up to the flood-zone terrace where riparian vegetation transitioned to a different adjacent land-use. Thus, 1st order buffer recommendations represent a healthy vegetated corridor with a small ephemeral channel, and 3rd order buffer recommendations represent a channel with base flow, floodplain, and vegetation defined by flood-zone terraces.

Fourth to 6th order buffer recommendations follow a clear linear progression definable in the field by the flood-zone terrace. In almost all cases, the planning team found that our field observations were equal to or less than the FEMA regulated width. Therefore the planning team feels that FEMA guidelines are accurate and in-line with the field method used to gather buffer recommendations. In short, the correlation with FEMA buffer recommendations in the lower order streams strengthens validity of the upper order stream observations. The Stream Buffer Recommendations are presented below.

STREAM BUFFER RECOMMENDATION SUMMARY

The numbers represented in the Stream Buffer Recommendations represent a natural gradient of stream corridor width that has been documented in other fluvial studies (see Dunne and Leopold, 1999) showing a linear gradient between riparian corridor width and volume of water conveyance, thus, both observations are in-line with accommodating the function of fluvial systems. In contrast, a constant stream buffer not responding to the natural pattern of increased flood-zone and flood water conveyence for higher order streams, may be wider than necessary for 1st order streams and not wide enough for 3rd or 4th order streams not covered under FEMA regulations. Undeniably, the stream buffer recommendations will result in a healthier riparian system for future Raymore residents, will have embedded space for greenway trails and vegetated buffers, and will provide a meaningful gradient between human and natural systems that can accommodate future growth and development.


City of Raymore
Watershed Management Plan
STREAM BUFFER RECOMMENDATIONS
Legend
Wetlands
EastCreek
BlueRiver
BigCreek
LumpkinsFork
East Fork
Raymore Limits
Growth Boundary
RayRoads
RayStreamOrder
1 Order: 100 foot
2 Order: 180 foot
3 Order: 200 foot
4 Order: 280 foot
5 Order: 370 foot
6 Order: 600 foot
Recommended Buffer
0 0.5 1 2 3 4
Miles
Cartographer: BNIM
Data Source: MARC, NRCS, MSDIS
March 21, 2006



1st Order Buffer
Raymore, Mo

5th Order Buffer
Raymore, Mo

Regional Detention Recommendations

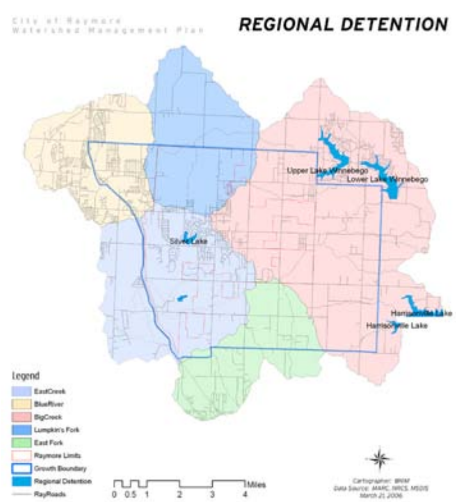
REGIONAL WET DETENTION

Regional wet detention is becoming a popular choice for stormwater management. Regional facilities are designed to intercept a volume of storm water runoff and provide storage and treatment of the runoff volume (Doll 1993). Furthermore, regional detention will reduce the peak discharge of stormwater runoff providing some level of flood protection downstream. During periods of no stormwater runoff, the detention basin maintains a permanent pool that provides multiple community uses. Regional facilities provide the optimal stormwater management for residential or low-density commercial areas (USEPA 2004a). Regional detention facilities can very in size, but generally are greater than 64 acres with some reaching as much as 600 acres (Doll 1993 and City of Round Rock, Texas 2005). Smaller lake facilities are also popular stormwater management options. These facilities are designed to manage stormwater at a sub-watershed scale and typically are less than 25 acres (City of Round Rock, Texas 2005). These facilities operate similar to large regional facilities but provide stormwater management to a smaller geographic area.

REGIONAL DETENTION DEVELOPMENT

Developing regional detention involves comprehensive watershed planning and time. First, regional facilities require a large parcel of land. Land in question will need tributary systems with enough base flow to sustain a permanent pool. The municipality must have enough authority to plan and regulate development (Maupin and Wagner 2002). Regional facilities often accommodate runoff from current landuse conditions as well as additional runoff from future watershed growth. It is essential that runoff from watershed growth does not exceed the limits of the regional facility. It is also important that local and county governments work together along with permit reviewers from state and federal agencies. Numerous state and federal agencies will review the design and impacts to environmental and cultural resources. Lack of communication will slow the permit process down.

Typically, maintenance of regional facilities is under jurisdiction of the local public entity. Local governments normally purchase land for regional detention and/or are responsible for facility maintenance (USEPA 2004a and Doll 1993). Maintenance is needed to prevent future malfunction and enhance aesthetics. Maintenance activities include mowing, inspection and repair of facility, removal of debris and litter, control of erosion, removal of accumulated sediment, and management of insects, pests, weeds, and odors (Doll 1993, USEPA 1999, and City of Knoxville 2003).



ADVANTAGES AND DISADVANTAGES OF REGIONAL DETENTION

Regional wet detention is a popular consideration because it provides advantages to on-site stormwater management. The list of advantages is referenced from Virginia Stormwater Management Program 1999, USEPA 1999a, USEPA 2004b, USEPA 2004a, Doll 1993, USEPA 1999b, Donovan 2000, and City of Knoxville 2003.

1. More efficient in managing and treating stormwater.
2. Protects larger areas which results in less dependency for on-site controls. This helps eliminate the uncer tainty of large numbers of on-site controls.
3. Can be engineered to control existing runoff as well as additional runoff from future development.
4. Lower lifetime maintenance costs and typically requires less total land when comparing to on-site control at a watershed scale.
5. Provides passive recreational amenity as well as wildlife and wetland habitat.
6. Regional facilities are effective at removing nutrients and contaminants. Suspended solids and associated pollutants are removed by gravity settling. Aquatic plants and microorganisms can provide uptake of nutrients and degradation of organic contaminants. Aquatic benches along the water fringe or littoral zones can remove additional pollutants by filtering sediment and removing some metals and nutrients through assimila tion.

With any stormwater management practice, there are some disadvantages to regional wet detention. The list summarized below references Virginia Stormwater Management Program 1999, USEPA 1991, USEPA 1999a, USEPA 2004a, Doll 1993, USEPA 1999b, and Donovan 2000.

1. Regional detention requires advanced watershed planning, necessary site feasibility, up-front financing, and time for implementation.
2. Continuous maintenance.
3. Disposal of lake sediments.
4. Poor removal of pollutants during periods of significant runoff.
5. Regional detention is a large environmental impact, especially for in-stream facilities. Such facilities will de stroy natural/predevelopment floodplains, wetlands, and stream habitat. It will also amplify a change in plant communities, block fish passage, disrupt downstream movement of food particles, eliminate species that thrive in flowing stream systems, increase water temperature, and potentially create channel instability in upstream and downstream reaches of the facility.
6. Potential for large population of nuisance waterfowl.
7. Safety hazard for people (attractive nuisance).

REGIONAL DETENTION RECOMMENDATIONS

Currently, there is one regional facility under construction with two potential locations for regional facilities to help manage the City of Raymore. In order to maximize the potential of regional detention, the City should be responsible for maintenance of these facilities and explore purchasing land for smaller sub-watershed facilities. This will allow the City to incorporate parks and greenway traill systems throughout Raymore.

In order to enhance reservoir protection, it is best to establish BMP"s above regional facilities. BMPs will decrease sediment delivery in regional facilities that will help increase the reservoir life and reduce maintenance costs. In addition to developing BMPs, encouraging low impact development above such facilities will also help sustain the usefulness of the reservoir and help manage stormwater further by slowing water down.

Ordinance Recommendations

MANAGEMENT

The riparian buffer, including wetlands and floodplains, shall be managed to enhance and maximize the unique value of these resources. Management includes specific limitations on alteration of the natural conditions of these resources. The following practices and activities are restricted within the riparian buffer, except as provided for in forest harvesting operations which are implementing a forest management plan approved by the City, Missouri Department of Natural Resources, the county forest conservancy district board, or the county soil conservation district, or as provided for in agricultural operations in accordance with a soil conservation and water quality plan approved by the county soil conservation district.

1. The existing vegetation within the riparian buffer shall not be disturbed except as provided in the permitted activities below. This includes, but is not limited to, disturbance by tree removal, shrub removal, clearing, mowing, burning, spraying, and grazing.

2. Soil disturbance shall not take place within the riparian buffer by grading, stripping of topsoil, plowing, cultivating, or other practices.

3. Filling or dumping shall not occur within the riparian buffer.

4. Except as permitted by the City, the forest buffer shall not be drained by ditching, under drains, or other drainage systems.

5. Pesticides shall not be stored, used, or applied within the riparian buffer, except for the spot spraying of noxious weeds consistent with the City maintenance ordinances.

6. Animals shall not be housed, grazed, or otherwise maintained within the riparian buffer.

7. Motorized vehicles shall not be stored or operated within the riparian buffer, except for maintenance and emergency use approved by the City.

8. Materials shall not be stored within the riparian buffer

9. If no vegetation exists within the buffer width at the time of surveying, the buffer shall be marked with silt fence and seeded with a native grass mixture.

10. During site development all riparian buffers shall be observed and none shall be disturbed. Silt fences will be placed around the buffer areas at initial surveying and no existing native vegetation shall be disturbed. At no time shall a developer be allowed to disturb area within a buffer and be allowed to replant the ascribed native plantings after the lot has been completed.

PERMITTED ACTIVITIES IN THE BUFFER

The following structures, practices, and activities are permitted in the riparian buffer, with specific design or maintenance features subject to review.

1. Roads, bridges, paths, utilities
    a. An analysis needs to be conducted to ensure that no economically feasible alternative is available

    b. The right of way should be the minimum width needed to allow for maintenance access and installation

    c. The angle of the crossing shall be perpendicular to the stream or buffer in order to minimize clearing require ments

    d. The minimum number of road crossings should be used within each subdivision, and no more than one fairway crossing is allowed for every 1,000 feed of buffer.

2. Public access facilities that must be on the water including boat ramps, docks, foot trails leading directly to the river, fishing platforms and overlooks

3. Stormwater Management

    a. An analysis needs to be conducted to ensure that no economically feasible alternative is available, and that the project is either necessary for flood control, or significantly improves the water quality or habitat in the stream.

    b. In new developments, on-site and non-structural alternatives will be preferred over larger facilities within the riparian buffer.

    c. When constructing stormwater management facilities (i.e., BMPs), the area cleared will be limited to the area required for construction, and adequate maintenance access

4. Activities to restore and enhance stream bank stability, vegetation, water quality and/or aquatic habitat, so long as native vegetation and bioengineering techniques are used.

5. Water quality monitoring and stream gauging are permitted within the forest buffer

6. Individual trees within the forest buffer may be removed which are in danger of falling, causing damage to dwellings or other structures, or causing blockage of the stream.

PROHIBITED ACTIVITIES IN THE BUFFER

1. At no time shall a pipe outlet be allowed to exit directly into a stream channel. All pipe outlets are required to exit into a sediment forebay planted with native plants. The forebay shall be designed to minimize negative impact upon stream banks during rainfall events and to help filter fertilizers, petrocarbons or pesticides/herbicides commonly associated with suburban development.

2. No non-native turf-grass may be planted in the buffer area.

VARIANCES

At a minimum, a variance request shall include the following information:

a. A site map that includes locations of all streams, wetlands, floodplain boundaries and other natural features, as determined by field survey;

b. A description of the shape, size, topography, slope, soils, vegetation and other physical characteristics of the property;

c. A detailed site plan that shows the locations of all existing and proposed structures and other impervious cover, the limits of all existing and proposed land disturbance, both inside and outside the riparian buffer and stream setback.

d. At least one alternative plan, which does not include a buffer or setback intrusion, or an explanation of why such a site plan is not possible;

e. A calculation of the total area and length of the proposed intrusion;

f. A stormwater management site plan, if applicable; and,

g. Proposed mitigation, if any, for the intrusion. If no mitigation is proposed, the request must include an explanation of why none is being proposed.

1. The buffer width may be relaxed and the buffer permitted to become narrower at some points as long as the average width of the buffer meets the minimum requirement.

2. Planning and Zoning may offer credit for additional density elsewhere on the site in compensation for the loss of developable land due to the requirements of this ordinance. This compensation may increase the total number of dwelling units on the site up to the amount permitted under the base zoning.

a. Sample Density Credit: when buffers consume more than five percent of a landowner's developable land, density credits may be granted to the landowner that allow one additional dwelling unit to be built for every five acres of his or her property affected by buffers. These density credits shall be accommodated at the develop ment site by allowing greater flexibility in setbacks, front age distances, or minimum lot sizes to squeeze in "lost lots." Cluster development may be used for this purpose.

3. The proposed land disturbing activity within the buffer may receive a permit with a mitigation plan from the United States Army Corps of Engineers (USACE) under Section 404 of the federal Water Pollution Control Act Amendment of 1972, 33 U.S.C. Section 1344.

4. A permit may be granted if the project involves the construction or repair of a structure that, by its nature, must be located within the riparian buffer. Such structures include dams and detention/retention ponds.

5. A property owner may be granted a waiver at the discretion of the planning and zoning department if he or she can demonstrate severe economic hardship or that unique circumstances make it impossible to meet some or all of the buffer requirements. Modifications to the width of the buffer may be allowed in accordance with the following criteria:

a. Modifications to the riparian buffer shall be the minimum necessary to achieve a reasonable buildable area for a principal structure and necessary utilities.

b. At no time shall any modification of buffer result in a buffer width less than the mean width per stream order:

1st order: 100 foot
2nd order: 135 foot
3rd order: 160 foot
4th order: 210 foot
5th order: 230 foot
6th order: 350 foot

c. In all cases where any reduction to buffer width is made from the recommended buffer width, a BMP should be applied from the accompanied BMP manual to mitigate water quality decreases and quantity increases that may result from the reduction of buffer.

d. Where possible, a vegetated area equal to the area encroaching upon the buffer shall be preserved or established elsewhere on the lot or parcel in a way to maximize water quality protection. The replacement patch of vegetation must be linked to the main riparian area through a vegetated corridor.

e. In no case shall the reduced portion of the buffer be less than twenty-five feet in width. If the request is denied, the owner may appeal to City council within thirty days of the denial.

6. In some cases where extensive BMP's have been applied to a site, the City may choose to relax the buffer width, therefore, a minimum buffer recommendation is provided as a variance. Minimum buffer recommendations were characterized in the field by lower quality riparian vegetation, impacted streams with adjacent land-use of grazing or intensive cropping, or upper reaches of stream orders where a channel is just beginning rather than the bottom of a stream order where the channel has widened to meet the next higher order. A narrow buffer is better than no buffer, and the minimum buffer measurements are being presented in response to developer and planning and zoning stakeholder concerns. These concerns are documented in comments 1, 3 and 4 under developer stakeholders and comments 3 and 12 under planning and zoning in the Planning Process Chapter.

In some cases, developers or land-owners may have difficulty implementing upper order buffers on 1st and 2nd order streams without decreasing some percentage of buildable area. In addition, most 4th through 6th order recommendations are covered under FEMA jurisdiction and have priority application over the recommended buffers. In this case, a recommendation is made to the City as an absolute minimum guideline to be adhered to in the case of a granted variance allowing a reduced buffer width. Since 4th through 6th order streams are covered under FEMA jurisdiction, this recommendation mainly addresses developer concerns to the extent of 1st through 3rd order buffer widths, and is a recommendation of the buffer width that could be achieved if BMP's such as rain gardens, roof collection, rain barrels, green roofs, or grey water recirculation is used for surface runoff. The Minimum Buffer Recommendations are presented below and illustrated on the follwing page.

The minimum buffer recommendations are:

1st order: 80 foot - 40 foot per side from stream centerline
2nd order: 136 foot - 68 foot per side from stream centerline
3rd order: 160 foot - 80 foot per side from stream centerline
4th order: 210 foot - 105 foot per side from stream centerline
5th order: 230 foot - 115 foot per side from stream centerline
6th order: 350 foot - 175 foot per side from stream centerline

7. A stream buffer may encroach upon a private suburban lot If the lot owner agrees to keep the portion of stream buffer vegetated with the prescribed native riparian plants. If the owner should sell their lot, the subsequent owner shall also be required to conform to above ordinance. The general vegetated conditions applying to stream buffers within private lots are:

a. No non-native turf-grass may be planted in the riparian buffer area. The City's noxious weed ordinance should be reviewed and several native turf-grasses in the native vegetation appendix should be adopted as acceptable riparian buffer turf grasses.

b. A rain garden or bio-swale must be designed with the site grading by the developer, planted with native rain gar den plantings as described in the native plants palette BMP, and up-kept by the property owner.
   1. The rain garden or bio-swale acts as a collector for sheet flow coming from lawn area and planted with plants designed to volatize excessive nutrient or herbicide loads being conveyed by fertilized non-native lawns.

c. At no time shall any buffer be reduced less than the observed mean width (above)

7. Stream buffers do not have to be equal on both sides of the stream centerline. In many cases, a stream will have an abrupt, steep bank on one side, and a gently sloping rise on the other side. If a reach of stream buffer has come into question and upon field verification by a professional landscape architect, fluvial geomorphologist, or engineer it is determined that one side of a stream bank has an abrupt incline and the other side has a gradual incline, the buffer may become asymmetrical to reflect this condition as long as the overall buffer width is not decreased. This variance will allow flexibility for developers and land owners where streams have hit bedrock and the cut bank is along exposed regolith and the point bar terrace is gradual. It is pointless to apply excessive stream buffer above a steep cut bank when more buffer is needed on the gradual point bar terrace where a stream will actually flood.

8. All plats adjacent to any stream and on hydric soils, either under FEMA jurisdiction or implemented as part of the stream setback ordinance, should be designed with a rain garden.. At the time of finished grading of the lot, the rain garden will be

graded into the lot and shall not be planted with turfgrass, rather, shall be planted with a native plant palette as described in the BMP appendix. Extensive direction on creation and maintnence of rain gardens is available from the Mid America Regional Council.

ENFORCEMENT

1. Any time a developer encroaches upon a riparian buffer without making the above modifications to the lot a fee of 10% of the final lot selling price shall be charged to developer at the time of sale for every lot in which greater than 1% of the buffer has been disturbed.

SITE DEVELOPMENT STRATEGIES

Many concerns were aired on the part of developers in regards to the "loss of land" incurred by private land owners when a riparian buffer system is applied. It is generally agreed upon by most developers that developing within the FEMA floodzone is unwise and mostly illegal, however the attitude and feasibility toward developing plats with non-FEMA regulated streams seems to be unclear at best. Here are a few strategies in regards to adapting development to cities which have recognized the importance of their riparian systems and applied a buffer ordinance.

1. Increase density of lots or build up to achieve number of units.

2. Give cost benefit analysis of standard suburban development short and long term development versus ecologi cally sensitive design of short and long term development. Where are the money sinks of both systems, and what are the investment return periods?

Best Management Practices (BMP's)

Designing stormwater systems that slowly release and treat water by filtering petrocarbons, soils, fertilizers, nutrients, and other contaminants improve the water quality and reduce downstream flooding by allowing water to infiltrate into the groundwater system. The planning team reccomends adoption of a water quality BMP manual along with a stream buffer plan, and has identified several sources that have developed stormwater BMPs. Among the recommended stormwater BMP's are gravel and pervious paving, bio-swales, sediment forebays, bio-retention, stream restoration, rain gardens, roof water collection, rain barrels and cisterns, native landscape palette. The planning team recommends a systematic approach to storm water BMP's in which multiple BMP's are designed into a system to maximize effectiveness. For full description of BMP's refer to the below documents.

1. Section 5600 – Design Criteria for Storm Drainage Systems and Facilities. Kansas City Metropolitan Chapter – American Public Works Association, November 2003.

2. Manual of Best Management Practices for Stormwater Quality. Mid-America Regional Council (MARC) and American Public Works Association. April, 2004.

PARKING, STREETS, AND ROADWAYS

GRAVEL PARKING AND PERVIOUS PAVING

Underground detention could be applied to all parking lots and side-street parking. Gravel parking should be designed to infiltrate water and temporarily store water below the surface so as to reduce or eliminate runoff and allow the surface to be used for parking or pedestrian traffic. Gravel lots should have perforated drain pipes to allow excessive water to flow into vegetated swales or bio-retention cells. Many prefabricated honeycomb support systems, such as the gravelpave system, exist to increase the bearing capacity of pervious parking lots.

BIO-SWALES

Bio-swales are very effective stormwater strategies, designed to immediately intercept roadway pollutants and manage runoff quantity and quality. Typical curb and gutter roadways comprise the majority of infrastructure development costs and practically eliminate on-site infiltration. Whenever possible, roads should be designed without curbs or with curb-cuts, so runoff is allowed to flow off the roadway and into a linear detention system for infiltration. The resulting increase in landscape buffer, animal habitat, and reduction in development costs is significant. Bio-swales should also be employed in the landscape to convey water off site instead of piping runoff.

SEDIMENT FOREBAY

A sediment forebay is a BMP applied to the outlet of subsurface piping. Typical unregulated pipes exit into stream channels and dump loads of unchecked petroleum, fertilizers, debris, and sediment directly into streams at velocities great enough to begin a process of stream bank erosion that is difficult and costly to stop. A sediment forebay is located at the outer edge of a riparian buffer and is a depression planted with native plants which serve to bind soil with deep roots and assimilate excess nutrients.

OPEN SPACE

BIO-RETENTION

Bio-retention facilities are topographic depressions designed to retain the quantity of water from 1.5" precipitation event and slowly release the water through soil infiltration and should be utilized as site-scale detention whenever possible. As the water is retained, wet-mesic plants utilize a portion of the water. As the water infiltrates through the porous mix of bio-retention soil, contaminates and nutrients are left behind for future plant uptake and volatizing. Bio-retention can be placed in sun or shade.

STREAM RESTORATION

If significant open space exists above and adjacent to degraded underground piped stormwater systems, stream restoration or "daylighting could be explored. A stream restoration is a multi-phased ecological assessment and restoration approach to develop a naturalized stream channel and flood way —to convey and infiltrate stormwater without hard-engineering prectices. Restored streams enhance water quality, decrease water velocity, provide habitat, and increase adjacent property values.

BUILDING LANDSCAPE AND ROOFS

RAIN GARDEN

Rain gardens are small versions of bio-retention cells aimed at capturing roof runoff from downspouts or small quantities of concentrated overland flow, and should be applied whenever possible. Rain gardens should be planted with diverse flowering mesic plants that can tolerate wet and dry conditions. Rain gardens can be excellent landscape amenities for full sun or shade. Rain gardens reduce the load of bio-retention cells and regional detention basins and increase water quality with native plants one lot at a time.

ROOF

Roof water harvesting should be employed when economically and spatially possible. Many systems can be developed to harvest water from roofs including: rain barrels at downspouts, underground or above ground cisterns/silos, or grey-water systems feeding back into the building. When rain water is stored vertically above ground, as in the case of a silo, water head pressure can be utilized to attach a water valve with hose for landscape watering and other multi-purpose uses. Stormwater from roofs should not be piped into the storm sewer.

RAIN BARRELS / CISTERNS

Rain barrels and cisterns are water storage components designed to collect water from almost any surface for storage and reuse as landscape watering, greywater, or slow return to the water table. Rain barrels are typically designed to capture roof water from downspots and can be appied in urban or suburban situations. Cisterns are typically large above ground or underground containers to capture higer volumes of water from larger surfaces.

NATIVE PLANT PALETTE

Native plants should be utilized for all residential, open space, stream buffers, and street trees. Native plants are unique and adapted to their climates, requiring no irrigation beyond establishment. Raymore is situated on the border between a the eastern deciduous forest and the tall grass prairie and has many native grassland and woodland species. A matrix of grassland and woodland species for the upland oak hickory forest and tall grass prairie, and their uses for stream buffers, rain gardens, grassland and woodland restorations, bioretention basins, butterfly gardens, and bioswales are included.

OVERALL SYSTEMATICS

Storm water systems should be thought of as components that flow from one to the other, resulting in multiple cleanings, polishings, and infiltration steps as water flows from rain to river. Storm water systems should be deigned to include native grasses, shrubs, trees, and aquatic vegetation, whenever possible, to ensure the filtration of the varied chemicals that runoff streets and lawns. Whenever possible, a continuous matrix of corridors and patches should be preserved/developed to treat and convey storm water.

"..the matrix is the most extensive and most connected landscape element type, and therefore plays the dominant role in the functioning of the landscape (Forman and Godron, Landscape Ecology, 1986)

Recommended Planting Palette

Latin Name	**Common Name**	***Tall Grs***	**Mxd Grs**	**Wtlnd**	**Wldf Mix**	**Bttrfly Mix**	**Rain Grdn**
Achellea millefolium	Wolly Yarrow	x	x	x		x	
Allium canadense	Wild Garlic	x					x
Amorpha canescens	Leadplant	x	x		x	x	
Andropogon gerardii	Big Bluestem	x	x				x
Anemone canadensis	Meadow Anemone	x					x
Anemone cylindrica	Candle Anemone	x	x				
Antennaria neglecta	Field Pussytoes	x	x				
Apocynum cannibinum	Hemp Dogbane	x					
Artemisia ludoviciana	White Sage	x	x				
Asclepias incarnata	Swamp Milkweed			x		x	x
Asclepias speciosa	Showy Milkweed					x	x
Asclepias stenophylla	Narrowleaf Milkweed	x	x				
Asclepias sullivantii	Prairie Milkweed					x	x
Asclepias syriaca	Common Milkweed	x				x	
Asclepias tuberosa spp. Interior	Butterfly Weed	x				x	
Asclepias veridiflora	Short Green Milkweed	x	x				
Asclepias verticillata	Whorled Milkweed	x	x			x	
Asclepias viridis	Spider Milkweed	x	x				
Astragalus canadensis	Canada Milkveatch	x			x		
Astragalus crassicarpus	Ground-plum	x	x				
Baptisia bracteata	Plains Wild Indigo	x					
Blue Joint	Calamagrostis canadensis						x
Bouteloua curtipendula	Side-oats Grama	x	x		x		
Bouteloua gracilis	Blue Grama		x				
Brickellia eupatorioides	False Boneset	x					
Callirhoe alcaeoides	Pale Poppy Mallow	x					
Calylophus serrulatus	Plains Yellow-primrose	x	x			x	
Carex bicknellii	Bicknell's Sedge	x					
Carex brevior	Short-break Sedge	x	x	x	x		x
Carex gravida	Heavy Sedge			x			
Carex heliohpila	Sun Sedge		x				
Carex pellita	Wolly Sedge			x			x
Carex stipata	Sawbreak Sedge						x
Carex vulpinoidea	Fox sedge			x			x
Ceanothus herbaceus	Redroot New Jersey Tea	x					
Chamaecrista fasciculata	partridge Pea	x			x		
Cirsium undulatum	Wavy-leaved Thistle		x				
Cleome serrulata	Rocky Mountain Bee Plant					x	
Comandra umbellata	Bastard Toadflax	x	x				
Coreopsis tinctoria	Golden Coreopsis			x			
Dalea candida	White Prairie-clover	x	x		x	x	
Dalea purpurea	Purple Prairie-clover	x	x		x	x	
Delphinium carolinianum	Prairie Larkspur	x					
Desmanthus illinoensis	Illinois Bundleflower				x		x
Desmodium canadense	Canada Tick-clover	x			x		x
Desmodium illinoense	Illinois Tick-Clover	x			x		
Echinacea angustifolia	Purple coneflower	x	x			x	
Eleocharis erythropoda	Bald Spikerush						x
Elymus canadensis	Canada Wildrye	x			x		x

Planting Palette Cont.

Latin Name	**Common Name**	***Tall Grs***	**Mxd Grs**	**Wtlnd**	**Wldf Mix**	**Bttrfly Mix**	**Rain Grdn**
Elymus smithii	Western Wheatgrass		x	x	x		x
Elymus trachycaulus	Slender Wheatgrass				x		x
Elymus Virginicus	Virginia Wildrye			x	x		x
Epilobium coloratum	Cinnamon Willow Herb						x
Eupatorium altissimum	Tall Boneset					x	
Eupatorium maculatum	Spotted Joe Pye Weed						x
Eupatorium Perfoliatum	Common Boneset						x
Euphorbia corolallata	Flowering Spurge	*x*					
Gaura coccinea	Scarlet Gaura		x				
Gaura mollis	Small-flowered Gaura	*x*	x				
Gentiana puberulenta	Downy Gentian	*x*					
Glycyrrhiza lepidota	Wild Licorice				x		x
Helianthus grosseserratus	Sawtooth Sunflower				x		x
Helianthus maximilianii	Maximillian Sunflower	*x*	x		x		x
Helianthus pauciflorus	Stiff Sunflower	*x*	x		x		
Heliopsis helianthoides	False Sunflower	*x*					x
Hesperostipa spartea	Porcupine Grass	*x*					
Hesperostipa spartea	Porcupine Grass				x		
Hieraicum longipilum	Longbeard Hawkweed	*x*					
Juncus interior	Inland Rush	*x*	x				
Juncus torreyi	Torrey's Rush						x
Koeleria macrantha	Junegrass	*x*	x		x		
Leersia oryzoides	Rice Cutgrass			x			
Lespedeza capitata	Round-head Bush-Clover	*x*	x		x	x	
Liatris aspera	Rough Gayfeather	*x*				x	
Liatris punctata	Dotted Gayfeather	*x*	x			x	
Liatris pychnostachya	Thickspike Gayfeather					x	
Liatrus lancifolia	Lanceleaf Gayfeather						x
Linum sulcatum	Grooved Yellow Flax	*x*					
Lobelia cardinalis	Cardinal Flower					x	
Lobelia siphilitica	Great Blue Lobelia					x	
Lotus unifoliolatus	Prairie Trefoil	*x*	x		x		
Mentha arvensis	Field Mint						x
Mimosa quadrivalvis	Sensitive Briar		x				
Mirabilis nyctaginea	Wild Four-o'clock	*x*					
Monarda fistulosa	Wild Bergamot	*x*			x	x	
Muhlenbvergia cuspidata	Plains Muhly		x				
Northern Reedgrass	Calamagrostis stricta						x
Oenothera villosa	Common Evening Primrose	*x*			*x*	x	
Onosmodium molle	False Gromwell	*x*					
Oxalis violacae	Violet Wood Sorrel	*x*					
Oxytropis lambertii	Purple Locoweed		x				
Panicum oligosanthes	Scribner's Spring Panicum	*x*	x				
Panicum virgatum	Switchgrass	*x*		x	*x*		x
Pediomelum argophyllum	Silver-leaf Scurf Pea	*x*	x				
Pediomelum esculentum	Prairie Turnip	*x*	x				
Penstemon digitalis	Foxglove Penstemon					x	x
Penstemon grandiflorus	Shell-leaf Penstemon	*x*	x			x	
Phlox pilosa spp. Fulgida	Prairie Phlox	*x*				x	
Poa arida	Plains Bluegrass			x			

Planting Palette Cont.

Latin Name	**Common Name**	***Tall Grs***	**Mxd Grs**	**Wtlnd**	**Wldf Mix**	**Bttrfly Mix**	**Rain Grdn**
Psoralidium tenuiflorum	Slender-flower Scurfpea	x	x		x		
Ratbida columnifera	Upright Prairie Coneflower	x	x			x	
Rosa arkansana	Dwarf Prairie Rose	x	x		x		
Rudbeckia hirta	Black-eyed Susan	x					
Rudbeckia hirta	Black-eyed Susan					x	x
Rudbeckia laciniata	Golden-glow						x
Salvia azurea	Pitcher's sage					x	
Salvia spp.	White Sage	x	x				x
Schizachyrium scoparium	Little Bluestem	x	x		x		x
Scutellaria galericulata	Marsh Skullcap						x
Senecio plattensis	Prairie Ragwort	x	x				
Silphium integrifolium	Rosinweed	x			x	x	x
Silphium laciniatum	Compass-plant	x			x	x	x
Sisyrinchium campestre	Prairie Blue-eyed Grass	x					
Solidago canadensis	Canada Goldenrod	x					x
Solidago gigantea	Late Goldenrod	x					x
Solidago missouriensis	Missouri Goldenrod	x	x			x	
Solidago rigida	Stiff Goldenrod	x				x	
Sorghastrum nutans	Indiangrass	x	x		x		x
Spartina pectinata	Prairie Cordgrass			x			x
Sphenopholis obtusata	Prairie Wedgegrass	x					
Sporobolus compositus	Tall Dropseed	x	x				
Sporobolus heterolepis	Prairie Dropseed	x					
Helianthus pauciflorous	Stiff Sunflower					x	
Symphyotrichum ericoides	Heath Aster	x		x		x	
Symphyotrichum laeve	Smooth Blue Aster	x				x	
Symphyotrichum lanceolatum	Panicled Aster			x		x	x
Symphyotrichum Novae-angliae	New England Aster					x	x
Symphyotrichum oblongifolium	Aromatic Aster		x			x	
Teucrium canadense	American Germander	x					
Thalictrum dasycarpum	Purple Meadow Rue						x
Thalicturm dasycarpum	Purple Meadow Rue	x					
Tradescantia bracteata	Long-bracted Spiderwort	x	x				
Verbena hastata	Blue Vervain						x
Vernonia baldwinii	Western Ironweed	x				x	x
Viola Pedatifida	Prairie Violet	x					
Zizia aurea	Golden Alexander	x					

Planting Palette Cont.

Latin Name	**Common Name**	**Woodland**		**Riparian**	
		Understory	*Canopy*	*Understrory*	*Canopy*
Cercis canadensis	Redbud	x			x
Cornus drumondiif	Roughleaf Dogwood	x			x
Symphoricarpos orbiculatus	Coralberry	x		x	
Sambucus canadensis	Elderberry	x		x	
Asimina triloba	PawPaw	x			x
Ribes missouriense	Missouri Gooseberry	x		x	
Parthencissus quinquefolia	Virginia Creeper	x		x	
Euonymus fortunii	Wintercreeper Euonymus	x		x	
Euonymus purpurea	Burning Bush	x			
Rosa arkansana	Prairie rose	x			
Platinus occidentalis	Sycamore		x		
Celtis occendentalis	Hackberry		x		
Fraxinus pennsylvania	Green Ash		x		
Quercus macrocarpa	Bur Oak		x		
Juglans nigra	Black Walnut		x		
Carya ovata	Shagbark hickort		x		
Acer saccharinum	Silver Maple		x		x
Quercus palustris	Pin Oak		x		
Vitis riparia	River-bank Grape			x	
Ostrya virginiana	Eastern Hophornbeam				x
Betula Nigra	River Birch				x

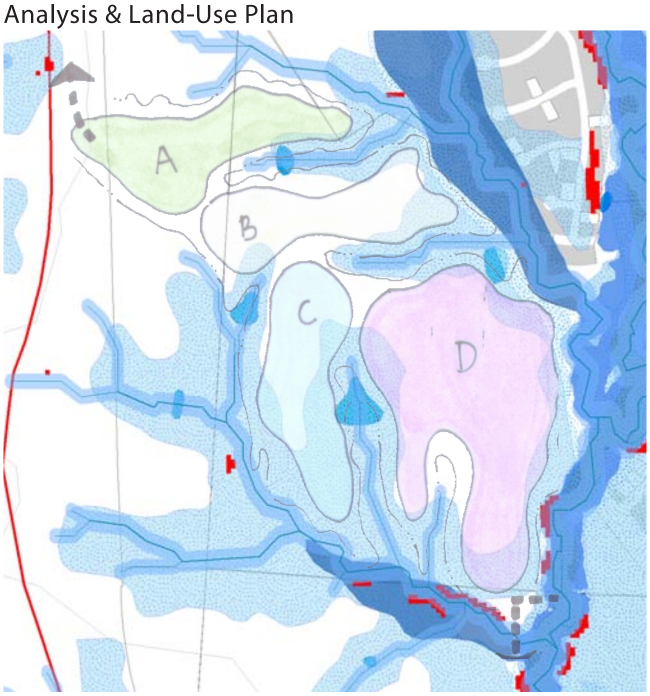
(Steinauer, 2003) (Dirr, 1998) (Kindscher, 1987) (Stephens, 1969)

Ecological Design Templates

Low Density Residential

Low density residential land-use of 3 lots per acre or less can be sited to achieve lot densities favorable for the developer's bottom line and responsive to the environment. Respecting stream corridors in initial land-use plans creates distinct nodes of development, as shown below by the zones marked A,B,C and D. Roadways are sighted on ridgelines and along contours to minimize earthwork. Lots abutting a stream corridor have native vegetation and rain gardens.

Analysis & Land-Use Plan



Lot Layout Design

LEGEND

125' x 175' Lot

Green Space

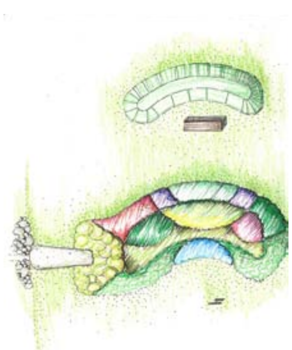
Wooded Lot

Stream Buffer

Recommended Best Management Practices

Rain Barrel

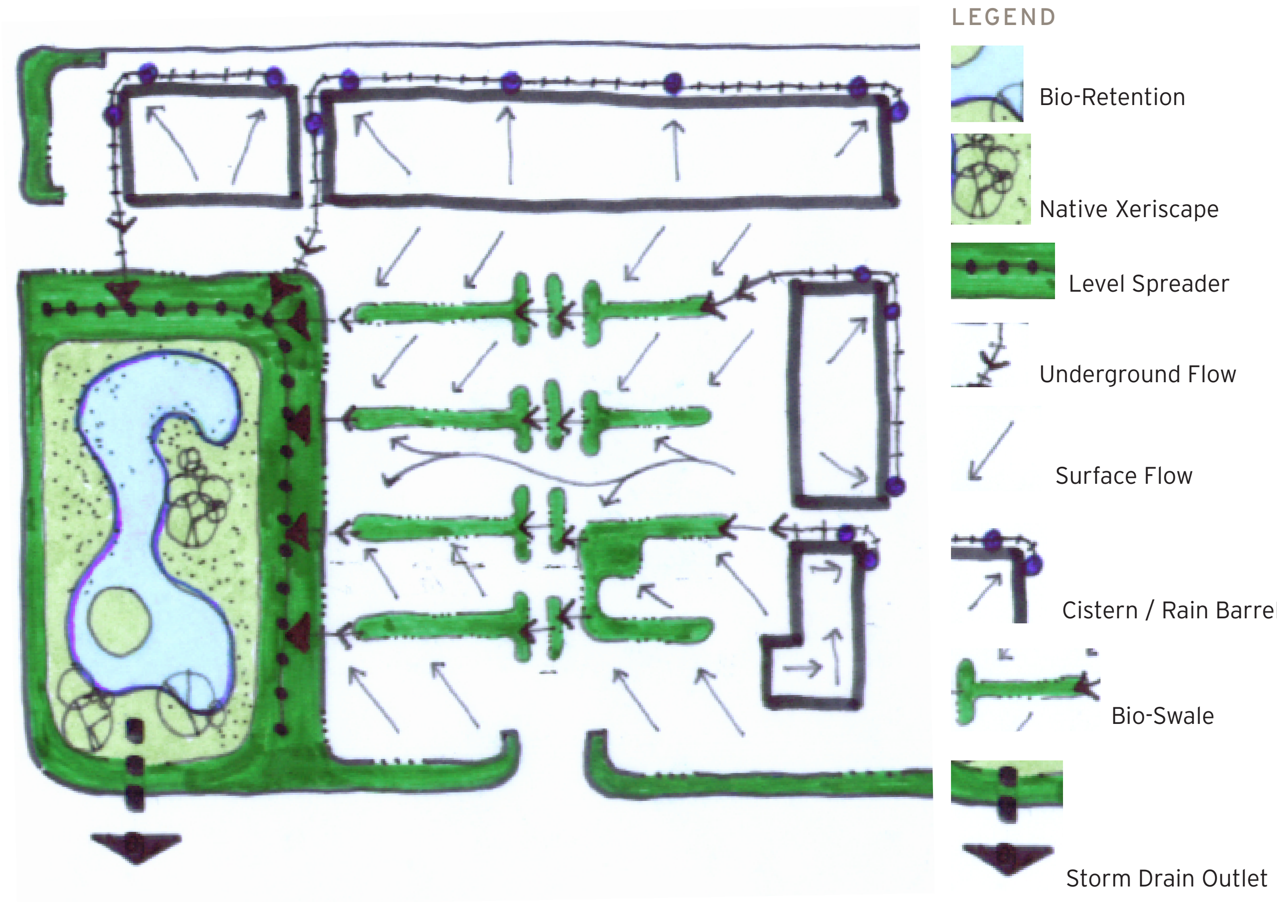
Stream Buffer



Rain Garden

Bio-Retention & Native Plants

Ecological Design Templates



Commercial

Commercial developments can be designed to catch and store rainwater, filter roadway pollutants, be aesthetically pleasing and cost effective. Typical components include bio-swales instead of curb islands, bioretention with native xeriscaping instead of rip rap depressions, above-ground water silos for roof water collection, and a level spreader to outlet excess collected water from rain barrels and bio-swales. Additional components could be pervious paving instead of concrete or asphalt, and roof gardens in-place of hot applied asphalt roofing. Collected water can be used for indoor plumbing and landscape watering

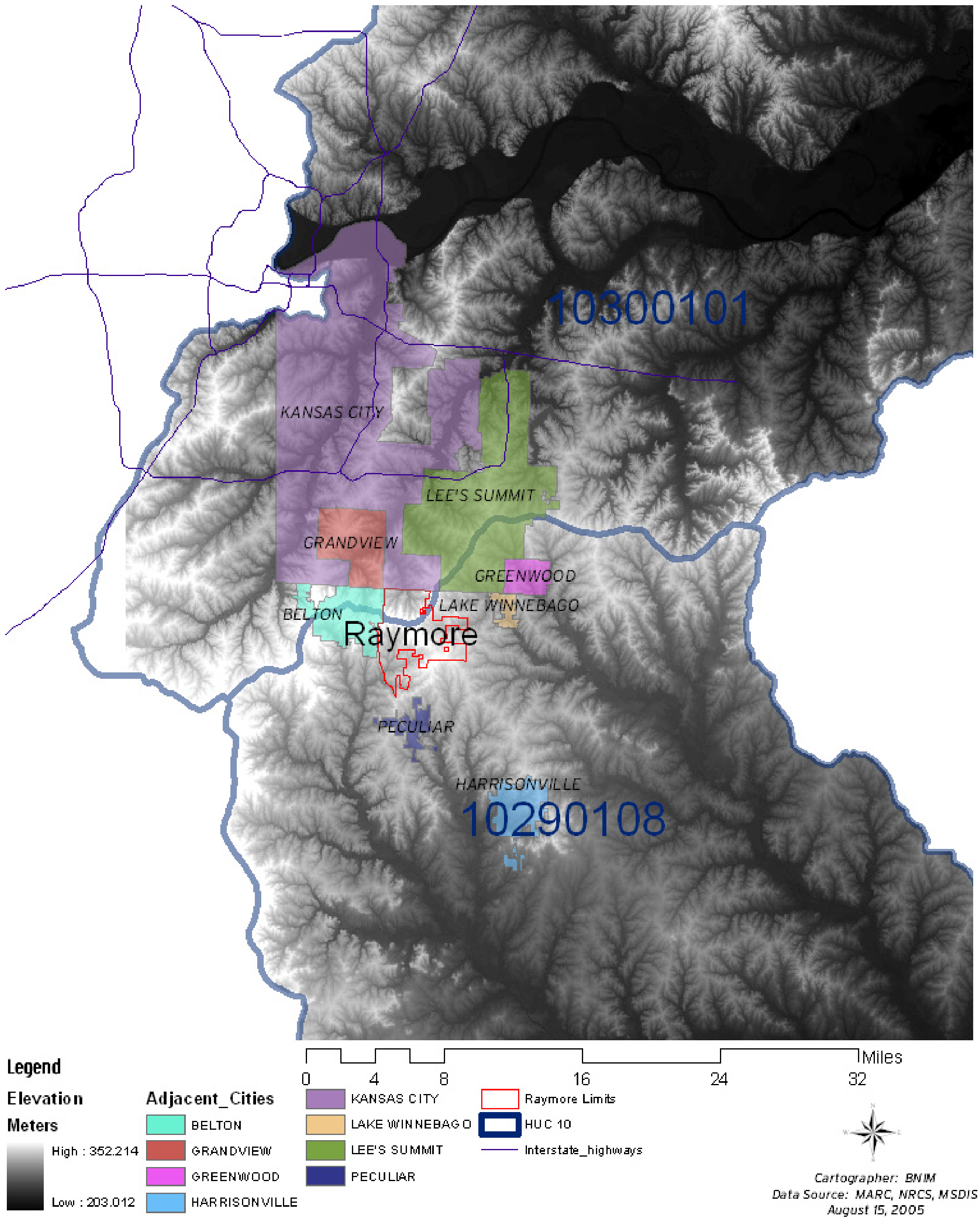

Bio-Swale

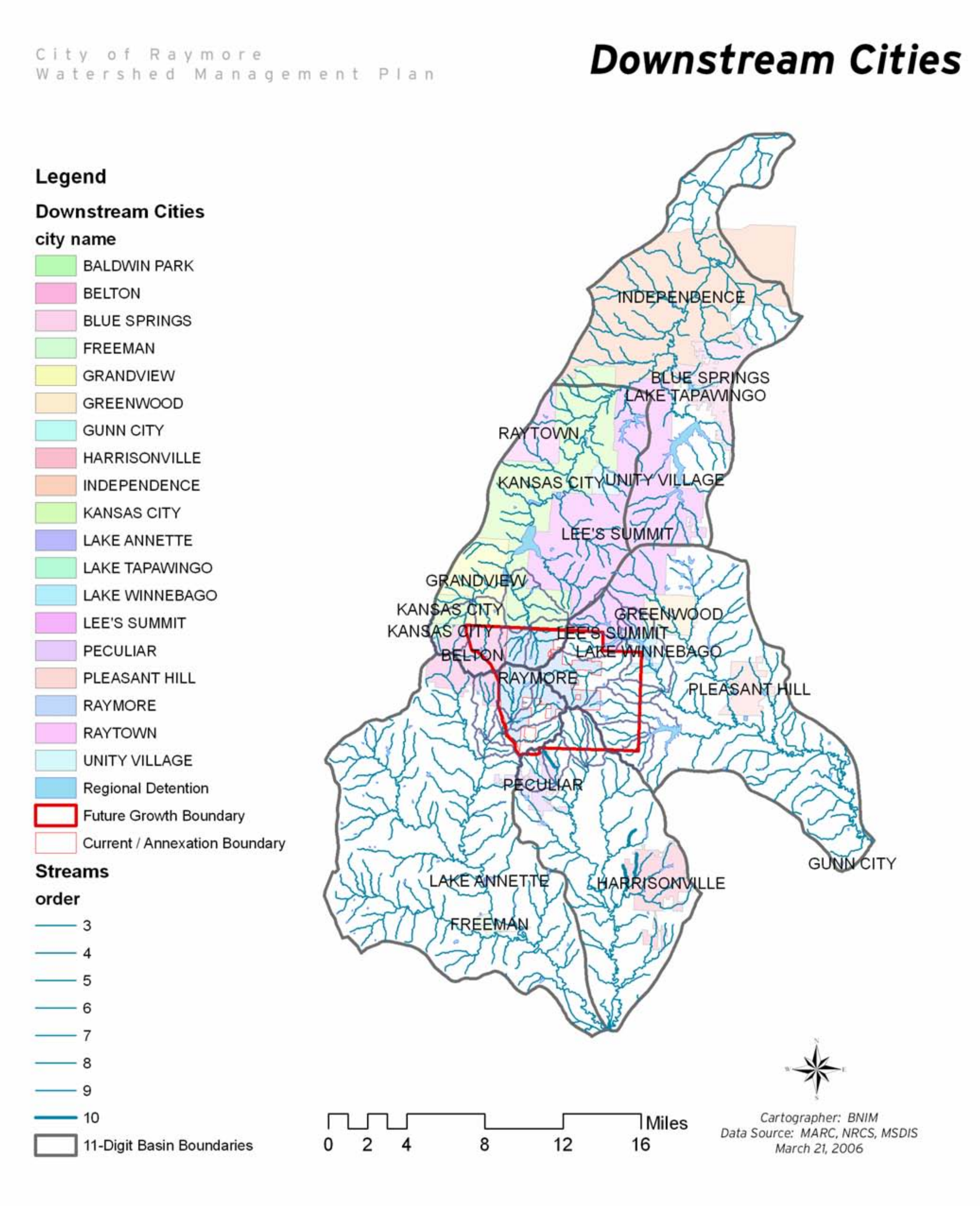

Pervious Paving

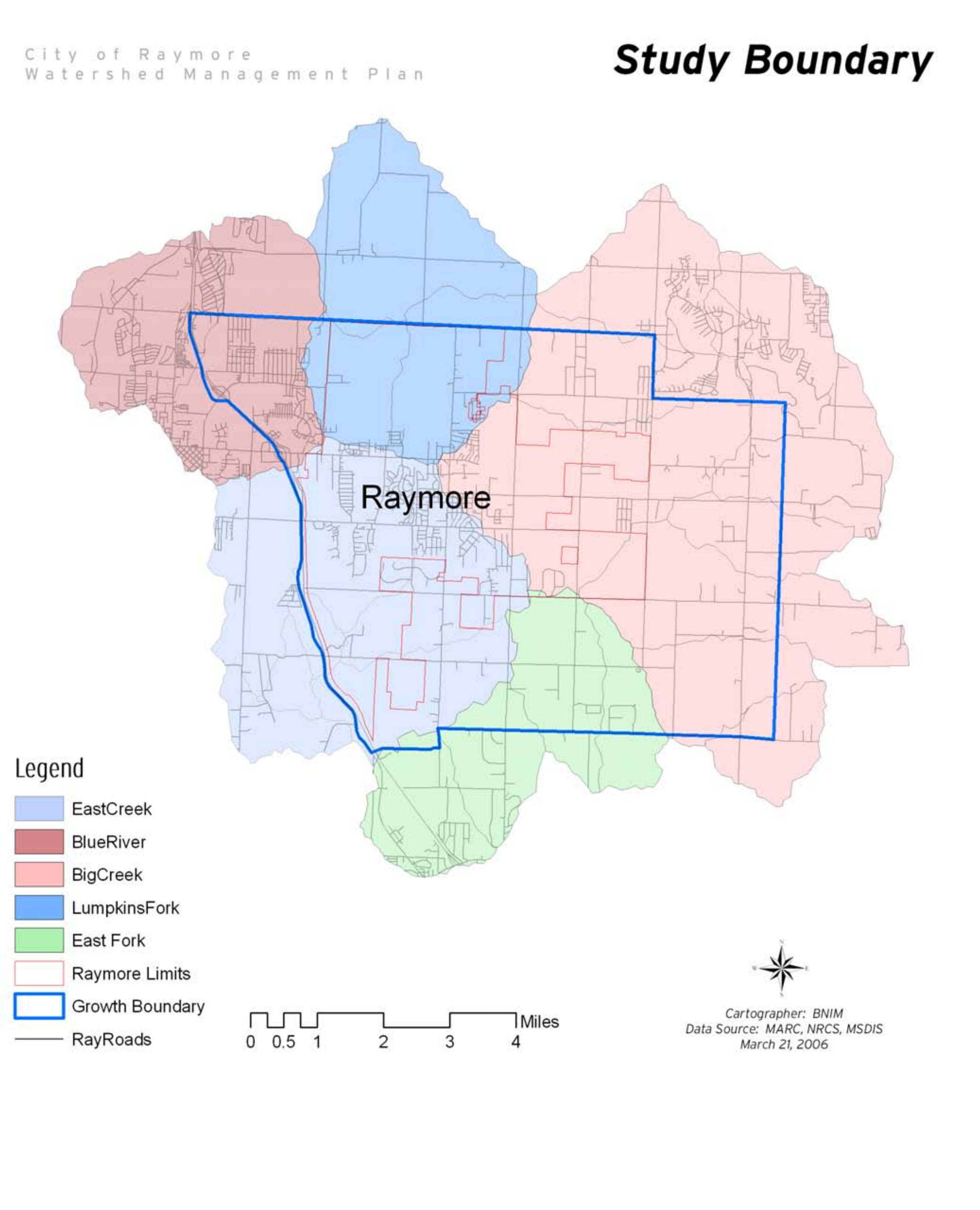

Bio-Retention


Cistern

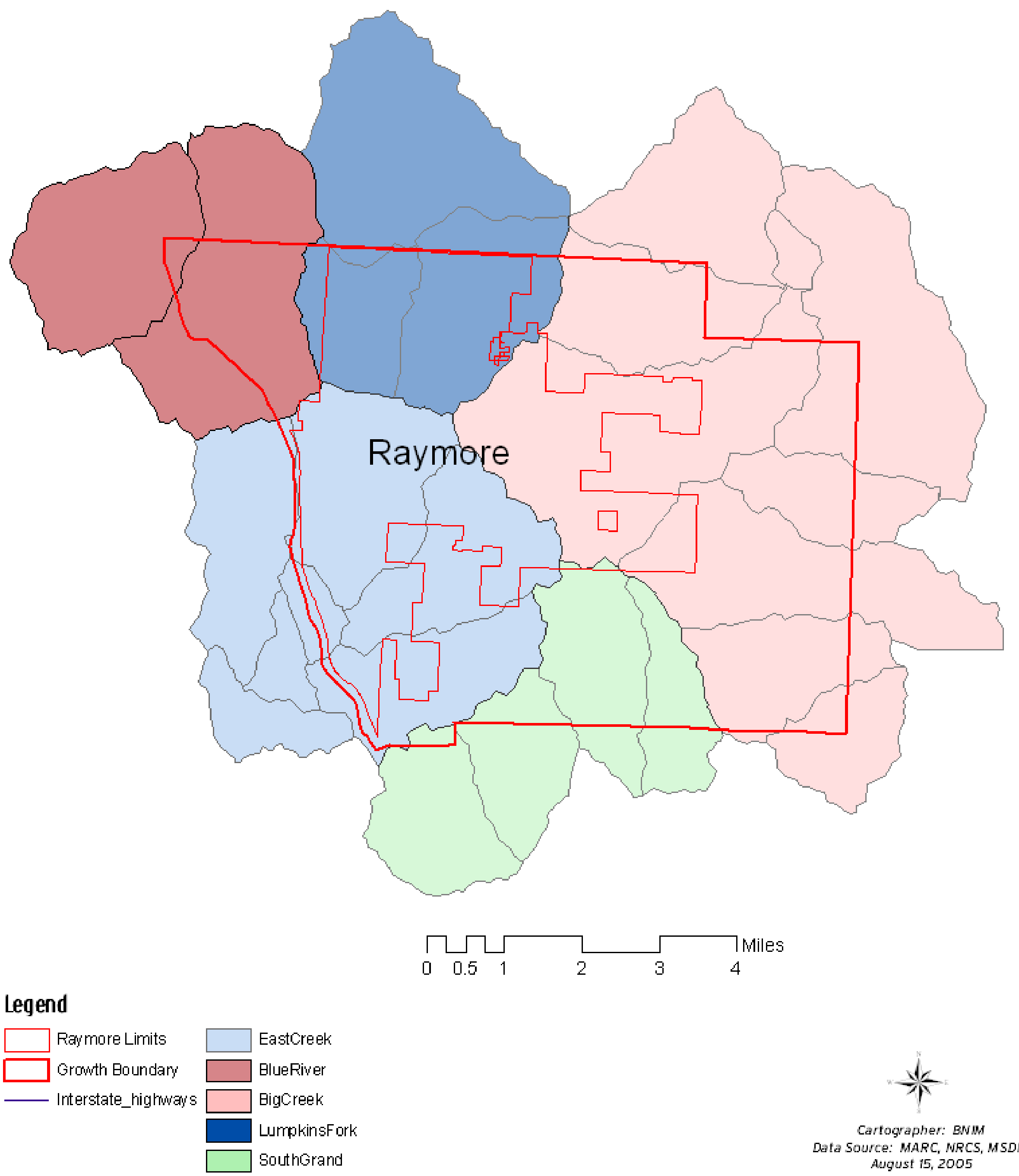
REGIONAL CONTEXT



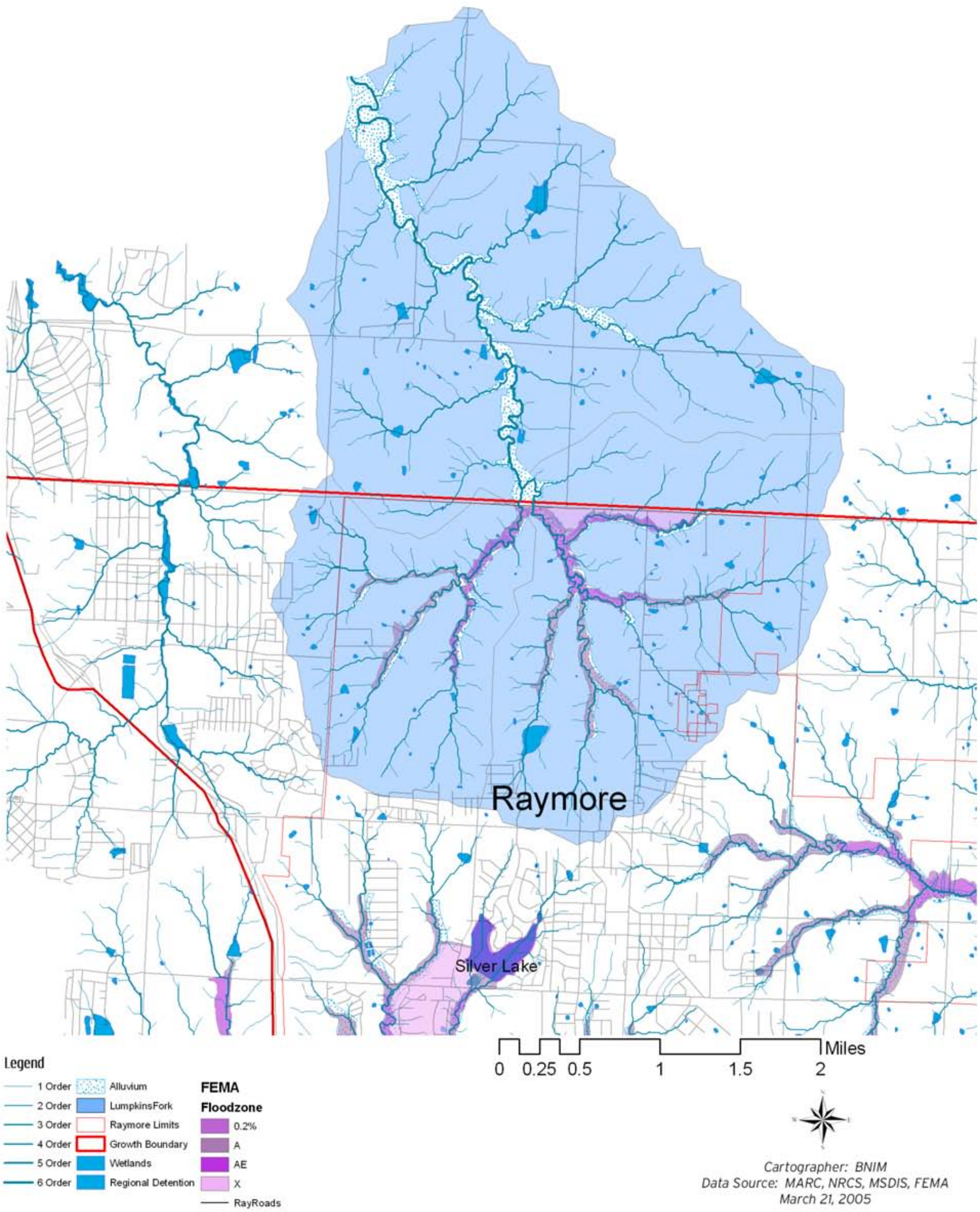

City of Raymore
Watershed Management Plan
Downstream Cities
Legend
Downstream Cities
city name
BALDWIN PARK
BELTON
BLUE SPRINGS
FREEMAN
GRANDVIEW
GREENWOOD
GUNN CITY
HARRISONVILLE
INDEPENDENCE
KANSAS CITY
LAKE ANNETTE
LAKE TAPAWINGO
LAKE WINNEBAGO
LEE'S SUMMIT
PECULIAR
PLEASANT HILL
RAYMORE
RAYTOWN
UNITY VILLAGE
Regional Detention
Future Growth Boundary
Current / Annexation Boundary
Streams
order
3
4
5
6
7
8
9
10
11-Digit Basin Boundaries
INDEPENDENCE
BLUE SPRINGS
LAKE TAPAWINGO
RAYTOWN
KANSAS CITY
UNITY VILLAGE
LEE'S SUMMIT
GRANDVIEW
KANSAS CITY
KANSAS CITY
GREENWOOD
LEE'S SUMMIT
BELTON
LAKE WINNEBAGO
RAYMORE
PLEASANT HILL
PECULIAR
GUNN CITY
LAKE ANNETTE
HARRISONVILLE
FREEMAN
0 2 4 8 12 16 Miles
Cartographer: BNIM
Data Source: MARC, NRCS, MSDIS
March 21, 2006

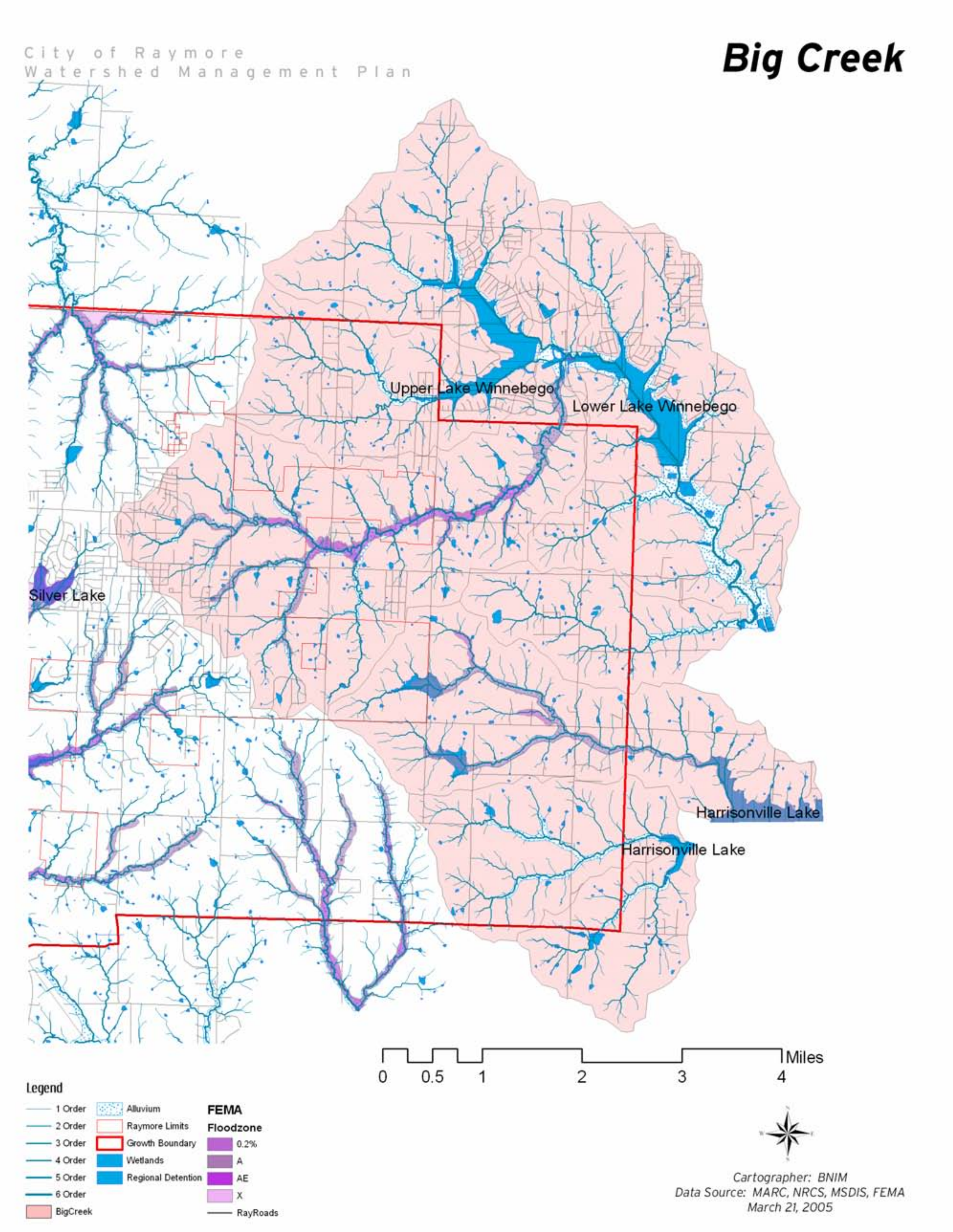

City of Raymore
Watershed Management Plan
Study Boundary
Raymore
Legend
EastCreek
BlueRiver
BigCreek
LumpkinsFork
East Fork
Raymore Limits
Growth Boundary
RayRoads
0 0.5 1 2 3 4
Miles
Cartographer: BNIM
Data Source: MARC, NRCS, MSDIS
March 21, 2006

Five Watersheds



Lumpkin's Fork

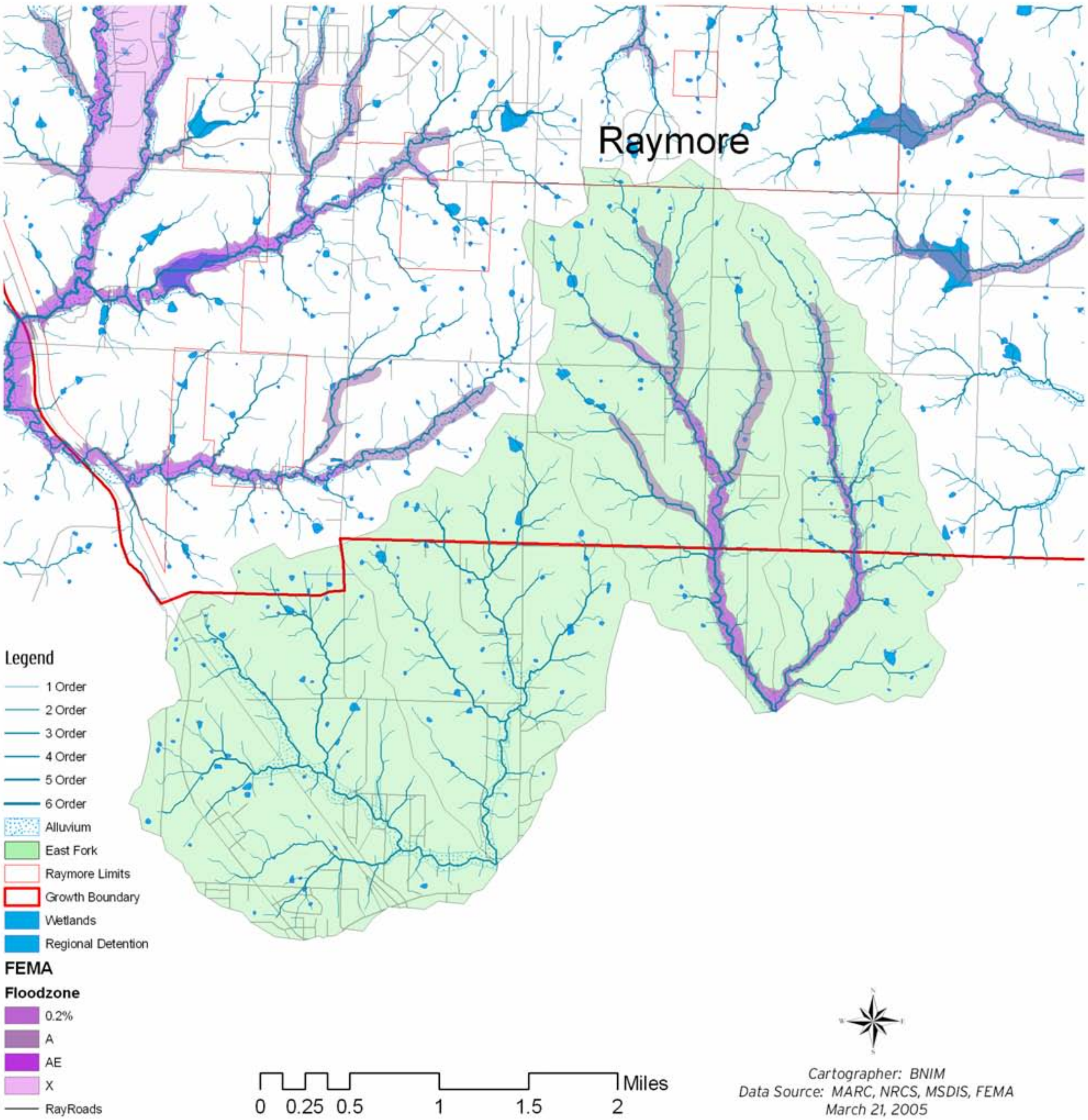


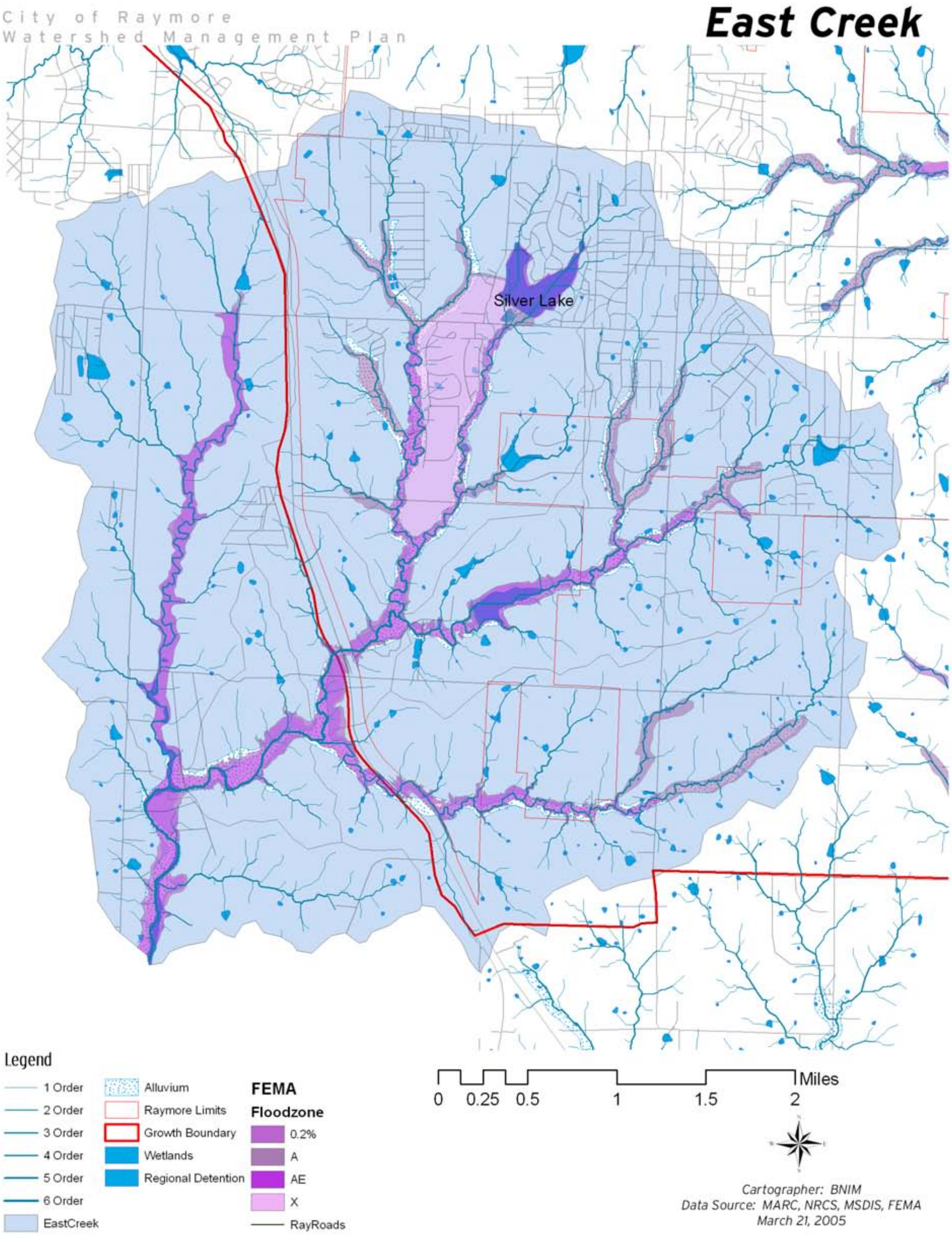


City of Raymore
Watershed Management Plan
Big Creek
Upper Lake Winnebego
Lower Lake Winnebego
Silver Lake
Harrisonville Lake
Harrisonville Lake
0
0.5
1
2
3
4
Miles
Legend
1 Order
2 Order
3 Order
4 Order
5 Order
6 Order
BigCreek
Alluvium
Raymore Limits
Growth Boundary
Wetlands
Regional Detention
FEMA
Floodzone
0.2%
A
AE
X
RayRoads
Cartographer: BNIM
Data Source: MARC, NRCS, MSDIS, FEMA
March 21, 2005

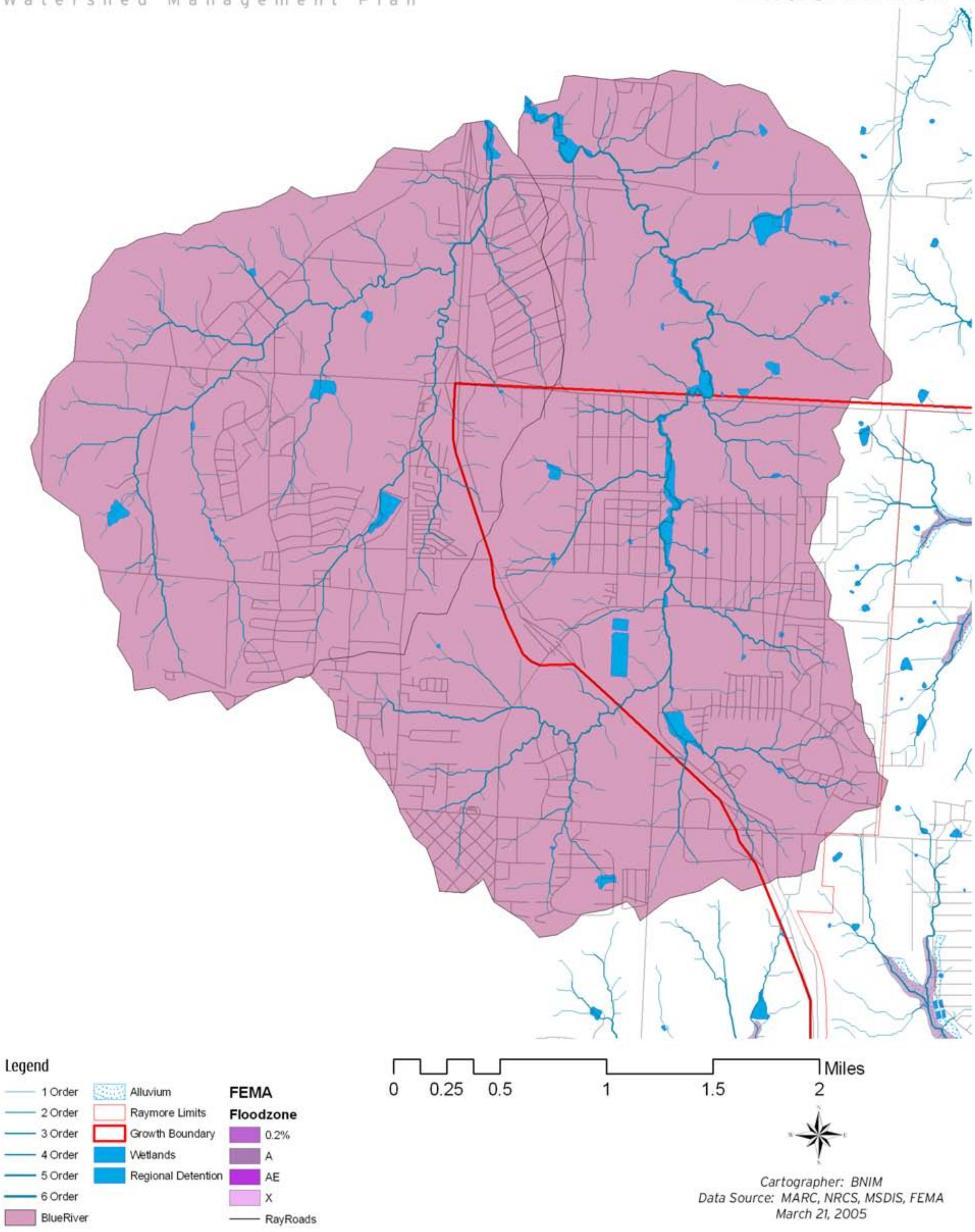
City of Raymore
Watershed Management Plan

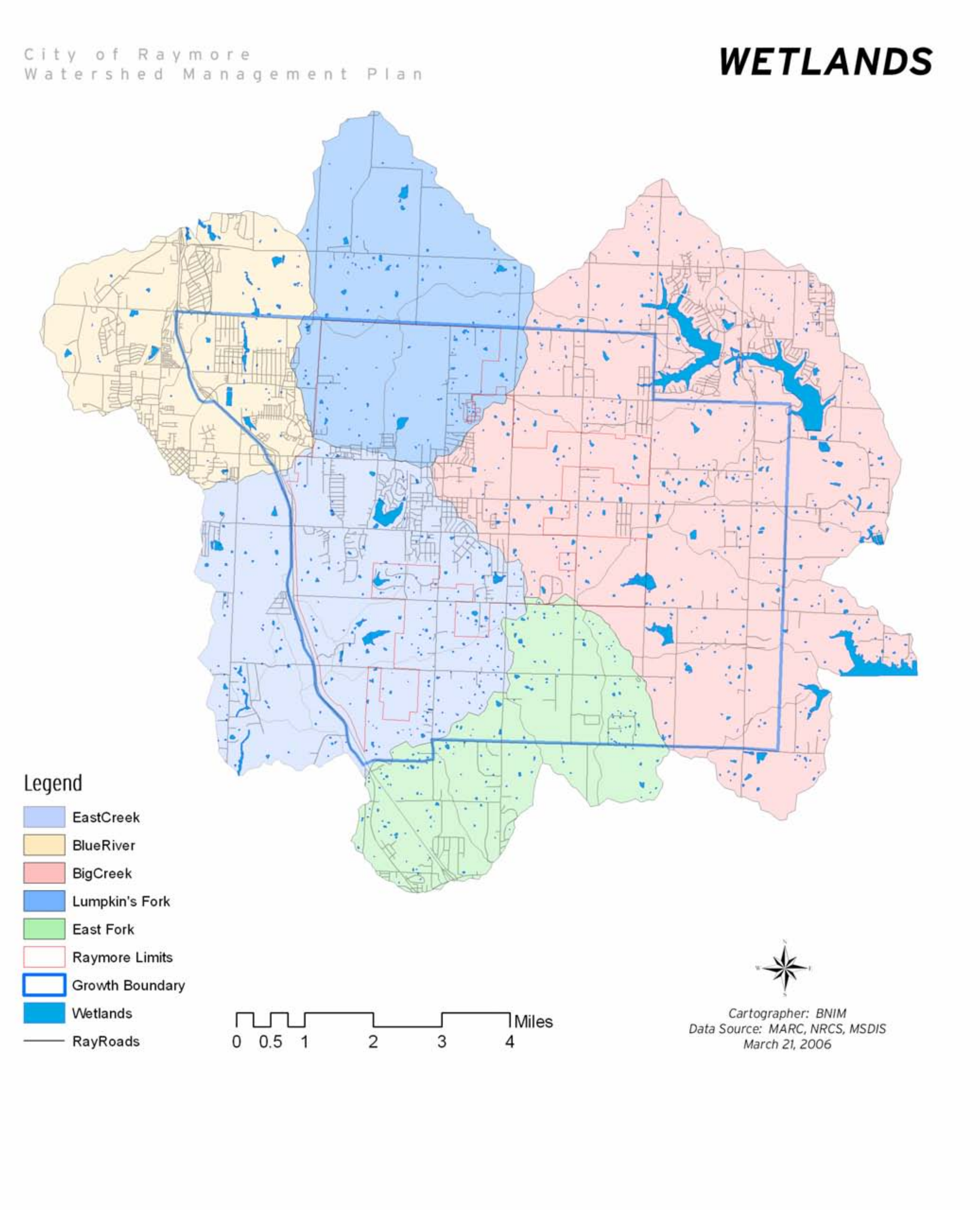
East Fork

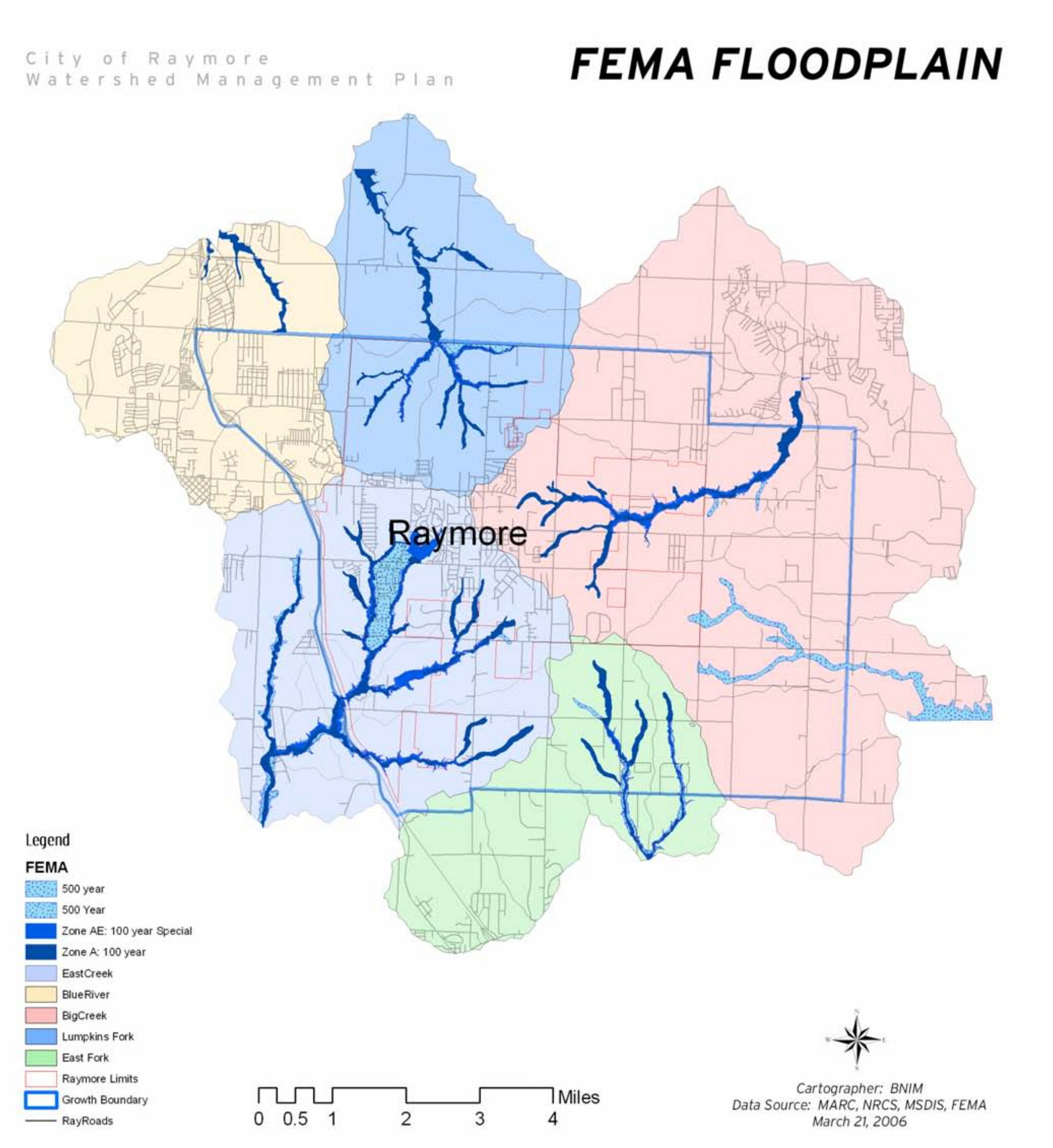


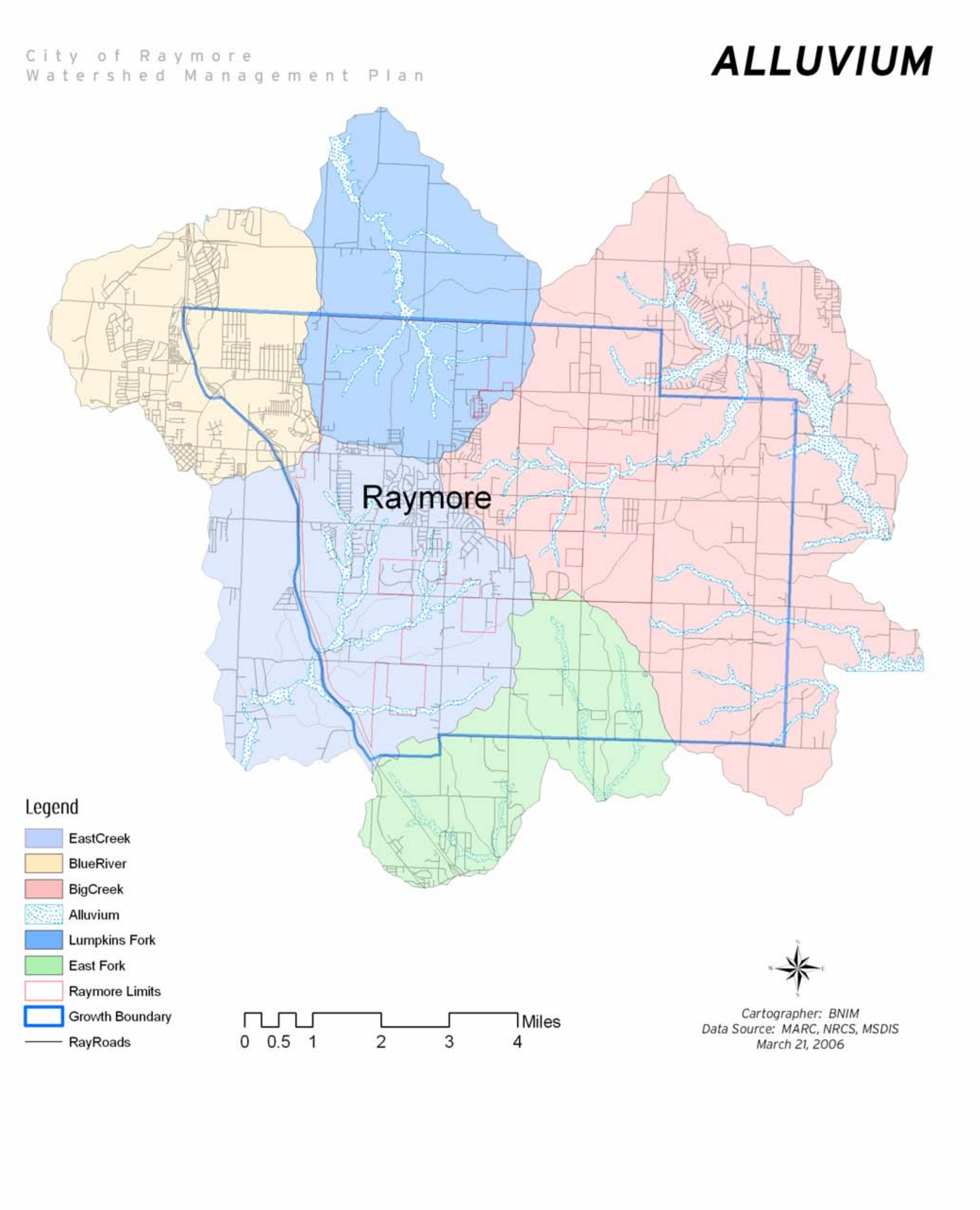

City of Raymore
Watershed Management Plan
East Creek
Silver Lake
Legend
1 Order
2 Order
3 Order
4 Order
5 Order
6 Order
EastCreek
Alluvium
Raymore Limits
Growth Boundary
Wetlands
Regional Detention
FEMA
Floodzone
0.2%
A
AE
X
RayRoads
0 0.25 0.5 1 1.5 2 Miles
Cartographer: BNIM
Data Source: MARC, NRCS, MSDIS, FEMA
March 21, 2005

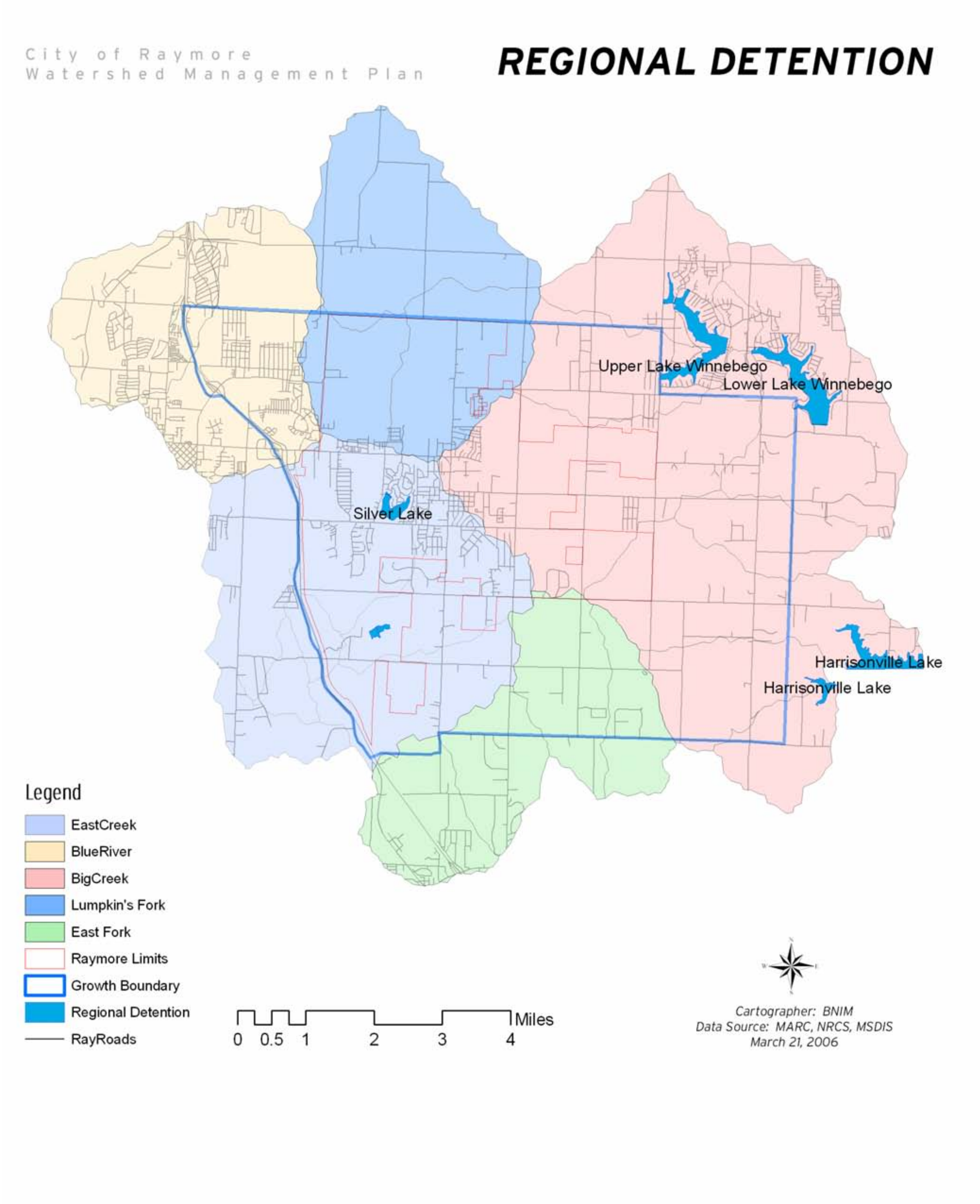
Blue River

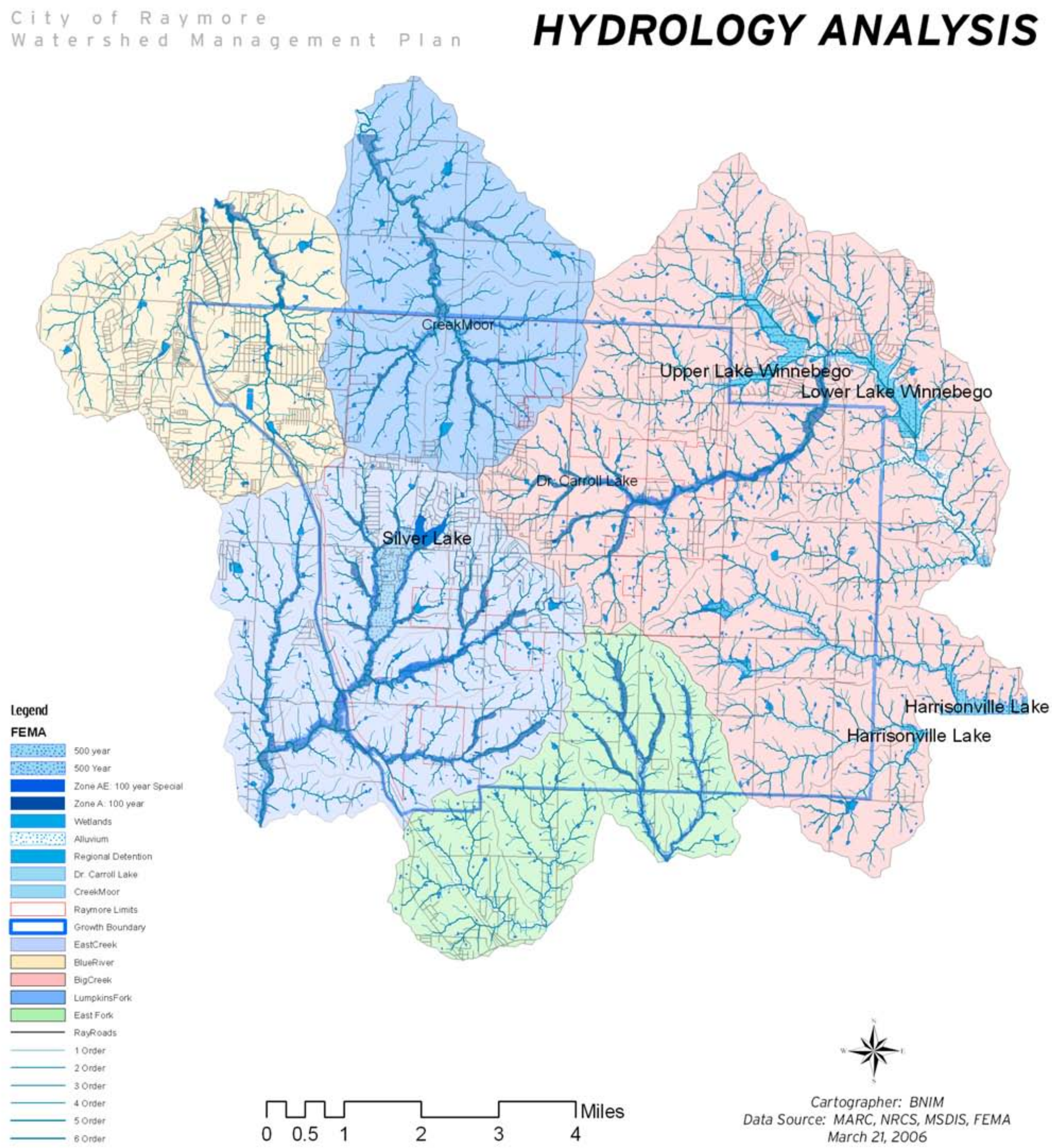

Legend
1 Order
2 Order
3 Order
4 Order
5 Order
6 Order
BlueRiver
Alluvium
Raymore Limits
Growth Boundary
Wetlands
Regional Detention
FEMA
Floodzone
0.2%
A
AE
X
RayRoads
0
0.25
0.5
1
1.5
2
Miles
Cartographer: BNIM
Data Source: MARC, NRCS, MSDIS, FEMA
March 21, 2005


City of Raymore
Watershed Management Plan
WETLANDS
Legend
EastCreek
BlueRiver
BigCreek
Lumpkin's Fork
East Fork
Raymore Limits
Growth Boundary
Wetlands
RayRoads
Miles
0 0.5 1 2 3 4
Cartographer: BNIM
Data Source: MARC, NRCS, MSDIS
March 21, 2006


City of Raymore
Watershed Management Plan
FEMA FLOODPLAIN
Raymore
Legend
FEMA
500 year
500 Year
Zone AE: 100 year Special
Zone A: 100 year
EastCreek
BlueRiver
BigCreek
Lumpkins Fork
East Fork
Raymore Limits
Growth Boundary
RayRoads
Miles
0 0.5 1 2 3 4
Cartographer: BNIM
Data Source: MARC, NRCS, MSDIS, FEMA
March 21, 2006


City of Raymore
Watershed Management Plan
ALLUVIUM
Raymore
Legend
EastCreek
BlueRiver
BigCreek
Alluvium
Lumpkins Fork
East Fork
Raymore Limits
Growth Boundary
RayRoads
0 0.5 1 2 3 4 Miles
Cartographer: BNIM
Data Source: MARC, NRCS, MSDIS
March 21, 2006

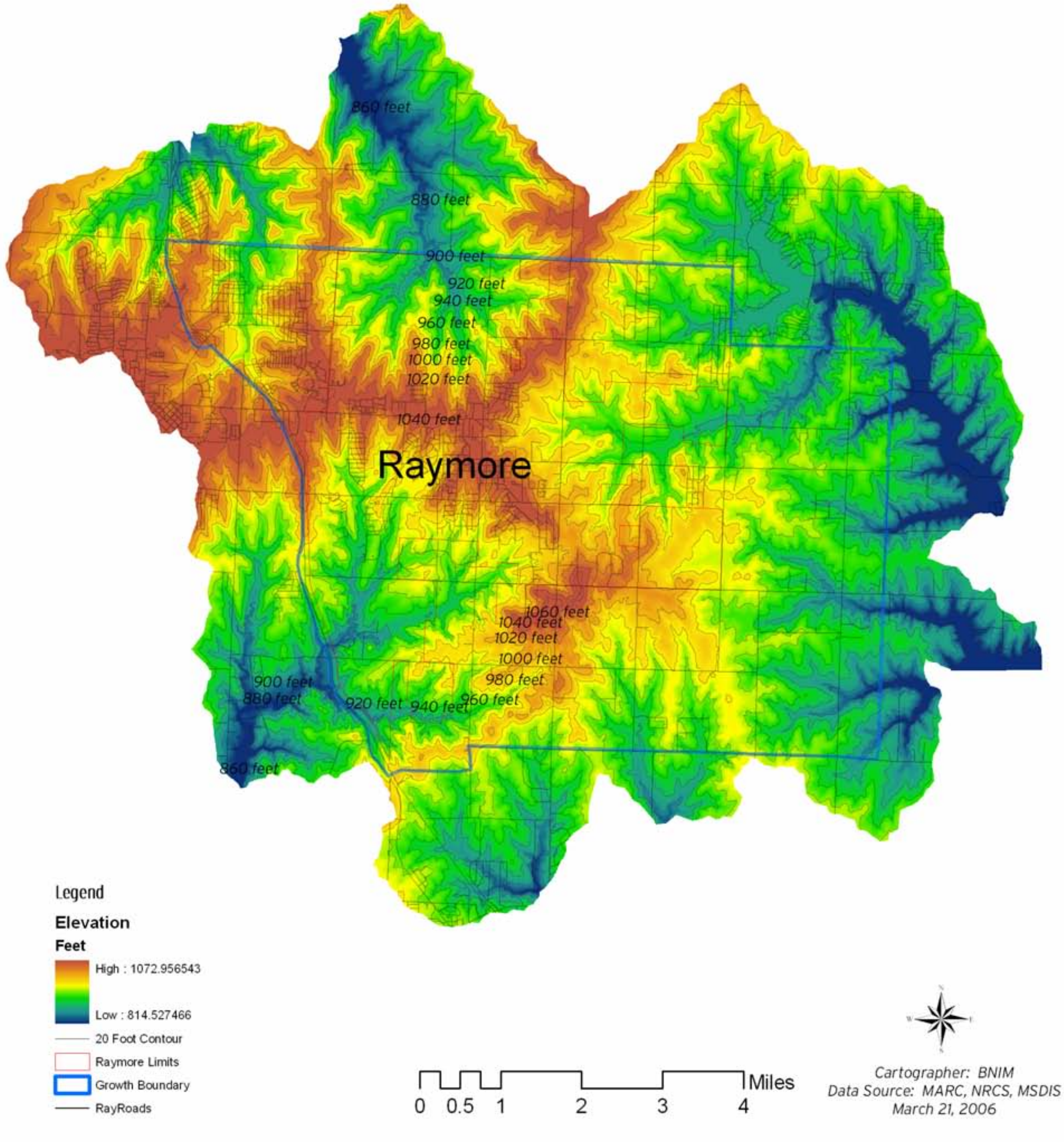

City of Raymore
Watershed Management Plan
REGIONAL DETENTION
Upper Lake Winnebego
Lower Lake Winnebego
Silver Lake
Harrisonville Lake
Harrisonville Lake
Legend
EastCreek
BlueRiver
BigCreek
Lumpkin's Fork
East Fork
Raymore Limits
Growth Boundary
Regional Detention
RayRoads
0 0.5 1 2 3 4 Miles
Cartographer: BNIM
Data Source: MARC, NRCS, MSDIS
March 21, 2006



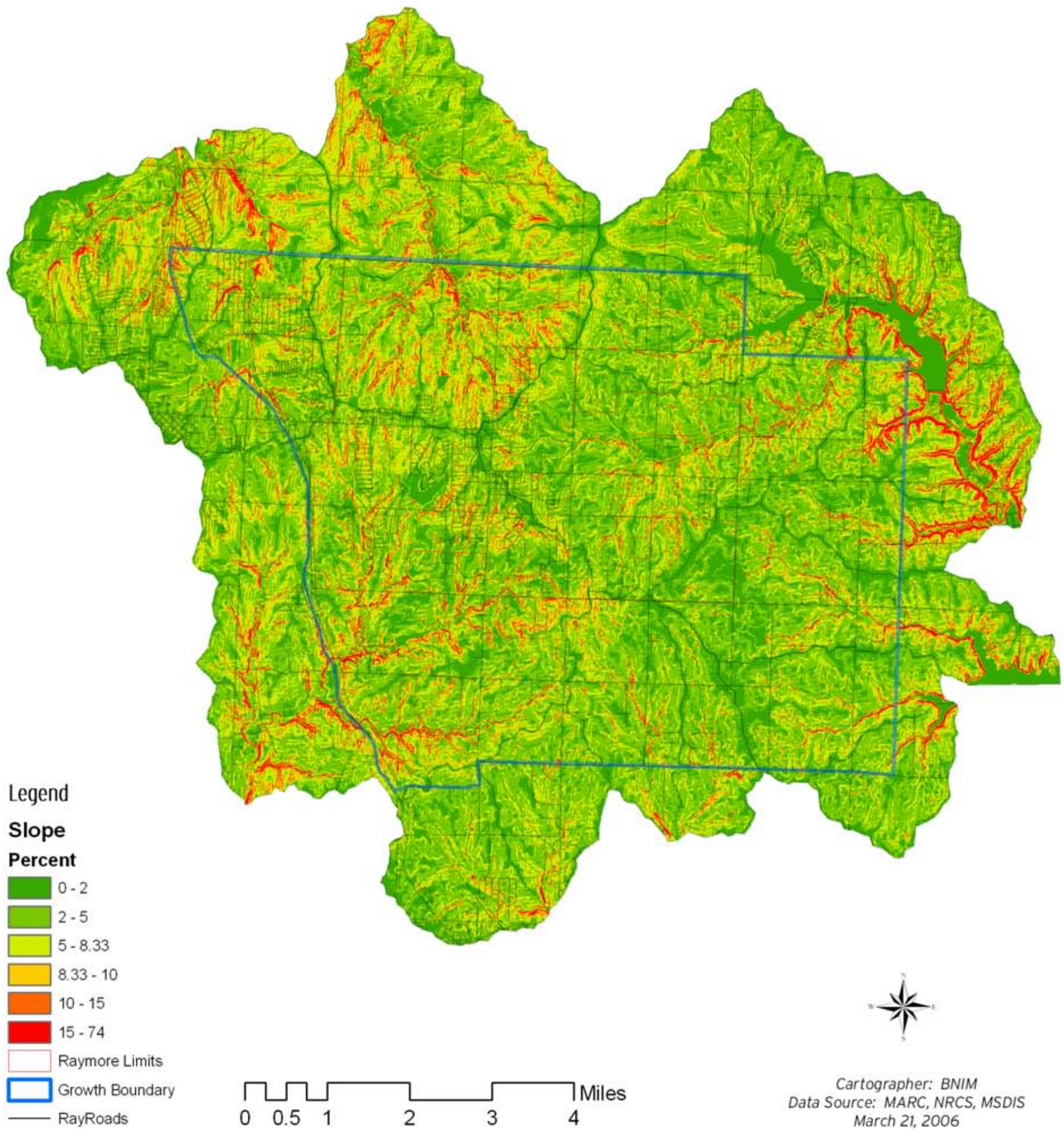
City of Raymore
Watershed Management Plan
HYDROLOGY ANALYSIS
CreekMoor
Upper Lake Winnebego
Lower Lake Winnebego
Dr. Carroll Lake
Silver Lake
Harrisonville Lake
Harrisonville Lake
Legend
FEMA
500 year
500 Year
Zone AE: 100 year Special
Zone A: 100 year
Wetlands
Alluvium
Regional Detention
Dr. Carroll Lake
CreekMoor
Raymore Limits
Growth Boundary
EastCreek
BlueRiver
BigCreek
LumpkinsFork
East Fork
RayRoads
1 Order
2 Order
3 Order
4 Order
5 Order
6 Order
Miles
0 0.5 1 2 3 4
Cartographer: BNIM
Data Source: MARC, NRCS, MSDIS, FEMA
March 21, 2006

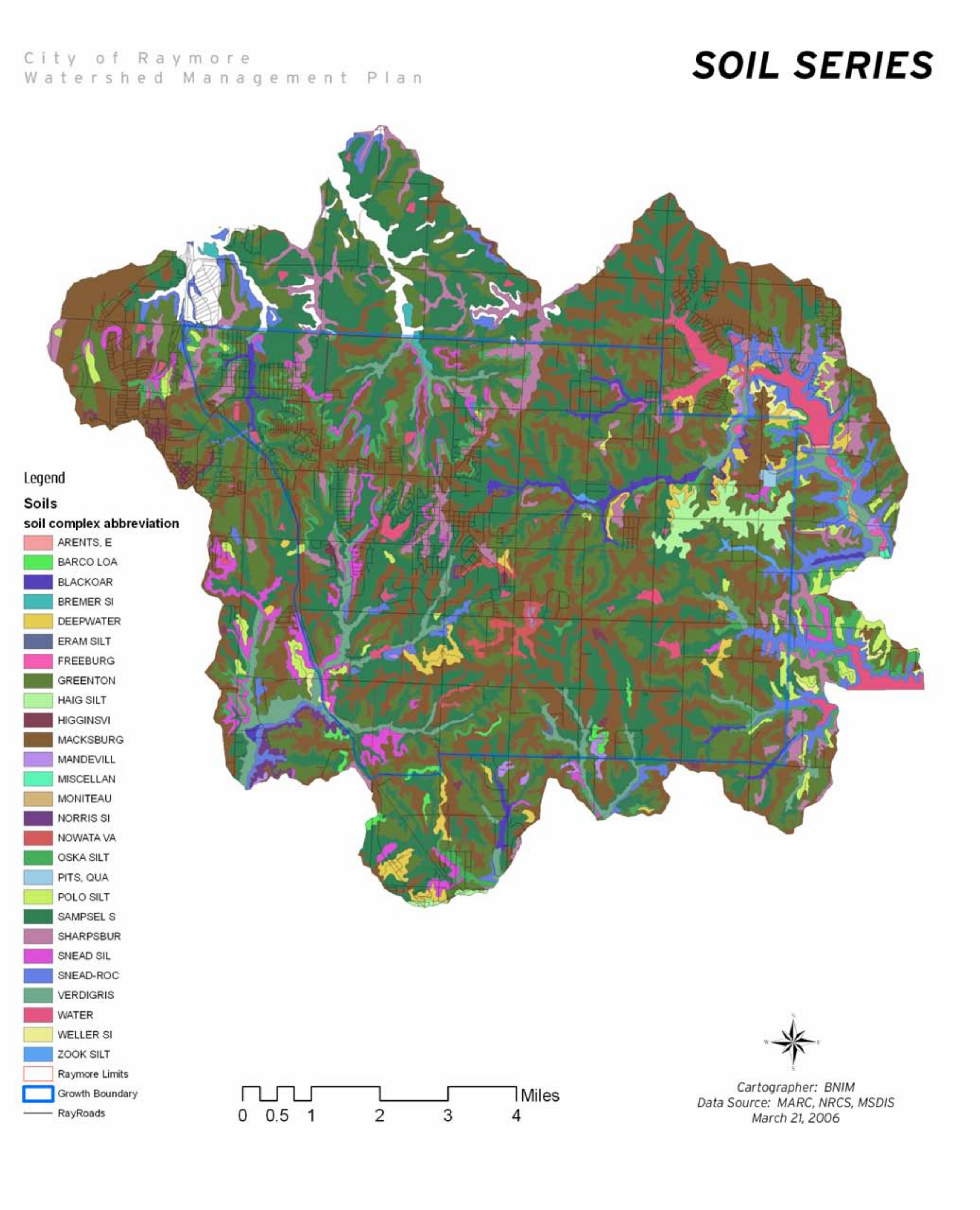
City of Raymore
Watershed Management Plan

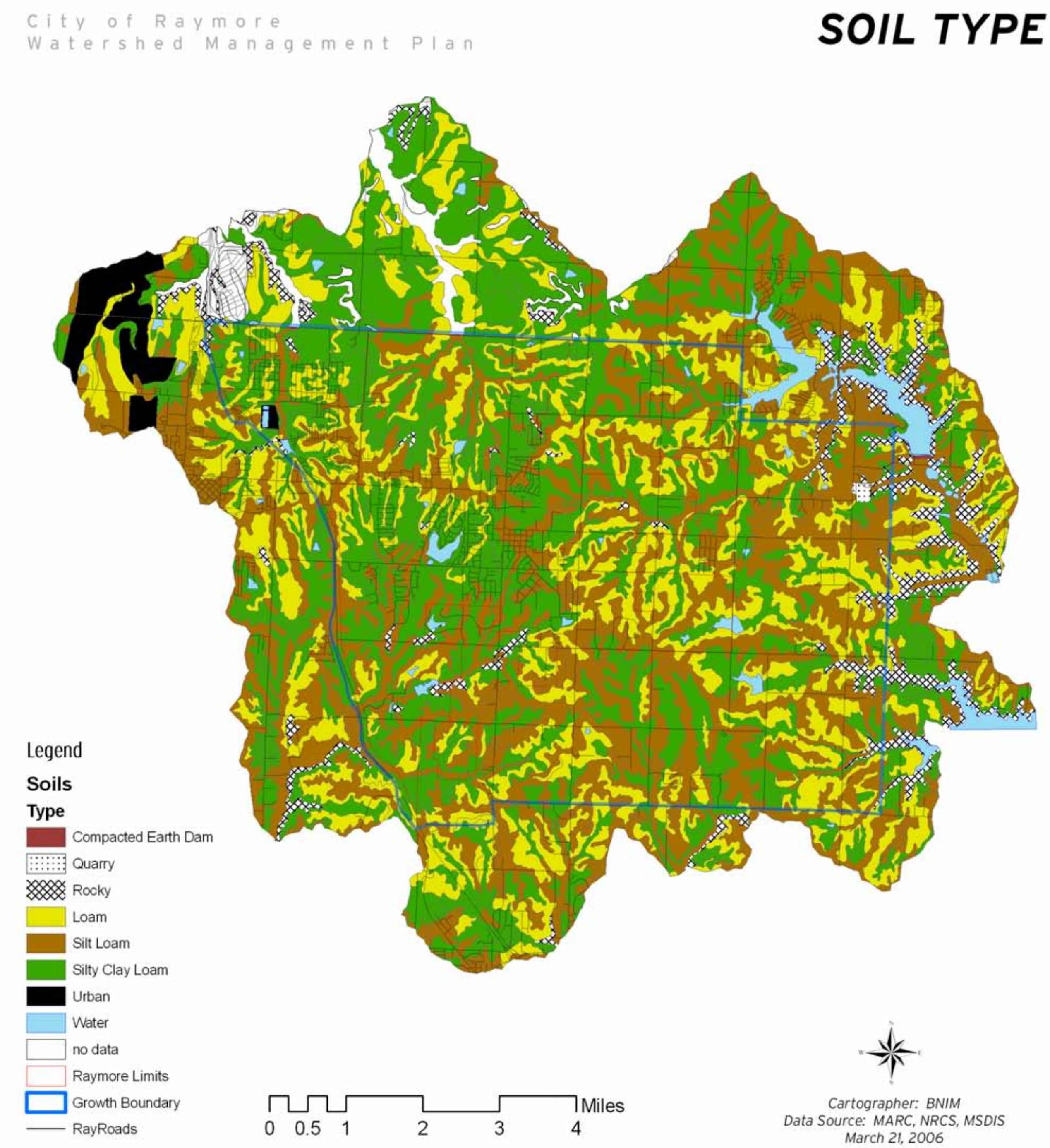
20 FOOT CONTOURS



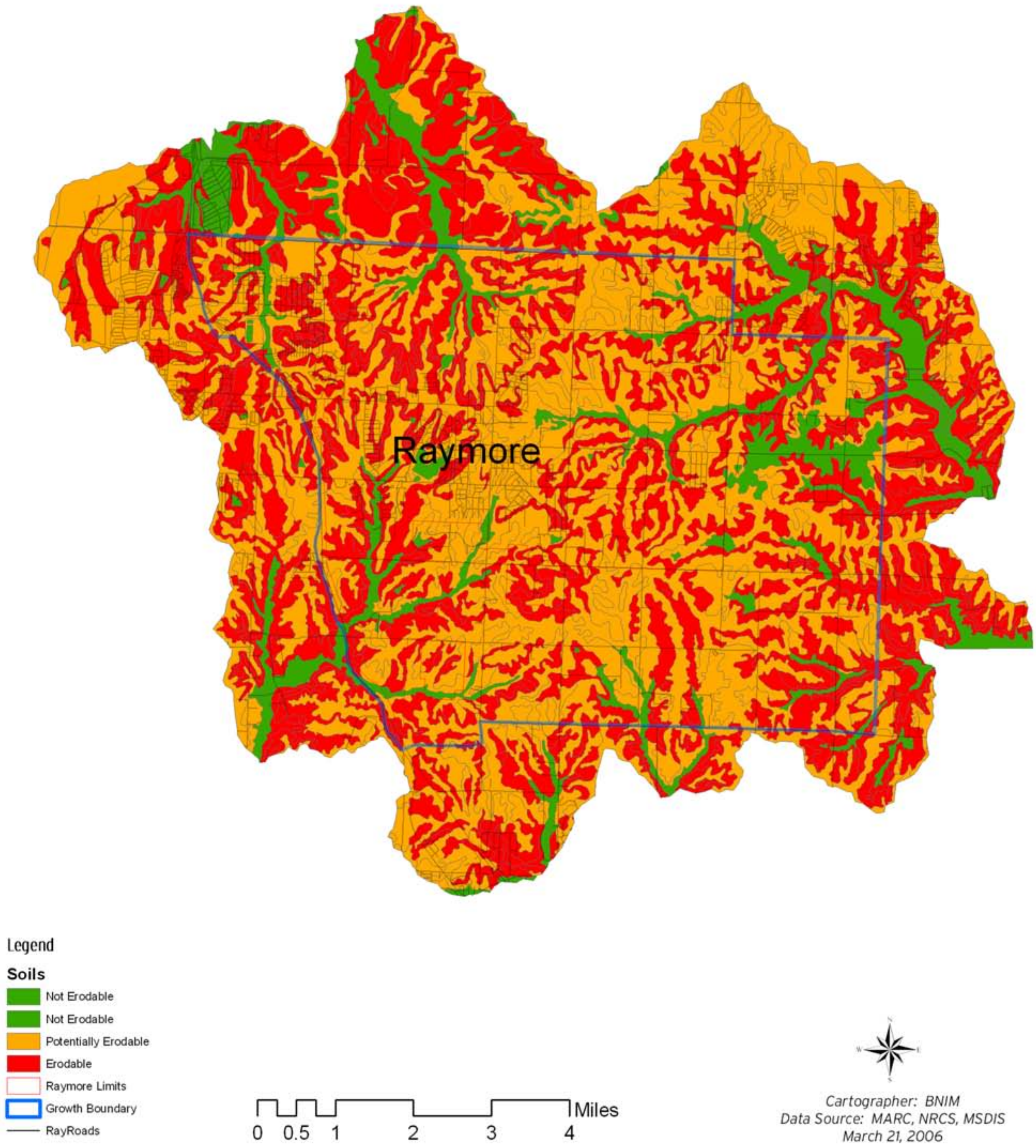
SLOPE

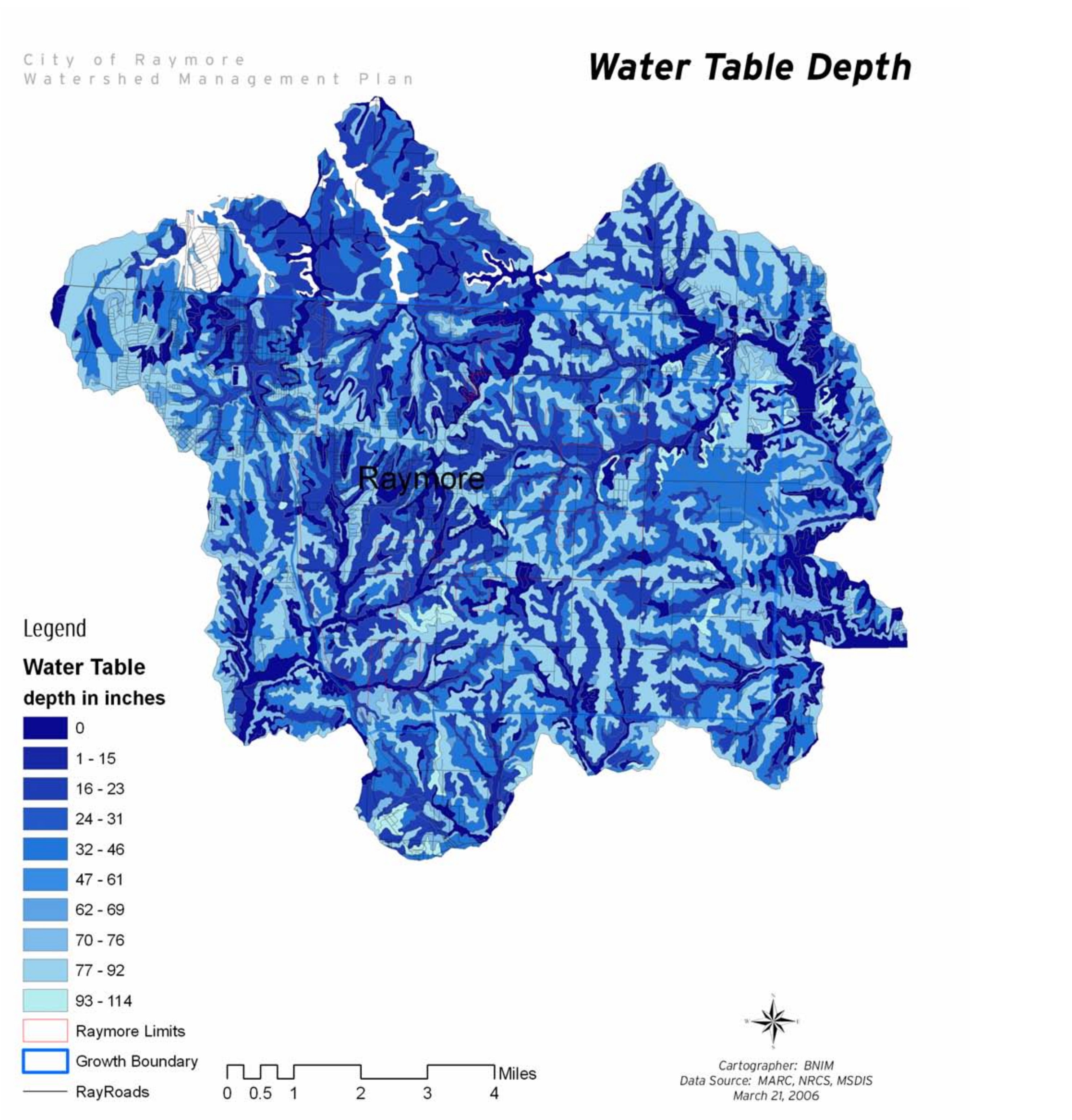

Legend
Slope
Percent
0 - 2
2 - 5
5 - 8.33
8.33 - 10
10 - 15
15 - 74
Raymore Limits
Growth Boundary
RayRoads
Miles
0 0.5 1 2 3 4
Cartographer: BNIM
Data Source: MARC, NRCS, MSDIS
March 21, 2006

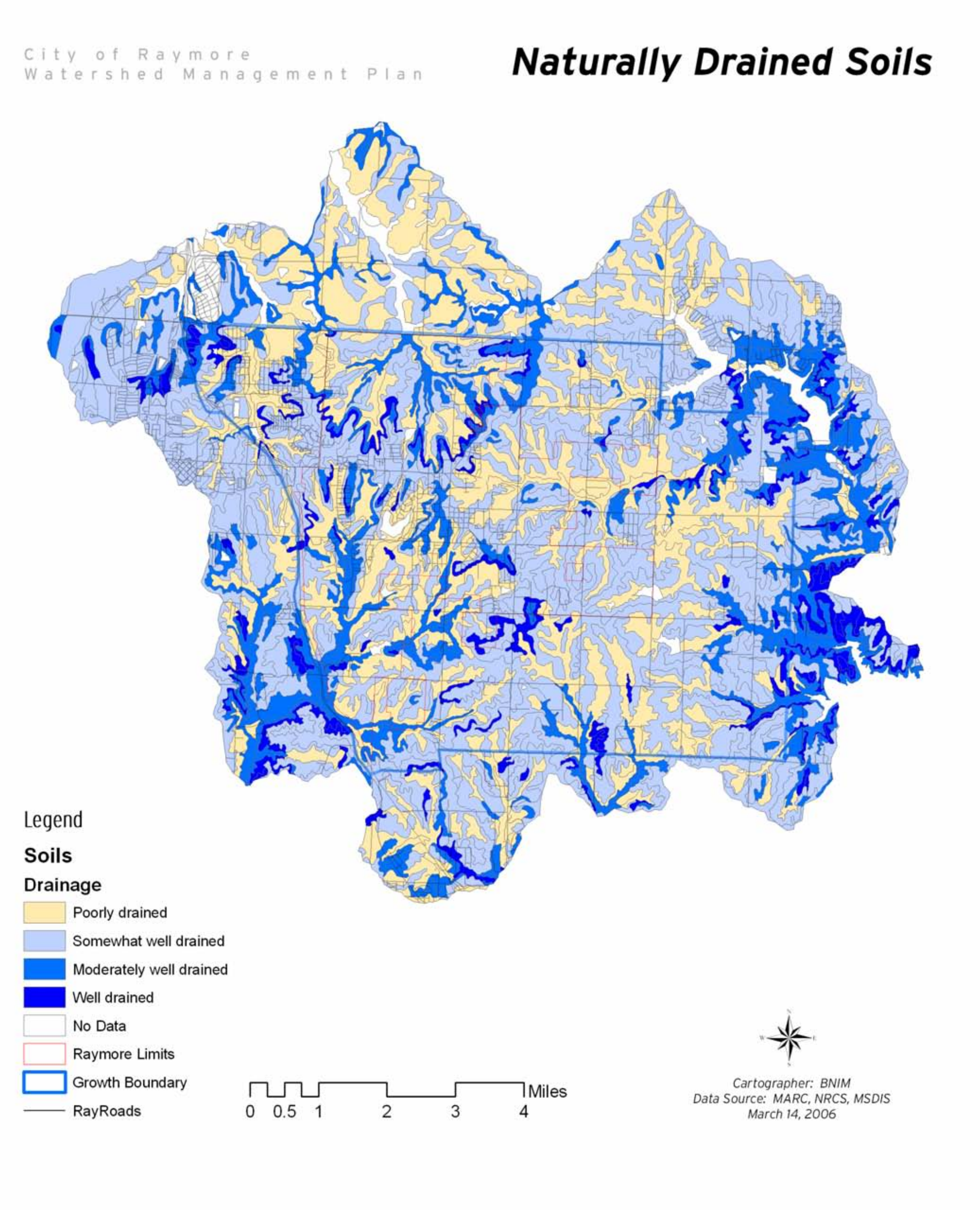

City of Raymore
Watershed Management Plan
SOIL SERIES
Legend
Soils
soil complex abbreviation
ARENTS, E
BARCO LOA
BLACKOAR
BREMER SI
DEEPWATER
ERAM SILT
FREEBURG
GREENTON
HAIG SILT
HIGGINSVI
MACKSBURG
MANDEVILL
MISCELLAN
MONITEAU
NORRIS SI
NOWATA VA
OSKA SILT
PITS, QUA
POLO SILT
SAMPSEL S
SHARPSBUR
SNEAD SIL
SNEAD-ROC
VERDIGRIS
WATER
WELLER SI
ZOOK SILT
Raymore Limits
Growth Boundary
RayRoads
0 0.5 1 2 3 4
Miles
Cartographer: BNIM
Data Source: MARC, NRCS, MSDIS
March 21, 2006


City of Raymore
Watershed Management Plan
SOIL TYPE
Legend
Soils
Type
Compacted Earth Dam
Quarry
Rocky
Loam
Silt Loam
Silty Clay Loam
Urban
Water
no data
Raymore Limits
Growth Boundary
RayRoads
0 0.5 1 2 3 4 Miles
Cartographer: BNIM
Data Source: MARC, NRCS, MSDIS
March 21, 2006

ERODABLE SOILS

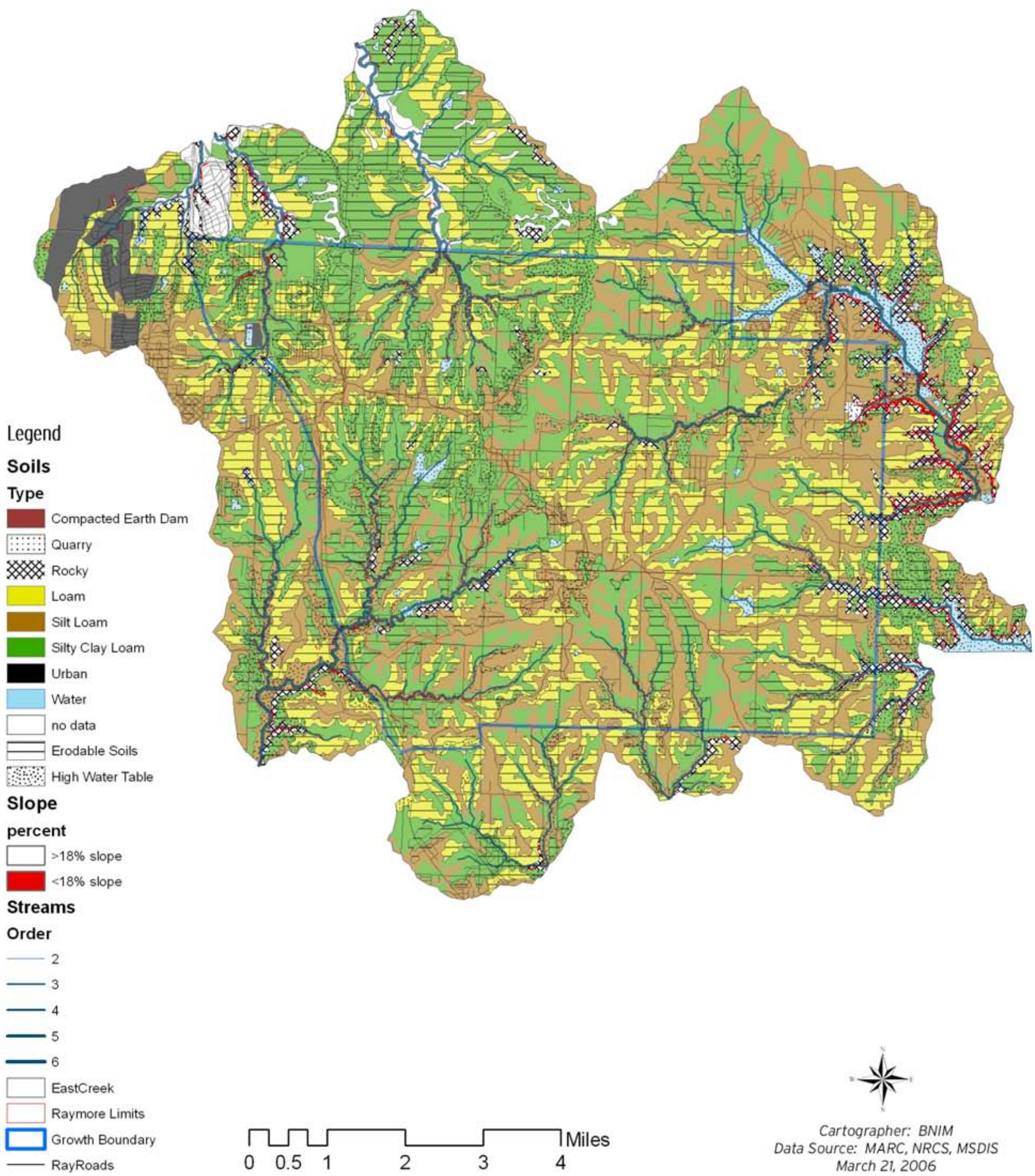



City of Raymore
Watershed Management Plan
Water Table Depth
Raymore
Legend
Water Table
depth in inches
0
1 - 15
16 - 23
24 - 31
32 - 46
47 - 61
62 - 69
70 - 76
77 - 92
93 - 114
Raymore Limits
Growth Boundary
RayRoads
Miles
0 0.5 1 2 3 4
Cartographer: BNIM
Data Source: MARC, NRCS, MSDIS
March 21, 2006

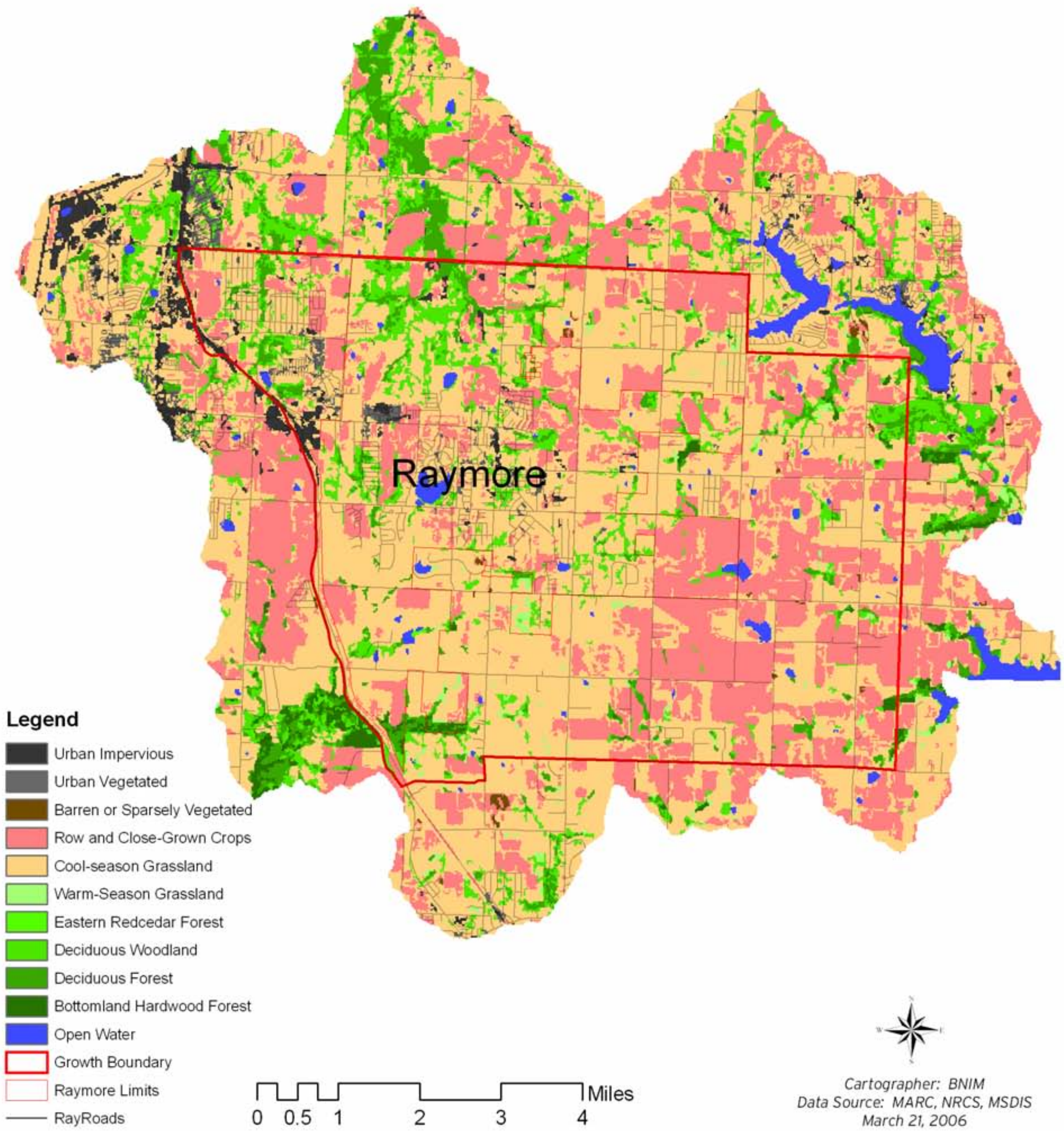

City of Raymore
Watershed Management Plan
Naturally Drained Soils
Legend
Soils
Drainage
Poorly drained
Somewhat well drained
Moderately well drained
Well drained
No Data
Raymore Limits
Growth Boundary
RayRoads
0 0.5 1 2 3 4 Miles
Cartographer: BNIM
Data Source: MARC, NRCS, MSDIS
March 14, 2006

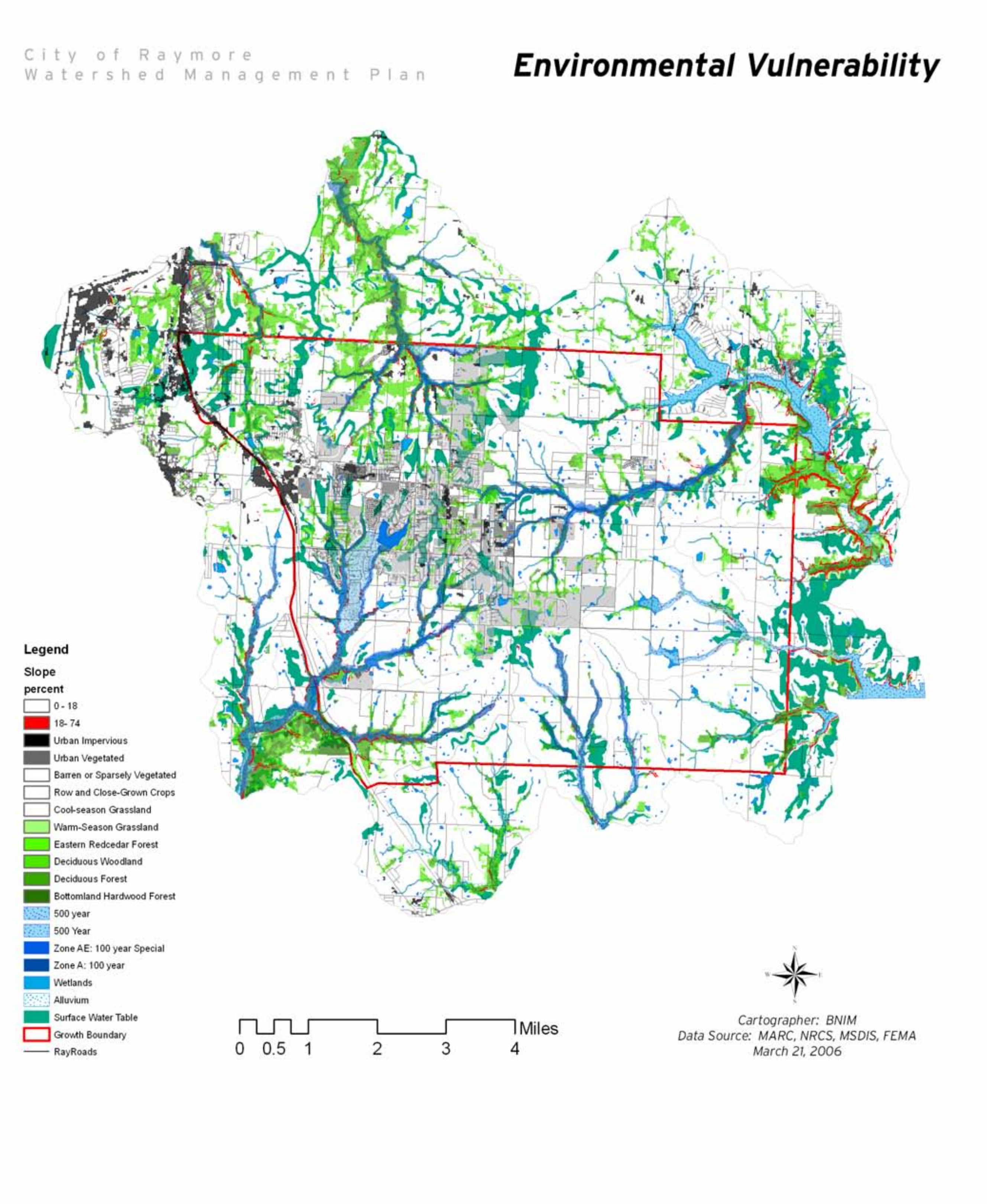
City of Raymore
Watershed Management Plan

SOIL ANALYSIS

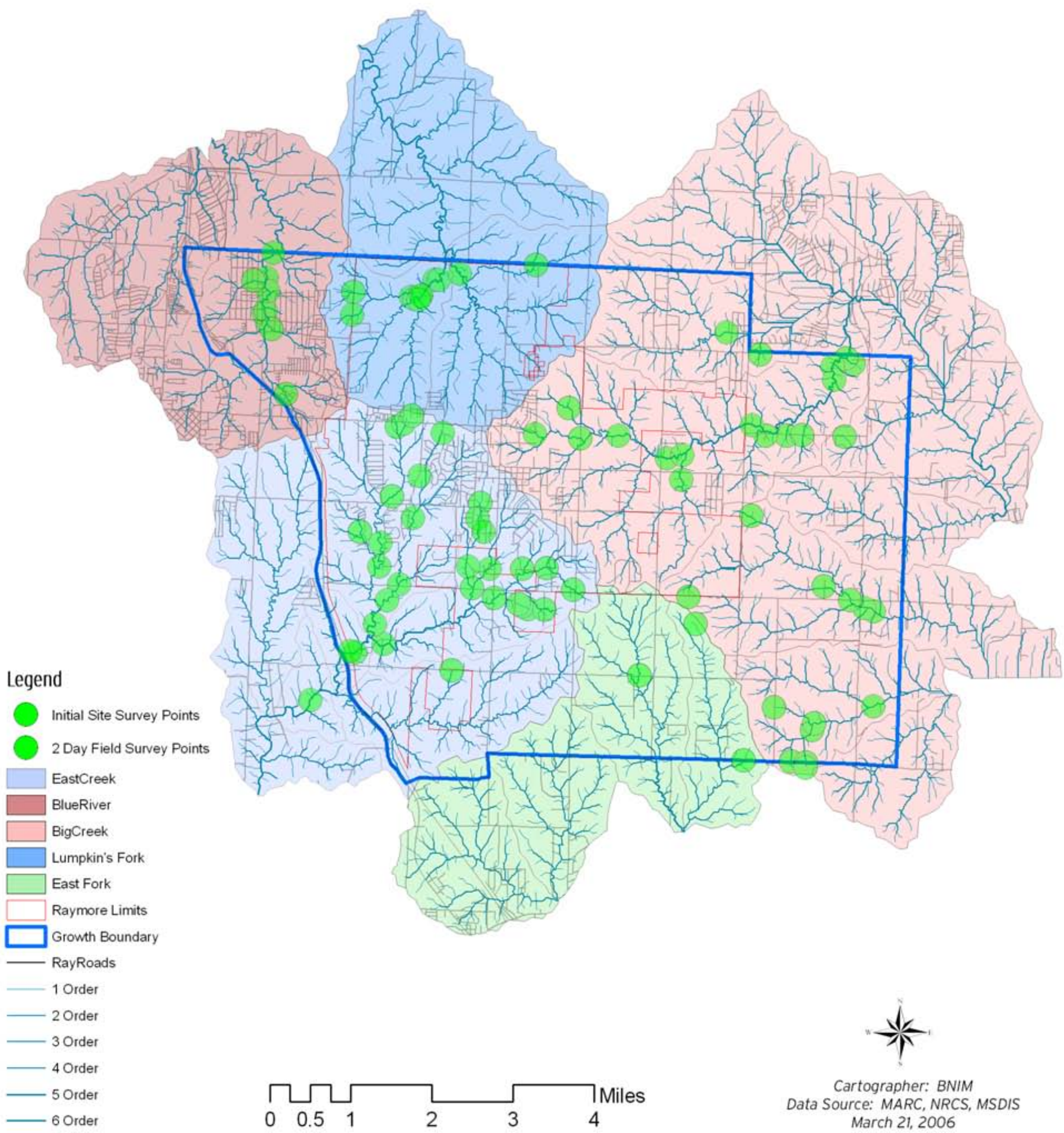


GAP Land Cover



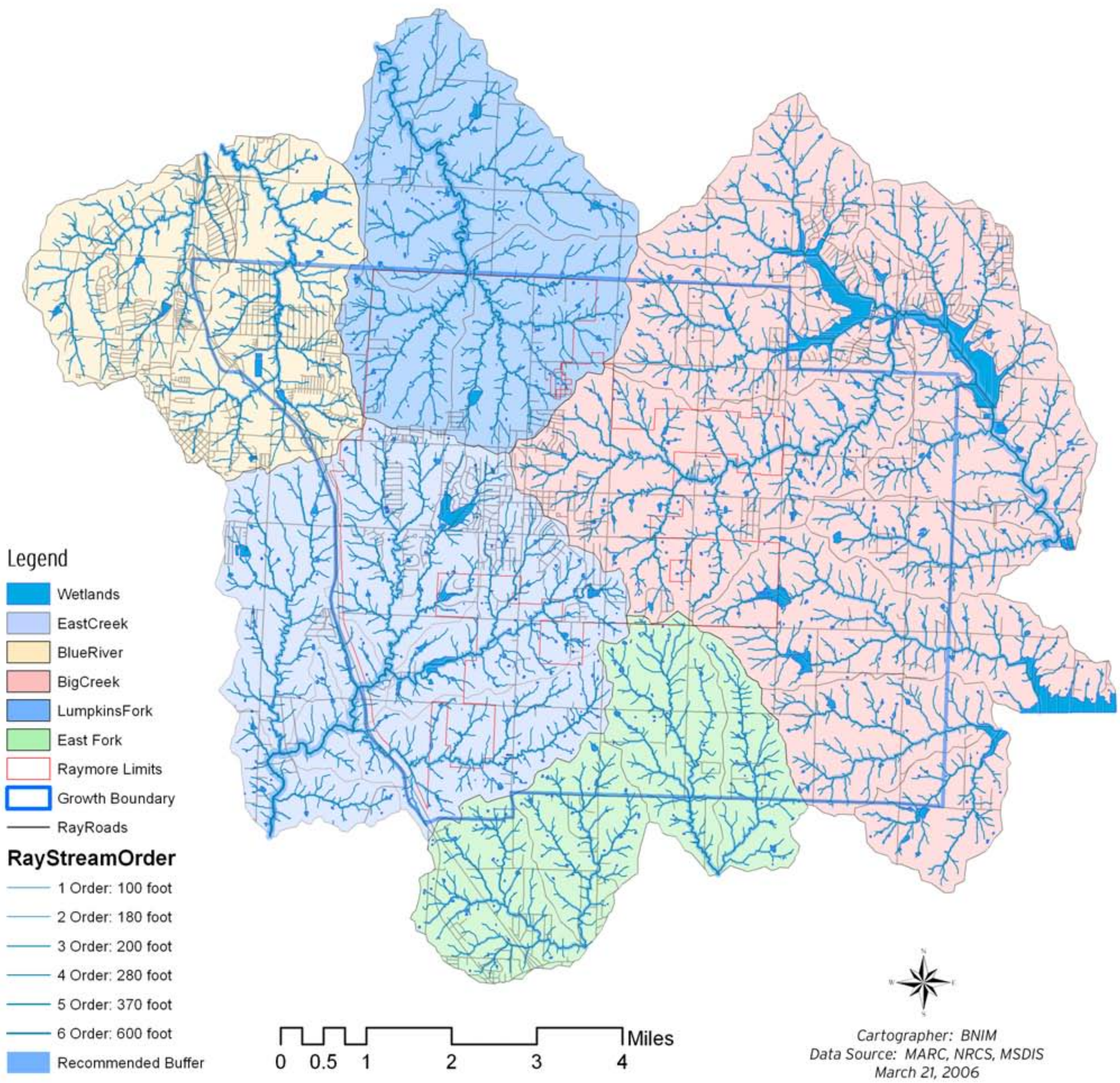

City of Raymore
Watershed Management Plan
Environmental Vulnerability
Legend
Slope
percent
0 - 18
18- 74
Urban Impervious
Urban Vegetated
Barren or Sparsely Vegetated
Row and Close-Grown Crops
Cool-season Grassland
Warm-Season Grassland
Eastern Redcedar Forest
Deciduous Woodland
Deciduous Forest
Bottomland Hardwood Forest
500 year
500 Year
Zone AE: 100 year Special
Zone A: 100 year
Wetlands
Alluvium
Surface Water Table
Growth Boundary
RayRoads
0 0.5 1 2 3 4 Miles
Cartographer: BNIM
Data Source: MARC, NRCS, MSDIS, FEMA
March 21, 2006

Points Data Log

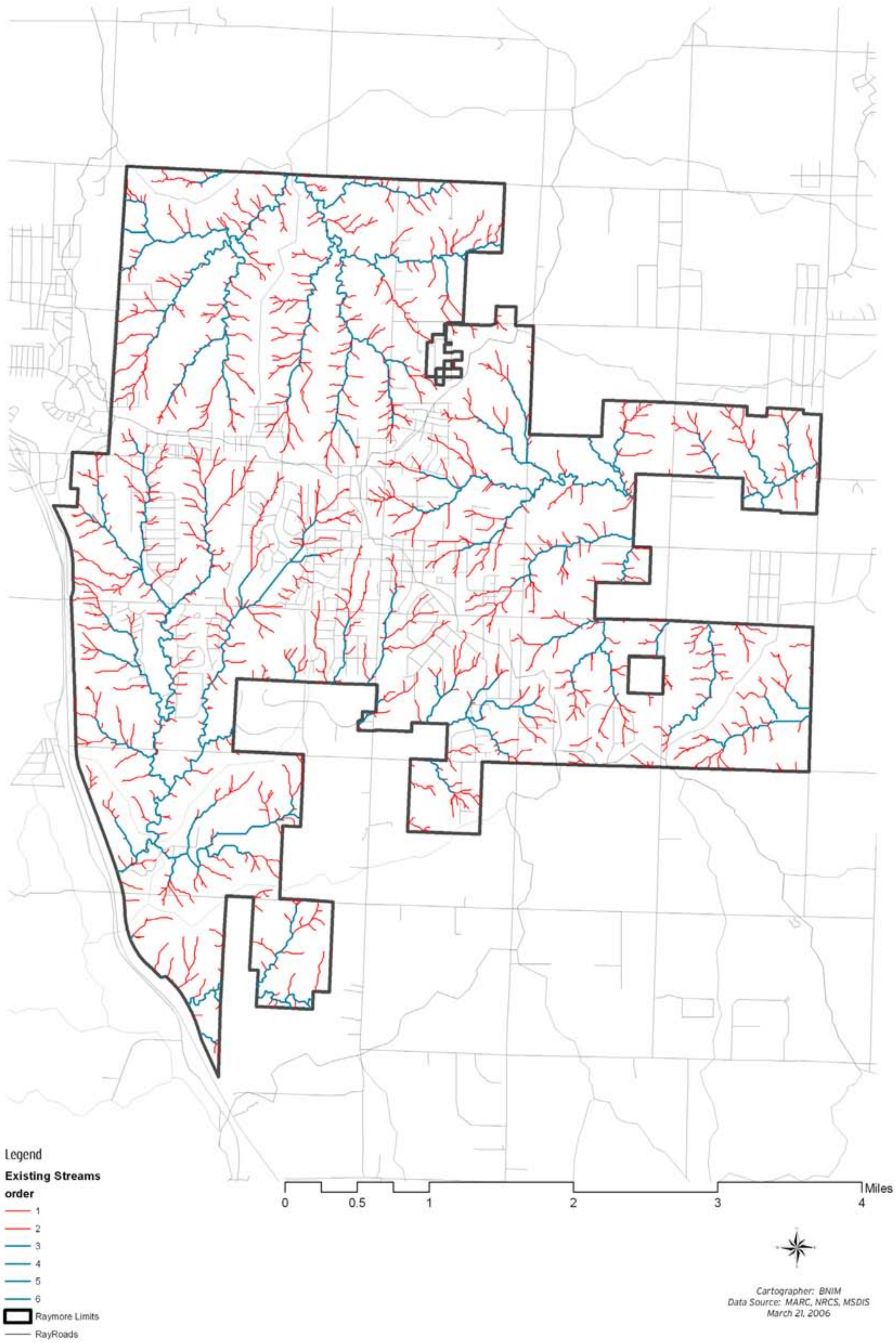


City of Raymore
Watershed Management Plan

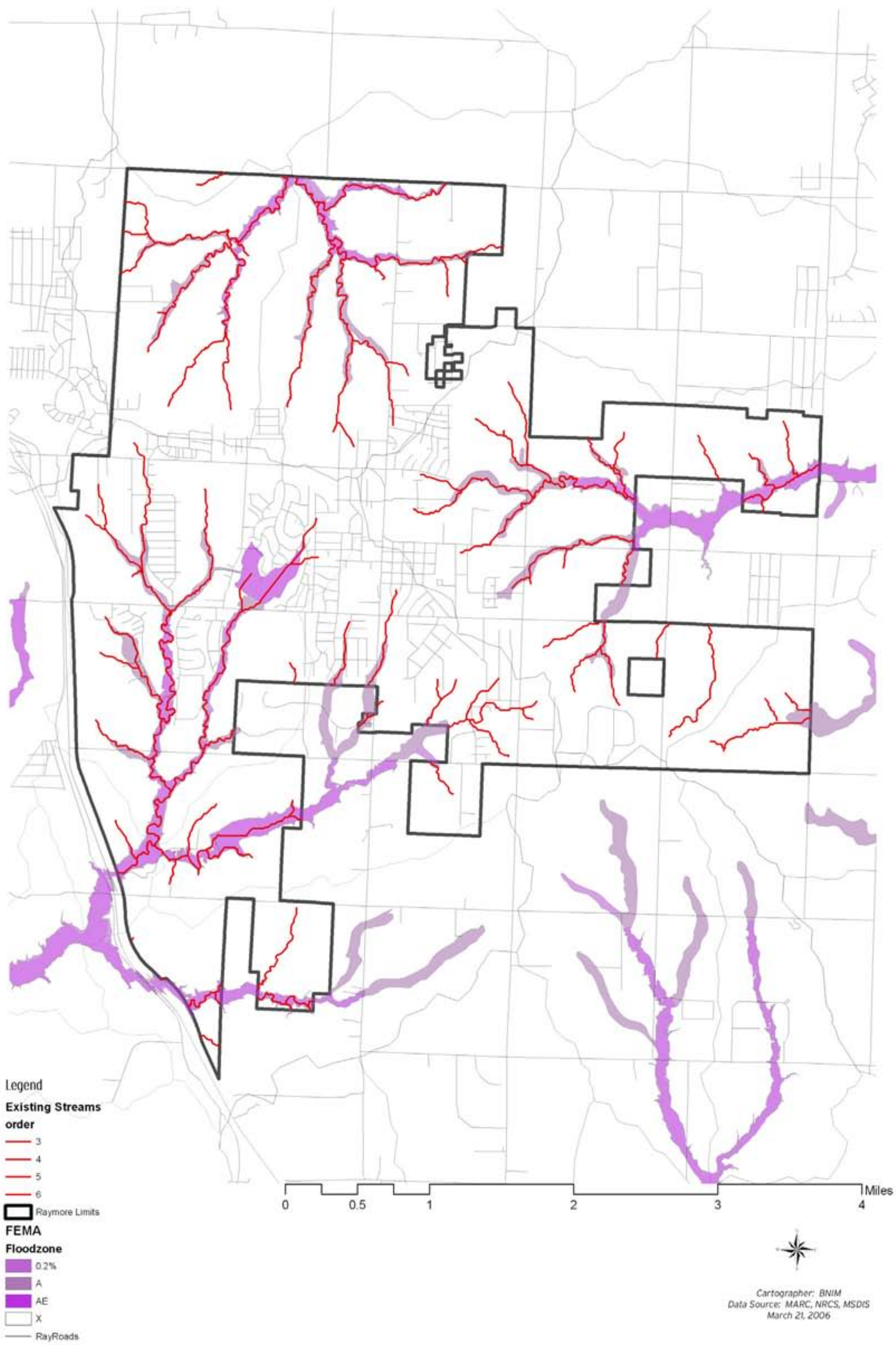
STREAM BUFFER RECOMMENDATIONS



FIRST AND SECOND ORDER STREAM DENSITY



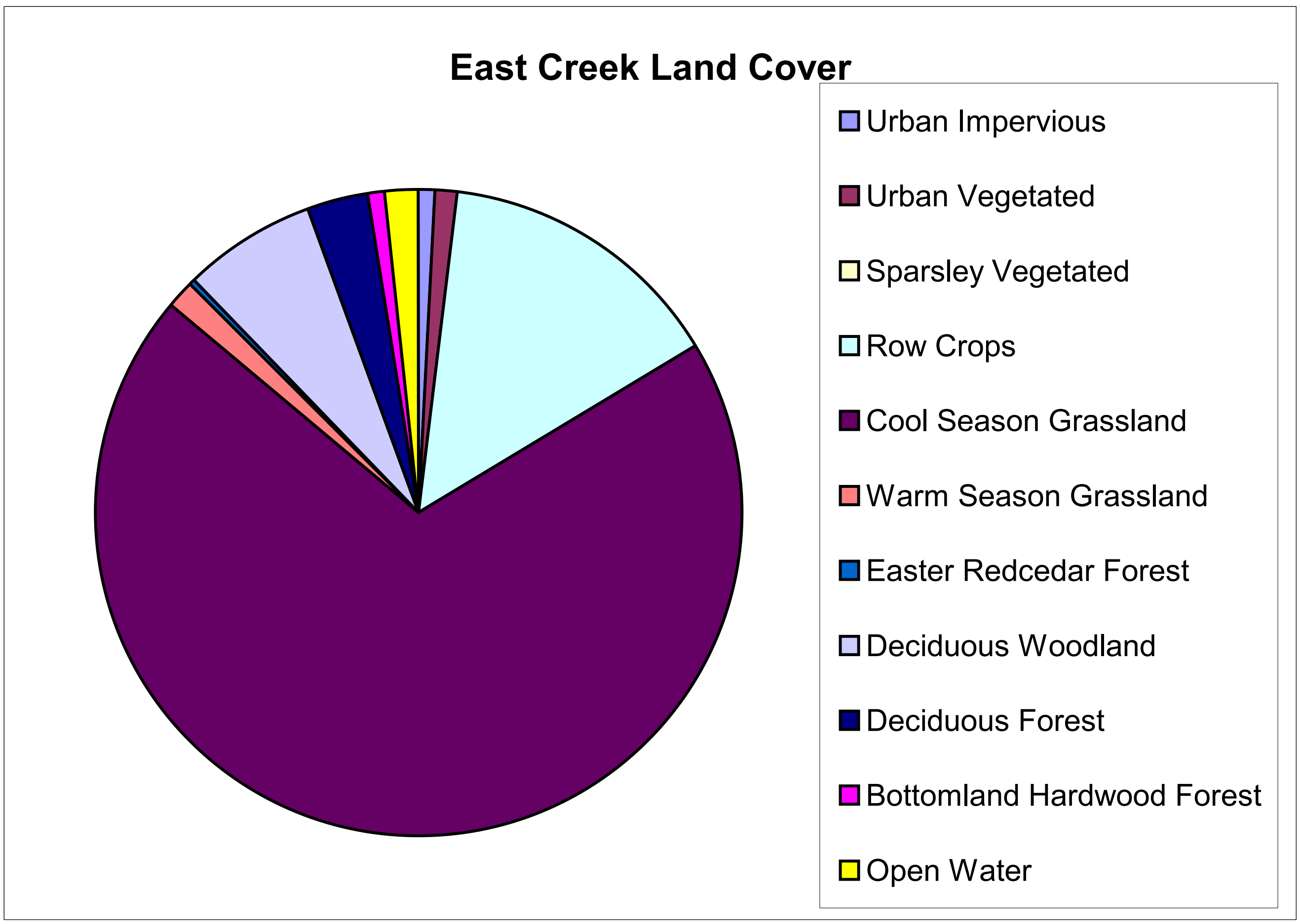
THIRD, FOURTH, FIFTH, AND SIXTH ORDER STREAM DENSITY



APPENDIX B - Sub-Basin Land -Use Statistics

East Creek Land Cover

ObjectID	Value	Count	Cover Type	Cover Percentage
0	1	262.00	Urban Impervious	0.80
1	2	371.00	Urban Vegetated	1.13
2	3	30.00	Sparsley Vegetated	0.09
3	4	4765.00	**Row Crops**	**14.47**
4	5	22947.00	**Cool Season Grassland**	**69.69**
5	6	474.00	Warm Season Grassland	1.44
6	8	27.00	Easter Redcedar Forest	0.08
7	9	2203.00	**Deciduous Woodland**	**6.69**
8	10	1035.00	Deciduous Forest	3.14
9	13	280.00	Bottomland Hardwood Forest	0.85
10	16	533.00	Open Water	1.62
		32927.00		



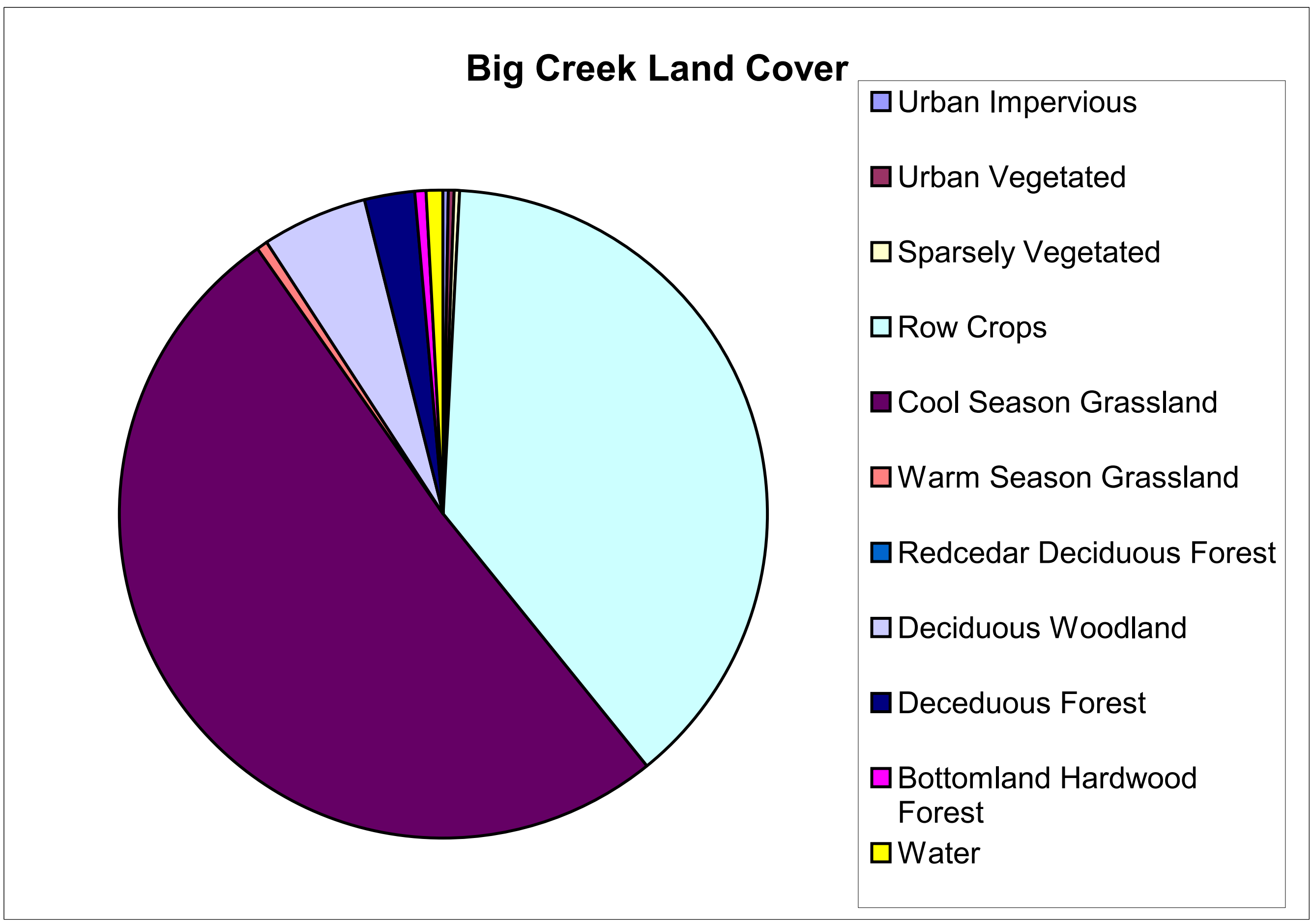
Drainage Density

East Creek of the Grand River: **17.55 Square Miles**

Stream Order	Percent
1	0.66
2	0.21
3	0.09
4	0.02
5	0.01
6	0.00

Big Creek Land Cover

ObjectID	Value	Count	Cover Type	Cover Percentage
0	1	229.00	Urban Impervious	0.40
1	2	111.00	Urban Vegetated	0.20
2	3	62.00	Sparsely Vegetated	0.11
3	4	21875.00	**Row Crops**	**38.45**
4	5	29021.00	**Cool Season Grassland**	**51.00**
5	6	413.00	Warm Season Grassland	0.73
6	8	21.00	Redcedar Deciduous Forest	0.04
7	9	2992.00	**Deciduous Woodland**	**5.26**
8	10	1347.00	Deceduous Forest	2.37
9	13	331.00	Bottomland Hardwood Forest	0.58
10	16	497.00	Water	0.87
				100.00
		56899.00		



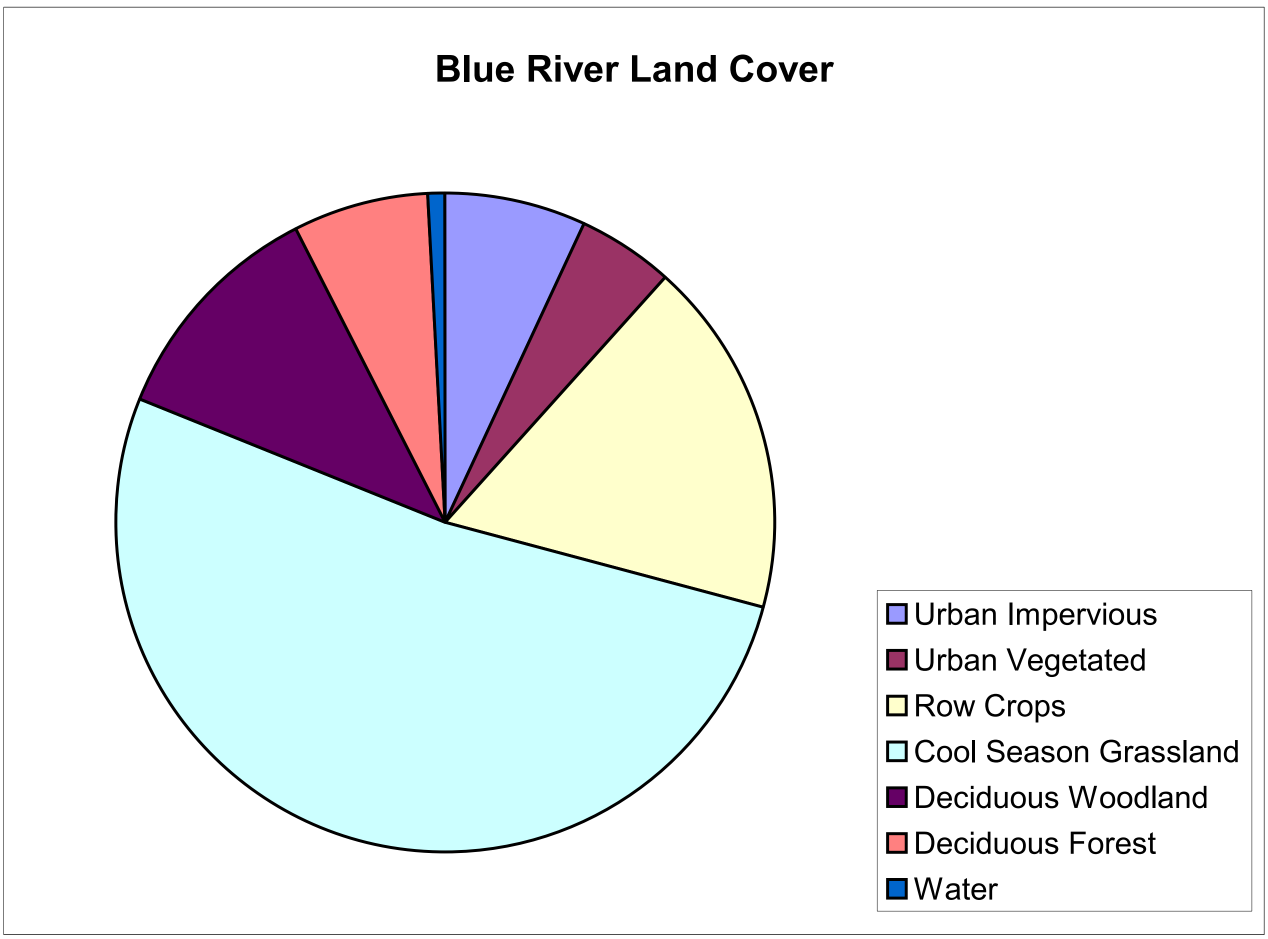
Drainage Density

Big Creek **36.16 square miles**

Stream Order	Percent
1	65.442
2	23.54948
3	7.003542
4	2.28548
5	0.936358
6	0.783139

Blue River Land Cover

ObjectID	Value	Count	Cover Type	Cover Percentage
0	1	583.00	*Urban Impervious*	*6.95*
1	2	407.00	*Urban Vegetated*	*4.85*
2	4	1461.00	**Row Crops**	**17.41**
3	5	4365.00	**Cool Season Grassland**	**52.01**
4	9	956.00	**Deciduous Woodland**	**11.39**
5	10	556.00	Deciduous Forest	6.62
6	16	65.00	Water	0.77
		8393.00		
				100.00



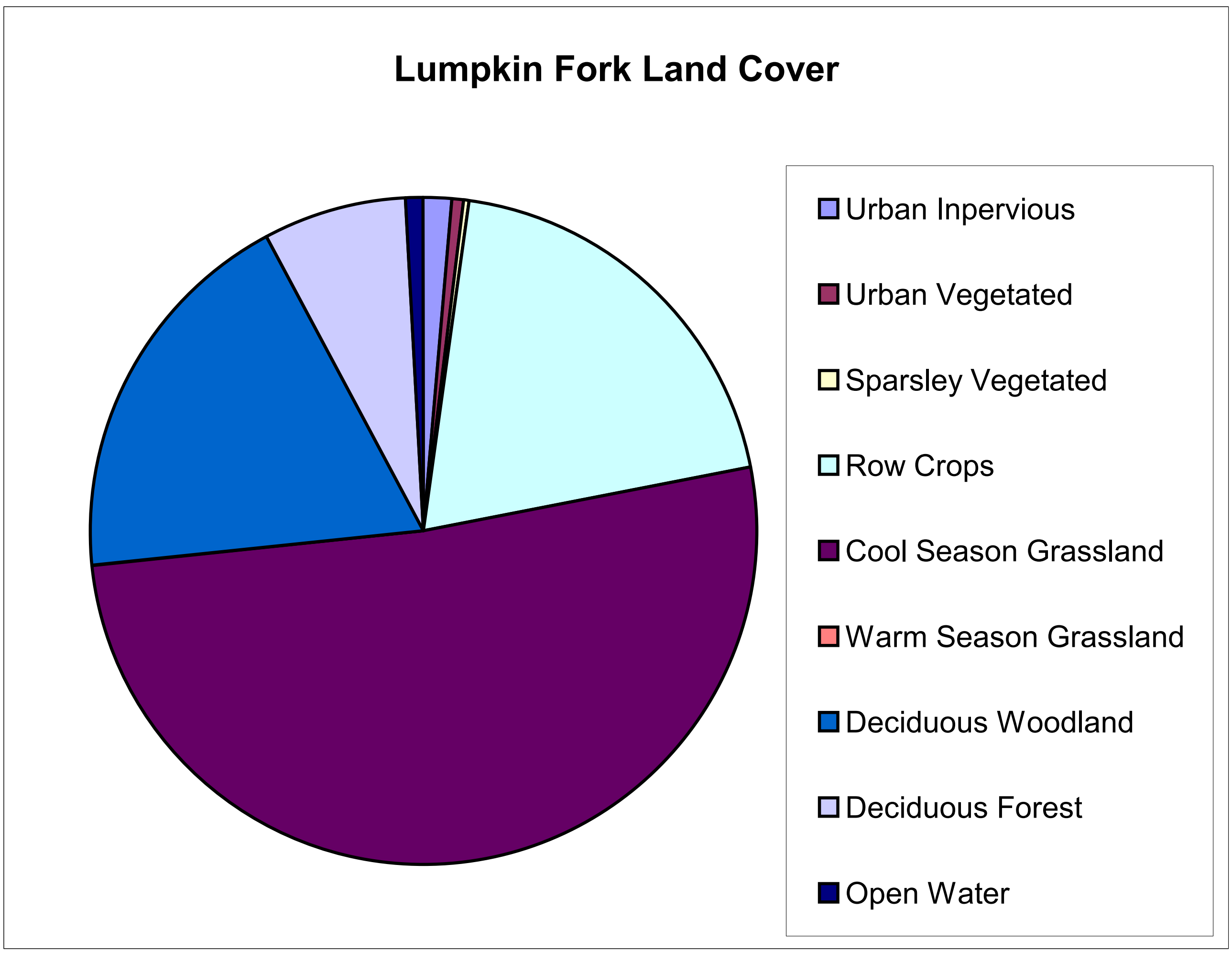
Drainage Density

Blue River: **11.29 square miles**

Stream Order	Percent
1	65.08
2	22.87
3	8.87
4	2.16
5	1.02

Lumpkins Fork of the Blue River Land Cover

ObjectID	Value	Count	Land Cover	Cover Percentage
0	1	234.00	*Urban Inpervious*	*1.45*
1	2	81.00	Urban Vegetated	0.50
2	3	35.00	Sparsley Vegetated	0.22
3	4	3178.00	**Row Crops**	**19.66**
4	5	8320.00	**Cool Season Grassland**	**51.48**
5	6	12.00	Warm Season Grassland	0.07
6	9	3064.00	**Deciduous Woodland**	**18.96**
7	10	1108.00	Deciduous Forest	6.86
8	16	130.00	Open Water	0.80
		16162.00		



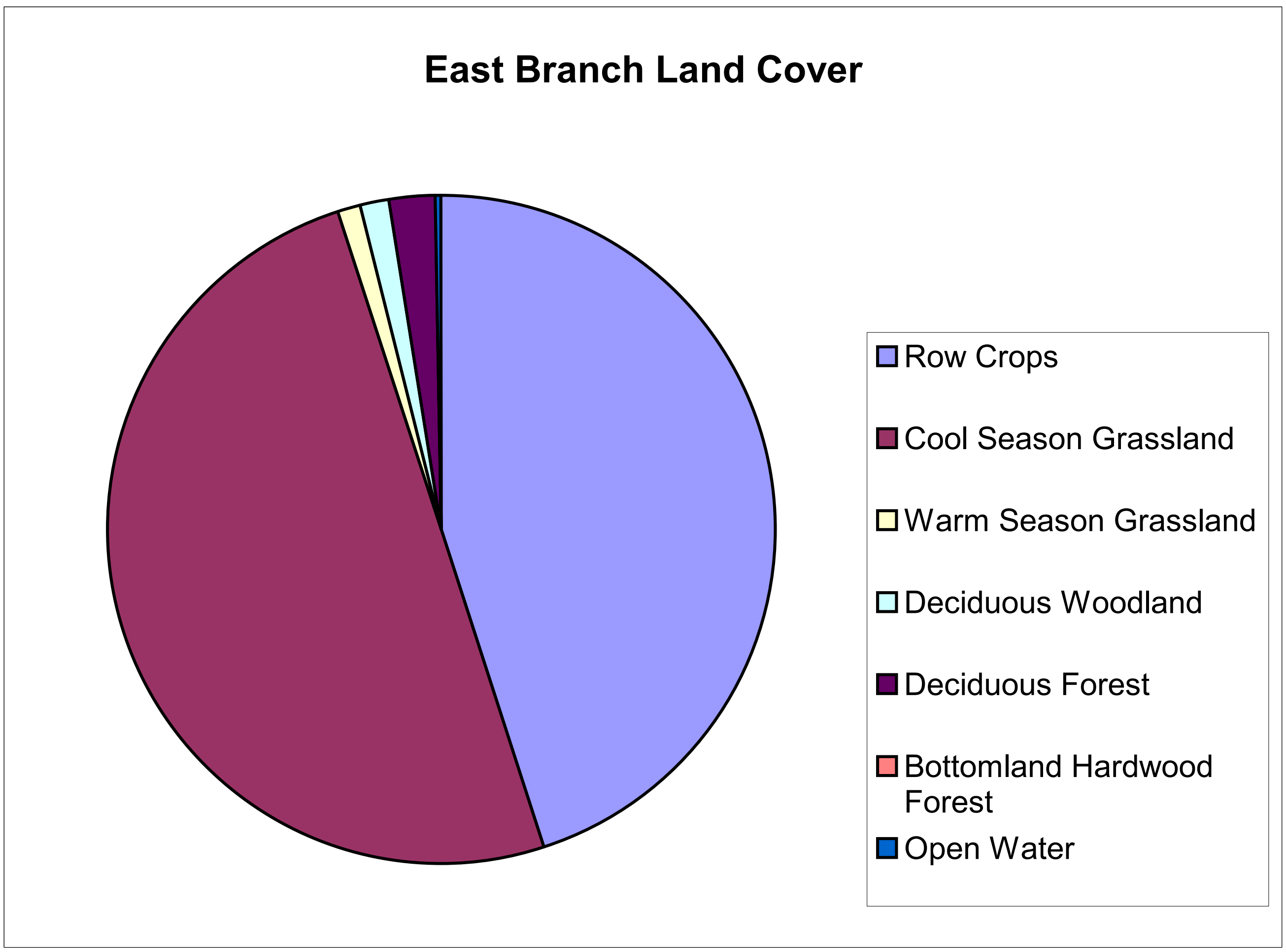
Drainage Density

Lumpkins Fork **12.577 square miles**

Stream Order	Percent
1	65.95
2	22.30
3	7.98
4	2.88
5	0.43
6	0.46

East Fork of the Grand River Land Cover

ObjectID	Value	Count	Land Cover	Cover Percentage
0	4	5580.00	**Row Crops**	**45.12**
1	5	6170.00	**Cool Season Grassland**	**49.89**
2	6	121.00	Warm Season Grassland	0.98
3	9	190.00	Deciduous Woodland	1.54
4	10	259.00	Deciduous Forest	2.09
5	13	13.00	Bottomland Hardwood Forest	0.11
6	16	33.00	Open Water	0.27
		12366.00		



Drainage Density

East Fork **9.985 square miles**

Stream order	Percent
1	0.63
2	0.24
3	0.09
4	0.03
5	0.01
6	0.00

APPENDIX C - Glossary

Active Channel: The area of the stream channel that is subject to frequent flows (approximately once per one and a half years), and that includes the portion of the channel below where the floodplain flattens.

ArcGIS: A GIS platform developed and released by Environmental Systems Research Institute (ESRI)

ArcHydro: An ESRI GIS plug-in designed to develop hydraulic modeling and mapping based on DEM's

Best Management Practice (BMP): Stormwater management practice used to prevent or control the discharge of pollutants to waters of the U.S. BMPs may include structural or non-structural solutions, a schedule of activities, prohibition of practices, maintenance procedures, or other management practices.

Bioretention: Soil and plant-based stormwater management practices designed to filter runoff from developed communities by mimicking vegetated systems that naturally control hydrology through detention, filtration, infiltration, and evapotranspiration.

Bio Swale: An open, vegetated, drainage channel or depression with an engineered soil matrix and underdrains designed to filter stormwater runoff.

Bottomlands: Low-lying lands along a watercourse subject to frequent flooding.

Detention Storage: The volume occupied by water below the level of the principal spillway crest during operation of a stormwater detention facility.

Detention Wetland: A land area that is permanently wet or periodically flooded by surface or groundwater, and has developed hydric soil properties that support vegetation growth under saturated soil conditions. It may have been engineered with adequate capacity to detain large storm flows.

Digital Elevation Model (DEM): A sattelite sensed image ascribing an elevation to 10 meter x 10 meter tiles on the surface of the earth.

Drainage Basin: The area of land which drains to a given point on a body of water.

Dry Detention Facility: Any detention facility designed to permit no permanent impoundment of water.

Floodplain: A relatively level surface that is submerged during times of flooding. Located at either side of a watercourse, it is composed of stratified alluvial soils built up by silt and sand carried out of the main channel.

Flood-zone - the area which fills with water on a annual or bi-annual cycle during seasonal rainfalls.

Geographic Information System (GIS): a computer system designed to allow users to collect, manage and analyze large volumes of spatially referenced information and associated attribute data.

Global positioning system (GPS): A handheld unit which references orbiting sattelites to create georeferenced pathways or points which are compatable with GIS

Grassed Filter Strip: A grassed area that accepts sheet flow runoff from adjacent surfaces. It slows runoff velocities and filters out sediment and other pollutants. Filter strips may be used to treat shallow, concentrated, and evenly distributed storm flows.

Grassed Swale: A broad, mildly sloped, open channel designed to convey stormwater runoff to a downstream point and to filter pollutants while doing so.

Impact Stilling Basin: A pool placed below an outlet spillway and designed for reducing discharge energies in order to minimize downstream erosive effects.

Impervious Surface: A surface that prevents infiltration of water.

Infiltration: Percolation of water into the ground.

Infiltration System: A system allowing percolation of water into the subsurface of the soil. This may recharge shallow or deep groundwater.

Landscape Patches: A non-linear surface area differing in appearance from its surroundings (Forman and Godron, 1986)

Landscape Corridors: Narrow strips of land which differ from the matirx on either side (Forman and Godron, 1986)

Landscape Matrix: The dominant landscape feature connecting patches and corridors, determined by its dominant relative area, level of connectivity, or influence on energy and nutrient dynamics. (Forman and Godron, 1986)

Mitigation: Actions taken on-site and/or off-site to offset the effects of temporary or permanent loss of a buffer or natural ecological feature

Natural Resources Inventory (NRI): An inventory of salient natural and biological resources

National Wetlands Inventory (NWI): An estimation of existing wetlands produced by the National Fish and Wildlife Service.

Native Species: Plant and animal species that exist in the region where they have evolved.

Natural Channel: Any river, creek, channel, or drainageway that has an alignment, bed and bank materials, profile, bed configuration, and channel shape predominately formed by the action of moving water, sediment migration, and biological activity. The natural channel's form results from regional geology, geography, ecology, and climate.

National Pollutant Discharge Elimination System (NPDES): Defined in Section 402 of the Clean Water Act, this provides for the permit system that is key for enforcing the effluent limitations and water quality standards of the Act. The Phase II Final Rule published in the Federal Register on December 8, 1999 requires NPDES permit coverage for stormwater discharges from certain regulated, small, municipal, separate storm sewer systems (MS4s) and from land areas between 1 and 5 acres disturbed by construction.

Perennial stream- means a stream that flows continuously throughout the year in most years. These streams usually appear as a blue line on USGS topographic quadrangle maps or on USDA County Soil Survey Maps.

Porous Pavement: A special type of pavement that allows water to infiltrate the surface layer and enter into a high-void, aggregate, sub-base layer. The captured water is stored in the reservoir layer until it either infiltrates the underlying soil strata or is routed through an underdrain system to a conventional stormwater conveyance system.

Predevelopment: The time period prior to a proposed or actual development activity at a site. Predevelopment may refer an undeveloped site or a developed site that will be redeveloped or expanded.

Rain Garden: A small residential depression planted with native wetland and prairie vegetation, rather than a turfgrass lawn, where runoff collects and infiltrates.

Raster: A digital square or cell containing a value.

Riparian Zone: The vegetated strip along the fringe of a stream or other water body.

Riparian Buffers: Strips of herbaceous and woody vegetation along perennial and intermittent streams and open bodies of water. Riparian Buffers capture sediment and other pollutants in surface runoff water before these enter the adjoining surface waterbody.

Stormwater Detention Facility: Any structure, device, or combination thereof with a controlled discharge rate less than its inflow rate.

Stream Bank Stabilization: A drainage channel stabilized with geosynthetic or other structural materials. A bioengineered channel embodies biological, ecological, and engineering concepts to convey stormwater runoff, prevent soil erosion, control sedimentation, and provide wildlife habitat.

Stream Channel: Part of a water course either naturally or artificially created which contains an intermittent or perennial base flow of groundwater origin. Base flows of groundwater origin can be distinguished by any of the following physical indicators:
1) Hydrophytic vegetation, hydric soil or other hydrologic indicators in the area(s) where groundwater enters the stream channel, in the vicinity of the stream headwaters, channel bed or channel banks
2) Flowing water not directly related to a storm event
3) Historical records of a local high groundwater table, such as well and stream gauge records.

Stream Order: A classification system for streams based on stream hierarchy. The smaller the stream, the lower its numerical classification. For example, a first order stream does not have tributaries and normally originates from springs and/or seeps. At the confluence of two first order streams, a second order stream begins, and so on.

Treatment Train: The series of BMPs (or other treatments) used to achieve biological and physical treatment efficiencies necessary for removing pollutants from stormwater (or other wastewater flows).

Tree Preservation: Maintenance of existing trees and shrubs.

Total Suspended Solids (TSS): Matter suspended in stormwater excluding litter, debris, and other gross solids exceeding 1 millimeter in diameter.

Uplands: Lands elevated above the floodplain that are seldom or never inundated.

Water Quality: The chemical, physical, and biological characteristics of water. This term also can refer to regulatory concerns about water's suitability for swimming, fishing, drinking, agriculture, industrial activity, and healthy aquatic ecosystems.

Water Quality Storm: The storm event that produces less than or equal to 90 percent stormwater runoff volume of all 24-hour storms on an annual basis.

Water Quality Volume (WQv): The storage needed to capture and treat 90 percent of the average annual stormwater runoff volume. It is calculated by multiplying the Water Quality Storm times the volumetric runoff coefficient and site area.

Watershed: All the land area that drains to a given body of water (also described as a basin, catchment, and drainage area).

Wet Detention: A constructed system with sufficient capacity to detain flood volumes and to store the WQv in a permanent pool.

Wetland Treatment System: A stormwater or wastewater treatment system consisting of shallow ponds and channels vegetated with aquatic or emergent plants. This system relies on natural microbial, biological, physical, and chemical processes to treat stormwater or wastewater.

APPENDIX D - References

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