2023 Upper Colorado Regional Flood Plan

draft December 21, 2022

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Draft 2023 Upper Colorado Regional Flood Plan

August 2022

Prepared for Upper Colorado Regional Flood Planning Group

Administered by Upper Colorado Regional Flood Planning Group Sponsor

Prepared by

Draft 2023 Upper Colorado Regional Flood Plan

August 2022

Upper Colorado Regional Flood Planning Group

Voting Members	Non-Voting Members
Kenneth Dierschke *Agriculture*	John McEachern *Texas Parks and Wildlife*
Rick Bacon (At-Large) *Counties*	Tim Frere *Texas Division of Emergency Management*
Henryk Olstowski *Electric Generating Utilities*	Larissa Place *Texas Department of Agriculture*
Shannon McMillan *Environmental*	Ben Wilde *Texas State Soil and Water Conservation Board*
Morse Haynes *Industries*	Jet Hays *General Land Office*
Lance Overstreet, PE (Secretary) *Municipalities*	Tressa Olsen *Texas Water Development Board*
David H. Loyd Jr., PhD *Public*	Winona Henry *Abilene, Texas Commission on Environmental Quality*
Scott McWilliams, PG *River Authorities*	Anne Yakimovicz *Lower Colorado River Authority*
Chuck Brown (Vice-Chairman) *Small Business*	
Cole D. Walker, PE *Water Districts*	
Allison Strube, PE (Chairman) *Water Utilities*	

The City Of

San Angelo, Texas

Water Utilities Department
301 W. Beauregard Avenue, San Angelo, TX 76903

August 1, 2022

Mr. Jeff Walker
Texas Water Development Board
Executive Administrator
P.O. Box 13231
1700 N. Congress Ave.
Austin, Texas 78711-3231

Re: Submittal of Draft 2023 Upper Colorado Regional Flood Plan

Dear Mr. Walker:

On July 6, 2022, the Upper Colorado Regional Flood Planning Group approved and adopted the Draft 2023 Regional Flood Plan for the Upper Colorado Flood Planning Region. The Plan was developed in accordance with Texas Water Code and 31 TAC Chapters 361 and 362 and is complete.

Following this Plan submittal to the TWDB, the Draft Flood Plan will be distributed for public inspection in accordance with 31 TAC Chapter 21(d)(4). A public hearing is scheduled for September 14, 2022. At the hearing, the Group will receive comments on the Draft 2023 Upper Colorado Flood Plan. This provides sufficient time to accept public comments according to statute to meet the January 10, 2023, adopted final Regional Flood Plan submission deadline.

The Upper Colorado Regional Flood Planning Group met all requirements under the Texas Open Meetings Act and Public Information Act in accordance with 31 TAC Chapters 357.12, 357.21, and 357.50(f) during development of the Draft 2023 Upper Colorado Flood Plan.

Included with this submittal, please find the following.

- Two (2) double-sided hard copies and two (2) electronic copies (one in searchable PDF and one in Microsoft Word format).
- An executive summary that contains less than 20 pages.
- Electronic excel versions using the templates provided by the TWDB
- A set of Arc-GIS compatible data constituting a single file geodatabase of feature classes.
- Models for each recommended FMP.

Sincerely,

Allison Strube

Allison Strube, P.E.
Upper Colorado Regional Flood Planning Group Chair
Director of Water Utilities, City of San Angelo

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Appendices

(TWDB-required tables and maps)

Acronyms

ARPA	American Rescue Plan Act
ASDSO	Association of State Dam Safety Officials
ATSDR	Agency for Toxic Substances and Disease Registry
BCA	benefit-cost analysis
BCR	benefit-cost ratio
BFE	base flood elevation
BIL	Bipartisan Infrastructure Law
BLE	base flood elevation
BRIC	Building Resilient Infrastructure and Communities
CAP	Continuing Authorities Program
CDBG-DR	Community Development Block Grant Disaster Recovery Funds
CDBG-MIT	Community Development Block Grant – Mitigation
CDC	Centers for Disease Control and Prevention
CFR	Code of Federal Regulations
cfs	cubic feet per second
CIP	capital involvement plan
COG	Council of Governments
CTP	Cooperating Technical Partners Program
CRS	Community Rating System
CVCOG	Concho Valley Council of Governments
CWSRF	Clean Water State Revolving Fund
DD	drainage district
Dfund	Texas Water Development Fund
DHS	U.S. Department of Homeland Security
DPS	Texas Department of Public Safety
EAP	Emergency Action Plan
EAS	Emergency Alert System
EWP	Emergency Watershed Protection
FAFDS	First American Flood Data Services
FCD	flood control district
FEMA	Federal Emergency Management Agency
FIF	Flood Infrastructure Fund
FIRM	Flood Insurance Rate Map
FIS	flood insurance study
FMA	Flood Mitigation Assistance
FME	flood management evaluation
FMP	flood mitigation project
FMS	flood management strategies

FRMP	Flood Risk Management Program
FWSD	fresh water supply district
GIS	geographic information system
GLO	Texas General Land Office
H&H	hydrologic and hydraulic
HHPD	Rehabilitation of High Hazard Potential Dam Grant Program
HMAP	hazardous mitigation action plan
HMPG	Hazard Mitigation Grant Program
HUC	hydrologic unit code
HUD	U.S. Department of Housing and Urban Development
IIJA	Infrastructure Investment and Jobs Act
LID	Low Income Development
LWC	low-water crossing
MS4	municipal separate storm sewer systems permit
MUD	municipal utility district
MWD	municipal water district
NFHL	National Flood Hazard Layer
NFIP	National Flood Insurance Program
NOAA	National Oceanic and Atmospheric Administration
NRCS	Natural Resources Conservation Service
NWS	National Weather Service
O&M	operations and maintenance
OSHA	Occupational Safety and Health Administration
PA	Public Assistance
PMF	probable maximum flood
RFC	River Forecast Center
RFPG	regional flood planning group
Risk MAP	FEMA Risk Mapping, Assessment and Planning Program
SB3	Senate Bill 3
SB7	Senate Bill 7
SB8	Senate Bill 8
SFHA	Special Flood Hazard Area
SFP	state flood plan
STORM	Safeguarding Tomorrow through Ongoing Risk Mitigation
SVI	Social Vulnerability Index
SWIFT	State Water Implementation Fund for Texas
SWCD	soil and water conservation district
SWMD	solid waste management district
TAC	Texas Administrative Code
TCEQ	Texas Commission on Environmental Quality
TDA	Texas Department of Agriculture

TDEM	Texas Division of Emergency Management
TFMA	Texas Floodplain Management Association
TIFP	Texas Instream Flow Program
TMDL	total maximum daily load
TNRIS	Texas Natural Resources Information System
TPDES	Texas Pollutant Discharge Elimination System
TPWD	Texas Parks and Wildlife Department
TSSWCB	Texas State Soil and Water Conservation Board
TWDB	Texas Water Development Board
TxCDBG	Community Development Block Grant Program for Rural Texas
TxDOT	Texas Department of Transportation
UCFPR	Upper Colorado Flood Planning Region
USACE	U.S. Army Corps of Engineers
USD	U.S. dollars
USDA	United States Department of Agriculture
USGS	U.S. Geological Survey
WCID	water control and improvement district
WCTCOG	West Central Texas Council of Governments
WRDA	Water Resources Development Acts
WSD	water supply district

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Executive Summary

In 2019, the Texas Water Development Board (TWDB) was assigned the administration of a new state and regional flood planning process with flood planning regions based on river basins. The TWDB designated 15 regional flood planning areas, including the Upper Colorado Flood Planning Region (UCFPR), also designated by the TWDB as Region 9. Regional flood planning groups (RFPGs) were designated and assigned the development of a regional flood plan for their region. The members of the Upper Colorado Regional Flood Planning Group (UCRFPG) are shown in Table ES-1. The initial RFPGs were formed on October 1, 2020. The first regional flood plans are due by January 2023. The TWDB will then bring the regional flood plans together to produce the first state flood plan (SFP) by September 1, 2024.

Table ES-1. UCRFPG Membership

Member Name	Interest Category	Organization
Kenneth Dierschke	Agriculture	Dierschke Farms
Rick Bacon (At-Large)	Counties	Tom Green County
Henryk Olstowski	Electric Generating Utilities	Luminant
Shannon McMillan	Environmental	Centurion Planning & Design
Vacant	Flood Districts	--
Morse Haynes	Industries	Andrews Economic Development Corporation
Lance Overstreet, PE (Secretary)	Municipalities	U.S. Air Force
David H. Loyd Jr., PhD	Public	Retired Physics Professor and Dean – Angelo State University
Scott McWilliams, PG	River Authorities	Upper Colorado River Authority
Chuck Brown (Vice-Chairman)	Small Business	Hydro Corporation
Cole D. Walker, PE	Water Districts	Colorado River Municipal Water District
Allison Strube, PE (Chairman)	Water Utilities	City of San Angelo

Guiding Principles

This executive summary presents the key findings and recommendations from the *2023 Regional Flood Plan for Flood Planning Region 9 – Upper Colorado* (UCRFP). The UCRFP for conforms with the guidance principles in Title 31 of the Texas Administrative Code (TAC) §362.3. Title 31 TAC §362.3 (b) states "Development of the region and state flood plans shall be guided by the following principles. The regional and state flood plans:", which is followed by 39 enumerated guidance principles. The Technical Guidelines for Regional Flood Planning[1] states the contents must include an explanation of how the UCRFP satisfies the requirements of each of the principles. The guidance principles and the means these requirements are met in the UCRFP are listed in Table ES-2 along with references to the UCRFP chapters, which are listed in Table ES-3.

Table ES-2. Title 31 TAC §362.3 Guidance Principles and the Means by which Requirement is Met in UCRFP

Guidance Principle	Means by which Requirement is Met in Upper Colorado Regional Flood Plan (UCRFP)
(1) shall be a guide to state, regional, and local flood risk management policy;	The UCRFP is a guide with management goals in Chapter 3, management strategies in Chapter 5, and management and policy recommendations in Chapter 8.
(2) shall be based on the best available science, data, models, and flood risk mapping;	Best available information from a quality, coverage, and contemporary perspective were used in UCRFP, for example in Chapter 2 analyses.
(3) shall focus on identifying both current and future flood risks, including hazard, exposure, vulnerability and residual risks; selecting achievable flood mitigation goals, as determined by each RFPG for their region; and incorporating strategies and projects to reduce the identified risks accordingly;	The UCRFP examines current and future flood risk in Chapter 2, mitigation goals in Chapter 3, and strategies in Chapter 5. Maps show the areas of flood risks.

[1] TWDB 2022. 2023 Regional Flood Plan Working Documents (2020-2023). [2023 Regional Flood Plan | Texas Water Development Board]

Guidance Principle	Means by which Requirement is Met in Upper Colorado Regional Flood Plan (UCRFP)
(4) shall, at a minimum, evaluate flood hazard exposure to life and property associated with 0.2 percent annual chance flood event (the 500-year flood) and, in these efforts, shall not be limited to consideration of historic flood events;	Flood hazard exposure is evaluated and presented in Chapter 2. Maps show the areas of flood risks associated with different percent annual chance flood event.
(5) shall, when possible and at a minimum, evaluate flood risk to life and property associated with 1.0 percent annual chance flood event (the 100-year flood) and address, through recommended strategies and projects, the flood mitigation goals of the RFPG (per item 2 above) to address flood events associated with a 1.0 percent annual chance flood event (the 100-year flood); and, in these efforts, shall not be limited to consideration of historic flood events;	Flood risks are evaluated and presented in Chapter 2, with recommended strategies and projects provided in Chapter 7 and Chapter 8.
(6) shall consider the extent to which current floodplain management, land use regulations, and economic development practices increase future flood risks to life and property and consider recommending adoption of floodplain management, land use regulations, and economic development practices to reduce future flood risk;	Floodplain management practices throughout the Upper Colorado Region are mostly low and could be expanded as described in Chapter 3. Increased recognition of floodplains and flood risk is needed for most of the region.
(7) shall consider future development within the planning region and its potential to impact the benefits of flood management strategies (and associated projects) recommended in the plan;	Future development is considered in Chapter 2 and Chapter 3. Midland, Odessa, and San Angelo are the areas with greatest potential for developmental pressures in flood prone areas needing management strategies.
(8) shall consider various types of flooding risks that pose a threat to life and property, including, but not limited to, riverine flooding, urban flooding, engineered structure failures, slow rise flooding, ponding, flash flooding, and coastal flooding, including relative sea level change and storm surge;	Various types of flooding risks that pose a threat to life and property, including, but not limited to, riverine flooding, urban flooding, engineered structure failures, slow rise flooding, ponding, playa flooding, and flash flooding, are considered in Chapter 2. Coastal flooding is not applicable in the Upper Colorado Region.

Guidance Principle	Means by which Requirement is Met in Upper Colorado Regional Flood Plan (UCRFP)
(9) shall focus primarily on flood management strategies and projects with a contributing drainage area greater than or equal to 1.0 (one) square miles except in instances of flooding of critical facilities or transportation routes or for other reasons, including levels of risk or project size, determined by the RFPG;	Chapter 4 and Chapter 5 focus on flood management strategies and projects.
(10) shall consider the potential upstream and downstream effects, including environmental, of potential flood management strategies (and associated projects) on neighboring areas. In recommending strategies, RFPGs shall ensure that no neighboring area is negatively affected by the regional flood plan;	Consideration of neighboring area is described in Chapter 4 and Chapter 5. Strategies and projects are assessed to confirm negative impacts to surrounding areas would not occur.
(11) shall include an assessment of existing, major flood mitigation infrastructure and will recommend both new strategies and projects that will further reduce risk, beyond what existing flood strategies and projects were designed to provide, and make recommendations regarding required expenditures to address deferred maintenance on or repairs to existing flood infrastructure;	Infrastructure is evaluated in Chapter 4 and Chapter 5. The strategies and projects include many related to infrastructure. In fact, there may be too much focus on classical infrastructure controls and a need for more deliberation on alternative solutions. Chapter 9 examines the financing aspects.
(12) shall include the estimate of costs and benefits at a level of detail sufficient for RFPGs and sponsors of flood mitigation projects to understand project benefits and, when applicable, compare the relative benefits and costs, including environmental and social benefits and costs, between feasible options;	Costs drive most decision making and are discussed in most chapters, although Chapter 4, Chapter 5, and Chapter 9 present the most information on costs. For the most part, costs are likely underestimated for a variety of reasons, including lack of problem and solution definition, extent of flood damage, and inflation.
(13) shall provide for the orderly preparation for and response to flood conditions to protect against the loss of life and property and reduce injuries and other flood-related human suffering;	Preparation and response is described in Chapter 7.

Guidance Principle	Means by which Requirement is Met in Upper Colorado Regional Flood Plan (UCRFP)
(14) shall provide for an achievable reduction in flood risk at a reasonable cost to protect against the loss of life and property from flooding;	Like costs and benefits in Chapter 4 and Chapter 5, reasonable costs to achievable reduction in flood risk is considered.
(15) shall be supported by state agencies, including the TWDB, General Land Office, Texas Commission on Environmental Quality, Texas State Soil and Water Conservation Board, Texas Parks and Wildlife Department, and the Texas Department of Agriculture, working cooperatively to avoid duplication of effort and to make the best and most efficient use of state and federal resources;	Agency representation is addressed in Chapter 10, Public Participation.
(16) shall include recommended strategies and projects that minimize residual flood risk and provide effective and economical management of flood risk to people, properties, and communities, and associated environmental benefits;	Chapter 5 includes recommended strategies and projects.
(17) shall include strategies and projects that provide for a balance of structural and nonstructural flood mitigation measures, including projects that use nature-based features, that lead to long-term mitigation of flood risk;	Chapter 2 includes nature-based goals. Chapter 4 and Chapter 5 include strategies and projects that are labeled as other, which includes nature-based solutions. A variety of strategies and projects are included but balance could be improved in future planning.
(18) shall contribute to water supply development where possible;	Contributions and impacts to water supply development are assessed in Chapter 6. Due to the hydrology and landscape of the region, there is little potential to contribute or impact water supply development.
(19) shall also follow all regional and state water planning guidance principles (31 TAC 358.3) in instances where recommended flood projects also include a water supply component;	Contributions and impacts to water supply development are assessed in Chapter 6. Due to the hydrology and landscape of the region, there is little potential to contribute or impact water supply development.

Guidance Principle	Means by which Requirement is Met in Upper Colorado Regional Flood Plan (UCRFP)
(20) shall be based on decision-making that is open to, understandable for, and accountable to the public with full dissemination of planning results except for those matters made confidential by law;	The UCRFP is based on the requirements of the TAC and the associated TWDB technical guidance documents.
(21) shall be based on established terms of participation that shall be equitable and shall not unduly hinder participation;	The UCRFP is based on the requirements of the TAC and the associated TWDB technical guidance documents. Chapter 10 directly addressed public participation.
(22) shall include flood management strategies and projects recommended by the RFPGs that are based upon identification, analysis, and comparison of all flood management strategies the RFPGs determine to be potentially feasible to meet flood mitigation and floodplain management goals;	The UCRFPG worked directly with the technical consultant in the development of the UCRFP as described in Chapter 1.
(23) shall consider land-use and floodplain management policies and approaches that support short- and long-term flood mitigation and floodplain management goals;	Land-use and floodplain management policies and approaches that support short- and long-term flood mitigation and floodplain management goals are addressed in Chapter 3
(24) shall consider natural systems and beneficial functions of floodplains, including flood peak attenuation and ecosystem services;	Chapter 3 includes natured-based goals like attenuation and ecosystem services within the category of environmental stewardship.
(25) shall be consistent with the National Flood Insurance Program (NFIP) and shall not undermine participation in nor the incentives or benefits associated with the NFIP;	This is a primary aspect of the goals and purpose of the UCRFP as stated in Chapter 1. The UCRFP is consistent with the NFIP.
(26) shall emphasize the fundamental importance of floodplain management policies that reduce flood risk;	Policies that reduce flood risk are a fundamental importance of the UCRFP and is specifically emphasize in Chapter 2.

Guidance Principle	Means by which Requirement is Met in Upper Colorado Regional Flood Plan (UCRFP)
(27) shall encourage flood mitigation design approaches that work with, rather than against, natural patterns and conditions of floodplains;	Chapter 3 includes natured-based goals to work with natural patterns and conditions within the category of environmental stewardship.
(28) shall not cause long-term impairment to the designated water quality as shown in the state water quality management plan as a result of a recommended flood management strategy or project;	The conclusion of Chapter 6 states there are no anticipated impacts to the State Water Quality Management Plan.
(29) shall be based on identifying common needs, issues, and challenges; achieving efficiencies; fostering cooperative planning with local, state, and federal partners; and resolving conflicts in a fair, equitable, and efficient manner;	These are part of the process for identifying the FME, FMS, and FMP lists as described in Chapter 5.
(30) shall include recommended strategies and projects that are described in sufficient detail to allow a state agency making a financial or regulatory decision to determine if a proposed action before the state agency is consistent with an approved regional flood plan;	Chapter 5 includes recommended strategies and projects.
(31) shall include ongoing flood projects that are in the planning stage, have been permitted, or are under construction;	Chapter 1 includes discussion about proposed and ongoing flood mitigation projects. Ongoing projects are primarily by the largest cities, Midland, Odessa and San Angelo.
(32) shall include legislative recommendations that are considered necessary and desirable to facilitate flood management planning and implementation to protect life and property;	Legislative recommendations along with rationale are provided in Chapter 8.
(33) shall be based on coordination of flood management planning, strategies, and mitigation projects with local, regional, state, and federal agencies projects and goals;	These are part of the process for identifying the FME, FMS, and FMP lists with the Upper Colorado Regional Flood Planning Group (UCRFPG) providing the coordination as described in Chapter 5.

Guidance Principle	Means by which Requirement is Met in Upper Colorado Regional Flood Plan (UCRFP)
(34) shall be in accordance with all existing water rights laws, including but not limited to, Texas statutes and rules, federal statutes and rules, interstate compacts, and international treaties;	The conclusion of Chapter 6 states there are no anticipated impacts to water rights.
(35) shall consider protection of vulnerable populations;	Flood risks to vulnerable populations are evaluated in Chapter 2 using the social vulnerability index. Vulnerability was then carried forward to the process for identifying FME, FMS, and FMP lists in Chapter 5.
(36) shall consider benefits of flood management strategies to water quality, fish and wildlife, ecosystem function, and recreation, as appropriate;	Chapter 4 recognizes the consideration of these additional benefits alongside the needs analysis results for developing strategies and projects.
(37) shall minimize adverse environmental impacts and be in accordance with adopted environmental flow standards;	Chapter 6 addresses minimizing adverse environmental impacts and meeting adopted environmental flow standards in the recommendations.
(38) shall consider how long-term maintenance and operation of flood strategies will be conducted and funded; and	Chapter 9 includes the consideration of conducting and funding O&M.
(39) shall consider multi-use opportunities such as green space, parks, water quality, or recreation, portions of which could be funded, constructed, and or maintained by additional, third-party project participants.	Chapter 4 recognizes the consideration of these additional opportunities alongside the needs analysis results for developing strategies and projects.

Table ES-3. Title 31 TAC §362.3 Guidance Principles and Means Requirement Met in Regional Flood Plan

Upper Colorado Regional Flood Plan (UCRFP) Chapter	General Content
1	Planning Area Description
2	Existing Condition Flood Risk Analyses Future Condition Flood Risk Analyses
3	Evaluation and Recommendations on Floodplain Management Practices Flood Mitigation and Floodplain Management Goals
4	Flood Mitigation Needs Analysis
5	Identification of Potential Flood Management Evaluations and Potentially Feasible Flood Management Strategies and Flood Mitigation Projects Evaluation and Recommendation of Flood Management Evaluations and Flood Management Strategies and Associated Flood Mitigation Projects
6	Impacts of Regional Flood Plan Contributions to and Impacts on Water Supply Development and the State Water Plan
7	Flood Response Information and Activities
8	Administrative, Regulatory, and Legislative Recommendations
9	Flood Infrastructure Financing Analysis
10	Public Participation and Plan Adoption

During the development of the 2023 UCRFP, the planning group met all requirements under the Texas Open Meeting Act and Public Information Act.

Planning Area Description

For the planning area description, the TWDB requires multiple items, including the following.

- Describe the flood planning region
- Inventory the natural features and constructed major flood infrastructure
- Assess the natural features and constructed major flood infrastructure
- Describe proposed or ongoing flood mitigation projects in the region

Description

The UCFPR has an area of 21,254 square miles (13,602,560 acres), approximately 7.9 percent of the state's land area (Figure ES-1). The region includes 32 counties, 10 in their entirety and 22 partially. The region is bound to the west by the Texas-New Mexico border, to the north by TWDB Flood Planning Region 7 (Upper Brazos), to the south by TWDB Flood Planning Region 14 (Upper Rio Grande), and to the east by TWDB Planning Region 10 (Lower Colorado-Lavaca).

In 2020, this region had a population of approximately 637,000. There are four~~five~~ cities with a population greater than 25,000, which are Big Spring, Midland, Odessa, and San Angelo.~~, and West Odessa.~~ There are 15 major lakes and reservoirs and approximately 8,044 stream miles. There are four ecoregions of Texas represented. Flood related claims between 1975 and 2019 are estimated to have exceeded $5,900,000.

Inventory and Assessment

Natural features identified include rivers, tributaries, functioning floodplains, wetlands, and sinkholes. The constructed major infrastructure includes dams and detention, retention ponds, and levees. Much of the Upper Colorado Region is undeveloped with appropriately functions floodplains. Developmental pressures are a threat to functional natural features. Existing infrastructure is generally rated as functional and serving its intended design level of service.

Ongoing Flood Mitigation Projects

Ongoing flood mitigation projects are generally related to stormwater in the major population areas.

Commented [NC1]: TWDB comment 38: add additional descriptive text including descriptions of which projects are ongoing in the region. When resolved, respond to the comment

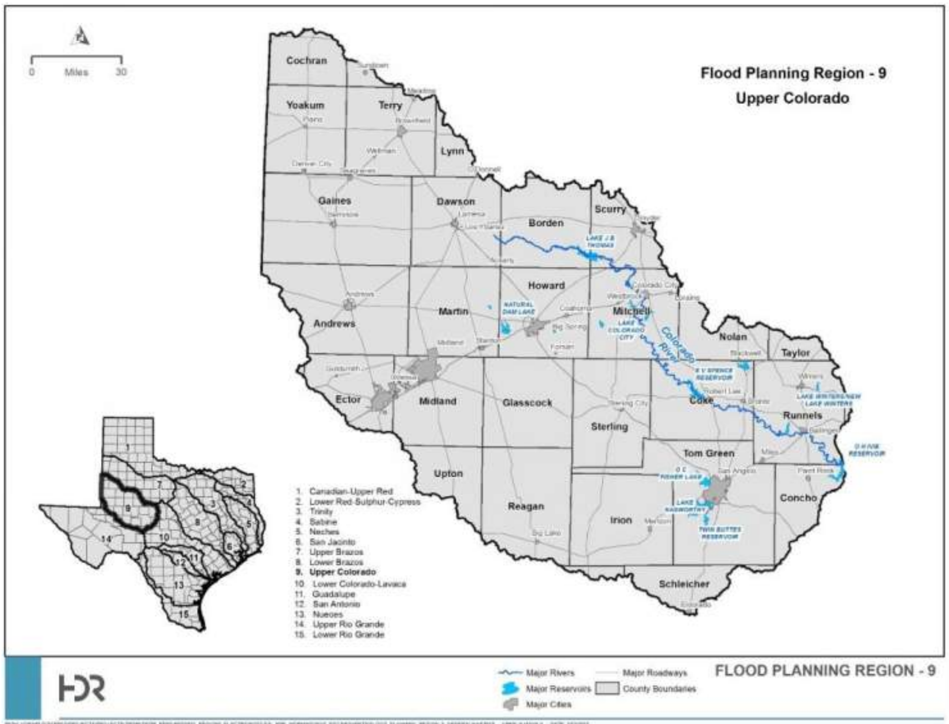

Figure ES-1. Upper Colorado Flood Planning Region

Flood Risk Analyses

Flood risk analyses were based on the best available information including mapping, location of hydrologic features, historic flooding, and/or local knowledge. Analyzes performed examined existing and future condition flood risk analyses for the region. The types of analyses included the following.

- Flood hazard analyses that determine location, magnitude, and frequency of flooding
- Flood exposure analyses to identify who and what might be harmed within the region
- Vulnerability analyses to identify vulnerabilities of communities and critical facilities

The existing flood hazard analysis revealed that the Upper Colorado Region is mostly unmapped or based on out-of-date maps for flood risk. The existing flood exposure analysis indicated that the urban centers of Midland-Odessa and San Angelo have the highest concentration of flood exposure along with roadways throughout the region. The exposure analysis may be skewed due to the limitations of the flood hazard information. The existing vulnerability analysis shows major communities with the vulnerability along with large areas of Cochran, Terry, and Gaines counties.

Figure ES-2 shows the flood hazard area under existing conditions. These floodplains cover over 5,900 square miles and 28 percent of the land area of the Upper Colorado flood planning region. Of the mapped flood hazard area, 4,521 square miles are inundated during the 1 percent annual chance event, and an additional 1,~~419~~ 127 square miles are inundated during the 0.2 percent annual chance floodplain.

The future flood hazard analysis was based on using the existing 0.2 percent annual chance floodplain as a proxy for the future 1 percent annual chance floodplain. Most of the increase in floodplain was in urbanized areas. The future flood exposure analysis indicated that Midland-Odessa and San Angelo continue to have a high concentration of flood exposure in the region. The future vulnerability analysis results show similar patterns to the existing.

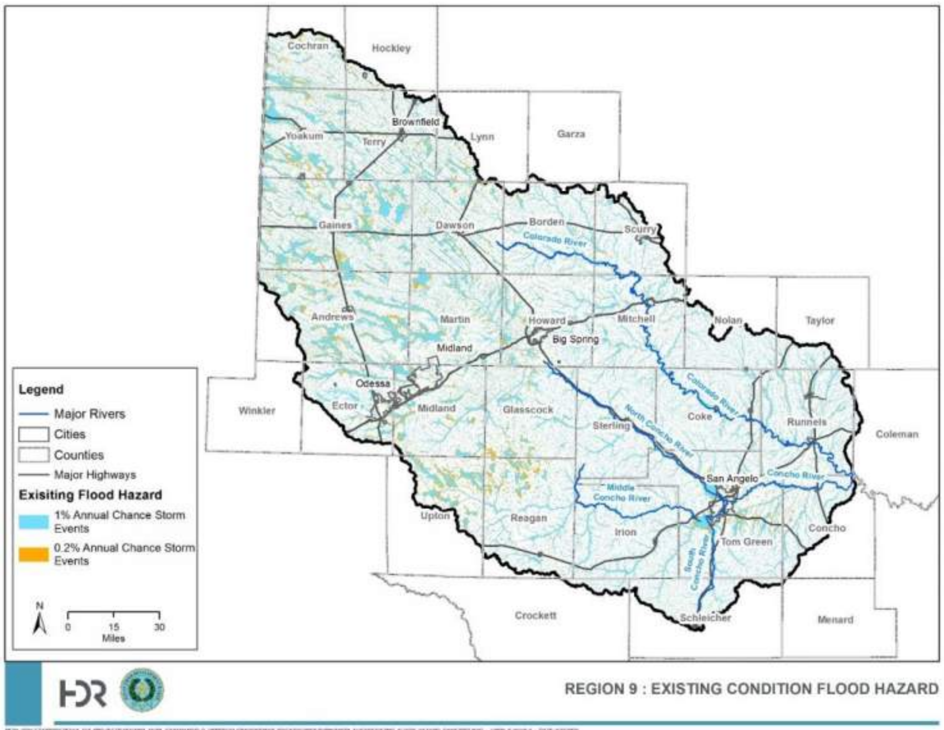

Figure ES-2. Flood hazard area under existing conditions

Floodplain Management Practices and Flood Protection Goals

RFPGs were tasked with evaluating and making recommendations on floodplain management practices within the flood planning region. RFPGs were instructed to define the overarching flood mitigation and floodplain management goals for their regional flood plans. These goals guide the overall approach and recommendations in the UCRFP. Key concepts to be incorporated were (1) identify and reduce the risk and impact to life and property that already exists and, (2) avoid increasing or creating new flood risk by addressing future development within the areas known to have existing or future flood risk. The Upper Colorado Regional Flood Planning Group (UCRFPG) adopted the flood mitigation and floodplain management goals as follows.

- Evaluations to Confirm Flood Risk
- Reduce Structures in 1% Existing Floodplain
- Improve Safety at Low Water Crossings and Dams
- Improved Standards (NFIP or Equivalent)

- Dedicated Funding Sources Dedicated Funding Sources

Assessment and Identification of Flood Mitigation Needs

An assessment and identification of flood mitigation needs was performed as a high-level analysis. The objectives were to (1) identify the region's flood prone areas where the greatest flood risk knowledge gaps exist and where the RFPG should consider identifying potentially feasible flood risk studies and (2) identify the areas of greatest known flood risk and flood mitigation needs in the regions and resulting need of potential strategies and projects to reduce risks.

Recommendation of Flood Management Evaluations and Flood Management Strategies and Associated Flood Mitigation Projects

On July 6, 2022, the UCRFPG met and approved the proposed lists of recommended FMEs, FMSs, and FMPs. Of the 367 FMEs, FMSs, and FMPs collected, 275 were recommended. Table ES-4~~Table ES-4~~, Table ES-5, and Table ES-6~~Table ES-6~~, respectively, describe the recommended FMEs, FMSs, and FMPs.

Table ES-4. FME Types and General Description

Flood Management Evaluation (FME) Type	General Description	Number of FMEs Identified
Watershed Planning – H&H Modeling, Regional Watershed Studies	Supports the development and analysis of hydrologic and hydraulic models to define flood risk or identify flood prone areas OR large-scale studies that are likely to benefit multiple jurisdictions.	37
Watershed Planning – Flood Risk Mapping Updates	Promotes the development and/or refinement of detailed flood risk maps to address data gaps and inadequate mapping. Create Federal Emergency Management Agency (FEMA) mapping in previously unmapped areas and update existing FEMA maps as needed.	30
Engineering Project Planning	Evaluation of a proposed project to determine whether implementation would be feasible OR initial engineering assessment including conceptual design, alternative analysis, and up to 30 percent engineering design.	33
Regulatory and Guidance	Create and implement an integrated stormwater management manual or higher standards program that contains minimum stormwater infrastructure design standards.	0

Flood Management Evaluation (FME) Type	General Description	Number of FMEs Identified
Studies on Flood Preparedness	Encourages preemptive evaluations and strategies to better prepare an area in the event of flood.	1
Other	Other projects not classified above. All FMEs classified as “Other” are associated with studies to support property acquisition programs (including high-risk and repetitive loss properties, and acquiring and preserving open space adjacent to floodplain areas).	27

Table ES-5. FMS Types and General Description

Flood Management Strategy (FMS) Type	General Description	Number of FMSs Identified
Education and Outreach	Develop a coordinated education, outreach, and training program to train staff and to inform and educate the public about the dangers of flooding and how to prevent flood damages to property as well as the ecological and societal benefits of flooding.	31
Flood Measurement and Warning Systems	Install gauges, sensors, and precipitation measuring sites to monitor streams and waterways for potential flooding and support emergency response.	8
Improved Data and Safety at Dams (Other)	Reinforcement of slopes, spillway expansion, dam repairs and upgrades	0
Property Acquisition and/or Structural Elevation	Acquire, relocate, and/or elevate flood prone structures OR acquire floodplain and protect environmentally sensitive areas by converting floodplain encroachments into open space land.	0
Regulatory and Guidance	Application to join NFIP or adoption of equivalent standards. Create and implement a drainage criteria manual or higher standards program that contains minimum stormwater infrastructure design standards.	78
Preventive Maintenance Programs (Other)	Adopt and implement a program for clearing debris from bridges, drains, ditches, channels, and culverts.	13

Flood Management Strategy (FMS) Type	General Description	Number of FMSs Identified
Engineering Project Planning	Evaluation of a project identified by an ongoing FIF study to determine whether implementation would be feasible or initial engineering assessment including conceptual design, alternative analysis, and up to 30 percent engineering design.	9

Table ES-6. FMP Types and General Description

Flood Mitigation Project (FMP) Type	General Description	Number of FMPs Identified
Flood Mitigation Project – Non-Structural: Early Warning System	Installation of sensors at three railroad underpasses	0
Flood Mitigation Project – Structural: Regional Improvements	Playa or detention pond excavation, open channel or storm drain construction.	8
Flood Mitigation Project – Non-Structural: Infrastructure (buyout program)	Buyout of five residential properties adjacent to a playa and provision of green space.	0

Impact and Contribution of the Regional Flood Plan

Implementation of the UCRFP will benefit the Upper Colorado Region by reducing areas impacted from flooding events. The benefits will vary within the region base the actions identified during this flood planning process. Implementing the UCRFP will provide numerous benefits and will not negatively impact neighboring areas within or outside the UCFPR. Benefits of implementing the plan are that it will protect the health and safety of the region by reducing flooding frequency and severity, advanced flood warning systems, removing roads from flooding, and providing officials the tools to properly manage flood prone areas.

There are no anticipated impacts from the recommended FMSs and FMPs on water supply, water availability, or projects in the state's water planning based on no anticipated measurable impact. Additionally, the recommended FMSs and FMPs have no anticipated impacts on existing water rights laws, including but not limited to, Texas statutes and rules, federal statutes and rules, interstate compacts, and international treaties. Furthermore, the recommended FMSs and FMPs have no anticipated impacts leading to long-term impairment to the designated water quality as listed in the state's water quality planning. Overall, the recommendations are based on minimizing adverse environmental impacts and are in accordance with adopted environmental flow standards.

Flood Response Information and Activities

Existing flood response and recovery activities in the region. Cities, or municipalities, generally are the lead entity for flood response in the region. The primary source of flood response information is state and federal agencies. For minor flooding events, the cities provide the primary flood response activities. For major flooding events, the Texas Division of Emergency Management (TDEM), a division of the Texas Department of Public Safety (DPS), coordinates state and local responses. TDEM carries out emergency preparedness activities and coordinates emergency response operations.

Administrative, Regulatory, and Legislative Recommendations

Legislative, regulatory, administrative, and other recommendations were developed by the UCRFPG. The UCRFPG supports the following actions.

- Appropriation of a certain percentage of the Flood Infrastructure Fund (FIF) financial assistance for rural areas of Texas.
- The increasing of state public education programs regarding flooding issues, including suitable land development practices in previously undeveloped areas.
- Implementation of flood mitigation projects (FMPs), flood management strategies (FMSs), and flood management evaluations (FMEs), including loans for completion of needed mapping efforts to better characterize unmapped basins.

Legislative recommendations are mostly related to funding and/or technical assistance to support flood management activities. Additional legislative recommendations are to provide state level strategies and guidance to inform flood management along with providing authority to local entities to regulate flood management activities and the ability to collect fees to fund such activities. Regulatory and administrative recommendations are generally related to rural and smaller entities present in the Upper Colorado Region. Recommendations are focused on the challenges of limited funding, smaller projects, lack of understanding of technical information, need for additional resources, cross jurisdictional issues, and assistance with maintain data tracking. Legal assistance is necessary to understand complex regulations and refute misconceptions about individual development by property owners within the framework of floodplain regulations. Other recommendations include several items that can be implemented to make the planning process more streamlined and effective.

Flood Infrastructure Financing Analysis

A flood infrastructure financing analysis was performed and included sponsors proposals for financing the recommended flood management evaluations, projects, and studies. A survey of project sponsors was completed to determine the flood risk mitigation efforts proposed to finance the recommended FMSs, FMPs, and FMEs included in the UCRFP. The survey results describe the role that the UCRFPG proposes for the state in financing the recommended FMSs, FMPs, and FMEs.

Adoption of Plan and Public Participation

The 2023 UCRFP was developed and adopted in accordance with 31 TAC §361.50 and §361.60–.61. The UCRFPG will approve and adopt the Final 2023 UCRFP in late 2022 and will direct the City of San Angelo and the Technical Consultant Team to submit the Final 2023 UCRFP to the TWDB on or before the January 10, 2023, deadline.

Stakeholder outreach and public participation are an important part of any planning process, including this first flood planning cycle for the State of Texas, initiated by Senate Bill 8 (SB8) of the 86th Texas Legislature. In 2020, the TWDB allocated funds for the 15 flood planning regions to concentrate on tasks related to public participation and flood planning development for their respective basins. In September 2021, the TWDB allocated additional funding related to stakeholder outreach and data collection efforts for each of the flood planning regions. The UCRFPG provided opportunity for the public to participate in the regional flood planning process. The UCRFPG met all requirements under the Texas Open Meetings Act and Public Information Act in accordance with 31 TAC Chapters 357.12, 357.21, and 357.50(f) during development of the *Draft 2023 Regional Flood Plan for Flood Planning Region 9 – Upper Colorado*.

1

Planning Area Description

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1 Planning Area Description

[31 TAC §361.30-32]

The 32-county Upper Colorado Region (Region 9) has an area of 21,254 square miles (13,602,560 acres), which is approximately 7.9 percent of the state's land area (Figure 1-1). The region is bound to the west by the Texas-New Mexico border, to the north by the Texas Water Development Board (TWDB) Flood Planning Upper Brazos Region (Region 7)~~ (Upper Brazos)~~, to the south by TWDB Flood Planning Upper Rio Grande Region (Region 14)~~ (Upper Rio Grande)~~, and to the east by TWDB Flood Planning Lower Colorado-Lavaca Region (Region 10)~~ (Lower Colorado-Lavaca)~~. In 2020, this region had a population of approximately 637,000.

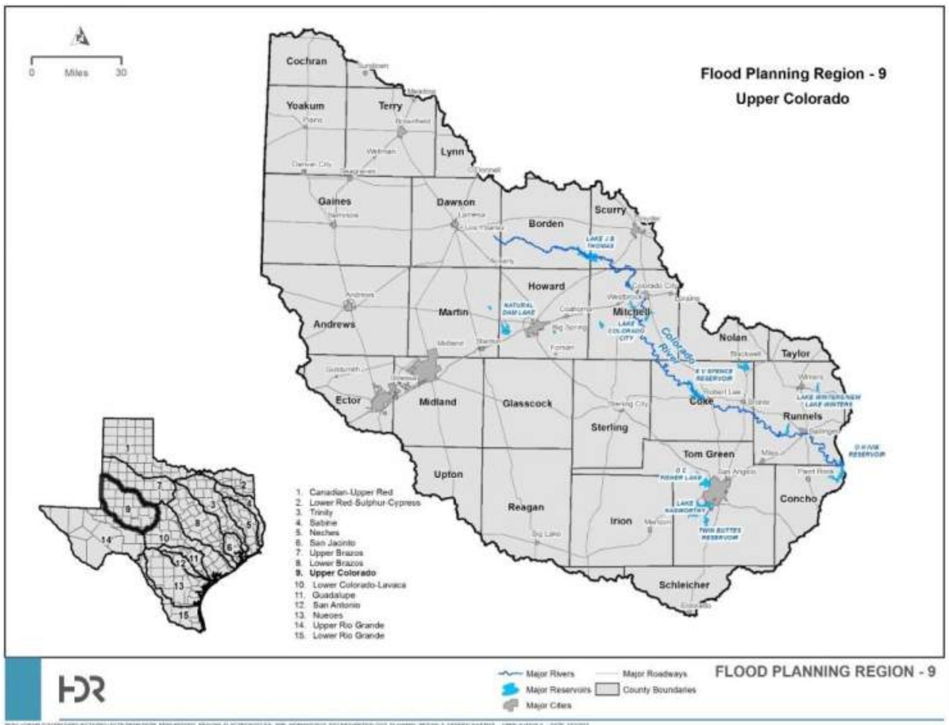

Figure 1-1. Upper Colorado (Region 9) Flood Planning Region

1.1 Background

In 2019, the Texas Legislature and Governor Abbott adopted changes to Texas Water Code §16.061 that established a regional and state flood planning process for 15 identified flood planning regions across the state. Information from each of the 15 regional flood plans will be compiled in the *2024 State Flood Plan*. The TWDB was charged with overseeing the development of each regional plan and compiling the state flood plan. The TWDB was also charged with providing funding for investments in flood science and mapping efforts to support plan development.

Th<u>ese</u>~~is~~ investment and planning efforts represent an important step in flood planning in Texas, because

- flood risks, impacts, and mitigation costs have never been assessed at a statewide level for Texas;
- flood risks pose a serious threat to lives and livelihoods across the state; and
- much of the flood risk in Texas is unmapped or is based on out-of-date maps.

Regional flood plans must be based on the best available science, data, models, and flood risk mapping. When complete, the plans will focus both on reducing existing risk to life and property and on enhancing floodplain management to avoid increasing flood risk in the future. The first regional flood plan must be submitted to the TWDB by January 10, 2023. The TWDB will then compile these regional plans into a single statewide flood plan and will present it to the Legislature in 2024. An updated version of the state flood plan (SFP) will be due every 5 years thereafter.

The TWDB has appointed a reginal flood planning group (RFPG) for each region and has provided them with funding to prepare their plans. The TWDB administers the regional flood planning process through a contract with the planning group's sponsor who is selected by the RFPG. The Upper Colorado Flood Planning Region (UCFPR) sponsor is the City of San Angelo. The Texas Legislature also allocated funding to be distributed by the TWDB for procuring technical assistance to develop the regional flood plans. HDR Engineering (HDR) was selected through a competitive process to serve as the technical consultant for the UCFPR flood planning effort.

Stakeholders residing in and representing various interest categories were appointed for each region to provide representation and lead a bottom-up approach to developing a 2023 regional flood plan. The RFPG's responsibilities include directing the work of the technical consultant; soliciting and considering public input; identifying specific flood risks; and identifying and recommending flood management evaluations, strategies and projects to reduce risk in their regions. To ensure diverse perspectives are included, members represent a wide variety of stakeholders potentially affected by flooding. The following interest categories are included.

1. Public
2. Counties
3. Municipalities
4. Industries

5. Agriculture
6. Environment
7. Small Business
8. Electric-generating utilities
9. River authorities
10. Water districts
11. Water utilities
12. Flood districts

The members of the RFPG for the first flood planning cycle are listed in Table 1-1~~Table 1-1~~ and Table 1-2~~Table 1-2~~.

Table 1-1. UCRFPG Voting Membership

Member Name	Interest Category	Organization
Kenneth Dierschke	Agriculture	Dierschke Farms
Rick Bacon (At-Large)	Counties	Tom Green County
Henryk Olstowski	Electric Generating Utilities	Luminant
Shannon McMillan	Environmental	Centurion Planning & Design
Vacant	Flood Districts	--
Morse Haynes	Industries	Andrews Economic Development Corporation
Lance Overstreet, PE (Secretary)	Municipalities	U.S. Air Force
David H. Loyd Jr., PhD	Public	Retired Physics Professor and Dean – Angelo State University
Scott McWilliams, PG	River Authorities	Upper Colorado River Authority
Chuck Brown (Vice-Chairman)	Small Business	Hydro Corporation
Cole D. Walker, PE	Water Districts	Colorado River Municipal Water District
Allison Strube, PE (Chairman)	Water Utilities	City of San Angelo

Table 1-2. UCRFPG Non-Voting Membership

Member Name	Title	Entity
John McEachern	Natural Resources Specialist	Texas Parks and Wildlife
Tim Frere	Hazard Mitigation Planner	Texas Division of Emergency Management
Larissa Place	Field Representative	Texas Department of Agriculture
Ben Wilde	Field Representative	Texas State Soil and Water Conservation Board
Jet Hays	Deputy Director	General Land Office
Tressa Olsen	Regional Flood Planner	Texas Water Development Board
Winona Henry	Regional Director	Abilene, Texas Commission on Environmental Quality
Anne Yakimovicz	Region 10 Liaison	Lower Colorado River Authority

1.2 Goal and Purpose of the 2023 Upper Colorado Regional Flood Plan

All regional flood plans are to be developed according to 39 guiding principles (see 31 Texas Administrative Code [TAC] 362.3). The 2023 Upper Colorado (Region 9) regional flood plan focuses on identifying both existing and future condition flood risks within the Upper Colorado basin; evaluates flood hazard exposure to life and property; identifies and evaluates potentially feasible flood management strategies (FMSs) and flood mitigation projects (FMPs); presents recommended strategies and projects that minimize residual flood risk; and provides effective and economical management of flood risk to people, properties, and communities, and associated environmental benefits amongst other information.

Commented [NC2]: Revisit grammar of this sentence on Wednesday morning

1.3 Upper Colorado Flood Planning Region

The following counties or a portion of the county are represented in the UCFPR.

- Andrews*
- Borden*
- Cochran
- Coke
- Coleman*
- Concho*
- Crockett*
- Dawson*
- Ector*
- Gaines
- Garza*
- Glasscock
- Hockley*
- Howard
- Irion
- Lynn*
- Martin
- Menard*
- Midland*
- Mitchell*
- Nolan*
- Reagan*
- Runnels*
- Schleicher*
- Scurry*
- Sterling
- Taylor*
- Terry*
- Tom Green
- Upton*
- Winkler*
- Yoakum

*Indicates this county is partially within this RFPG and represented by at least one other RFPG.

Following are the municipalities considered in the development of the UCRFP.

- City of Ackerly
- City of Andrews
- City of Ballinger
- City of Big Lake
- City of Big Spring
- City of Bronte
- City of Brownfield
- City of Coahoma
- City of Colorado City
- City of Denver City
- City of El Dorado
- City of Forsan
- City of Goldsmith
- City of Lamesa
- City of Los Ybanez
- City of Mertzon
- City of Midland
- City of Miles
- City of Odessa
- City of O'Donnell
- City of Plains
- City of Robert Lee
- City of San Angelo
- City of Seagraves
- City of Seminole
- City of Snyder
- City of Stanton
- City of Sterling City
- City of Sundown
- City of Westbrook
- City of Winters
- Town of Blackwell
- Town of Loraine
- Town of Meadow
- Town of Paint Rock
- Town of Wellman

A total of 29 other entities considered in the development of the RFP are provided in Table 1-3~~Table 1-3~~.

Table 1-3. Other Flood or Water-Related Entities in the UCFPR

Entity	Type
Upper Colorado River Authority	River Authority
Colorado River MWD	River Authority
Brazos River Authority	River Authority
Central Colorado River Authority	River Authority
Lower Colorado River Authority	River Authority
Canadian River Municipal Water Authority	River Authority
Concho Valley Council of Governments	Other (COG)
Permian Basin Regional Planning Commission	Other (COG)
South Plains Association of Governments	Other (COG)
West Central Texas Council of Governments	Other (COG)
Coke County Kickapoo WCID 1	Other
Ector County Utility District	Other
Gaines County SWMD	Other
Howard County WCID 1	Other
Martin County FWSD 1	Other
Midland County FWSD 1	Other
Midland County Utility District	Other
Downtown Midland Management District	Other
Nolan County FWSD 1	Other
Reagan County WSD	Other
Red Creek MUD	Other
Salt Fork Water Quality District	Other
Tom Green County FWSD 1	Other
Tom Green County FWSD 2	Other
Tom Green County FWSD 3	Other
Tom Green County WCID 1	Other
Upton County Water District	Other
Valley Creek Water Control District	Other
Willow Creek Water Control District	Other

MWD=municipal water district; WCID=water control and improvement district; SWMD= solid waste management district; FWSD= fresh water supply district; MUD=municipal utility district; COG= Council of Governments

The UCFPR includes an area that drains to the Colorado River and associated tributaries. The Colorado River is the largest of major river systems in the region, beginning in Dawson County in the northwest part of the region. In the southern portion of Mitchell County, the Colorado River reaches its confluence with Beals Creek. It then continues southeast, flowing through Ed Spence Reservoir, proceeding through

Ballinger until it reaches the southeast edge of the region where the Concho River joins it at O.H. Ivie Reservoir. In the southeast part of the region, the North Concho, South Concho, Middle Concho River, and Spring Creek combine to form the Concho River near San Angelo. The Concho River then flows northeast, combining with Lipan and Kickapoo creeks before joining the Colorado River.

The UCFPR contains the following major reservoirs:

- Champion Creek Reservoir
- E V Spence Reservoir
- Lake Ballinger/Lake Moonen
- Lake Colorado City
- Lake J B Thomas
- Lake Nasworthy
- Lake Winters / New Lake Winters
- Mitchell County Reservoir
- Natural Dam Lake
- O.C. Fisher Lake
- O.H. Ivie Reservoir
- Oak Creek Reservoir
- Red Draw Reservoir
- Sulphur Springs Draw Storage Reservoir
- Twin Buttes Reservoir

The UCFPR includes three of the 10 ecoregions identified by Texas Parks and Wildlife Department (TPWD). These ecoregions are the High Plains, Edwards Plateau, and the Rolling Plains (Figure 1-2).

Most of the UCFPR is dominated by clayey and alkaline soils, restricting the species of trees that flourish in the region.[2] In the High Plains portion of the UCFPR, the surface is dominated by clays that sit on top of caliche, a natural cement of lime, gravel and sand. Further south lies the Trans-Pecos ecoregion. While the UCFPR is not located in the Trans-Pecos ecoregion, some southern portions of the region retain characteristics of this ecoregion, which is more arid and mountainous, characteristic of the Chihuahuan desert. Soils are derived from igneous and sedimentary rock. Caliche is common as well. Downstream of the High Plains lies the Rolling Plains ecoregion. Rainfall is more plentiful, and the terrain is less rugged than in the High Plains. Soils are less alkaline and more fertile. Downstream of the Rolling Plains is the Edwards Plateau, informally referred to as the Texas Hill Country. This region receives more rainfall than the Rolling

[2] Service, T. A. (2021). Texas Ecoregions. Retrieved from Trees of Texas: http://texastreeid.tamu.edu/content/texasEcoRegions/

Plains, making the soil loamier than upstream. Clays dominate the surface, with limestone bedrock underneath.

Most precipitation comes from violent spring and early summer thunderstorms. These thunderstorms produce short, intense rainfall over very limited areas. These intermittent storms punctuate periods of drought. Average annual rainfall over the region ranges from 14.7 inches in Odessa to 21.3 inches of rain in San Angelo with rainfall increasing downstream.

Figure 1-2. Upper Colorado Flood Planning Region Ecoregions

The Upper Colorado Region is a very productive agricultural region with many ties to farming and ranching. Although fewer individuals are exposed to flood hazards in rural areas, the impact of flooding on agriculture and ranching can be severe. Floods can delay planting and ruin crops, kill livestock, and damage barns or other structures, causing significant economic hardship to the farmers and ranchers.

Ranchland and farmland are the predominant use of working lands across the UCFPR, as shown in Figure 1-3. Together these land use types account for 94.4 percent of the total land area with ranchland being 70.0 percent and farmland being 24.4 percent.

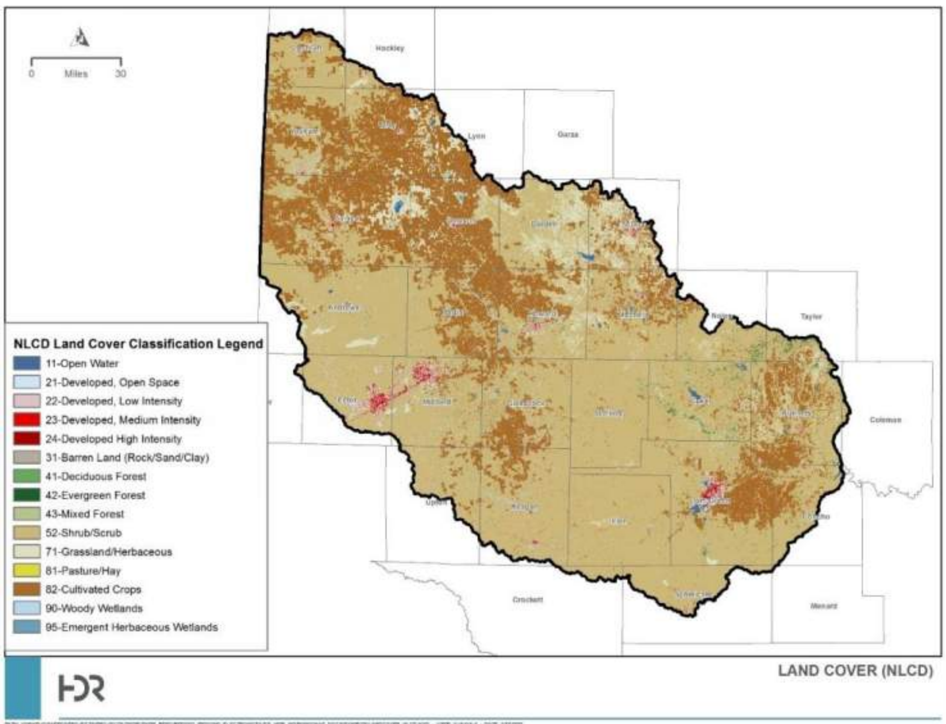

Figure 1-3. Upper Colorado Flood Planning Region Land Cover (NLCD)

The vegetative cover in the UCFPR aligns closely with the land cover, as shown in Figure 1-4. The top vegetative cover types by land area are native grasslands (24.7 percent), row crops (21.4 percent), Edwards Plateau (15.4 percent), High Plains (12.1 percent), and Rolling Plains (11.6 percent). Only 1.2 percent of the land area is in urban development with low intensity development the predominate type of development within the region.

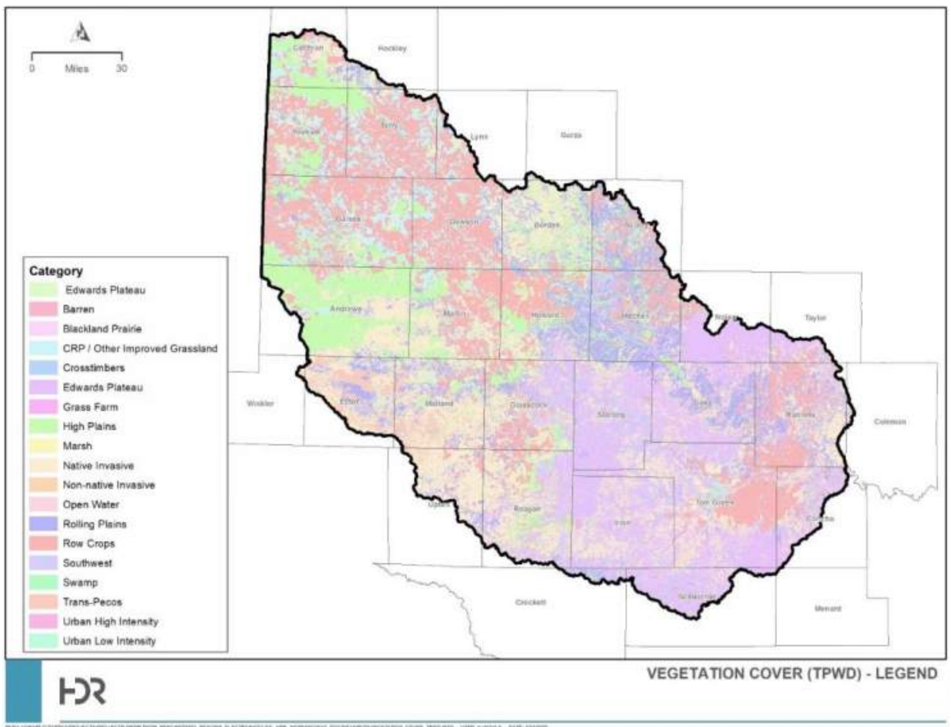

Figure 1-4. Upper Colorado Flood Planning Region Vegetation Cover (TPWD)

1.3.1 Socioeconomic Characteristics

The Upper Colorado Region is largely rural in nature with three major population centers (Midland, Odessa, and San Angelo). The three cities combined contain almost 60 percent of the total region's population. This population diversity within the region means that the needs of rural stakeholders must be balanced with those of the urban population centers.

Overall, the region is expected to grow by 33 percent between 2020 and 2050 to a population of about 834,000 (Figure 1-5). Most of this growth is expected to be centralized within cities and towns that will add areas of new development and experience some redevelopment of existing areas to provide housing and businesses to support the growing population. As the region experiences population growth, more people will be exposed to flooding events, and flooding events may be more extreme as permeable land surfaces are replaced with impermeable services associated with development.

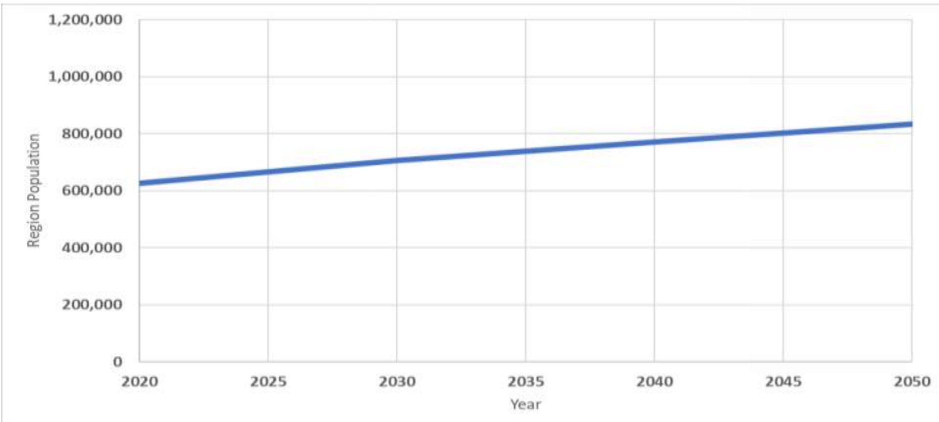

Figure 1-5. Upper Colorado Flood Planning Region Population Projection

There are 11 cities projected to grow by at least 20 percent between 2020 and 2050 (Table 1-4~~Table 1-4~~). The fastest growing city in the region is projected to be Andrews with a projected growth rate of 65 percent over that time. The three largest cities of Midland, Odessa, and San Angelo are expected to grow by more than 20 percent, with Odessa being the fastest growing large city with a projected growth rate of 45 percent.

Table 1-4. Cities with Highest Projected Growth Rate, 2020-2050

Cities	2020	2050	% Growth
Andrews	14,661	24,171	65%
Odessa	127,558	185,428	45%
Seminole	7,102	9,855	39%
Midland	141,690	194,767	38%
Plains	1,702	2,335	37%
Denver City	5,072	6,955	37%
Snyder	13,307	17,855	34%
San Angelo	103,243	131,315	27%
Big Lake	3,357	4,193	25%
Stanton	2,693	3,339	24%
Brownfield	10,000	12,250	23%

The five counties with the highest projected growth rates are Gaines, Andrews, Ector, Midland, and Yoakum (Table 1-5~~Table 1-5~~).

Table 1-5. Counties with Highest Projected Growth Rate, 2020-2050

Counties	2020	2050	% Growth
Gaines	21,316	36,654	72%
Andrews	19,076	30,094	58%
Ector	163,387	231,782	42%
Midland	169,062	232,357	37%
Yoakum	8,920	12,232	37%

The Midland-Odessa area is home to more than 260,000 people, making it the largest urban area in the Upper Colorado Region. Energy production is the most prominent industry in the region, with 2020 earnings totaling $13,493,750,000. Historically, Odessa is home to the industrial facilities of the energy companies, while corporate offices are located in Midland. Midland and Odessa also hold three of the region's major colleges: Midland College, Odessa College and The University of Texas Permian Basin.

San Angelo is in the Concho Valley. The city contains many oil field service companies, which support drilling in the Permian basin. The agricultural industry is also prominent in San Angelo, as well as many meat processing plants and one of the nation's top livestock auctions. The largest employer in San Angelo is Goodfellow Air Force Base. San Angelo is also home to San Angelo State University.

In the UCFPR, mining and energy production account for the most earnings, with Midland being the center of oil and gas activity in the region. In the Midland-Odessa metro area, transportation and warehousing are the next most prominent industries, followed by construction. In the San Angelo metro area, the state, local and federal governments account for the largest share of earnings. Outside of the government institutions, retail, energy production and hospitals are the largest earners.

Outside of the large cities, the largest source of earnings is energy production. Agriculture, government, wholesale trade and retail are all significant economic sectors.

Agriculture is a significant part of the economy of the UCFPR. Commonly cultivated crops are cotton, wheat, corn, grain, sorghum, peanuts, soybeans, and hay. The main livestock raised are feedlot animals, cattle, calves, beef cows, milk cows, swine, sheep, lambs, and poultry. The amount of land dedicated to pasture is far greater than the amount of land devoted to crops. The market value of crops and livestock is about equal in this region.

The median household income in the UCFPR ranged from $79,421 in Midland County to $40,962 in Cochran County, a difference of $38,459. The regional average household median income is $56,732, with 17 counties having median household income values less that the state average. The median household income for the State of Texas is $61,874. The UCFPR contained several outliers in the statistic of median household income (Midland, Glasscock, and Andrews counties all have median household incomes above $75,000). All three counties were among the highest exporters of oil and gas in the state, with Midland ranked first and Glasscock ranked 11th among 254 counties in Texas.

Median household income levels can be affected by many factors, including education levels, opportunity of employment, and location. Overall, the lower median income in the UCFPR indicates that average individuals affected by floods in this region may be at a financial disadvantage compared to their state counterparts. Even within the basin, individuals with higher income levels may be able to recover faster and more fully than others with a lower income.

The per capita income of the cities of Midland, Odessa and San Angelo account for 61 percent of the total personal income earned in the counties included in the UCFPR.

1.3.2 Flood Prone Areas and Major Flood Risks

Due in part to the availability of Cursory Floodplain Data ~~Fathom~~ flood risk boundaries for the entire basin, the 1 percent and 0.2 percent annual chance flood risk boundaries were defined for all waterways with contributing drainage areas larger than one square mile for the entire basin. Where multiple data sets were available, the most accurate risk boundaries were applied.

Commented [NC3]: Does this work or should we write cursory flood risk boundaries instead of cursory floodplain data flood risk boundaries?

The TWDB provided the initial “flood risk quilt,” which consists of multiple layers of data from various sources available throughout the state to “quilt” together a single flood hazard dataset. The “flood risk quilt” does not typically include localized flooding or complex urban flooding problems. The Fort Worth District of the U.S. Army Corps of Engineers (USACE) provided additional flood risk boundaries and HDR identified some flood-prone areas from public comments. The following is a list of the various flood risk data sets used in their order of accuracy from most accurate to least accurate, with the Federal Emergency Management Agency (FEMA) Base Level Engineering (BLE) base flood elevation (BFE) data set and those listed above it considered accurate.

- National Flood Hazard Layer (NFHL) Pending Data
- NFHL Preliminary Data
- USACE Section 205 Study
- NFHL Effective Data
- FEMA BLE Base Flood Elevations
- NFHL Approximate Study Areas
- First American Flood Data Services (FAFDS)
- Cursory Floodplain Data ~~Fathom Cursory Data~~ – October 29, 2021
- Public Comments

A large portion of the regional flood planning area contains approximate 1 percent annual chance flood risk boundaries but no 0.2 percent annual chance flood risk boundaries (NFHL approximate study areas). Flood risks are described in further detail in Chapter 2.

1.3.3 Key Historical Flood Events

1.3.3.1 Historical Flood Events

The UCFPR has generally fewer and less intense flooding events compared to other areas of Texas. Table 1-6~~Table 1-6~~ summarizes past flooding events. In addition to these events, the West Central Texas Council of Governments (WCTCOG) and the Concho Valley Council of Governments (CVCOG) have compiled summary data on past flooding events. These are summarized in Table 1-7~~Table 1-7~~ (WCTCOG) and Table 1-8~~Table 1-8~~ (CVCOG).

Table 1-6. Listing of Historical Flood Events

Area	Flood Experience Description
Dawson County	The floods of 1954 and 1955 caused significant flooding in the City of Lamesa. In addition to the floodplain of Sulphur Springs Draw, there are several other flood-prone areas within the city. They are in the vicinity of playa lakes where flooding occurs as a result of runoff into the lakes
Ector County	Major storms in the Odessa area are characterized by heavy rainfall from frontal-type storms. Major flooding can be produced by these localized thunderstorms, which may occur at any time during the year but are more prevalent in the spring and summer months. Significant flooding occurred in 1936, 1959, 1978, 1979, and 1986. In September 2004, flash flooding in the City of Odessa caused the closure of many city roads. A significant flood event occurred in May 2007 that damaged homes and closed roads throughout the county.
Howard County	The storm of May 10, 1957, produced heavy rains throughout Howard County over a 24-hour period. At one location, 4.5 inches of rainfall was recorded. This storm caused flooding on Beals Creek at Big Spring. The flood was the maximum recorded during the period of record for stream flow measurements at and above Big Spring by the U.S. Geological Survey (USGS). The U.S. Army Corps of Engineers (USACE) estimated the discharge of this flood to be 6,600 cubic feet per second (cfs) with an estimated recurrence interval of approximately 30 years. Flooding that occurs on the tributaries of Beals Creek in and around Big Spring is often elevated by flooding from Beals Creek, due to the backwater effect that results. The City of Big Spring has constructed nine flood detention reservoirs on small tributaries south of the central business district.
Midland County	Most of Midland County’s flood problems occur because of the combination of intense localized storms and the flat topography. Based on interviews with local residents, major flooding occurred in 1936. Other floods of note occurred in 1959, 1978, 1979, and 1986.

Area	Flood Experience Description
Scurry County	Three major floods in Snyder occurred on June 19,1938, June 12, 1967, and August 13, 1972. The flood of June 19,1938, was the largest and most destructive of the three. The peak flow of the August 13, 1972, flood was measured to be 37,000 cfs at the 37th Street bridge at an elevation of 2,109.16 feet mean sea level (MSL). The calculated 0.2% annual chance profile for Deep Creek at the 37th Street bridge has a peak discharge of 37,200 cfs at an elevation of 2,109.31 feet MSL.
Tom Green County	Tom Green County, particularly San Angelo, has experienced loss of life and physical property due to flooding along its major streams. The earliest flood of considerable size of which definite knowledge is available occurred in June 1853. Other large floods known to have occurred include the disastrous Ben Ficklin flood of 1882, which destroyed that community; and floods in May 1884, October 1896, April 1900, August 1906, September 1936, July 1938, April-June 1957, and September to October 1959. The flood of September 14-19, 1936, was the most damaging flood on record on the Concho River at San Angelo. The 1906 flood with an estimated discharge of 246,000 (cfs) was the largest flood of record. The 1957 flood with a peak discharge of 106,000 on May 9 at the San Angelo stream gage was partially reduced by the O.C. Fisher Lake, which allowed no discharge from the North Concho River.

Table 1-7. Flood Events by County, 1993 – 2010 as Summarized by the WCTCOG

County	Total Reported Events	Annualized Events	Deaths	Injuries	Property Damage (in Dollars)	Crop Damage (in Dollars)	Annual Loss Estimates (in Dollars)
Mitchell	15	0.9	0	0	846,526	72,499	54,060
Nolan	15	0.9	0	0	2,179,810	138,256	136,357
Runnels	14	0.8	0	0	2,973,916	3,114,529	358,144
Scurry	20	1.2	1	0	3,550,969	540,119	240,652
Taylor	36	2.1	1	0	54,984,848	453,736	3,261,093

Table 1-8. Flood Events by County, 1993 – 2010 as Summarized by the CVCOG

County	Events	Deaths	Injuries
Coke	16	0	0
Concho	9	0	0
Irion	16	0	1
Reagan	13	0	0
Schleicher	14	0	0
Tom Green	60	0	3

The WCTCOG and CVCOG also have summarized vulnerability to flooding in their hazard mitigation plans. The results of this analysis are summarized in Table 1-9~~Table 1-9~~.

Table 1-9. WCTCOG and CVCOG Hazard Mitigation Plans Flooding Vulnerability Summary

Jurisdiction	2010 Population		2010 Housing Units		Bldg. Values 2000/2006	
	By Jurisdiction	Vulnerable to Flood	By Jurisdiction	Vulnerable to Flood	By Jurisdiction	Vulnerable to Flood
Mitchell County	9,403	560	4,064	166	$494,000,000	$19,100,000
City of Colorado City	4,146	63	1,997	41	$253,000,000	$5,000,000
Town of Loraine	602	4	301	4	$34,200,000	$360,000
City of Westbrook	253	0	114	0	$9,800,000	$0
Nolan County	15,216	1,346	7,152	598	$936,300,000	$78,900,000
Runnels County	10,501	N/A	5,298	N/A	$690,800,000	N/A
Town of Ballinger	3,767	248	1,765	162	$279,900,000	$48,200,000
City of Miles	829	64	343	28	$38,200,000	$2,700,000
City of Winters	2,562	N/A	1,272	N/A	$145,500,000	N/A
Scurry County	16,921	629	6,963	312	$993,200,000	$62,600,000
City of Snyder	11,202	384	4,787	160	$693,100,00	$47,800,000
Coke County	3,320		2,667		$291,400,000	
City of Bronte	999	82	473	44	$54,900,000	$6,600,000
City of Robert Lee	1,049	35	636	19	$70,800,000	$2,600,000
Concho County	4,087		1,637		$187,200,000	
Irion County	1,599		856		$112,300,000	
City of Mertzon	781	62	358	39	$38,600,000	$3,300,000
Reagan County	3,367		1,372		$178,800,000	
City of Big Lake	2,936		1,089			

Jurisdiction	2010 Population		2010 Housing Units		Bldg. Values 2000/2006	
	By Jurisdiction	Vulnerable to Flood	By Jurisdiction	Vulnerable to Flood	By Jurisdiction	Vulnerable to Flood
Schleicher County	3,461		1,489		$163,700,000	
City of Eldorado	1,951	27	838	10	$95,800,000	$1,300,000
Tom Green County	110,224	5,145	46,571	2,360	$6,423,000,000	$320,200,000
City of San Angelo	93,200	2,707	39,548	1,304	$5,600,000	$195,800,000

1.3.4 Political Subdivisions with Flood-Related Authority

A total of 71 entities have authority to enact floodplain management regulations in the UCFPR. The extents of floodplain management regulations within the basin are shown below in Figure 1-6.

A total of 51 entities are participants of the National Flood Insurance Program (NFIP), consisting of 28 counties and 27 municipalities. Six entities in the UCFPR (Ballinger, Levelland, Midland, Odessa, San Angelo, Tom Green County, and Taylor County) have adopted higher standards according to the Texas Floodplain Management Association (TMFA) 2016 higher standards survey. Two entities in the UCFPR (San Angelo and Midland) have an existing stormwater or drainage fee.

The level of floodplain management practices and enforcement was identified as high, moderate, low, or none, as defined below, within the UCFPR.

- High – Actively enforces the entire ordinance; performs many inspections throughout the construction process; issues fines, violations, and Section 1316s, where appropriate; and enforces substantial damage and substantial improvement.
- Moderate – Enforces much of the ordinance, performs limited inspections, and is limited in issuance of fines and violations.
- Low – Provides permitting of development in the floodplain, may not perform inspections, and may not issue fines or violations.
- None – Does not enforce floodplain management regulations.

No entities reported having a high level, 7 entities reported having a moderate level, 45 entities reported having a low level, and 20 entities reported having no floodplain management practices and enforcement. Figure 1-6 shows the locations of moderate and strong floodplain management practices.

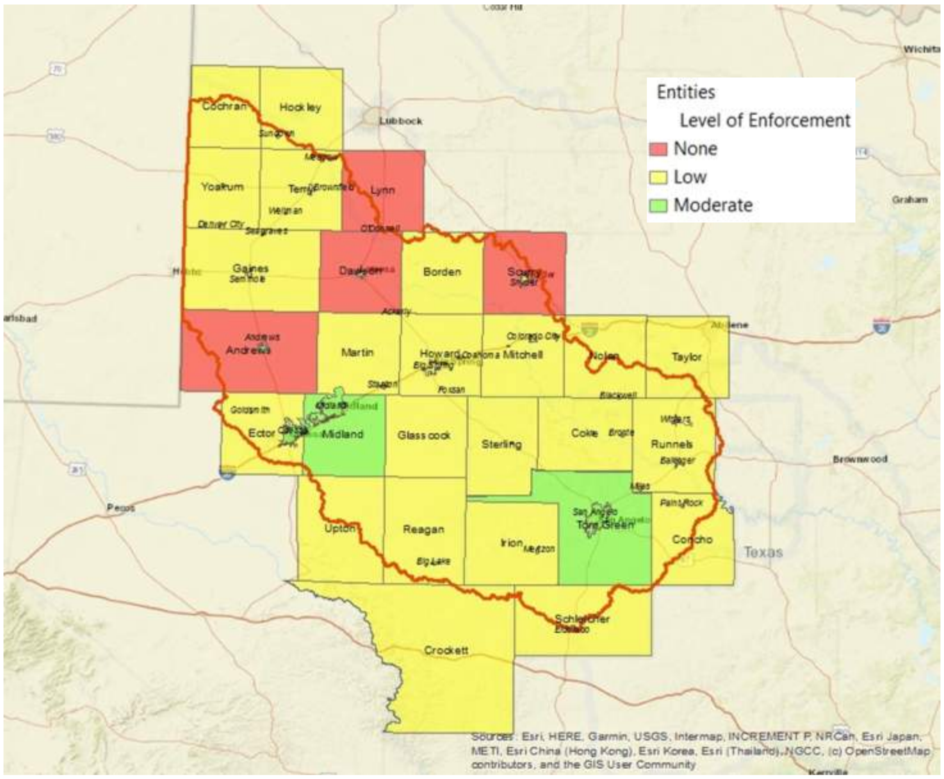

Figure 1-6. Degree of Floodplain Management Practices

1.3.5 Flood Risk Local Regulation and Development Codes

Using policies and regulations to reduce the exposure of people and properties to flood risk are forms of non-structural flood control. By encouraging or requiring communities to avoid developing in flood prone areas altogether, or to take precautions such as increasing building elevation, preserving overflow areas through buffering and avoiding sensitive natural areas such as wetlands, communities can reduce the likelihood and extent of damages to existing and new development. Local regulations and development codes pertaining to flooding include:

- **Floodplain Ordinances** – Floodplain ordinances regulate development and the impact new development has on a community's floodplain. Community regulations are typically based on FEMA-provided flood hazard information but can be based on other local sources of data as well. Participation in the NFIP requires a community to have adopted a floodplain ordinance with minimum requirements established by FEMA.

- **Building Standards** – Building standards may include considerations for structures located within a floodplain, including minimum finish floor elevations and flood proofing requirements. NFIP requirements also set standards for property owners seeking to renovate structures in a floodplain, including those that experience repetitive or server flood losses.
- **Drainage Design Standards** – Adopted drainage design standards set the minimum standards for stormwater management that must be met prior to the approval of construction plans. Drainage criteria in the region are typically adopted by municipalities but are also used by counties.
- **Zoning and Land Use Policies** – Planning and zoning ordinances regulate acceptable types of land uses within a community to promote appropriate development, safety, and general welfare. Some communities use zoning and land use ordinances to establish open space requirements, conservation easements, and minimum setbacks from creeks and wetlands to preserve floodplain function and promote sustainable and resilient development.
- **Local and Regional Flood Plans** – Local and regional flood plans analyze a community's flood risk and present how that entity will improve its resiliency. Drainage master plans describe a community's physical and institutional planning environment and establish interjurisdictional roles and responsibilities when many drainage entities are present. Capital improvement plans (CIPs) identify capital project alternatives for an entity, provide economic analysis for alternatives, and often rank alternatives based on feasibility. The cities of Midland, Odessa, and San Angelo have completed drainage master plans to develop a drainage CIP organizing future projects.

Local regulations and development codes, as well as their prevalence in the UCFPR, are discussed in detail in Chapter 3.

1.3.6 Agricultural and Natural Resources Impacted by Flooding

The Upper Colorado basin is a productive agricultural region with many ties to farming and ranching. Although fewer individuals are exposed to flood hazards in rural areas, the impact of flooding on agriculture and ranching can be sever. Floods can delay planting and ruin crops, kill livestock, and damage barns or other structures, causing significant economic hardship to the farmers and ranchers.

Ranchland and farmland are the predominant use of working lands across the UCFPR, as shown in Figure 1-3. Together these land use types account for 94.4 percent of the total land area with ranchland being 70.0 percent and farmland being 24.4 percent.

The basin has experienced impacts to agricultural lands and natural resources because of flooding. Some of these impacts have been identified and quantified in previous sections and additional qualitative impacts are described in the following sections.

1.3.6.1 Farming

Flooding or excess precipitation can delay and reduce crop harvest, and erosion of sediment and nutrients downstream result in complete or partial crop loss. The impact that flooding has on farming depends on factors, including crop type, stage of the growing or harvesting season when the flood event occurs, and the magnitude of flooding. The numerous crop types grown in the Upper Colorado basin region have varying degrees of resiliency to excess precipitation and prolonged standing water. Permanent crops, such as trees, tend to be more resilient to excess precipitation and standing water than row crops, such as corn or cotton. In the Upper Colorado basin, row crops comprise most of the farming production. Heavy rain before planting can delay planting or prevent planting for the season. In addition, flooding damages can occur after a crop, like cotton or hay, has been harvested but not bailed or processed.

1.3.6.2 Ranching

Ranching activities in the region are also impacted by flooding. Livestock can be swept away, drowned, or injured by flash floods. After a flood, livestock can be particularly susceptible to certain types of parasites and diseases. Excessive rain may cause an increase in vectors, including flies and mosquitos, and cases of footrot, which is a foot disease of cattle, sheep, and goats[3]. Flood events can cause delays in building back livestock herds. Flood damages to livestock silage can reduce livestock head counts.

1.3.6.3 Natural Resources

The Upper Colorado region contains numerous natural resources that can be impacted by flood events. As with livestock, wildlife can be injured or killed by flash floods. Severe flood conditions can degrade stream health and impact ecosystems in the region.

In some ways, flooding can be a benefit for fields, wetlands, riparian areas if limited in depth, duration, and velocity. However, typically, in this region where flash floods are common, flooding causes erosion of sediment and nutrients, which can cause nutrient overgrowth and algal blooms in water bodies and nutrient deficiencies in agricultural producing lands.

1.3.7 Existing Local and Regional Flood Plans

Table 1-10~~Table 1-10~~ lists previous flood studies that the RFPG considered relevant to the development of the UCRFP.

[3] https://www.mla.com.au/research-and-development/dealing-with-natural-disasters/flood-recovery/. Accessed on March 18, 2022.

Table 1-10. Previous Local and Regional Relevant Flood Plans

Flood Study	Description	Jurisdictions	Counties	Year
Midland Master Drainage Plan	This effort was initiated in 1991 to develop hydrologic and hydraulics models of the 6 major watersheds for Existing 1993, Future – No Action and Future – Playas conditions. The playas model was refined to also include in-line channel detention and bridge/culvert improvements. The opinion of probable cost to fully realize the master drainage plan was $62,889,750 in 1996 dollars.	Midland	Midland	1996
Odessa Master Drainage Plan	This effort was initiated in 2001 to develop hydrologic and hydraulics models of the watershed for Existing 1993, Future – No Action and Future – Playas conditions.	Odessa	Ector	2001
Jal and Midland Draw Watershed Study	This effort was initiated in 2015 to develop updated detailed hydrologic and hydraulic analyses of the Jal and Midland Draw watersheds for existing and fully developed conditions, along with a master plan and conceptual design of drainage improvements projects to help guide development adjacent to the draws.	Midland	Midland	2017
San Angelo Master Drainage Plan	This effort was initiated in 2019 to evaluate regional detention opportunities in the Red Arroyo watershed and update the Drainage capital improvement plan (CIP) list. Six regional detention opportunities in the Red Arroyo were evaluated for potential benefits at College Hills Boulevard. A total of 38 problem areas were evaluated and prioritized, and Drainage CIP projects were developed to address the top 10 problem areas, including conceptual design and capital cost estimates. Potential funding alternatives were also identified and described.	San Angelo	Tom Green	2021

Flood Study	Description	Jurisdictions	Counties	Year
Deep Creek Section 205 Study	This effort was initiated in 2016 to address water resource opportunities. Project authorized under Section 205 of the 1948 Flood Control Act meant for small flood control projects.	Snyder	Scurry	2021
Concho Valley Hazard Mitigation Action Plan	The Concho Valley Council of Governments Hazard Mitigation Plan is a multi-jurisdictional plan covering 7 counties and 8 cities in the Upper Colorado Flood Planning Region (UCFPR). The purpose of the plan is to minimize or eliminate long-term risks to human life and property from known hazards and to break the cycle of high-cost disaster response and recovery within the planning area.	Bronte, Mertzon, Robert Lee, Sterling City, Paint Rock, San Angelo, Eldorado, Big Lake	Coke, Concho, Sterling, Reagan, Irion, Tom Green, Schleicher	2013-2018
Tom Green County Hazard Mitigation Action Plan	The plan was prepared by Tom Green County, participating jurisdictions, and H2O Partners, Inc. The purpose of the plan is to protect people and structures and to minimize the costs of disaster response and recovery. The goal of the plan is to minimize or eliminate long-term risks to human life and property from known hazards by identifying and implementing cost-effective hazard mitigation actions.	San Angelo	Tom Green	2020-2025
West Central Texas COG Regional Hazard Mitigation Action Plan Update	The West Central Texas Council of Governments Hazard Mitigation Plan is a multi-jurisdictional plan covering 5 counties and 8 cities in the UCFPR. The mitigation strategies seek to identify potential loss-reduction opportunities. The goal of this effort is to work towards more disaster-resistant and resilient communities.	Snyder, Colorado City, Loraine, Westbrook, Blackwell, Ballinger, Miles and Winters	Scurry, Mitchell, Nolan, Taylor and Runnells	2020-2025

Flood Study	Description	Jurisdictions	Counties	Year
Ector County Multi-Jurisdictional Hazard Mitigation Action Plan	The plan was prepared by Ector County, participating jurisdictions, and H2O Partners, Inc. The purpose of the plan is to minimize or eliminate long-term risks to human life and property from known hazards and to break the cycle of high-cost disaster response and recovery within the planning area."	Odessa and Goldsmith	Ector	2011-2016
Cochran County Multi-Jurisdictional Hazard Mitigation Action Plan	The plan was prepared by Cochran County, participating jurisdictions, and H2O Partners, Inc. The purpose of the plan is to minimize or eliminate long-term risks to human life and property from known hazards and to break the cycle of high-cost disaster response and recovery within the planning area."	None are in the UCFPR	Cochran	2014
Terry County Multi-Jurisdictional Hazard Mitigation Action Plan	The plan was prepared by Terry County, participating jurisdictions, Texas Department of Emergency Management (TDEM) and LAN, Inc. The purpose of the plan is to minimize or eliminate long-term risks to human life and property from known hazards and to break the cycle of high-cost disaster response and recovery within the planning area."		Terry	
Lynn County Multi-Jurisdictional Hazard Mitigation Action Plan	The plan was prepared by Lamb and Lynn counties, participating jurisdictions, and H2O Partners, Inc. The purpose of the plan is to minimize or eliminate long-term risks to human life and property from known hazards and to break the cycle of high-cost disaster response and recovery within the planning area."	O’Donnell	Lynn	2020

1.4 Assessment of Existing Infrastructure

Background knowledge of the UCFPR's existing natural and structural flood infrastructure provides context in identifying strategies and flood planning recommendations throughout the planning process. This section details the natural flood mitigation features and major flood infrastructure in the UCFPR. Natural features and infrastructure included, as applicable, are summarized in Table 1-11~~Table 1-11~~. Existing flood infrastructure is shown in Map 1 in Appendix A.

Table 1-11. Natural Features and Constructed Major Flood Infrastructure

Flood Infrastructure	Source / Description	Non-Functional/ Deficient
Natural Features*		
Rivers, Tributaries, and functioning floodplains	National Hydrography Dataset (NHD)	Functional
Functioning Floodplains	Floodplains from TWDB compiled ‘flood quilt’	Functional
Wetlands	National Wetland Inventory	Functional
Sinkholes	NHD and HDR Engineering, Inc. (HDR), many others not defined	Functional
Alluvial Fans	None known	n/a
Playa Lakes	Undefined	n/a
Constructed Major Infrastructure		
Levees	Undefined	Unknown
Stormwater Tunnels	None known	n/a
Stormwater Canals	None known	n/a
Dams that Provide Flood Protection	Texas Commission on Environmental Quality (TCEQ) and Natural Resources Conservation Service (NRCS)	Functional
Detention and Retention Ponds	Numerous sources, including TCEQ and individual municipalities and counties	Unknown
Weirs	None known	Unknown
Storm Drain Systems	Undefined	Unknown

* 31 TAC §361.31 states that regional flood plans include a general description of the location, condition, and functionality of natural features and constructed major infrastructure within the flood planning region. Several of these do not exist within the Upper Colorado Flood Planning Region, including vegetated dunes; sea barriers, walls, and revetments; and tidal barriers and gates.

n/a=not applicable; TBD=to be determined

Existing flood infrastructure in the UCFPR consists of both natural features and constructed features, which are owned and managed by numerous entities, including governmental entities to individual property owners. Flood infrastructure may include non-structural measures, such as natural area preservation, buyout of repetitive flood loss properties, or flood warning systems, and includes major public infrastructure, like flood control dams. The TWDB Flood Data Hub[4] provides data to assist with the identifying flood management infrastructure. The UCFPR's geodatabase was populated with available information from the TWDB and other state and federal sources. The multiple data sources were reviewed and amended to include one data point per location if duplication occurred across datasets.

1.4.1 Natural Features

As land uses change and rangeland is, for example, overgrazed and soils compacted, the permeability of the soil can decrease, making land less efficient at detaining stormwater and allowing for infiltration into unsaturated soils. In more urban areas, drainage infrastructure is designed to collect stormwater. This concentration of stormwater increases the velocity and intensity of runoff, which can lead to higher and faster flood flow peaks.

As land fragmentation in some areas of the UCFPR increases due to urbanization, oil and gas development, and other factors, focused land management efforts will be necessary to continue to receive the flood control benefits of certain natural features of open land. The USACE's program Engineering with Nature[5] aims to bring natural and engineered processes together to deliver more efficient and sustainable projects. In the UCFPR, local, state, and federal governments manage local, state, and regional parks and lands, and wildlife management areas that form part of the region's natural infrastructure.

When left in their natural state, open lands are typically efficient at managing rainfall. Rainfall is slowed by vegetation, which allows rainfall an opportunity to infiltrate into the soil. Rangeland performs this function effectively. However, rainfall on cropland may pool and runoff comparatively more quickly. Well-designed parklands in more urban areas can attain nearly the same rate of capture and detention of stormwater as lands in undeveloped areas. For engineered natural features to achieve flood mitigation effectively, they are often designed to form part of an interconnected network of open space consisting of natural areas, which is known as low-impact development[6] or green infrastructure. These practices can be defined as replicating natural processes to

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[4] https://www.twdb.texas.gov/flood/planning/data.asp, Accessed March 18, 2022.

[5] https://ewn.erdc.dren.mil/, Accessed March 21, 2022.

[6] https://lowimpactdevelopment.org/, Accessed March 21, 2022.

capture stormwater runoff where even small changes in developed areas can lessen downstream flooding.

1.4.1.1 Rivers, Tributaries and Functioning Floodplains

Streams and rivers and their associated floodplains have the natural flood storage capacity to contribute significantly to overall flood control and management. The natural hydrologic features operate as a single integrated natural system. When this system is disrupted, effects can cascade through the watershed, increasing the flood risk. Floodplain maintenance in an undeveloped state provides rivers and streams the ability to store the maximum volume of floodwater and reduce flood peak volumes. Preservation of a natural integrated system of waterways and floodplains serves a valuable function in urban areas, as well.

With a length of approximately 862 miles, the Colorado River is the longest river with both its source and its mouth within Texas. The Colorado River's watershed drains an area of about 39,900 square miles, including almost 15 percent of Texas. It flows generally southeast from Dawson County through Ballinger in the UCFPR before emptying into the Gulf of Mexico at Matagorda Bay. The long-term average flow at the U.S. Geological Survey (USGS) gaging station USGS 08126380 Colorado Rv nr Ballinger, TX[7], in the UCFPR is 62,000 acre-feet per year. Other significant rivers and streams within the basin include the Concho, Red Draw, South Concho, and Middle Concho rivers and Beals, Grape, Brushy, Spring, Dove and Deep creeks.

The UCFPR's lakes, reservoirs, parks, and preserves serve as important components of the ecosystem as they encompass a wide variety of plants, animals and physical features that are imperative for the continued ecological health of the UCFPR. These water bodies and natural areas retain water during flood events. These types of natural flood infrastructure are generally located in or close to floodplain areas throughout the basin with higher concentrations located along or close to the major rivers and tributaries.

1.4.1.2 Karst Features

Recharge-related sinkhole flooding, flow-related flooding, and discharge-related flooding are associated with karst. Even if there are no sinkholes visible in a karst region, continuing karstic development under urban areas can affect building foundations. Rapid urban development on karst usually increases the mass on the land surface, which increases the chance of surface collapse. In addition, impervious paved surface of urban areas can block infiltration, altering native groundwater flow paths. In some situations, karst features can rapidly infiltrate surface flood waters and provide flood

[7] USGS 08126380 Colorado Rv nr Ballinger, TX. https://waterdata.usgs.gov/nwis/uv?08126380, Accessed on March 21, 2022.

reduction capabilities. Water quality control measures and flood management should occur simultaneously to prevent groundwater contamination.

1.4.2 Constructed Flood Infrastructure

Major constructed flood infrastructure can range from dams and levees to municipal drainage systems, which consist of constructed channels and storm drain systems. Dams serve many purposes, including flood risk reduction and water supply for numerous uses, from water supply to irrigation and recreation.

1.4.2.1 Dams, Reservoirs, Levees, and Weirs

Impounded water features such as reservoirs serve many purposes, including recreation, flood risk reduction, irrigation, water supply and fire protection, among others. The TWDB maintains the dataset used to identify major reservoirs. Fifteen major reservoirs were identified in the UCFPR, as shown in Table 1-12~~Table 1-12~~.

Table 1-12. Major reservoirs in the UCFPR

Reservoir	Location	Reservoir	Location
Champion Creek Reservoir	Mitchell County, seven miles south of Colorado City	Natural Dam Lake	Howard County, 10 miles from Stanton
E V Spence Reservoir	Coke County, 2 miles west of Robert Lee	O.C. Fisher Lake	
Lake Ballinger/Lake Moonen	Runnels County, four miles northwest of Ballinger	O.H. Ivie Reservoir	Tom Green County, west side of San Angelo
Lake Colorado City	Mitchell County, four miles southwest of Colorado City	Oak Creek Reservoir	Coke County, 8 miles north of Bronte
Lake J B Thomas	Scurry County, 16 miles from Snyder	Red Draw Reservoir	Howard County, six miles southeast of Big Spring
Lake Nasworthy	Tom Green County, southwest of San Angelo	Sulphur Springs Draw Storage Reservoir	Martin County, fourteen miles northeast of Stanton

Reservoir	Location	Reservoir	Location
Lake Winters / New Lake Winters	Runnels County, five miles east of Winters	Twin Buttes Reservoir	Tom Green County, 6 mi southwest of San Angelo
Mitchell County Reservoir	Mitchell County, nine miles southwest of Westbrook	--	--

Additional dams on smaller tributaries exist across the UCFPR and were identified from several sources, including the Texas State Soil and Water Conservation Board (TSSWCB), the Texas Commission on Environmental Quality (TCEQ), and USACE. The National Resource Conservation Service (NRCS), formerly the Soil Conservation Service (SCS), designed and constructed several dams, , and although not , readily available in documentation, the function of these dams often was for flood control. All identified dams have been included as part of the UCFPR's infrastructure inventory.

No individual weir structures were identified. However, dam spillways can act as weirs during flood events that overtop the spillway.

Levees are man-made embankments that artificially contain flood flows to a restricted floodplain. More than one million Texans and $127 billion dollars' worth of property are protected by levees, including 51 USACE levee systems. Two levees constructed as part of the Twin Buttes Reservoir were identified in the UCFPR.

1.4.2.2 Stormwater Management Systems

Stormwater management systems serve to manage both the quantity and quality of the water that drains into natural waterways. The TCEQ regulates the discharge of municipal separate storm sewer systems (MS4) through the two sets of permits administered under the Texas Pollutant Discharge Elimination System (TPDES), known as Phase I (large) or Phase II (small) MS4 permits. To be subject to MS4 permit requirements, a municipality must own and operate storm drainage infrastructure. Phase I MS4s are cities that had populations exceeding 100,000 as of the 1990 census. In the UCFPR, San Angelo, Midland, and Odessa, as well as Tom Green, Ector, and Midland counties, are subject to the Phase II MS4 permit requirements.

1.5 Assessment of Condition and Functionality of Existing Infrastructure

The general location, description, level of service, functionality, deficiency, and owning/operating entities for each identified natural flood mitigation features and constructed major flood infrastructure are summarized in Table 1 in 0 (to be determined

Commented [NC4]: revisit
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and completed) and the GIS geodatabase attached in 0. Additional information for significant or deficient/non-functioned features or infrastructure are detailed in subsequent sections as necessary.

The TWDB defines infrastructure functionality as follows.

- Functional infrastructure is defined as serving its intended design level of service.
- Non-functional infrastructure is defined as not providing its intended or design level of service.
- Deficient is defined as infrastructure or natural features in poor structural or non-structural condition and needs replacement, restoration, or rehabilitation.

1.5.1 Non-Functional or Deficient Flood Mitigation Infrastructure

Information compiled and responses provided to stakeholder outreach has been limited to date. Two explanations for non-functional and deficient infrastructure include lack of funding for a stormwater utility and higher design standards since the construction of existing stormwater drainage systems. Many municipalities lack a dedicated funding source for stormwater projects, operations, and maintenance. Texas state law does provide a mechanism for municipalities to establish a dedicated revenue source for drainage through the implementation of a stormwater utility fee. In the UCFPR, San Angelo, Midland, and Odessa, as well as Midland County have existing drainage fees.

Map 3 in Appendix B shows the non-functional or deficient flood mitigation features or infrastructure in the basin.

1.5.2 Dam Safety Assessment

In 2019, the Association of State Dam Safety Officials (ASDSO) estimated the cost to rehabilitate all non-federal dams in Texas at around $5 billion. The TSSWCB estimates about $2.1 billion is needed to repair or rehabilitate dams included in the Small Watershed Programs. A dam is classified as high hazard if its failure could cause significant loss of life, serious damage to structures, or disruption to important public utilities or transportation facilities. A dam's hazard classification is not an assessment of condition. Information about the condition of many dams is not publicly available. The TCEQ maintains condition data for non-federal dams as part of the Texas Dam Safety Program. However, of the 7,200 non-federal dams in our state, more than 3,200 Texas are exempt from dam safety requirements, representing almost half of these dams.

1.6 Proposed or Ongoing Flood Mitigation Projects

Table 2 in Appendix A ~~(to be completed)~~ and the attached GIS database include a general description of the location, source of funding, and anticipated benefits of proposed or ongoing flood mitigation projects in the UCFPR including:

1. New structural flood mitigation projects currently under construction,
2. Non-structural flood mitigation projects currently being implemented, and
3. Structural and non-structural flood mitigation projects with dedicated funding to construct and the expected year of completion.

The data for this section is derived from two primary sources: the UCFPR's existing hazard mitigation plans and a stakeholder survey. Gaps and limitations exist within the data. Overall, it only represents a small number of the communities within the basin and little data was provided on individual projects. Additional information for proposed or ongoing flood mitigation projects are detailed in subsequent sections as necessary.

Map 2 in Appendix B shows existing or ongoing flood mitigation projects in the basin.

1.6.1 Structural Projects under Construction

The cities of San Angelo, Midland, and Odessa have developed recent drainage master plans with lists of drainage capital improvement projects, some of which have been constructed and others that are still awaiting funding. Responses from other communities regarding projects under construction were insufficient to provide additional details regarding these projects. Chapter 4 provides a more detailed assessment of current and potential projects.

1.6.2 Implementation of Nonstructural Flood Mitigation Projects

Information provided in response to stakeholder outreach has been limited to date. The top goal of respondents has been implementation of protective standards and policies, followed by identification and communication of flood risk, restoring failing infrastructure, and implementation of flood warnings and responses. Chapter 3 includes further information regarding the region's goals and practices, and Chapter 4 describes implementation of nonstructural flood mitigation projects.

2

Flood Risk Analysis

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2 Flood Risk Analysis

[31 TAC §361.33-34]

This chapter describes the comprehensive flood risk analysis conducted for the Upper Colorado Flood Planning Region (UCFPR). Flood risks were assessed for the 1 percent annual chance and 0.2 percent annual chance events for existing conditions of the basin and a future condition scenario that considers changes in flood hazards over the 30-year planning horizon. The overall flood risk analysis is comprised of three separate but related evaluations, including:

1. Flood Hazard Analyses –characterize location, magnitude, and frequency of flooding.
2. Flood Exposure Analyses – identify who and what might be harmed within the region.
3. Vulnerability Analyses – identify vulnerabilities of communities and critical facilities.

The following sections describe the process undertaken to determine and quantify flood hazards in the region and present the results of the evaluation, including a summary of the types and magnitude of flooding and the communities most susceptible to its harmful effects. Existing Condition Flood Risk Analysis

2.1 Existing Condition Flood Hazard Analysis

The existing condition flood hazard analysis compiles a comprehensive outlook of existing flood hazards in the region. To date, no full-coverage evaluation of flood risk has ever taken place in the UCFPR or in the State of Texas. In addition, much of the flood risk in the Upper Colorado Region (Region 9) is unmapped or based on out-of-date maps. Therefore, most of the flood risk across the region is not well quantified, meaning that people and their property are unknowingly in harm’s way.

The outcome of the flood hazard analysis is a map of flood hazard areas that are subject to flooding during the 1 percent and 0.2 percent annual chance events. This effort is not regulatory in nature, and the results of this evaluation do not have an impact on National Flood Insurance Program (NFIP) insurance requirements or premiums. Rather, this exercise is intended to gather a single, comprehensive set of best available information on actual flood risk in the region to help communities understand their current risks and better prepare in the event of a flood.

Existing condition flood risk analyses are shown in Table 3 in Appendix A.

The following pertinent maps for this section are included in Appendix B:

- Map 4: Existing Condition Flood Hazard

- Map 5: Existing Condition Flood Hazard - Gaps in Inundation Boundary Mapping including Identification of Known Flood-Prone Areas
- Map 6: Existing Condition Flood Exposure
- Map 7: Existing Condition Flood Vulnerability including Critical Infrastructure

2.1.1 Types of Flood Hazards in the Region

To plan for a flood, it is important to understand the types of flooding an area faces. Each type of flooding is different in how it occurs, how it is forecast, and the damages it can cause. This evaluation considered several different types of flooding in the development of the flood hazard areas.

Riverine Flooding: Riverine flooding is caused by bank overtopping when the flow capacity of rivers is exceeded. Rising water generally originates from high-intensity rainfall creating soil saturation and large volumes of runoff to the receiving waters, either locally and/or in upstream watershed areas.

Pluvial Flooding, including Urban Flooding: One of the common misconceptions about flooding is that one must be located near a body of water to be at risk. Yet pluvial, or "urban" floods are not caused by swelling rivers. Urban floods can occur when the inflow of stormwater in urban areas exceeds the capacity of drainage systems, causing flooding into streets and nearby structures. Pluvial flooding also includes flash floods, where high velocity surface waters sweep through low-lying areas.

Coastal Flooding: Coastal flooding occurs when normally dry, low-lying land is flooded by seawater. Since the Upper Colorado Region is contained entirely inland, this type of flooding does not occur in the region.

Playa Flooding: Playa flooding occurs when playas overtop and flood surrounding areas.

2.1.2 Possible Flood Prone Areas

This analysis also considers potentially flood prone areas that the regional flood planning group (RFPG) identifies outside of previously-mapped flood hazard areas. They can be identified through the location of hydrologic features, historic flooding, and/or local knowledge. Since the cause and recurrence of flooding in these areas is uncertain, separate flood hazard areas have been developed and are listed with "unknown" flood frequency in this analysis.

The Upper Colorado Region is subject to both the danger of swift-moving flood waters in riverine areas, in addition to standing water associated with flooded lakes and other low-lying areas. Urban flooding is likely also a source of significant flooding exposure, particularly in the cities of Midland, Odessa and San Angelo. However, this type of flooding was not specifically defined in the available hazard datasets and has not been discretely identified for the first planning cycle.

Possible flood prone areas were identified through two sources of data. The first was through an evaluation of the region's low-water crossing data compared to known flood hazard areas. Low-water crossing points outside of the 1 percent and 0.2 percent flood hazard areas were delineated as possible flood prone areas, since their status as low-water crossings indicates that there is likely flooding occurring at these locations, even if it is not mapped.

The second source of data was comments on an ArcGIS Online web map where the public can report areas of flooding. This web map was shared on the Upper Colorado Regional Flood Planning Group (UCRFPG) website, as well as emailed to community officials in the region. Points that were outside of the 1 percent and 0.2 percent flood hazard area were delineated as possible flood prone areas based on the description included in the comment.

2.1.3 Existing Hydrologic & Hydraulic Model Availability

The development of the flood hazard areas relied on floodplain modeling and mapping information from existing sources, rather than the development of new flood hazard information. Hydrologic and hydraulic models used for the purposes of defining flood risk boundaries are currently only available for roughly 20 percent of the region, as summarized in Table 2-1.

Table 2-1. List of Models Relevant to the Regional Flood Plan

Model Title	Hydrology Software	Hydraulics Software	Study Area	Sponsor Entity	Date
Crockett County FIS*	NUDALLAS	HEC-2	Crockett County	FEMA	1981
Dawson County FIS	17B/ Regression	USFHA / RAS	Dawson County	FEMA	2011
Ector County FIS	HEC-1	HEC-2	Ector County	FEMA	2012
Hockley County FIS	17B/ Regression	USFHA / HEC-2	Dawson County	FEMA	1977
Howard County FIS	TR-20	HEC-2	Howard County	FEMA	2010
Midland County FIS	HEC-1	HEC-2	Midland County	FEMA	2005
Mitchell County FIS	17B/ Regression	USFHA / HEC-2	Mitchell County	FEMA	1985
Nolan County FIS	NUDALLAS	HEC-2	Nolan County	FEMA	1990
Scurry County (Snyder) FIS	NUDALLAS	HEC-2	Scurry County	FEMA	1980

Model Title	Hydrology Software	Hydraulics Software	Study Area	Sponsor Entity	Date
Tom Green County FIS	SWFHYD/ HEC-1	HEC-2	Tom Green County	FEMA	2012
Deep Creek Section 205 Study	HEC-HMS	HEC-RAS	City of Snyder	USACE	2021

*FIS - Flood Insurance Study

2.1.4 Best Available Data Determination

To assist RFPGs with the flood hazard analysis, the TWDB prepared a statewide, geographic information system (GIS) dataset that is comprised of the most recent flood hazard data in Texas, referred to as the "flood risk quilt." The floodplain quilt is comprised of data from several sources, including First American Flood Data Services (FAFDS) flood zone determinations, the Federal Emergency Management Agency's (FEMA) National Flood Hazard Layer (NFHL) information developed from detailed and approximate flood studies, and FEMA Base Level Engineering (BLE) data.

Due in part to the availability of Cursory Floodplain Data~~Fathom~~ flood risk boundaries for the entire basin, the 1 percent and 0.2 percent annual chance flood risk boundaries were defined for all waterways with contributing drainage areas larger than 1 square mile for the entire basin. Where multiple data sets were available, the most accurate risk boundaries were applied.

The TWDB provided the initial "flood risk quilt," which consists of multiple layers of data from various sources available throughout the state to "quilt" together a single flood hazard dataset. The "flood risk quilt" does not typically include localized flooding or complex urban flooding problems. The Fort Worth District of the U.S. Army Corps of Engineers (USACE) provided additional flood risk boundaries and some flood prone areas were identified from public comments. The following is a list of the various flood risk data sets used in their order of accuracy from most accurate to least accurate, with the base flood elevation (BFE) data set and sets above it considered accurate.

- National Flood Hazard Layer (NFHL) Pending Data
- NFHL Preliminary Data
- USACE Section 205 Study
- NFHL Effective Data
- FEMA BLE Base Flood Elevations
- NFHL Approximate Study Areas
- First American Flood Data Services (FAFDS)
- Cursory Floodplain Data ~~Fathom Cursory Data~~ – October 29, 2021
- Public Comments

A large portion of the regional flood planning area contains approximate 1 percent annual chance flood risk boundaries but no 0.2 percent annual chance flood risk boundaries (NFHL Approximate Study Areas). However, the Cursory Floodplain Data ~~Fathom Cursory Data~~ has both the 1 percent and 0.2 percent annual chance flood risk boundaries. The remainder had to be estimated for approximate areas by buffering the 1 percent annual chance inundation boundary by 100 feet to each side. This 100-foot buffer was approximated by evaluating portions of the region that had available detailed studies that defined both the 1 percent and 0.2 percent annual chance flood inundation boundary using a similar offset between the 1 percent and 0.2 percent annual chance flood inundation boundary.

2.1.5 Identified Existing Flood Hazard Areas

Figure 2-1 shows the flood hazard area under existing conditions. These floodplains cover over 5,900 square miles and 28 percent of the land area of the UCFPR. Of the mapped flood hazard area, 4,521 square miles are inundated during the 1 percent annual chance event, and an additional 1,419 square miles are inundated during the 0.2 percent annual chance floodplain.

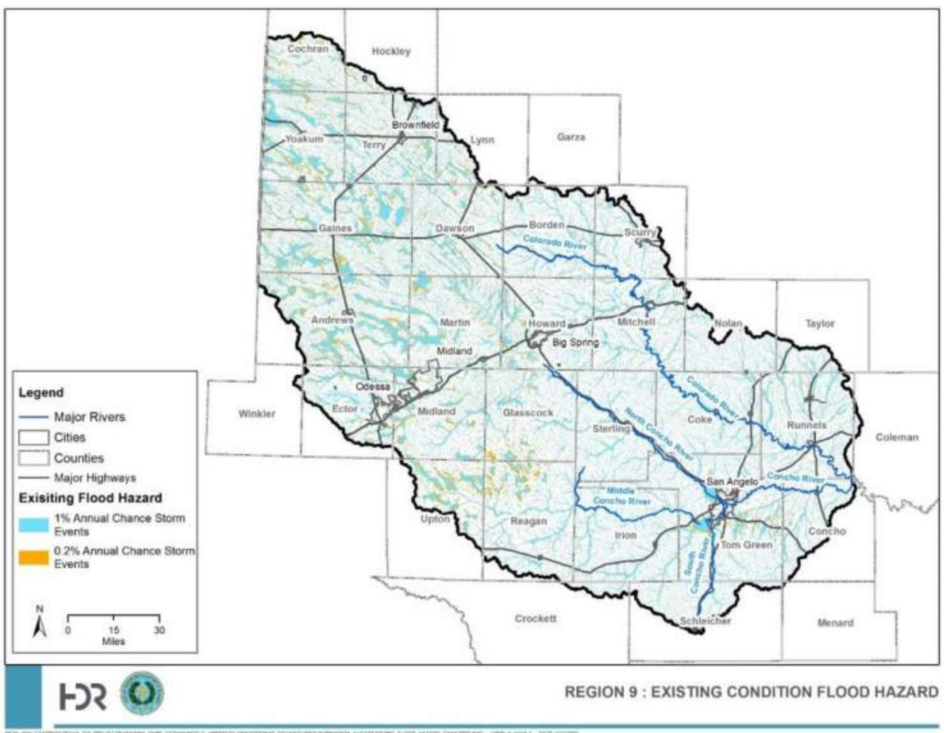

Figure 2-1. Flood Hazard Area Under Existing Conditions

Figure 2-2 presents the total flood hazard area by county. Overall, the counties of Gaines, Tom Green, and Andrews have the highest total flood hazard area, with over 400 square miles of flood hazard area per county.

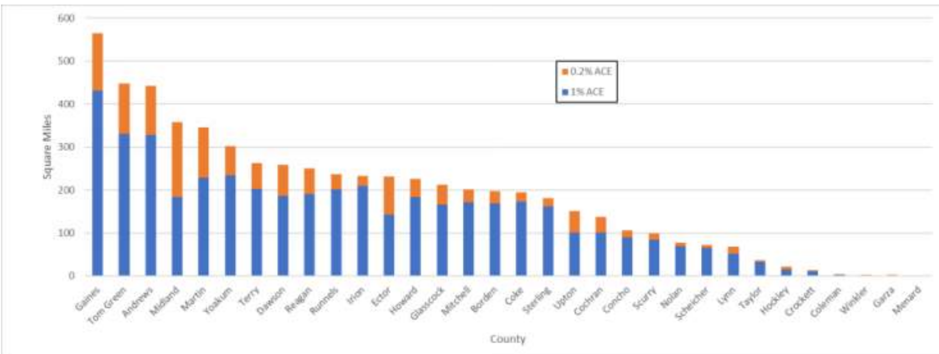

Figure 2-2. Total Flood Hazard Area by County

2.1.6 Existing Conditions Data Gaps

As previously described, most of the Upper Colorado Region is lacking flood mapping information, and the areas that are mapped are generally decades old. For the gap analysis, the UCRFPG determined that anything other than detailed study information less than 10 years old is a data gap. This results in the entire region being listed as a gap, though further refinement considered the severity of the gap (i.e., an area that has old mapping information versus an area that has had no mapping). Additionally, the very western portion of the region has no cursory floodplain data available, so a separate gap type was created for this area. This information is presented visually in Figure 2-3~~Figure 2-3~~.

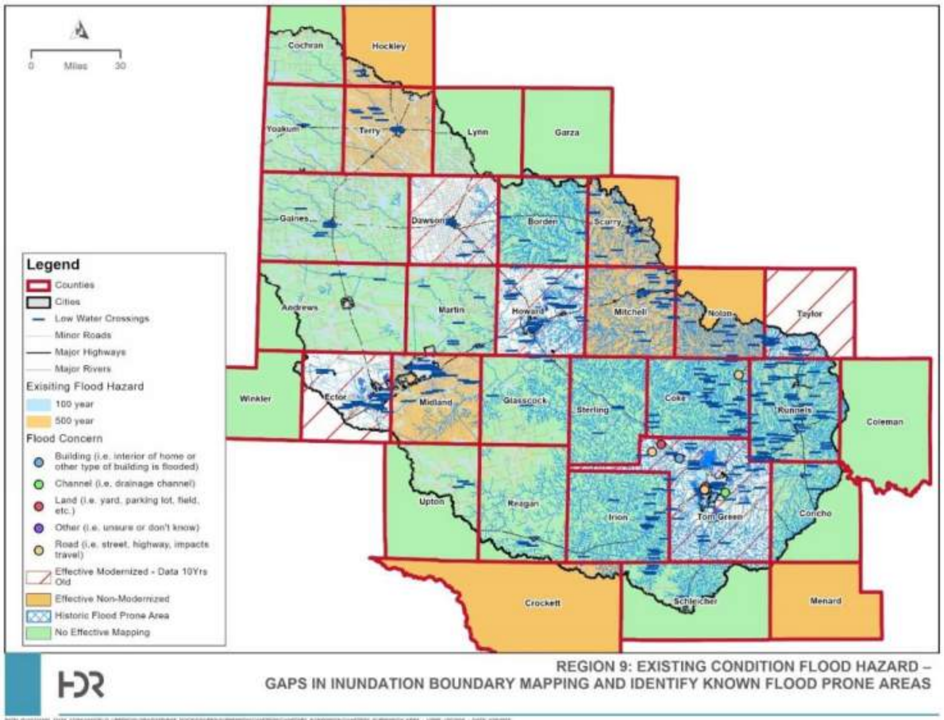

Figure 2-3. Existing Conditions Data Gaps

2.1.7 Existing Condition Flood Exposure Analysis

After defining the existing condition flood hazard areas, the existing condition flood exposure analysis was performed to identify the people and property at risk. This analysis was completed using an automated GIS process that intersected various data sources with the flood hazard area boundaries to create the various flood exposure feature classes for the different feature types. The analysis considered exposure of different types of existing development within the flood hazard area, including the following:

1. Buildings: This includes residential and non-residential structures, those structures identified as critical facilities, and the associated population at risk. The population at risk evaluated both the day and night population estimates for each structure, with the higher of the two values being used to estimate the population in the flood hazard area.
2. Roadways: This includes estimated number of road crossings and total roadway length inundated by flooding. Those road crossings identified as low water

crossings were specifically identified, as these crossings are generally overtopped by floodwaters more frequently.

3. Agricultural Areas: This includes the total area of farming and ranching lands within the flood hazard area.

2.1.7.1 Flood Exposure Due to Existing Levees or Dams

An analysis requirement is to consider population and property located in areas where existing levees or dams do not meet FEMA accreditation as inundated by flooding without those structures in place. No dams or levees in the region were specifically identified as not meeting FEMA accreditations. Therefore, it was assumed that the current floodplain limits properly reflect the flood protection benefits of these structures.

2.1.7.2 Existing Flood Exposure Summary

The following sections describe the results of the existing flood exposure analysis with a summary table following. Unsurprisingly, the urban centers of Midland, Odessa, and San Angelo have the highest concentration of flood exposure in the region, due to the density of development and total population in these areas. However, flooded roadways and agricultural areas are found throughout the region, and the impacts due to the loss of function in these areas should not be understated.

When anticipating the likely extent of damages to a community from catastrophic floods, it is important to consider each community's relative "vulnerability" to floods when they do occur. Disasters affect different people or groups in different ways, which range from their ability to evacuate an area in harm's way, to the likelihood of damage to their homes and properties, to their capacity to marshal the financial resources needed to recover and rebuild after a flooding event.

Several factors are evaluated to determine an area's social vulnerability, which measures a person's or group's "capacity to anticipate, cope with, resist and recover from the impacts of a natural hazard," based on their relative vulnerability. The Social Vulnerability Index (SVI) is a standard system developed by the Centers for Disease Control and Prevention (CDC) for assigning a social vulnerability score at a census-tract basis. SVI as an indicator of a community's need for support before, during, or after a disaster. SVI is provided as a decimal value from 0.00 to 1.00; the higher the SVI, the more assistance a community is likely to need. A score of 0.75 or greater indicates that a community is highly vulnerable to impacts from a natural disaster. Knowledge of a community's SVI allows planners to better prepare for emergency events ranging from disease outbreaks, hurricanes, and exposure to dangerous chemicals.

Figure 2-4~~Figure 2-4~~ shows the existing flood hazards along with the average SVI score for each county. Those counties with higher SVI scores could have a harder time recovering after a flood event.

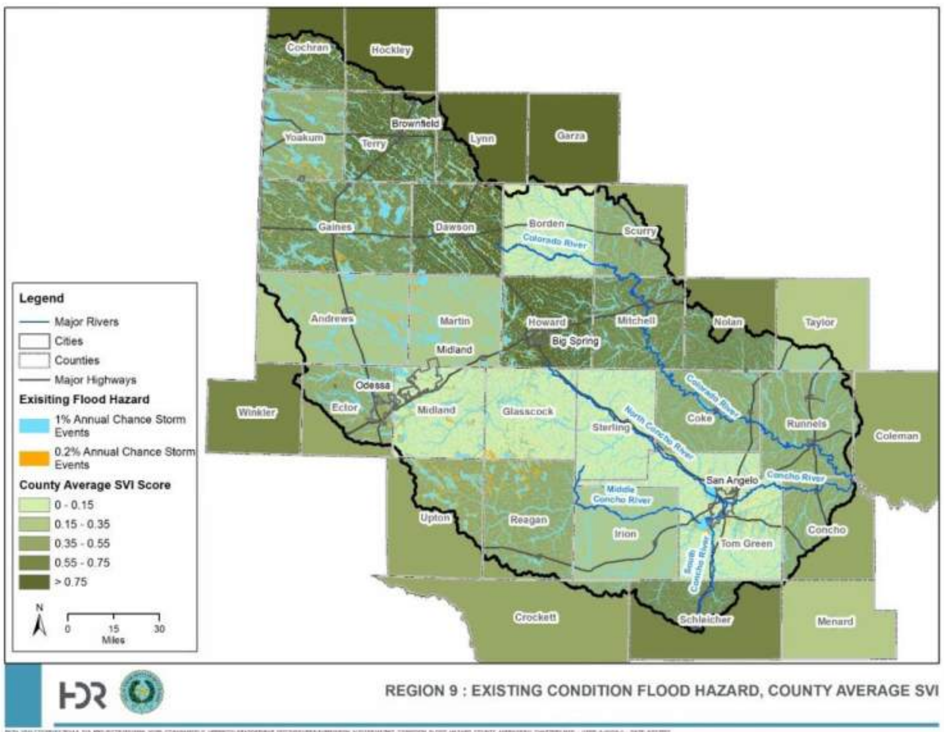

Figure 2-4. Existing Flood Hazards and Average SVI Score

Residential Properties

The three counties with the highest number of residential properties in the flood hazard area are Ector, Midland, and Tom Green, which contain the cities of Midland, Odessa, and San Angelo. Outside of these larger metro areas, the next highest residential property counts are in Howard, Gaines and Andrew counties, due to flooding in urbanized areas. The remaining counties have drastically lower counts compared to these top six, with four counties containing no residential structures in the flood hazard area. The number of residential properties in the existing flood hazard area is summarized in Table 2-2.

Non-Residential Properties

Non-residential properties within the flood hazard area follow a similar exposure pattern as residential structures. Midland, Ector and Tom Green counties have the highest number of structures at risk, followed by Gaines, Howard and Irion counties. The number of non-residential structures in the existing flood hazard area is summarized in Table 2-2.

Public Infrastructure

Public infrastructure is a broad term that includes roads; public water collection, treatment, and distribution facilities; gas and electrical facilities; and other public utilities. These facilities often perform essential functions that require enhanced levels of flood protection so that they may continue to function and provide services during and after a flood. As a result, a concentrated effort to identify "critical facilities" was performed in the flood exposure analyses. Examples of critical facilities include hospitals, fire stations, police stations, power generation facilities, and schools. Figure 2-5~~Figure 2-5~~ shows critical infrastructure located within the UCFPR in relation to the 1 percent and 0.2 percent change flood events. Most lie within Midland, Odessa, and San Angelo, but other critical infrastructure is located throughout the UCFPR.

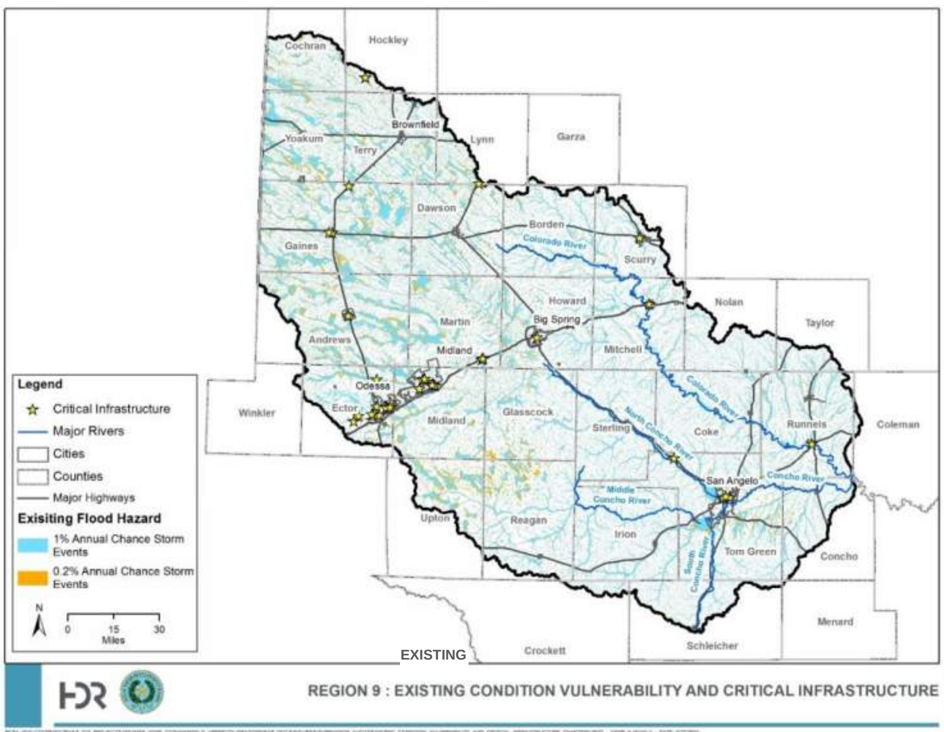

Figure 2-5. Critical Infrastructure within the UCFPR in Relation to the 1% and 0.2% Change Flood Events

Roadway impacts are also evaluated under a separate subcategory of analysis. Flooded roadways pose a substantial risk to motorists, as over half of all flood-related drownings occur when vehicles are driven into hazardous flood waters. Functioning roadways serve a critical function during flood events, providing access to first responders and clear routes to safety in the case of an evacuation.

Other impacts to public infrastructure are not specifically quantified in this analysis, due to the lack of publicly available data for most of these infrastructure types. However, some general impacts and expected loss of function for these infrastructure types are outlined in the Expected Loss of Function section.

Major Industrial and Power Generation Facilities

There are 918 buildings in the existing flood hazard that are marked as industrial, including 28 critical facilities. Within the flood hazard area, there are 16 facilities associated with power generation: 7 are natural gas processing plants, 6 are petroleum refineries, and 3 are power plants. These facilities are summarized in Table 2-2.

Critical Facilities

There are 63 critical facilities total within the existing flood hazard area. The two most common types of facilities within the flood hazard area are schools and nursing homes.

Roadway Crossings

The three counties with the highest number of roadway stream crossings are Tom Green, Mitchell, and Runnels, centered around San Angelo, with several major roadways and arterials converging through downtown San Angelo, as well as the surrounding area. Additionally, this portion of the watershed contains the Upper Colorado River and its vast network of tributaries, meaning several major river crossings are found along these transportation corridors.

Roadway Segments

Terry, Dawson and Gaines counties have the most miles within the floodplain due to a large number of primarily rural roads associated with farmland in these counties. Ector and Midland also have a large number of miles within the floodplain associated with primarily urban roads within the Midland-Odessa metropolitan area.

Agricultural Areas

The county with the most agricultural areas within the floodplain is Gaines County. All of the remaining counties have much smaller amounts of agricultural area within the floodplain.

In order to evaluate the value of land exposed, average values for agricultural land in Texas were identified using the from the 2020 United States Department of Agriculture (USDA) Land Values Summary. This summary included an average value of $2,030 per acre for cropland and $1,680 per acre for pasture. Within the entire region, there is 5,158 square miles of cropland and 14,813 square miles of ranchland. From these values, a weighted average cost for agricultural land was identified as $1,770 per acre. Within the entire flood hazard area, there is over 2.7 million acres, or $4.8 billion of crops and pasture exposed.

Table 2-2. Summary of structures in the existing flood hazard areas

County	Area in Flood Planning Region (sqmi)	1% Annual Chance Flood Risk								0.2% Annual Chance Flood Risk							
		Area in Flood-plain (sqmi)	Num. of Struct. in Flood-plain	Resid. Struct. in Flood-plain	Pop.	Roadways Stream Crossing (#)	Roadways Segments (miles)	Ag. Areas (sqmi)	Critical Facilities (#)	Area in Flood-plain (sqmi)	Num. of Struct. in Flood-plain	Resid. Struct. in Flood-plain	Pop.	Roadways Stream Crossing (#)	Roadways Segments (miles)	Ag. Areas (sqmi)	Critical Facilities (#)
Andrews	1231.36	328.40	996	786	1,310	0	181.9	214.5	0	110.00	1,011	771	1,533	0	61.4	67.7	2
Borden	851.20	168.60	71	9	11	32	27.9	89.8	1	29.40	79	12	29	2	10.9	16.8	0
Cochran	449.86	100.40	24	12	14	0	149.9	82.4	0	37.20	14	8	3	0	27.1	30.4	0
Coke	928.14	172.30	267	112	81	58	63.4	80.5	4	22.80	332	151	119	7	11.8	9.9	0
Coleman	17.58	2.03	6	1	1	1	0.247	0.92	0	0.30	3	1	1	0	0.107	0.14444	0
Concho	476.39	90.00	110	53	55	25	28.10	50.6	0	14.80	96	41	42	2	8.90	8.6	0
Crockett	76.35	11.40	0	0	0	0	0.7	7.8	0	1.53	0	0	0	0	0.09	1.3	0
Dawson	897.98	186.20	510	10	2	3	558.2	162.5	0	57.10	579	7	1	0	114.1	53.3	0
Ector	620.05	33.70	14,339	10,882	26,443	78	325.1	99	9	33.80	7,617	6,049	16,755	11	103.3	20.6	5
Gaines	1502.48	4,665.82	2,125	913	1,281	0	452.5	340.9	3	1,431.99	1,603	782	1,306	0	130.3	103.7	1
Garza	8.71	12.70	0	0	0	0	0	0.65	0	1.93	0	0	0	0	0	0.107	0
Glasscock	901.24	1,790.02	155	3	2	6	44.6	137.3	0	512.98	125	5	3	4	20.3	43	0
Hockley	95.40	165.49	48	19	20	0	43.5	14.9	0	75.21	69	28	38	0	10.8	7	1
Howard	904.13	1,983.78	1,678	741	1,356	74	207.3	74,621.50	2	460.91	1,604	958	2,004	13	71	21,991.40	4
Irion	1052.31	2,262.89	957	127	61	24	48.5	118.8	0	256.98	616	99	48	6	9	17.3	0
Lynn	217.67	550.65	367	214	256	0	165.5	47.8	1	189.52	87	66	96	0	24.2	17.1	0
Martin	915.62	2,471.44	1,008	481	972	4	248.8	196.7	4	722.29	387	142	368	2	30.1	60.5	0
Menard	1.04	1.08	0	0	0	0	0	0	0	0.06	0	0	0	0	0	0	0
Midland	894.96	1,983.68	9,727	6,338	18,006	63	314	148.4	9	641.34	6,780	4,636	14,351	6	110.8	148.4	1
Mitchell	907.80	1,859.86	379	220	252	101	112.5	87.1	4	314.92	619	429	445	7	28.8	15.1	0
Nolan	451.37	749.14	96	18	6	20	22.4	37.1	0	84.37	47	9	5	3	5.4	4	0
Reagan	1092.81	2,066.75	206	103	68	11	43.6	147.7	1	646.69	292	147	100	0	31.3	52.5	0
Runnels	1018.38	2,171.97	188	45	32	93	128.9	152.1	1	382.50	136	21	28	11	33.1	26.6	0
Schleicher	436.59	700.08	115	48	53	9	18.4	27	0	81.36	120	72	58	1	4.5	3.1	0
Scurry	515.80	918.16	725	361	427	87	77.9	56.4	1	152.61	278	176	231	9	15.4	7.3	0
Sterling	923.69	1,755.22	219	119	97	25	33	83.8	0	200.91	175	95	88	5	9.1	13	0
Taylor	171.01	355.45	82	56	41	12	20	24.3	0	46.85	49	40	35	2	5.5	2.9	0
Terry	865.43	2,194.71	527	190	340	4	660.9	186.6	1	639.72	505	222	460	0	104.9	55.4	1

County	Area in Flood Planning Region (sqmi)	1% Annual Chance Flood Risk								0.2% Annual Chance Flood Risk							
		Area in Flood-plain (sqmi)	Num. of Struct. in Flood-plain	Resid. Struct. in Flood-plain	Pop.	Roadways Stream Crossing (#)	Roadways Segments (miles)	Ag. Areas (sqmi)	Critical Facilities (#)	Area in Flood-plain (sqmi)	Num. of Struct. in Flood-plain	Resid. Struct. in Flood-plain	Pop.	Roadways Stream Crossing (#)	Roadways Segments (miles)	Ag. Areas (sqmi)	Critical Facilities (#)
Tom Green	1541.44	3,578.62	6,122	3,845	6,669	170	263.8	227.4	7	724.15	3,928	2,416	6,132	23	96.6	53.5	0
Upton	480.50	1,084.47	43	18	5	0	40.8	74	0	553.65	36	8	12	0	11.6	43.5	0
Winkler	9.41	13.80	0	0	0	0	0	0	0	7.11	0	0	0	0	0	0	0
Yoakum	799.53	2,529.65	673	294	505	0	309.2	216.7	0	734.83	343	139	187	0	61.5	62.3	0

sqmi=square mile; Pop.=population; Resid.=residential; Struct.=structures; Ag.=agricultural; Num.=number

2.1.7.3 Expected Loss of Function

The impacts of flooding on lives and livelihoods are often felt not just during a flood event but long afterwards. As communities assess damages after a flood, several different types of impacts must be evaluated. Historical flood impacts, including dollar values of damages and known injuries and losses of life are quantified in Chapter 1. This section presents a qualitative assessment of the types of flood impacts and the expected losses of function in both the public and private sectors.

Inundated Structures

Structural flooding can be devastating to property owners and communities as a whole. Structural flooding can cause water damage to a building as well as the contents inside. Often times, this leads to costs due to families being displaced from their homes. Businesses may also lose inventory that is damaged during a flood and may not be able to operate while repairs are being made. In extreme cases, the flood damages can be so severe that the structure and contents constitute a total loss. These impacts are lessened at lower flood elevations, which is why it is important to consider depth when evaluating flood impacts on structures.

Health and Human Services

Health impacts from flooding can be both direct and indirect. The two-thirds of flood-related deaths worldwide are due to drowning, but other impacts can also have negative implications for human health (World Health Organization, 2014). Direct effects of flooding include heart attacks, drowning from travelling through flood waters, injuries from flood conditions, and disease. Indirect impacts include damage to health care infrastructure, water shortages and contamination, disruption of food supplies, population displacement, and disruption of livelihoods (World Health Organization, 2014). Hospital preparedness is important during flooding. Natural disasters can cause both damage to existing infrastructure and increase the number of patients who need assistance (World Health Organization, 2014).

Water Supply and Wastewater Treatment

Water treatment plants can be particularly at risk during flooding events, as many are located next to rivers or other water sources. Failure of water supply systems results in both direct costs (repairing pipes, contamination of the network) and indirect costs (service disruptions impacting people outside of flood waters) (Arrighi, Tarani, Vicario, & Castelli, 2017). The indirect impacts can reach up to three times as many people as were directly flooded (Arrighi, Tarani, Vicario, & Castelli, 2017).

Flooding can also negatively affect water quality. In 2018, flooding caused high turbidity in the water flowing into water treatment plants in Austin, Texas (FOX 7 Austin Digital Team, 2021). This resulted in a weeklong boil water advisory as the treatment plants struggled to remove high levels of silt and reduce turbidity levels (FOX 7 Austin Digital Team, 2021).

There are also several impacts from flooding on wastewater systems. For houses using septic tanks, sewage can be carried back into the house through piping in some flood events, which will cause physical damage and could introduce disease-causing bacteria and viruses (Heger & Anderson, 2018). This is particularly a concern in rural areas that often do not have a community wastewater collection system. Flooding can also damage the wastewater system, and if untreated wastewater is released, there can be environmental and water-quality damage (Heger & Anderson, 2018). Wastewater treatment plants can be impacted by flooding through loss of power, damage to the plant, and personnel being unable to safely reach the plant (Nielsen, 2018). If systems are damaged in a flood, people can be left without adequate wastewater management systems until they can be repaired.

2.1.7.4 Utilities and Energy Generation

Damage to power lines and electricity distribution equipment from floating debris and inundation are some of the direct impacts of flooding on utilities and energy (U.S. Environmental Protection Agency, n.d.). Due to road impacts, maintenance and repair can also be delayed (U.S. Environmental Protection Agency, n.d.). Electricity disruptions have impacts on other aspects of energy production as well, as oil and gas pipeline disruptions are often due to power outages after severe weather events ((U.S. Environmental Protection Agency, n.d.).

Transportation and Emergency Services

Flooding can cause immediate impacts to transportation systems by causing delays or disruptions due to inundated and damaged infrastructure (Rebally, Valeo, He, & Saidi, 2021). On a greater scale, these conditions impact the economics of the region. Due to roads being unsafe for travel, closed, or submerged, connectivity is reduced, deviated, or cancelled for people, goods, and services (Rebally, Valeo, He, & Saidi, 2021). For these reasons, flood impacts on transportation infrastructure has consequences throughout the region, in both flooded and dry areas.

Flooding has a negative impact on emergency services. Due to inaccessible roads and increased traffic congestions, it can take a longer time to get to people in need (Loughborough University, 2020). Within England, researchers found that 84 percent of the population can be reached with 7 minutes for emergency situations, however, in a 30-year flood scenario, it drops to 70 percent, and in a 100-year event, it drops even lower to 61 percent (Loughborough University, 2020).

2.1.8 Existing Conditions Vulnerability Analysis

After completing the flood exposure analysis, the populations and structures exposed to flooding within the identified flood hazard area were analyzed to determine their vulnerability to flooding. Vulnerability was assessed using the SVI scale.

TWDB provided a building dataset that included SVI values for each building. SVI was also assigned to the other exposure features (low water crossings, critical infrastructure, etc.) based on the average SVI of the surrounding census tract. Based on the exposure features in the existing condition flood hazard area, an average SVI of the exposed area was computed for each county. Using these results, vulnerable portions of the region were identified.

The results of the analysis are summarized in Figure 2-6. For areas with a high SVI value and many items labeled as critical infrastructure, the potential affects from flooding could be higher due to damage to this infrastructure and potential lack of services after the flooding event.

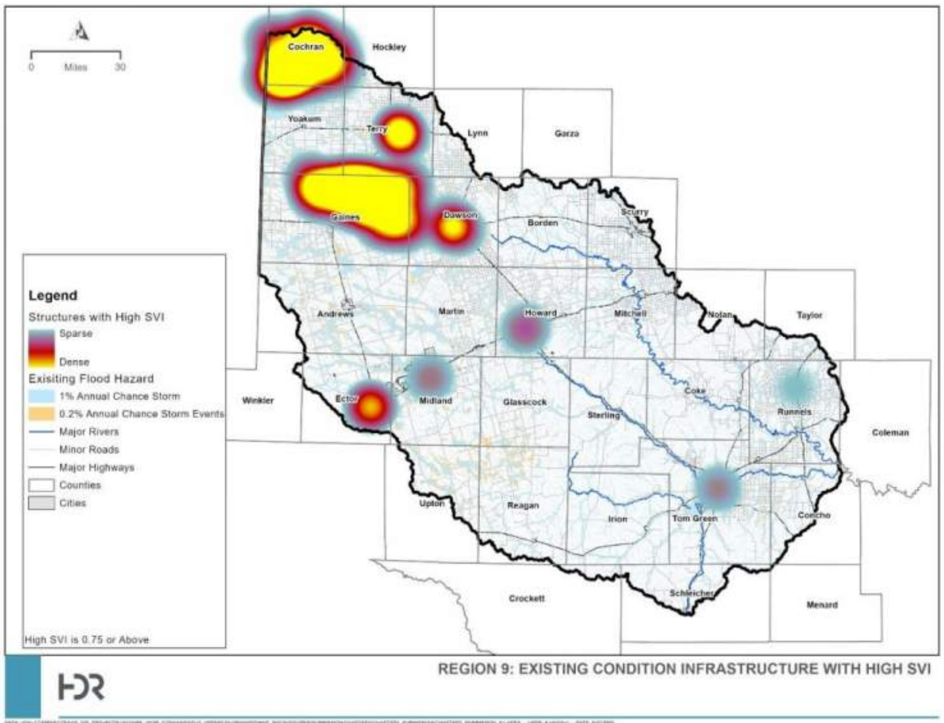

Figure 2-6. Existing Conditions Vulnerability Analysis

2.1.9 Resilience of Communities Located in Flood-prone Areas

Natural disasters pose threats to a community's wellbeing. Several factors, including socioeconomic levels, access to hospital systems, and crowded housing affects a community's resilience. The average SVI of features in floodplain or flood-prone areas per county is provided in Appendix A – Table 3 – Existing Condition Flood Risk Summary Table. Locations of high SVI areas located in floodplains or flood-prone areas are shown in Figure 2-6.

(1) Most vulnerable areas: Gaines, Cochran, and Terry counties

(2) Other vulnerable areas: Odessa, Big Spring, Midland, and San Angelo

2.2 Future Condition Flood Risk Analysis

In addition to quantifying the current flood risk, it is helpful to consider the change in flood risk over the course of the planning horizon to help communities plan for new or increased risks. With this concept in mind, a future condition flood risk analysis was performed for the UCFPR.

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The future condition flood risk analysis included two components: projected increases in flood hazard and additional exposure/vulnerability. The first step was to define of a future flood hazard area boundary to identify areas of existing development that, while not currently at risk of flooding during the 1 percent or 0.2 percent chance events, may be at risk of flooding during these events in the future. The second step was to identify areas that face an increase in future flood risk due to new development or redevelopment that may occur in these areas. The methods employed to evaluate future risk and the results of the analysis are explored in the following sections.

Existing condition flood risk analyses are shown in Table 5 in Appendix A.

The following pertinent maps for this section are included in Appendix B:

- Map 8: Future Condition Flood Hazard
- Map 9: Future Condition Flood Hazard - Gaps in Inundation Boundary Mapping including Identification of Known Flood-Prone Areas
- Map 10: Extent of Increase of Flood Hazard Compared to Existing Condition
- Map 11: Future Condition Flood Exposure
- Map 12: Future Condition Flood Vulnerability including Critical Infrastructure

2.2.1 Future Condition Flood Hazard Analysis

History has demonstrated that flood hazards tend to increase over time in populated areas due to projected increases in impervious cover, anticipated sedimentation in flood control structures, as well as other factors that result in increased or altered flood hazards. As a result, the future condition flood hazard area was defined based on an expected increase in flooding extents and magnitude across the region.

The TWDB provided several methods by which to determine the future flood hazard layer. The first step of this task is to identify areas within the region where future condition hydrologic and hydraulic model results and maps already exist. For the Upper Colorado Region, no such results or maps have been identified. Therefore, one of the following four methods must be used to identify the future flood risk across the region:

1. Increase water surface elevation based on projected percent population increase (as a proxy for land development)
2. Use the existing 0.2% annual chance floodplain as a proxy for the future 1% annual chance floodplain
3. Use a combination of methods 1 and 2 or a RFPG-proposed method
4. Request TWDB for a desktop analysis

The UCRFPG employed Method 2, described further in this section.

2.2.1.1 Future Conditions Based on “No Action” Scenario

Estimated changes in flood hazard extents are meant to represent the “30-year, no action” scenario for the purpose of evaluating the potential magnitude for future flood risk. This information will in no way be used for floodplain mapping for regulatory purposes, such as local (municipal) floodplain management and development regulation, or in any way by FEMA or NFIP. This is simply a planning-level analysis for the purpose of supporting the regional flood planning process.

2.2.1.2 RFPG Method for Developing the Future Flood Hazard Layer

RFPGs are tasked with performing a future condition flood analysis to determine both 1 percent annual chance and 0.2 percent annual chance flood extents 30 years into the future (year 2050). Due to the lack of available detailed flood inundation data and hydrologic/hydraulic models, an approximate approach was used for this planning cycle - where it is available the existing 0.2 percent flood risk areas will be used as a proxy for the future 1 percent flood risk areas, per Method 2 in TWDB’s guidance.

2.2.1.3 Future Conditions 0.2 Percent – Urban and Downstream

Over the 30-year planning horizon, increases in future flood flows are dependent on population growth, which occurs primarily in and around existing cities. For each stream in an urban area (municipal and extra-territorial jurisdiction boundaries), a horizontal flood risk area buffer width was established as the average difference in width between the 1 percent and 0.2 percent flood boundaries. To develop the future 0.2 percent mapping extents (Method 3), the 0.2 percent boundaries of streams were increased by that width within each urban area and downstream to the next major confluence.

2.2.1.4 Future Conditions 0.2 Percent – Rural Areas

Population growth projections outside of population centers are generally less than 20 people per square mile. Therefore, it was determined no flood risk areas increases due to population growth would occur outside the urban areas. Both the future 1 percent and 0.2 percent annual chance flood risk area extents within the county regions, outside of cities or populated areas, are assumed to remain the same as the existing flood risk areas extent, as summarized in Table 2-3.

Table 2-3. Future Conditions Flood Risk Methods

Condition	Best Available		→		→		Most Approximate	
	Local Flood risk areas *(if current)*		Zone AE on NFHL or FAFDS		Zone A on NFHL / FAFDS		No FEMA or Better than Quilt	
	1%	0.2%	1%	0.2%	1%	0.2%	1%	0.2%
Existing	Local Study (if provided)		Existing Quilt 1%	Existing Quilt 0.2%	Fathom 1%	Fathom 0.2%	Fathom 1%	Fathom 0.2%
Future - Urban Downstream of City	Local Ultimate Development Study (if provided)		Existing Quilt 0.2%	Existing 0.2% + Delta* Mapping	Fathom 0.2%	Fathom 0.2% + Delta* Mapping	Fathom 0.2%	Fathom 0.2% + Delta* Mappin g
Future Rural	Local Ultimate Development Study (if provided)		Existing Quilt 1%	Existing Quilt 0.2%	Fathom 1%	Fathom 0.2%	Fathom 1%	Fathom 0.2%

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2.2.1.5 Identified Future Flood Hazard Areas

Using the method described earlier, the maps for the 1 percent and 0.2 percent annual chance future flood hazard areas were developed in GIS. Figure 2-7 summarizes the results of the future flood analysis.

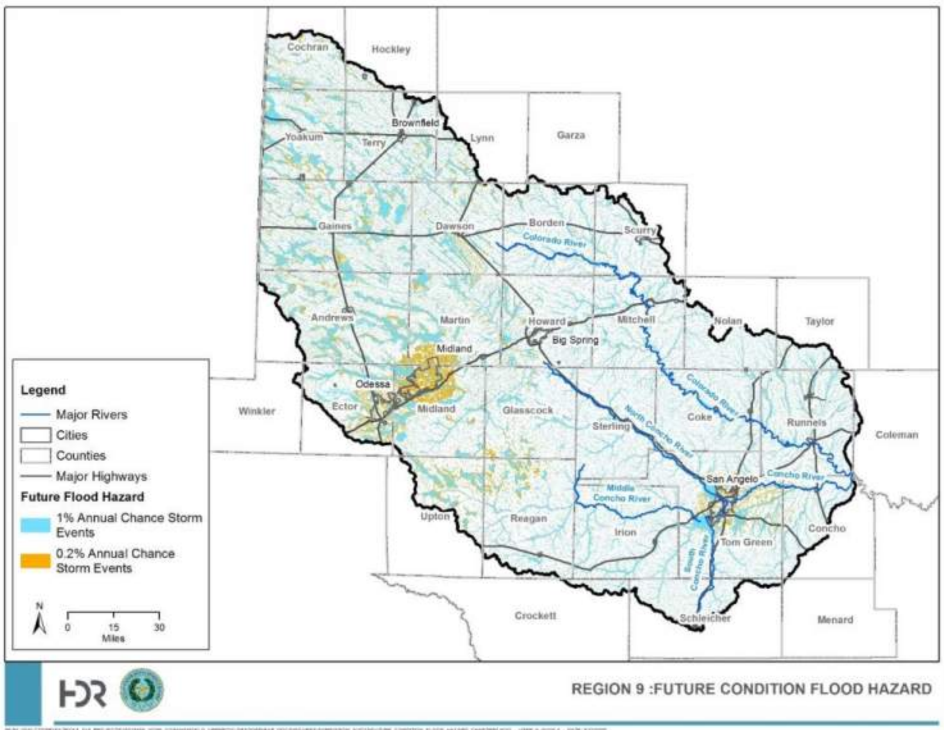

Figure 2-7. Future Flood Hazard Areas

A comparison of the existing and future flood hazard area is presented in Table 2-4**.** An additional 384 square miles of flood hazard area is added to the floodplain with estimated future conditions, or an increase of 7 percent.

Table 2-4. Comparison of Existing and Future Flood Hazard Areas

Flood Hazard Area	Total Existing Area (Sq.Mi.)	Total Future Area (Sq.Mi.)	Area Change (Sq.Mi.)	Area Change (%)
1%	4,521	4,617	96	2%
0.2%	1,132	1,419	288	25%
Total	5,653	6,037	384	7%

Sq.Mi.=square miles

The total future condition flood hazard area is summarized by county in Figure 2-8. As with existing conditions, Gaines, Tom Green, and Andrews are the counties with the highest total area. The change in flood hazard area between existing and future conditions is represented in Figure 2-9. Due to the methodology selected, most of the increase in floodplain is from more urbanized counties. Of the counties located primarily in UPFPR, the flood hazard area increased the most in Midland, Tom Green, Ector, and Martin counties.

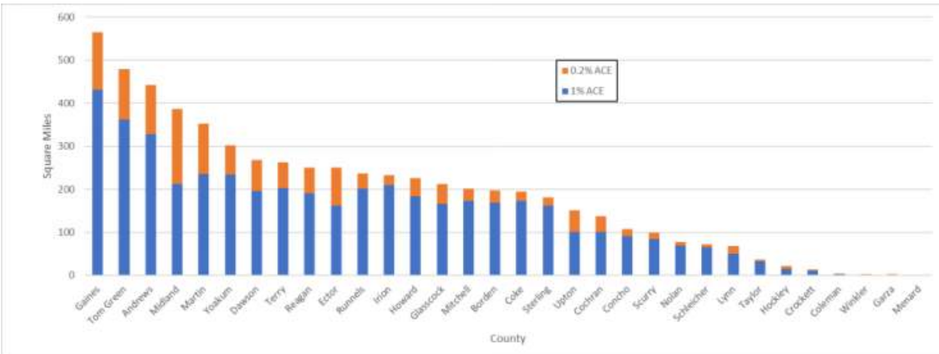

Figure 2-8. Future Condition Flood Hazard Area

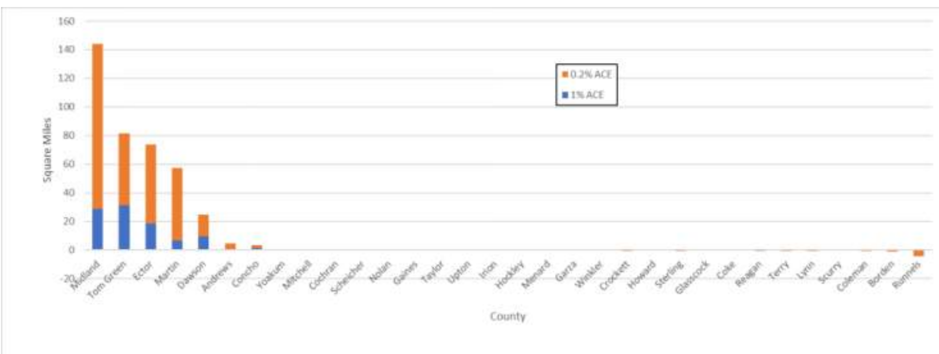

Figure 2-9. Change in Flood Hazard Area between Existing and Future Conditions

2.2.1.6 Future Conditions Data Gaps

No hydrologic or hydraulic models were identified for future conditions. As a result, large portions of the region are considered to be a data gap under future conditions (Figure 2-10).

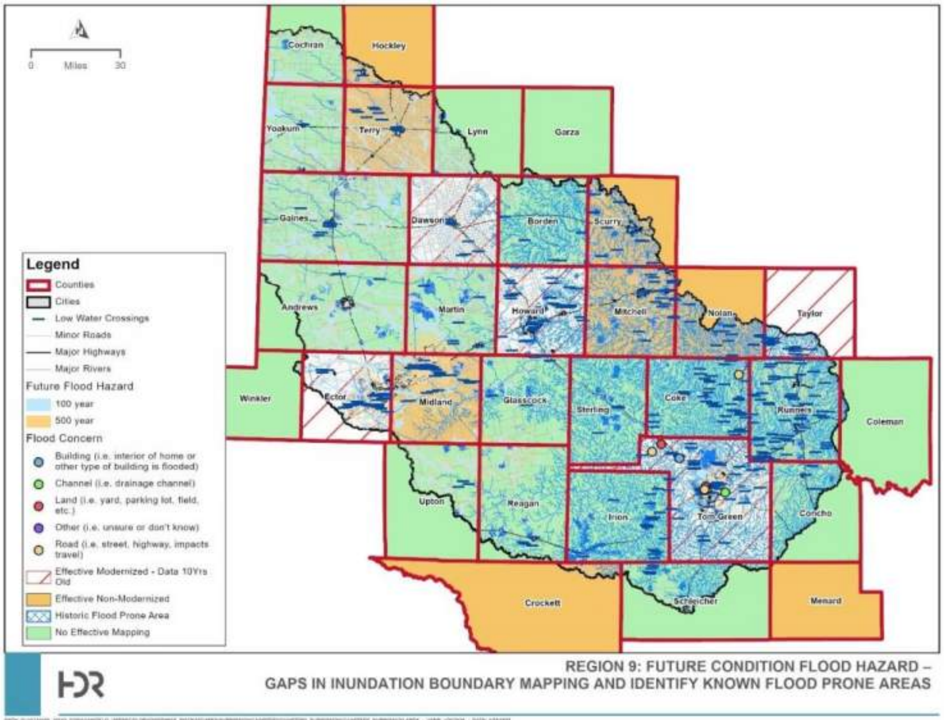

Figure 2-10. Data Gaps under Future Conditions and Flood-prone Areas

2.2.2 Future Condition Flood Exposure Analysis

The same flood exposure analysis procedure was followed to quantify exposure under future conditions. This exposure was only quantified for existing development as it compared to the future condition flood hazard area. It is difficult to quantify exposure of future development due to the inherent uncertainty in the exact location of development and changes in population. However, an effort was made to evaluate areas of future development and provide qualitative information regarding potential exposure in these areas.

2.2.2.1 Future Flood Exposure Summary

The following sections describe the results of the future flood exposure analysis through the same series of maps that is presented for existing flood exposure. Midland, Odessa, and San Angelo continue to have a high concentration of flood exposure in the region. However, other portions of the region see a greater density of flood exposure as compared to existing conditions.

Residential Properties

Table 2-5 summarizes residential property exposure by county. Those counties with the largest increase in number of residential structures impacted are the most urbanized counties in the region (Ector, Midland and Tom Green). In these counties, the number of impacted residential structures more than doubles with future flood risk. Other counties saw no increase or a small decrease in the number of residential structures impacted.

Non-Residential Properties

Table 2-5 summarizes non-residential property exposure by county. While the total number of non-residential properties contained in the future flood hazard area did not increase as dramatically residential properties, urbanized counties still saw an increase. Ector, Midland and Tom Green counties, which saw high residential building increases, are also represented in some of the highest increases of non-residential properties in the same areas. Dawson County also saw a large increase in the number of non-residential properties affected by flooding.

Public Infrastructure

There are more buildings marked as public infrastructure within the future flood hazard than in the existing flood hazard. Within this group, 150 buildings are critical facilities and discussed further below. Most of these buildings are located within municipalities, particularly Midland, Odessa and San Angelo.

Major Industrial and Power Generation Facilities

There are 918 buildings in the future flood hazard that are marked as industrial. These facilities are summarized in Table 2-5.

Critical Facilities

There are 150 critical facilities total within the future flood hazard area, 87 more than in the existing flood hazard. Figure 2-11 shows the location of these facilities. The two most common types of facilities within the flood hazard area are schools and nursing homes.

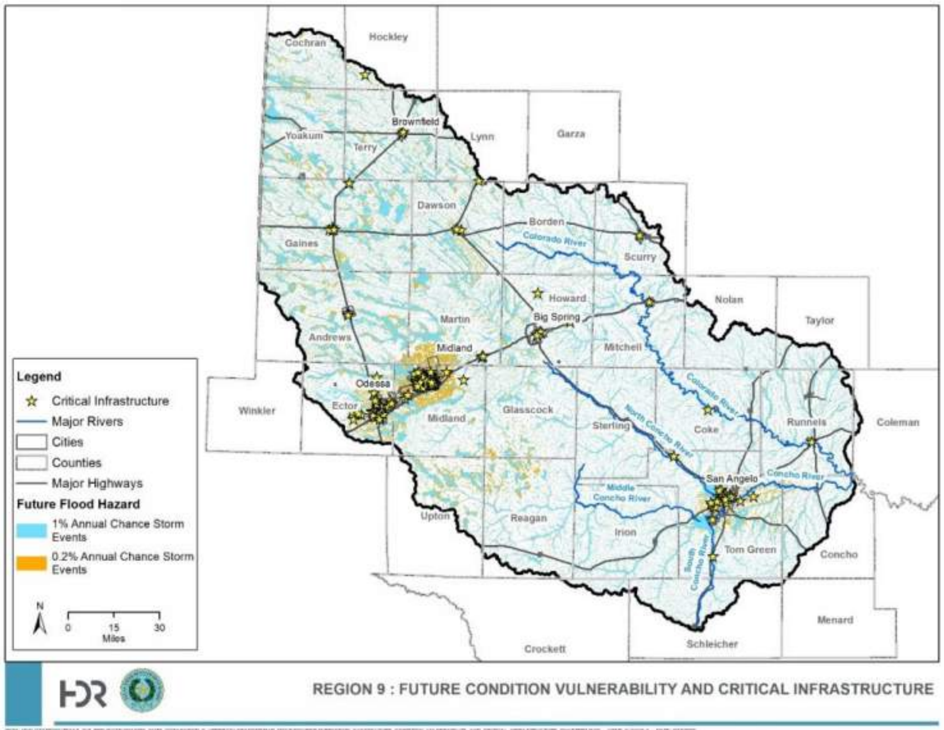

Figure 2-11. Future Condition Vulnerability and Critical Infrastructure

Roadway Crossings

The three counties with the highest number of roadway stream crossings in the future flood hazard area are Tom Green, Midland, and Ector (Table 2-5). The increased stream crossings for these counties are associated with a greater extend of urban flooding projected under the future flooding scenario.

Roadway Segments

Midland, Ector and Tom Green counties have the most miles of roadway with the future hazard area. Similar to roadway crossings, this is related to increased urbanized flooding in the future flood scenario. Terry, Dawson and Gaines counties are the next three highest counties with the most miles within the floodplain. These are primarily rural roads associated with farmland in those counties.

Agricultural Areas

Table 2-5 shows the relative number of agricultural areas inundated by flooding under future conditions by county. The amount and value of agricultural areas impacted by flooding increased by only 3.8 percent in the future flood hazard condition to 2.8 million acres and almost $5.0 billion. Of the counties located primarily in in the Upper Colorado Region, the counties with the largest increase are Concho, Crockett, and Coleman. These areas saw larger increases in overall floodplain size and are largely agricultural in land use, so this increase is expected for the area's characteristics.

Future Developments within the Future Conditions Floodplain

Midland sees both a large increase in flood hazard and a large amount of anticipated development as well as Odessa, although to a lesser extent. San Angelo is also projected to see additional development over the projections period.

Potential Flood Mitigation Projects

A requirement of the future condition flood exposure analysis is to consider impacts from flood mitigation projects in progress with dedicated construction funding that are scheduled for completion prior to the adoption of the next state flood plan (SFP). No projects have been identified in the Upper Colorado Region that meet these criteria. As a result, no potential flood mitigation projects were considered in the creation or analysis of the existing flood hazard layer.

Major cities within the region have capital improvement plans (CIPs) and stormwater fees, which may lead to the implementation of some local stormwater projects. However, these projects do not have specific allocations, so they were not considered in the development of the future flood hazard layer since their construction is not guaranteed. Additionally, these projects will have a small-scale impact on the floodplain and will not result in major impacts on regional flood risk.

Table 2-5. Future Flood Exposure Areas

County	Area in Flood Planning Region (sqmi)	1% annual chance flood risk								0.2% annual chance flood risk							
		Area in Flood-plain (sqmi)	Num. of Struct. in Flood-plain	Resid. Struct. in Flood-plain	Pop.	Roadways Stream Crossing (#)	Roadways Segments (miles)	Ag. Areas (sqmi)	Critical Facilities (#)	Area in Flood-plain (sqmi)	Num. of Struct. in Flood-plain	Resid. Struct. in Flood-plain	Pop.	Roadways Stream Crossing (#)	Roadways Segments (miles)	Ag. Areas (sqmi)	Critical Facilities (#)
Andrews	1,226	329	996	786	1,289	0	173	215	0	114	1011	771	1507	0	61	69	2
Borden	848	169	70	9	11	32	26	90	0	29	76	11	26	2	11	16	0
Cochran	449	100	24	12	14	0	144	82	0	37	14	8	3	0	27	30	0
Coke	924	172	254	107	79	58	55	80	3	23	318	144	110	7	12	10	0
Coleman	17	2	6	1	1	1	0	1	0	0	3	1	1	0	0	0	0
Concho	474	91	107	52	53	25	24	51	0	17	113	45	51	2	10	9	0
Crockett	76	11	0	0	0	0	1	8	0	2	0	0	0	0	0	1	0
Dawson	895	196	711	10	3	3	563	172	0	72	2064	9	1	0	159	68	2
Ector	618	161	18,953	14825	36,569	89	404	111	15	89	24638	19439	53654	25	386	45	19
Gaines	1,498	432	1,967	837	1,174	0	435	341	4	133	1491	731	1201	0	131	104	3
Garza	9	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Glasscock	897	166	147	4	3	6	34	137	0	47	122	5	3	4	19	43	0
Hockley	95	15	46	19	20	0	42	15	0	7	65	28	38	0	11	7	1
Howard	901	184	1,528	694	1,278	74	196	117	2	43	1523	916	1942	13	70	34	4
Irion	1,047	209	889	117	58	24	48	119	0	24	581	91	43	6	9	17	0
Lynn	217	51	351	206	243	0	152	48	1	18	84	64	93	0	24	17	0
Martin	912	235	990	467	930	4	232	202	4	118	676	209	406	2	80	84	0
Menard	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Midland	891	212	13,323	8985	25,895	69	388	171	10	175	46637	34536	98603	48	752	137	46
Mitchell	905	172	373	215	249	102	108	87	2	29	604	419	436	7	29	15	0
Nolan	450	69	94	18	6	20	21	37	0	8	46	9	5	3	5	4	0
Reagan	1,087	191	193	98	61	11	39	148	0	60	272	139	92	0	31	52	0
Runnels	1,014	201	165	41	30	93	125	152	1	35	121	19	25	11	33	27	0
Schleicher	434	65	106	43	44	9	17	27	0	8	115	69	55	1	4	3	0
Scurry	513	85	677	347	406	86	76	56	1	14	273	173	226	9	15	7	0
Sterling	919	162	194	105	85	25	30	84	0	19	159	83	68	5	9	13	0
Taylor	170	33	72	51	37	12	18	24	0	4	46	37	32	2	5	3	0
Terry	863	203	505	185	333	4	633	187	1	59	495	216	445	0	105	55	1

County	Area in Flood Planning Region (sqmi)	1% annual chance flood risk								0.2% annual chance flood risk							
		Area in Flood-plain (sqmi)	Num. of Struct. in Flood-plain	Resid. Struct. in Flood-plain	Pop.	Roadways Stream Crossing (#)	Roadways Segments (miles)	Ag. Areas (sqmi)	Critical Facilities (#)	Area in Flood-plain (sqmi)	Num. of Struct. in Flood-plain	Resid. Struct. in Flood-plain	Pop.	Roadways Stream Crossing (#)	Roadways Segments (miles)	Ag. Areas (sqmi)	Critical Facilities (#)
Tom Green	1,534	362	7,681	4858	9,903	185	318	252	7	117	19667	14749	32726	63	431	88	21
Upton	478	100	42	17	4	0	34	74	0	51	33	6	10	0	11	43	0
Winkler	9	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Yoakum	798	235	599	273	462	0	292	217	0	68	316	132	175	0	63	62	0

sqmi=square mile; Pop.=population; Resid.=residential; Struct.=structures; Ag.=agricultural; Num.=number

2.2.3 Future Conditions Vulnerability Analysis

The vulnerability analysis for future conditions was performed in the same manner as the existing analysis but considering the future condition flood exposure features. The results of the analysis are summarized in Figure 2-12.

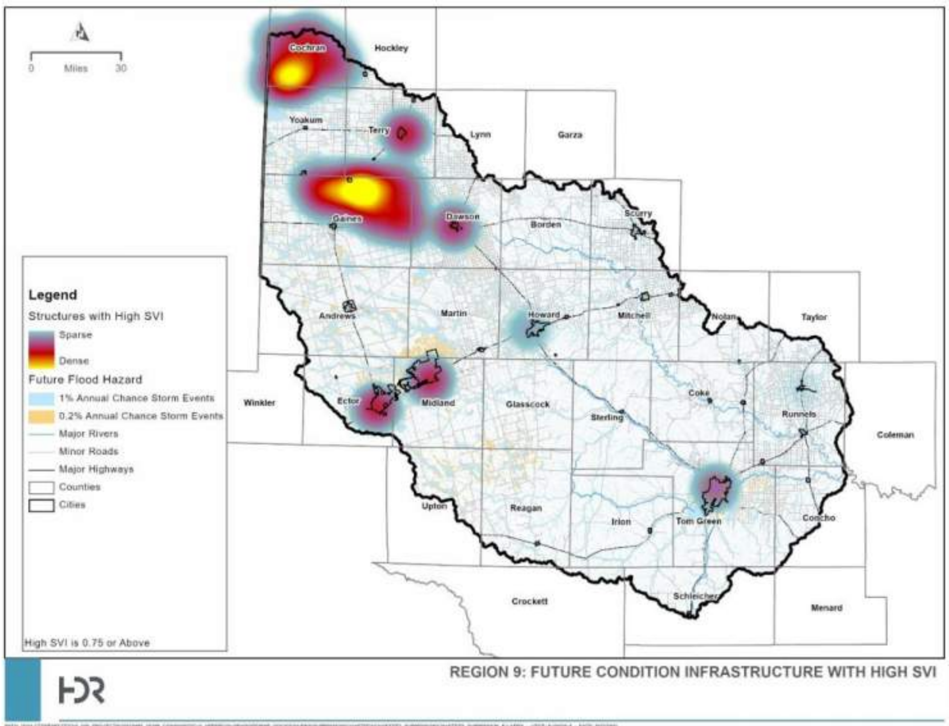

Figure 2-12. Future Conditions Vulnerability Analysis

2.2.4 Resilience of Communities Located in Flood-prone Areas

Natural disasters pose threats to a community's wellbeing. Several factors, including socioeconomic levels, access to hospital systems, and crowded housing affects a community's resilience. The average SVI for the future condition floodplain or flood-prone areas per county is provided in Appendix A –Table 5 – Future Condition Flood Risk Summary Table. Locations of high SVI areas located in floodplains or flood prone areas are shown in Figure 2-12. The most vulnerable areas to flood risk are similar to those identified in the existing condition.

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3

Floodplain Management Practices and Flood Protection Goals

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3 Floodplain Management Practices and Flood Protection Goals

The Upper Colorado Regional Flood Planning Group (UCRFPG) is tasked with evaluating and recommending floodplain management practices (Task 3A) and flood mitigation goals (Task 3B) within the region. This chapter describes the processes undertaken by the UCRFPG to complete these tasks and summarizes the outcomes of this endeavor.

3.1 Evaluation and Recommendations on Floodplain Management Practices (361.35)

The initial effort under Task 3A was to collect and perform a qualitative assessment of current floodplain management regulations within the region (i.e., floodplain ordinances, court orders, drainage design standards, and other related policies). The UCRFPG collected floodplain management regulations that were readily available on the regulatory entity's websites and sent a web-based survey to each regulatory entity in the region to gather additional information.

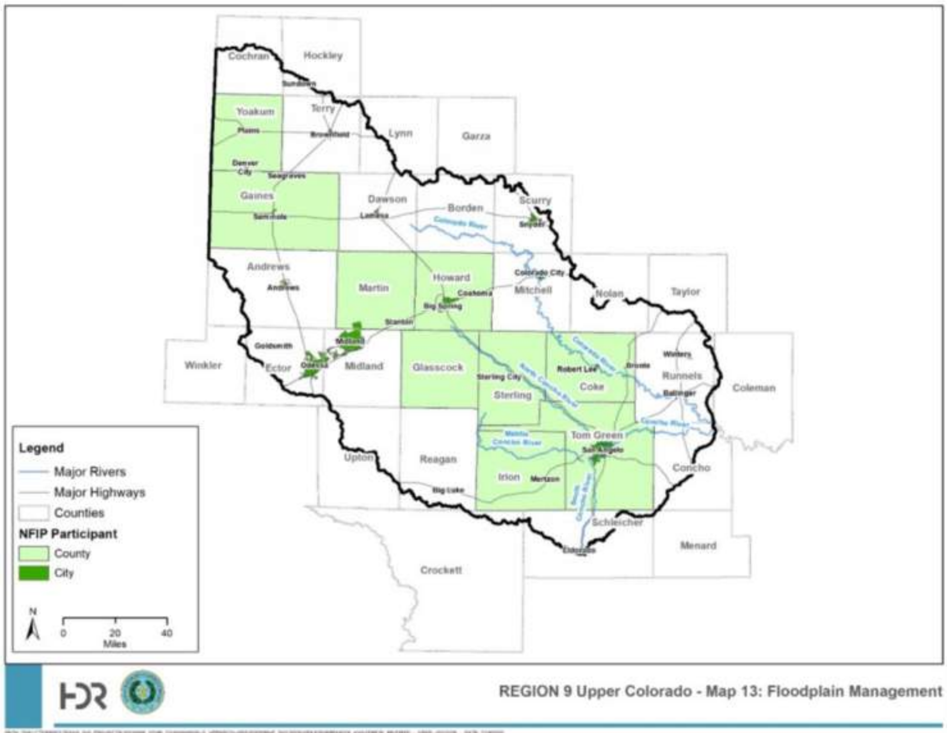

Figure 3-1. Communities with Floodplain Management Regulations

Based on the data collected in this effort, a total of 15 out of 32 counties (47 percent) and 17 out of 36 cities/towns (47 percent) within the region have some form of floodplain management regulation. Figure 3-1~~Figure 3-1~~ shows floodplain management within the UCFPR, including NFIP participation.

3.1.1 Extent to which Current Floodplain Management and Land Use Practices Increase Flood Risks

Floodplain management and land use practices look at regulations, policies, and trends in the region. From a flood risk perspective, these management practices improve protection of life and property. Floodplain management and land use practices may vary widely from one entity to another. The Federal Emergency Management Agency (FEMA) manages the National Flood Insurance Program (NFIP) that provides the minimum standards for development in and around the floodplain.

In 1968, Congress established the NFIP through the National Flood Insurance Act of 1968 to provide federally subsidized flood insurance protection. The program has been updated multiple times since then to strengthen the program, provide fiscal soundness, and inform the public of flood risk through insurance rate maps. Title 44 of the Code of Federal Regulations (44 CFR) includes the program rules and regulations. CFR 44 Part 60 establishes the minimum criteria that FEMA requires for NFIP participation, which includes identifying special flood hazard areas within the community.

Cities and counties who participate in the NFIP provide their residents and businesses the opportunity to purchase flood insurance to reduce the socio-economic impacts of floods, as well as making the community eligible for disaster assistance following a flood event. The Upper Colorado Region is primarily sparsely populated agricultural and ranch land; therefore, many entities in the region have very small local governments with quite limited resources. Many of these rural local governments do not have the resources to enact, adopt, and enforce specific floodplain management practices, nor have they worked with FEMA to develop Special Flood Hazard Areas (SFHAs) and Flood Insurance Rate Maps (FIRMs). For this reason, most of the existing practices found in the region come from its large cities.

Cities and counties that choose to participate in the NFIP work with FEMA to establish base flood elevations (BFEs) and SFHAs around playas and along rivers, creeks, and large tributaries that are shown on FIRMs. The BFE is the elevation of surface water that has a 1 percent probability of occurring each year, also known as a 100-year flood. Communities use the FIRM, BFE, and SFHA data in their floodplain permitting processes as a requirement for participating in the NFIP. Insurance agents use FIRMs to determine flood risk, which determines the flood insurance rate for individual properties. Only 37 percent of the counties in the Upper Colorado Region have FIRMs to communicate flood risk to the public.

Cities and counties have the authority to establish their own policies, standards, and practices to manage land use in and around areas of flood risk. Participating NFIP communities have the responsibility and authority to permit development that is reasonably safe from flooding. They can adopt and enforce higher standards than the FEMA NFIP minimum standards to better protect people and property from flooding. FEMA supports entities who choose to establish higher standards to better protect life and property. Communities were asked to rate their floodplain management practices in the May 2021 initial data collection survey. Communities' floodplain management practices were rated strong, moderate, low, or none. The consultant team then supplemented the survey responses with ratings developed by reviewing available drainage criteria and ordinances. The following criteria was provided by the Texas Water Development Board (TWDB) guidelines.

- None (no floodplain management practices in place)
- Low (regulations meet the minimum NFIP standards)
- Moderate (some higher standards, such as freeboard, detention requirements, or fill restrictions)

- Strong (e.g., significant regulations that exceed NFIP standard with enforcement, or community belongs to FEMA's Community Rating System [CRS])

A summary of level of floodplain management practices is shown in Figure 3-2~~Figure 3-2~~.

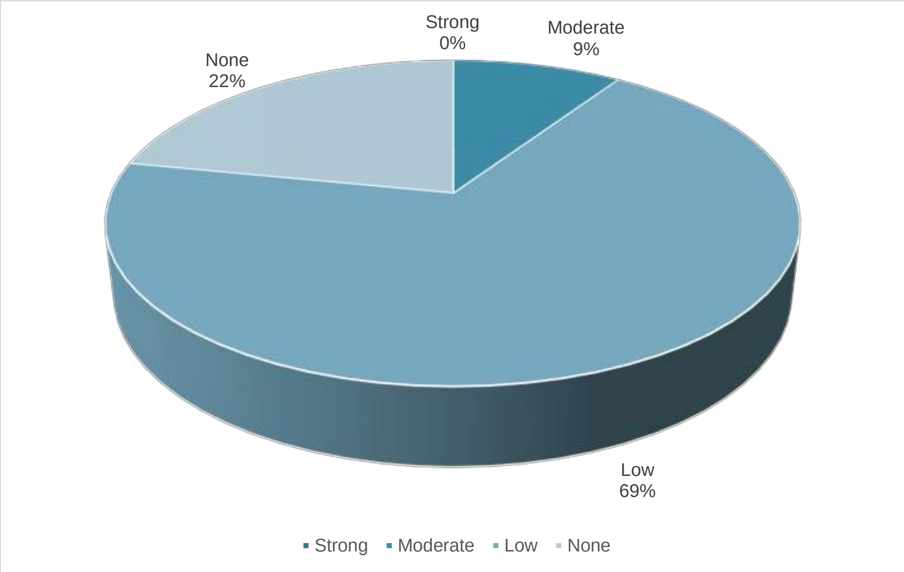

Figure 3-2. Upper Colorado Floodplain Management Practices

FEMA provides an opportunity for entities to discount their communities' flood insurance premium rates through the CRS. The CRS is a voluntary incentive program that recognizes and encourages community floodplain management practices that exceed the minimum requirements of the NFIP. In CRS communities, flood insurance premium rates are discounted to reflect the reduced flood risk resulting from the community's efforts that address the three goals of the program: 1) reduce and avoid flood damage to insurable property, 2) strengthen and support the insurance aspects of the NFIP, and 3) foster comprehensive floodplain management. As of October 2021, FEMA reports two communities in the Upper Colorado Region participate in the CRS program – the cities of Midland and Odessa (Table 3-1~~Table 3-1~~).

Table 3-1. Upper Colorado Region Entities Participating in Community Rating System (CRS) Program

Community Name	Current Class	% Discount for SFHA	% Discount for Non- SFHA
Midland, City of	8	10	5
Odessa, City of	8	10	5

SFHA = Special Flood Hazard Areas

As additional Upper Colorado Region communities gain a better understanding of flood risk, the practices that increase flood risk, and policies that prevent the development of flood risk, the effort to decrease flood risk becomes a greater possibility.

3.1.1.1 Existing Population and Property

The UCRFPG considered multiple resources in determining the extent to which current floodplain management and land use practices impact flood risk to existing population and property. Cities and counties have the ability to approve floodplain ordinances or court orders, respectively. Therefore, the NFIP participants are limited to these entities, and the results included in this section of the report are limited to cities and counties.

Communities that participate in the NFIP are required to have a floodplain ordinance or court order that meets or exceeds the NFIP minimum standards. As of October 2021, 24 counties (75 percent) and 26 cities (72 percent) in the Upper Colorado Region participate in the NFIP, but no counties or cities have adopted higher standards.

CFR 44 Part 60 establishes minimum standards that a city or county must meet to be eligible to participate in the NFIP. The minimum standards require buildings to be constructed at or above the BFE (100-year flood), provide for floodproofing options for buildings, and mandate provisions specific to the elevation and anchoring of manufactured houses. The minimum standards are based on maps that represent "current" conditions, which may be based on outdated topography, rainfall and runoff data. Therefore, minimum standards set at the BFE leave no room for a safety factor, error in maps, or outdated data resulting in limited protection from flood damages.

According to the TWDB Exhibit C guidance document, "higher standard" is defined as freeboard, detention requirements, or fill restrictions in excess of minimum standards. FEMA defines freeboard as additional height above the BFE that serves as a factor of safety when determining the elevation of the lowest floor. The BFE is the elevation of surface water resulting from a flood that has a 1 percent chance of occurring in any given year. The BFE is typically based on FEMA FIRMs (maps) and associated flood insurance studies (FIS; models). Only 1.7 percent of the Upper Colorado Region has FEMA-established BFEs; however, the local community may have an established BFE developed by local studies to which they regulate that may not be incorporated into a FEMA mapping product.

According to the data collected as part of Task 3A, seven entities within the region have higher standards. Table 3-2~~Table 3-2~~ documents various freeboard requirements identified in 2018/2019 Texas Floodplain Management Association (TFMA) Higher Standards Survey, TWDB data, Community Engagement Prioritization (CEP) tool data, and community assistance contact (CAC) tracker data.

Table 3-2. Communities Adopting Higher Standards

CID	City or County Name	County	Feet above Fully Developed BFE	Feet above Existing BFE	Zone X(B) (Shaded Above Street or Curb)	Zone X(C) (Unshaded) Above Street or Curb	Special Notes
480549	Ballinger	Runnels	0	0	0	0	Elevation Certification required before CO
480354	Levelland	Hockley	0	0	1	0	--
480477	Midland	Midland	0	1	0	0	Playas Lowest floor must be +1 foot above overflow elevation or BFE, whichever is higher. No import of fill is allowed in playas. This is difficult to enforce. Midland is Community Rating System (CRS) 8.

CID	City or County Name	County	Feet above Fully Developed BFE	Feet above Existing BFE	Zone X(B) (Shaded Above Street or Curb)	Zone X(C) (Unshaded) Above Street or Curb	Special Notes
--	Odessa	Ector	0	1	0	1	(1) Developer must conduct a study to establish both BFE and floodway in Zone A areas (2) Detention is required to mitigate development (3) Developer must mitigate downstream impacts. (4) Development in Zone X must be elevated a minimum of 1 foot above NG and above the crown of the nearest street (5) EC required after construction is completed and prior to CO. (6) Biggest problems are determining the BFE for unnumbered A zones in already developed areas and localized flooding
--	San Angelo	Tom Green	0	1	2	0	Lowest Flood elevated +1 foot above BFE on Flood Insurance Rate Map (FIRM).
--	Taylor County	Taylor	1	0	0	0	--

CID	City or County Name	County	Feet above Fully Developed BFE	Feet above Existing BFE	Zone X(B) (Shaded Above Street or Curb)	Zone X(C) (Unshaded) Above Street or Curb	Special Notes
--	Tom Green County	Tom Green	0	0	0.5	0	(1) Developer must establish BFE in Zone A. (2) Developer must mitigate all fill placed in floodway (3) EC is required prior to framing/pouring lowest flood, when construction is completed and prior to CO. One (1) CFM on staff.

BFE = base flood elevation

While the Upper Colorado Region does have approximately 74 percent participation in the NFIP by entities, 86 percent of the region has no effective floodplain data or outdated detailed studies (Figure 3-3~~Figure 3-3~~). These limitations in reliable data produced significant challenges in the development of the regional flood plan. To improve the effectiveness of the flood plan, the UCRFPG has established goals to encourage higher participation in the NFIP, adoption of minimum FEMA standards and building construction regulations, and local ordinances to encourage prevention of flood damages.

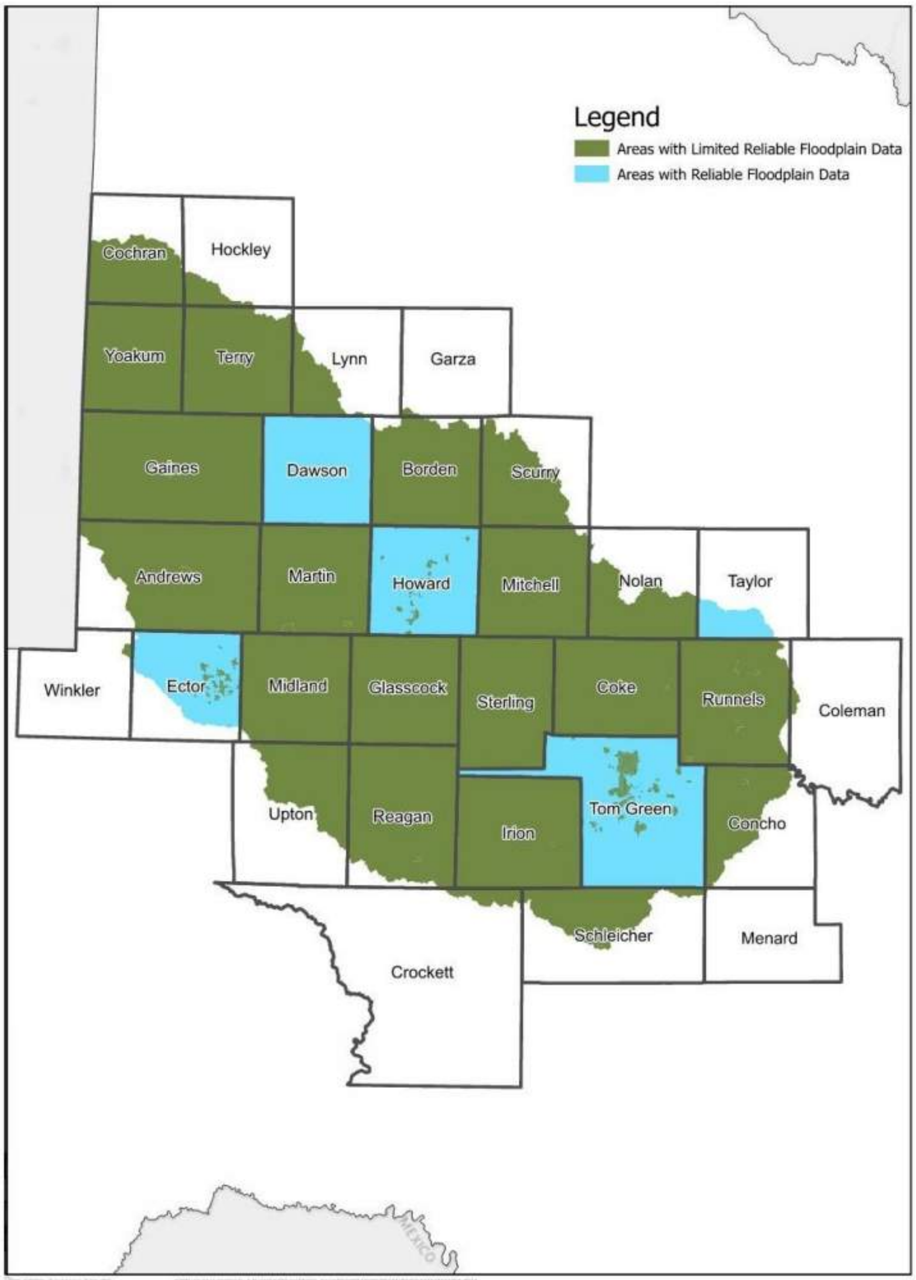

Figure 3-3. Areas with Limited Reliable Floodplain Data

3.1.1.2 Future Population and Property

Between 2020 and 2050, the Upper Colorado Region is expected to grow by 33 percent. Some of the existing floodplain ordinances with higher standards may continue to protect future population and property as long as they are enforced. However, the gap in key floodplain management practices across the region poses an increasing level of flood risk as population continues to increase in certain areas. Local floodplain regulations with at least minimum standards should be adopted. Outreach programs explaining the need for minimum standards and why higher standards would be preferred are key goals in the region. Key objectives will be to explain why enforcing these standards will better protect both existing and future population and property.

Future floodplains are uncertain. However, it is anticipated that the future floodplains will look different from existing floodplains in some areas within the region. The hydrologic and hydraulic models used to generate floodplain maps are updated with new topography, survey, precipitation, runoff, and other data as development occurs in and around floodplains. Maps are refined with improved technology and better data as it becomes available. The future BFE could increase with increased development and population, expanding floodplain areas.. Cities and counties can develop comprehensive future land use plans considering areas of anticipated population growth and development within their communities that can be used to anticipate what future floodplains could look like. However, the existing and future floodplains are not necessarily a component of the future land use plan. Incorporating the existing and future floodplains will allow cities and counties to plan future development around flood-potential areas avoiding the risk of future flooding and damages, thereby reducing future flooding damages and to protect people and property. Some of the region's cities and counties have already incorporated requirements where hydrologic and hydraulic analyses should be based on fully developed land use conditions. Entities who currently use future flood conditions as part of their design criteria provide a factor of safety that reduces future flood hazard exposure for new and existing developments.

While no community can predict the future, adopting minimum practices can be the first incremental step to introducing the community to its potential flood risks. A community that has been introduced to minimum standards will be prepared for higher adopted standards should population (and corresponding development) increase as projected.

Another factor of safety that can be implemented to reduce future flood hazard exposure is freeboard. Freeboard provides additional height above the BFE. While the BFE is likely to change in the future with increased development, the freeboard is intended to allow the structure to remain above the unanticipated future water surface elevation, protecting people and property from potential flood risk and damage.

Across the state, multiple methods are used to mitigate the impacts associated with development land use changes that increase impervious surfaces and more efficient drainage infrastructure design to convey the runoff from a developed property to downstream outlets. The approach is typically dependent upon the watershed conditions. Playas typically bring a volume-based system which can operate differently from a riverine setting. In West Texas communities, rain events are less frequent and the annual rainfall volumes are smaller than is typical for the state. The standard engineering design requirement in the Upper Colorado Region is to convey stormwater in the local streets or public rights-of-way to managed outfall points like playas or streams. This method has worked well with smaller communities but as development increases, the need for stormwater mitigation like additional conveyance or detention ponds are becoming necessary. Detention ponds are designed to mitigate the runoff volume and rate to existing conditions. Incorporating this requirement mitigates increased runoff in the future, which in turn can reduce future flood hazard exposure.

Few entities within the region currently incorporate stormwater detention requirements in their design criteria. In lieu of detention ponds, many communities in the Upper Colorado Region allow stormwater mitigation through volumetric mitigation at playas through reclamation and/or alteration. By preserving the storage functions at these naturally low-lying features, these communities are providing similar benefits to regional detention ponds. In the Upper Colorado Region, additional conveyance improvements are more common than detention. Additional conveyance is typically seen as parallel channels along roadways at maximum depth limitations.

Areas without maps and models or with outdated maps and models are at greater risk in terms of future population and property development within the floodplain. Entities need comprehensive and updated maps to direct development away from flood-prone areas before they can take additional measures to reduce flood risk like freeboard and detention. Future floodplain maps and models are anticipated to be updated with higher resolution data, best available data, and advanced modeling techniques in the years to come. Reducing floodplain mapping gaps within the region and increasing mapping accuracy should reduce flood risk uncertainty and translate into life and property savings in the future. Future conditions inundations gaps are shown on Appendix B-Map 9.

3.1.2 Consideration of Recommendation or Adoption of Minimum Floodplain Management and Land Use Practices

The UCRFPG is required to consider the possibility of recommending or adopting consistent minimum floodplain management standards and land use practices for the entire region. Recommended practices encourage entities with flood control responsibilities to establish minimum floodplain management standards over the next several years to reduce or eliminate potential flooding areas.

The UCRFPG considered all the information gathered and analyzed as part of Task 3A to deliberate on whether to recommend or adopt minimum floodplain management standards. This topic was first introduced during the July 2021 UCRFPG meeting. During this public meeting, an interactive web-based polling session (MENTI) was conducted to start gathering feedback from the UCRFPG and members of the community with regards to the following topics.

- Main flooding concerns
- Issues considered the main impediments to effective floodplain management
- Recommending or adopting minimum standards for all entities within the region
- Most important outcomes of the regional flood planning effort

The UCRFPG recommends, but does not adopt, minimum standards for the region. The recommended practices were presented in the October 2021 UCRFPG meeting.

- Developers building in a Zone A must provide a study establishing to BFE
- Finished floor 1 foot above existing BFE (100-year)
- Finished floor 1.5 feet above street or curb
- New culverts or bridges must have 1 foot of freeboard above the BFE

The UCRFPG recognizes the importance of increasing and improving floodplain mapping coverage across the region as a means to reduce flood risk uncertainty and improve the tools for regulating development within the floodplain. As development continues within the region, it is important to leverage best available data and modeling tools to establish BFEs, update approximate floodplain boundaries (FEMA Zone A), and create new floodplain maps where they are nonexistent. At that point, it will become more likely to advance the flood mitigation practices and floodplain management goals across the entire basin.

3.2 Flood Mitigation and Floodplain Management Goals (361.36)

One of the critical components of the inaugural state flood plan (SFP) process was the development of flood mitigation and floodplain management goals. The objective of Task 3B is to define and select a series of goals that will serve as the drivers of the regional flood planning effort. As such, the UCRFPG spent a significant amount of time and resources exploring values and discussing what they felt were the best goals for the region.

The overarching goal of all regional flood plans must be “to protect against the loss of life and property” as set forth in the Guidance Principles (31 Texas Administrative Code [TAC] §362.3). This goal is further defined as follows:

1. Identify and reduce the risk and impact to life and property that already exists, and
2. Avoid increasing or creating new flood risk by addressing future development within the areas known to have existing or future flood risk.

The RFPG must identify goals that are specific and achievable, and when implemented, will demonstrate progress towards the overarching goa set by the state. Per TWDB requirements and guidelines, the goals selected by the RFPG must include the following information:

- Description of the goal
- Term of the goal set at 10 years (short-term) and 30 years (long-term)
- Extent or geographic area to which the goal applies
- Residual risk that remains after the goal is met
- Measurement method that will be used to measure goal attainment
- Association with overarching goal categories

The UCRFPG used the existing and future condition flood risk analyses from Task 2, and the assessment of current floodplain management and land use practices from Task 3A, as guides for developing and defining the goals for the region. After careful consideration of these factors, the UCRFPG adopted the flood mitigation and floodplain management goals listed in Table 3-3~~Table 3-3~~. The UCRFPG reviewed and approved these specific goals on October 2021 during the UCRFPG public meeting. The adopted goals apply to the entire flood planning region; no sub-regional goals were identified.

The selected specific goals will guide the development of the flood management strategies (FMSs), flood management evaluations (FMEs), and flood mitigation projects (FMPs) for the Upper Colorado Flood Planning Region (UCFPR). They build upon the TWDB regional flood planning guidance and provide a comprehensive framework for future strategy development focused on reducing flood risk to people and property without adding risk to adjacent areas. The process for defining, refining, and selecting these goals is described in the following sub-sections.

Table 3-3. Recommended Flood Mitigation and Floodplain Management Goals

Category	Short Term (10 year)	Long Term (30 year)
Evaluations to Confirm Flood Risk	Study watersheds containing 50% of Existing Structures in Approximate Floodplains	Study watersheds containing 100% of Existing Structures in Approximate Floodplains
Reduce Structures in 1% Existing Floodplain	Remove 20% of Existing Structures in Detailed Floodplains	Remove 50% of Existing Structures in Detailed Floodplains

Category	Short Term (10 year)	Long Term (30 year)
Improve Safety at Low Water Crossings and Dams	Eliminate or Mitigate 20% of Low Water Crossings	Eliminate or Mitigate 50% of Low Water Crossings
	Assess 100% of High Hazard Dams	N/A
	Rehabilitate 50% of Non-Functional or Deficient High Hazard Dams	Rehabilitate 100% of Non-Functional or Deficient High Hazard Dams
Improved Standards (NFIP or Equivalent)	Increase to 90% of Cities and 90% of Counties with NFIP or Equivalent Standards	Increase to 100% of Cities and 100% of Counties with NFIP or Equivalent Standards
Dedicated Funding Sources	Increase to 10% of Cities and 5% of Counties with Funding Sources Dedicated to Drainage	Increase to 20% of Cities and 10% of Counties with Funding Sources Dedicated to Drainage
Environmental Stewardship	25% of Recommended FMPs to include nature-based components	50% of Recommended FMPs to include nature-based components

NFIP = National Flood Insurance Program; FMPs = flood mitigation projects

3.2.1 Flood Mitigation and Floodplain Management Goal Selection Process

The preliminary set of goals was presented and considered during the July 2021 UCRFPG public meeting. Discussion of the goals continued during the September 2021 UCRFPG public meeting to further refine long-term and short-term goal metrics. Based on the feedback received during this meeting, the preliminary goals and targets were refined (Table 3-3~~Table 3-3~~) and presented for a vote and formal adoption during the October 2021 UCRFPG public meeting.

3.2.2 Benefits and Residual Risk after Goals are Met

The adopted goals were developed in a manner to set the stage for specific actions that can be quantified and measured in future regional and state flood planning cycles. Future data collection efforts or implementation of evaluations, strategies, and/or projects may be used to establish baseline data for future measurements to determine progress towards achieving the goals. Implementation efforts will also demonstrate progress towards the overall purpose and intent of the regional flood planning process and will provide various benefits to individuals, communities, and the region as a whole.

Achieving the adopted goals will reduce current and future levels of flood risk in the region.

However, it is not possible to protect against all potential flood risks. In selecting the flood risk reduction goals, the UCRFPG is inherently determining the accepted residual risk for the region.

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4

Flood Mitigation Needs Analysis

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4 Flood Mitigation Needs Analysis

This chapter describes the process that the Upper Colorado Regional Flood Planning Group (UCRFPG) adopted to conduct the flood mitigation needs analysis (Task 4A) in order to identify the areas with the greatest gaps in flood risk knowledge and the areas of greatest known flood risk and mitigation needs. The needs analysis then guides the effort to identify flood management evaluations (FMEs), flood mitigation projects (FMPs), and flood management strategies (FMSs) (Task 4B, included as part of Chapter 5). Additional guidance principles are considered alongside the results of the needs analysis to identify flood minimization actions. These considerations include assessing benefits of flood management strategies to water quality, fish and wildlife, ecosystem function, and recreation, as appropriate and evaluating multi-use opportunities such as green space, parks, water quality, or recreation, portions of which could be funded, constructed, and or maintained by additional, third-party project participants.

4.1 Flood Mitigation Needs Analysis [31 TAC §361.37]

Table 4-1 summarizes the Texas Water Development Board's (TWDB) guidance and factors that were considered in the Task 4A flood mitigation needs analysis.

Table 4-1. TWDB Guidance and Factors to Consider

Guidance	Factors to Consider
1. Most prone to flooding that threatens life and property	• Area overlapped by inundation mapping or included in historical flooding record • Buildings within flood hazard layer • Critical facilities impacted by flooding • Low water crossings • Agricultural areas at risk of flooding
2. Locations, extent and performance of current floodplain management and land use policies and infrastructure	• Communities not participating in National Flood Insurance Program (NFIP) • Disadvantaged / Underserved communities
3. Inadequate inundation mapping	• Presence of Fathom/Base-level engineering (BLE)/Federal Emergency Management Agency (FEMA) Zone A flood risk data • Detailed FEMA models older than 10 years
4. Lack of hydrologic and hydraulic (H&H) models	• Communities with limited models

Commented [NC8]: Can we use Cursory Floodplain Data here?

Guidance	Factors to Consider
5. Emergency need	• Limited data was provided to the Regional Flood Planning group. For this initial cycle, emergency need had limited impact on identifying Flood Mitigation Actions.
6. Existing modeling analyses and flood risk mitigation plans	• Exclude flood mitigation plans already in implementation • Leverage existing models, analyses, and flood risk mitigation plans
7. Previously identified and evaluated flood mitigation projects	• Exclude flood mitigation projects already in implementation • Leverage existing flood mitigation projects • Benefit-Cost Ratio > 1
8. Historic flooding events	• Disaster declarations • Flood insurance claim information • Other significant local events
9. Previously implemented flood mitigation projects	• Limited data was provided to the Regional Flood Planning group. For this initial cycle, previously implemented flood mitigation projects had limited impact on identifying Flood Mitigation Actions.
10. Additional other factors deemed relevant by regional flood planning group (RFPG)	• Alignment with RFPG goals • Alignment with Texas Water Development Board (TWDB) guidance principles

4.1.1 Process and Scoring Criteria

The main objectives of the flood mitigation needs analysis are to identify the areas of greatest known flood risk and areas where the greatest flood risk knowledge gaps exist. The analysis is based on a geospatial process that combines information from multiple datasets representing several of the factors listed in Table 4-1 and provides a basis for achieving the objectives. The geospatial process was developed in geographical information systems (GIS) and was based on the data collected in tasks 1 through 3. A variety of data sources were used in this assessment, including GIS data collected directly from stakeholders during outreach efforts. During the data collection phase, stakeholders participated in an online survey where they were able to respond geographically on a map. The stakeholder responses, as of December 1, 2021, were directly applied to this assessment.

The geospatial assessment was prepared at a HUC-12 watershed level of detail, which is consistent with the minimum watershed size for Task 4B specified in the Technical Guidelines (at least 1 square mile). A Hydrologic Unit Code (HUC) is a unique code assigned to watersheds in the United States. As the watersheds get smaller, the number of units used to identify them get longer. Therefore, the smallest unit of division used to identify a watershed is 12 digits, or a HUC-12. The Upper Colorado basin has a total of 503 HUC-12 watersheds, with an average size of 43.7 square miles.

A total of 12 data categories were used in the geospatial assessment. A scoring range was determined for each data category based on the distribution of the data. The scoring ranges vary for each category based on the HUC-12s with the smallest and largest quantity. A uniform scoring scale of zero to five and each HUC-12 was assigned an appropriate score for each category. The scores for each HUC-12 under each category were then added to obtain a total score that was used to reveal the areas of greatest known flood risk. A separate score was also determined for each HUC-12 to reveal the areas where the greatest flood risk knowledge gaps exist. The second score was based on two of the data categories that represented flood risk data gaps discussed below.

4.1.2 Flood Risk Knowledge Gaps

The following section gives a brief description of the data categories included and how each HUC-12 watershed was scored related to flood risk knowledge gaps. Note that the objective of the Task 4A process is to determine the factors that are present within a given HUC-12, and to what degree; not necessarily to determine the relative importance of each factor in determining flood risk. Therefore, no weight has been applied to emphasize one factor over another at this time.

4.1.2.1 Areas That Need Mitigation, Study Need, or Data Gap

These polygon layers were populated by community responses to the survey in Task 2 and data collected from National Oceanic and Atmospheric Administration (NOAA). Survey responses and data collected were combined into one polygon layer for this task. The scoring for this category gives points to any HUC-12 intersecting these polygons, according to the scoring in Table 4-2~~Table 4-2~~.

Table 4-2 Scoring for Areas that Need Mitigation, Study Need, or Data Gaps

Mitigation Areas	Score					
	0 points	1 point	2 points	3 points	4 points	5 points
# of Mitigation Areas	0	1	2	3	4	5+

4.1.2.2 Inadequate Inundation Mapping

This analysis is completed using the ExFldHazard layer. This layer contains both flood quilt and cursory data ~~fathom data~~ for the floodplain. The flood quilt includes the source of the floodplain data. Based on the definitions of the source data from TWDB[8], the sources that represented adequate inundation mapping data are:

[8] https://twdb-flood-planning-resources-twdb.hub.arcgis.com/pages/flood-quilt-pri

- National Flood Hazard Layer (NFHL) Preliminary Data (zones AE, AH, OH, and VE)
- NFHL Effective Data (zones AE, AH, OH, and VE)

The following flood quilt data sources were considered inadequate inundation mapping data in this assessment:

- Base Level Engineering (BLE)
- NFHL Zone A
- First American Flood Data Services (FAFDS)
- Cursory Floodplain Data ~~Fathom~~

The total amount of floodplain area (from all sources in the flood quilt) and the amount of inadequate floodplain data in each HUC-12 were calculated. This computation produced a percentage of the HUC-12 floodplain data that is considered inadequate for the purposes of this assessment. These percentages were scored on the following metrics outlined in Table 4-3~~Table 4-3~~.

Table 4-3 Scoring Ranges for the Percentage of Inadequate Flood Risk Data

Score (points)	0 points	1 point	2 points	3 points	4 points	5 points
% Inadequate	0	1-30%	31-60%	61-80%	81-95%	95-100%

4.1.3 Known Flood Risk

The following section gives a brief description of the data categories included and how each HUC-12 watershed was scored related to known flood risk. Note that the objective of the Task 4A process is to determine the factors that are present within a given HUC-12, and to what degree; not necessarily to determine the relative importance of each factor in determining flood risk. Therefore, no weight has been applied to emphasize one factor over another at this time.

4.1.3.1 Areas Most Prone to Flooding that Threatens Life and Property

Each category related to areas most prone to flooding are described below. The points breakdown for each metric is summarized in Table 4-4~~Table 4-4~~.

Buildings in the 100-year Floodplain

This dataset was divided into point values based on the total number of buildings in the 100-year floodplain within each HUC-12. The buildings dataset was provided by the TWDB on the Data Hub. The count ranged widely for each HUC-12, varying from zero buildings in potential flood risk areas. Some of the rural HUC-12s to hundreds of buildings in the more urban areas.

Low-Water Crossings

Low-water crossings (LWCs) were identified in Task 1 and were downloaded from the TWDB Data Hub. LWCs were added or removed from feedback in the stakeholder survey in Task 1. This category is scored based on the quantity of LWCs occurring in a HUC-12. Urban areas have more roadways and more identified LWCs; therefore, urban HUC-12s will tend to score higher than rural areas in this category. Since this application is somewhat unique to the region, it may be appropriate to take a closer look at the data provided by TWDB to ensure it is appropriate for examination of potential impacts of identified projects.

Locations where the Road Floods

Roadway flooding can be difficult to quantify in West Texas primarily because of the usage of roadways in the Upper Colorado Basin and across West Texas as primary routes of stormwater conveyance. Roadways are commonly built at or near existing grade in order to save cost, and this commonly results in overtopping of the pavement section by the wide and shallow floodplains common to the region. Elevation of roadways is typically saved for more major roadway sections, or where there has been a history of loss of life or property associated with flooding.

Agricultural Areas at Risk of Flooding

Agricultural areas have been defined for this task as a land use of either farming or ranching. For this category, impacted agricultural areas were analyzed in each HUC-12. The impacted agricultural area is the farming and ranching land use parcel area located within the 100-year floodplain (as defined by the flood quilt data).

Critical Facilities

Critical facilities for the needs analysis include hospitals, schools, fire stations, shelters, water and sewer plants, electric and gas lines. Existing critical facilities were identified in Task 1 from the TWDB Data Hub. Stakeholders were able to update the existing critical facilities by adding or removing facilities in the survey from Task 2. This category is scored based on the total number of critical facilities identified within the 100-year floodplain. The number of critical facilities within a HUC-12 is primarily a function of population density.

Table 4-4 Scoring Criteria for Areas Most Prone to Flooding

Score (points)	0 points	1 point	2 points	3 points	4 points	5 points
# of Buildings	0	1-9	10-19	20-99	100-499	500+
# of Low Water Crossings	0	1-4	5-9	10-19	20-49	50+
# of Road Flooding Locations	0	1	2	3	4	5+
Agricultural Area (square miles)	0	0.01-1.3	1.3-3.0	3.0-4.6	4.6-7.2	7.2+
# of Critical Facilities	0	1-4	5-9	10-19	20-49	50+

4.1.3.2 Historical Flooding

Each category related to historical flooding is described below. The points breakdown for each metric is summarized in Table 4-5~~Table 4-5~~.

Areas With a History of Flooding

The communities entered datapoints into the survey performed in Task 1 to mark areas in their communities that repetitively flood. This dataset is limited to locations identified by stakeholders in the survey, it does not include additional information regarding high water rescues, injuries, or deaths. To supplement this data, information obtained from the NOAA National Centers for Environmental Information (NCEI) Storm Events Database is included. This dataset compiles all the Federal Emergency Management Agency (FEMA) flood claims within the Upper Colorado basin as of June 2021. The geospatial data assigned to the claims was highly redacted; therefore, the cities to which the flood claims were assigned was used. Each city was divided into the HUC-12s that intersected the city limits. The value and number of flood claims for each city was divided proportionately amongst the HUC-12s composing each city. Most of the claims recorded in this dataset occurred in the areas around Midland, Odessa, and San Angelo.

Historic Storms

The occurrence of historic storms was evaluated using the hazard mitigation action plans (HMAPs) from the region as well as the NOAA National Centers for Environmental Information Storm Events Database[9]. This database compiles historic storms from 1950 to 2020. The number of historic storms on record occurring within each HUC-12 was tabulated and scored.

Damages from Historic Storms

In addition to the frequency of historic storms, the severity of these storms was also considered in the analysis. The historic storms dataset included information on reported

[9] https://www.ncdc.noaa.gov/stormevents/details.jsp

damages, injuries, and deaths associated with each storm. Historical storm data was extracted from county HMAPs and from the NOAA NCEI data. Severity was considered as follows: 0 to 5 points based on reported property damages, 1 additional point if injuries were reported, and 2 additional points if deaths were reported (Table 4-5~~Table 4-5~~).

Table 4-5 Scoring Criteria for areas with Historical Flooding

Score (points)	0 points	1 point	2 points	3 points	4 points	5 points
# of Areas with a History of Flooding	0	1	2	3	4	5+
Value of FEMA Claims	0	$1-$10,000	$10,001-$50,000	$50,001-$100,000	$100,001-$500,000	$500,001+
# of FEMA Claims	0	1-5	6-10	11-30	31-50	51+
# of Historical Storms	0	1-2	3-4	5-7	8-10	11+
Damages from Historical Storms	$0	$1-10,000	$10,000-50,000	$50,000-100,000	$100,000-500,000	$500,000+

4.1.3.3 Other Factors

Additional factors to known flood risk are a proxy for a region's resiliency to a flood event and preparedness. The points breakdown for each metric is summarized in Table 4-6~~Table 4-6~~.

Communities Not Participating in the NFIP

Participation in the NFIP was considered as a proxy for flood awareness. NFIP participation status can be found in Task 3. Non-participating communities are also not eligible for flood insurance under the NFIP. Furthermore, if a presidentially declared disaster occurs as a result of flooding, no federal financial assistance can be provided to non-participating communities for repairing or reconstructing insurable buildings in Special Flood Hazard Areas. Therefore, this analysis considered non-NFIP communities as being more vulnerable to flooding risks. If most of the HUC-12 (>= 50 percent) intersected a non-NFIP community it was assigned 5 points. Otherwise, no points were allocated. Residents of a community not participating in the NFIP are less likely to be aware of their flood risk.

Social Vulnerability Index

The Social Vulnerability Index (SVI) can be used as a proxy for a community's resiliency to a flood event. SVI refers to the potential negative effects on communities caused by external stresses on human health. Such stresses include natural or human-caused disasters, or disease outbreaks. The most recent SVI values (2018) for the State of Texas were downloaded from the Agency for Toxic Substances and Disease Registry (ATSDR) website[10]. SVI values are assigned per census tract, which was converted to SVI per HUC-12. SVI values were assigned to each HUC-12 based on an area-weighted average. The SVI ratings vary between 0 and 1 and were scored according to Table 4-6~~Table 4-6~~. The higher the SVI, the higher the vulnerability of a community; the lower the SVI, the higher the resilience.

Table 4-6 Additional Scoring Criteria for Known Flood Risk

Score (points)	0 points	1 point	2 points	3 points	4 points	5 points
Community Flood Awareness	NFIP Participant	--	--	--	--	Non-NFIP Participant
SVI rating	0	0.01-0.19	0.20-0.39	0.40-0.49	0.50-0.64	0.65+

4.1.4 Needs Analysis Results

The process and scoring methodology described above was implemented across the entire Upper Colorado Region. As previously discussed, two separate assessments were performed to address the two goals of the needs analysis.

The first goal is to identify the areas where the greatest flood risk knowledge gaps exist. These areas are represented in Figure 4-1~~Figure 4-1~~ and Appendix B-Map 14. Figure 4-1~~Figure 4-1~~ was generated based on the analysis of areas that need mitigation, study need or data gap, and inadequate inundation mapping. The majority of the Upper Colorado watershed is considered inadequately mapped (as indicated by the dark green HUC-12s in Map 14). Note that the lighter green HUC-12s may contain studies that have been completed but are not yet regulatory products.

The second assessment addresses the second goal: to determine the areas of greatest known flood risk and flood mitigation needs. For each HUC-12 in the Upper Colorado Region, the scores from each of the categories were added together to obtain a total score. All categories have an equal representation in the total score. This analysis also included flood risk knowledge gaps because uncertainty itself is a risk. Based on the distribution of the final scores in this preliminary assessment, the top 10 percent were colored red, and the top 30 percent were colored either red or orange. Figure 4-2~~Figure 4-2~~ and Appendix B-Map 15 highlights areas in red and orange where there is more data indicating a known flood risk occurs. HUC-12s shaded light yellow represent areas where there is less known about the flood risk level for that area.

The maps resulting from the needs analysis assessment will serve as a guide to the UCRFPG's subsequent efforts in Task 4B. The darker green HUC-12s in

[10] https://www.atsdr.cdc.gov/placeandhealth/svi/index.html

Figure 4-1~~Figure 4-1~~ highlight the areas in the Upper Colorado watershed where potentially feasible flood risk studies (FMEs) should be considered as part of Task 4B. The lighter green HUC-12s in Figure 4-2~~Figure 4-2~~ emphasize watersheds where the UCRFPG should strive to identify and implement FMSs and FMPs as part of Task 4B to reduce the known flood risks within those areas.

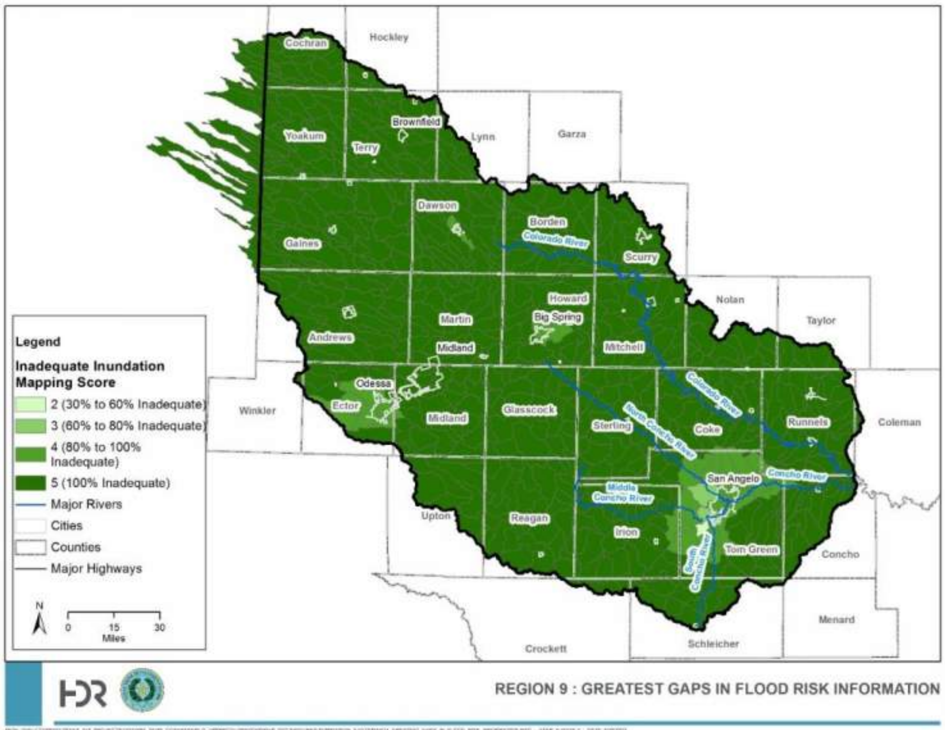

Figure 4-1. Flood Risk Knowledge Gaps

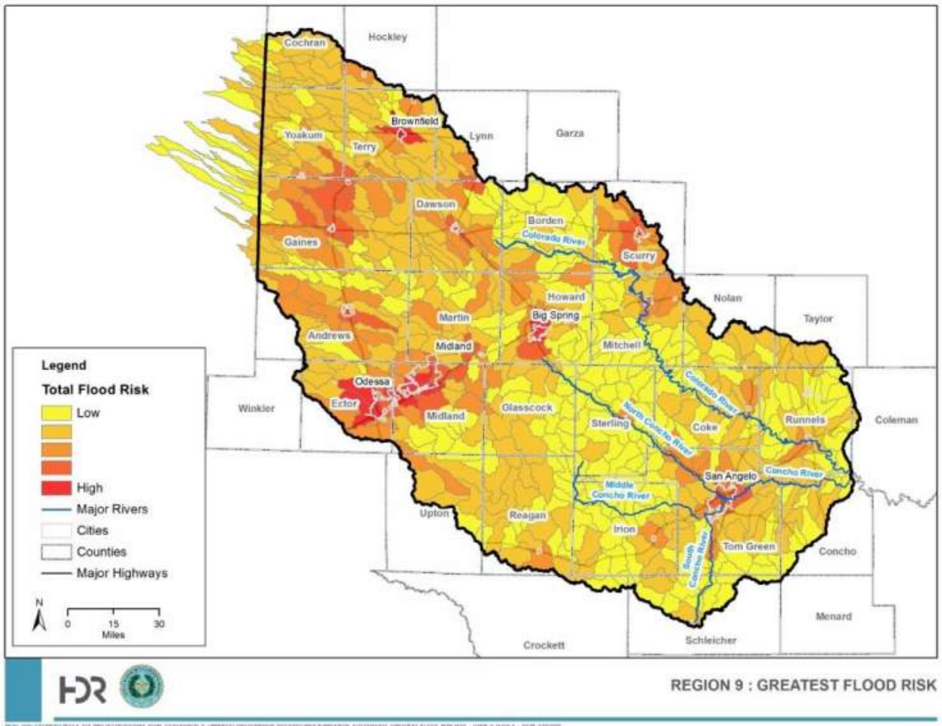

Figure 4-2. Areas of Greatest Known Flood Risk

5

Recommendation of Flood Management Evaluations and Flood Management Strategies and Associated Flood Mitigation Projects

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5 Recommendation of Flood Management Evaluations and Flood Management Strategies and Associated Flood Mitigation Projects

[31 TAC §361.38-361.39]

5.1 Introduction

The objective of this task is to evaluate and recommend potential flood management evaluations (FMEs), flood management strategies (FMSs), and their associated flood mitigation projects (FMPs) to be included in the regional flood plan, including the technical evaluations, and presents which entities will benefit from the recommended FMSs and FMPs.

Chapter 5 describes those flood management and mitigation efforts recommended through the planning process and identified through efforts encompassed by Tasks 4B and 5 of the regional flood planning process as described in the Texas Water Development Board's (TWDB) Technical Guidelines.[11]

5.2 Identify and Evaluate Potential FMEs, Potentially Feasible FMS and FMP

5.2.1 Process to Identify FMEs, FMSs, and FMPs

The goal is to define and evaluate a wide range of potential actions to identify and mitigate flood risk across the basin. These actions have been broadly categorized into the following three distinct types:

- **Flood Management Evaluation (FME)**: a proposed flood study of a specific, flood-prone area that is needed in order to assess flood risk and/or determine whether there are potentially feasible FMSs or FMPs.
- **Flood Mitigation Project (FMP)**: a proposed project, either structural or non-structural, that has non-zero capital costs or other non-recurring cost and, when implemented, will reduce flood risk or mitigate flood hazards to life or property.
- **Flood Management Strategy** (**FMS**): a proposed plan to reduce flood risk or mitigate flood hazards to life or property.

[11] TWDB, 2021. Exhibit C. Technical Guidelines for Regional Flood Planning, April 2021.

Identifying potential FMEs and potentially feasible FMPs and FMSs begins with completing the flood mitigation analysis (Chapter 4) to identify the areas with the greatest gaps in flood risk knowledge and the areas of greatest known flood risk. Based on the results of this analysis, several sources of data were used to develop a list of potential flood risk reduction actions that may address the basin's needs. The data includes information compiled under previous tasks:

- Existing flood infrastructure, flood mitigation projects currently in progress, and known flood mitigation needs (Task 1);
- Existing and future flood risk exposure and vulnerability (Tasks 2A and 2B);
- Floodplain management and flood protection goals and strategies developed by the regional flood planning group (RFPG) for the Region (Tasks 3A and 3B); and
- Stakeholder input.

These actions were identified and evaluated through initial screening and data gathering under Task 4B. As part of Task 5, FMEs, FMPs, and FMSs were further evaluated in order to compile the necessary technical data for the Upper Colorado Regional Flood Planning Group (UCRFPG) to decide whether to recommend these actions or a subset of these actions.

This first regional flood planning cycle relies primarily on compiling readily available information to determine appropriate flood mitigation actions to recommend for inclusion in the draft regional flood plan, rather than performing technical analysis to identify new actions. The list of potential FMEs and potentially feasible FMPs and FMSs for the draft regional flood plan were compiled based on contributions from the UCRFPG and other regional stakeholders from sources, including previous flood studies, drainage master plans, flood protection studies, and capital improvement studies. The process also involved identifying common needs, issues, and challenges; achieving efficiencies; fostering cooperative planning with local, state, and federal partners; and resolving conflicts in a fair, equitable, and efficient manner. The UCRFPG serves as the focal point and entity to accomplish this coordination during the process, particularly coordination of flood management planning, strategies, and mitigation projects with local, regional, state, and federal agencies projects and goals.

The specific list of previous flood studies and models relevant to flood plan development for the Upper Colorado Region are provided in Table 5-1~~Table 5-1~~ and Table 5-2~~Table 5-2~~.

Table 5-1. List of Studies Relevant to the Upper Colorado Regional Flood Plan

Flood Study	Description	Jurisdiction	Counties	Year
Midland Master Drainage Plan	This effort was initiated in 1991 to develop hydrologic and hydraulics models of the 6 major watersheds for Existing 1993, Future – No Action and Future – Playas conditions. The Playas model was refined to also include in-line channel detention and bridge/culvert improvements. The opinion of probable cost to fully realize the MDP was $62,889,750 in 1996 dollars.	Midland	Midland	1996
Odessa Master Drainage Plan	This effort was initiated in 2001 to develop hydrologic and hydraulics models of the watershed for Existing 1993, Future – No Action and Future – Playas conditions.	Odessa	Ector	2001
Jal and Midland Draw Watershed Study	This effort was initiated in 2015 to develop updated detailed hydrologic and hydraulic analyses of the Jal and Midland Draw watersheds for existing and fully developed conditions, along with a master plan and conceptual design of drainage improvements projects to help guide development adjacent to the draws.	Midland	Midland	2017
San Angelo Master Drainage Plan	This effort was initiated in 2019 to evaluate regional detention opportunities in the Red Arroyo watershed and update the Drainage CIP list. Six regional detention opportunities in the Red Arroyo were evaluated for potential benefits at College Hills Boulevard. A total of 38 problem areas were evaluated and prioritized, and Drainage CIP projects were developed to address the top 10 problem areas, including conceptual design and capital cost estimates. Potential funding alternatives were also identified and described.	San Angelo	Tom Green	2021
Deep Creek Section 205 Study	This effort was initiated in 2016 to address water resource opportunities. Project authorized under Section 205 of the 1948 Flood Control Act meant for small flood control projects.	Snyder	Scurry	2021

Flood Study	Description	Jurisdiction	Counties	Year
Concho Valley Hazard Mitigation Action Plan	The Concho Valley Council of Governments Hazard Mitigation Plan is a multi-jurisdictional plan covering 7 counties and 8 cities in Region 9. The purpose of the Plan is to minimize or eliminate long-term risks to human life and property from known hazards and to break the cycle of high-cost disaster response and recovery within the planning area.	Bronte, Mertzon, Robert Lee, Sterling City, Paint Rock, San Angelo, Eldorado, Big Lake	Coke, Concho, Sterling, Reagan, Irion, Tom Green, Schleicher	2013-2018
Tom Green County Hazard Mitigation Action Plan	The plan was prepared by Tom Green County, participating jurisdictions, and H2O Partners, Inc. The purpose of the Plan is to protect people and structures and to minimize the costs of disaster response and recovery. The goal of the Plan is to minimize or eliminate long-term risks to human life and property from known hazards by identifying and implementing cost-effective hazard mitigation actions.	San Angelo	Tom Green	2020-2025
West Central Texas COG Regional Hazard Mitigation Action Plan Update	The West Central Texas Council of Governments Hazard Mitigation Plan is a multi-jurisdictional plan covering 5 counties and 8 cities in Region 9. The mitigation strategies seek to identify potential loss-reduction opportunities. The goal of this effort is to work towards more disaster-resistant and resilient communities.	Snyder, Colorado City, Loraine, Westbrook, Blackwell, Ballinger, Miles and Winters	Scurry, Mitchell, Nolan, Taylor and Runnells	2020-2025
Ector County Multi-Jurisdictional Hazard Mitigation Action Plan	The plan was prepared by Ector County, participating jurisdictions, and H2O Partners, Inc. The purpose of the Plan is to minimize or eliminate long-term risks to human life and property from known hazards and to break the cycle of high-cost disaster response and recovery within the planning area."	Odessa and Goldsmith	Ector	2011-2016

Flood Study	Description	Jurisdiction	Counties	Year
Cochran County Multi-Jurisdictional Hazard Mitigation Action Plan	The plan was prepared by Cochran County, participating jurisdictions, and H2O Partners, Inc. The purpose of the Plan is to minimize or eliminate long-term risks to human life and property from known hazards and to break the cycle of high-cost disaster response and recovery within the planning area."	None are in Region 9	Cochran	2014
Terry County Multi-Jurisdictional Hazard Mitigation Action Plan	The plan was prepared by Terry County, participating jurisdictions, TDEM and LAN, Inc. The purpose of the Plan is to minimize or eliminate long-term risks to human life and property from known hazards and to break the cycle of high-cost disaster response and recovery within the planning area."	--	Terry	--
Lynn County Multi-Jurisdictional Hazard Mitigation Action Plan	The plan was prepared by Lamb and Lynn County, participating jurisdictions, and H2O Partners, Inc. The purpose of the Plan is to minimize or eliminate long-term risks to human life and property from known hazards and to break the cycle of high-cost disaster response and recovery within the planning area."	O'Donnell	Lynn	2020

Table 5-2. List of Relevant Models Collected for the Upper Colorado Regional Flood Plan

Model Title	Hydrology Software	Hydraulics Software	Study Area	Sponsor Entity	Date
Crockett County FIS	NUDALLAS	HEC-2	Crockett County	FEMA	1981
Dawson County FIS	17B / Regression	USFHA / RAS	Dawson County	FEMA	2011
Ector County FIS	HEC-1	HEC-2	Ector County	FEMA	2012
Hockley County FIS	17B/Regression	USFHA / HEC-2	Dawson County	FEMA	1977
Howard County FIS	TR-20	HEC-2	Howard County	FEMA	2010
Midland County FIS	HEC-1	HEC-2	Midland County	FEMA	2005
Mitchell County FIS	17B/Regression	USFHA / HEC-2	Mitchell County	FEMA	1985
Nolan County FIS	NUDALLAS	HEC-2	Nolan County	FEMA	1990
Scurry County (Snyder) FIS	NUDALLAS	HEC-2	Scurry County	FEMA	1980
Tom Green County FIS	SWFHYD/HEC-1	HEC-2	Tom Green County	FEMA	2012
Deep Creek Section 205 Study	HEC-HMS	HEC-RAS	City of Snyder	USACE	2021

FIS=flood insurance study; FEMA=Federal Emergency Management Agency; USACE=U.S. Army Corps of Engineers

5.2.2 Classification of Potential FMEs and Potentially Feasible FMPs and FMSs

FMEs, FMPs, and FMSs are broadly categorized as “flood risk reduction projects” in the *Technical Guidelines*. The *Technical Guidelines* also list several potential project types for each subcategory, summarized in Table 5-3~~Table 5-3~~. Once potential flood risk reduction actions were preliminarily identified using this list, a high-level screening process was used to confirm that potential actions had been sorted into their appropriate categorization. The screening process is shown in Figure 5-1~~Figure 5-1~~.

Table 5-3. Flood Risk Reduction Project Types

Flood Risk Reduction Project Category	Project Types
Flood Management Evaluation (FME)	1. Watershed Planning 2. H&H Modeling 3. Flood Mapping Updates 4. Regional Watershed Studies 5. Engineering Project Planning 6. Feasibility Assessments 7. Floodproofing 8. Preliminary Engineering (alternative analysis and up to 30% design) 9. Property or Easement Acquisition 10. Regulatory Requirements for Reduction of Flood Risk 11. Studies on Flood Preparedness
Flood Mitigation Project (FMP)	Structural 1. Low Water Crossings or Bridge Improvements 2. Infrastructure (channels, ditches, ponds, stormwater pipes, etc.) 3. Regional Detention 4. Regional Channel Improvements 5. Storm Drain Improvements 6. Reservoirs 7. Dam Improvements, Maintenance, and Repair 8. Flood Walls/Levees 9. Nature Based Projects – living levees, increasing storage, increasing channel roughness, increasing losses, de-synchronizing peak flows, dune management, river restoration, riparian restoration, run-off pathway management, wetland restoration, low impact development, green infrastructure, playas improvements 10. Comprehensive Regional Project – includes a combination of projects intended to work together
	Non-Structural 1. Property or Easement Acquisition 2. Elevation of Individual Structures 3. Flood Readiness and Resilience 4. Flood Early Warning Systems, including stream gauges and monitoring stations 5. Floodproofing Regulatory Requirements for Reduction of Flood Risk

Flood Risk Reduction Project Category	Project Types
Flood Management Strategy (FMS)	None specified; at a minimum, regional flood planning groups (RFPGs) should include as FMSs any proposed action that the group would like to identify, evaluate, and recommend that does not qualify as either a FME or FMP.

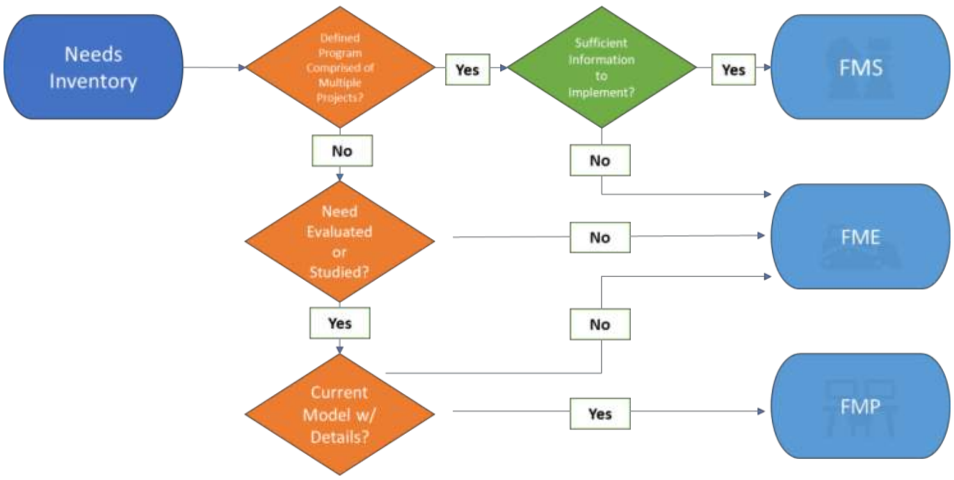

Figure 5-1. Potential Flood Risk Reduction Action Screening Process

Generally, an action was considered an FME if it required a study to quantify flood risk in an area, define potential FMPs and FMSs to address the risk, or assess downstream impacts. Potential actions that could be considered FMPs and FMSs were screened to determine if they have been developed in enough detail and include sufficient data to meet the technical requirements for these action types. Actions that were initially considered for FMSs and FMPs that did not meet these requirements were adapted and repurposed as FMEs. The specific requirements for each action type are described in subsequent sections.

FMSs were also identified for other strategies the UCRFPG wishes to pursue. One example of a potential FMS is identifying repetitive loss properties and establishing a community-wide program of voluntary acquisitions to be implemented over several years. Another example would be a program to enhance public education and awareness about flooding throughout the region, which does not include a construction cost.

5.2.3 Evaluation of Potential FMEs

Several actions were identified as potential FMEs to address gaps in available flood risk data associated with the first planning cycle. The following sources of data were used to identify FMEs across the basin:

- Hazard Mitigation Action Plans (HMAP)
- Drainage Master Plans
- Direct input from the RFPG and Stakeholders

The evaluation of FMEs relied on the compilation of planning level data to gauge alignment with regional strategies and flood planning guidance, the potential flood risk in the area, and the funding need and availability. This data included the following.

- Type of study and location
- Availability of existing modeling and mapping data
- Regional flood mitigation and floodplain management goals addressed by the FME, and whether the FME meets an emergency need
- Flood risk information, including flood risk type, number and location of structures, population, roadways, and agricultural areas at risk
- Sponsor entity and other entities with oversight
- Cost information, including study cost and potential funding sources

5.2.3.1 FME Types

The definition of an FME allows for a variety of study types to help assess flood risk and potentially define future FMPs and FMSs. A general list of study types was previously summarized in Table 5-3~~Table 5-3~~. The following section describes these project types in more detail and provides a summary of the different potential FMEs identified in the Upper Colorado Region.

Watershed Planning

FMEs classified as watershed planning typically involve efforts associated with hydrologic and hydraulic (H&H) modeling to help define flood risk or identify flood prone areas at a regional and/or watershed scale. The goal of watershed planning is to distribute resources equitably throughout the watershed to implement plans, programs, and projects that maintain watershed function and prevent adverse flood effects. A wide variety of project types fit under the umbrella of watershed planning. The subcategories defined in the Upper Colorado Region include the following.

- Federal Emergency Management Agency (FEMA) Mapping
- Drainage Master Plans
- Watershed Studies

Engineering Project Planning

FMEs classified as engineering project planning include studies to evaluate potential structural mitigation projects. These evaluations include feasibility assessments, preliminary alternatives analysis, and preliminary engineering design.

Flood Preparedness Studies

FMEs classified as flood preparedness studies include proactive evaluations of a community's readiness to respond to a flood event. The identified FMEs under this category consider non-structural mitigation actions such as early warning systems, public awareness of flooding, and channel maintenance efforts to avoid reductions in flow capacity along rivers and creeks and maintenance of playas to preserve storage capacity and natural function.

FME Summary

In total, 128 potential FMEs were identified and evaluated. The geographical distribution of the identified FMEs is shown in Figure 5-2. Color gradations in Figure 5-2 reflect the number of FMEs that overlap for the same area; the darker the color, the greater the number of FMEs.

Table 5-4. FME Types and General Description

Flood Management Evaluation (FME) Type	General Description	Number of FMEs Identified
Watershed Planning – H&H Modeling, Regional Watershed Studies	Supports the development and analysis of hydrologic and hydraulic models to define flood risk or identify flood prone areas OR large-scale studies that are likely to benefit multiple jurisdictions.	37
Watershed Planning – Flood Risk Mapping Updates	Promotes the development and/or refinement of detailed flood risk maps to address data gaps and inadequate mapping. Create Federal Emergency Management Agency (FEMA) mapping in previously unmapped areas and update existing FEMA maps as needed.	30
Engineering Project Planning	Evaluation of a proposed project to determine whether implementation would be feasible OR initial engineering assessment including conceptual design, alternative analysis, and up to 30 percent engineering design.	33

Flood Management Evaluation (FME) Type	General Description	Number of FMEs Identified
Regulatory and Guidance	Create and implement an integrated stormwater management manual or higher standards program that contains minimum stormwater infrastructure design standards.	0
Studies on Flood Preparedness	Encourages preemptive evaluations and strategies to better prepare an area in the event of flood.	1
Other	Other projects not classified above. All FMEs classified as “Other” are associated with studies to support property acquisition programs (including high-risk and repetitive loss properties, and acquiring and preserving open space adjacent to floodplain areas).	27

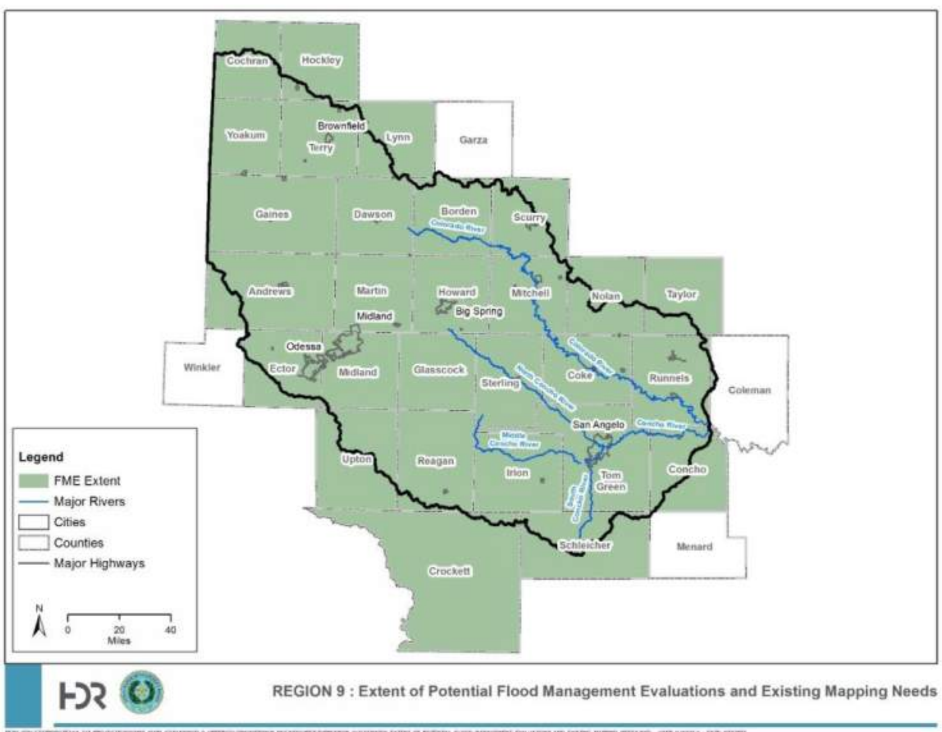

Figure 5-2. Geographical Distribution of Potential FMEs

5.2.3.2 Planning Level Cost Estimates

A planning level cost estimate was developed for each FME in accordance with the *Technical Guidelines*. The process to produce these cost estimates for each FME project type is outlined in the following sections. Cost estimates presented in this section are for planning purposes only and are not supported by detailed scopes of work or manhour estimates. It is anticipated that scopes of work and cost estimates will be refined prior to any future funding application through TWDB or other sources.

Watershed Planning – Drainage Master Plans

The objective of drainage master plan FMEs is to evaluate and define flood risk, identify flood prone areas, and evaluate alternatives for mitigating such risks. Planning level cost estimates were developed for these types of FMEs assuming a typical scope of work that includes management, data collection, topographic survey, hydrologic analysis, hydraulic analysis, alternatives evaluation, and final deliverables. A range of unit costs were developed to generate estimates based on the square mileage of the study areas and the total length of stream miles for which hydraulic modeling would be performed. Experience from previous studies was used to scale the study effort and estimate the level of detail associated with the H&H analyses that are required for these studies. It was estimated that 20 percent of the total project area could be analyzed with low level of detail, 70 percent with medium level of detail, and 10 percent would require highly detailed H&H models. Unit costs were applied to reflect these different levels of detail, which reflect differences in the physical characteristics of the basins and their levels of urban development.

Each cost estimate also includes standard budget items based on the total project cost. These include a markup of 2 percent to account for quality assurance and quality control and 15 percent for project management, survey data capture, and technical reporting. Finally, a 30 percent contingency was applied to account for uncertainties associated with planning level estimates.

Watershed Planning – FEMA Mapping

Flood risk mapping data helps communities quantify and manage their flood risk. It also provides communities a pathway to access flood insurance administered through the National Flood Insurance Program (NFIP). FEMA Mapping FMEs were identified for all counties within the Upper Colorado Region. The FMEs included both projects to develop regulatory maps where none exist and to update existing maps to account for revised rainfall data, recent development or topographic changes, and advances in floodplain modeling and mapping methodologies.

A spreadsheet was generated to produce planning level cost estimates for watershed planning studies where estimates were not available utilizing relevant line items from the FEMA guidance document *Estimating the Value of Partner Contributions to Flood*

Mapping Projects ("Blue Book") version 4.1. Costs pertaining to management, discovery data capture, hydrologic data capture, hydraulic data capture, floodplain mapping data capture, and final deliverables were included as part of the overall cost. The FME study area was defined as the portion of the county boundary that is within the Upper Colorado River basin. A range of unit costs were developed to generate estimates based on the square mileage of the study areas and the total length of stream miles for which hydraulic modeling would be performed. It was estimated that the stream miles to be included would be 25 percent of the total stream miles classified as FEMA Zone A or unmapped within a given study area. This estimate was based on the adopted short-term goal of reducing areas identified as having gaps in flood mapping by 25 percent (see Chapter 3).

Experience with previous mapping projects was used to estimate the level of detail associated with the hydrologic and hydraulic analyses that are required for these studies. The level of detail needed to perform a regulatory study reflects differences in the physical characteristics of the basins and their levels of urban development. In terms of hydrologic analysis, it was estimated that 80 percent of the total project area could be analyzed using low-detail methods, while 20 percent would require more detailed rainfall-runoff analyses. For the hydraulic analysis, it was estimated that 70 percent of the included streams could be properly modeled with a low-detail hydraulic model, 20 percent with a medium-detail model, and the remaining 10 percent would require highly detailed models. Unit costs were applied to reflect these different levels of detail.

Each cost estimate also includes standard budget items based on the total project cost. These include a markup of 2 percent to account for quality assurance and quality control and 15 percent for project management, survey data capture, and technical reporting. Finally, a 30 percent contingency was applied to account for uncertainties associated with planning level estimates.

Engineering Project Planning

Engineering project planning considers two important components: (1) the evaluation of a proposed project to determine whether implementation would be feasible, and (2) an initial engineering assessment including conceptual design, alternative analysis, and up to 30 percent engineering design. Each evaluation area is project-specific and varies greatly due to the wide range of improvements in channels, low water crossings, roads and bridges, storm drain systems, and levee systems. HMAPs were used, when available, for the respective entity in determining planning level cost estimates. It was assumed that each evaluation would be 10 percent of the total construction cost reported in the HMAP. In instances where no HMAP was available, additional research was conducted to gather supplemental information from FME sponsors or from similar studies to develop a scope of work and planning level cost estimate.

Studies on Flood Preparedness

Studies on flood preparedness encourage preemptive evaluations and strategies to better prepare an area in the event of a flood. The identified FMEs in this category include a variety of studies to evaluate alternatives for debris removal from stream channels, stream restoration programs, studies to determine needed upgrades and repairs to dams, the feasibility of installing flood warning systems and low water crossing barriers, and channel stability studies. Due to the open-ended nature of the scope of work for these FMEs, it was not possible to scale the cost estimates for these studies. Therefore, placeholder costs were assigned to these FMEs based on professional engineering experience with similar projects.

Regulatory and Guidance

All recommended development of drainage criteria and ordinances were included as FMSs.

Other

All FMEs classified as “Other” are associated with studies to develop and support property acquisition programs. The scope and scale of property acquisition programs can vary widely, and there is great uncertainty in terms of the number of properties/parcels that could potentially be acquired, and their fluctuating market values. Therefore, rather than scaling each FME individually, a standard project cost of $100,000 was assigned to each FME.

It is assumed that this placeholder budget would provide sufficient funds to perform an initial assessment to identify potential areas for acquisition, prioritize areas/properties, perform market research, and define a scope of work for specific acquisition projects. This scope of work could include H&H studies, deed studies, property appraisals, inquiries about voluntary participation, identifying potential funding sources, and identifying supplementary work such as stream restoration and other flood risk reduction projects. This placeholder budget is not intended for acquiring properties. Further funding will be required in the future to implement the acquisition programs developed under these FMEs.

5.2.3.3 Process to Determine Flood Risk Indicators

Flood risk indicators were quantified to define the existing flood hazard, flood risk, and flood vulnerability within each FME project area. An automated tool was developed in geographic information systems (GIS) to combine and summarize this information by clipping the flood risk information generated for the basin as part of Task 2A to the individual project boundaries associated with each FME. The resulting flood risk indicator information was used to populate the associated fields in the FME feature class.

5.2.3.4 Comparison and Assessment of FMEs

Due to the lack of available detailed studies in the regions, FMEs are the most numerous flood mitigation actions in the regional flood plan. The inclusion of FMPs and some FMSs in this plan was hampered by the lack of detailed hydrologic and hydraulic modeling needed to assess them to meet the TWDB's technical requirements. Over 99 percent of the region has no detailed Zone AE flood studies, and most counties had no Flood Insurance Rate Maps (FIRMs) at all. New flood insurance studies (FISs), and associated floodplain maps and models, are recommended to ensure that appropriate regulation of the floodplains can occur, flood damages can be mitigated, and of a solid basis for future assessment of riverine flooding issues and solutions is available. This includes all counties in the region and would help reduce flood risks to over 99 percent of the people in the Upper Colorado Region.

Numerous potential FMPs, or collections of FMPs, were submitted by communities within the region, but they did not have adequate modeling to meet TWDB requirements. These potential FMPs have been included as FMEs to support preparation of the needed studies and verify that the projects would meet TWDB requirements.

A total of 32 preparedness FMEs were requested, including stream gauge and warning systems, debris and vegetation removal, and potential channelization projects. These tended to be relatively vague concepts that needed and FME to determine specific needs.

Seven property acquisition and buyout programs were requested. These were general requests without specific locations indicated; therefore, they were included as FMEs to allow for analysis of which properties need to be required, the priority, and potential funding options.

5.2.3.5 Determination of Emergency Need

For the purposes of this evaluation, an action was considered to meet an emergency need if it addresses an issue related to infrastructure in immediate need for repair or construction, particularly following a natural disaster or other destructive event, or where flood risk data is needed as a foundation for this effort. As a result, 32 of the identified FMEs were classified as demonstrating an emergency need. While flooding can occur at any time of year with any magnitude, and often without warning, studies and evaluations on flooding generally do not meet these criteria because of the time it takes to complete a study and develop actionable alternatives.

5.2.4 Evaluation of Potentially Feasible FMSs and FMPs

Potentially feasible FMPs were identified based on responses to survey, reviews of previous studies, and direct coordination with stakeholders. FMSs and FMPs are required to be developed in a sufficient level of detail to be included in the regional flood plan and recommended for state funding. In most cases, this includes having recent H&H modeling data in order to assess the impacts of the project and an associated project cost to develop the project's benefit-cost ratio (BCR). The development and use of the technical information to evaluate potentially feasible actions is described in the subsections that follow.

5.2.4.1 Potentially Feasible FMPs

Thanks to multiple completed drainage master plans, the RFPG was able to identify 8 potentially feasible FMPs, mostly within the cities of Andrews, Midland and San Angelo. Due to the limited number of flood studies that have taken place elsewhere in the Upper Colorado Region, no additional FMPs were identified. These potential FMPs are focused on playa excavation, detention, storm drain and open channel improvements. None has been classified as meeting an emergency need. A summary listing of FMP types is provided in Table 5-5~~Table 5-5~~.

The geographical distribution of each identified FMP is shown in Figure 5-3~~Figure 5-3~~. Color gradations in Figure 5-3~~Figure 5-3~~ reflect overlap of FMPs for the same area.

Additional potentially feasible FMPs may be identified through continued outreach with regional stakeholders under Task 11 and through the execution of identified FMEs, either as FMEs are approved by the RFPG to be performed under Task 12, or as other funding sources are acquired by individual stakeholders.

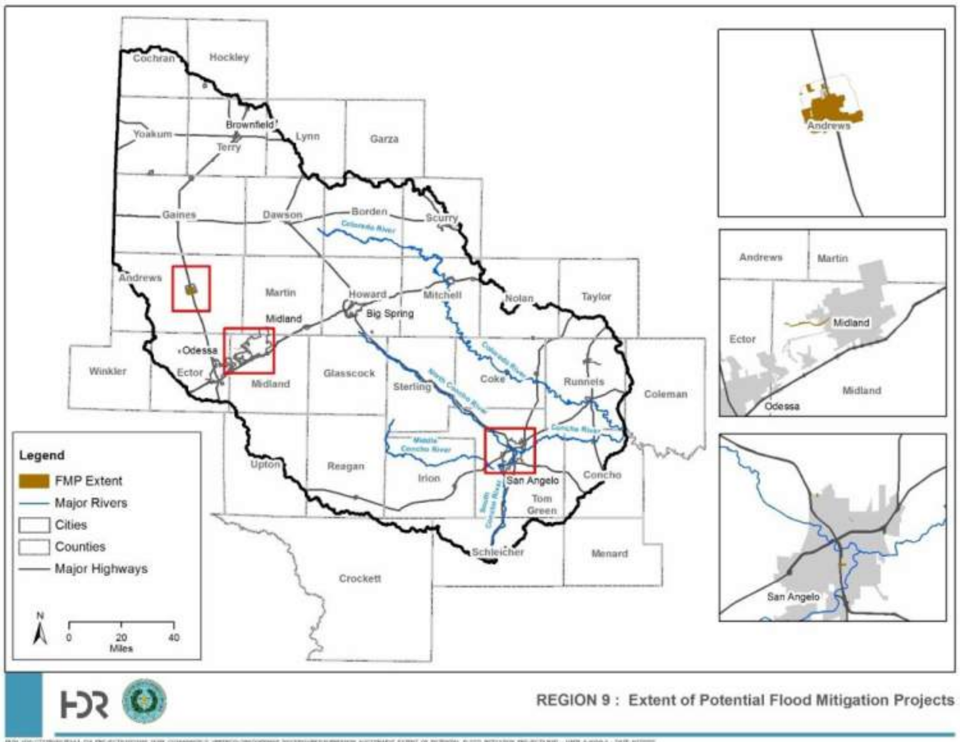

Figure 5-3. Geographical Distribution of Identified FMPs

Table 5-5. FMP Types and General Description

Flood Mitigation Project (FMP) Type	General Description	Number of FMPs Identified
Flood Mitigation Project – Non-Structural: Early Warning System	Installation of sensors at three railroad underpasses	0
Flood Mitigation Project – Structural: Regional Improvements	Playa or detention pond excavation, open channel or storm drain construction.	8
Flood Mitigation Project – Non-Structural: Infrastructure (buyout program)	Buyout of five residential properties adjacent to a playa and provision of green space.	0

5.2.4.2 Potentially Feasible FMSs

The UCRFPG identified 139 potentially feasible FMSs for the Upper Colorado Region. The geographic distribution of each FMS is shown in Figure 5-4~~Figure 5-4~~. Color gradations in Figure 5-4~~Figure 5-4~~ reflect the number of FMSs that overlap for the same area, the darker the color, the greater the number of FMSs.

A variety of FMS types were identified. Some strategies encourage and support communities and municipalities to actively participate within the NFIP. Other FMSs recommend the establishment and implementation of public awareness and educational programs to better inform communities of the risks associated with flood waters. Additional FMSs promote preventive maintenance programs to optimize the efficiency of existing stormwater management infrastructure, recommend the development of a stormwater management manual to encourage best management practices, or promote the establishment of community-wide flood warning systems. None have been classified as meeting an emergency need. A summary listing of FMS types is provided in Table 5-6~~Table 5-6~~.

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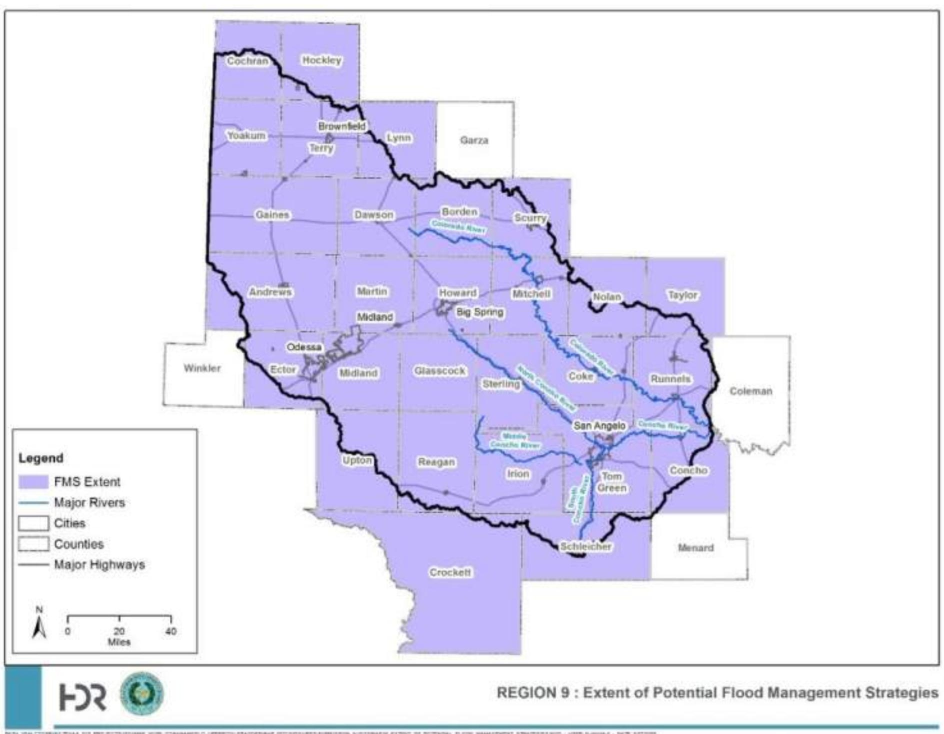

Figure 5-4. Geographical Distribution of Identified FMSs

Table 5-6. FMS Types and General Description

Flood Management Strategy (FMS) Type	General Description	Number of FMSs Identified
Education and Outreach	Develop a coordinated education, outreach, and training program to train staff and to inform and educate the public about the dangers of flooding and how to prevent flood damages to property.	31
Flood Measurement and Warning Systems	Install gauges, sensors, and precipitation measuring sites to monitor streams and waterways for potential flooding and support emergency response.	8
Improved Data and Safety at Dams (Other)	Reinforcement of slopes, spillway expansion, dam repairs and upgrades	0
Property Acquisition and/or Structural Elevation	Acquire, relocate, and/or elevate flood prone structures OR acquire floodplain and protect environmentally sensitive areas by converting floodplain encroachments into open space land.	0
Regulatory and Guidance	Application to join NFIP or adoption of equivalent standards. Create and implement a drainage criteria manual or higher standards program that contains minimum stormwater infrastructure design standards.	78
Preventive Maintenance Programs (Other)	Adopt and implement a program for clearing debris from bridges, drains, ditches, channels, and culverts.	13
Engineering Project Planning	Evaluation of a project identified by an ongoing FIF study to determine whether implementation would be feasible OR initial engineering assessment including conceptual design, alternative analysis, and up to 30 percent engineering design.	9

5.2.4.3 Comparison and Assessment of FMPs

Out of the originally requested FMPs, 8 potential FMPs appear to have the TWDB required analysis to support them as FMPs. These range in cost from $840,000 to $6,700,000.

5.2.4.4 Comparison and Assessment of FMSs

A total of 139 potential FMSs were generated or requested by communities. Regulatory and guidance was the largest category with 78 potential FMSs. These included adding communities to the NFIP, developing and adopting stormwater management criteria, and floodplain management staff acquisition and training. Developing minimum NFIP or higher floodplain regulatory standards for new development near a floodplain preserves the natural capacity of the flooding source and limits upstream and downstream negative impacts. Minimum FEMA NFIP floodplain regulations can be found in Chapter 44 of the Code of Federal Regulations (44 CFR). The Texas Floodplain Management Association (TFMA) has developed a Guide for Higher Standards for Floodplain Management (2018), which can serve as an example for higher floodplain development standards for the referenced FMSs. These FMSs can have the greatest impact as they help prevent future flooding through better understanding of flood risks, preventing development in the floodplain, and improving drainage design and development standards.

There were 31 identified flood education, awareness, and safety education support FMSs. These FMSs range from implementing the National Weather Service's "Turn Around, Don't Drown" campaign to general education in regards the NFIP. Of the sponsors requesting education and outreach support, the City of Odessa demonstrated the highest flood risk to habitable structures and road crossings.

There were 8 identified FMSs related to flood measuring, monitoring, and warning systems. These systems include local warning notifications, monitoring/measuring gages, highwater detection systems, sirens, warning lights, signage, and automated gates.

Zero projects requested were related to floodproofing lift stations in the Upper Colorado Region. Lift stations should generally be considered critical infrastructure and important to continued operation of sanitary sewer systems.

5.2.4.5 Effects on Neighboring Areas of FMS or FMP

Each potentially feasible FMP and FMS must demonstrate that there would be no negative flood impacts on a neighboring area due to its implementation. No negative impact means that a project will not increase flood risk to surrounding properties. The analysis must be based on best available data and be sufficiently robust to demonstrate that the post-project flood hazard is no more than the existing flood hazard.

Some communities in the Upper Colorado basin have established no negative adverse flood impact policies for proposed development, but communities have different thresholds for defining what level of impact is considered adverse and require the analysis to be performed for different flood event scenarios. The *Technical Guidelines* and *Rules* governing state flood planning require the impacts analysis to be performed for the 1 percent annual chance event. Additionally, the *Technical Guidelines* require the following criteria to be met, as applicable, to establish no negative flood impact:

1. Stormwater does not increase inundation in areas beyond the public right-of-way, project property, or easement.
2. Stormwater does not increase inundation of storm drainage networks, channels, and roadways beyond design capacity.
3. Maximum increase of one-dimensional (1D) water surface elevation must round to 0.0 feet (< 0.05 feet) measured along the hydraulic cross-section.
4. Maximum increase of two-dimensional (2D) water surface elevations must round to 0.3 feet (< 0.35 feet) measured at each computational cell.
5. Maximum increase in hydrologic peak discharge must be < 0.5 percent measured at computational nodes (sub-basins, junctions, reaches, reservoirs, etc.). This discharge restriction does not apply to a 2D overland analysis.

If negative impacts are identified, mitigation measures may be utilized to alleviate such impacts. Projects with design level mitigation measures already identified may be included in the regional flood plan and could be finalized at a later stage to conform to the “No Negative Impact” requirements prior to funding or execution of a project.

A comparative assessment of pre- and post-project conditions for the 1 percent annual chance event was performed for each potentially feasible FMP based on their associated hydrologic and hydraulic models. The floodplain boundary extents, resulting water surface elevations, and peak discharge values were compared at pertinent locations to determine if the FMP conforms to the no negative impacts requirements. This comparative assessment was performed for the entire zone of influence of the FMP.

5.2.4.6 Estimated Benefits of FMS or FMP

To be recommended, each FMP or FMS must align with a regional floodplain management goal established under Task 3 and demonstrate a flood risk reduction benefit. To quantify the flood risk reduction benefit of each FMP or FMS, the anticipated impact after project implementation was evaluated with the following criteria:

- Reduction in habitable, equivalent living units flood risk
- Reduction in residential population flood risk
- Reduction in critical facilities flood risk
- Reduction in road closure occurrences
- Reduction in acres of active farmland and ranchland flood risk
- Estimated reduction in fatalities, when available
- Estimated reduction in injuries, when available

- Reduction in expected annual damages from residential, commercial, and public property
- Other benefits as deemed relevant by the RFPG, including environmental benefits and other public benefits

These estimated benefits were produced from geospatial data by analyzing the existing 1 percent and 0.2 percent annual chance floodplain boundaries with the proposed post-project floodplain boundaries. These proposed flood risk conditions were compared to the existing conditions flood risk indicators for a given area to quantify the reduction of flood risk achieved by implementation of an FMP or FMS.

5.2.4.7 Potential Impacts and Benefits from the FMS or FMP to other resources

Potential impacts and benefits from FMS or FMP are explored for the Upper Colorado Region from the standpoint of environment, agriculture, recreation, navigation, water quality, erosion and sedimentation. Factors unique to the Region were reviewed and an assessment of how these factors might interact with a potential FMS or FMP are discussed below.

Environmental

Senate Bill 3 (SB3) was designed to establish environmental flow standards for all major river basins and bay systems in Texas through a scientific, stakeholder-driven and consensus-based process. The following are key questions addressed by the SB3 process as defined by TWDB:

1. What is the quantity of water required by the state's rivers/estuaries to sustain a sound ecological environment?
2. How can this water be protected?
3. What is the appropriate balance between water needed to sustain a sound ecological environment and water needed for human or other uses?

FMS or FMP in the region should consider potential impacts as it relates to the ecological flows established under the directive of SB3. Five of the proposed FMSs or FMPs involved detention or retention; therefore, there would be minimal or no impact to base or environmental flows.

FMS or FMP in the region should also consider potential impacts to Species of Greatest Conservation Need (SGCN) and priority habitats as they relate to ecological flows using information from the Texas Conservation Action Plan (TCAP). TCAP is a guiding document for conservation in the state of Texas, with the goals of realizing conservation benefits, preventing species listings, and preserving our natural heritage for future generations. SGCN include numerous aquatic species such as fish, freshwater mussels, and salamanders. The TCAP handbook (Texas Parks and Wildlife Department, 2012) includes six types of priority habitats, three of which are aquatic: water resources; riparian

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TCAP Statewide Multi-region Handbook (texas.gov)
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and floodplains; and caves and karst. Issues affecting these environments include environmental flows, impoundments and dam operations, and water quality issues (including stormwater runoff).

Impacts to SGCN and priority habitats can be minimized by considering sediment transport, passage of aquatic organisms, and non-impoundment of water when evaluating FMS or FMP that involve designing future stream crossings. When possible, the following guidelines taken from the U.S. Forest Service's stream simulation approach for designing road-stream crossing structures should be observed:

1. Bridges will span the creek or culverted crossings will be designed with the culvert(s) in the active channel area lower than those in the floodplain benches so that the flow in the channel will not overly spread out.
2. The central/low flow culvert(s) will be large enough to handle a 1.5-year flow without backing up water.
3. The bottoms of these lower culverts will be set at least a foot below grade (i.e., recessed) to allow natural substrate to cover the culvert bottom and to allow for aquatic organism passage.
4. These lower, recessed culverts will be installed in the thalweg or deepest part of the channel and be aligned with the low flow channel.

These guidelines maintain the sustainability of the ecological environment by allowing for the passage of "aquatic organisms at all life stages at road stream crossings while meeting vehicle transportation objectives…(and) without compromising the hydraulic capacity of the structure" (Clarkin et al., 2006).

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Agricultural

According to the Texas A&M AgriLife Extension Service economists, Hurricane Harvey caused more than $200 million in crop and livestock losses in Texas. Flood waters have the potential to destroy standing crops, create water-logged conditions that delay planting or harvesting, wash away productive topsoil, and damage farm equipment and infrastructure. FMS or FMP potentially reduce extremely high flows in rivers and streams thereby preventing flood waters from inundating areas outside of the floodway including agricultural areas. Structural FMS or FMP like small flood control ponds also have the potential to assist in agricultural production by serving dual purpose of flood mitigation and water supply. Non- structural FMS or FMP have similar impacts on flood peak flow reduction and flooding including agricultural conservation practices such as such as conservation tillage, residue management, cover crops and furrow dikes. These practices not only reduce downstream flooding by reducing surface runoff and increasing infiltration on agricultural lands but also sediment and nutrient losses thereby improving downstream water quality.

Most of the mitigation FMPs and FMEs are focused on urban areas and will have only incidental benefits to agriculture. The Regulatory and Guidance FMSs and Watershed Planning FMEs have the potential to benefit agricultural operations by improving their understanding of flood risks, making insurance available for structures, and preventing construction of regulated structures within the floodplain.

Recreational Resources

There are 15 major lakes and reservoirs in the Upper Colorado Region. Most of these reservoirs have a flood control function. Recreational opportunities associated with these lakes and reservoirs have the potential to be impacted when they are being operated to mitigate flood risk. Flood control reservoirs hold water in their flood pools during peak runoff periods until the impounded water can be safely released downstream. During these periods, recreation use potential of adjacent parks and playgrounds may be vastly reduced. No new flood control reservoirs, or other reservoirs of any kind, are being proposed in the regional flood plan. None of the proposed actions should impact the current reservoir operations.

Navigation

None of the major rivers within the Upper Colorado Region are used for commercial navigation.

Water Quality, Erosion, and Sedimentation

Water quality, erosion, and sedimentation are complex and interrelated issues. Water quality usually relates to nutrient and bacterial loading, but also includes turbidity, which relates to sediment load. Most water quality issues are influenced by upland portions of the watershed, while sedimentation and erosion are more impacted by channel dynamics. Playa sedimentation is a consideration in the Upper Colorado Region. However, limited studies have focused on the impacts of playa sedimentation, particularly regarding flood-related issues.

Most of the other actions considered in this plan will improve understanding of the floodplains and allow for better understanding of any future projects impacts. None of the proposed actions are expected to have adverse impacts to water quality, erosion, or sedimentation, but these will need to be considered as future FMPs are developed.

5.2.4.8 Estimated Capital Cost of FMPs and FMSs

Cost estimates for each FMP were acquired from the engineering report that was used to generate the FMP. Cost estimates were adjusted as needed to account for inflation and other changes in price of labor and commodities that had taken place since the publication date of the original reports. The cost estimates are expressed in 2020 dollars.

Cost estimates for each FMS were acquired from the HMAPs that were used to generate the FMS. Cost assumptions from Table 5-7~~Table 5-7~~ were used if the HMAPs did not have associated costs or if the reported costs were lower than the cost assumptions. The cost assumptions are expressed in 2020 dollars and were developed based on engineering experience and other similar projects.

Table 5-7 FMS Cost Assumptions

FMS Type	Cost Estimate Range	Scope and Assumptions
Public Awareness and Educational Programs	$50,000-$100,000	Region-Wide Public Education on Flooding: Assume $100,000 based on other similar educational programs. Community Public Education on Flooding: Assume $50,000 based on smaller scope.
Flood Warning Systems	$50,000-$375,000	Early Alert System/Gauge Notification: Costs identified in HMAPs or estimated
Property Acquisition and/or Flood Proofing Programs	$25,000	Tax incentives to encourage development of low-hazard land parcels.
Regulatory and Guidance	$100,000	Assume $100,000 to cover engineering consultant fees and support communities in their implementation process.
Preventive Maintenance Programs	$250,000 to $300,000	Varied maintenance aimed at mitigating flood velocity damage and provision of needed storage volume for flood events.
NFIP/CRS	$50,000	Join National Flood Insurance Program (NFIP): Assume $50,000 to cover engineering consultant fees and adopt standards. Participate in Community Rating System (CRS): Assume $50,000 to cover engineering consultant fees and implement projects to increase rating.

5.2.4.9 Benefit-Cost Ratio for FMPs

Benefit-cost analysis (BCA) is the method by which the future benefits of a hazard mitigation project are determined and compared to its costs. The end result is a BCR, which is calculated by dividing the project's total benefits, quantified as a dollar amount, by its total costs. The BCR is a numerical expression of the relative "cost-effectiveness" of a project. A project is generally considered to be cost effective when the BCR is 1.0

or greater, indicating the benefits of a prospective hazard mitigation project are sufficient to justify the costs (FEMA 2009). However, a BCR equal or greater than 1.0 is not a requirement for inclusion in the regional flood plan. The UCRFPG can decide to recommend a project with a lower BCR with appropriate justification.

When a BCR had been previously calculated in an engineering report or study that was used to create an FMP, the previously calculated BCR value was utilized for the FMP analysis. For any FMP that did not already have a calculated BCR value, the TWDB BCA Input Spreadsheet was used in conjunction with the FEMA BCA Toolkit 6.0 to generate BCR values.

5.2.4.10 Residual, Post-Project, and Future-Risks of FMPs

It is expected that the implementation of recommended FMPs will reduce current and future levels of flood risk in the region. However, it is not possible to protect against all potential flood risks and there is potential for future increases in flood risk due to lack of maintenance or even a catastrophic failure. In general, residual and future risks for FMPs could be characterized as follows:

1. Flood events may exceed the level of service for which infrastructure is designed.
2. Potential failure or overtopping of dams and levees.
3. Communities depend on future funding and program priorities to maintain, repair, and replace flood protection assets. Routine maintenance of infrastructure is required to maintain its design capacity. Maintenance is sometimes overlooked due to budget, staff, and time constraints.
4. In our representative government, policy changes that adversely impact budgets, prior plans, assets, and standards is always a possibility.
5. Human behavior is unpredictable, people may choose to ignore flood warning systems or cross over flooded roadways for a variety of reasons.

The engineering studies that provide the supporting data for the potential Upper Colorado Region FMPs were reviewed to identify the residual, post-project and future risks associated with each FMP.

5.2.4.11 Implementation Issues of FMPs

Implementation issues that could be identified include conflicts pertaining to rights-of-way, permitting, acquisitions, utility or transportation relocations, amongst other issues that might be encountered before an FMP is able to be fully implemented.

5.2.5 Potential Funding Sources

A wide variety of funding opportunities could be utilized to fund the identified actions. Traditionally, stormwater and FMP funding sources have either been locally sourced user fees or general taxes, or externally by state and federal grants. While low-interest loan programs do provide for additional funding, few local entities chose this path due to the lack of a dedicated funding source sufficient to cover debt service. Therefore, many communities adopted a “pay-as-you-go” method of funding stormwater projects or in the event of a disaster, applying for state and federal disaster recovery grants. Today, communities have a broader range of funding sources and programs that include the above plus recently created mitigation grant and loan programs such as the Building Resilient Infrastructure and Communities (BRIC) and the TWDB Flood Infrastructure Fund (FIF). The potential funding sources for the identified FME, FMP and FMS are listed in Tables 12, 13 and 14, respectively. Further details on funding opportunities and the anticipated funding sources for the recommended actions are included in Chapter 9.

5.3 Recommended FMEs, FMPs and FMSs

On July 6, 2022, the UCRFPG met and approved the proposed lists of recommended FMEs, FMSs, and FMPs. Of the 367 FMEs, FMSs, and FMPs collected, 275 were recommended.

5.3.1 Flood Management Evaluations

As defined by the TWDB, an FME is a proposed flood study of a specific, flood prone area that is needed to assess flood risk. These flood prone areas require technical studies to better quantify flood risk or to update outdated flood risk information. The UCRFPG has recommended FMEs that they determined are most likely to result in identification of potentially feasible FMSs and FMPs that would, at a minimum, identify and investigate one solution to mitigate for flood events associated with a 1 percent annual chance flood event and that support specific the UCRFPG flood mitigation and/or floodplain management goals. Figure 5-5~~Figure 5-5~~ depicts the recommended flood management evaluations.

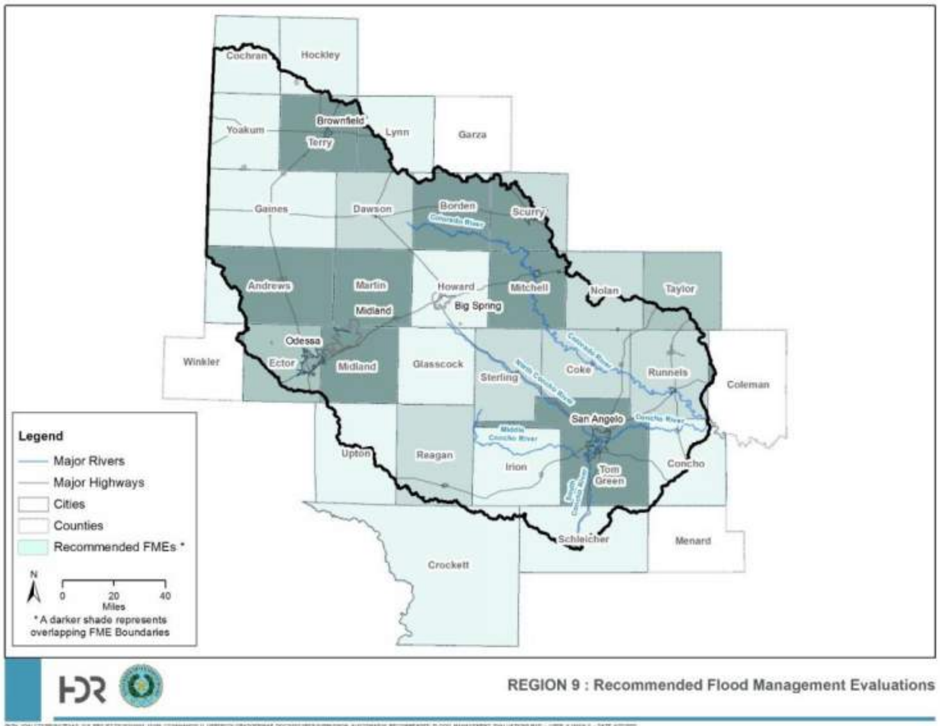

Figure 5-5. Recommended Flood Management Evaluations

5.3.2 Flood Mitigation Projects

As defined by the TWDB, an FMP is a proposed project, structural and non-structural, that has a non-zero capital cost or other non-recurring cost and that when implemented will reduce flood risk, mitigate flood hazards to life or property. The UCRFPG has recommended FMPs that provide measurable reductions in flood impacts in support of the RFPG's specific flood mitigation and/or floodplain management goals.

If a flood mitigation or management effort was initially identified as an FMP but the required supporting modeling and data were not available, then the FMP was reclassified as an FME with the assumption that more evaluation would be necessary to provide the required project data. The identified FMPs provided flood mitigation benefits for the 1 percent annual chance (100-year) flood. They were also determined to have no negative impacts to neighboring areas or to an entity's water supply. None of the recommended FMPs contribute to water supply and will not result in an overallocation of a water source based on the water availability allocations included in the 2022 State

Water Plan. as required by the TWDB. The recommended FMPs are shown in Figure 5-6~~Figure 5-6~~.

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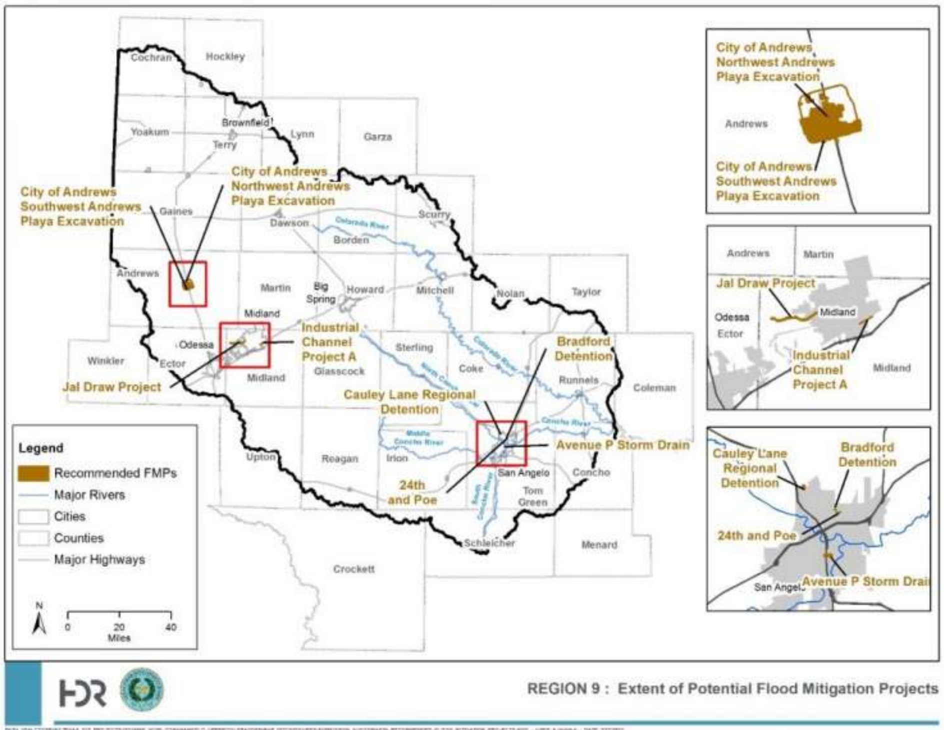

Figure 5-6. Recommended Flood Mitigation Projects

5.3.2.1 Project Details

Texas Water Code Section 16.061 requires the state flood plan to include "A statewide, ranked list of ongoing and proposed flood control and mitigation projects and strategies necessary to protect against the loss of life and property…" The Project Details table included in Appendix A summarizes the scoring of the project details for each of the recommended FMPs. Scores are based on the following points.

1. Severity Level - Pre-Project Average Depth of Flooding (100-year): indication of severity based on the baseline/pre-project average 100-year flood depth.
2. Severity Level - Community Need (% Population): indication of severity based on a community's need by percentage of project community affected by population.
3. 3. Flood Risk Reduction: indication of reduced flood risk by percentage of structures removed from the 100-year floodplain in post-project condition.

4. Flood Damage Reduction: indication of flood risk reduction (property protection) by a percentage of 100-year damage reduction calculation.
5. Critical Facilities Damage Reduction: indication of reduced flood risk by percentage of critical facilities removed from the 100-year floodplain in post-project condition.
6. Life and Safety (Injury/Loss of life): indication of life/injury risk percentage using estimates of area hazard rating, area vulnerability rating, and historical loss of life injury data for project.
7. Water Supply Benefit: indication of a project's direct or indirect water supply benefits to a specific supply need identified in the most recently approved state or regional water plan.
8. Social Vulnerability: based on the Centers for Disease Control and Prevention (CDC) Social Vulnerability Index (SVI) data for Texas, by calculating an average project SVI by census tract and classifying the vulnerability level.
9. Nature-Based Solution: Indication of the percentage of project cost that qualifies as nature based as reported by RFPG.
10. Multiple Benefit: indication of significant, measurable, expected benefits to: recreation, agriculture, transportation, social and quality of life, local economic impacts, meeting sustainability goals, and/or project resilience goals.
11. Operations and Maintenance (O&M): Indication of expected level of O&M needs and annual costs provided.
12. Administrative, Regulatory, and other Implementation Obstacles/Difficulty: indication of project limitations and/or requirements in terms of administrative, regulatory, and other implementation obstacles.
13. Environmental Benefit: Indication of expected level of environmental benefits to be delivered by project to agricultural resources, water quality, cultural heritage, habitat, air quality, natural resources, and soils/erosion and sedimentation.
14. Environmental Impact: indication of expected level of adverse environmental impacts due to project affecting water quality, cultural heritage, habitat, air quality, natural resource protection, agricultural resources, and erosion and sedimentation.
15. Mobility: Indication of project improvement and protection of mobility during flood events, with particular emphasis on emergency service access and major access routes.

5.3.3 Flood Management Strategies

As defined by the TWDB, an FMS is a proposed plan to reduce flood risk or mitigate flood hazards to life or property. The UCRFPG has recommended FMSs that provide measurable reductions in flood impacts in support of the RFPG's specific flood mitigation and/or floodplain management goals.

Similar to the recommended FMPs, the recommended FMSs were determined to have no negative impacts to neighboring areas or to an entity's water supply. None of the recommended FMSs contribute to water supply and will not result in an overallocation of a water source based on the water availability allocations included in the 2022 State Water Plan. as required by the TWDB The recommended FMSs are shown in Figure 5-7~~Figure 5-7~~.

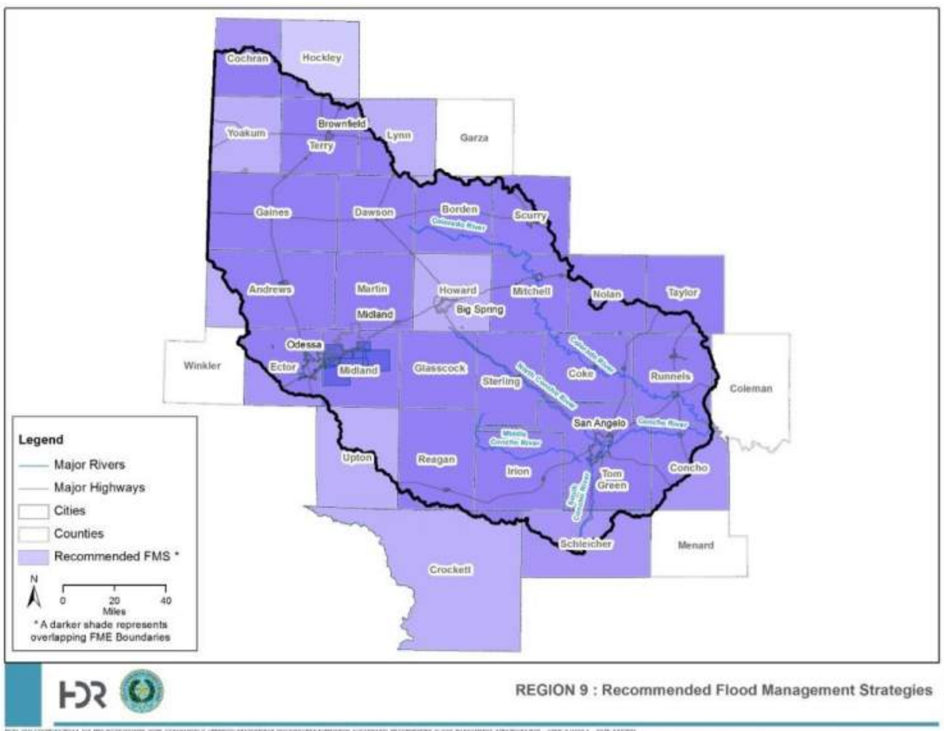

Figure 5-7. Recommended Flood Management Strategies

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Impact and Contribution of the Regional Flood Plan

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6 Impact and Contribution of the Regional Flood Plan

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This chapter summarizes the impacts of implementing the Upper Colorado regional flood plan (UCRFP). In previous chapters, existing conditions were determined based on 1 percent and 0.2 percent annual chance events within the flood planning region. In addition, an inventory of existing infrastructure and natural features was compiled for use as a baseline. Flood mitigation needs were identified leading to recommendations of flood management evaluations and strategies, and flood mitigation projects. This chapter provides an overview of the impacts associated with implementing the UCRFP (Section 6.1), along with any contributions to and impacts on water supply development and the state water plan (Section 6.2).

6.1 Impacts of Regional Flood Plan

Implementing the UCRFP will benefit the Upper Colorado Region by reducing areas impacted from flooding events. The benefits will vary within the region based on the flood management evaluations (FMEs), flood mitigation projects (FMPs), and flood management strategies (FMSs) identified during this flood planning process.

The overall impacts of the UCRFP include potential impacts to areas at risk of flooding that include structures and populations in the floodplain; low-water crossings (LWCs); water supply; and impacts on the environment, agriculture, recreational resources, water quality, erosion, sedimentation, and navigation. This section describes the processes the Upper Colorado Regional Flood Planning Group (UCRFPG) undertook to achieve these tasks and summarizes the outcomes of this effort.

The impact of the UCRFP also includes how future flood risk will be avoided through implementation of recommended improvements to the region's floodplain management policies. Direct and indirect benefits of other FMPs, FMSs, and FMEs not currently recommended are also discussed. These details are provided to highlight the importance of stakeholder involvement and support in maximizing the UCRFP's effectiveness during amendment periods and future planning cycles.

6.1.1 Floodplain Management and Modeling

While compiling data during the baseline development of the UCRFP, the UCRFPG identified many data gaps within the Upper Colorado Region pertaining to areas of high flood risks that lacked floodplain management practices, flood management enforcement, detailed hydrologic and hydraulic models, and inundation mapping. The gap areas covered approximately 99.5 percent of the entire region, impacting an estimated population of 634,000. The lack of information exposes people and structures to unnecessary danger. FMEs were developed to begin reducing that exposure. In general, the FMEs include flood hazard modeling and mapping, flood mitigation alternatives analysis, and feasibility studies. There is a total of 139 FMEs identified in the UCRFP. The FMEs will reduce the gap areas not covered by flood risk maps to zero. The region currently only has 99 square miles of adequate maps, resulting in 0.5 percent of the region knowing their flood risk potential (Table 6-1).

Table 6-1. Reductions in Existing Flood Impacted Areas

Annual Chance Event	Area in Floodplain (Sq. Mi.)	Reduction due to UCRFP (Sq. Mi.)	Change in Area (Sq. Mi.)	Change in Area (%)
1%	4,521	4.5	4,516.5	0.1
0.2%	1,127	-	-	-
Total	5,648	4.5	4,516.5	0.1

UCRFP = Upper Colorado regional flood plan; Sq.Mi. = square miles

6.1.2 Reduction in Flood Impacted Areas

There are currently an estimated 261 structures that have been identified as providing a current flood reduction benefit. Through the flood planning process, 9 FMPs and 6 FMSs have been developed and added to the RFP. Implementing the RFP will provide numerous benefits and will not negatively impact neighboring areas within or outside the FPR. These benefits are described below.

In Chapter 2, existing and future flood hazard areas were identified and quantified for both the 1 percent and 0.2 percent annual chance events. The tables below show the flood-impacted areas in square miles for both existing and future scenarios based on both annual chance flood events and the reduction of impacted areas. Table 6-2 shows the reduction in areas that would be impacted from future flood events by implementing the recommended FMPs in the UCRFP.

Table 6-2. Reductions in Future Flood Impacted Areas

Annual Chance Event	Area in Floodplain (Sq. Mi.)	Reduction due to UCRFP (Sq. Mi.)	Change in Area (Sq. Mi.)	Change in Area (%)
1%	4,617	4.5	4,612.5	0.1
0.2%	1,420	-	-	-
Total	6,037	4.5	4,612.5	0.1

UCRFP = Upper Colorado regional flood plan; Sq.Mi. = square miles

6.1.3 Benefits to Population and Structures at Risk

Implementing the UCRFP will reduce the number of square miles affected by flooding. The ultimate beneficiary is the population living within those areas. Since the area of land being impacted by flooding will be reduced, the subsequent population benefitting from the RFP within the region is estimated to be 195 people.

Four of the recommended FMPs are proposed detention projects. These projects are proposed to increase storage to offset future development in the neighboring areas. These projects are also proposed to capture the increase in storm runoff typically created by residential and commercial development, thereby preventing future or increased flooding to existing neighbor hoods. Future development is planned in the next 2 to 3 years in these areas and the estimated number of structures and population are unknown at this time. The socioeconomic benefits to the population vary based upon location. Descriptions of those benefits are provided in Section 6.1.6.

Table 6-3 shows the estimated population removed from the floodplain. While the number of injuries and deaths prevented by implementing the plan is not quantifiable, the benefits are expected to be significant. The benefits will be generated by mitigation projects to reduce flood risk to structures, roads, and property.

Table 6-3. Population Removed from the Floodplain

Annual Chance Event	Existing Population Impacted	Estimated Population Impacted after Plan Implementation	Decrease in Population Impacted
1%	1,197	195	16

Removing structures from flood danger benefits communities who rely on those structures for residences, work, industry, and critical facilities. Table 6-4 shows the estimated number of structures removed from the floodplain by implementing the UCRFP.

Table 6-4. Structures Removed from the Floodplain

Annual Chance Event	Existing Structures Impacted	Estimated Structures Impacted after Plan Implementation	Decrease in Structures Impacted
1%	392	66	17

Critical facilities identified generally as municipal utilities and buildings, hospitals and care facilities, and schools are of special importance. Table 6-5 shows the estimated number of critical facilities that are currently impacted and those which will be removed from the floodplain with UCRFP implementation.

Table 6-5. Critical Facilities Removed from the Floodplain

Annual Chance Event	Existing Critical Facilities Impacted	Estimated Critical Facilities Impacted after Plan Implementation	Decrease in Critical Facilities Impacted
1%	4	4	100

6.1.4 Education and Outreach Programs

Education and outreach includes informing the public about flood risk and how to recognize changing the way people interact with flood risk (non-structural flood mitigation projects and strategies) through regulatory improvements, educating people about flood risks, and implementing flood early warning and evacuation measures. Education and outreach also includes providing information to people about the ecological and societal benefits of flooding.

6.1.5 Low-Water Crossings and Impacted Roadways

Implementing FMSs and FMPs across the region will have a significant impact on the number of existing LWCs. As projects are implemented over time, the number of LWCs will be reduced, saving life and property. The total number of LWCs being removed due to implementing the UCRFP is shown in Table 6-6.

Table 6-6. Low-Water Crossings Removed

Annual Chance Event	Existing Low Water Crossings	Low Water Crossings Removed after Plan Implementation	Decrease in Low Water Crossings
1%	255	3	-

Flooded roadways also benefit from the UCRFP being implemented. Roadways that are often closed due to flooding pose risks to life, property, and transportation in general. Table 6-7 shows the benefit to transportation infrastructure by reducing the amount of time a roadway is closed or removing it from flooding altogether.

Table 6-7. Reduction in Roadway Closures and Road Removal from Flood Risk

Annual Chance Event	Reduction in Roadway Closures after Plan Implementation	Roadways Removed from Floodplain after Plan Implementation (Mi.)
1%	1	1.5

6.1.6 Socioeconomic Impacts

Socioeconomic impacts were taken into consideration while developing the UCRFP to ensure flood reduction benefits were evenly distributed among all groups and balanced across the region. The Upper Colorado Region has a diverse population with wide-ranging economic levels. Less populated counties and cities tend to have less tax base. Rural areas are shrinking as more people are moving to larger, more populated areas. Smaller communities are experiencing job decreases, which in turn, is leading to decreasing population. Shrinking rural areas and disadvantaged socioeconomic populations have limited access to resources hindering response and recovery from flood events. Many of the governmental entities do not have the staff or experience to seek needed assistance and relief during disaster events. The UCRFPG developed goals and recommended flood and construction standards mitigate or reduce impacts due to flood events..

Many of the recommended FMPs, FMSs, and FMEs city-wide, county-wide or watershed-wide benefit the disproportionally socially vulnerable population by reducing risk and promoting recovery. Watershed planning can contribute to the region's ability to prepare for, respond to, and recover from flood events. Reducing socioeconomic disparities by implementing measures to create equity can be initiated through planning. This is done by ensuring that vulnerable populations have the same access to resources and social infrastructure as those unaffected by flooding.

6.1.7 Recreation Impacts

The northern section of the UCFPR has unique stormwater detention areas known as playa lakes. Playa lakes in urbanized communities are typically used as local parks. Many of these playas serve as the only flood mitigation entities. Many areas in the region do not have running streams. Some areas have draws to convey stormwater toward the south but many of the playa lake watersheds do not contribute to these draws or streams. When a playa fills with stormwater, the lake is dependent on infiltration and evaporation to recover for the next storms. Large storm events typically leave playa lakes full for several weeks to several months, rendering the recreational areas unusable during rainy seasons and storms.

Cities with rivers or streams running through them are designing multiple use recreational facilities near and along the banks. River walks and parks are a developing trend around these rivers and streams. The challenge is that the river's floodplains are extending past the banks and into many of these developed areas for recreation. The benefits of the developments are recreation, tourism, and hiking and biking trails to list a few. During storm events with flooding, these recreational benefits are lost or minimized.

There are 15 major lakes and reservoirs in the Upper Colorado. Although not specifically identified in this regional flood plan, as FMSs and FMPs are implemented, removing structures from floodplains, and existing floodplains removed, new opportunities become available for local sponsors to add natural solutions to enhance opportunities for recreation. These areas are often used in cities throughout the state for hiking and biking trails. The UCRFPG will encourage secondary benefits such as recreational opportunities that will not supply a negative impact to the local area or the region. While the UCRFP suggests opportunities, these will not negatively impact existing recreation activities located throughout the UCFPR.

6.1.8 Environmental Impacts

Senate Bill 3 (SB3) was designed to establish environmental flow standards for all major river basins and bay systems in Texas through a scientific, stakeholder-driven, and consensus-based process. The key questions addressed by the SB3 process as defined by TWDB include the following.

1. What is the quantity of water required by the state's rivers/estuaries to sustain a sound ecological environment?
2. How can this water be protected?
3. What is the appropriate balance between water needed to sustain a sound ecological environment and water needed for human or other uses?

FMS or FMP in the Region should consider potential impacts as it relates to the ecological flows established under the directive of SB3. Four of the proposed FMSs or FMPs involve detention or retention. Therefore, no impact to base or environmental flows would occur.

6.1.9 Agricultural and Energy Impacts

Flood waters have the potential to destroy standing crops, create water-logged conditions that delay planting or harvesting, wash away productive topsoil, and damage farm equipment and infrastructure. Oil and gas pumps, intermediate storage and processing centers, and electrical substations have potential of being flooded or the access paths being cut off by high stormwater events.

FMSs or FMPs potentially reduce extremely high flows over land in flat regions or in rivers and streams, thereby preventing flood waters from inundating areas outside of the floodway, including agricultural and energy areas. Structural FMSs or FMPs like small flood control ponds, natural channels, or restored playa lake functionality also have the potential to assist in agricultural production, restoring access to energy facilities by serving dual purpose of flood mitigation and water supply. Non- structural FMSs or FMPs have similar impacts on flood peak flow reduction and flooding, including agricultural conservation practices such as such as conservation tillage, residue management, cover crops and furrow dikes. These practices not only reduce downstream flooding by reducing surface runoff and increasing infiltration on agricultural lands but also sediment and nutrient losses, thereby improving downstream water quality.

The regulatory and guidance FMSs and watershed planning FMEs have the potential to benefit agricultural operations by improving their understanding of flood risks, making insurance available for structures, and preventing construction of regulated structures within the floodplain.

6.1.10 Water Quality, Erosion, and Sedimentation Impacts

Water quality, erosion, and sedimentation are complex and interrelated issues. Water quality usually relates to nutrient and bacterial loading but also includes turbidity, which relates to sediment load. Most water quality issues are influenced by upland portions of the watershed, while sedimentation and erosion are more impacted by hydraulic dynamics.

In this region, playa sedimentation is a concern, especially in urbanized areas. Playas are a volume-dependent drainage system and sedimentation over time gradually reduces the natural flood protection. However, limited studies have been focused on the impacts of playa sedimentation. Through the Texas Playa Conservation Initiative, the Texas Parks and Wildlife Department (TPWD) has an existing program focused on increasing the understanding of playa behavior and the restoration of these features to aid in groundwater infiltration and recharge and water quality protection. In water bodies such as the City of Lubbock’s Canyon Lakes, stakeholders have identified an FMS to dredge this sedimentation and restore flood storage.

6.1.11 Navigation Impacts

None of the major rivers within the UCFPR are used for commercial navigation.

6.2 Contributions to and Impacts on Water Supply Development and the State Water Plan

Regional flood plans must include a regionwide summary of the contribution that the regional flood plan would have to water supply. As part of this analysis, each FMS and FMP will be reviewed to determine whether impacts to water supply/availability exist. Impacts include contributions as well as reductions in water supply and availability. These impacts as determined would be placed in one of the following categories:

1. Involves directly impacting water supply volume available during drought of record which requires both availability and directly connecting supply to specific water user group(s)
2. Directly benefits water availability
3. Indirectly benefits water availability
4. Or has no anticipated impact on water supply

A coordinated effort with representatives from multiple regional water planning groups occurred to identify water management strategies that could be impacted. Those regional water planning groups include Region F, Region G (Brazos), and Region O (Llano Estacado) (Figure 6-1). The UCRFPG has not identified any negative impacts to the state water plan (SWP) nor has it developed a study or project to enhance the SWP.

There are no anticipated impacts from the recommended FMSs and FMPs on water supply, water availability, or projects in the State Water Plan[12] based on no anticipated measurable impact. Additionally, the recommended FMSs and FMPs have no anticipated impacts on existing water rights laws, including but not limited to, Texas statutes and rules, federal statutes and rules, interstate compacts, and international treaties. Furthermore, the recommended FMSs and FMPs have no anticipated impacts leading to long-term impairment to the designated water quality as shown in the State Water Quality Management Plan[13]. Overall, the recommendations are based on minimizing adverse environmental impacts and are in accordance with adopted environmental flow standards.

[12] TWDB 2022. 2022 State Water Plan, Water for Texas, Texas Water Development Board. Austin, TX. 2022 State Water Plan | Texas Water Development Board

[13] TCEQ 2022. 2022 Texas Water Quality Management Plan. Water Quality Division, Office of Water, Texas Commission on Environmental Quality. Austin, TX. Water Quality Management Plan: Updates - Texas Commission on Environmental Quality - www.tceq.texas.gov

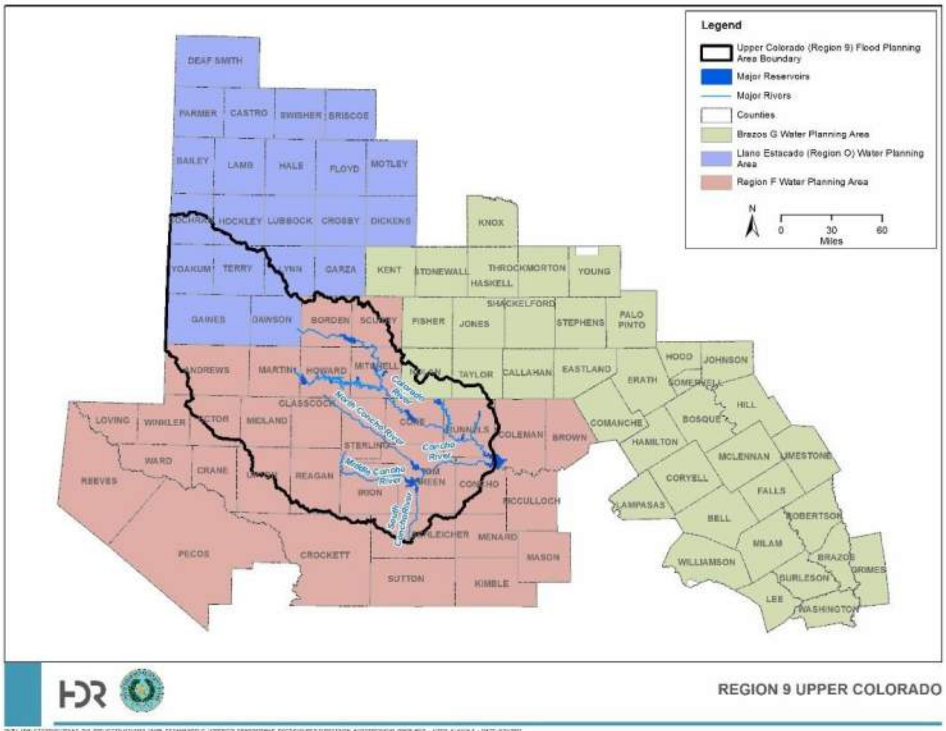

Figure 6-1. Upper Colorado Flood Planning Region in Relation to Regional Water Planning Areas

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7

Flood Response Information and Activities

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7 Flood Response Information and Activities

[31 TAC §361.42]

7.1 Flood Response and Recovery Activities in the Region

This chapter summarizes the flood response preparations using demographic, historical, projected, and statistical data from the previous chapters and further research. The Texas Water Development Board (TWDB) specifically stated that the regional flood planning group (RFPG) "shall not perform analyses or other activities related to planning for disaster response or recovery activities." The focus of this chapter is summarizing the information obtained and providing general recommendations regarding flood response activities.

7.1.1 Types of Flooding in the Upper Colorado Region

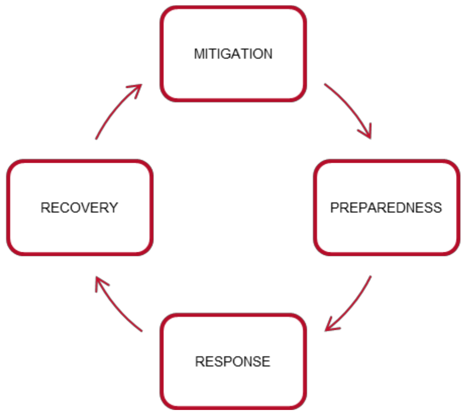
Across the state, there are five different types of floods: flash floods, coastal floods, urban floods, river floods, and pluvial floods. The most common types of flooding in the Upper Colorado Region are river and pluvial floods. River flooding tends to be more widespread, encompassing huge swaths of land while pluvial floods tend to be more dangerous, impacting mobility and emergency access. Stormwater in the Upper Colorado Region is typically conveyed through streets and the natural drainage features that make the region susceptible to flash flooding. The Upper Colorado Region is prone to different types of flooding depending on the part of the region.

- Flash floods are floods caused by heavy rainfall over a period. The flood water can occur quickly and be very powerful making it extremely dangerous.
- Pluvial floods happen when there is flooding independent from an overflowing body of water due to extreme rain fall. The most common example of this is when the drainage system is overwhelmed and the excess water floods into the streets.
- Riverine floods occur when excess rain fall moves downstream causing an overtopping of the riverbank. This overtopping then spills the water onto the nearby land.
- Urban flooding is caused by excess runoff water in developed areas where the water does not have anywhere else to go.

When such flood events occur, it is imperative that plans are in place to combat the effects of the flooding.

7.1.2 The Nature and Types of Flood Response Preparations

There are four phases to emergency management:



- **Flood Mitigation:** The implementation of actions, including structural and non-structural solutions, to reduce flood risk to protect against the loss of life and property.
- **Flood Preparedness:** Actions, aside from mitigation, that are taken before flood events to prepare for flood response activities.
- **Flood Response:** Actions taken during and in the immediate aftermath of a flood event.
- **Flood Recovery:** Actions taken after a flood event involving repairs or other actions necessary to return to pre-event conditions.

For example, when a severe rain event is projected to occur, steps are taken for preparedness: disaster preparedness plans are in place, drills and exercises are performed, an essential supply list is created, and potential vulnerabilities are assessed. During the response phase, disaster plans are implemented, search and rescues may occur, low water crossing signs may be erected. In the recovery phase, evaluation of flood damage, rebuilding damaged structures, and removing debris occurs.

Mitigation is an important step of the four phases of emergency management. Hazard mitigation is defined as any sustained action taken to reduce or eliminate the lasting risk to life and property from hazard events. It is an on-going process that seeks to break the cycle of damage and restoration in hazardous areas.

Flood mitigation is the primary focus of the regional flood planning process through the RFPG identifying and recommending flood management evaluations (FMEs), flood management strategies (FMSs), and flood management projects (FMPs). The plan may also include flood preparedness FMEs, FMSs, and FMPs.

Examples of mitigation actions include planning and zoning, floodplain protection, property acquisition and relocation, or public outreach projects. Examples of preparedness actions include installing disaster warning systems, purchasing radio communications equipment, or conducting emergency response training.

7.1.2.1 Actions and Preparations:

The Upper Colorado Regional Flood Planning Group (UCRFPG) collected a total of six hazard mitigation plans from the Upper Colorado Region, reviewed them, and identified the following mitigation actions by communities in the Upper Colorado Region:

- Buyout/Acquisition/Elevation projects
- Drainage Control & Maintenance
- Education & Awareness for Citizens
- Equipment Procurement for Response
- Flood Insurance Education
- Flood Study/Assessment
- Infrastructure Improvement
- Installation/Procurement of Generators
- Natural Planning Improvement
- Outreach and Community Engagement

7.1.3 Relevant Entities in the Region

The purpose of flood risk management is to help prevent or reduce flood risk by using either structural or non-structural means or a combination of the two. Responsibility for flood risk management is shared between federal, state, and local government agencies; private-sector stakeholders; and the general public. There are 97 political subdivisions in the Upper Colorado Region with flood-related authority. Following are all of the political subdivisions with flood-related authority.

7.1.3.1 Counties

- Andrews
- Borden
- Cochran
- Coke
- Coleman
- Concho
- Crockett
- Dawson
- Ector
- Gaines
- Garza
- Glasscock
- Hockley
- Howard
- Irion
- Lynn
- Martin
- Menard
- Midland
- Mitchell
- Nolan
- Reagan
- Runnels
- Schleicher
- Scurry
- Sterling
- Taylor
- Terry
- Tom Green
- Upton
- Winkler
- Yoakum

7.1.3.2 Municipalities

- Ackerly
- Andrews
- Ballinger
- Big Lake
- Big Spring
- Blackwell
- Bronte
- Brownfield
- Coahoma
- Colorado City
- Denver City
- Eldorado
- Forsan
- Goldsmith
- Lamesa
- Loraine
- Los Ybanez
- Meadow
- Mertzon
- Midland
- Miles
- O'Donnell
- Odessa
- Paint Rock
- Plains
- Robert Lee
- San Angelo
- Seagraves
- Seminole
- Snyder
- Stanton
- Sterling City
- Sundown
- Wellman
- Westbrook
- Winters

7.1.3.3 Other (Water Authorities, Districts, Commissions, Councils of Governments)

- Brazos River Authority
- Canadian River Municipal Water Authority
- Central Colorado River Authority
- Coke County Kickapoo Water Control and Improvement District (WCID) 1
- Colorado River Municipal Water District (MWD)
- Concho Valley Council of Governments (COGs)
- Downtown Midland Management District
- Ector County Utility District
- Gaines County Solid Waste Management District (SWMD)
- Howard County WCID 1
- Lower Colorado River Authority
- Martin County Fresh Water Supply District (FWSD) 1
- Midland County FWSD 1
- Midland County Utility District Nolan County FWSD 1
- Permian Basin Regional Planning Commission
- Reagan County Water Supply District (WSD)
- Red Creek Municipal Utility District (MUD)
- Salt Fork Water Quality District
- South Plains Association of Governments
- Tom Green County FWSD 1
- Tom Green County FWSD 2
- Tom Green County FWSD 3
- Tom Green County WCID 1
- Upper Colorado River Authority
- Upton County Water District
- Valley Creek Water Control District
- West Central Texas COGs
- Willow Creek Water Control District

Various stakeholders can play in a role in flood response. Agriculture, cities, counties, councils of government (COGs), districts (e.g., municipal utility districts [MUDs], fresh water supply districts [FWSDs]), and state and federal agencies are all entities that can impact and be involved in flood preparations. Following are the various contributing entities and partners with a description of their role related to flooding. These include entities listed above, as well as other types of entities not previously mentioned.

Agricultural extension agents are employed by land-grant universities and serve the citizens of that particular state by serving as an expert or teacher on the topic of agriculture. Agricultural extension agents can provide valuable information about preparing for and recovering from flood events specific to agricultural entities. The Upper Colorado Region has a significant agricultural footprint, making working closely with agricultural extension agents crucial to preventing losses.

Cities, or municipalities, generally take responsibility for parks and recreation services, police and fire departments, housing services, emergency medical services, municipal courts, transportation services (including public transportation), and public works (streets, sewers, snow removal, signage, and so forth). There are 36 municipalities within the Upper Colorado Region.

The major responsibilities of the 32 Upper Colorado Region county governments include providing public safety and justice, holding elections at every level of government, maintaining Texans' most important records; building and maintaining roads, bridges, and in some cases, county airports; providing emergency management services; providing health and safety services; collecting property taxes for the county and sometimes for other taxing entities; issuing vehicle registration and transfers; and registering voters.

The two Upper Colorado COGs are voluntary associations that represent member local governments, mainly cities and counties, that seek to provide cooperative planning, coordination, and technical assistance on issues of mutual concern that cross-jurisdictional lines. COGs can serve a resource for flood data, flood planning, and flood management.

The mission of the TWDB is to lead the state's efforts in ensuring a secure water future for Texas and its citizens. The TWDB provides water planning, data collection and dissemination, financial assistance, and technical assistance services to the citizens of Texas.

The Federal Emergency Management Agency (FEMA) is an agency of the U.S. Department of Homeland Security (DHS). While on-the-ground support of disaster recovery efforts is a major part of FEMA's charter, the agency provides state and local governments with experts in specialized fields and funding for rebuilding efforts and relief funds for infrastructure by directing individuals to access low-interest loans, in conjunction with the Small Business Administration. In addition to this, FEMA provides funds for training of response personnel throughout the United States and its territories as part of the agency's preparedness effort.

A flood control district is a special purpose district created by the Texas Legislature and governed by County Commissioners Courts. It is a government agency established to reduce the effects of flooding. There are currently no flood control districts in the Upper Colorado Region.

Dams and levees are owned and operated by individuals, private and public organizations, and the government. The responsibility for maintaining a safe dam rests with the owner. A dam failure resulting in an uncontrolled release of the reservoir can have a devastating effect on persons and property downstream. It is critical that the owners are part of the flood planning process to ensure collaborative and cohesive flood planning.

The National Weather Service (NWS) mission is to provide weather, water and climate data, forecasts, warnings, and impact-based decision support services for the protection of life and property and enhancement of the national economy. NWS provides flash flood indicators through watches, warnings, and emergency notices.

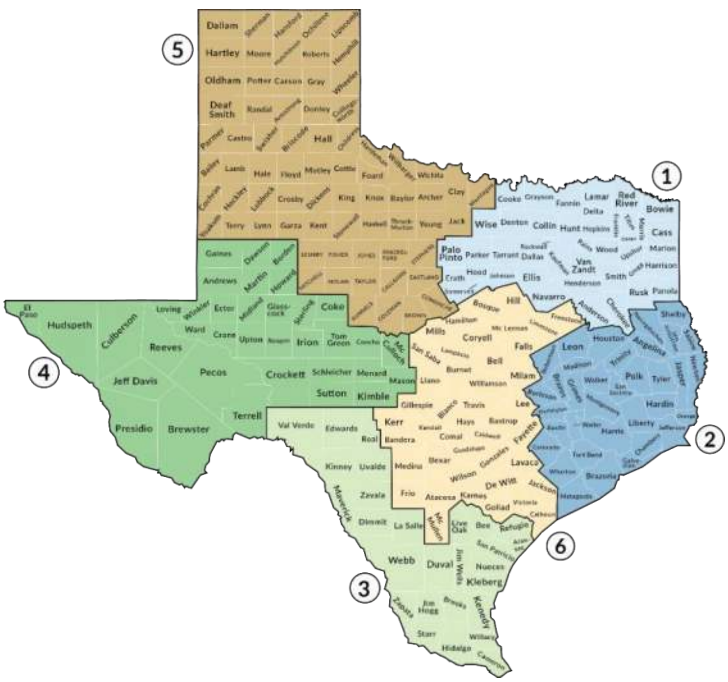
- Flash Flood WATCH is issued when conditions look favorable for flash flooding. A watch usually encompasses several counties. This is the time the public should start thinking about their plan of action and where they would go if water begins to rise.
- Flash Flood WARNING is issued when dangerous flash flooding is happening or will happen soon. A warning is usually a smaller, more specific area. This can be issued due to excessive heavy rain or a dam/levee failure. This is when the public must act quickly as flash floods are an imminent threat to them and their family. They may only have seconds to move to higher ground.
- Flash Flood EMERGENCY is issued for the exceedingly rare situations when extremely heavy rain is leading to a severe threat to human life and catastrophic damage from a flash flood is happening or will happen soon. Typically, emergency officials are reporting life threatening water rises resulting in water rescues/evacuations.

The National Oceanic and Atmospheric Administration (NOAA) is a scientific and regulatory agency within the U.S. Department of Commerce that forecasts weather, monitors oceanic and atmospheric conditions, charts the seas, conducts deep sea exploration, and manages fishing and protection of marine mammals and endangered species in the U.S. exclusive economic zone. NOAA provides historical data that can help communities determine their future probability of flood events and is key in the planning and mitigation process.

River authorities or districts in Texas are public agencies established by the state legislature and given authority to develop and manage the waters of the state. Upper Colorado has six river authorities within its region that each have the power to conserve, store, control, preserve, use, and distribute the waters of a designated geographic region for the benefit of the public.

Daily river forecasts are issued by River Forecast Centers (RFCs) using hydrologic models based on rainfall, soil characteristics, precipitation forecasts, and several other variables. Some RFCs, especially those in mountainous regions, also provide seasonal snowpack and peak flow forecasts. A wide variety of users rely on these forecasts, including those in agriculture, hydroelectric dam operation, and water supply resources. The forecasts can provide essential information on the river levels and conditions.

The Texas Division of Emergency Management (TDEM), a division of the Texas Department of Public Safety (DPS), is charged with coordinating state and local responses to natural disasters and other emergencies in Texas. TDEM is intended to ensure the state and its local governments respond to and recover from emergencies and disasters and implement plans and programs to help prevent or lessen the impact of emergencies and disasters. There are six TDEM regions within Texas, and in those regions, there are assistant chiefs and district coordinators, who serve as TDEM's field response personnel stationed throughout the state (Figure 7-1~~Figure 7-1~~). They have a dual role as they carry out emergency preparedness activities and coordinate emergency response operations. In their preparedness role, they assist local officials in carrying out emergency planning, training, and exercises, and developing emergency teams and facilities. They also teach a wide variety of emergency management training courses. In their response role, they deploy to incident sites to assess damages, identify urgent needs, advise local officials regarding state assistance, and coordinate deployment of state emergency resources to assist local emergency responders. The Upper Colorado Region is mostly in TDEM region 4 with some counties extending in to TDEM region 5.



Source: Texas Department of Emergency Management

Figure 7-1. Texas Division of Emergency Management Regions

The Texas Department of Transportation (TxDOT) is a government agency. Though the public face of the agency is generally associated with the construction and maintenance of the state's immense state highway system, the agency is also responsible for overseeing aviation, rail, and public transportationhttps://en.wikipedia.org/wiki/Texas_Department_of_Transportation - cite_note-3 systems in the state. TxDOT can provide real-time road closure and low-water crossing information during and after a flood event. Users can access this data through TxDOT's Drive Texas website: https://drivetexas.org.

The U.S. Corps of Engineers (USACE) is responsible for a wide range of efforts in the United States, including addressing safety issues related to waterways, dams, and canals but also environmental protection, emergency relief, hydroelectric power, and much more. USACE composed of several districts in which Upper Colorado Region is in both the Southwestern Division (as a part of the Fort Worth District) and the South Pacific Division (as a part of the Albuquerque District). The USACE Flood Risk Management Program (FRMP) works across the agency to focus the policies, programs and expertise of USACE toward reducing overall flood risk. This includes the appropriate use and resiliency of structures such as levees and floodwalls, as well as promoting alternatives when other approaches (e.g., land acquisition, flood proofing, etc.) reduce the risk of loss of life, reduce long-term economic damages to the public and private sector, and improve the natural environment.

7.1.4 Emergency Information

There are various means by which data can be collected and disseminated in a flood event. These include gauges to measure the current flood risk and communication systems to alert the public.

Two types of gauges used are rain gauges and stream gauges. A rain gauge is a meteorological instrument to measure the precipitating rain in a given amount of time per unit area. It collects water falling on it and records the change over time in the rainfall depth. Stream gauging is a technique used to measure the discharge, or the volume of water moving through a channel per unit time, of a stream. The height of water in the stream channel, known as a stage or gauge height, can be used to determine the discharge in a stream. Within the Upper Colorado Region, there are 51 U.S. Geological Survey (USGS) stream gages.

In addition to the NWS, local news stations or radio stations are vital components in relaying real time information to local residents of inclement weather and flooding. They can also alert residents to low-water crossing closings, dam or levee breaches, and other potential dangers. They can also issue flood watches, warnings, and emergency notifications.

An Emergency Alert System (EAS) is software that provides alert messages during an emergency Messages can interrupt radio and television to broadcast emergency alert information. Messages cover a large geographic footprint. Emergency message audio/text may be repeated twice, but EAS activation interrupts programming only once, then regular programming continues.

A reverse 911 system allows an agency to pull up a map on a computer, define an area and send off a recorded phone message to each business or residence in that area. It can provide data to residents of flood dangers in their area.

School emergency alert systems are a tools that allows schools to communicate quickly to staff, students, first responders, and others so that they can take appropriate action in the event of an emergency situation. Various versions this tool are used in schools through the region from daycares to K-12 grade, as well as universities.

7.1.5 Plans to be Considered

7.1.5.1 State and Regional Plans

The state hazard mitigation plan is an effective instrument to reduce losses by reducing the impact of disasters upon people and property. Although mitigation efforts cannot completely eliminate impacts of disastrous events, the plan endeavors to reduce the impacts of hazardous events to the greatest extent possible. The plan evaluates, profiles and ranks natural and human-caused hazards affecting Texas as determined by frequency of event, economic impact, deaths, and injuries. The plan

- assesses hazard risk,
- reviews current state and local hazard mitigation and climate adaption capabilities, and
- develops strategies and identifies state agency (and other entities) potential actions to address needs.

The Regional Emergency Preparedness Program is one of the largest and most effective programs of its kind nationwide. Bringing together urban, suburban, and rural jurisdictions, the program facilitates information sharing, collaboration, and cooperation between jurisdictions in a politically neutral and supportive environment. The Regional Preparedness Program accomplishes this through networking, standardizing policy and procedures, and coordinating efforts with stakeholders. Increased participation in the Regional Emergency Preparedness Program is beneficial for the safety of the region.

7.1.5.2 Local Plans

To examine the state of its flood preparedness, the UCRFPG obtained emergency management plans, hazard mitigation plans, and other regional and local flood planning studies from county and local jurisdictions.

An emergency management plan is a course of action developed to mitigate the damage of potential events that could endanger an organization's ability to function. Such a plan should include measures that provide for the safety of personnel and, if possible, property and facilities.

The Upper Colorado Region has several plans and regulations in place region wide that provide the framework that dictates a community's capabilities in implementing mitigation and preparedness actions. Figure 7-2 illustrates the floodplain management practices in place currently.

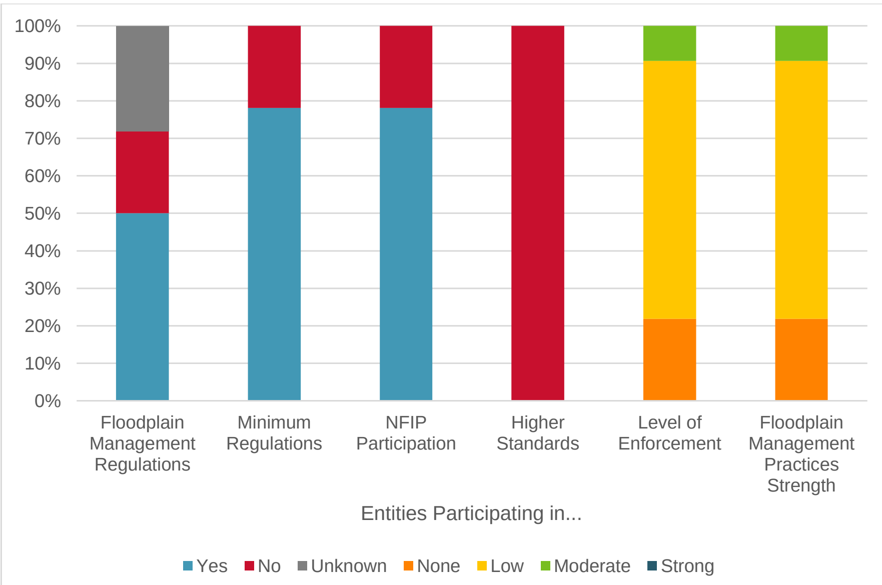


Figure 7-2. Upper Colorado Region Floodplain Management Practices

Hazard mitigation planning reduces loss of life and property by minimizing the impact of disasters. It begins with state, tribal, and local governments identifying natural disaster risks and vulnerabilities that are common in their area. After identifying these risks, they develop long-term strategies for protecting people and property from similar events. Mitigation plans are key to breaking the cycle of disaster damage and reconstruction. Having an up-to-date hazard mitigation action plan (HMAP) is key in assessing risk and in developing mitigation actions. Table 7-1~~Table 7-1~~shows which entities in the Upper Colorado Flood Planning Region (UCFPR) have hazard mitigation plans.

Table 7-1 Upper Colorado Hazard Mitigation Plans

Jurisdiction	HMAP Year
West Central Texas Council of Governments	2020
Cochran County	2014
Concho Valley Council of Governments	2012
Ector County	2011
Lamb and Lynn Counties	2020
Terry County	In Progress

The purpose of an EAP is to facilitate and organize employer and employee actions during workplace emergencies. They are an essential element in emergency management for critical facilities. In the private sector, an EAP is a document required by particular Occupational Safety and Health Administration (OSHA) standards.

As part of the Dam Safety Program, owners of significant and high hazard dams are required to submit an EAP to the Texas Commission on Environmental Quality (TCEQ). Dam EAPs document responsibilities during flood response and identifies the flood inundation area. Table 7-2~~Table 7-2~~ summarizes the state-regulated dams in the UCFPR. A high hazard classification indicates that if the dam were to fail, there would be large consequences (such as loss of life), not that the dam is in a condition that is more likely to fail.

Table 7-2 Upper Colorado State Regulated Dams in 2021

Hazard Potential	No of State Regulated Dams
High Hazard Potential: 21	21
Significant Hazard Potential: 20	20
Low Hazard Potential: 98	98

Watershed master plans promote that all sectors of the community work together to create a flood hazard resilient community. A watershed master plan addresses existing flooding, erosion, and water quality problems. It can be useful in preparing for future challenges. Watershed master plans inform recommendations, help educate the public and influence decision makers regarding land use changes, investment in capital projects, and modifications to development regulations within the basin.

The UCFPR's ability to prepare, respond, recover, and mitigate disaster events is determined by several factors. With a clear understanding of the plans that determine a community's capabilities, a recognition of the entities with whom coordination is key, and knowledge of the actions sustained to promote resiliency, the region can be better equipped to implement sound measures for flood mitigation and preparedness.

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8

Administrative, Regulatory, and Legislative Recommendations

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8 Administrative, Regulatory and Legislative Recommendations

[31 TAC §361.43]

As set forth in the Texas Water Development Board (TWDB) rules and guidelines for regional flood planning, the regional flood planning groups (RFPGs) may adopt recommendations on policy issues related to floodplain management and flood mitigation planning and implementation. Specifically, the RFPGs may adopt:

1. Legislative recommendations considered necessary to facilitate floodplain management and flood mitigation planning and implementation.
2. Other regulatory or administrative recommendations considered necessary to facilitate floodplain management and flood mitigation planning and implementation.
3. Any other recommendations that the RFPG believes are needed and desirable to achieve its regional flood mitigation and floodplain management goals.
4. Recommendations regarding potential, new revenue-raising opportunities, including potential new municipal drainage utilities or regional flood authorities, that could fund the development, operation, and maintenance of floodplain management or flood mitigation activities in the region.

Legislative, regulatory, and administrative recommendations adopted by the Upper Colorado Regional Flood Planning Group (UCRFPG) follow.

RURAL AND AGRICULTURAL FLOOD PLANNING

The Upper Colorado Regional Flood Planning Group (UCRFPG) supports the appropriation of a certain percentage of the Flood Infrastructure Fund (FIF) financial assistance for rural areas of Texas.

The UCRFPG supports increasing state public education programs regarding flooding issues, including suitable land development practices in previously undeveloped areas.

The UCRFPG supports the implementation of flood mitigation projects (FMPs), flood management strategies (FMSs), and flood management evaluations (FMEs), including loans for completion of needed mapping efforts to better characterize unmapped basins.

8.1 Importance of Agriculture and Stewardship

The UCRFPG recognizes the importance of agriculture in the region. Agricultural lands represent the major land use in the region and maintain the greatest area for natural attenuation of stormwater as well. In addition, the UCRFPG supports agricultural land management and production techniques and technologies that maintain soil structure and enhance soil water holding capacity.

Ruminant grazing is of importance in the Upper Colorado Flood Planning Region (UCFPR) as it produces improved nutrient cycling and plant health, uses the beneficial climate for livestock, and can help achieve a long-term economic benefit of land use diversification, providing transition from large-scale, monoculture crop acres to increasingly regenerative land use models.

The UCRFPG supports funding for flood-related education and research as it pertains to developing a continually evolving set of best management practices (BMPs) in each segment of the agricultural industry, and financial incentives to help producers sustainably manage their lands.

8.2 Funding for Project Implementation in the Rural and Agricultural Sectors

The UCRFPG supports the funding that the Texas Legislature has provided for project implementation, particularly the Flood Infrastructure Fund (FIF) created by the 86th Texas Legislature with the passage of Senate Bill 7 (SB7). Similar to the TWDB's State Water Implementation Fund for Texas (SWIFT) loan program for water infrastructure projects, only political subdivisions are eligible to apply for financial assistance. The FIF has progressed funding opportunities for flood control, flood mitigation, and drainage projects. However, the UCRFPG recommends that additional programs be developed that offer direct grants or cost-sharing arrangements in addition to the FIF. The UCRFPG recommends ongoing dedicated funding for regional and state flood plan projects, particularly for those in rural and agricultural sectors.

The UCRFPG supports the implementation of prioritized projects and additional funding that supports completion of the following.

- Appropriation of a certain percentage of funding for rural areas of Texas
- Implementation of flood mitigation projects (FMPs), flood management strategies (FMSs) and flood management evaluations (FMEs), including loans for completion of needed mapping efforts to better characterize previously unmapped basins.
- Increasing state public education programs regarding flooding issues, including appropriate land development practices in previously undeveloped areas.

- Continuation and expansion of funding and support for collecting, processing, and analyzing flood-related data needed to continually update and improve understanding of flood-related engineering, science, and planning.

8.3 Legislative Recommendations

Being a part of the state flood planning effort has allowed the RFPGs, sponsors, and technical consultants to interact with a wide variety of entities. There are trends and occurrences throughout a large portion of the state. Some of these trends and occurrences are positive and should be encouraged while others may be detrimental to the floodplain and stormwater management of the entities within the region, and/or state. Some flood-related policy issues require approaches and solutions that require action by the Texas Legislature, either establishing new or amending authorities or programs through statute, or through new or increased appropriations through the state budget process. Table 8-1 presents recommendations related to flood planning, flood risk mitigation, and funding adopted by the UCRFPG that will require legislative action.

Table 8-1. Legislative Recommendations

ID	Recommendation	Rationale for Recommendation
8.1.1	Direct state funding to counties to maintain drainage and stormwater infrastructure in unincorporated areas.	Counties have floodplain and drainage related responsibilities in the State of Texas without a consistent way to fund projects.
8.1.2	Develop state strategies to aid in acquiring federal funds.	Projects for entities in Texas do not compete well for some federal funding programs. For example, the Federal Emergency Management Agency's (FEMA) Building Resilient Infrastructure and Communities (BRIC) Grant requires statewide building codes.
8.1.3	Provide funding and/or technical assistance to develop regulatory floodplain maps.	Several entities who have outdated maps or no mapping at all are not able to fund the projects necessary to update or create accurate depictions of flood risk.
8.1.4	Provide funding and/or technical assistance to update drainage criteria and development standards.	Up-to-date drainage criteria and development standards at the county level improve resiliency and prevent additional flood risk. However, many entities do not have the funding to update criteria and standards.

ID	Recommendation	Rationale for Recommendation
8.1.5	Provide funding and/or technical assistance to update or perform flood planning and/or master drainage planning studies.	Many communities and entities do not have up-to-date studies or plans that are reflective of growth or updated rainfall data.
8.1.6	Expand eligibility for and use of funding for stormwater and flood mitigation solutions (local, state, federal, public/private partnerships, etc.)	Flood mitigation studies/projects do not generate revenue, which makes them more challenging to fund at the local level. Funding sources could utilize different financial/economic benefit metrics for projects that do not generate revenue.
8.1.7	Provide additional grant funding to enable the continued function of regional flood planning groups (RFPGs) during the interim timeframe between planning cycles.	In the interim of the planning cycles, not only could RFPGs continue adding flood management evaluations (FMEs), flood management strategies (FMSs), and flood mitigation plans (FMPs) to the regional flood plan, but they could also implement RFPG-sponsored flood management activities, outreach, and stay informed on regional flood-related occurrences.
8.1.8	Extend Local Government Code, Title 13, Subtitle A, Chapter 552 to allow counties the opportunity to establish and collect drainage utilities/fees in the unincorporated areas.	Counties have floodplain- and drainage-related responsibilities in the State of Texas. Currently, counties do not have the ability to establish and collect stormwater utility fees, thus limiting their ability to fund stormwater or drainage projects, despite having the responsibility to do so.
8.1.9	Grant counties additional authority to regulate land use in unincorporated flood prone areas.	Regulation of development in flood prone unincorporated areas by counties will aid in prevention of additional flood risk.

ID	Recommendation	Rationale for Recommendation
8.1.10	Establish and fund a state program to assist counties and cities with the assessment and prioritization of low water crossings. Funding should also be provided on a cost-sharing basis for implementation of structural and/or non-structural flood risk reduction measures at high-risk low water crossings (LWC).	Many of the LWCs experience frequent flooding but may have relatively minor flood risk, in terms of public safety and/or the integrity of the roadway. Others, however, are at high-risk and experience flood depths and velocities that do pose a significant risk. The cost to mitigate flood risk at high-risk LWC with structural solutions (e.g., bridges) is typically very high, often prohibitive. It is therefore important the flood risk at LWCs be systematically and fully evaluated to prioritize those LWCs in need of mitigation, either through structural measures or non-structural (e.g., closures, reverse 911 notifications) measures.

8.4 Regulatory and Administrative Recommendations

The UCRFPG has also developed recommendations of a regulatory or administrative nature, concerning existing procedures, state entities, or state/regional regulations. Alterations to these procedures could also be proposed to the TWDB for consideration.

Recommendations in Table 8-2 are suggested changes to existing standards, state-controlled entities, or procedures.

Table 8-2. Regulatory and Administrative Recommendations

ID	Recommendation	Rationale for Recommendation
8.2.1	Simplify all funding application processes and criteria.	Current funding applications require significant time and resources to prepare a project for consideration, as well as complete the application itself, especially for jurisdictions with limited resources. Thus, jurisdictions that may need the funding the most typically do not apply for current opportunities, despite having need.

ID	Recommendation	Rationale for Recommendation
8.2.2	Review and revise as necessary all state infrastructure entities' (i.e., Texas Department of Transportation [TxDOT]) standards and practices for legislative and regulatory compliance with stormwater best practices.	State entities should be aware of the drainage and stormwater standards in the areas where they are active. State entities should be required to comply with local regulations when local regulations are higher than state minimum criteria.
8.2.3	Develop resources for and educate local and regional officials regarding the respective entities' ability/authorization to establish and enforce higher development standards.	Local and regional officials are often unaware of their authority to establish and enforce stormwater regulations (Texas Local Government Code Title 7, Subtitle B; Texas Water Code Chapter 16, Section 16.315). Flooding and drainage components of local and regional officials' training is often inadequate for their level of responsibility.
8.2.4	Provide measures to allow and encourage jurisdictions to work together towards regional flood mitigation solutions.	Flooding does not recognize jurisdictional boundaries. Allowing and encouraging entities to work together towards common flood mitigation goals would be beneficial to all involved. This should also include state agencies.
8.2.5	Develop a publicly available, statewide database and tracking system to document flood-related fatalities and injuries.	In order to more accurately address the health, safety, and welfare of the public, high flood-risk areas should be tracked and reported. Doing so would increase awareness of the area, both so the public could be aware of the risks, and elected officials and decision-makers could institute solutions to reduce the risk in those areas.
8.2.6	Revise the scoring criteria for funding associated with stormwater and flood-related projects that benefit agricultural activities.	The traditional benefit-cost analysis tools prevent agricultural projects from competing with municipal benefit-cost ratios.

ID	Recommendation	Rationale for Recommendation
8.2.7	Provide financial or technical assistance to smaller/rural jurisdictions.	Appropriation of a certain percentage of funding for rural areas of Texas would provide an opportunity for upland areas of Texas for flood protection and mitigation projects.
8.2.8	Address the concern of "takings" with regards to floodplain development regulations, comprehensive plans, land use regulations and zoning ordinances.	Jurisdictions should be allowed to regulate development in a responsible manner that reduces future flood risk exposure without the fear of legal action by property owners. Develop documentation that states the land owner has been made aware of current flood risk on a property and verify documented first floor elevations.

8.5 Flood Planning Recommendations

As the region has learned from the first planning cycle, there are several issues that can be implemented to make the planning process more streamlined and effective for each individual region. Recommendations in Table 8-3 should be considered to improve the regional flood planning process in future planning cycles.

Table 8-3. Flood Planning Recommendations

ID	Recommendation	Rationale for Recommendation
8.3.1	Update the scope of work, guidance documents, rules, checklists, etc. based on the adjustments and lessons learned made to these planning documents during the first cycle of planning.	During the first cycle of the state flood plan (SFP), multiple amendments and additions to the Texas Water Development Board (TWDB) documents and the TWDB's interpretation of its documents occurred. Moving forward, the TWDB documents provided at the onset of each new planning cycle should reflect what is ultimately required of the regional flood planning groups (RFPGs).
8.3.2	Develop a fact sheet and/or other publicity measures to encourage entities to participate in the regional flood planning effort.	Many entities were unaware of the regional and state flood planning efforts despite the RFPG outreach efforts.

ID	Recommendation	Rationale for Recommendation
8.3.3	Host "lessons learned" discussions with RFPG members, sponsors and technical consultants following the submittal of the final regional plans.	Opening dialogue among these participants to discuss proposed improvements to the regional planning process will streamline and improve future regional flood planning cycles.
8.3.4	Develop an amendment process to efficiently amend approved regional flood plans to incorporate additional recommended flood management evaluations (FMEs), flood management strategies (FMSs), and flood mitigation plans (FMPs), and to allow the RFPG to advance the recommended FMEs to FMPs.	Amending the regional flood plan can be an extensive process. Amendments to move FMEs to FMPs and incorporate new flood management solutions should have a quicker turn-around time to efficiently include them in the regional flood plan.
8.3.5	Reduce the amount of information required to escalate potentially feasible FMEs to FMPs. Align required information to be similar to what is required for design/construction funding.	Some of the data currently requested for FMPs is more detailed than traditional planning level data. Therefore, certain FMPs had to be submitted as FMEs or FMSs despite having sufficient data to produce a project. The RFPs should focus on meeting the minimum requirement to produce funding, rather than spending time and money elements of a project design.
8.3.6	Revise the criteria for the "No Adverse Impact" Certification required for FMPs.	The current criteria gives thresholds for increases in flow, water surface elevation, and inundation extents. Though useful, the current criteria does not allow for consideration of projects that exceed these thresholds but account for the impact through design or downstream accommodations.

ID	Recommendation	Rationale for Recommendation
8.3.7	Streamline the data collection requirements, specifically those identified in Task 1. Focus on collecting the data that was most useful to the regional flood plan development.	This first round of planning proved that very few entities have the data requested as part of the flood planning process readily available in a geographic information system (GIS) format. Of those entities who did have GIS data, most were unable to share that information. As a result, some of this data was not used or was used minimally to develop potentially feasible and recommended FMEs, FMPs and FMSs.
8.3.8	Provide statewide data and a methodology to determine infrastructure functionality and deficiencies in the next cycle of the flood planning process. Consider the lack of readily available local data when developing the methodology.	Most entities do not have information regarding the functionality and deficiency of their infrastructure. Some fields required by the TWDB-required tables in the regional flood plans are based on data that is not available to entities without extensive field work. A statewide database with this information would be useful to all entities.
8.3.9	Review and revise the geodatabase submittal attributes and elements.	Normalizing the geodatabase with relationships would allow for cross-referencing of data elements and attributes. More domains for attributes need to be developed.
8.3.10	Use the Federal Emergency Management Agency's (FEMA) Social Vulnerability Index (SVI) when available instead of the Centers for Disease Control and Prevention (CDC) SVI in future planning cycles.	FEMA's SVI is reasoned to be more relevant to flood resiliency and risk than the CDC's SVI. SVI should not be the primary component considered when allocating funding.

ID	Recommendation	Rationale for Recommendation
8.3.11	Use consistent hydrologic unit code (HUC) reporting requirements throughout the TWDB-required tables.	The RFPG Guidance requires HUC-8 in some tables, HUC-10 in other tables, HUC-12 in yet other tables. Some tables require multiple HUCs to be provided. The RFPG recommends that the TWDB require HUC-8 in all TWDB-required tables for consistency and to correspond to FEMA's base level watershed planning granularity.
8.3.12	Improve upon flood risk identification and exposure process with regards to building footprints and population at risk by including first-floor elevations of structures.	While the building footprints are helpful, without the first-floor elevations of each structure, it is difficult to determine the actual extent of flood risk per structure. If the structure is sufficiently elevated above the base flood elevation (BFE), for example, the footprint still shows the structure in the floodplain and the corresponding population is considered "at risk" though the structure meets National Flood Insurance Program (NFIP) standards, This likely overestimates of the population at risk.

9

Flood Infrastructure Financing Analysis

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9 Flood Infrastructure Financing Analysis

[31 TAC §361.44]

The Texas Water Development Board (TWDB) requires that each regional flood planning group (RFPG) assess and report on how Sponsors propose to finance recommended flood management evaluations (FME), flood management strategies (FMS), and flood mitigation projects (FMP). A primary aim of this survey effort is to understand the funding needs of local Sponsors and propose what role the state should have in financing the recommended FMEs, FMSs, and FMPs.

Section 9.1 presents an overview of common sources of funding for flood mitigation planning, projects, and other flood management efforts. The methodology and results of the financing survey are presented in Section 9.2.

9.1 Sources of Funding for Flood Management Activities

Communities across the state utilize a variety of funding sources for their flood management efforts, including local, state, and federal sources. This section discusses some of the most common avenues of generating local funding and various state and federal financial assistance programs available to communities. Table 9-1. on the following page summarizes the local, state, and federal sources discussed in this chapter, and characterizes each by the following three key parameters: first, which state and federal agencies are involved, if applicable; second, whether they offer grants, loans, or both; and third, whether they are classified as regularly occurring opportunities or are only available after a disaster.

A combination of increased local capabilities and increased funding amounts and opportunities from the state and federal government will be required to meet the flood risk study and mitigation needs identified through this planning process. State funding will be particularly needed to provide access to funding for small, rural communities, incentivizing high-priority projects and project types, and improving access to and leveraging federal funding sources. Chapter 8 includes the RFPG's recommendations for increasing local revenue-raising opportunities and state funding.

9.1.1 Local Funding

Overall, larger urban communities typically bear a greater percentage of the burden for funding flood and stormwater-related activities in their jurisdictions than the smaller, more resource-limited communities who are often are unable to generate a significant amount of funding for these activities.

This section primarily focuses on the funding mechanisms available to municipalities and counties, as a large majority of the FME, FMS, and FMP Sponsors are these types of entities. Special purpose districts are briefly discussed as there may be opportunities to create more of these types of districts in the region.

A community's general fund revenue (for cities or counties) stems from sales, property, and other taxes and is typically the primary fund used by a government entity to support most departments and services such as police, fire, parks, trash collection, and local government administration. Due to the high demands on this fund for many local needs, there is often not a significant amount available for funding flood projects out of the general fund.

Table 9-1. Common Sources of Flood Funding in Texas

Source	Federal Agency	State Agency	Program Name	Grant (G)	Loan (L)	Post-Disaster (D)
Federal	FEMA	TWDB	Flood Mitigation Assistance (FMA)	G	-	-
	FEMA	TDEM	Building Resilient Infrastructure and Communities (BRIC)	G	-	-
	FEMA	TCEQ	Rehabilitation of High Hazard Potential Dam Grant Program (HHPD)	G	-	-
	FEMA	*TBD*	Safeguarding Tomorrow through Ongoing Risk Mitigation (STORM)	-	L	-
	FEMA	TDEM	Hazard Mitigation Grant Program (HMGP)	G	-	D
	FEMA	TDEM	Public Assistance (PA)	G	-	D
	HUD	GLO	Community Development Block Grant – Mitigation (CDBG-MIT)	G	-	D
	HUD	GLO	Community Development Block Grant Disaster Recovery Funds (CDBG-DR)	G	-	D
	HUD	TDA	Community Development Block Grant (TxCDBG) Program for Rural Texas	G	-	-
	USACE	-	Partnerships with USACE, funded through Continuing Authorities Program (CAP), Water Resources Development Acts	-	-	-

Source	Federal Agency	State Agency	Program Name	Grant (G)	Loan (L)	Post-Disaster (D)
			(WRDA), or other legislative vehicles*			
	EPA	TWDB	Clean Water State Revolving Fund (CWSRF)	G**	L	-
State	-	TWDB	Flood Infrastructure Fund (FIF)	G	L	-
	-	TWDB	Texas Water Development Fund (Dfund)	-	L	-
	-	TSSWCB	Structural Dam Repair Grant Program	G	-	-
	-	TSSWCB	Operation and Maintenance (O&M) Grant Program	G	-	-
	-	TSSWCB	Flood Control Dam Infrastructure Projects - Supplemental Funding	G	-	-
Local	-	-	General fund	-	-	-
	-	-	Bonds	-	-	-
	-	-	Stormwater or drainage utility fee	-	-	-
	-	-	Special-purpose district taxes and fees	-	-	-

*Opportunities to partner with USACE are not considered grant or loan opportunities, but shared
participation projects where USACE performs planning work and shares in the cost of construction.
**The CWSRF program offers principal forgiveness, which is similar to grant funding.

Dedicated fees such as stormwater or drainage fees are an increasingly popular tool for local flood-related funding, primarily in more urban areas. Municipalities can establish a stormwater utility (sometimes called a drainage utility), which is a legal mechanism used to generate revenue to finance a city's cost to provide and manage stormwater services. Currently there are three cities in the Upper Colorado Basin that has been identified with stormwater utilities. To provide these services, municipalities assess fees from users of the stormwater utility system. Impact fees, which are collected from development to cover a portion of the expense to expand storm water systems necessitated by the new development, can also be used as a source of local funding for flood-related efforts.

Another source for local funding to support flood management efforts includes special districts. A special district is a political subdivision established to provide a single public service (such as water supply, drainage, or sanitation) within a specific geographic area. Examples of these special districts include water control and improvement districts (WCID), municipal utility districts (MUD), drainage districts (DD), and flood control districts (FCD). Each of the different types of districts are governed by different state laws, which specify the authorities and process for creation of a district. Districts can be created by various entities, from the Texas Legislature or the Texas Commission on Environmental Quality to county commissioners' courts or city councils. Depending on the type of district, the districts may have the ability to raise revenue through taxes, fees, or issuing bonds to fund flood and drainage-related improvements within a district's area.

Lastly, municipalities and counties have the option to issue debt through general obligation bonds, revenue bonds, or certificates of obligation, which are typically paid back using any of the previously mentioned local revenue raising mechanisms.

Overall, local governments have various options for raising revenue to support local flood-related efforts; however, each avenue presents its own unique challenges and considerations. It is important to note that municipalities have more authority to establish various revenue raising options in comparison to counties. Of the communities that do have access to local funding, the amount available is generally much lower than the total need, leading local communities to seek out state and federal financial assistance programs.

9.1.2 State Funding

Communities have a broader range of state and federal funding sources and programs available due to new grant and loan programs that didn't exist even five years ago. There are two primary state agencies currently involved in providing state funding for flood projects: the TWDB and the Texas State Soil and Water Conservation Board (TSSWCB). It is important to note that state and federal financial assistance programs discussed herein are not directly available to homeowners and the general public. Local governments apply on behalf of their communities to receive and implement funding for flood projects in their jurisdiction. In the Upper Colorado Basin several counties and larger cities have applied for disaster Relief funds. Cities such as Midland, Odessa and San Angelo have applied for FEMA grants.

The TWDB's Flood Infrastructure Fund (FIF) is a new funding program passed by the Texas Legislature and approved by Texas voters through a constitutional amendment in 2019. The program provides financial assistance in the form of low or no interest loans and grants (cost match varies) to eligible political subdivisions for flood control, flood mitigation, and drainage projects. FIF rules allow for a wide range of flood projects, including structural and nonstructural projects, planning studies, and preparedness efforts such as flood early warning systems. After the first State Flood Plan is adopted, only projects included in the most recently adopted state plan will be eligible for funding from the FIF. FMEs, FMSs, and FMPs recommended in this regional flood plan will be included in the overall state flood plan and will thus be eligible for this funding source.

The TWDB also manages the Texas Water Development Fund (Dfund) program, which is a state-funded streamlined loan program that provides financing for several types of infrastructure projects to eligible political subdivisions. This program enables the TWDB to fund projects with multiple eligible components (water supply, wastewater, or flood control) in one loan at low market rates. Financial assistance for flood control may include structural and nonstructural projects, planning efforts, and flood warning systems.

The TSSWCB has three state-funded programs specifically for flood control dams: the Operation and Maintenance (O&M) Grant Program; the Flood Control Dam Infrastructure Projects - Supplemental Funding Program; and the Structural Repair Grant Program. The O&M Grant Program is a grant program for local SWCD and certain co-sponsors of flood control dams. This program reimburses SWCDs 90 percent of the cost of an eligible operation and maintenance activity as defined by the program rules; the remaining 10 percent must be paid with non-state funding. The Flood Control Dam Infrastructure Projects - Supplemental Funding program was newly created and funded in 2019 by the Texas Legislature. Grants are provided to local sponsors of flood control dams, including SWCDs, to fund the repair and rehabilitation of the flood control structures, to ensure dams meet safety criteria to adequately protect lives downstream. The Structural Repair Grant Program provides state grant funds to provide 95 percent of the cost of allowable repair activities on dams constructed by the United States Department of Agriculture - Natural Resources Conservation Service (USDA-NRCS), including match funding for federal projects through the Dam Rehabilitation Program and the Emergency Watershed Protection (EWP) Program of the Texas NRCS.

9.1.3 Federal Funding

The federal governments play an important, sometimes critical role, particularly in the financing of large-scale flood mitigation projects and studies that would otherwise be beyond the capabilities of the state and local governments. Commonly utilized funding programs administered by seven different federal agencies are discussed in this section. The funding for these programs originates from the federal government but for many of the programs, a state agency partner plays a key role in the management of the program. Each funding program has its own unique eligible applicants, eligible project types, requirements, and application and award timelines. A few examples of eligibility requirements for some of the federal grant programs are: requiring recipients of funding to participate in the National Flood Insurance Program (NFIP), requiring recipients to have an approved Hazard Mitigation Plan, or requiring a project to have a benefit cost ratio of 1.0 or greater. More information regarding each program and their unique eligibility requirements and award processes can be found at the links in this section.

9.1.3.1 Federal Emergency Management Agency (FEMA)

Common FEMA-administered federal flood-related funding programs include Flood Mitigation Assistance (FMA), Building Resilient Infrastructure and Communities (BRIC), Safeguarding Tomorrow through Ongoing Risk Mitigation (STORM), Rehabilitation of High Hazard Potential Dam (HHPD) Grant Program, Hazard Mitigation Grant Program (HMGP), the Public Assistance (PA) program, and the Cooperating Technical Partners (CTP) Program.

FMA is a nationally competitive annual grant program that provides funding to states, local communities, federally recognized tribes, and territories. FMA is administered in Texas by the TWDB. Funds can be used for projects that reduce or eliminate the risk of repetitive flood damage to buildings insured by the NFIP. Funding is typically a 75 percent federal grant with a 25 percent local match. Projects mitigating repetitive loss and severe repetitive loss properties may be funded through a 90 percent federal grant and 100 percent federal grant, respectively. FEMA's FMA program now includes a disaster initiative called Swift Current. The program was released as a pilot initiative in 2022 and explored ways to make flood mitigation assistance more readily available during disaster recovery. Similar to traditional FMA, the program mitigates repetitive losses and substantially damaged buildings insured under the NFIP.

BRIC is a new nationally competitive non-disaster annual grant program implemented in 2020. The program supports states, local communities, tribes, and territories as they undertake hazard mitigation projects, reducing the risks they face from disasters and natural hazards. BRIC is administered in Texas by the Texas Division of Emergency Management (TDEM). Funding is typically a 75 percent federal grant with a 25 percent local match. Small, impoverished communities may be funded through a 90 percent federal grant and 100 percent federal grant, respectively.

STORM is a new revolving loan program enacted through federal legislation in 2021 to provide needed and sustainable funding for hazard mitigation projects. The program is designed to provide capitalization grants to states to establish revolving loan funds for projects to reduce risks from disaster, natural hazards, and other related environmental harm. At the time of the publication of this plan, the program does not yet appear to be operational and has not yet been implemented in Texas.

FEMA’s HHPD Grant Program, administered in Texas by the Texas Commission on Environmental Quality (TCEQ), provides technical, planning, design, and construction assistance in the form of grants for rehabilitation of eligible high hazard potential dams. The cost share requirement is typically no less than 35 percent state or local share.

Under the HMGP, FEMA provides funding to state, local, tribal, and territorial governments so they can rebuild from a recent disaster in a way that reduces, or mitigates, future disaster losses in their communities. The program is administered in Texas by TDEM. Funding is typically a 75 percent federal grant with a 25 percent local match. While the program is associated with Presidential Disaster Declarations, the HMGP is not a disaster relief program for individual disaster victims or a recovery program that funds repairs to public property damaged during a disaster. The key purpose of HMGP is to ensure that the opportunity to take critical mitigation measures to reduce the risk of loss of life and property from future disasters is not lost during the reconstruction process following a disaster.

FEMA’s PA program provides supplemental grants to state, tribal, territorial, and local governments, and certain types of private non-profits following a declared disaster so communities can quickly respond to and recover from major disasters or emergencies through actions such as debris removal, life-saving emergency protective measures, and restoring public infrastructure. Funding cost share levels are determined for each disaster and are typically not less than 75 percent federal grant (25 percent local match) and typically not more than 90 percent federal grant (10 percent local match). In Texas, FEMA PA is administered by TDEM. In some situations, FEMA may fund mitigation measures as part of the repair of damaged infrastructure. Generally, mitigation measures are eligible if they directly reduce future hazard impacts on damaged infrastructure and are cost-effective. Funding is limited to eligible damaged facilities located within PA-declared counties.

The CTP program is an effort launched by FEMA in 1999 to increase local involvement in developing and updating Flood Insurance Rate Maps (FIRMs), Flood Insurance Study reports, and associated geospatial data in support of FEMA’s Risk Mapping, Assessment and Planning (Risk MAP) Program. To participate in the program, interested NFIP-participating communities, state or regional agencies, universities, territories, tribes, or nonprofits must complete training and execute a partnership agreement. Working with the FEMA regions, a program participant can develop business plans and apply for grants to perform eligible activities.

9.1.3.2 Housing and Urban Development (HUD)

HUD administers the following three federal funding programs: Community Development Block Grant – Disaster Recovery (CDBG-DR), Community Development Block Grant – Mitigation (CDBG-MIT), and Community Development Block Grant (TxCDBG) for Rural Texas.

Following a major disaster, Congress may appropriate funds to the Department of Housing and Urban Development (HUD) under the Community Development Block Grant – Disaster Recovery (CDBG-DR) program when there are significant unmet needs for long-term recovery. Appropriations for CDBG-DR are frequently very large, and the program provides 100 percent grants in most cases. The CDBG-DR is administered in Texas by the Texas General Land Office (GLO). The special appropriation provides funds to the most impacted and distressed areas for disaster relief, long term-recovery, restoration of infrastructure, housing, and economic revitalization.

The CDBG-MIT is administered in Texas by the GLO. Eligible grantees can use CDBG-MIT assistance in areas impacted by recent disasters to carry out strategic and high-impact activities to mitigate disaster risks with typically 100 percent grants. The primary feature differentiating CDBG-MIT from CDBG-DR is that unlike CDBG-DR, which funds recovery from a recent disaster to retore damaged services, systems, and infrastructure, CDBG-MIT funds are intended to support mitigation efforts to rebuild in a way which will lessen the impact of future disasters.

The Community Development Block Grant (CDBG) program provides annual grants on a formula basis to small, rural cities and to counties to develop viable communities by providing decent housing and suitable living environments, and expanding economic opportunities principally for persons of low- to moderate-income. Funds can be used for public facilities such as water and wastewater infrastructure, street and drainage improvements, and housing. In Texas, the CDBG program is administered by the Texas Department of Agriculture (TDA).

9.1.3.3 U.S. Army Corps of Engineers (USACE)

The USACE works with non-federal partners (states, tribes, counties, or local governments) throughout the country to investigate water resources and related land problems and opportunities and, if warranted, develop civil works projects that would otherwise be beyond the sole capability of the non-Federal partner(s). Partnerships are typically initiated or requested by the local community to their local USACE District office. Before any project or study can begin, USACE determines whether there is an existing authority under which the project could be considered, such as the US Army Corps of Engineers Continuing Authorities Program (CAP), or whether Congress must establish study or project authority and appropriate specific funding for the activity. New study or project authorizations are typically provided through periodic Water Resource Development Acts (WRDA) or via another legislative vehicle. Congress will not provide project authority until a completed study results in a recommendation to Congress of a water resources project, conveyed via a Report of the Chief of Engineers (Chief's Report) or Report of the Director of Civil Works (Director's Report). Opportunities to partner with USACE are not considered grant or loan opportunities, but shared participation projects where USACE performs planning work and shares in the cost of construction. USACE also has technical assistance opportunities, including Floodplain Management Services and the Planning Assistance to States program, available to local communities.

9.1.3.4 U.S. Environmental Protection Agency (EPA)

The Clean Water State Revolving Fund (CWSRF) provides financial assistance in the form of loans with subsidized interest rates and opportunities for partial principal forgiveness for planning, acquisition, design, and construction of wastewater, reuse, and stormwater mitigation infrastructure projects. Projects can be structural or non-structural. Low Impact Development (LID) projects are also eligible. The CWSRF is administered in Texas by the TWDB.

9.1.3.5 U.S. Department of Agriculture (USDA)

The USDA's Natural Resources Conservation Service (NRCS) provides technical and financial assistance to local government agencies through the following programs: Emergency Watershed Protection Program, Watershed Protection and Flood Prevention Program, Watershed Surveys and Planning, and Watershed Rehabilitation. The EWP program, a federal emergency recovery program, helps local communities recover after a natural disaster by offering technical and financial assistance to relieve imminent threats to life and property caused by floods and other natural disasters that impair a watershed. The Watershed Protection and Flood Prevention Program helps units of federal, state, local and tribal government protect and restore watersheds; to prevent erosion, floodwater, and sediment damage; to further the conservation development, use and disposal of water; and to further the conservation and proper use of land in authorized watersheds. The focus of Watershed Surveys and Planning program is funding watershed plans, river basin surveys and studies, flood hazard analyses, and floodplain management assistance aimed at identifying solutions that use land treatment and nonstructural measures to solve resource problems. Lastly, the Watershed Rehabilitation Program helps project sponsors rehabilitate aging dams that are reaching the end of their design lives. This rehabilitation addresses critical public health and safety concerns. The USDA also offers various Water and Environmental grant and loan funding programs, which can be used for water and waste facilities, including stormwater facilities, in rural communities.

9.1.3.6 Special Appropriations

On occasion and when the need is large enough, Congress may appropriate funds for special circumstances such natural disasters or pandemics (COVID-19). A few examples of recent special appropriations from the federal government that can be used to fund flood-related activities are discussed in this section.

In 2021, the American Rescue Plan Act (ARPA) provided for a substantial infusion of resources to eligible state, local, territorial, and tribal governments to support their response to and recovery from the COVID-19 pandemic. Coronavirus State and Local Fiscal Recovery Funds (SLFRF), a part of ARPA, delivers $350 billion directly to state, local, and tribal governments across the country. Communities have significant flexibility to meet local needs within the eligible use categories, one of which includes improving stormwater facilities and infrastructure as an authorized use. Eligible entities may request their allocation of Coronavirus State and Local Fiscal Recovery Funds directly from the U.S. Department of Treasury.

Although not a direct appropriation to local governments like ARPA, the 2021 Infrastructure Investment and Jobs Act (IIJA), also called the Bipartisan Infrastructure Law (BIL), authorizes over $1 trillion for infrastructure spending across the U.S. and provides for a significant infusion of resources over the next several years into existing federal financial assistance programs, including several of the flood funding programs discussed in this Chapter, as well as creating new programs.

9.1.4 Barriers to Funding

Local communities encounter barriers to accessing or seeking funding sources for flood management activities, including lack of knowledge of funding sources, lack of expertise and staff time to apply for funding, and no local funds available for local match requirements. As opposed to some other types of infrastructure, flood projects do not typically generate revenue and many communities do not have steady revenue streams to fund flood projects, as discussed in Section 9.1.1. Consequently, communities struggle to generate funds for local match requirements or loan repayment. Complex or burdensome application or program requirements as well as prolonged timelines also act as barriers to accessing state and federal financial assistance programs. Of those communities able to overcome these barriers, apply for funding, and generate local resources for match requirements, the high demand for state and federal funding, particularly for grant opportunities, means that need outstrips supply, leaving many local communities without the resources they need to address flood risks.

9.2 Flood Infrastructure Financing Survey

This task required obtaining relevant information from Sponsors of the recommended FMEs, FMSs, and FMPs that have capital costs, for example, in the form of a mailed survey or other means of collecting the required information. The primary aim of this survey effort was to understand the funding needs of local Sponsors and then propose what role the state should have in financing the recommended FMEs, FMSs, and FMPs. For the Upper Colorado region, a first round of targeted outreach via in person meetings, phone calls and emails to Sponsors gathered preliminary information on funding needs for recommended FMEs, FMSs, and FMPs. To gather additional information, a follow-up survey via email was sent to Sponsors.

To assess the remaining need, estimated percentages of local investment and state or federal need were applied for actions where Sponsors did not respond to the survey. For municipalities with a population less than 2000 and counties with a population of less than 2500, 100 percent of the total project costs were estimated as being needed from state or federal sources. Smaller communities often have limited resource and are unable to generate funding for flood-related projects and activities. For the municipalities with a population more than 2000 and counties with a population more than 2500, it was estimated that 90 percent of total project costs are required from state and federal sources and 10 percent projected local investment. A high percentage of outside need is supported by discussions with stakeholders during outreach efforts for this plan, which confirmed that many communities, particularly smaller and more rural communities, do not have any local funding available for flood management activities and larger communities that did report having local funding indicated relatively little local funding available in relation to overall need.

Overall, there is a total of $127,715,827 needed to implement the recommended FMEs, FMSs, and FMPs in this regional flood plan. From the total cost, it is projected that $114,944,244 in state and federal funding is needed. Since most federal funding programs are dependent on availability or on project selection in a nationally competitive grant program, it is difficult to estimate how much federal funding may be available to implement these studies, strategies, and projects. It is conservatively estimated that as much as the full amount may be needed from state sources. This number does not represent the amount of funding needed to mitigate all risks in the region and solve flooding problems in their totality. This number simply represents the funding needs for the specific, identified studies, strategies, and projects in this cycle of regional flood planning. Future cycles of regional flood planning will continue to identify projects and studies needed to further flood mitigation efforts in the Upper Colorado region.

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10

Public Participation and Adoption

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10 Public Participation and Adoption of Plan

[31 TAC §361.30-32]

10.1 Introduction

The objective of this task is to describe public participation and public meetings related to the flood planning process. Additional objectives include activities necessary to complete and submit the draft and final regional flood plan and to obtain Texas Water Development Board (TWDB) approval.

In this task, the regional flood planning group (RFPG) must evaluate and ensure that the draft and final regional flood plans satisfy the requirements for regional flood plans in the guidance principles adopted in Title 31 Texas Administrative Code (TAC) §362.3 and must include a statement in the draft and final regional flood plans explaining how the regional flood plan satisfies the requirements of each of the guidance principles in accordance with Title 31 TAC §361.20.

The Upper Colorado regional flood plan (UCRFP) satisfies each of the 39 flood planning guidance principles delineated in 31 TAC §361.20 (31 TAC §362.3), including that the plan will not negatively affect a neighboring area. The guidance principles and the means by which these requirements are met in the UCRFP are listed in Table 10-1~~Table 10-1~~, along with references to the UCRFP chapters, which are listed in Table 10-2~~Table 10-2~~.

Table 10-1. Title 31 TAC §362.3 Guidance Principles and the Means by which Requirement is Met in UCRFP

Guidance Principle	Means by which Requirement is Met in Upper Colorado Regional Flood Plan (UCRFP)
(1) shall be a guide to state, regional, and local flood risk management policy;	The UCRFP is a guide with management goals in Chapter 3, management strategies in Chapter 5, and management and policy recommendations in Chapter 8.
(2) shall be based on the best available science, data, models, and flood risk mapping;	Best available information from a quality, coverage, and contemporary perspective were used in UCRFP, for example in Chapter 2 analyses.

Guidance Principle	Means by which Requirement is Met in Upper Colorado Regional Flood Plan (UCRFP)
(3) shall focus on identifying both current and future flood risks, including hazard, exposure, vulnerability and residual risks; selecting achievable flood mitigation goals, as determined by each RFPG for their region; and incorporating strategies and projects to reduce the identified risks accordingly;	The UCRFP examines current and future flood risk in Chapter 2, mitigation goals in Chapter 3, and strategies in Chapter 5. Maps show the areas of flood risks.
(4) shall, at a minimum, evaluate flood hazard exposure to life and property associated with 0.2 percent annual chance flood event (the 500-year flood) and, in these efforts, shall not be limited to consideration of historic flood events;	Flood hazard exposure is evaluated and presented in Chapter 2. Maps show the areas of flood risks associated with different percent annual chance flood event.
(5) shall, when possible and at a minimum, evaluate flood risk to life and property associated with 1.0 percent annual chance flood event (the 100-year flood) and address, through recommended strategies and projects, the flood mitigation goals of the RFPG (per item 2 above) to address flood events associated with a 1.0 percent annual chance flood event (the 100-year flood); and, in these efforts, shall not be limited to consideration of historic flood events;	Flood risks are evaluated and presented in Chapter 2, with recommended strategies and projects provided in Chapter 7 and Chapter 8.
(6) shall consider the extent to which current floodplain management, land use regulations, and economic development practices increase future flood risks to life and property and consider recommending adoption of floodplain management, land use regulations, and economic development practices to reduce future flood risk;	Floodplain management practices throughout the Upper Colorado Region are mostly low and could be expanded as described in Chapter 3. Increased recognition of floodplains and flood risk is needed for most of the region.
(7) shall consider future development within the planning region and its potential to impact the benefits of flood management strategies (and associated projects) recommended in the plan;	Future development is considered in Chapter 2 and Chapter 3. Midland, Odessa, and San Angelo are the areas with greatest potential for developmental pressures in flood prone areas needing management strategies.

Guidance Principle	Means by which Requirement is Met in Upper Colorado Regional Flood Plan (UCRFP)
(8) shall consider various types of flooding risks that pose a threat to life and property, including, but not limited to, riverine flooding, urban flooding, engineered structure failures, slow rise flooding, ponding, flash flooding, and coastal flooding, including relative sea level change and storm surge;	Various types of flooding risks that pose a threat to life and property, including, but not limited to, riverine flooding, urban flooding, engineered structure failures, slow rise flooding, ponding, playa flooding, and flash flooding, are considered in Chapter 2. Coastal flooding is not applicable in the Upper Colorado Region.
(9) shall focus primarily on flood management strategies and projects with a contributing drainage area greater than or equal to 1.0 (one) square miles except in instances of flooding of critical facilities or transportation routes or for other reasons, including levels of risk or project size, determined by the RFPG;	Chapter 4 and Chapter 5 focus on flood management strategies and projects.
(10) shall consider the potential upstream and downstream effects, including environmental, of potential flood management strategies (and associated projects) on neighboring areas. In recommending strategies, RFPGs shall ensure that no neighboring area is negatively affected by the regional flood plan;	Consideration of neighboring area is described in Chapter 4 and Chapter 5. Strategies and projects are assessed to confirm negative impacts to surrounding areas would not occur.
(11) shall include an assessment of existing, major flood mitigation infrastructure and will recommend both new strategies and projects that will further reduce risk, beyond what existing flood strategies and projects were designed to provide, and make recommendations regarding required expenditures to address deferred maintenance on or repairs to existing flood infrastructure;	Infrastructure is evaluated in Chapter 4 and Chapter 5. The strategies and projects include many related to infrastructure. In fact, there may be too much focus on classical infrastructure controls and a need for more deliberation on alternative solutions. Chapter 9 examines the financing aspects.

Guidance Principle	Means by which Requirement is Met in Upper Colorado Regional Flood Plan (UCRFP)
(12) shall include the estimate of costs and benefits at a level of detail sufficient for RFPGs and sponsors of flood mitigation projects to understand project benefits and, when applicable, compare the relative benefits and costs, including environmental and social benefits and costs, between feasible options;	Costs drive most decision making and are discussed in most chapters, although Chapter 4, Chapter 5, and Chapter 9 present the most information on costs. For the most part, costs are likely underestimated for a variety of reasons, including lack of problem and solution definition, extent of flood damage, and inflation.
(13) shall provide for the orderly preparation for and response to flood conditions to protect against the loss of life and property and reduce injuries and other flood-related human suffering;	Preparation and response is described in Chapter 7.
(14) shall provide for an achievable reduction in flood risk at a reasonable cost to protect against the loss of life and property from flooding;	Like costs and benefits in Chapter 4 and Chapter 5, reasonable costs to achievable reduction in flood risk is considered.
(15) shall be supported by state agencies, including the TWDB, General Land Office, Texas Commission on Environmental Quality, Texas State Soil and Water Conservation Board, Texas Parks and Wildlife Department, and the Texas Department of Agriculture, working cooperatively to avoid duplication of effort and to make the best and most efficient use of state and federal resources;	Agency representation is addressed in Chapter 10, Public Participation.
(16) shall include recommended strategies and projects that minimize residual flood risk and provide effective and economical management of flood risk to people, properties, and communities, and associated environmental benefits;	Chapter 5 includes recommended strategies and projects.
(17) shall include strategies and projects that provide for a balance of structural and nonstructural flood mitigation measures, including projects that use nature-based features, that lead to long-term mitigation of flood risk;	Chapter 2 includes nature-based goals. Chapter 4 and Chapter 5 include strategies and projects that are labeled as other, which includes nature-based solutions. A variety of strategies and projects are included but balance could be improved in future planning.

Guidance Principle	Means by which Requirement is Met in Upper Colorado Regional Flood Plan (UCRFP)
(18) shall contribute to water supply development where possible;	Contributions and impacts to water supply development are assessed in Chapter 6. Due to the hydrology and landscape of the region, there is little potential to contribute or impact water supply development.
(19) shall also follow all regional and state water planning guidance principles (31 TAC 358.3) in instances where recommended flood projects also include a water supply component;	Contributions and impacts to water supply development are assessed in Chapter 6. Due to the hydrology and landscape of the region, there is little potential to contribute or impact water supply development.
(20) shall be based on decision-making that is open to, understandable for, and accountable to the public with full dissemination of planning results except for those matters made confidential by law;	The UCRFP is based on the requirements of the TAC and the associated TWDB technical guidance documents.
(21) shall be based on established terms of participation that shall be equitable and shall not unduly hinder participation;	The UCRFP is based on the requirements of the TAC and the associated TWDB technical guidance documents. Chapter 10 directly addressed public participation.
(22) shall include flood management strategies and projects recommended by the RFPGs that are based upon identification, analysis, and comparison of all flood management strategies the RFPGs determine to be potentially feasible to meet flood mitigation and floodplain management goals;	The Upper Colorado Regional Flood Planning Group (UCRFPG) worked directly with the technical consultant in the development of the UCRFP as described in Chapter 1.
(23) shall consider land-use and floodplain management policies and approaches that support short- and long-term flood mitigation and floodplain management goals;	Land-use and floodplain management policies and approaches that support short- and long-term flood mitigation and floodplain management goals are addressed in Chapter 3
(24) shall consider natural systems and beneficial functions of floodplains, including flood peak attenuation and ecosystem services;	Chapter 3 includes natured-based goals like attenuation and ecosystem services within the category of environmental stewardship.

Guidance Principle	Means by which Requirement is Met in Upper Colorado Regional Flood Plan (UCRFP)
(25) shall be consistent with the National Flood Insurance Program (NFIP) and shall not undermine participation in nor the incentives or benefits associated with the NFIP;	This is a primary aspect of the goals and purpose of the UCRFP as stated in Chapter 1. The UCRFP is consistent with the NFIP.
(26) shall emphasize the fundamental importance of floodplain management policies that reduce flood risk;	Policies that reduce flood risk are a fundamental importance of the UCRFP and is specifically emphasize in Chapter 2.
(27) shall encourage flood mitigation design approaches that work with, rather than against, natural patterns and conditions of floodplains;	Chapter 3 includes natured-based goals to work with natural patterns and conditions within the category of environmental stewardship.
(28) shall not cause long-term impairment to the designated water quality as shown in the state water quality management plan as a result of a recommended flood management strategy or project;	The conclusion of Chapter 6 states there are no anticipated impacts to the State Water Quality Management Plan.
(29) shall be based on identifying common needs, issues, and challenges; achieving efficiencies; fostering cooperative planning with local, state, and federal partners; and resolving conflicts in a fair, equitable, and efficient manner;	These are part of the process for identifying the FME, FMS, and FMP lists as described in Chapter 5.
(30) shall include recommended strategies and projects that are described in sufficient detail to allow a state agency making a financial or regulatory decision to determine if a proposed action before the state agency is consistent with an approved regional flood plan;	Chapter 5 includes recommended strategies and projects.
(31) shall include ongoing flood projects that are in the planning stage, have been permitted, or are under construction;	Chapter 1 includes discussion about proposed and ongoing flood mitigation projects. Ongoing projects are primarily by the largest cities, Midland, Odessa and San Angelo.

Guidance Principle	Means by which Requirement is Met in Upper Colorado Regional Flood Plan (UCRFP)
(32) shall include legislative recommendations that are considered necessary and desirable to facilitate flood management planning and implementation to protect life and property;	Legislative recommendations along with rationale are provided in Chapter 8.
(33) shall be based on coordination of flood management planning, strategies, and mitigation projects with local, regional, state, and federal agencies projects and goals;	These are part of the process for identifying the FME, FMS, and FMP lists with the UCRFPG providing the coordination as described in Chapter 5.
(34) shall be in accordance with all existing water rights laws, including but not limited to, Texas statutes and rules, federal statutes and rules, interstate compacts, and international treaties;	The conclusion of Chapter 6 states there are no anticipated impacts to water rights.
(35) shall consider protection of vulnerable populations;	Flood risks to vulnerable populations are evaluated in Chapter 2 using the social vulnerability index. Vulnerability was then carried forward to the process for identifying FME, FMS, and FMP lists in Chapter 5.
(36) shall consider benefits of flood management strategies to water quality, fish and wildlife, ecosystem function, and recreation, as appropriate;	Chapter 4 recognizes the consideration of these additional benefits alongside the needs analysis results for developing strategies and projects.
(37) shall minimize adverse environmental impacts and be in accordance with adopted environmental flow standards;	Chapter 6 addresses minimizing adverse environmental impacts and meeting adopted environmental flow standards in the recommendations.
(38) shall consider how long-term maintenance and operation of flood strategies will be conducted and funded; and	Chapter 9 includes the consideration of conducting and funding O&M.
(39) shall consider multi-use opportunities such as green space, parks, water quality, or recreation, portions of which could be funded, constructed, and or maintained by additional, third-party project participants.	Chapter 4 recognizes the consideration of these additional opportunities alongside the needs analysis results for developing strategies and projects.

Table 10-2. Title 31 TAC §362.3 Guidance Principles and Means Requirement Met in UCRFP

Upper Colorado Regional Flood Plan (UCRFP) Chapter	General Content
1	Planning Area Description
2	Existing Condition Flood Risk Analyses Future Condition Flood Risk Analyses
3	Evaluation and Recommendations on Floodplain Management Practices Flood Mitigation and Floodplain Management Goals
4	Flood Mitigation Needs Analysis
5	Identification of Potential Flood Management Evaluations and Potentially Feasible Flood Management Strategies and Flood Mitigation Projects Evaluation and Recommendation of Flood Management Evaluations and Flood Management Strategies and Associated Flood Mitigation Projects
6	Impacts of Regional Flood Plan Contributions to and Impacts on Water Supply Development and the State Water Plan
7	Flood Response Information and Activities
8	Administrative, Regulatory, and Legislative Recommendations
9	Flood Infrastructure Financing Analysis
10	Public Participation and Plan Adoption

10.2 Public Participation

Stakeholder outreach and public participation are an important part of any planning process, including this first flood planning cycle for the State of Texas, initiated by Senate Bill 8 (SB8) of the 86th Texas Legislature. Public participation has aided in every aspect of the regional flood plan development – from the identification of flood risks and management and mitigation project needs to the formation of legislative and policy recommendations specific to the Upper Colorado basin. In 2020, the TWDB allocated funds for the 15 flood planning regions to concentrate on tasks related to public participation and flood planning development for their respective basins. In September 2021, the TWDB allocated additional funding related to stakeholder outreach and data collection efforts for each of the flood planning regions.

The Upper Colorado Regional Flood Planning Group (UCRFPG) provided opportunity for the public to participate in the regional flood planning process. The UCRFPG met all requirements under the Texas Open Meetings Act and Public Information Act in accordance with 31 TAC Chapters 357.12, 357.21, and 357.50(f) during development of the *Draft 2023 Regional Flood Plan for Flood Planning Region 9 – Upper Colorado*. UCRFPG meeting agendas and other meeting materials were posted on the UCRFPG website (https://www.cosatx.us/departments-services/water-utilities/region-9-upper-colorado-flood-planning-region) prior to each meeting. The public was invited to speak during public comment periods during each UCRFPG meeting.

Non-voting members of the UCRFPG included representatives from the following state agencies: TWDB, General Land Office (GLO), Texas Commission on Environmental Quality (TCEQ), Texas State Soil and Water Conservation Board (TSSWCB), Texas Parks and Wildlife Department (TPWD), and the Texas Department of Agriculture (TDA). The representatives provided input for the UCRFP and worked cooperatively to avoid duplication of effort and to make the best and most efficient use of state and federal resources.

In addition to the UCRFPG's website, an associated email address, FloodRegion9@hdrinc.com, was developed to provide a tool to inform and communicate with the public and stakeholders on the progress of the 2023 UCRFP.

To comply with the TWDB Regional Flood Planning Rules [31 TAC Section 361.21(h)(2)], written comments from the public were accepted for a period of 14 days prior to and 14 days after the meeting, where the pre-planning public meeting to obtain input on development of the next regional flood plan, determining flood mitigation and floodplain management goals, and approving the process for identifying potential flood management evaluations (FMEs) and potentially feasible flood management strategies (FMSs) and flood management projects (FMPs). Public comments were also accepted at the December 16, 2021, meeting where the UCRFPG considered the technical memorandum for approval.

10.3 UCRFPG Communications

10.3.1 Regional Website and Email Address

To better communicate the activities of the UCRFPG and receive input from the public and stakeholders, the UCRFPG created a website for the UCRFPG: https://www.cosatx.us/departments-services/water-utilities/region-9-upper-colorado-flood-planning-region. The website has been used to convey the following information.

- General Upper Colorado basin information;
- Notifications of upcoming monthly RFPG meetings, including a virtual meeting option with a link to Microsoft Teams;
- Meeting archives containing past meeting agendas, supporting documentation, and meeting minutes;

- Links to multiple surveys to inform the UCRFPG of previous drainage or flood studies or the need proposed/ongoing flood mitigation projects, including the following specific survey formats.
  - General stakeholder
  - City or county official
  - Floodplain administrator
  - Independent school district
  - Existing project/study
- Links to additional flood planning resources, including the Texas Natural Resources Information System (TNRIS) Flood Planning Regions Map Collection and the TWDB's Flood Planning website;
- Email address to submit public comments for a particular agenda item and/or submit questions to the UCRFPG.
- Interactive map to share experiences with flooding in the basin and help the UCRFPG identify flood risks in communities, such as low water crossings.

10.4 Coordination with Other Planning Regions

Coordination with other planning regions was accomplished primarily through the technical consultants, who coordinated data and shared information that was then reported to the planning groups. Coordination was accomplished with adjacent RFPGs, including Regions 7, 10, and 14. Other coordination was accomplished through the participation of UCRFPG members as liaisons with adjacent planning groups.

10.5 Upper Colorado Regional Flood Planning Group Meetings

The UCRFPG regularly met in accordance with the approved bylaws. The UCRFPG has met on a more frequent basis as needed in order to facilitate and direct the flood planning of the region. Following is a list of the 2023 UCRFP development meetings.

- July 6, 2022
- June 1, 2022
- May 4, 2022
- March 31, 2022
- March 4, 2022
- December 16, 2021
- November 16, 2021
- October 7, 2021
- September 2, 2021
- July 29, 2021
- June 24, 2021
- May 20, 2021
- April 15, 2021
- April 1, 2021
- March 4, 2021
- January 28, 2021
- October 29, 2020

10.6 Public Hearing and Responses to Public Comments on Draft Plan

The UCRFPG approved the *Draft 2023 Regional Flood Plan for Flood Planning Region 9 – Upper Colorado* on July 6, 2022, for submittal to the TWDB. The Draft 2023 UCRFP will be submitted to the TWDB by August 1, 2022. The public hearing to receive comments on the Draft 2023 UCRFP will be held in September 2022, providing sufficient time to accept public comments according to statute to meet the January 10, 2023, deadline for submission of the adopted Final 2023 UCRFP. The Draft 2023 UCRFP will be provided as hard copies as required and posted on the UCRFP website for public review and comment. The comments received on the Draft 2023 UCRFP with responses will be included as an appendix in the Final 2023 UCRFP.

10.7 Plan Adoption

The 2023 UCRFP was developed and adopted in accordance with 31 TAC §361.50 and §361.60–.61. The UCRFPG will approve and adopt the Final 2023 UCRFP in late 2022 and will direct the City of San Angelo and the Technical Consultant Team to submit the Final 2023 UCRFP to the TWDB on or before the January 10, 2023, deadline.

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Appendix A. Tables

Table 2: Summary of Proposed or Ongoing Flood Mitigation Projects

Existing Project ID	RFPG No.	RFPG Name	Project Name	Description	Counties	HUC8s	HUC12s	Watersheds	Project Status	Project Cost	Dedicated Funding for Construction (Yes/No)	Source of Funding	Expected Year of Completion	Anticipated Benefit
0900002	9	Upper Colorado	Ave. P Neighborhood Flooding	Excessive street flow, street flooding	Tom Green	12090102	--	--	Ongoing	Unknown	No	Unknown	Unknown	Flood Reduction
0900003	9	Upper Colorado	Southwest Blvd Low Water Crossing	Low water crossing, significant street flooding	Tom Green	12090102	--	--	Ongoing	Unknown	No	Unknown	Unknown	Flood Reduction
0900004	9	Upper Colorado	College Hills Blvd Street Flooding	Street flow south of Oxford enters Red Arroyo, 3-4' deep in street	Tom Green	12090102	--	--	Ongoing	Unknown	No	Unknown	Unknown	Flood Reduction
None	9	Upper Colorado	City of Snyder - USACE - 2021	Corps project	Scurry	Unknown	--	--	Ongoing	Unknown	No	Unknown	Unknown	Flood Reduction
None	9	Upper Colorado	San Angelo	City projects	Tom Green	Unknown	--	--	Ongoing	Unknown	No	Unknown	Unknown	Flood Reduction
None	9	Upper Colorado	Midland	City projects	Midland	Unknown	--	--	Ongoing	Unknown	No	Unknown	Unknown	Flood Reduction
~~None~~	~~9~~	~~Upper Colorado~~	~~Jal Draw Project~~	~~The proposed channel has a top width of 500-feet for much of the reach to match the existing top width. There are two existing crossings, one at Crowley Road and the other at Holiday Hill Road. FNI recommends that both crossings remain.~~	~~Midland~~	~~Unknown~~	~~--~~	~~--~~	~~Proposed~~	~~Unknown~~	~~No~~	~~Unknown~~	~~Unknown~~	~~Flood Reduction~~
~~None~~	~~9~~	~~Upper Colorado~~	~~Industrial Channel Project A~~	~~Channel improvements are planned for the Industrial Channel beginning at the channel's confluence with Midland Draw just south of U.S. Highway 80 (Business 20) at Station 0+00.~~	~~Midland~~	~~Unknown~~	~~--~~	~~--~~	~~Proposed~~	~~Unknown~~	~~No~~	~~Unknown~~	~~Unknown~~	~~Flood Reduction~~
~~None~~	~~9~~	~~Upper Colorado~~	~~Cauley Lane Regional Detention~~	~~21-ac regional detention pond, pumped to O.C. Fisher~~	~~Tom Green~~	~~Unknown~~	~~--~~	~~--~~	~~Proposed~~	~~Unknown~~	~~No~~	~~Unknown~~	~~Unknown~~	~~Flood Reduction~~
~~None~~	~~9~~	~~Upper Colorado~~	~~Bradford Detention~~	~~12-ac regional detention along overflow path to East Angelo Draw~~	~~Tom Green~~	~~Unknown~~	~~--~~	~~--~~	~~Proposed~~	~~Unknown~~	~~No~~	~~Unknown~~	~~Unknown~~	~~Flood Reduction~~
~~None~~	~~9~~	~~Upper Colorado~~	~~24th and Poe~~	~~intersection and channel improvement~~	~~Tom Green~~	~~Unknown~~	~~--~~	~~--~~	~~Proposed~~	~~Unknown~~	~~No~~	~~Unknown~~	~~Unknown~~	~~Flood Reduction~~
~~None~~	~~9~~	~~Upper Colorado~~	~~City of Andrews Southwest Andrews Playa Excavation~~	~~Proposed excavation in playa located South of FM 1910 and East of new SW Mustang Dr. Approximate 183,000 cu-yd. of removed earth material.~~	~~Andrews~~	~~Unknown~~	~~--~~	~~--~~	~~Proposed~~	~~Unknown~~	~~No~~	~~Unknown~~	~~Unknown~~	~~Flood Reduction~~
~~None~~	~~9~~	~~Upper Colorado~~	~~City of Andrews Northwest Andrews Playa Excavation~~	~~Proposed excavation in playa located South of Taylor and West of new 5th Street (FM301). Approximate 53,000 cu-yd. of removed earth material.~~	~~Andrews~~	~~Unknown~~	~~--~~	~~--~~	~~Proposed~~	~~Unknown~~	~~No~~	~~Unknown~~	~~Unknown~~	~~Flood Reduction~~

* Summary of proposed or ongoing flood mitigation projects currently under construction, being implemented; and or with dedicated construction funding

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Table 3: Existing Condition Flood Risk Summary Table, by County

					1% Annual Chance Flood Risk										0.2% Annual Chance Flood Risk							
#	RFPG No.	RFPG Name	County	Area in Flood Planning Region (sqmi)	Area in Floodplain (sqmi)	Number of Structures in Floodplain	Residential Structures in Floodplain	Population (daytime)	Population (nighttime)	Population	Roadway Stream Crossings (#)	Roadways Segments (miles)	Agricultural Areas (sqmi)	Critical Facilities (#)	Area in Floodplain (sqmi)	Number of Structures in Floodplain	Residential Structures in Floodplain	Population	Roadway Stream Crossings (#)	Roadways Segments (miles)	Agricultural Areas (sqmi)	Critical Facilities (#)
1	9	Upper Colorado	Andrews	1,231	328.4	959	763	1154	1463	1463	0	173.19	12.17	0	110	704	553	1770	0	61.13	4.72	1
2	9	Upper Colorado	Borden	851	168.6	69	9	9	20	20	0	26.08	16.36	0	29.4	44	5	24	0	10.85	5.54	0
3	9	Upper Colorado	Cochran	450	100.4	23	12	17	53	53	0	142.49	24.39	0	37.2	6	3	7	0	27.35	9.43	0
4	9	Upper Colorado	Coke	928	172.3	245	104	97	124	124	0	55.41	8.47	0	22.8	201	91	249	0	11.79	2.65	0
5	9	Upper Colorado	Coleman	18	2.3	6	1	0	1	1	0	0.25	0.04	0	0.3	0	0	0	0	0.11	0.01	0
6	9	Upper Colorado	Concho	476	89.9	103	52	16	77	77	0	23.62	19.16	0	14.8	63	27	54	0	8.68	5.5	0
7	9	Upper Colorado	Crockett	76	11.37	0	0	0	0	0	0	0.7	0.01	0	1.53	0	0	0	0	0.09	0.001	0
8	9	Upper Colorado	Dawson	898	186.2	474	9	484	710	710	0	537.9	119.07	0	57.1	339	3	418	0	113.87	41.15	0
9	9	Upper Colorado	Ector	620	142.9	13046	10081	32290	28758	32290	0	306.42	0	13	33.8	5187	4315	12662	0	102.24	0	7
10	9	Upper Colorado	Gaines	1,502	432	1887	814	2071	2675	2675	0	434.38	109.17	1	132.6	944	493	2037	0	129.97	31.82	2
11	9	Upper Colorado	Garza	9	1.17	0	0	0	0	0	0	0	0.001	0	0.18	0	0	0	0	0	2.055E-05	0
12	9	Upper Colorado	Glasscock	901	165.6	141	3	36	74	74	0	33.84	39.42	0	47.4	59	2	40	0	19.09	18.26	0
13	9	Upper Colorado	Hockley	95	15.3	44	18	851	165	851	0	42.33	2.1	3	7	44	19	39	0	10.76	0.83	0
14	9	Upper Colorado	Howard	904	183.6	1373	662	3981	1746	3981	0	196.2	55.42	2	42.7	899	591	2454	0	70.28	17.18	2
15	9	Upper Colorado	Irion	1,052	209.2	354	104	149	235	235	0	47.82	3.85	0	23.8	129	43	72	0	9.02	0.57	0
16	9	Upper Colorado	Lynn	218	51	340	204	236	352	352	0	152.08	36.84	1	17.6	64	47	86	0	24.14	13.25	0
17	9	Upper Colorado	Martin	916	228.8	901	451	2015	1266	2015	0	229.11	87.01	3	66.8	259	111	452	0	59.78	29.74	0
18	9	Upper Colorado	Menard	1	0.1	0	0	0	0	0	0	0	0	0	0.01	0	0	0	0	0	0	0
19	9	Upper Colorado	Midland	895	183.5	8431	5661	23036	18315	23036	0	289.49	12.77	22	59.3	4377	3135	11122	0	109.77	3.91	5
20	9	Upper Colorado	Mitchell	908	172.2	344	206	737	593	737	0	107.48	26.11	2	29.1	341	248	377	0	28.76	5.88	0
21	9	Upper Colorado	Nolan	451	69.3	90	16	12	23	23	0	20.94	6.07	0	7.8	10	1	6	0	5.4	1.16	0
22	9	Upper Colorado	Reagan	1,093	191.1	161	79	184	200	200	0	38.91	20.8	0	59.8	139	67	169	0	31.32	13.76	0
23	9	Upper Colorado	Runnels	1,018	200.9	164	41	172	178	178	0	124.78	61.28	1	39.8	68	9	57	0	32.9	17.22	0
24	9	Upper Colorado	Schleicher	437	64.7	99	40	191	72	191	0	16.63	1.97	0	7.5	51	36	40	0	4.49	0.54	0
25	9	Upper Colorado	Scurry	516	85	606	324	1754	647	1754	0	76.03	18.28	1	14.1	122	81	155	0	15.38	4.45	0
26	9	Upper Colorado	Sterling	924	162.3	179	97	180	133	180	0	29.68	3.58	0	18.6	77	38	40	0	9.07	0.58	0
27	9	Upper Colorado	Taylor	171	32.9	70	51	4	46	46	0	17.77	5.46	0	4.3	20	15	19	0	5.49	1.26	0
28	9	Upper Colorado	Terry	865	203.3	499	183	1052	869	1052	0	633.13	131.47	0	59.3	322	144	547	0	104.87	39.62	0
29	9	Upper Colorado	Tom Green	1,541	330.8	5166	3373	9948	9045	9948	0	253.42	75.75	7	67	2612	1681	7117	0	96.22	31.63	1
30	9	Upper Colorado	Upton	481	100.3	41	16	23	10	23	0	34.07	9.43	0	51.2	23	3	12	0	11.18	4.87	0
31	9	Upper Colorado	Winkler	9	1.27	0	0	0	0	0	0	0	0	0	0.66	0	0	0	0	0	0	0
32	9	Upper Colorado	Yoakum	800	234.3	546	263	758	803	803	0	290.23	99.47	0	68.1	169	87	220	0	61.92	24.77	0

Table 3: Existing Condition Flood Risk Summary Table, by County (continued)

#	County	Area in Flood Planning Region (sqmi)	Possible Flood-Prone Areas							Average SVI of features in floodplain or flood prone areas
			Area (sqmi)	Number of Structures in Flood Prone Area	Population	Roadway Stream Crossings (#)	Roadways Segments (miles)	Agricultural Areas (sqmi)	Critical Facilities (#)	
1	Andrews	1,231	--	--	--	--	--	--	--	--
2	Borden	851	--	--	--	--	--	--	--	--
3	Cochran	450	--	--	--	--	--	--	--	--
4	Coke	928	--	--	--	--	--	--	--	--
5	Coleman	18	--	--	--	--	--	--	--	--
6	Concho	476	--	--	--	--	--	--	--	--
7	Crockett	76	--	--	--	--	--	--	--	--
8	Dawson	898	--	--	--	--	--	--	--	--
9	Ector	620	--	--	--	--	--	--	--	--
10	Gaines	1,502	--	--	--	--	--	--	--	--
11	Garza	9	--	--	--	--	--	--	--	--
12	Glasscock	901	--	--	--	--	--	--	--	--
13	Hockley	95	--	--	--	--	--	--	--	--
14	Howard	904	--	--	--	--	--	--	--	--
15	Irion	1,052	--	--	--	--	--	--	--	--
16	Lynn	218	--	--	--	--	--	--	--	--
17	Martin	916	--	--	--	--	--	--	--	--
18	Menard	1	--	--	--	--	--	--	--	--
19	Midland	895	--	--	--	--	--	--	--	--
20	Mitchell	908	--	--	--	--	--	--	--	--
21	Nolan	451	--	--	--	--	--	--	--	--
22	Reagan	1,093	--	--	--	--	--	--	--	--
23	Runnels	1,018	--	--	--	--	--	--	--	--
24	Schleicher	437	--	--	--	--	--	--	--	--
25	Scurry	516	--	--	--	--	--	--	--	--
26	Sterling	924	--	--	--	--	--	--	--	--
27	Taylor	171	--	--	--	--	--	--	--	--
28	Terry	865	--	--	--	--	--	--	--	--
29	Tom Green	1,541	--	--	--	--	--	--	--	--
30	Upton	481	--	--	--	--	--	--	--	--
31	Winkler	9	--	--	--	--	--	--	--	--
32	Yoakum	800	--	--	--	--	--	--	--	--

Commented [LPJ15]: populate

Table 5: Future Condition Flood Risk Summary Table, by County

					1% Annual Chance Flood Risk								0.2% Annual Chance Flood Risk							
#	RFPG No.	RFPG Name	County	Area in Flood Planning Region (sqmi)	Area in Floodplain (sqmi)	Number of Structures in Floodplain	Residential Structures in Floodplain	Population	Roadway Stream Crossings (#)	Roadways Segments (miles)	Agricultural Areas (sqmi)	Critical Facilities (#)	Area in Floodplain (sqmi)	Number of Structures in Floodplain	Residential Structures in Floodplain	Population	Roadway Stream Crossings (#)	Roadways Segments (miles)	Agricultural Areas (sqmi)	Critical Facilities (#)
1	9	Upper Colorado	Andrews	1,226	329	0	0	0	0	173.2	12.17	0	114	0	0	0	0	61.13	4.72	0
2	9	Upper Colorado	Borden	848	169	70	9	20	32	26.08	16.36	0	29	45	5	24	2	10.85	5.54	0
3	9	Upper Colorado	Cochran	449	100	23	12	53	0	142.49	24.39	0	37	7	3	9	0	27.35	9.43	0
4	9	Upper Colorado	Coke	924	172	252	110	130	58	55.41	8.47	0	23	204	87	241	7	11.8	2.65	0
5	9	Upper Colorado	Coleman	17	2	6	1	1	1	0.25	0.04	0	0	0	0	0	0	0.11	0.01	0
6	9	Upper Colorado	Concho	474	91	106	52	79	25	23.89	19.4	0	17	84	31	70	2	9.71	5.74	0
7	9	Upper Colorado	Crockett	76	11	0	0	0	0	0.7	0.01	0	2	1	0	1	0	0.09	0.001	0
8	9	Upper Colorado	Dawson	895	196	738	10	1153	3	563.34	126.48	1	72	1749	5	3578	0	159.2	51.59	0
9	9	Upper Colorado	Ector	618	161	597	366	595	0	404.4	0	1	89	189	137	250	0	386.02	0	0
10	9	Upper Colorado	Gaines	1,498	432	0	0	0	0	434.38	227.01	0	133	0	0	0	0	129.97	70.79	0
11	9	Upper Colorado	Garza	9	1	0	0	0	0	0	0.001	0	0	0	0	0	0	0	2.055E-05	0
12	9	Upper Colorado	Glasscock	897	166	145	3	78	6	33.84	39.42	0	47	64	2	46	4	19.09	18.26	0
13	9	Upper Colorado	Hockley	95	15	47	21	854	0	42.33	2.1	2	7	48	20	50	0	10.76	0.83	0
14	9	Upper Colorado	Howard	901	184	1408	686	4031	74	196.2	55.42	0	43	914	608	2521	13	70.28	17.18	1
15	9	Upper Colorado	Irion	1,047	209	360	104	239	24	47.82	3.85	0	24	128	44	71	6	9.02	0.57	0
16	9	Upper Colorado	Lynn	217	51	341	205	355	0	152.08	36.84	1	18	68	50	92	0	24.14	13.25	0
17	9	Upper Colorado	Martin	912	235	932	457	2047	4	232.81	30.73	5	118	545	183	621	2	79.52	9.93	0
18	9	Upper Colorado	Menard	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	9	Upper Colorado	Midland	891	212	13027	8955	35631	69	388.05	0	37	175	41695	31675	106563	48	751.41	0	180
20	9	Upper Colorado	Mitchell	905	172	352	211	738	101	107.48	26.11	2	29	355	255	486	7	28.76	5.88	0
21	9	Upper Colorado	Nolan	450	69	92	16	28	20	20.94	6.07	0	8	10	1	1	3	5.4	1.16	0
22	9	Upper Colorado	Reagan	1,087	191	167	80	217	11	38.91	20.8	0	60	144	75	180	0	31.32	13.76	0
23	9	Upper Colorado	Runnels	1,014	201	165	41	179	93	124.78	61.28	1	35	71	9	58	11	32.9	17.22	0
24	9	Upper Colorado	Schleicher	434	65	101	40	191	9	16.63	1.97	0	8	55	40	43	1	4.49	0.54	0
25	9	Upper Colorado	Scurry	513	85	619	334	1757	87	76.03	18.28	1	14	119	78	169	9	15.38	4.45	0
26	9	Upper Colorado	Sterling	919	162	184	100	182	25	29.68	3.58	0	19	78	37	42	5	9.07	0.58	0
27	9	Upper Colorado	Taylor	170	33	71	52	48	12	17.77	5.46	0	4	23	15	19	2	5.5	1.26	0
28	9	Upper Colorado	Terry	863	203	506	192	1113	4	633.13	131.47	0	59	326	150	578	0	104.87	39.62	0
29	9	Upper Colorado	Tom Green	1,534	362	7417	4810	16618	185	318.19	92.15	42	117	16442	12694	43395	63	430.54	45.62	53
30	9	Upper Colorado	Upton	478	100	41	16	23	0	34.07	0	0	51	23	3	12	0	11.18	0	0
31	9	Upper Colorado	Winkler	9	1	9	1.27	0	0	0	0	0	1	0	0	0	0	0	0	0
32	9	Upper Colorado	Yoakum	798	235	559	271	827	0	290.23	99.47	0	68	180	98	281	0	61.92	24.77	0

Table 5: Future Condition Flood Risk Summary Table, by County (continued)

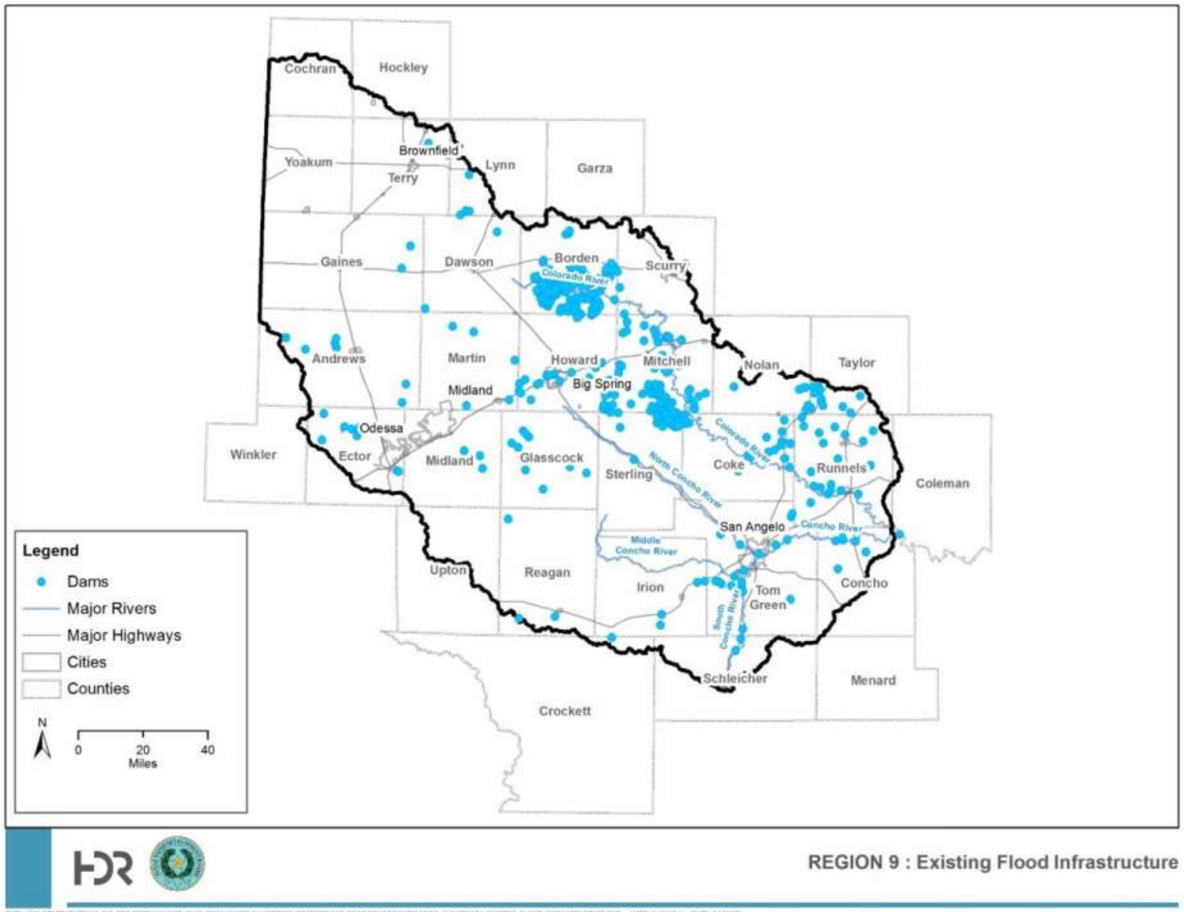
#	County	Area in Flood Planning Region (sqmi)	Possible Flood-Prone Areas							Average SVI of features in floodplain or flood prone areas
			Area (sqmi)	Number of Structures in Flood-Prone Area	Population	Roadway Stream Crossings (#)	Roadways Segments (miles)	Agricultural Areas (sqmi)	Critical Facilities (#)	
1	Andrews	1,226	--	--	--	--	--	--	--	--
2	Borden	848	--	--	--	--	--	--	--	--
3	Cochran	449	--	--	--	--	--	--	--	--
4	Coke	924	--	--	--	--	--	--	--	--
5	Coleman	17	--	--	--	--	--	--	--	--
6	Concho	474	--	--	--	--	--	--	--	--
7	Crockett	76	--	--	--	--	--	--	--	--
8	Dawson	895	--	--	--	--	--	--	--	--
9	Ector	618	--	--	--	--	--	--	--	--
10	Gaines	1,498	--	--	--	--	--	--	--	--
11	Garza	9	--	--	--	--	--	--	--	--
12	Glasscock	897	--	--	--	--	--	--	--	--
13	Hockley	95	--	--	--	--	--	--	--	--
14	Howard	901	--	--	--	--	--	--	--	--
15	Irion	1,047	--	--	--	--	--	--	--	--
16	Lynn	217	--	--	--	--	--	--	--	--
17	Martin	912	--	--	--	--	--	--	--	--
18	Menard	1	--	--	--	--	--	--	--	--
19	Midland	891	--	--	--	--	--	--	--	--
20	Mitchell	905	--	--	--	--	--	--	--	--
21	Nolan	450	--	--	--	--	--	--	--	--
22	Reagan	1,087	--	--	--	--	--	--	--	--
23	Runnels	1,014	--	--	--	--	--	--	--	--
24	Schleicher	434	--	--	--	--	--	--	--	--
25	Scurry	513	--	--	--	--	--	--	--	--
26	Sterling	919	--	--	--	--	--	--	--	--
27	Taylor	170	--	--	--	--	--	--	--	--
28	Terry	863	--	--	--	--	--	--	--	--
29	Tom Green	1,534	--	--	--	--	--	--	--	--
30	Upton	478	--	--	--	--	--	--	--	--
31	Winkler	9	--	--	--	--	--	--	--	--
32	Yoakum	798	--	--	--	--	--	--	--	--

Project Details Scoring Summary Table

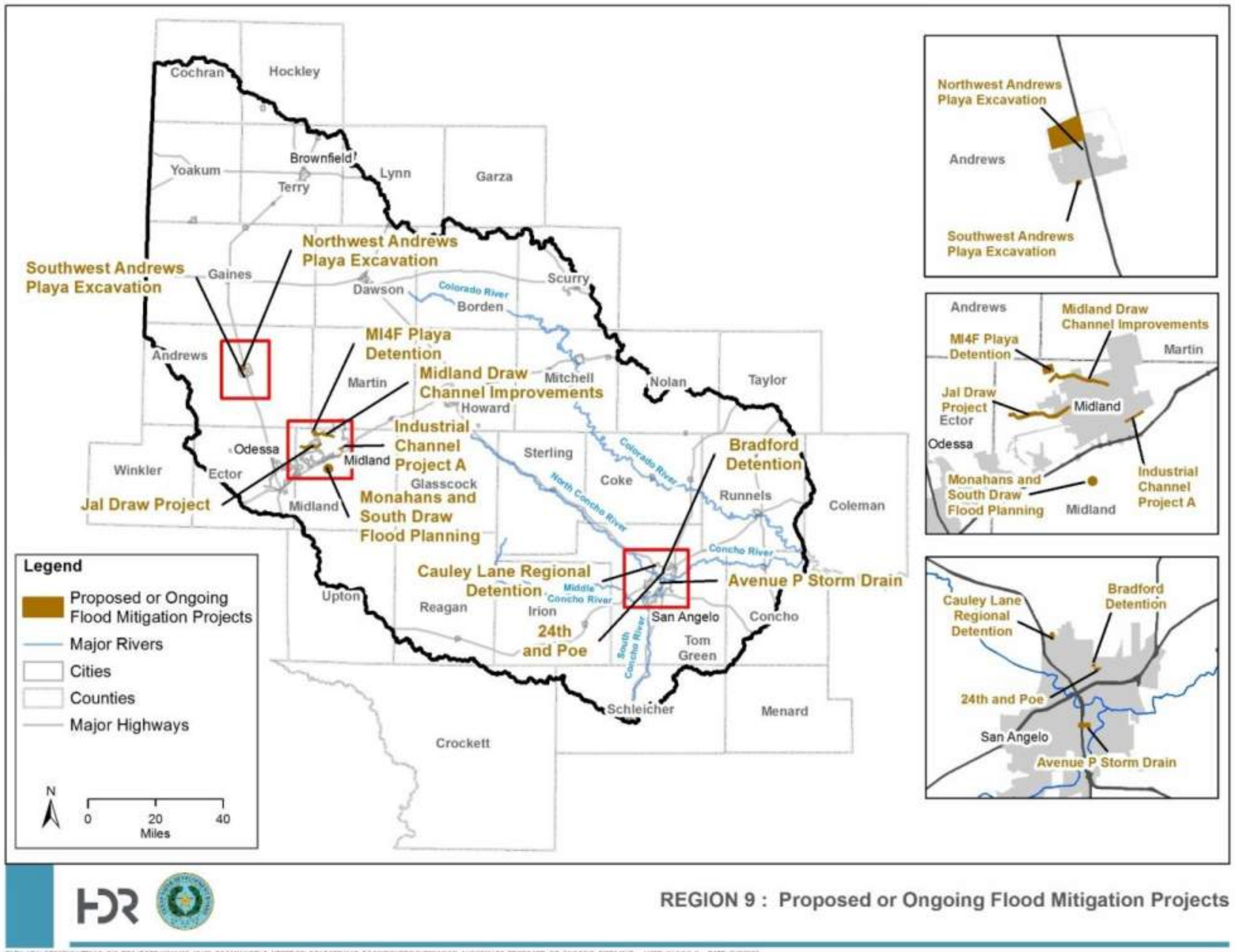
Project	Severity Ranking: Pre-Project Average Depth of Flooding (100-year)	Severity Ranking: Community Need (% Population)	Flood Risk Reduction	Flood Damage Reduction	Reduction in Critical Facilities Flood Risk	Life and Safety Ranking (Injury/Loss of life)	Water Supply Yield Ranking	Social Vulnerability Ranking	Nature-Based Solutions Ranking	Multiple Benefit Ranking	Operations and Maintenance Ranking	Administrative, Regulatory and Other Obstacle Ranking	Environmental Benefit Ranking	Environmental Impact Ranking	Mobility Ranking	Total Score
Avenue P Storm Drain - Construct 2900 LF of 8' x 8' box culverts under Avenue P from Bryant BLVD to Chadbourne St-Red Arroyo.	6	1	4	4	0	10	4	7	1	4	10	6	3	10	4	74
Cauley Lane Regional Detention - The proposed project includes a 21-ac regional detention pond that is pumped to O.C. Fisher Reservoir.	2	4	4	6	4	2	4	1	1	0	7	6	3	10	4	58
Bradford Detention - The proposed project includes a 12-ac regional detention pond along the overflow path to East Angelo Draw.	2	4	0	6	7	2	4	1	1	0	7	6	3	10	4	57
24th and Poe - The proposed project includes intersection and channel improvements.	2	4	0	6	7	2	0	1	1	0	10	6	3	10	4	56
Jal Draw Project - Proposed channel has two major reaches, one with top width of 250' from loop 349 to SH 158, and one with top width of 500' which includes crossings at Crowley Road and Holiday Hill Road. In first reach are two existing crossings and six proposed crossings. In second reach, proposed channel will be improved but both existing crossings will remain.	6	4	7	8	4	10	4	4	1	10	10	6	6	10	7	97
Industrial Channel Project A - Channel improvements are planned for Industrial Channel beginning at channel's confluence with Midland Draw south of U.S. Hwy 80 (Bus 20) at Station 0+00 and ending at point downstream of Lamesa Rd at Station 87+56. Maintenance and slight shaping of existing channel is proposed for channel station's 18+80 to 26+15. Proposed improvements include excavation of existing channel, new culverts, and proposed extension of channel.	8	1	10	10	10	10	4	10	1	7	10	6	6	10	10	113
City of Andrews Southwest Andrews Playa Excavation - Proposed excavation in playa located South of FM 1910 and East of new SW Mustang Dr. Approximate 183,000 cu-yd. of removed earth material. Project aims to maintain existing floodplain to account for anticipated development.	10	7	10	4	7	8	4	1	10	4	10	6	10	10	10	111
City of Andrews Northwest Andrews Playa Excavation - Proposed excavation in playa located South of Taylor and West of new 5th Street (FM301). Approximate 53,000 cu.yd. of removed earth material. Project aims to maintain existing floodplain to account for anticipated development.	10	7	10	4	7	2	4	1	10	4	10	6	10	10	10	105

Appendix B. Maps

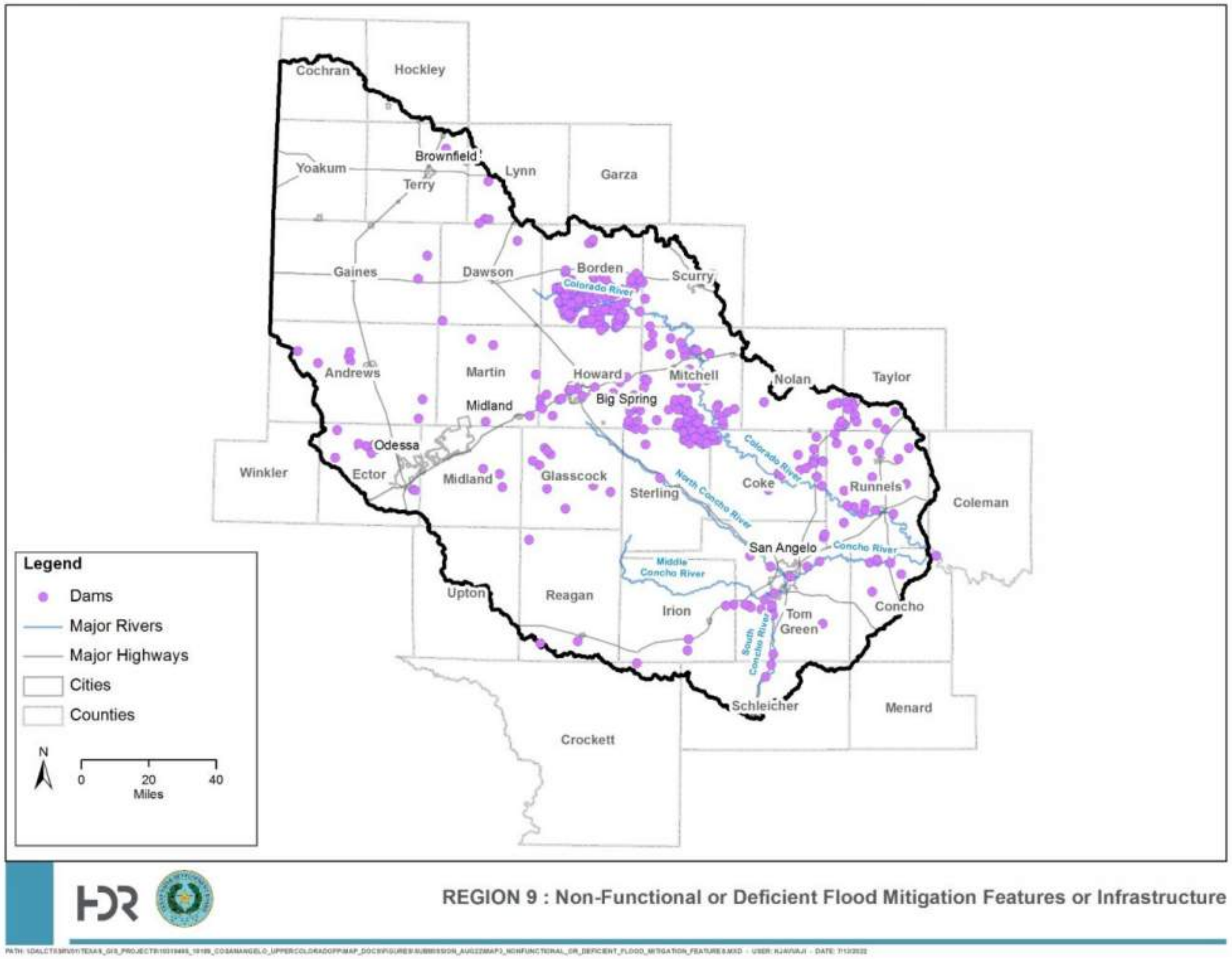
Map 1: Existing Flood Infrastructure (2.1 Task 1 – Planning Area Description)



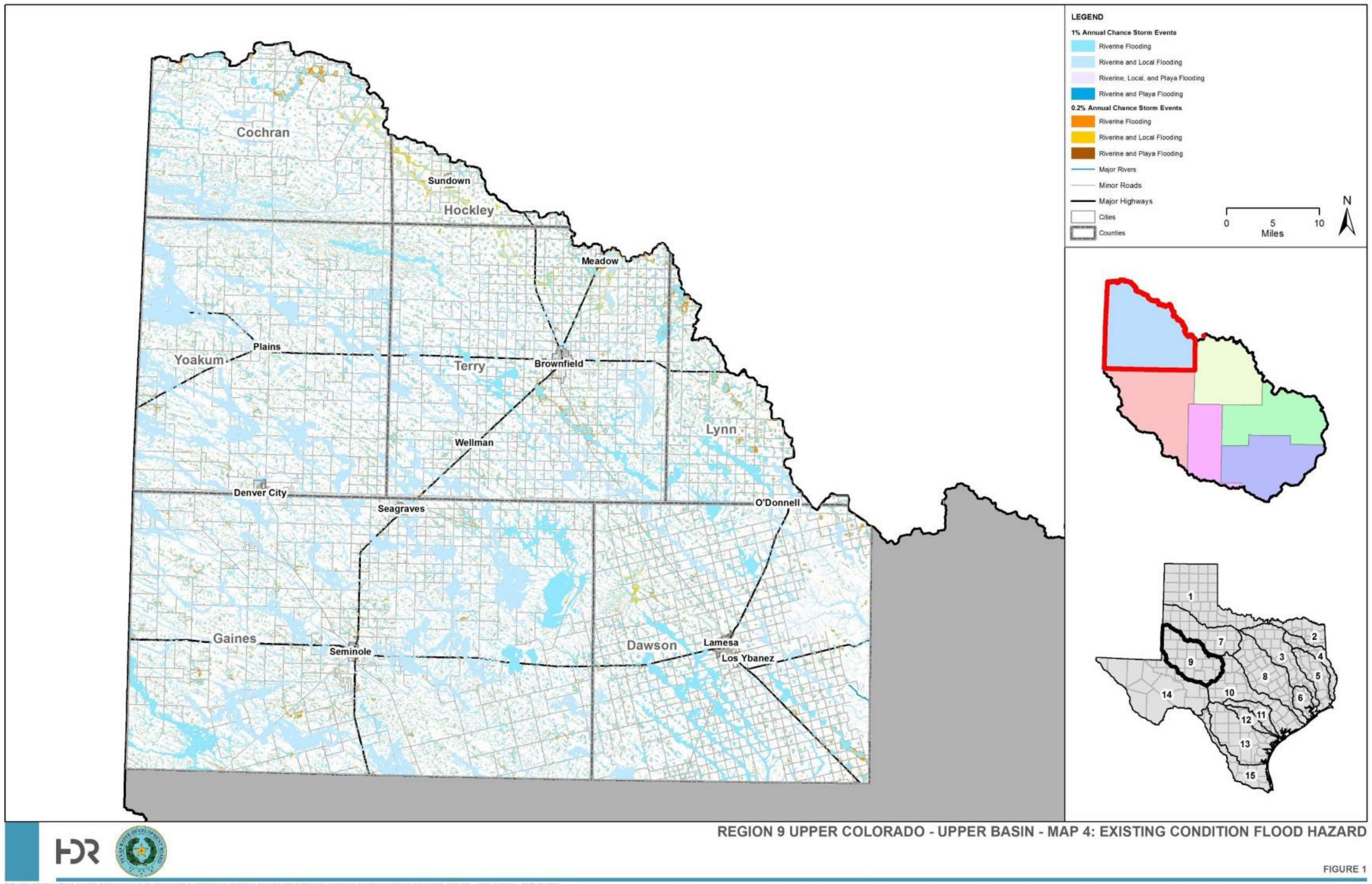
Map 2: Proposed or Ongoing Flood Mitigation Projects (2.1 Task 1 – Planning Area Description)

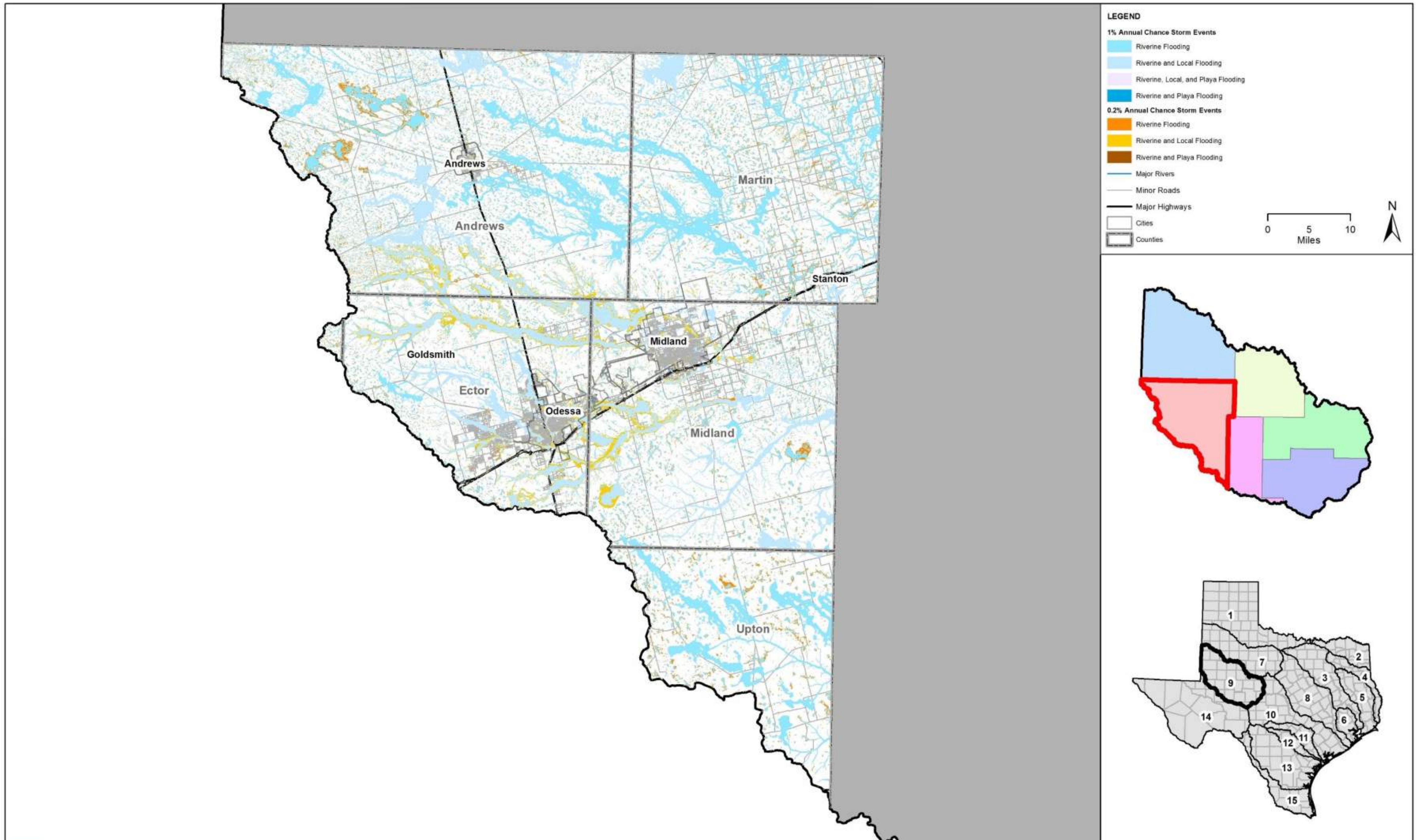


Map 3: Non-Functional or Deficient Flood Mitigation Features or Infrastructure (2.1 Task 1 – Planning Area Description)



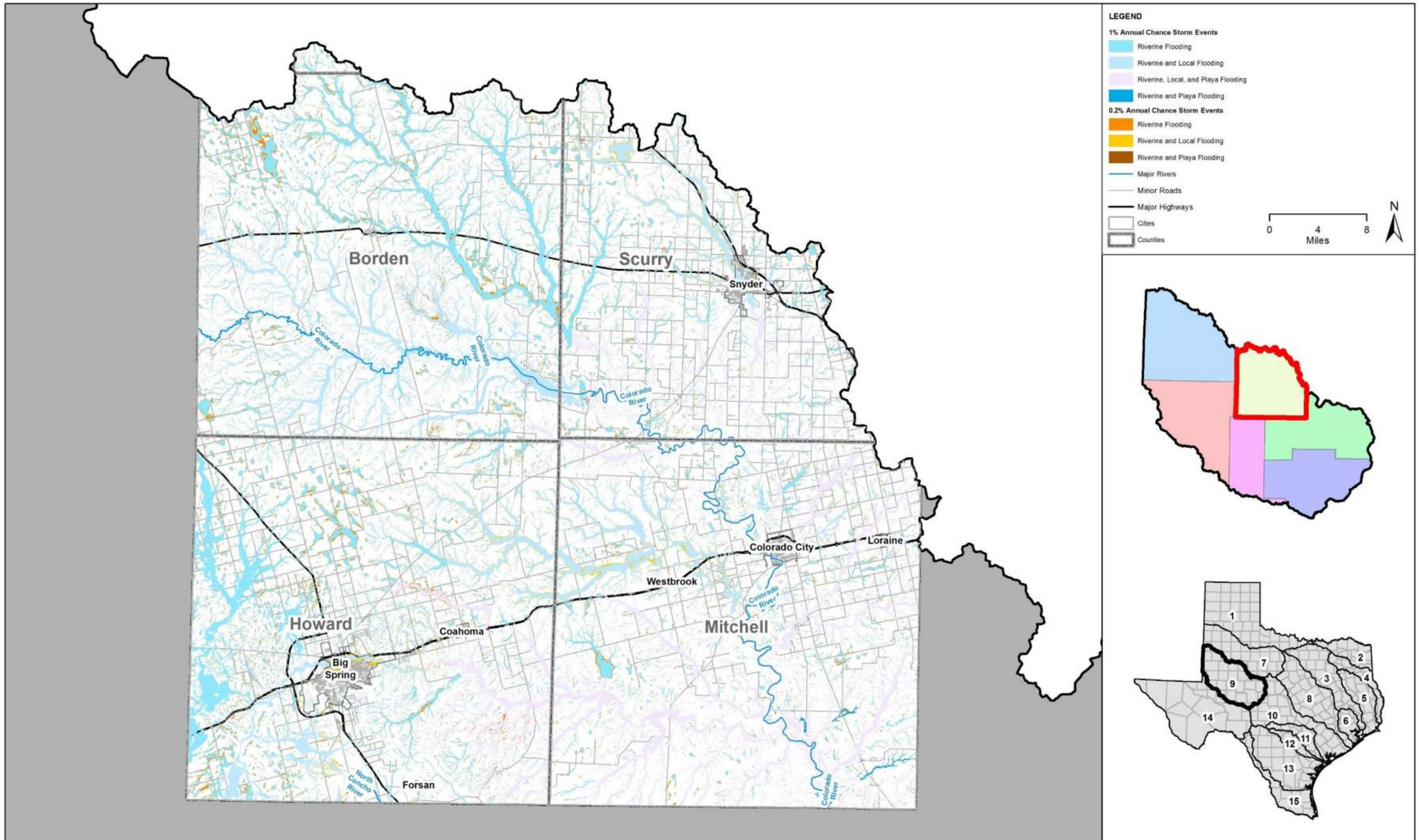
Map 4: Existing Condition Flood Hazard (2.2.A.1 Existing condition flood hazard analysis)





REGION 9 UPPER COLORADO - UPPER MID BASIN - MAP 4: EXISTING CONDITION FLOOD HAZARD

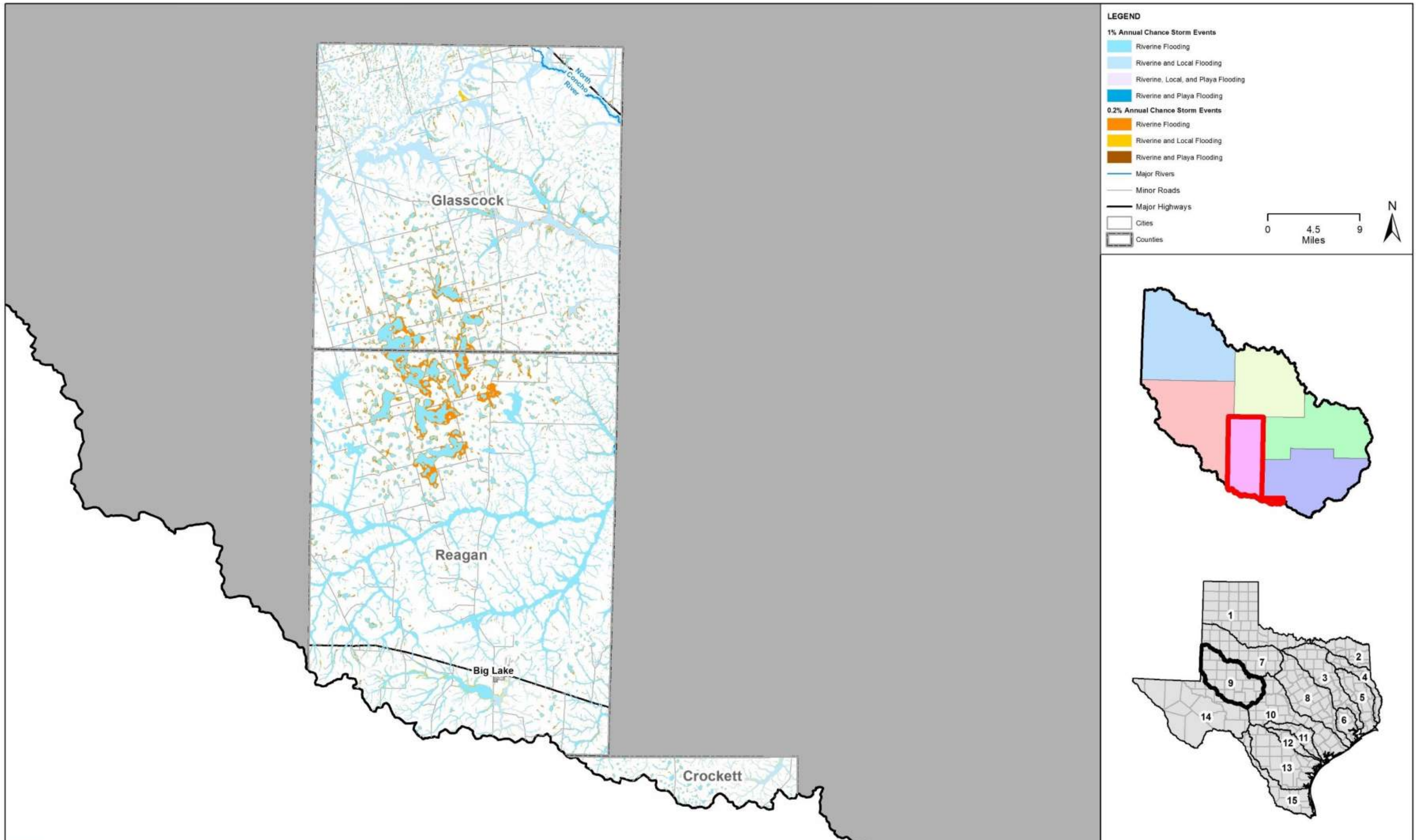
FIGURE 2



REGION 9 UPPER COLORADO - MID UPPER BASIN - MAP 4: EXISTING CONDITION FLOOD HAZARD

FIGURE 3

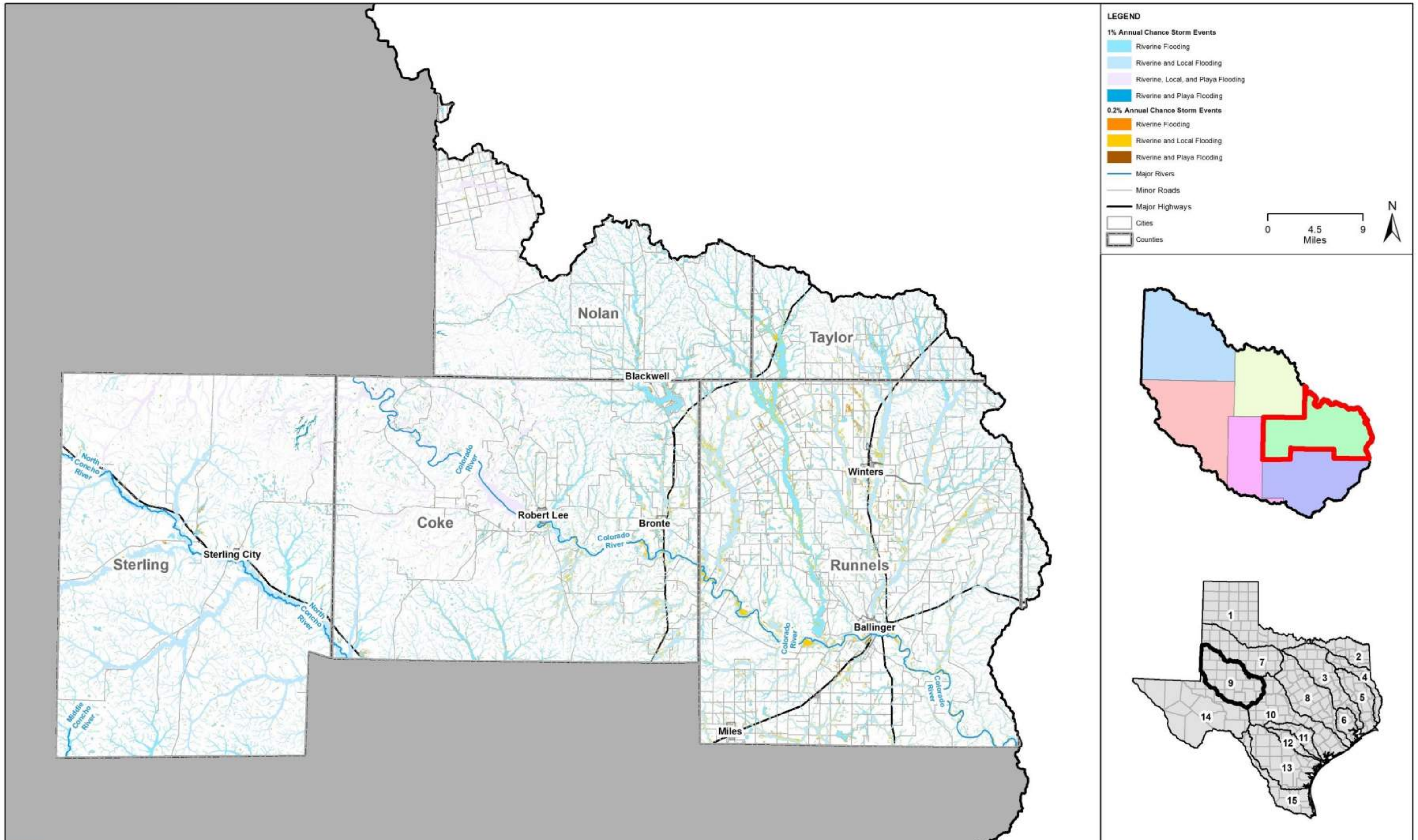
PATH: \\DALCTXSRV01\TEXAS_GIS_PROJECTS\10310495_10189_COSANANGELO_UPPERCOLORADOFP\MAP_DOCS\FIGURES\SUBMISSION_AUG22\MAP4EXISTINGCONDITIONFLOODHAZARD_SA22.MXD - USER: KJAVVAJI - DATE: 7/14/2022



REGION 9 UPPER COLORADO - MID LOWER BASIN - MAP 4: EXISTING CONDITION FLOOD HAZARD

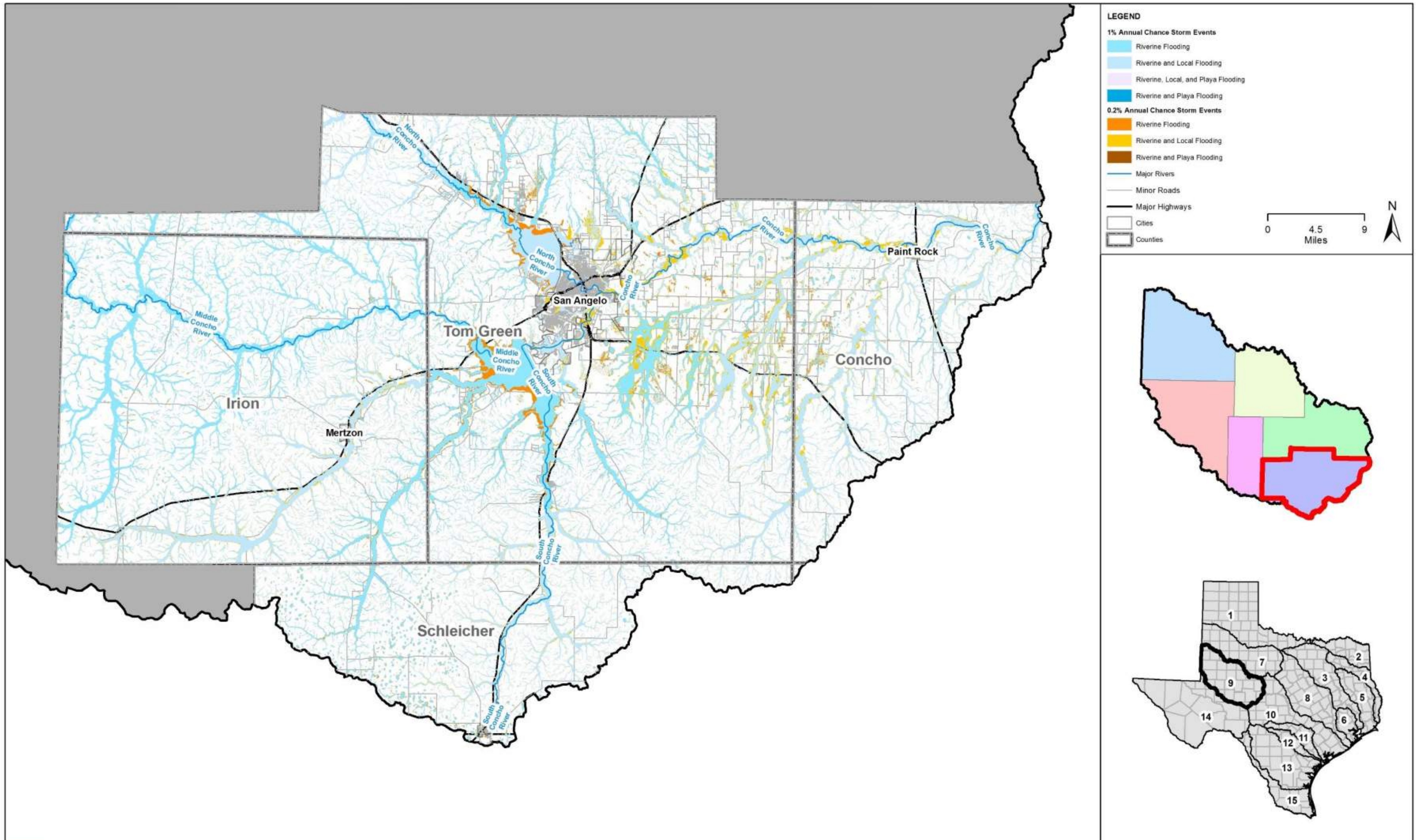
FIGURE 4

PATH: \\DALCTXSRV01\TEXAS_GIS_PROJECTS\10310495_10189_COSANANGELO_UPPERCOLORADOFP\MAP_DOCS\FIGURES\SUBMISSION_AUG22\MAP4EXISTINGCONDITIONFLOODHAZARD_SA22.MXD - USER: KJAVVAJI - DATE: 7/14/2022



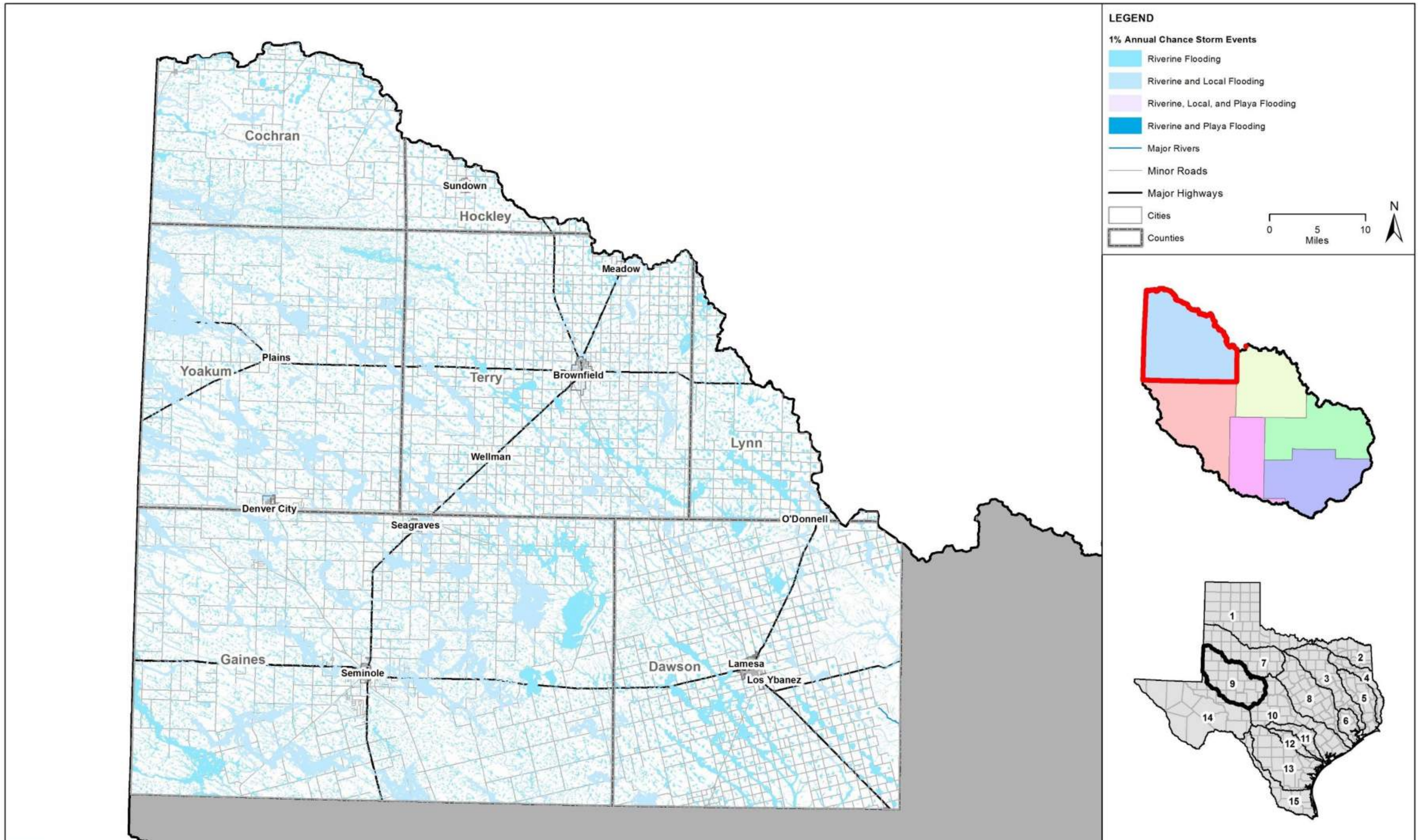
REGION 9 UPPER COLORADO - LOWER MID BASIN - MAP 4: EXISTING CONDITION FLOOD HAZARD

FIGURE 5



REGION 9 UPPER COLORADO - LOWER BASIN - MAP 4: EXISTING CONDITION FLOOD HAZARD

FIGURE 6



REGION 9 UPPER COLORADO - UPPER BASIN - MAP 4: EXISTING CONDITION FLOOD HAZARD

FIGURE 1

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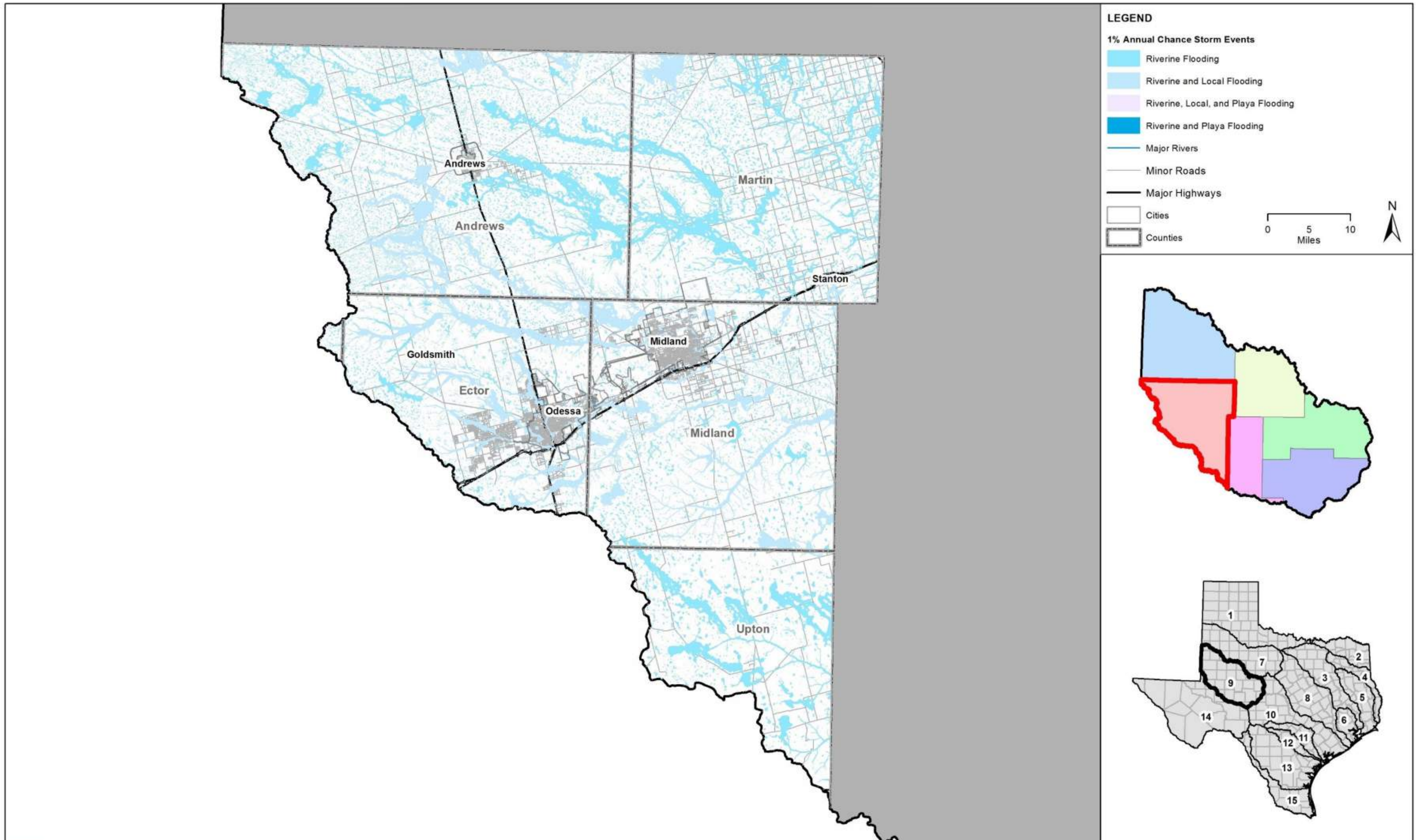
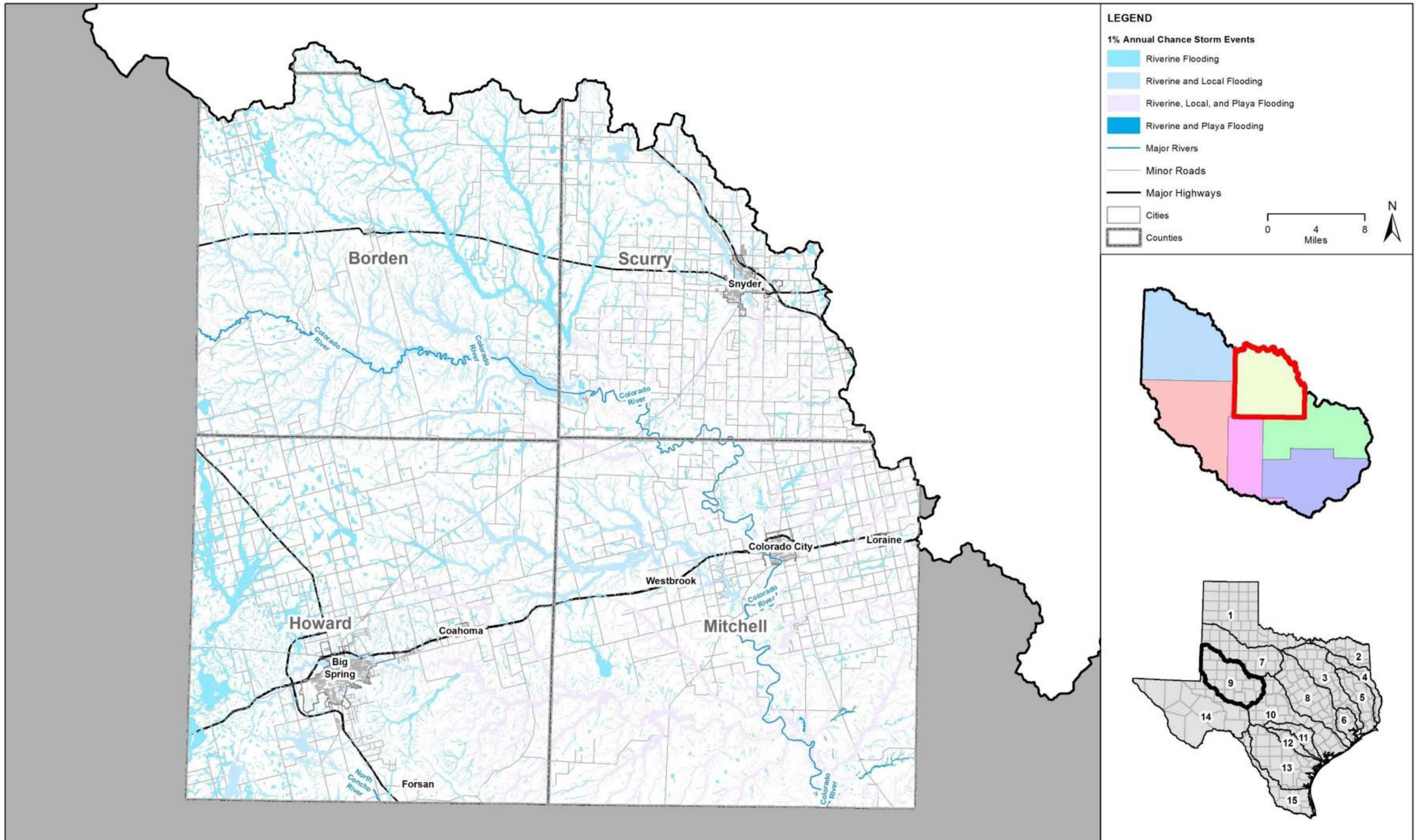


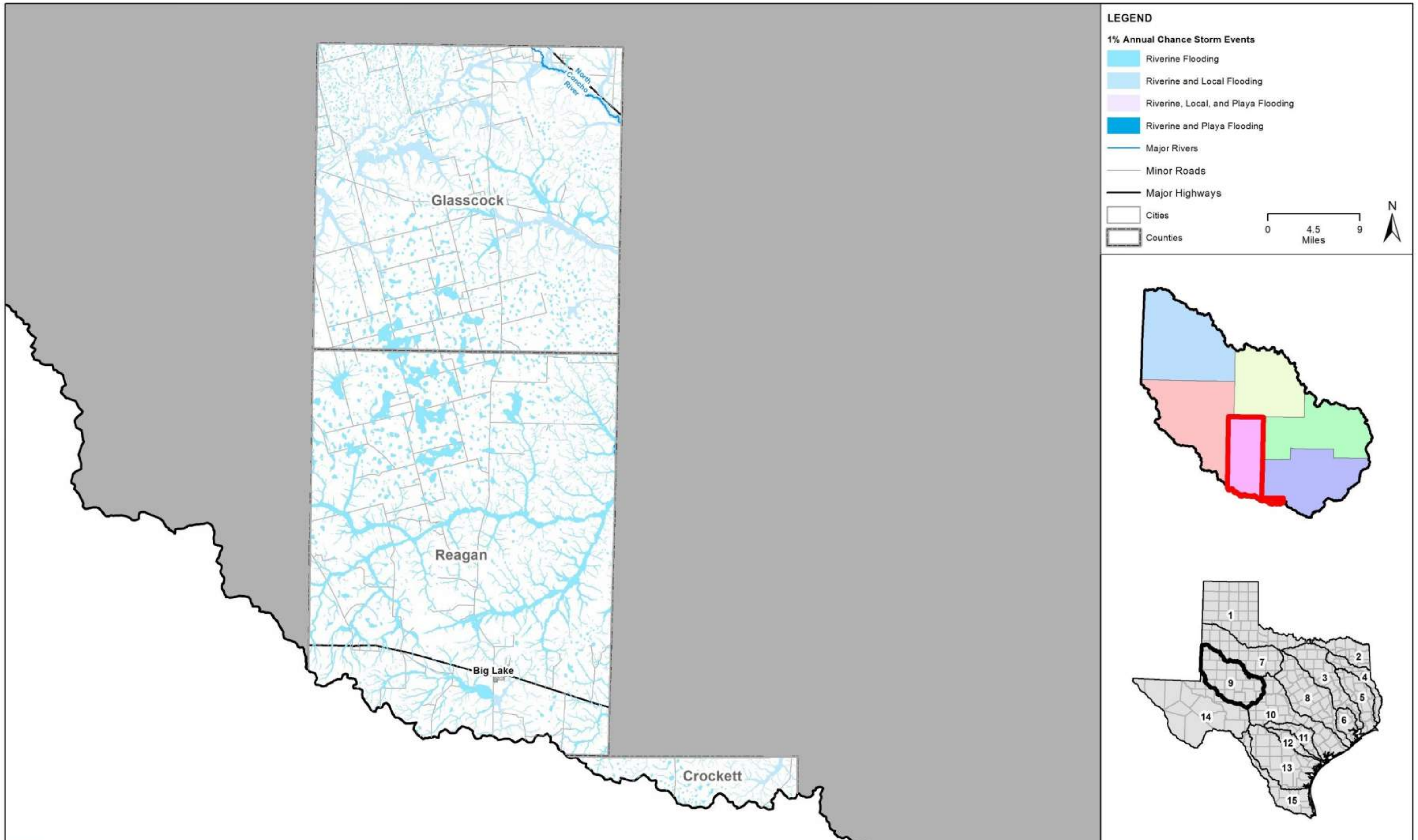
REGION 9 UPPER COLORADO - UPPER MID BASIN - MAP 4: EXISTING CONDITION FLOOD HAZARD

FIGURE 2



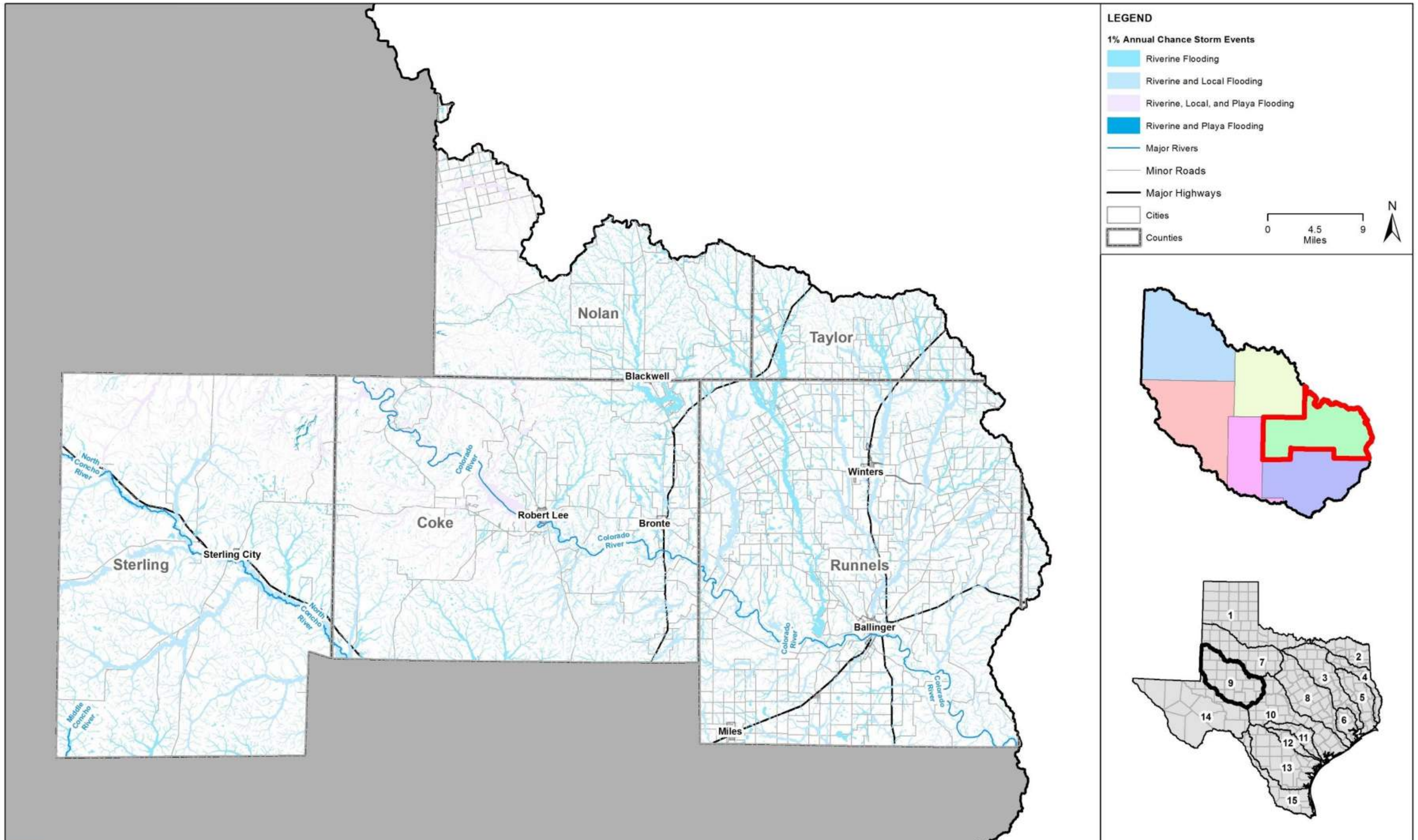
REGION 9 UPPER COLORADO - MID UPPER BASIN - MAP 4: EXISTING CONDITION FLOOD HAZARD

FIGURE 3



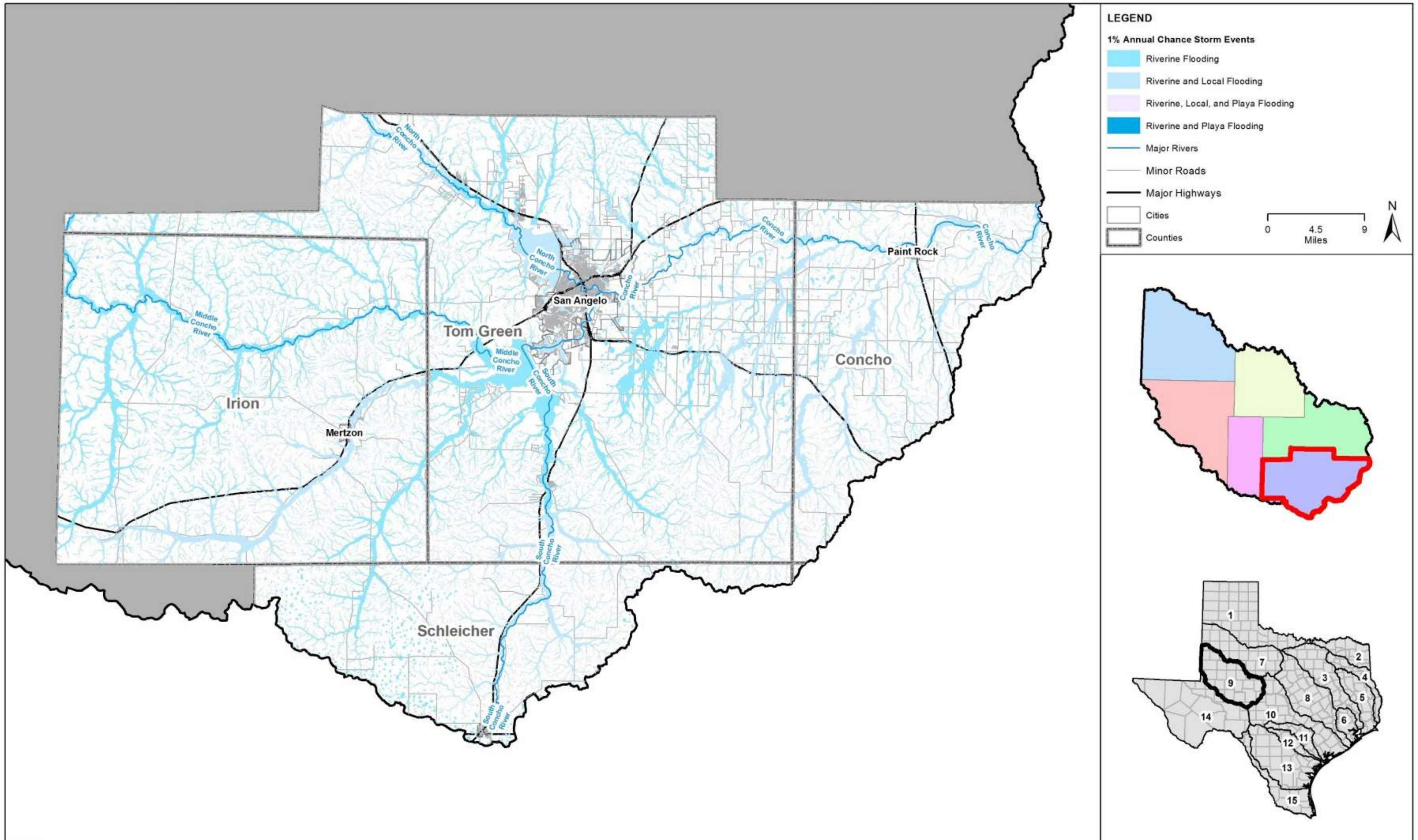
REGION 9 UPPER COLORADO - MID LOWER BASIN - MAP 4: EXISTING CONDITION FLOOD HAZARD

FIGURE 4



REGION 9 UPPER COLORADO - LOWER MID BASIN - MAP 4: EXISTING CONDITION FLOOD HAZARD

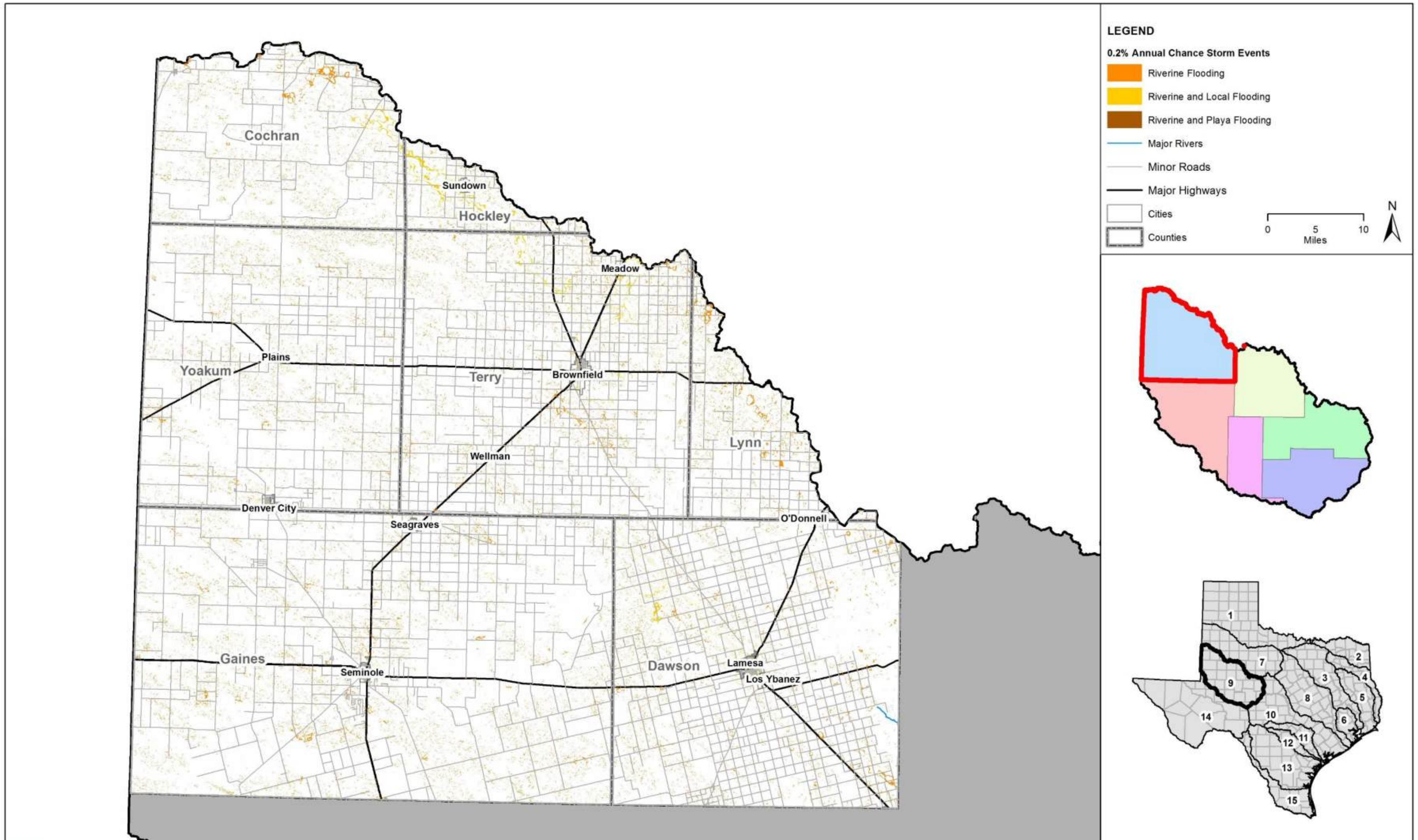
FIGURE 5



REGION 9 UPPER COLORADO - LOWER BASIN - MAP 4: EXISTING CONDITION FLOOD HAZARD

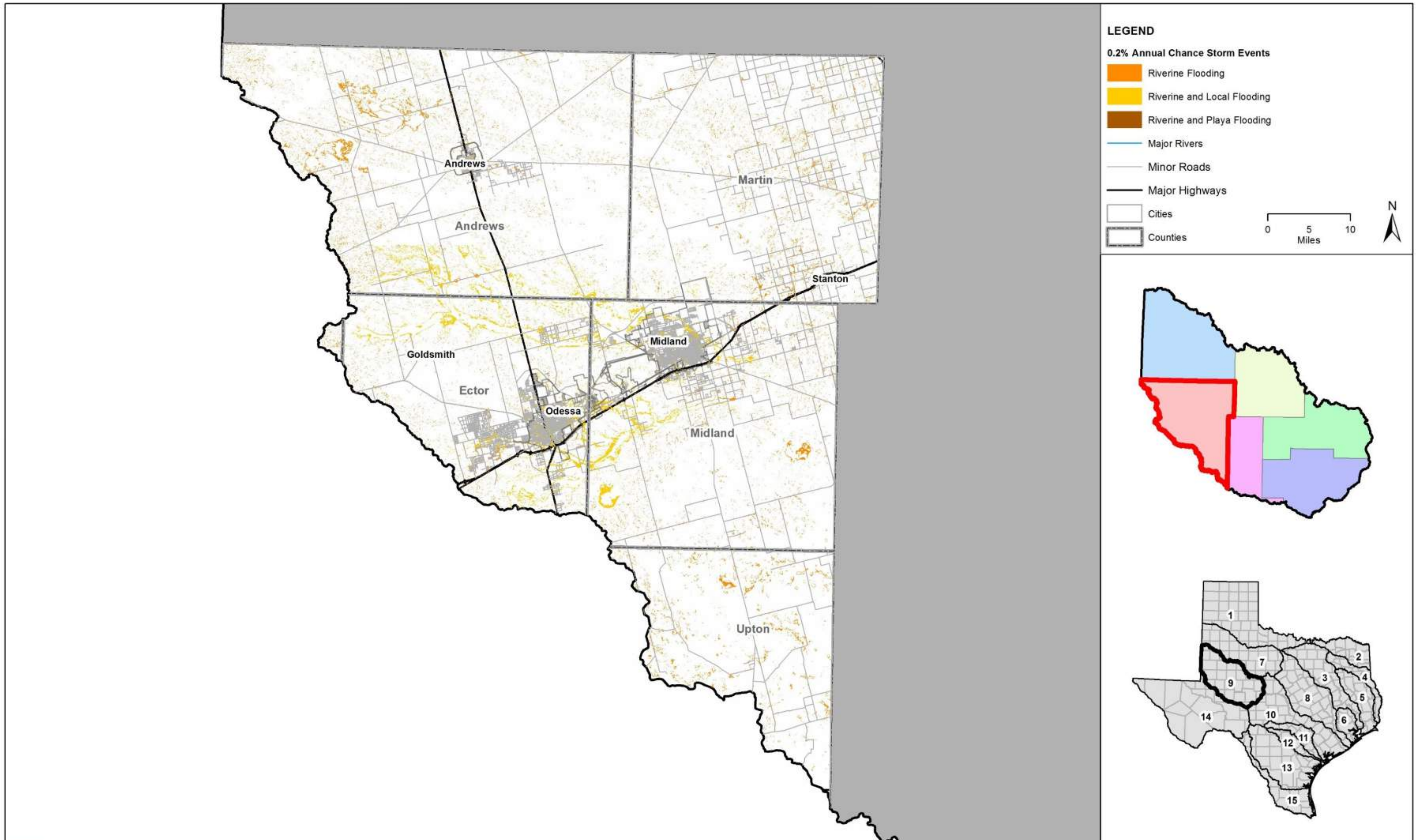
FIGURE 6

PATH: \\DALCTXSRV01\TEXAS_GIS_PROJECTS\10310495_10189_COSANANGELO_UPPERCOLORADOFP\MAP_DOCS\FIGURES\SUBMISSION_AUG22\MAP4EXISTINGCONDITIONFLOODHAZARD_SA22.MXD - USER: KJAVVAJI - DATE: 7/14/2022



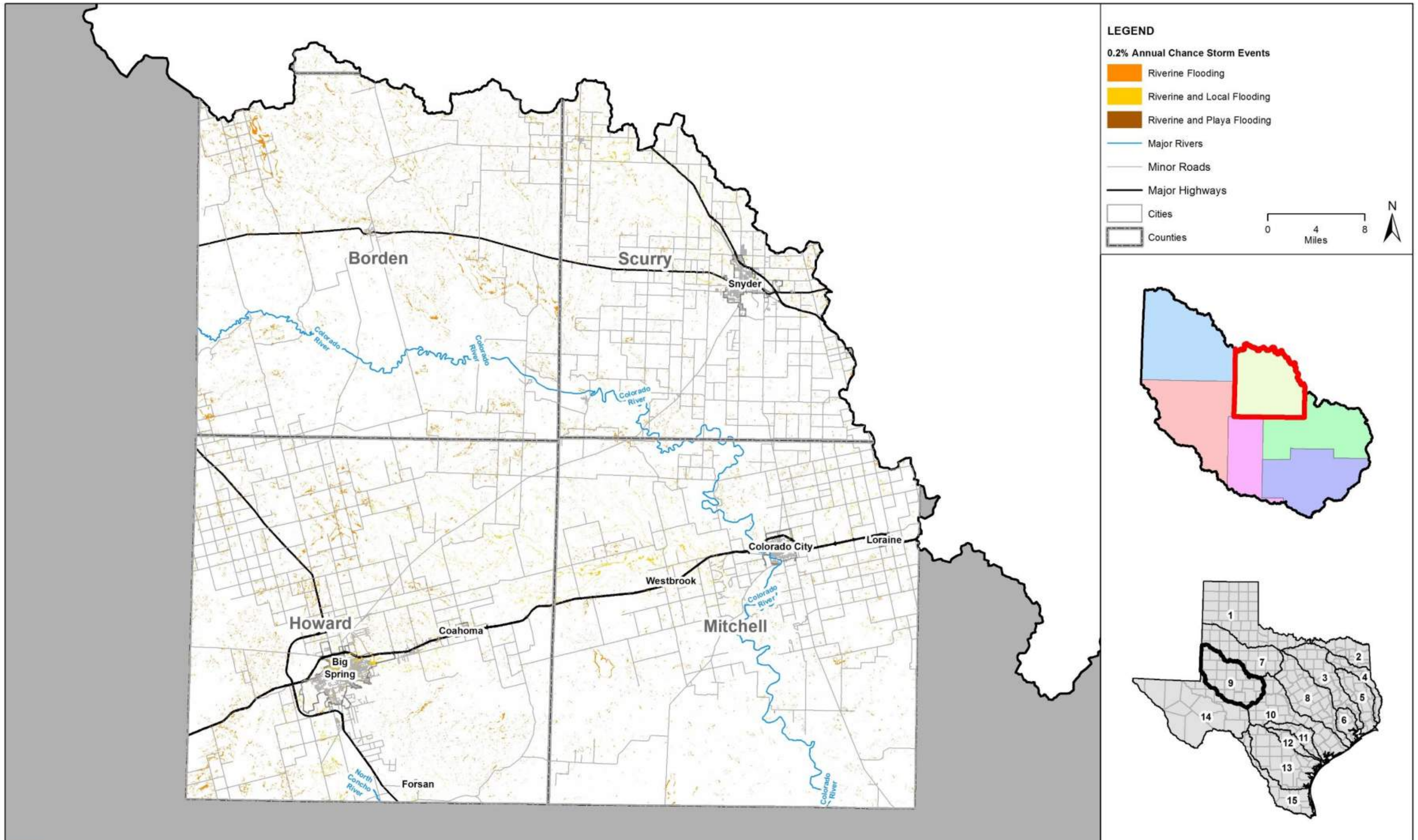
REGION 9 UPPER COLORADO - UPPER BASIN - MAP 4: EXISTING CONDITION FLOOD HAZARD

FIGURE 1



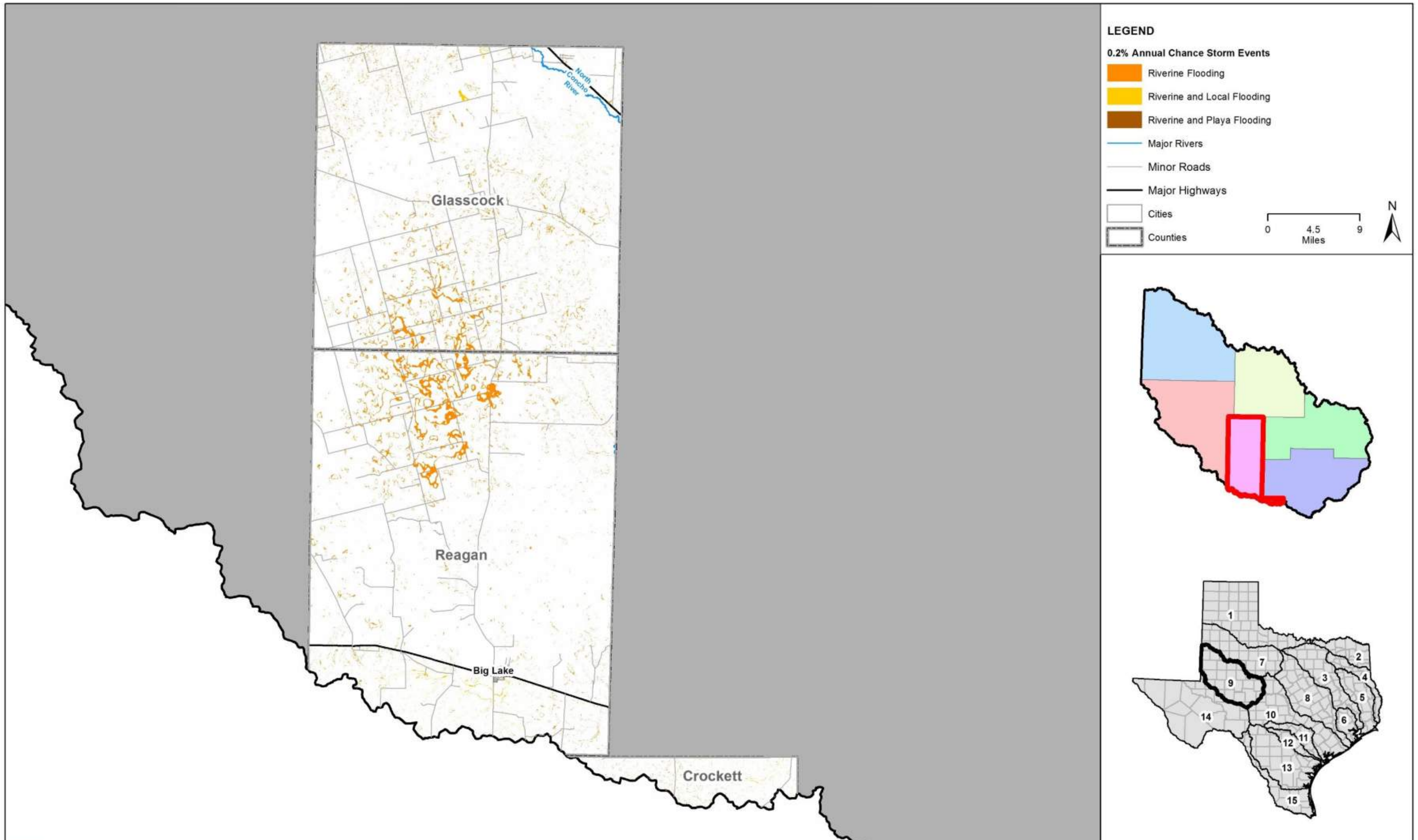
REGION 9 UPPER COLORADO - UPPER MID BASIN - MAP 4: EXISTING CONDITION FLOOD HAZARD

FIGURE 2



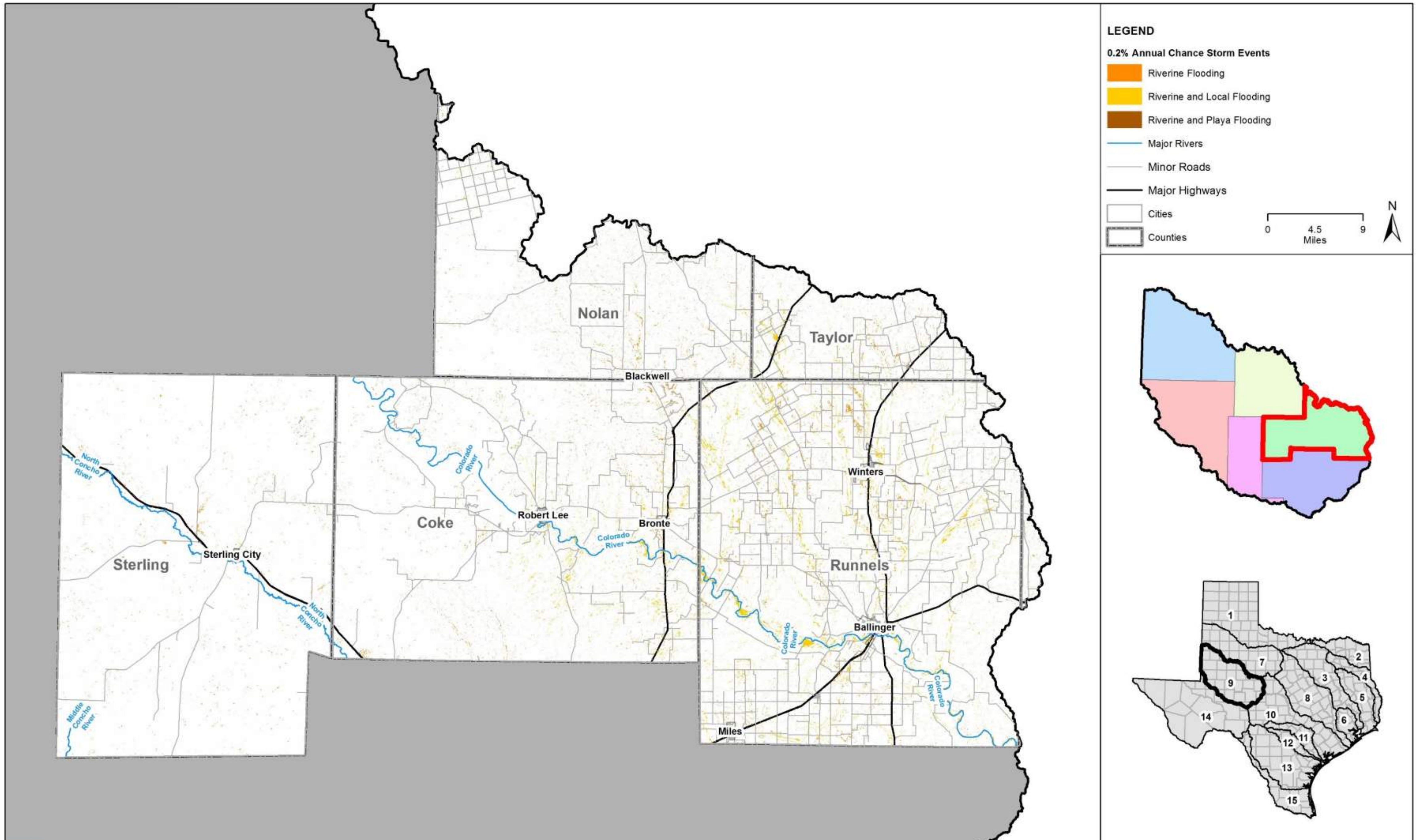
REGION 9 UPPER COLORADO - MID UPPER BASIN - MAP 4: EXISTING CONDITION FLOOD HAZARD

FIGURE 3



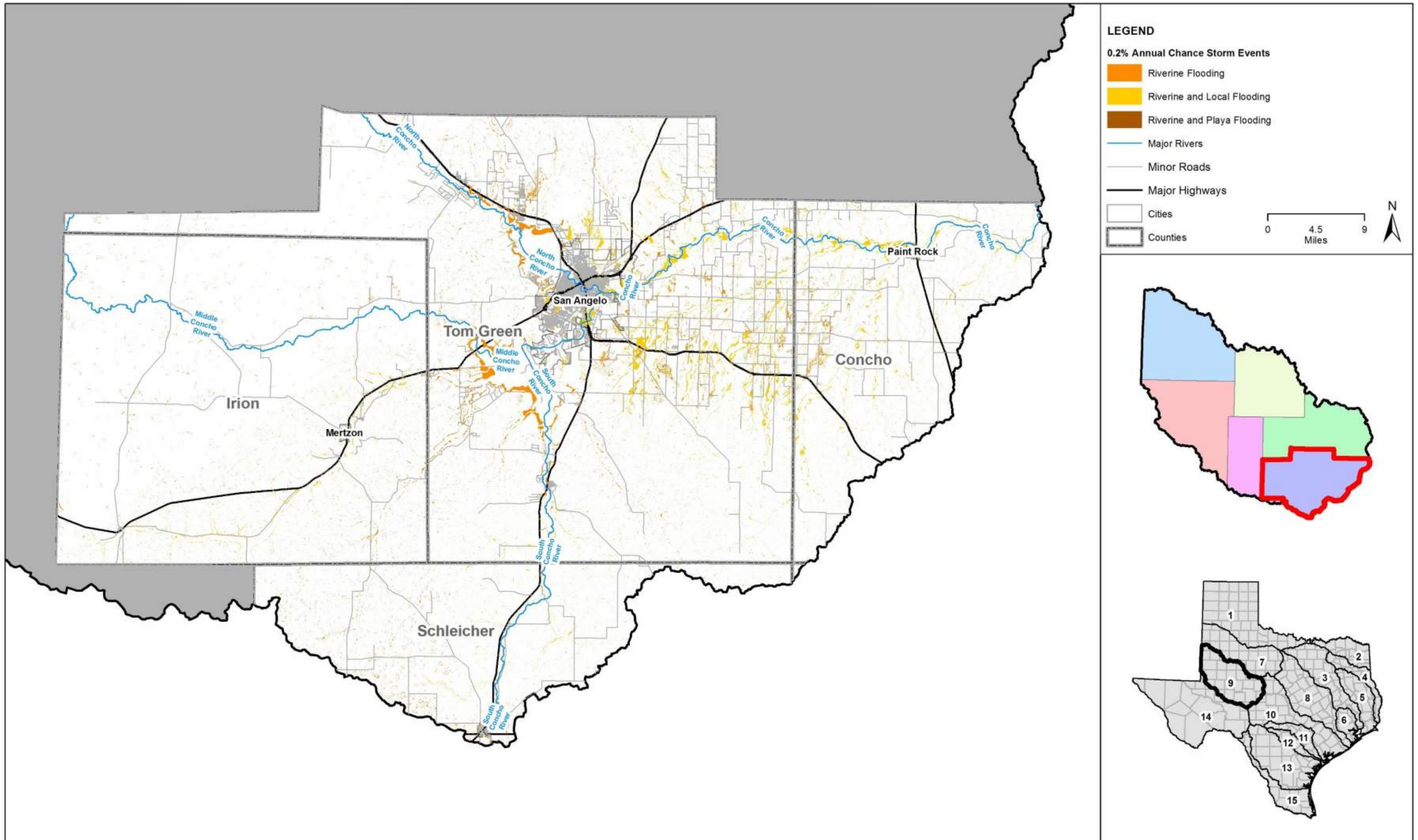
REGION 9 UPPER COLORADO - MID LOWER BASIN - MAP 4: EXISTING CONDITION FLOOD HAZARD

FIGURE 4



REGION 9 UPPER COLORADO - LOWER MID BASIN - MAP 4: EXISTING CONDITION FLOOD HAZARD

FIGURE 5

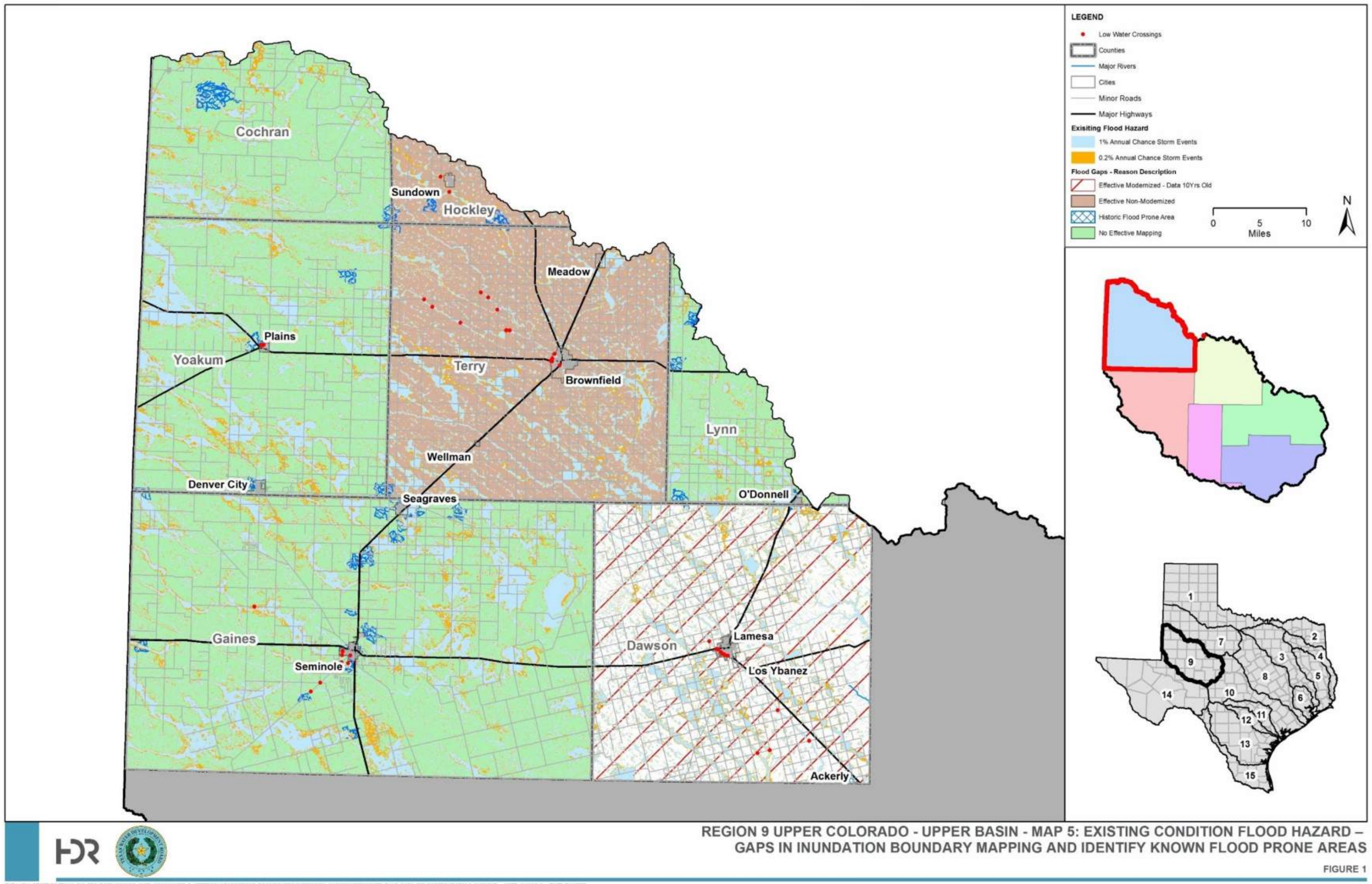


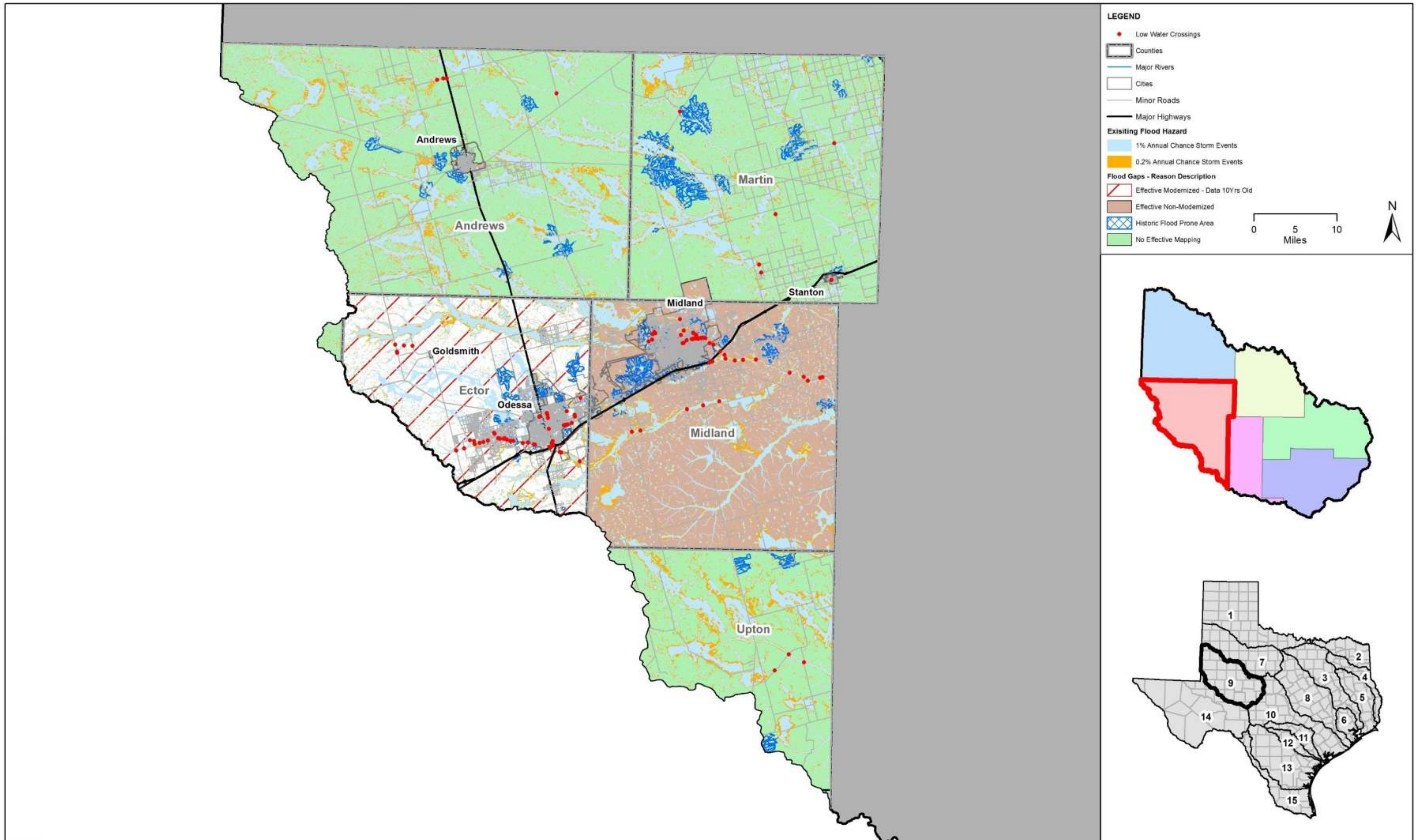
REGION 9 UPPER COLORADO - LOWER BASIN - MAP 4: EXISTING CONDITION FLOOD HAZARD

FIGURE 6

PATH: \\DALCTXSRV01\TEXAS_GIS_PROJECTS\10310495_10189_COSANANGELO_UPPERCOLORADOFP\MAP_DOCS\FIGURES\SUBMISSION_AUG22\MAP4EXISTINGCONDITIONFLOODHAZARD_SA22.MXD - USER: KJAVVAJI - DATE: 7/14/2022

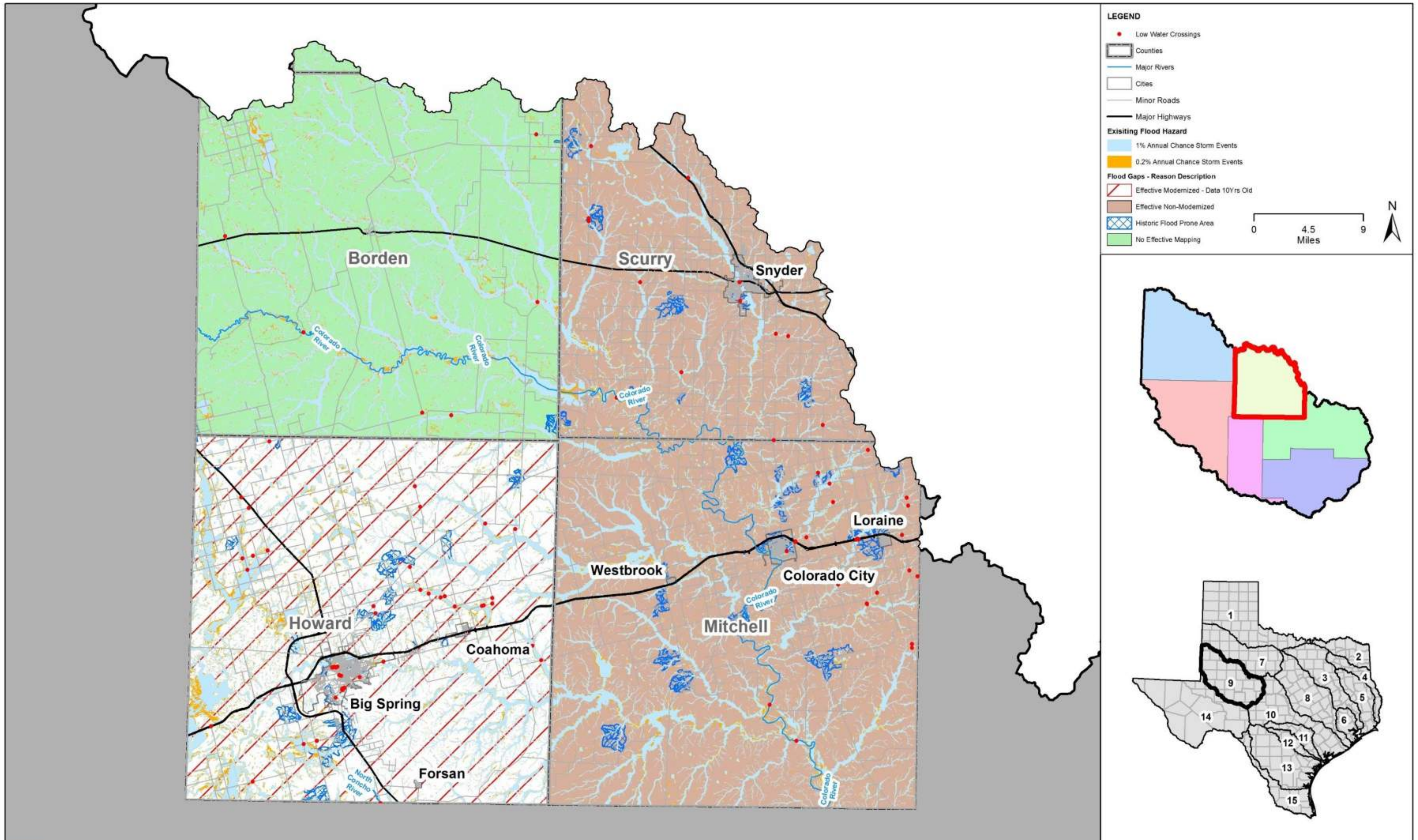
Map 5: Existing Condition Flood Hazard - Gaps in Inundation Boundary Mapping including Identification of Known Flood-Prone Areas (2.2.A.1 Existing condition flood hazard analysis)





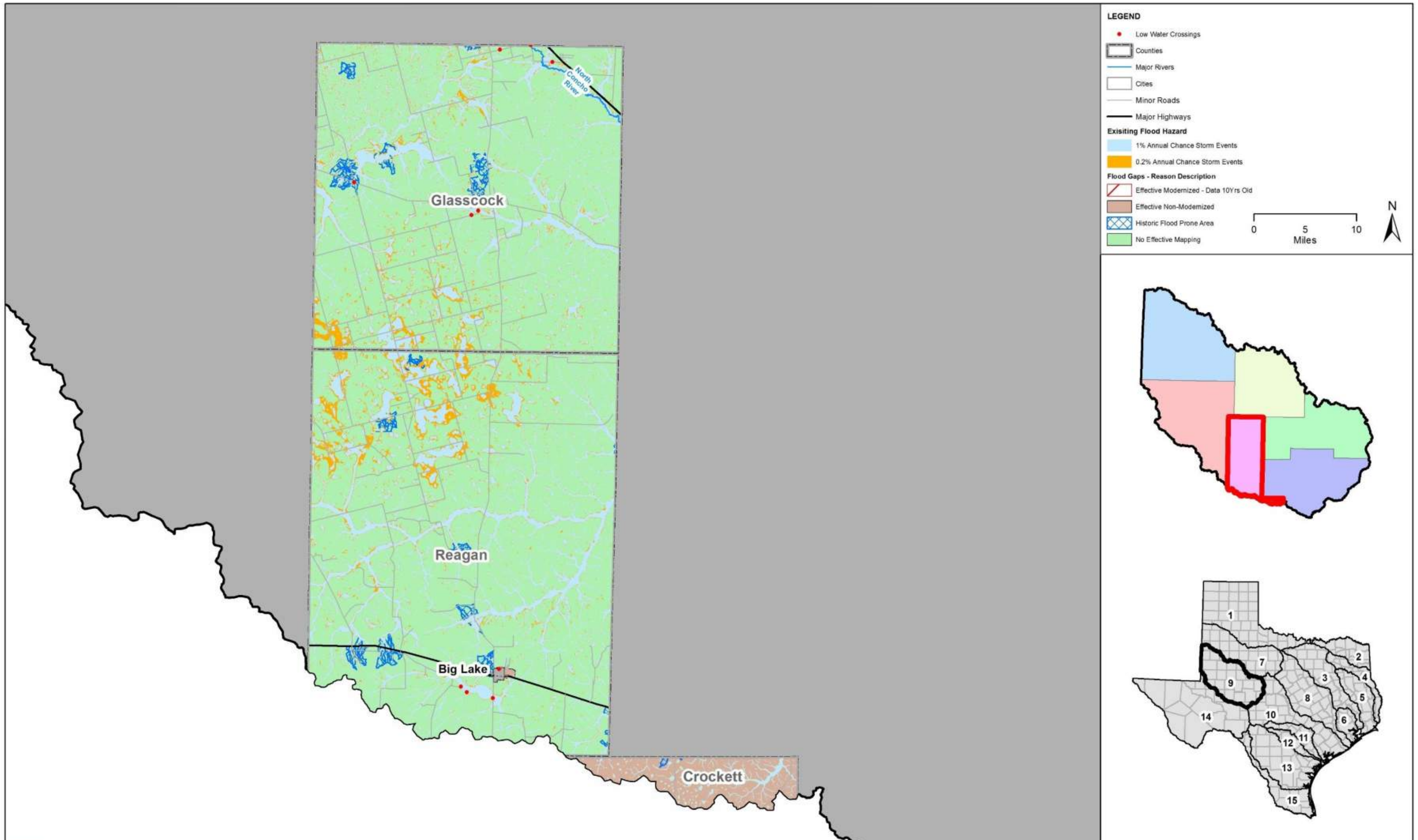
REGION 9 UPPER COLORADO - UPPER MID BASIN - MAP 5: EXISTING CONDITION FLOOD HAZARD – GAPS IN INUNDATION BOUNDARY MAPPING AND IDENTIFY KNOWN FLOOD PRONE AREAS

FIGURE 2



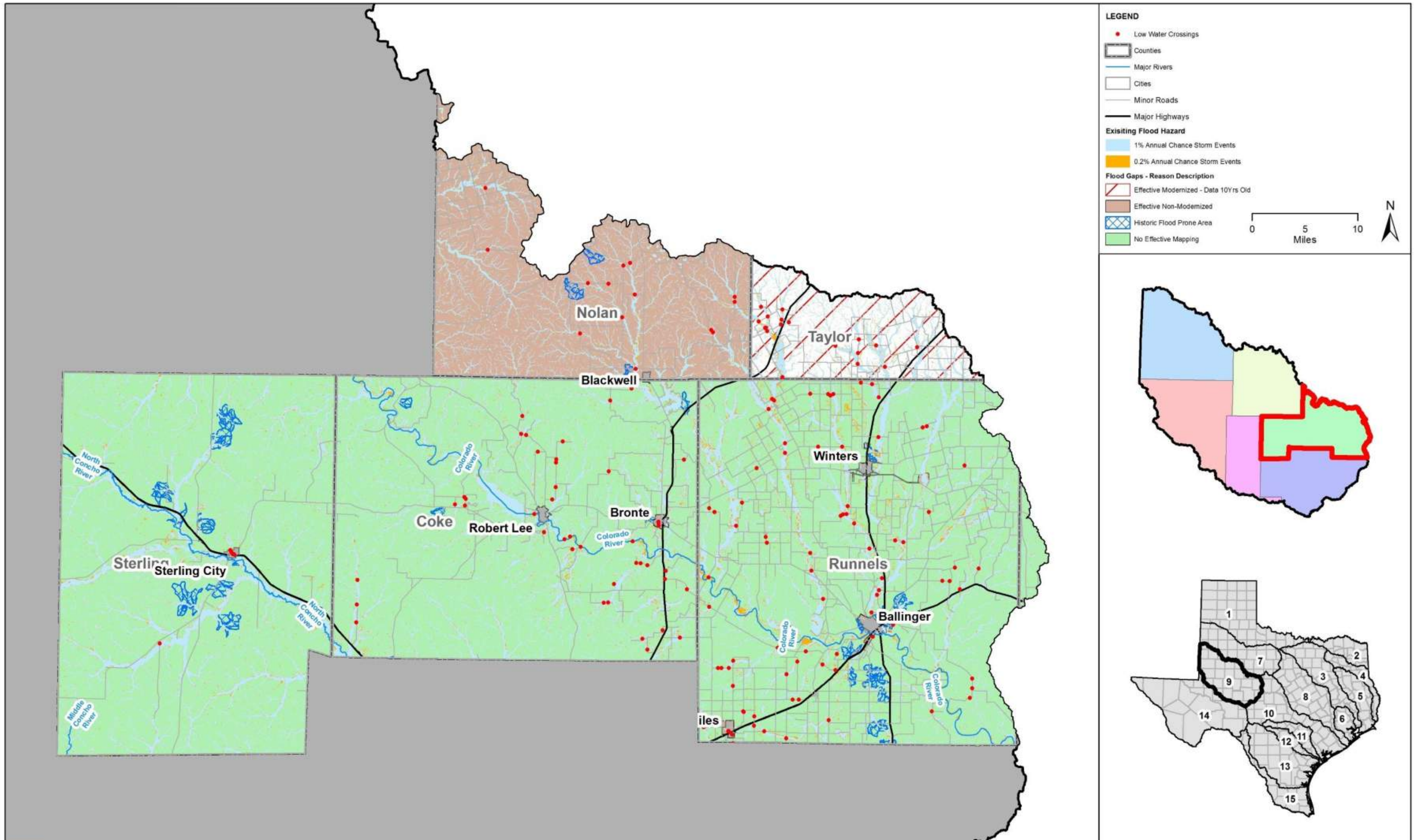
REGION 9 UPPER COLORADO - MID UPPER BASIN - MAP 5: EXISTING CONDITION FLOOD HAZARD – GAPS IN INUNDATION BOUNDARY MAPPING AND IDENTIFY KNOWN FLOOD PRONE AREAS

FIGURE 3



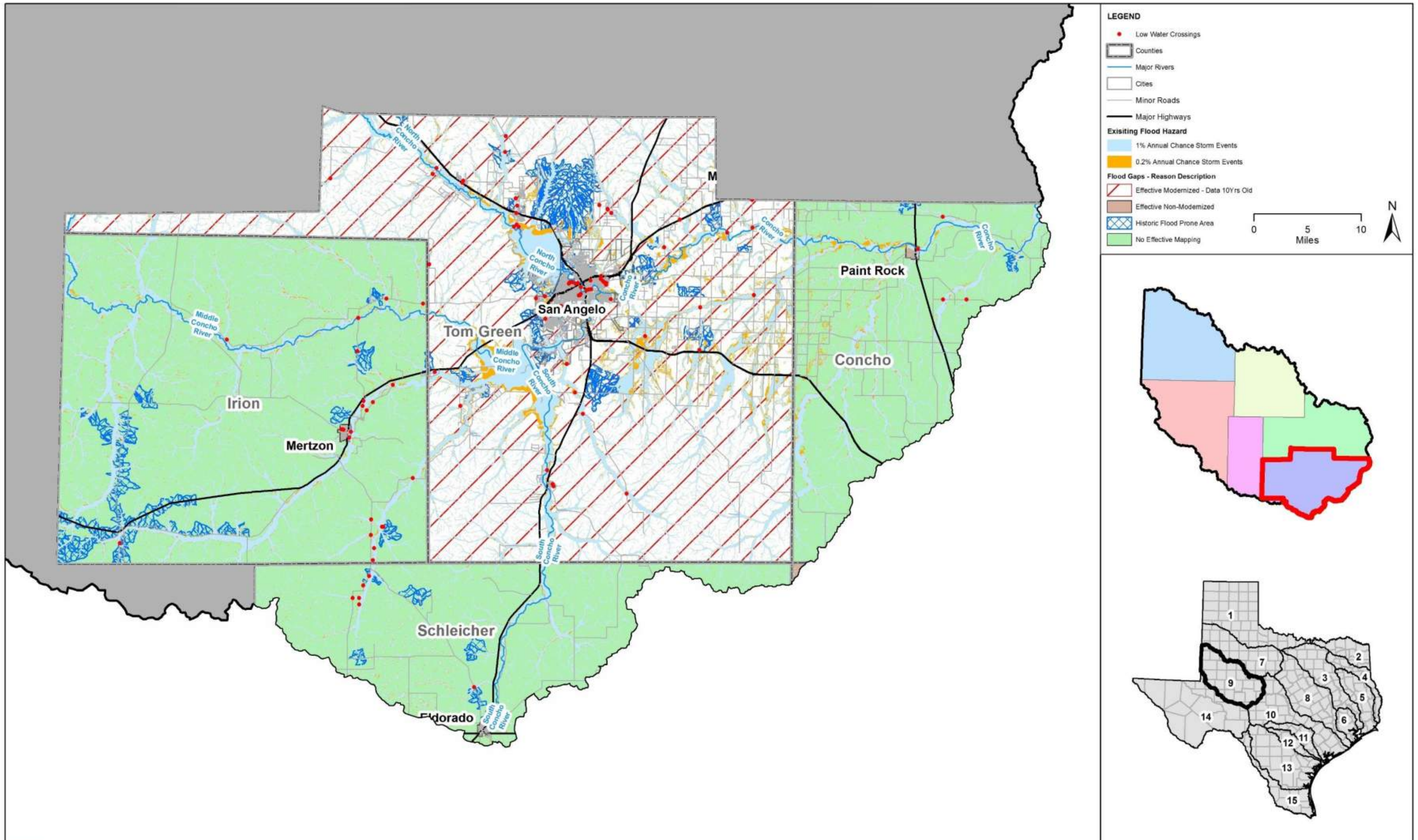
REGION 9 UPPER COLORADO - MID LOWER BASIN - MAP 5: EXISTING CONDITION FLOOD HAZARD – GAPS IN INUNDATION BOUNDARY MAPPING AND IDENTIFY KNOWN FLOOD PRONE AREAS

FIGURE 4



REGION 9 UPPER COLORADO - LOWER MID BASIN - MAP 5: EXISTING CONDITION FLOOD HAZARD – GAPS IN INUNDATION BOUNDARY MAPPING AND IDENTIFY KNOWN FLOOD PRONE AREAS

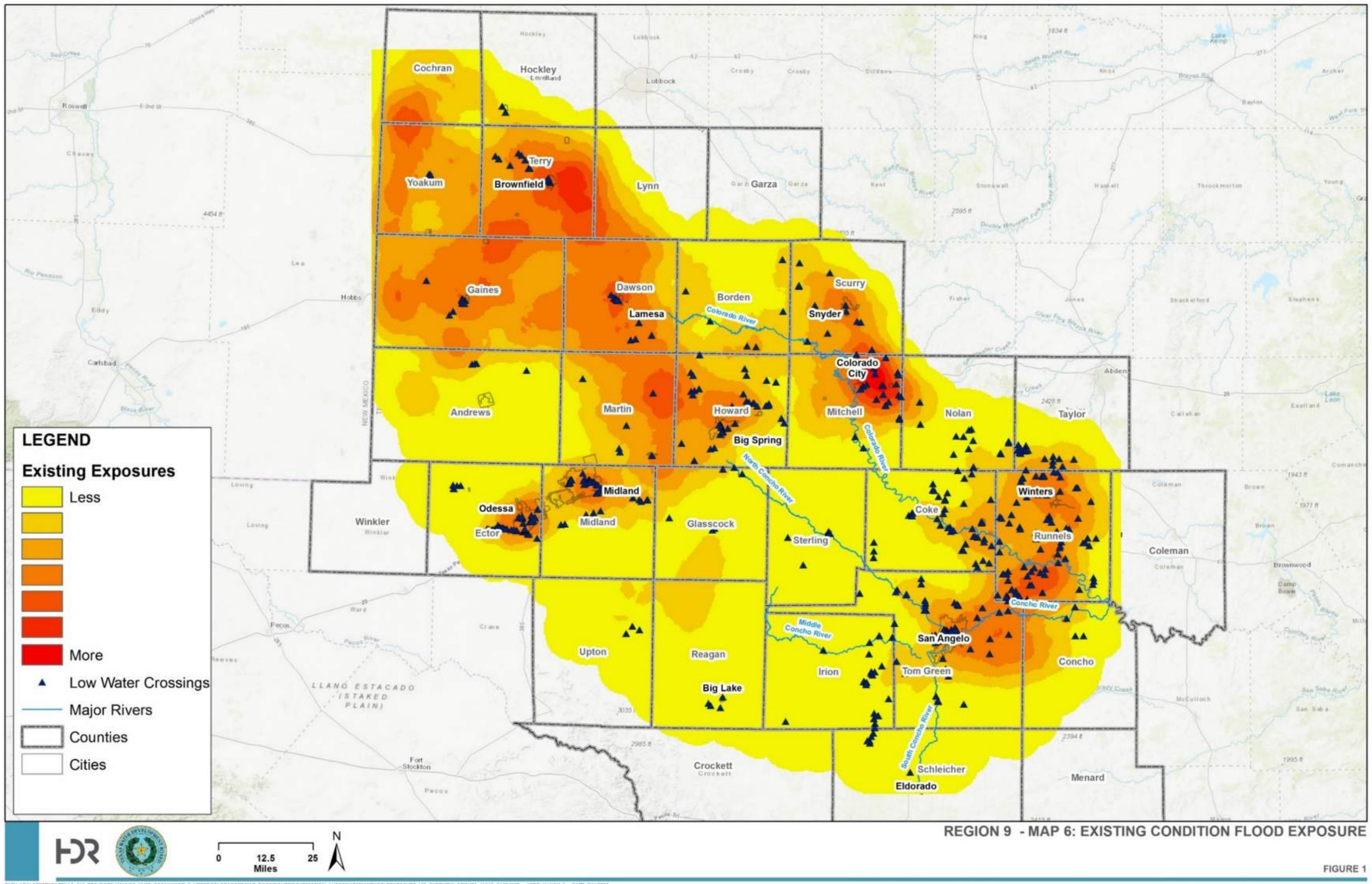
FIGURE 5

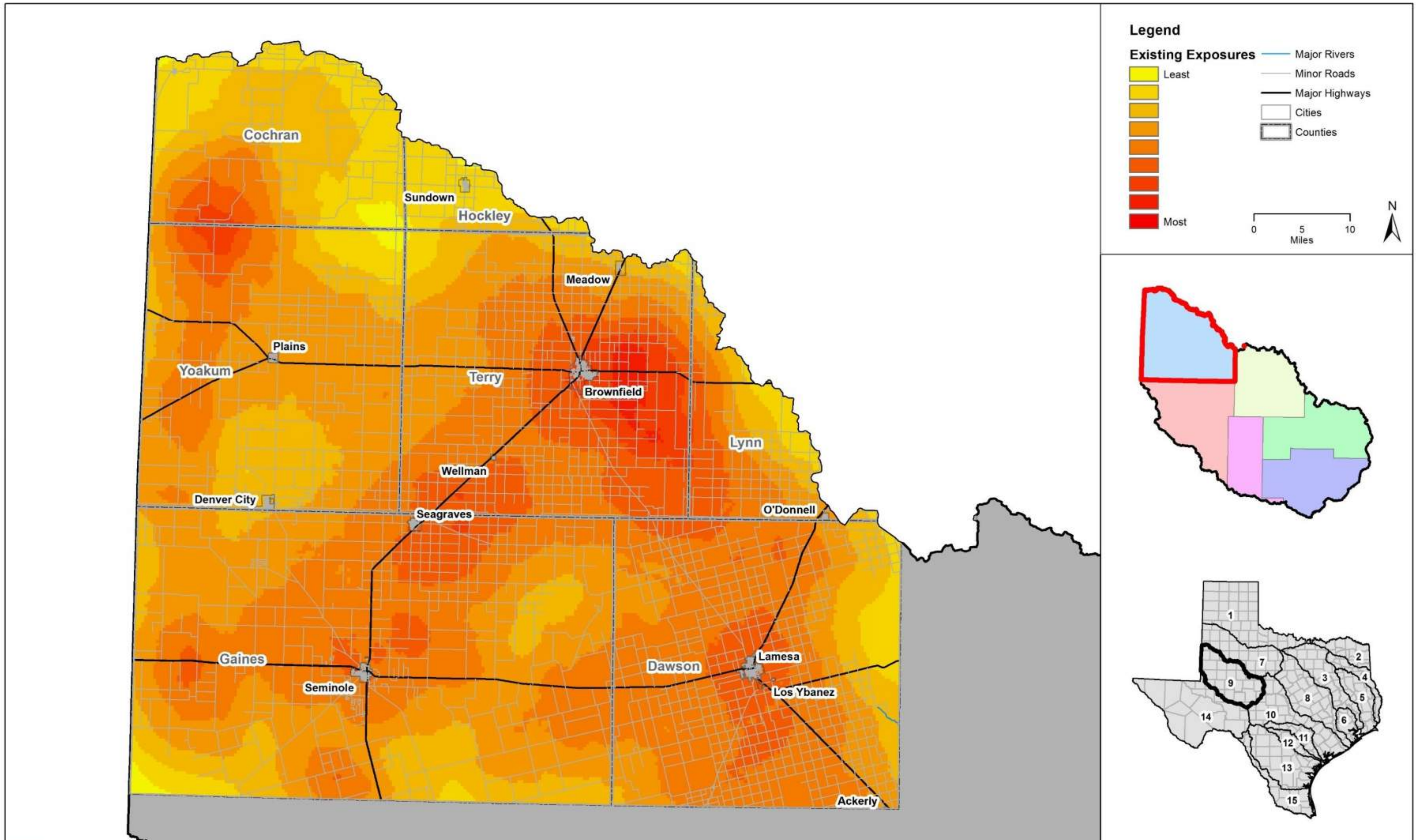


REGION 9 UPPER COLORADO - LOWER BASIN - MAP 5: EXISTING CONDITION FLOOD HAZARD – GAPS IN INUNDATION BOUNDARY MAPPING AND IDENTIFY KNOWN FLOOD PRONE AREAS

FIGURE 6

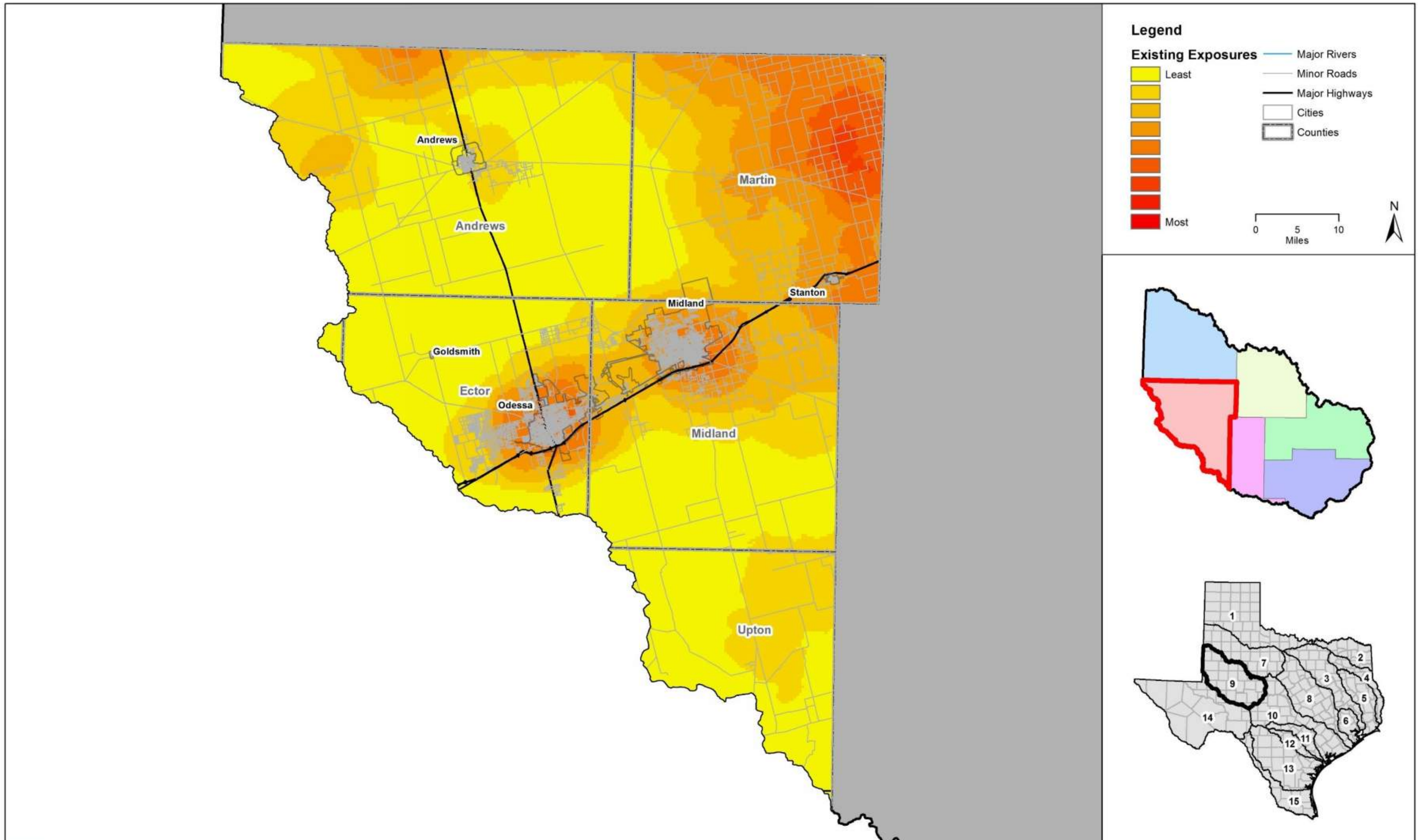
Map 6: Existing Condition Flood Exposure (2.2.A.2 Existing condition flood exposure analysis)





REGION 9 UPPER COLORADO - UPPER BASIN - MAP 6: EXISTING CONDITION FLOOD EXPOSURE

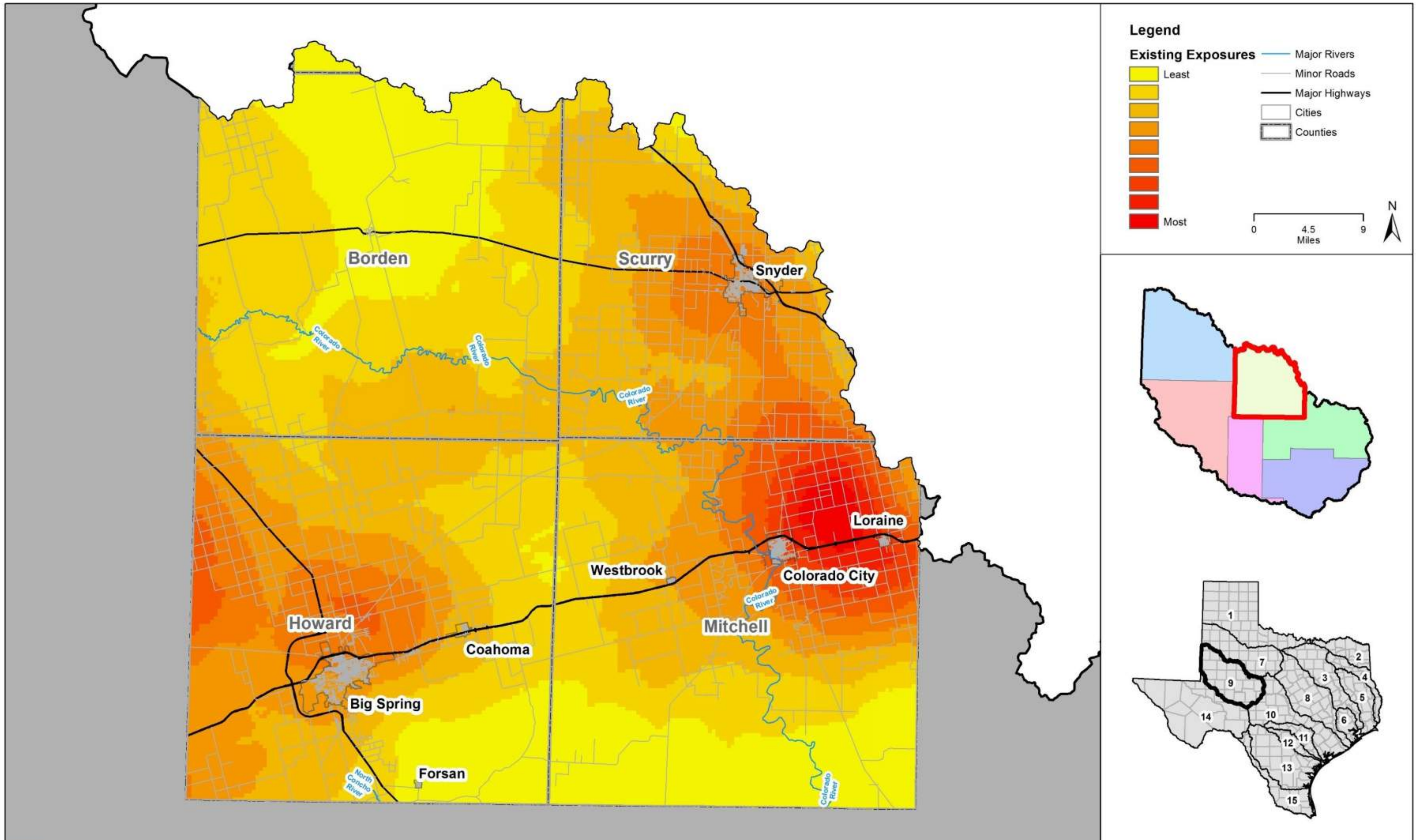
FIGURE 1



REGION 9 UPPER COLORADO - UPPER MID BASIN - MAP 6: EXISTING CONDITION FLOOD EXPOSURE

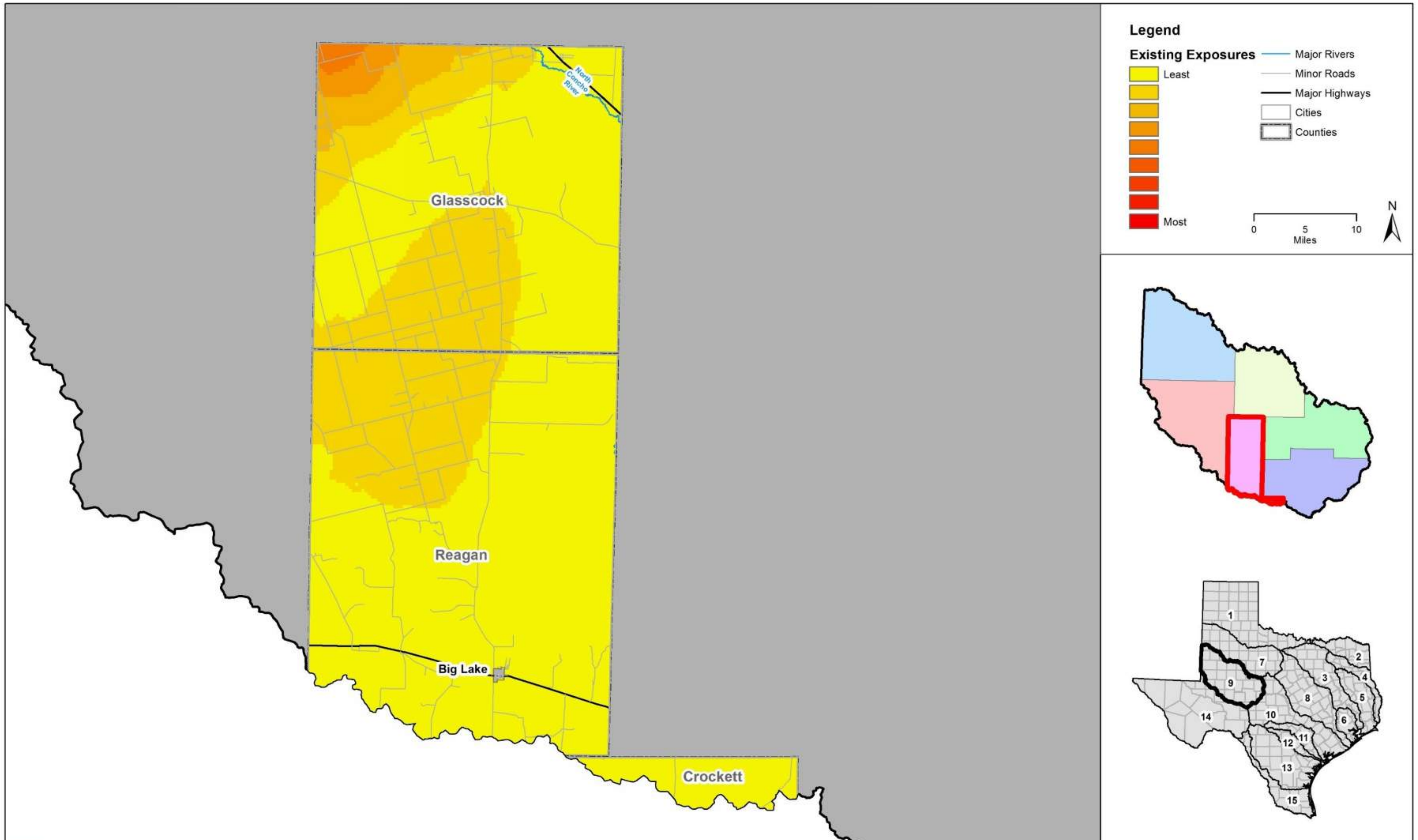
FIGURE 2

PATH: \\DALCTXSRV01\TEXAS_GIS_PROJECTS\10310495_10189_COSANANGELO_UPPERCOLORADOFP\MAP_DOCS\FIGURES\SUBMISSION_AUG22\MAP6EXISTINGFLDEXPOSURE_HM_GROUPA_11X17_SA22.MXD - USER: KJAVVAJI - DATE: 7/14/2022



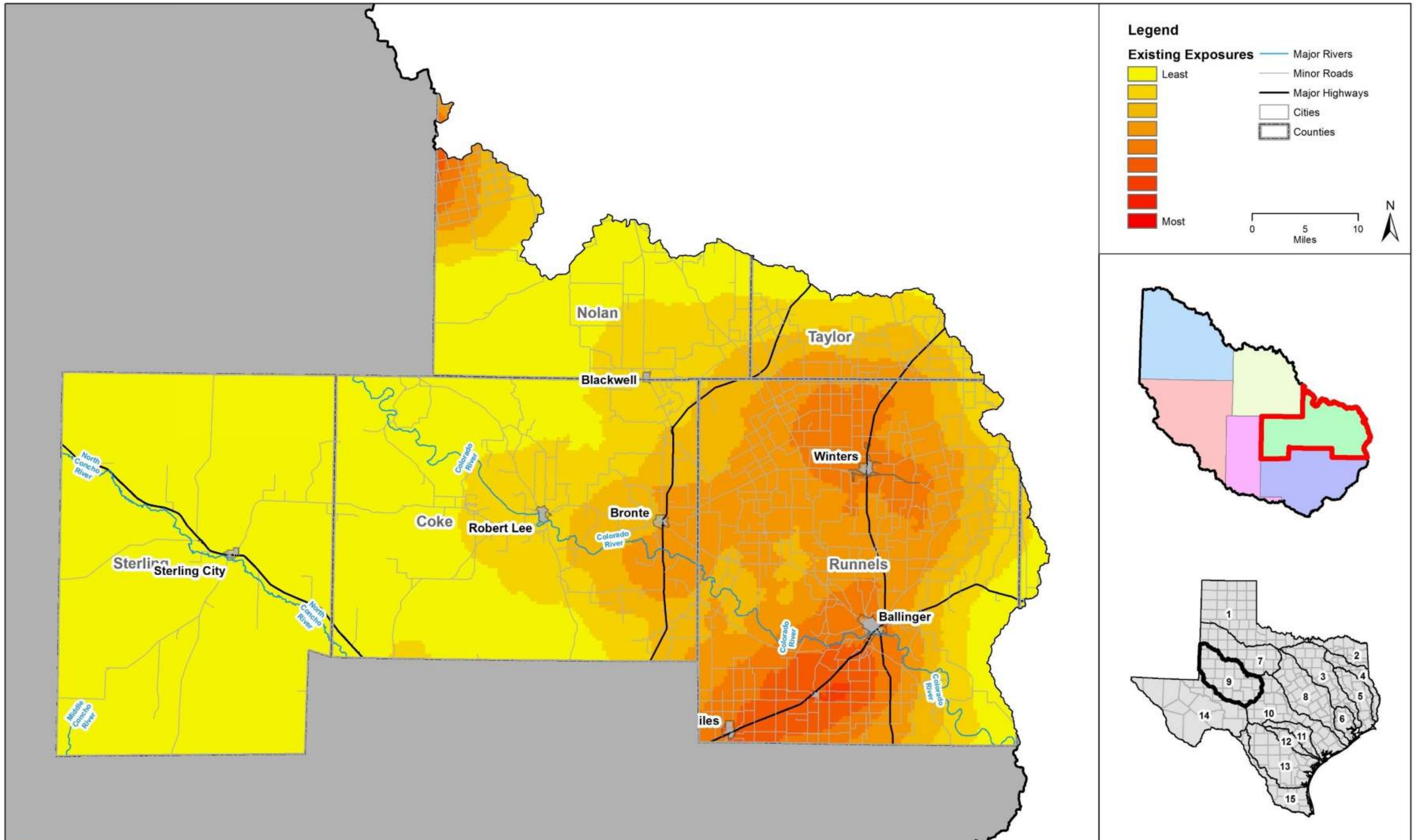
REGION 9 UPPER COLORADO - MID UPPER BASIN - MAP 6: EXISTING CONDITION FLOOD EXPOSURE

FIGURE 3



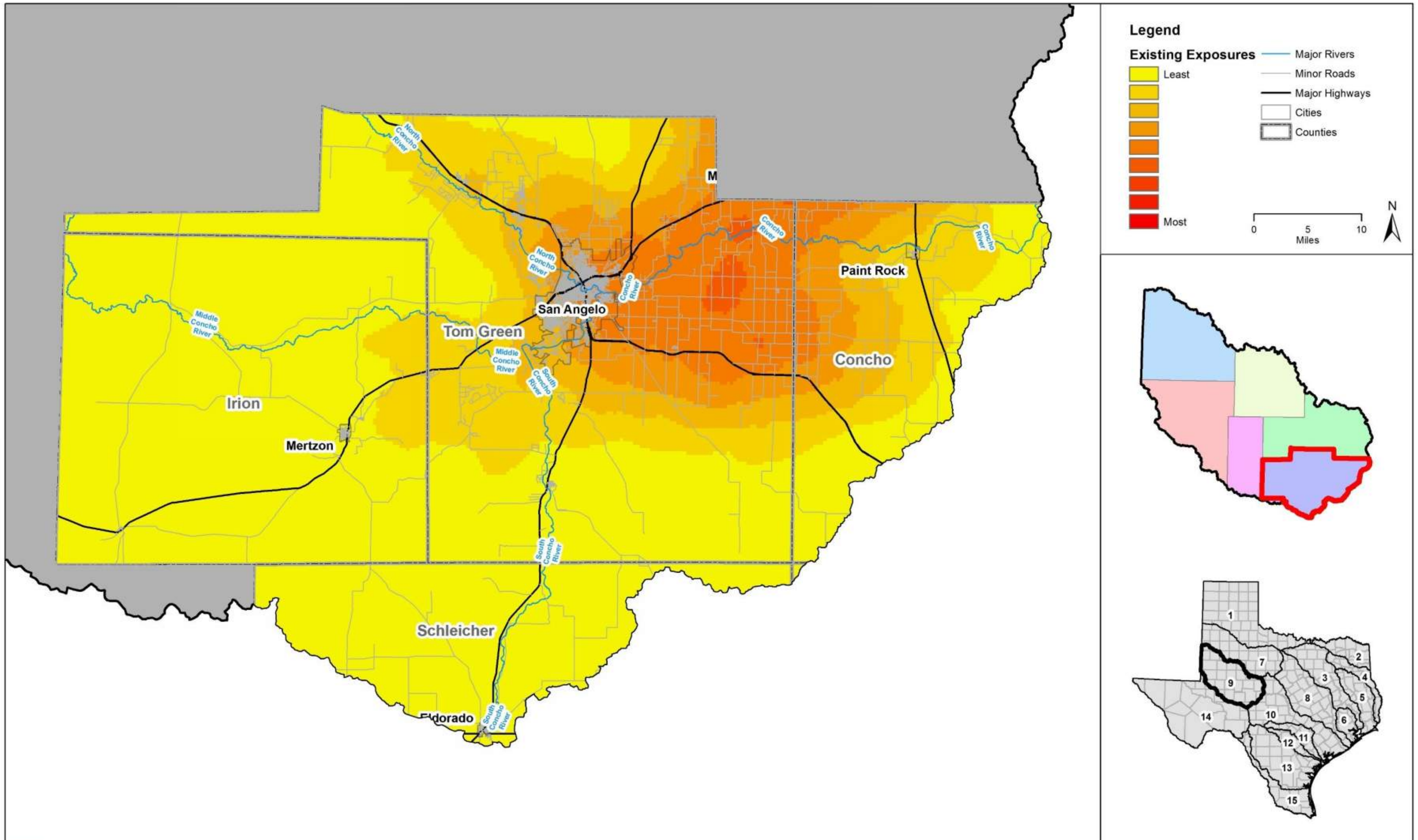
REGION 9 UPPER COLORADO - MID LOWER BASIN - MAP 6: EXISTING CONDITION FLOOD EXPOSURE

FIGURE 4



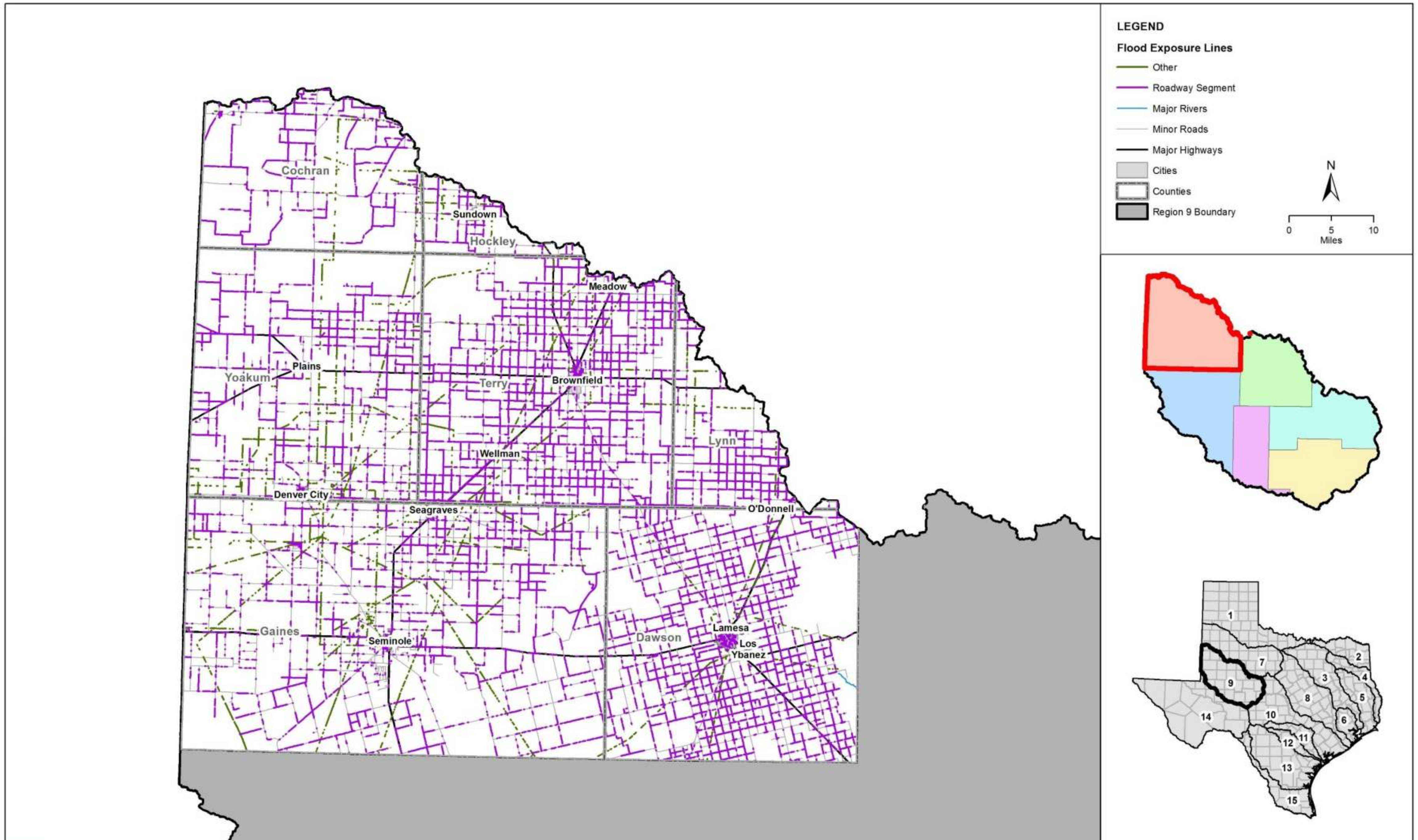
REGION 9 UPPER COLORADO - LOWER MID BASIN - MAP 6: EXISTING CONDITION FLOOD EXPOSURE

FIGURE 5



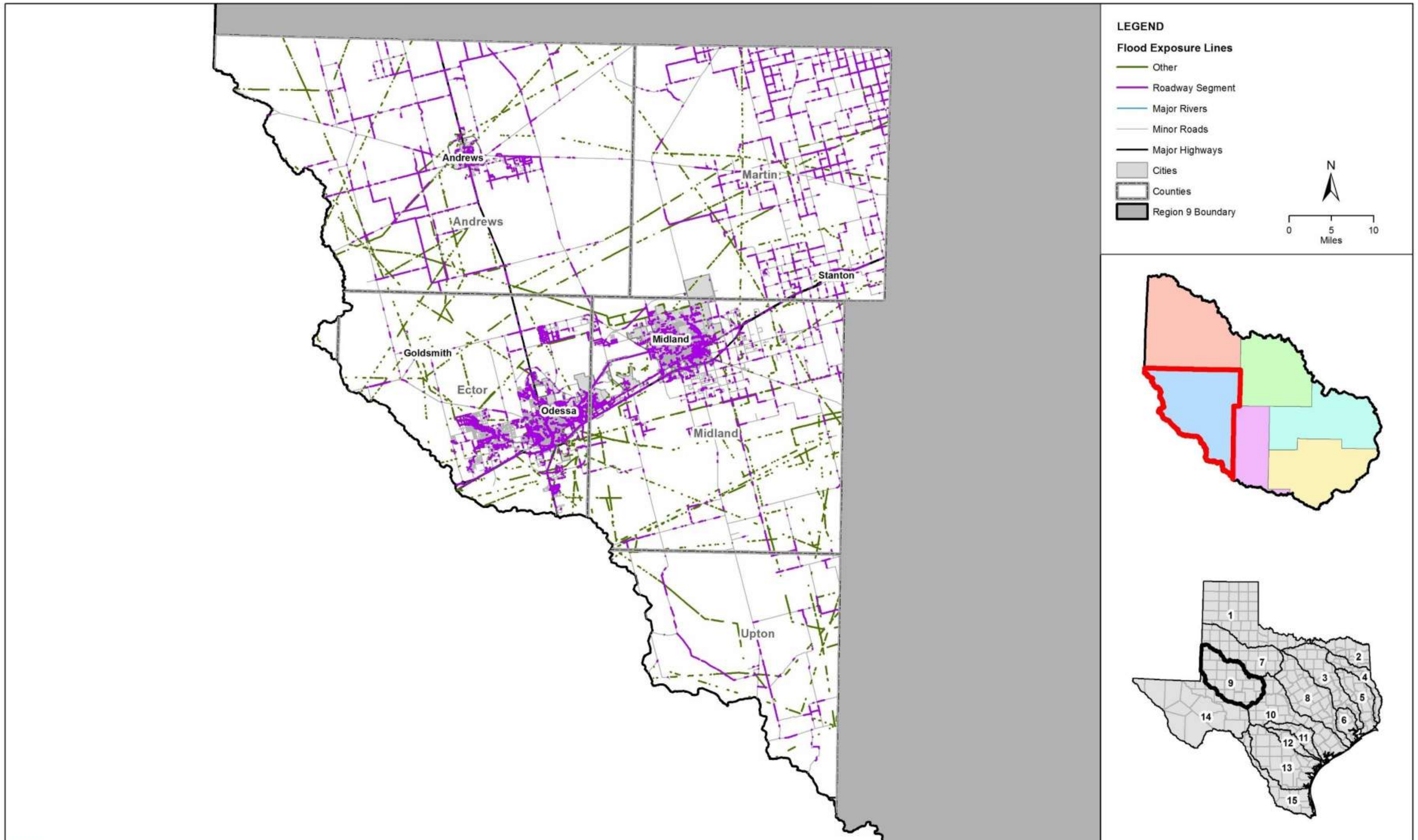
REGION 9 UPPER COLORADO - LOWER BASIN - MAP 6: EXISTING CONDITION FLOOD EXPOSURE

FIGURE 6



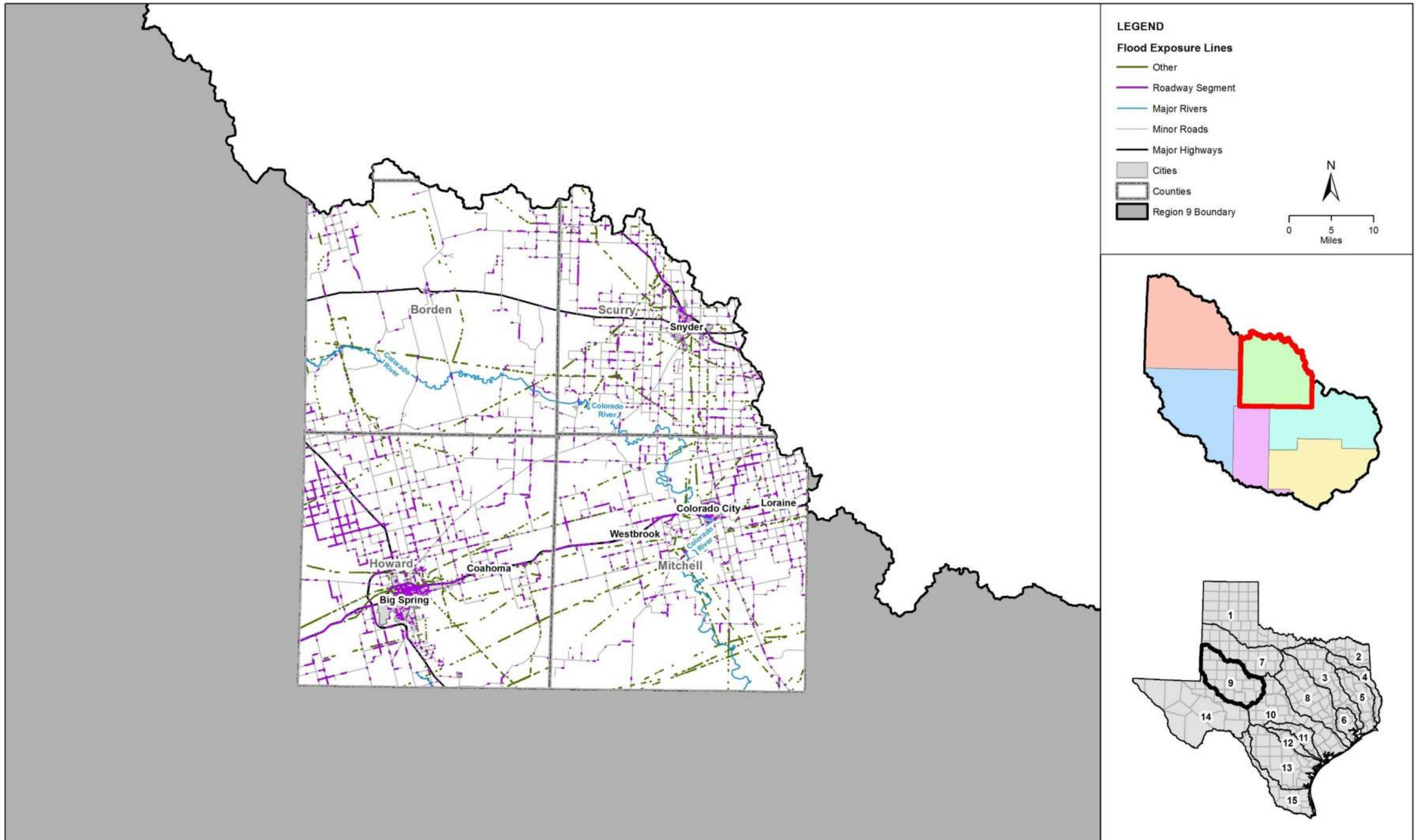
REGION 9 UPPER COLORADO - UPPER BASIN - MAP 6: EXISTING CONDITION FLOOD EXPOSURE

FIGURE 1



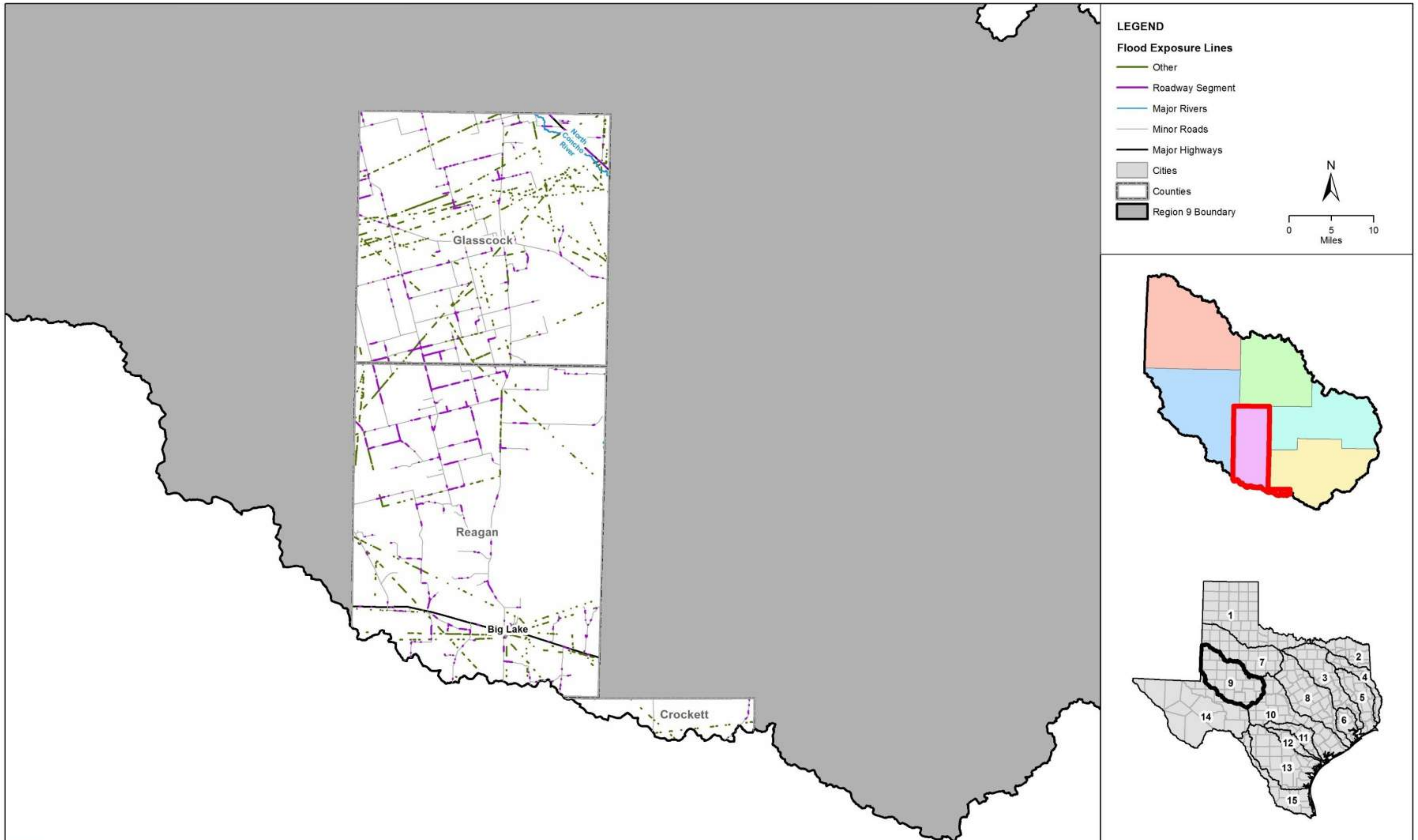
REGION 9 UPPER COLORADO - UPPER MID BASIN - MAP 6: EXISTING CONDITION FLOOD EXPOSURE

FIGURE 2



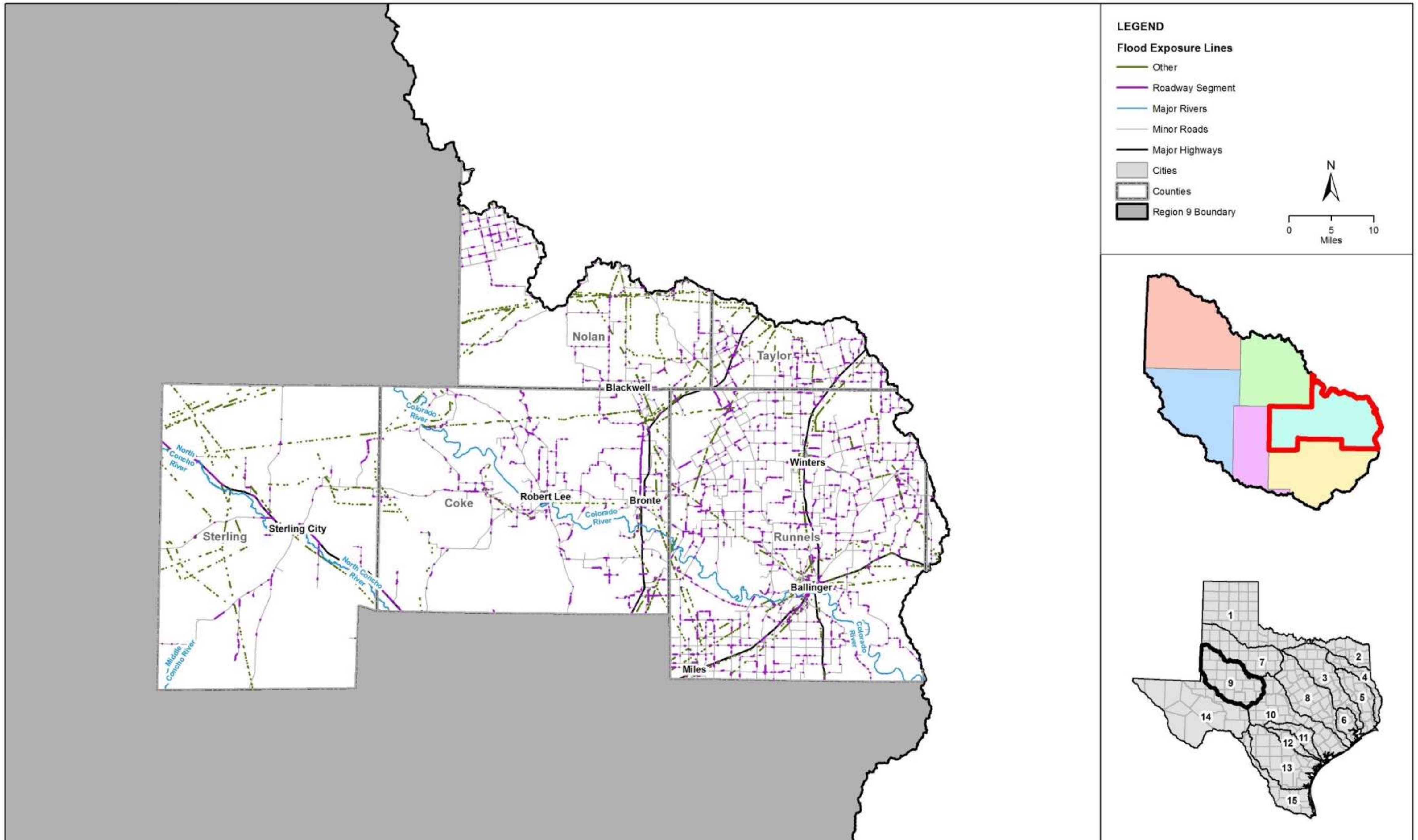
REGION 9 UPPER COLORADO - MID UPPER BASIN - MAP 6: EXISTING CONDITION FLOOD EXPOSURE

FIGURE 3



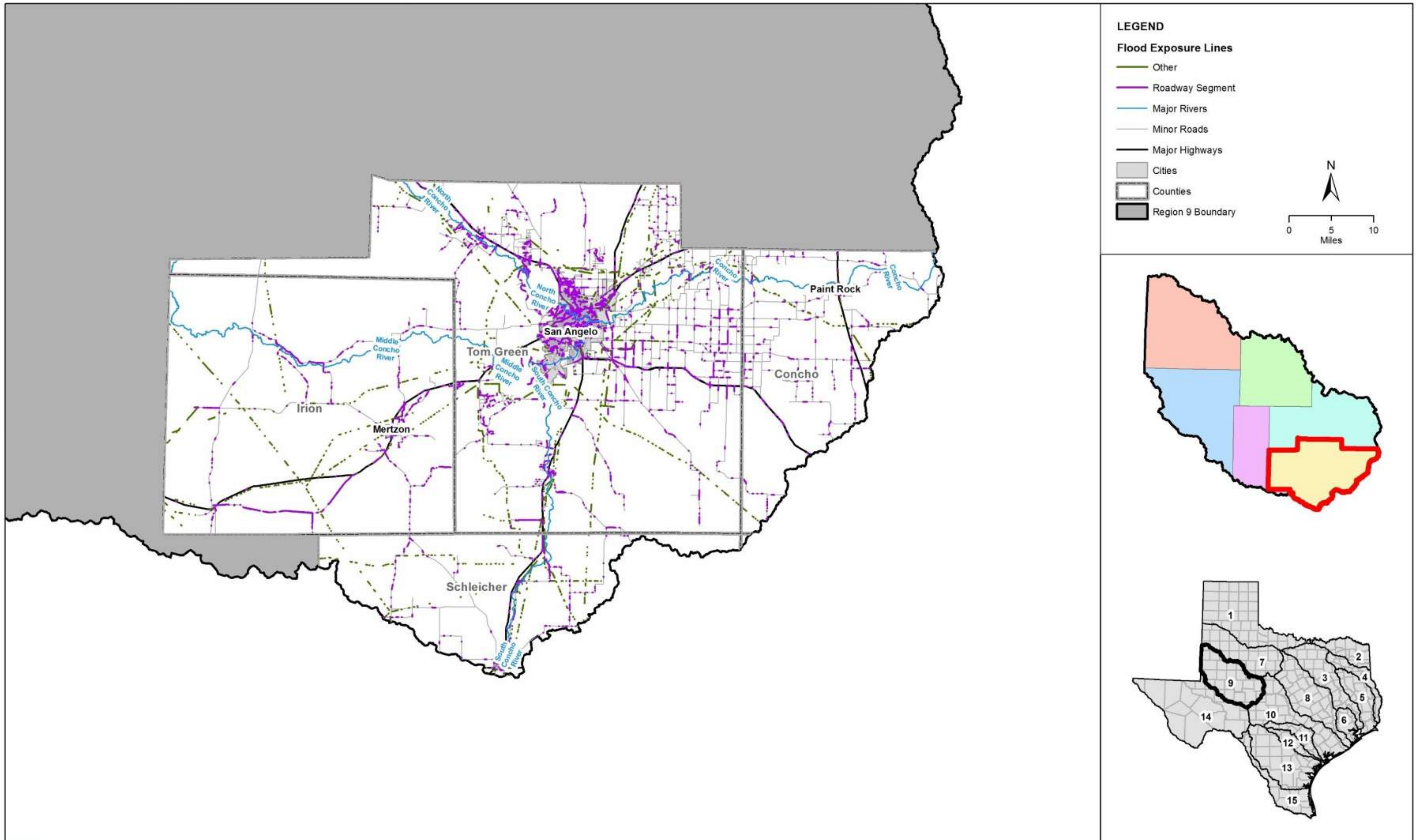
REGION 9 UPPER COLORADO - MID LOWER BASIN - MAP 6: EXISTING CONDITION FLOOD EXPOSURE

FIGURE 4



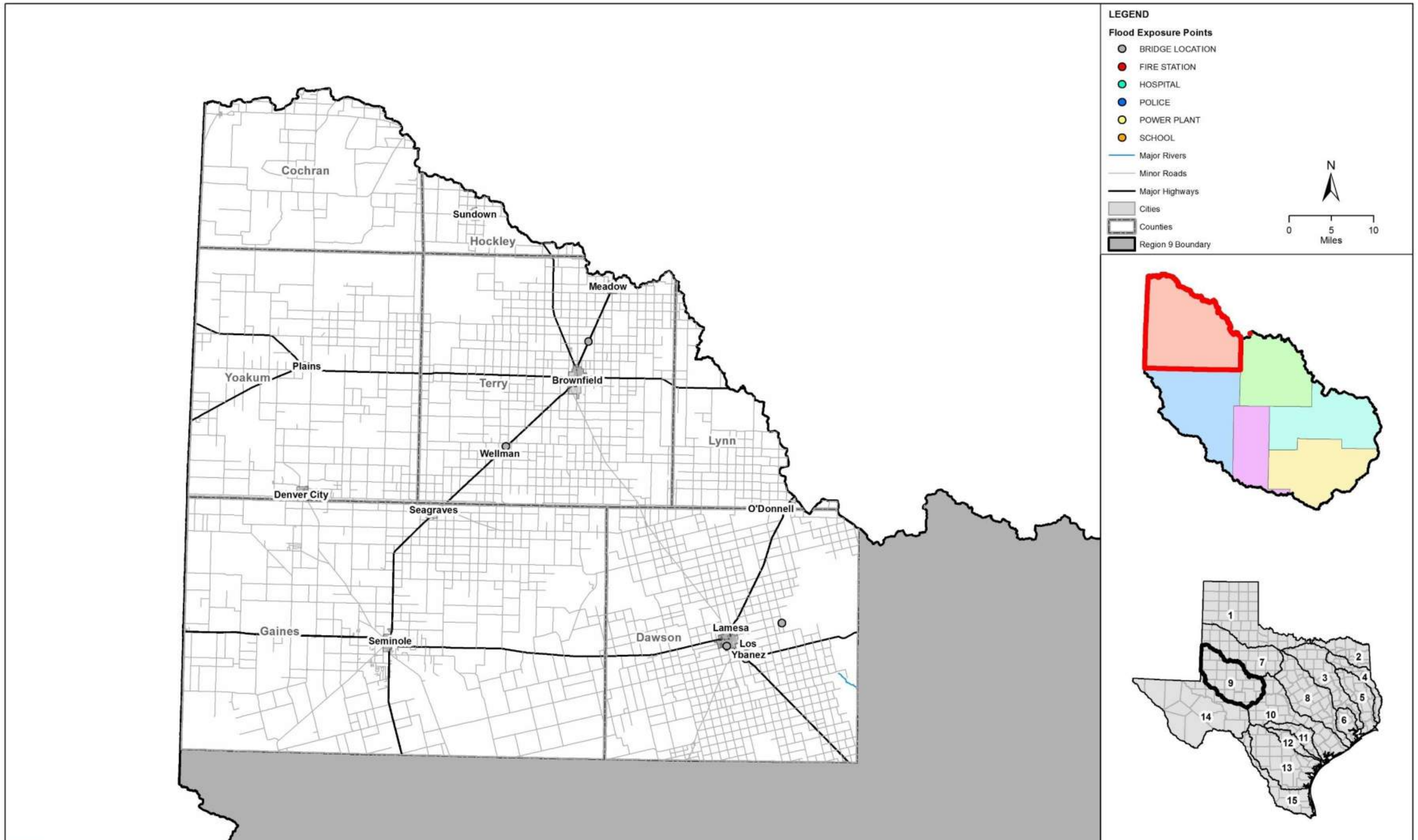
REGION 9 UPPER COLORADO - LOWER MID BASIN - MAP 6: EXISTING CONDITION FLOOD EXPOSURE

FIGURE 5



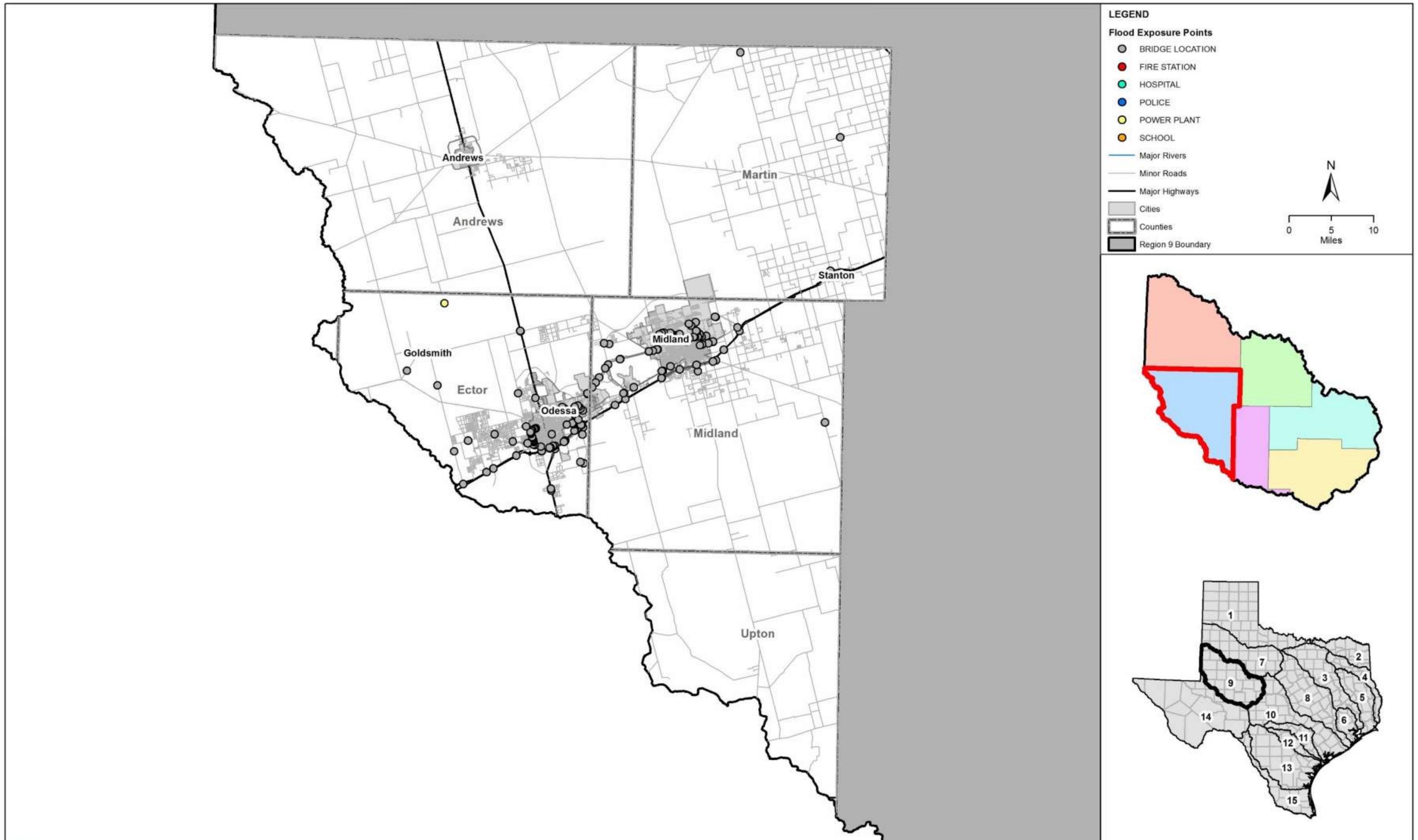
REGION 9 UPPER COLORADO - LOWER BASIN - MAP 6: EXISTING CONDITION FLOOD EXPOSURE

FIGURE 6



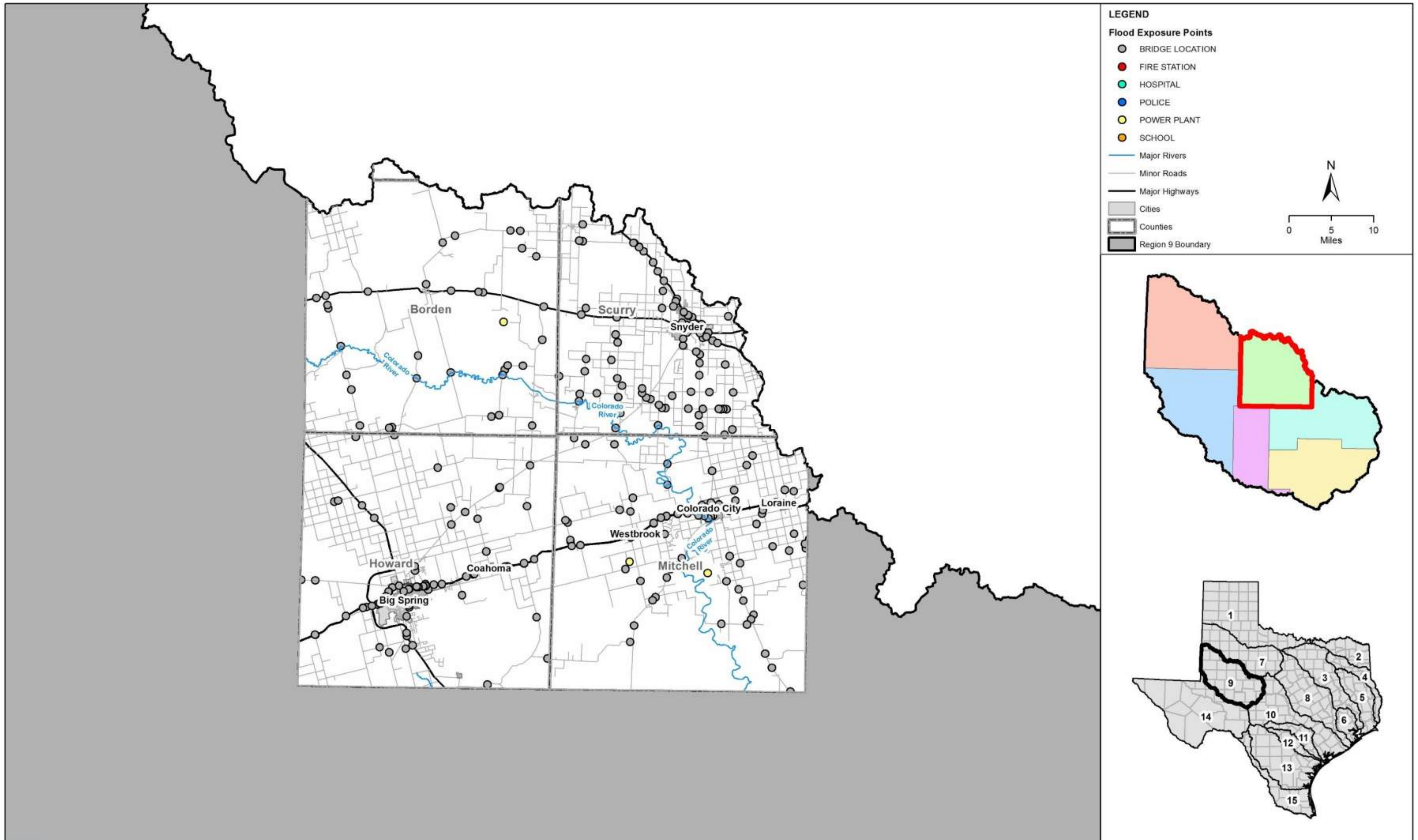
REGION 9 UPPER COLORADO - UPPER BASIN - MAP 6: EXISTING CONDITION FLOOD EXPOSURE

FIGURE 1



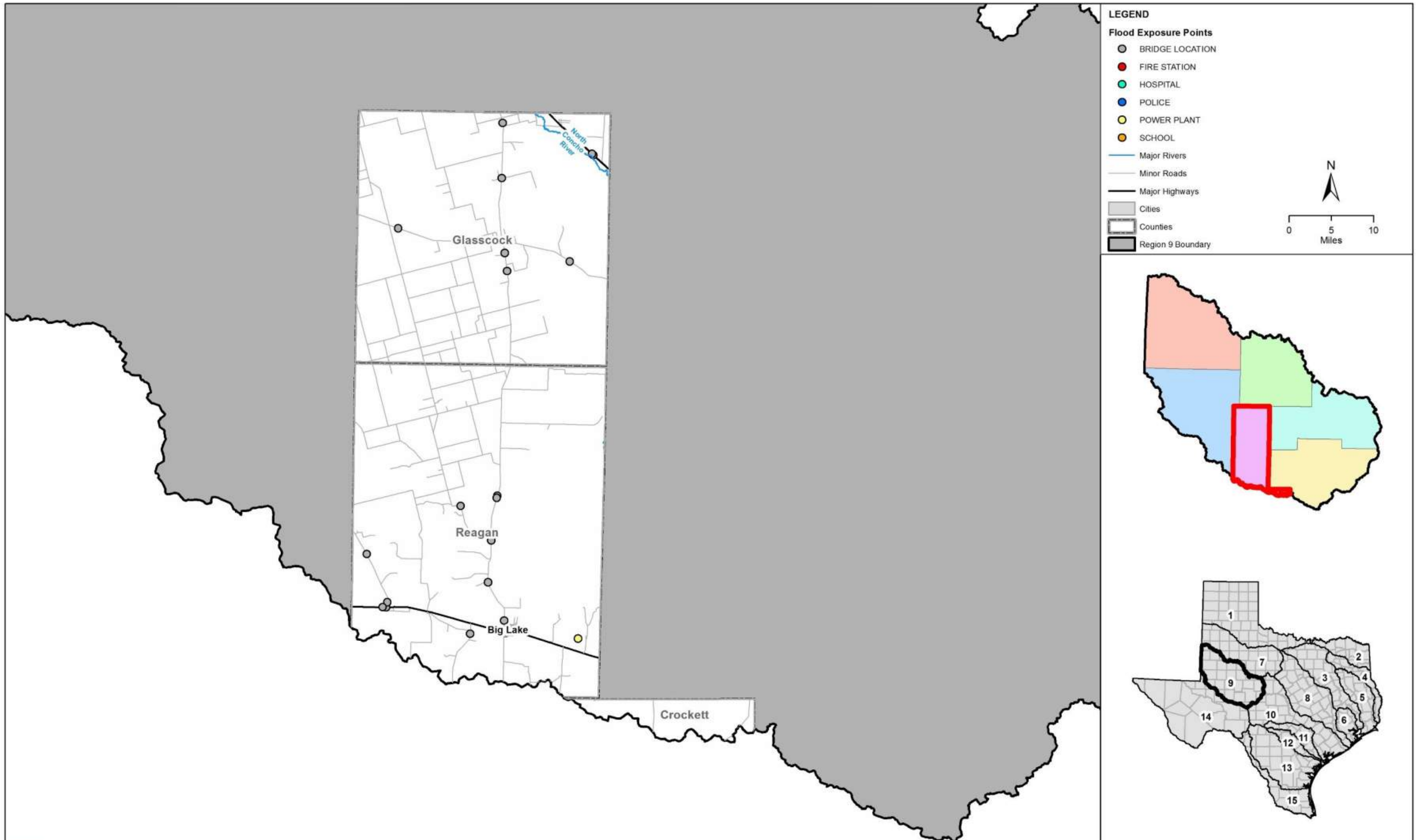
REGION 9 UPPER COLORADO - UPPER MID BASIN - MAP 6: EXISTING CONDITION FLOOD EXPOSURE

FIGURE 2



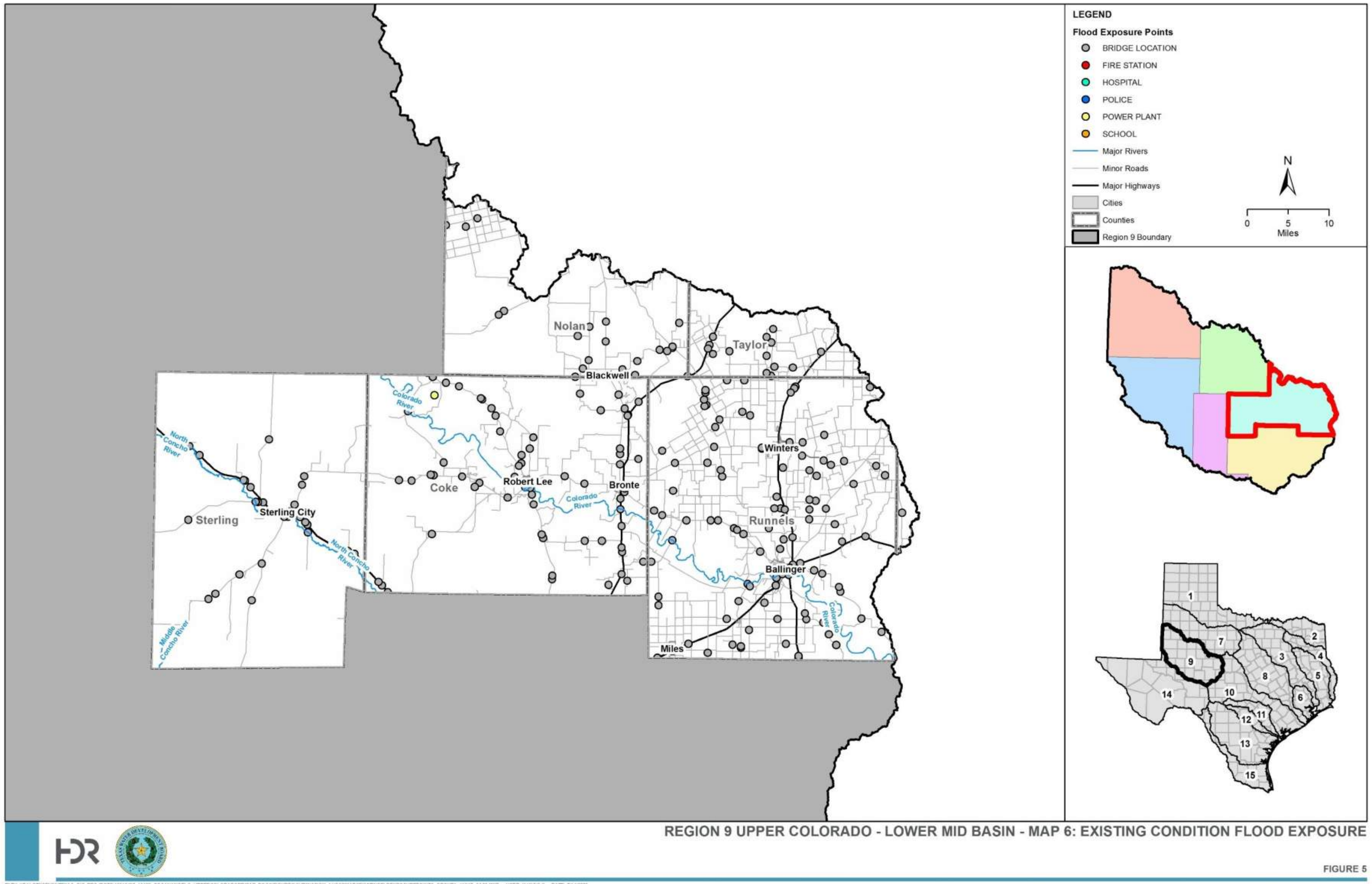
REGION 9 UPPER COLORADO - MID UPPER BASIN - MAP 6: EXISTING CONDITION FLOOD EXPOSURE

FIGURE 3



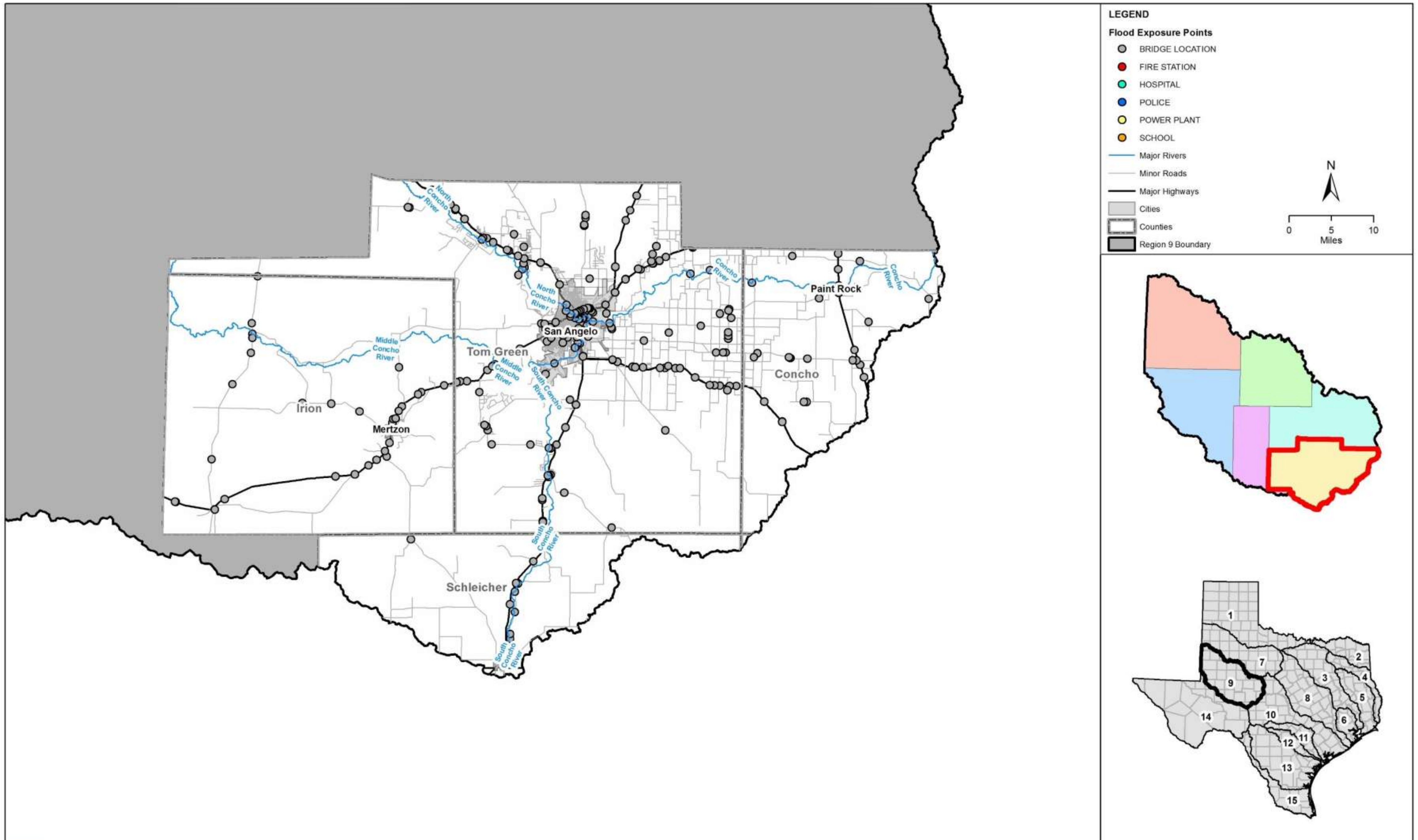
REGION 9 UPPER COLORADO - MID LOWER BASIN - MAP 6: EXISTING CONDITION FLOOD EXPOSURE

FIGURE 4



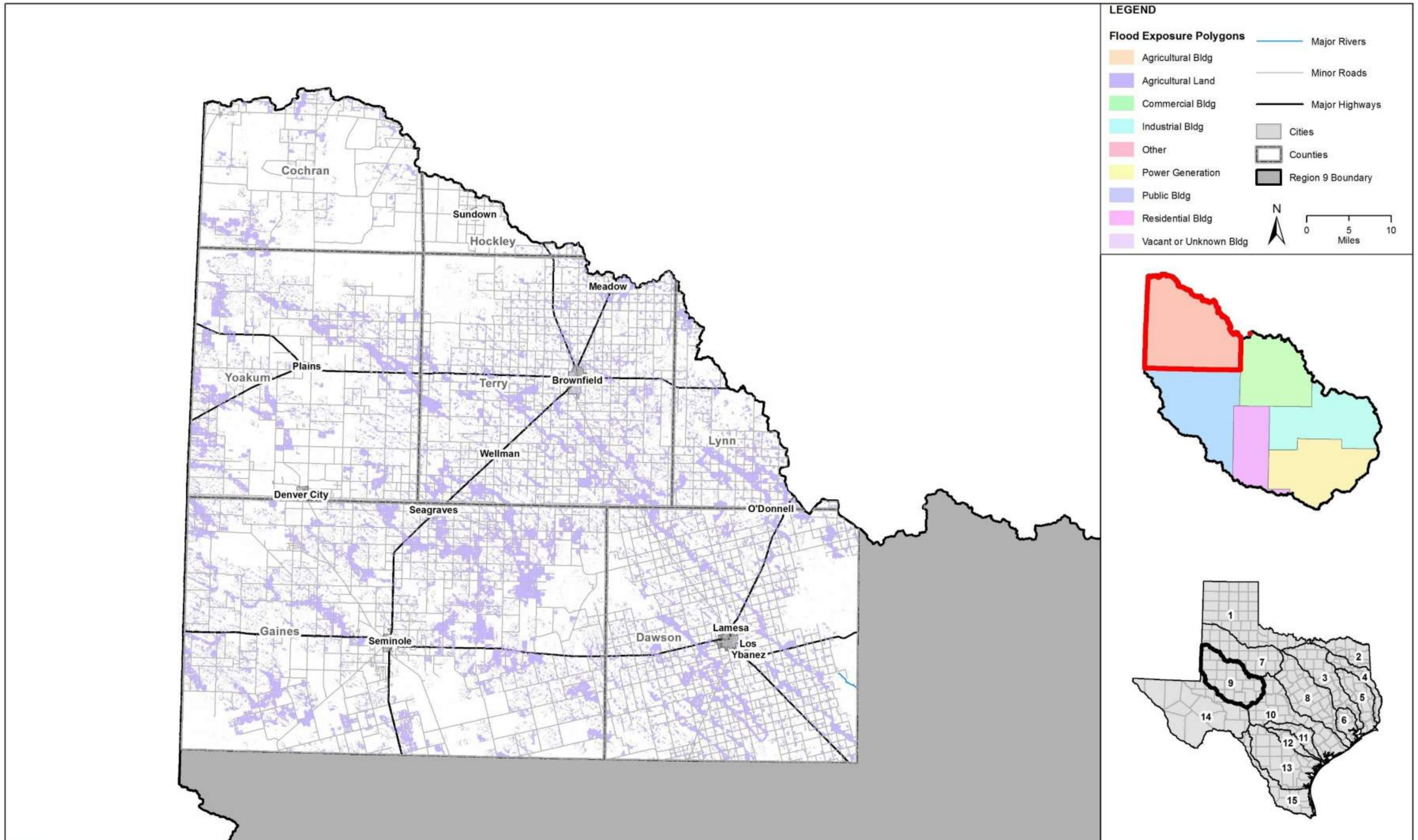
LEGEND
Flood Exposure Points
BRIDGE LOCATION
FIRE STATION
HOSPITAL
POLICE
POWER PLANT
SCHOOL
Major Rivers
Minor Roads
Major Highways
Cities
Counties
Region 9 Boundary
N
0
5
10
Miles
Nolan
Taylor
Blackwell
Coke
Robert Lee
Bronte
Winters
Runnels
Ballinger
Miles
Sterling
Sterling City
North Concho River
Colorado River
Middle Concho River
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
REGION 9 UPPER COLORADO - LOWER MID BASIN - MAP 6: EXISTING CONDITION FLOOD EXPOSURE

FIGURE 5



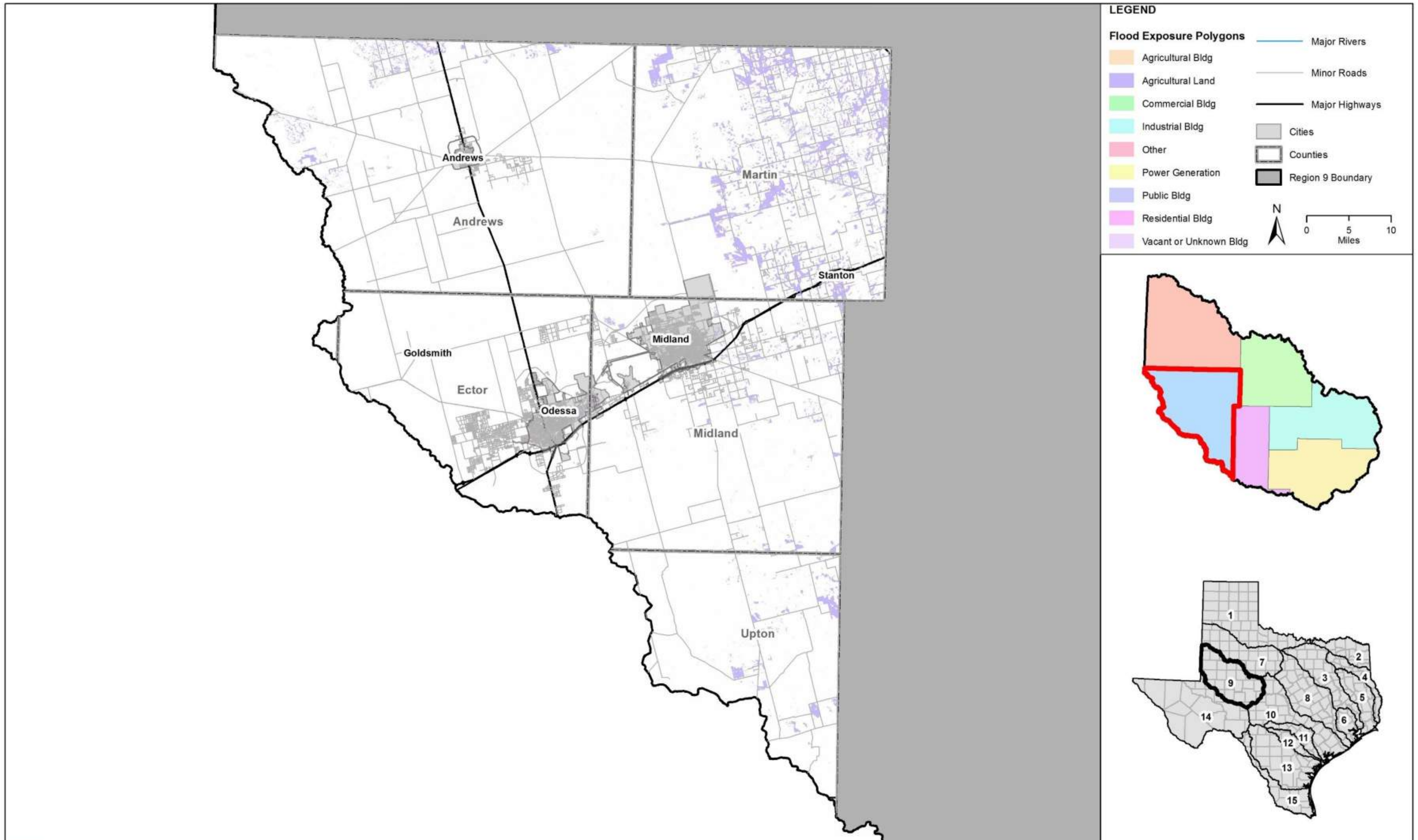
REGION 9 UPPER COLORADO - LOWER BASIN - MAP 6: EXISTING CONDITION FLOOD EXPOSURE

FIGURE 6



REGION 9 UPPER COLORADO - UPPER BASIN - MAP 6: EXISTING CONDITION FLOOD EXPOSURE

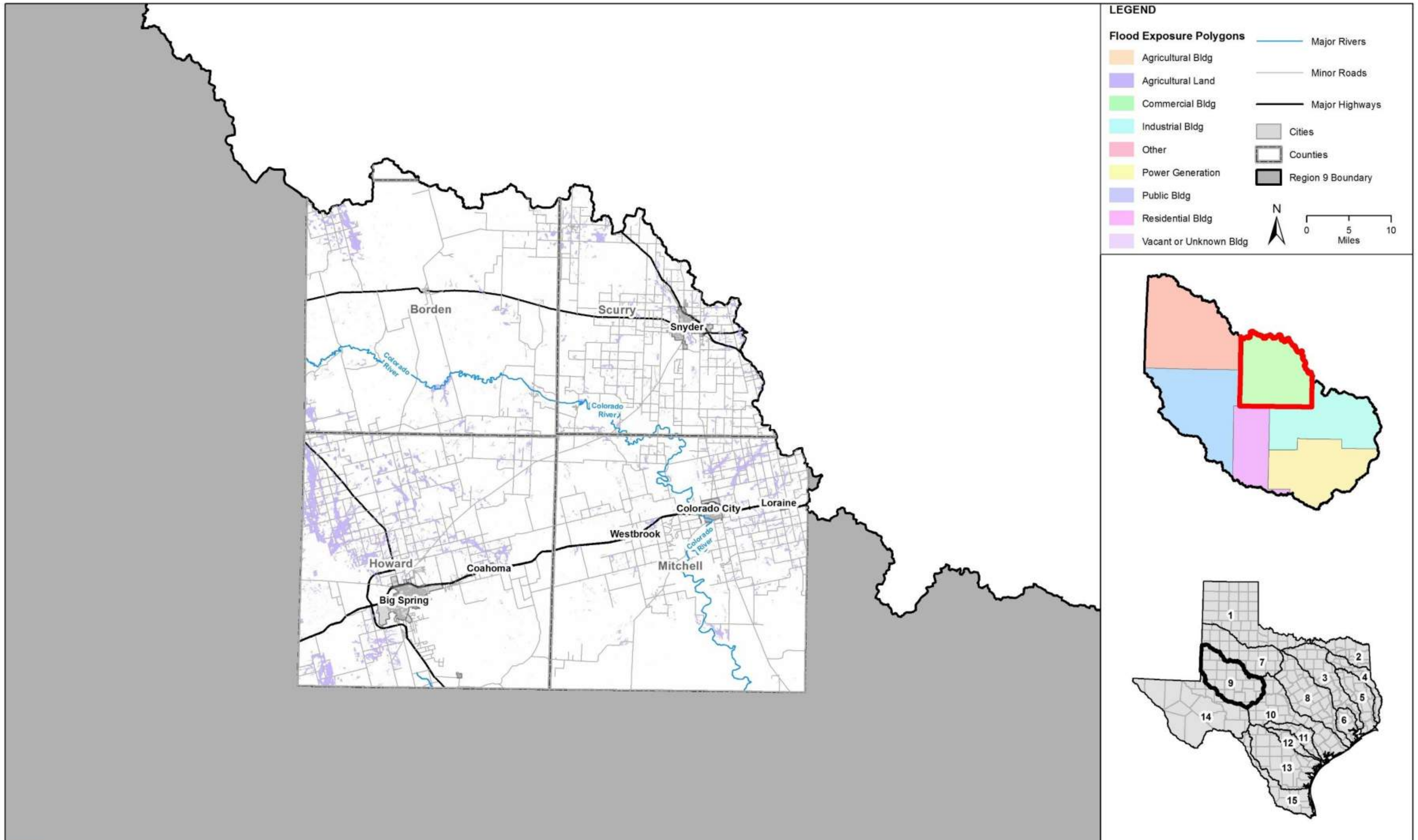
FIGURE 1



REGION 9 UPPER COLORADO - UPPER MID BASIN - MAP 6: EXISTING CONDITION FLOOD EXPOSURE

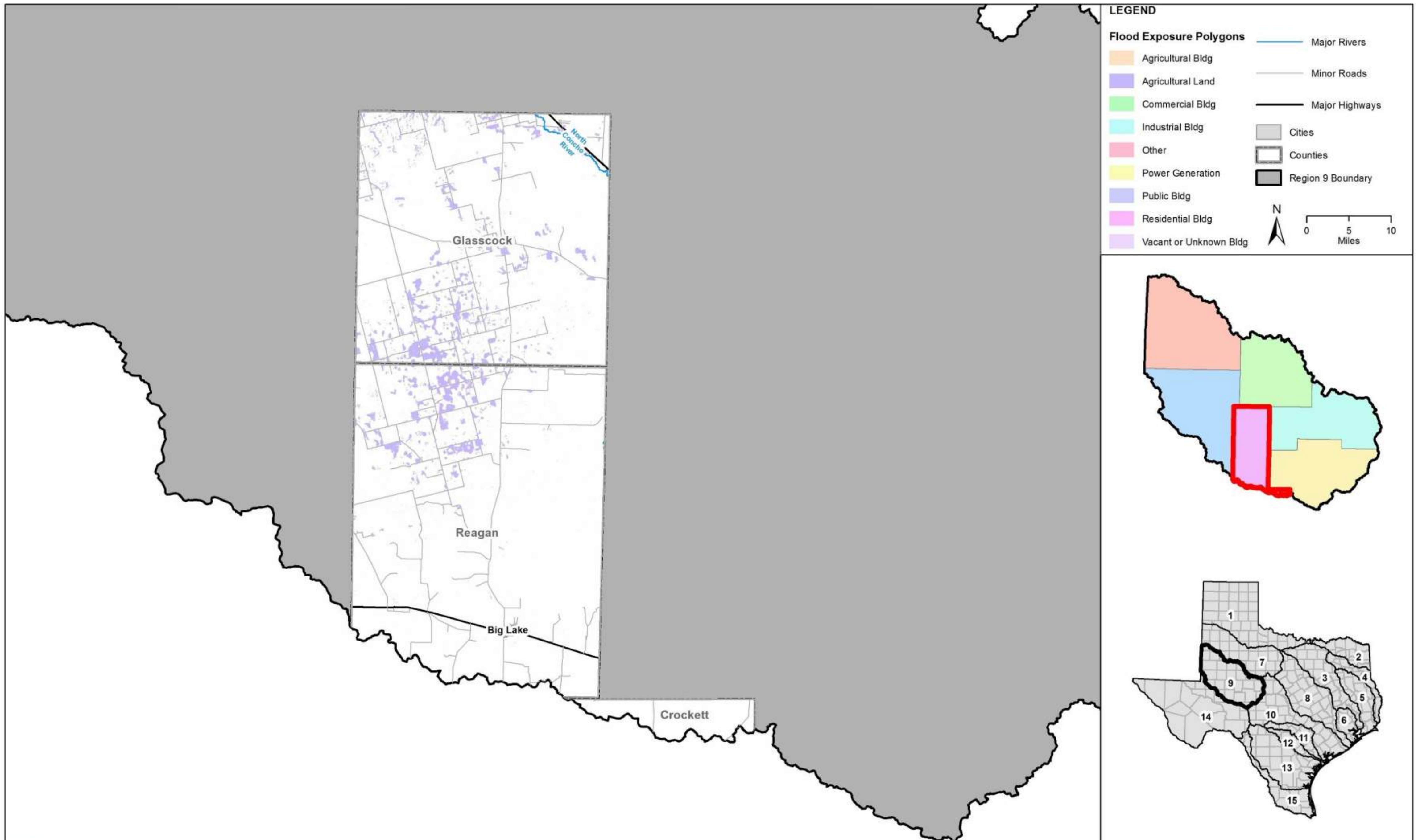
FIGURE 2

PATH: \\DALCTXSRV01\TEXAS_GIS_PROJECTS\10310495_10189_COSANANGELO_UPPERCOLORADOFP\MAP_DOCS\FIGURES\SUBMISSION_AUG22\MAP6EXISTINGFLDEXPOSUREPOLYGONS_GROUPA_11X17_SA22.MXD - USER: KJAVVAJI - DATE: 7/14/2022



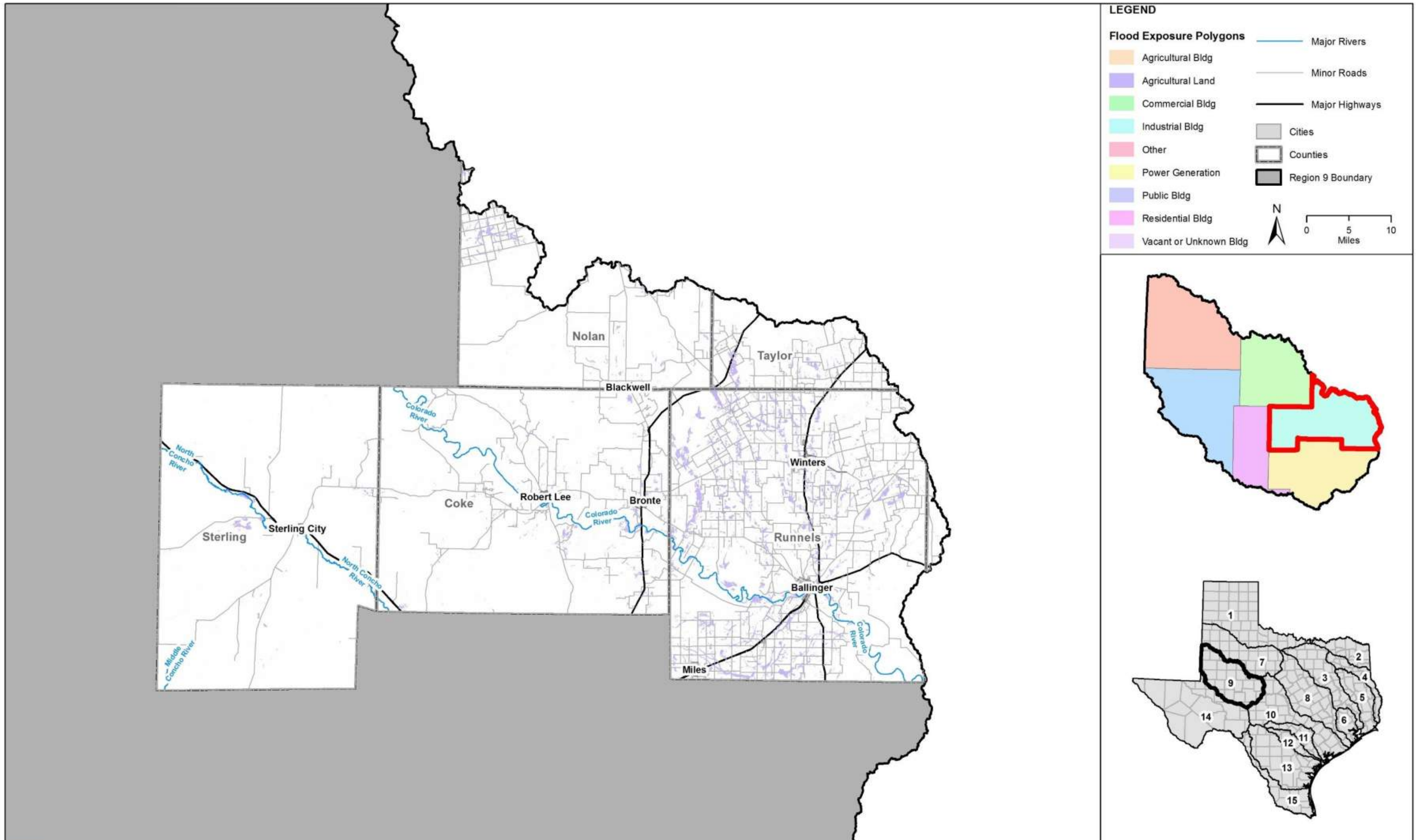
REGION 9 UPPER COLORADO - MID UPPER BASIN - MAP 6: EXISTING CONDITION FLOOD EXPOSURE

FIGURE 3



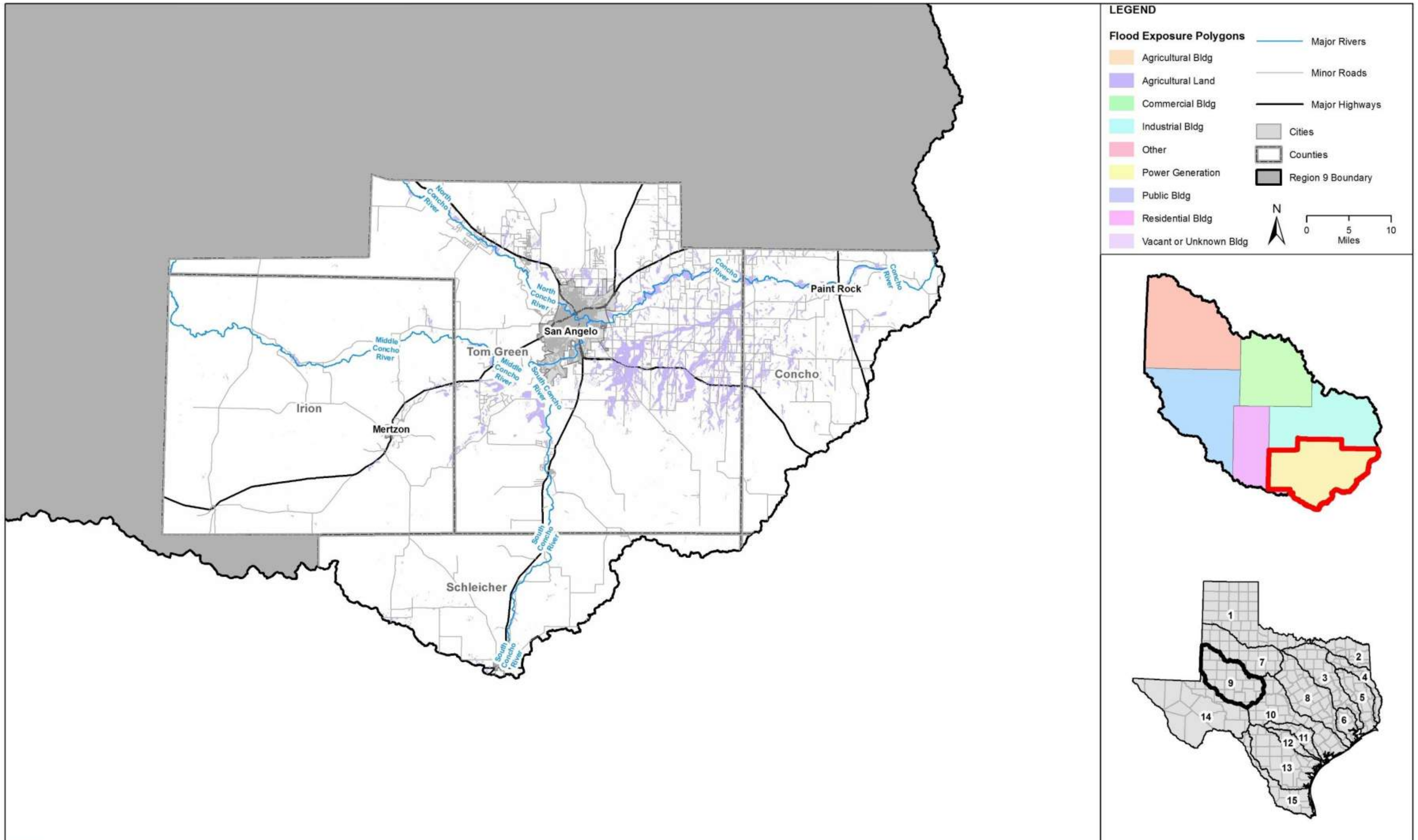
REGION 9 UPPER COLORADO - MID LOWER BASIN - MAP 6: EXISTING CONDITION FLOOD EXPOSURE

FIGURE 4



REGION 9 UPPER COLORADO - LOWER MID BASIN - MAP 6: EXISTING CONDITION FLOOD EXPOSURE

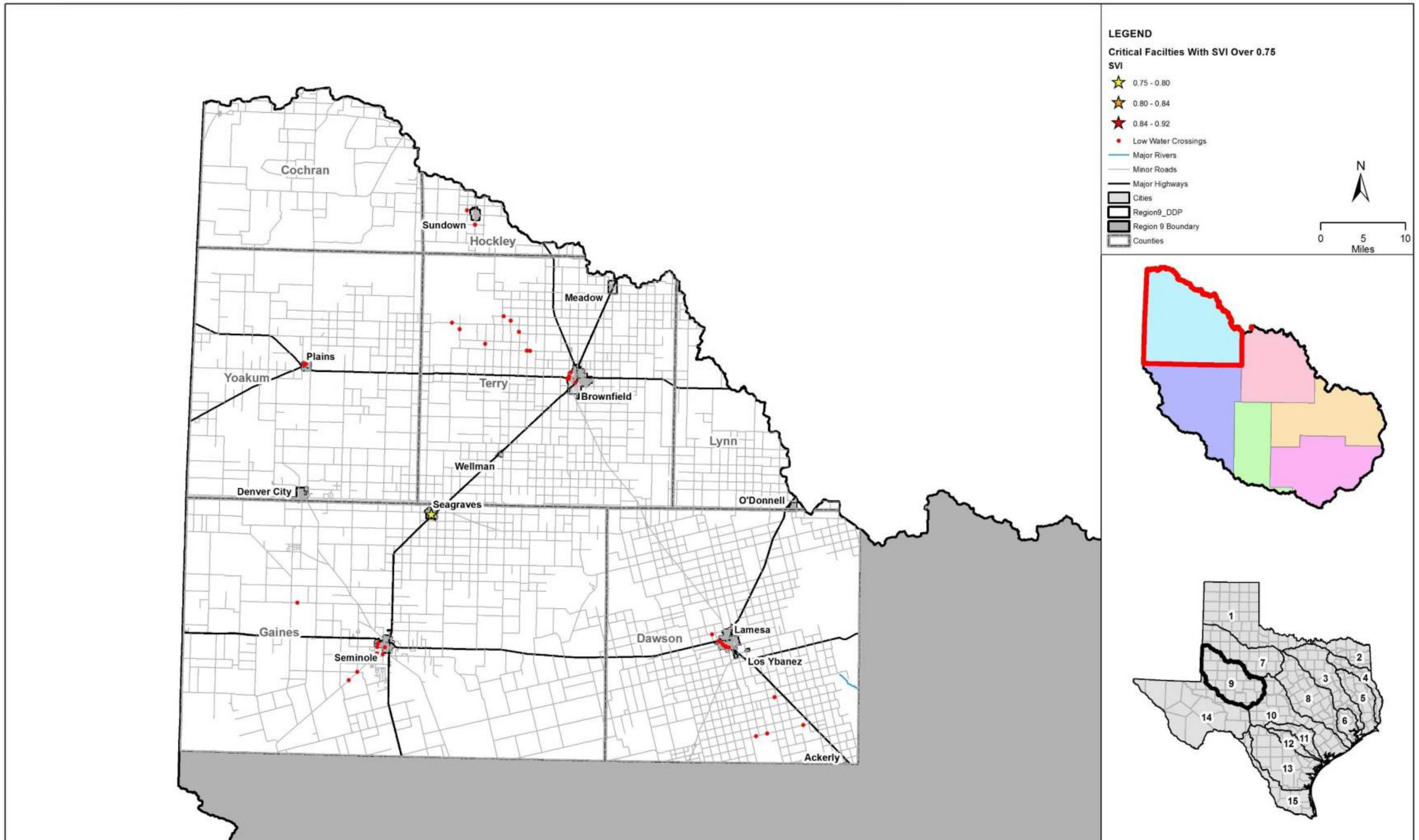
FIGURE 5



REGION 9 UPPER COLORADO - LOWER BASIN - MAP 6: EXISTING CONDITION FLOOD EXPOSURE

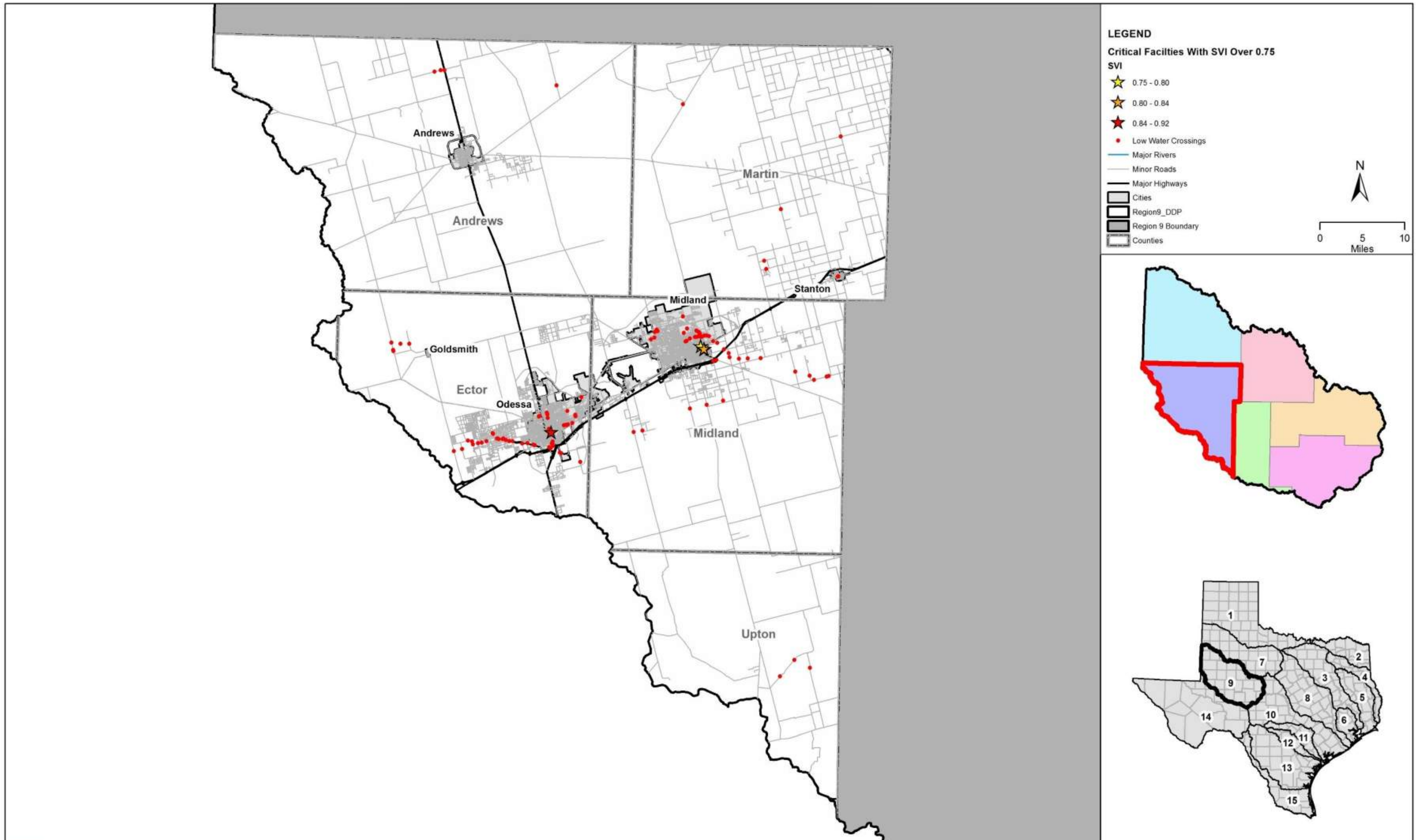
FIGURE 6

Map 7: Existing Condition Flood Vulnerability including Critical Infrastructure (2.2A.3 Existing condition vulnerability analysis)



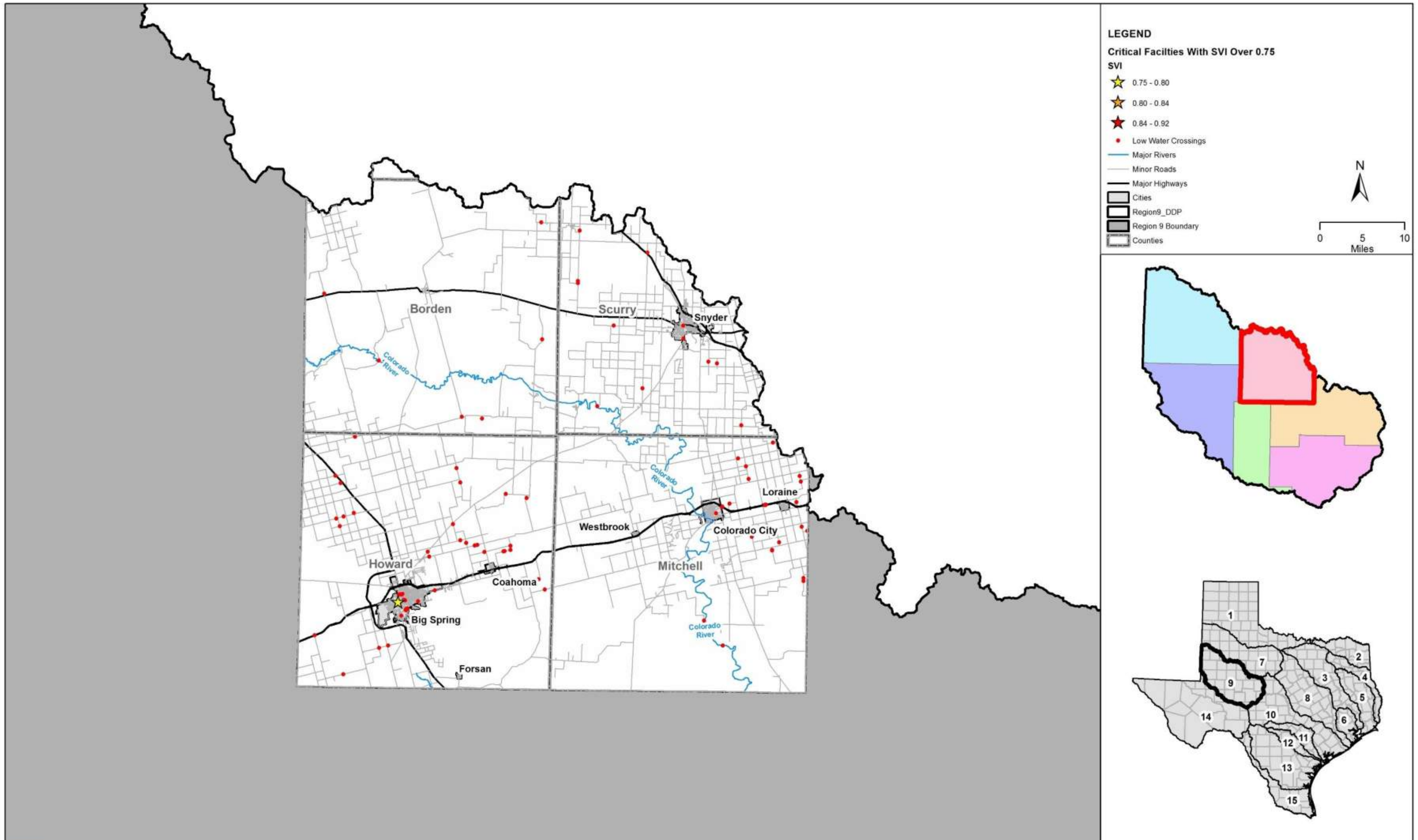
REGION 9 UPPER COLORADO - UPPER BASIN - MAP 7: EXISTING CONDITION VULNERABILITY AND CRITICAL INFRASTRUCTURE

FIGURE 1



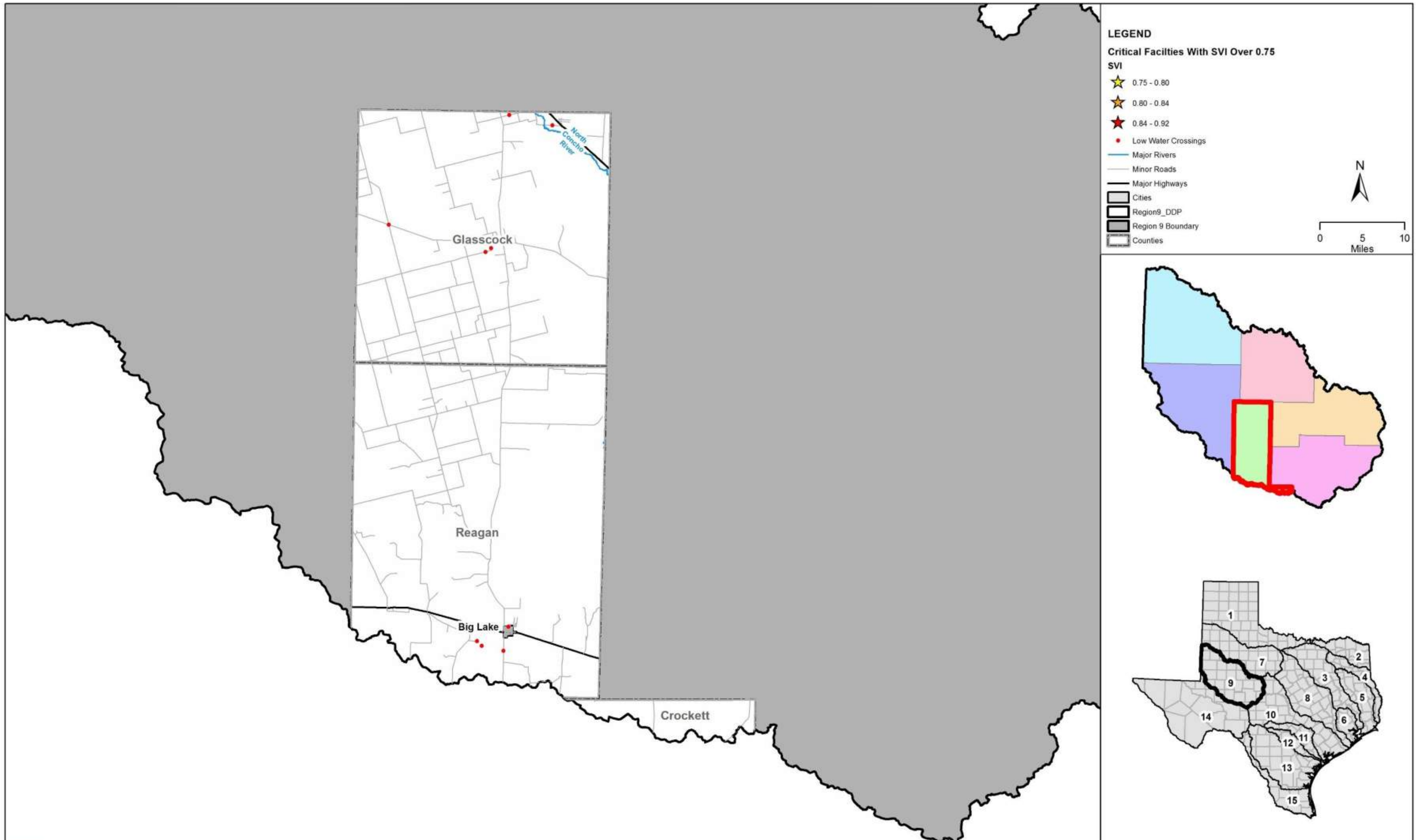
REGION 9 UPPER COLORADO - UPPER MID BASIN - MAP 7: EXISTING CONDITION VULNERABILITY AND CRITICAL INFRASTRUCTURE

FIGURE 2



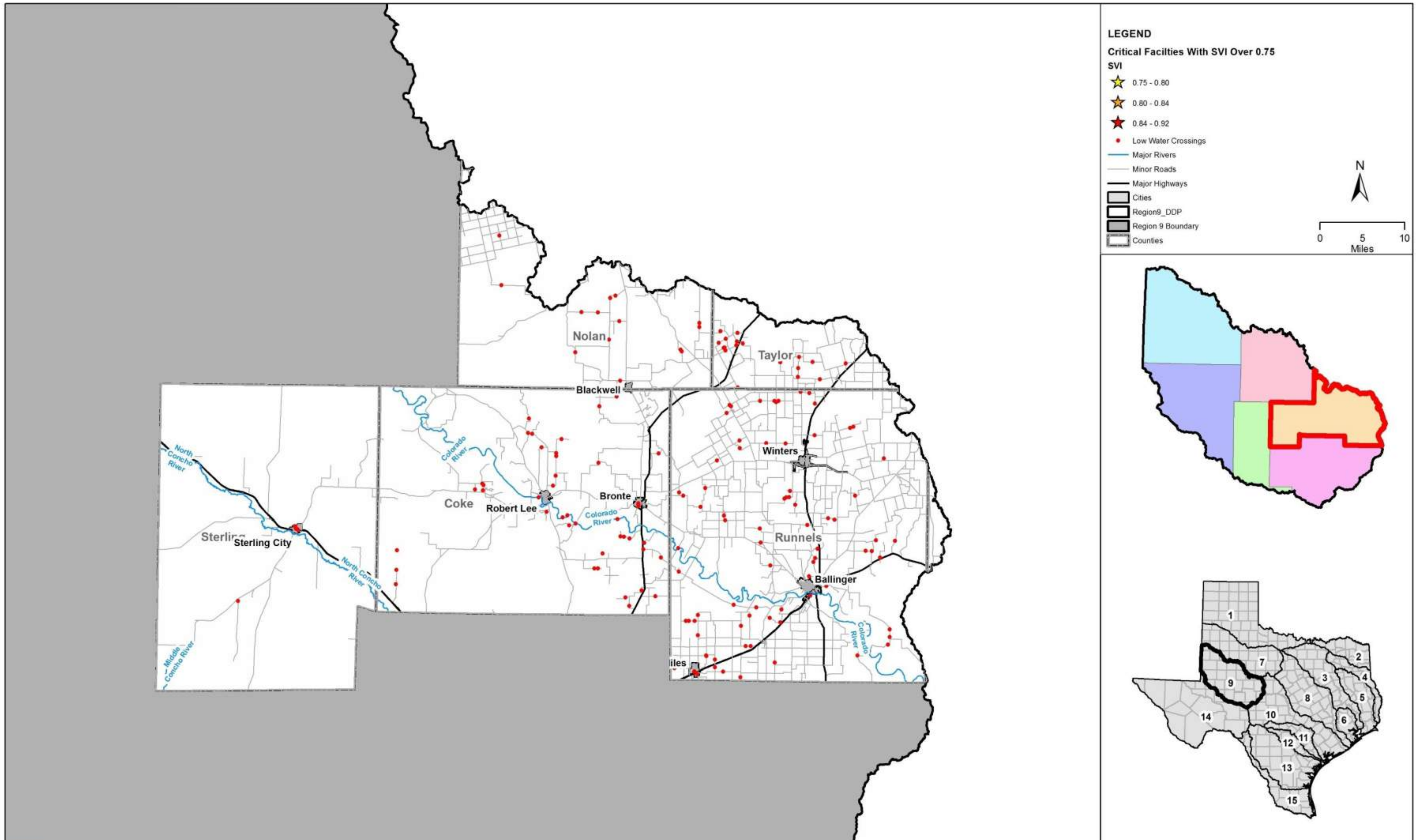
REGION 9 UPPER COLORADO - MID UPPER BASIN - MAP 7: EXISTING CONDITION VULNERABILITY AND CRITICAL INFRASTRUCTURE

FIGURE 3



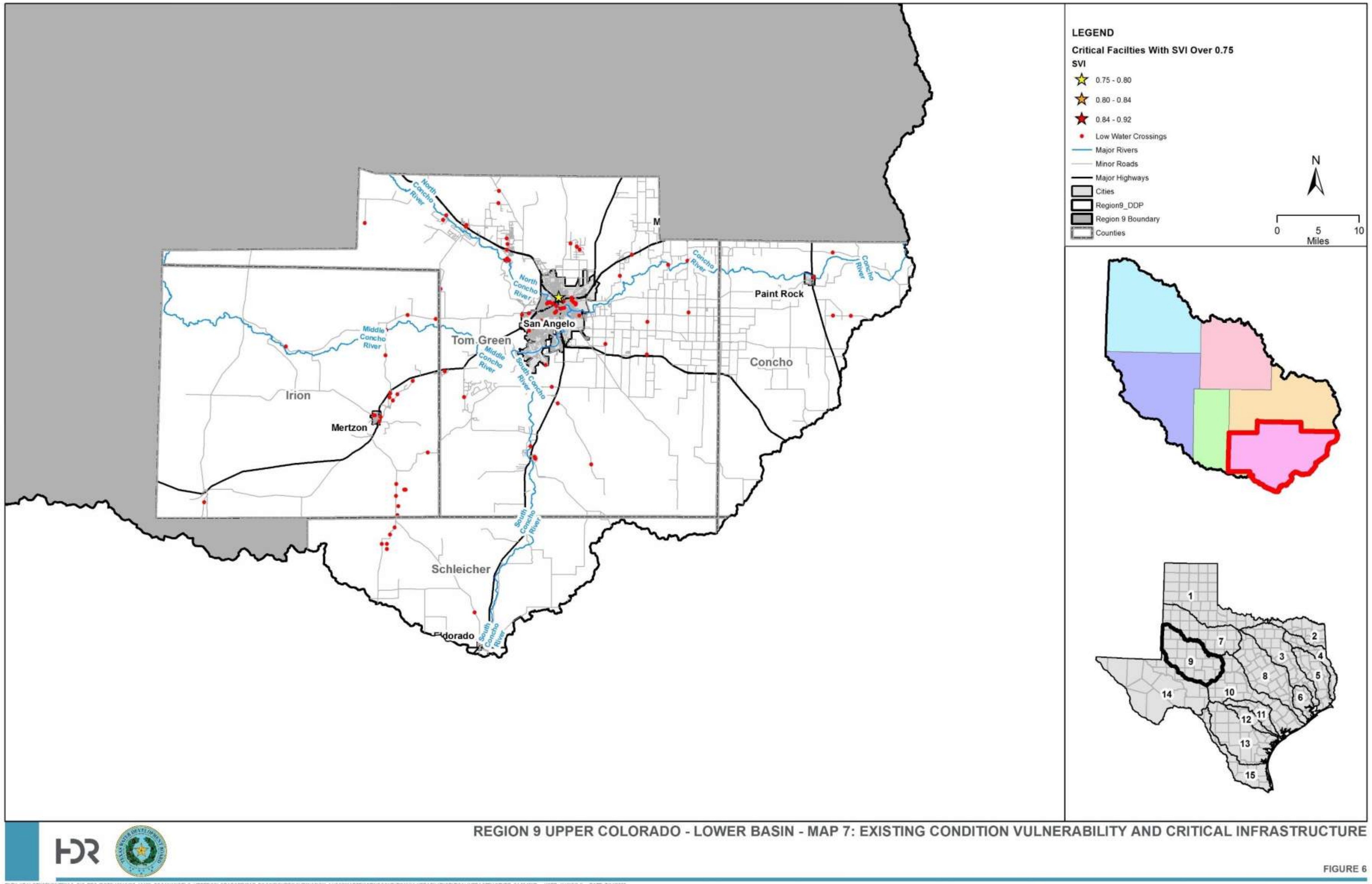
REGION 9 UPPER COLORADO - MID LOWER BASIN - MAP 7: EXISTING CONDITION VULNERABILITY AND CRITICAL INFRASTRUCTURE

FIGURE 4

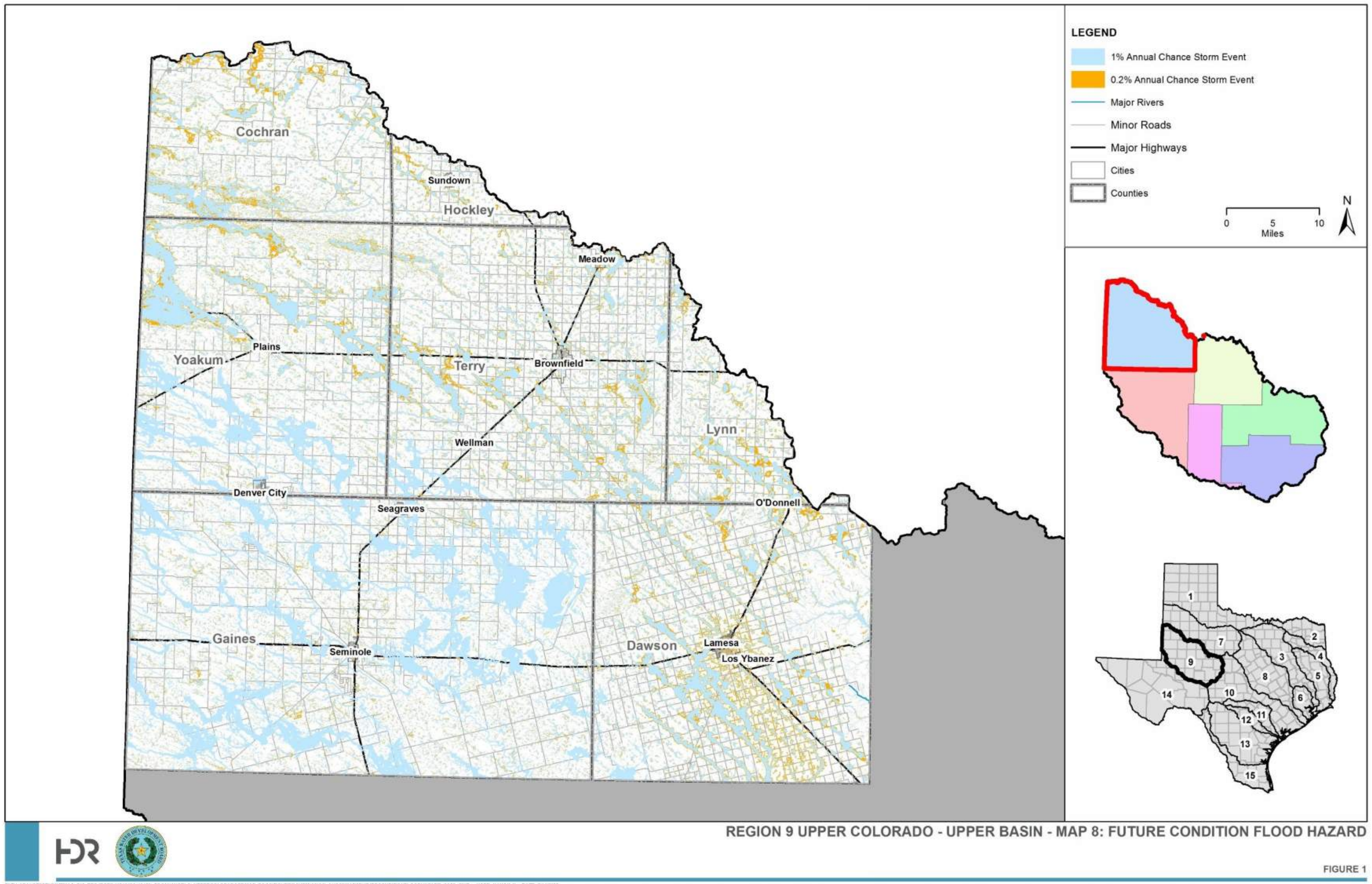


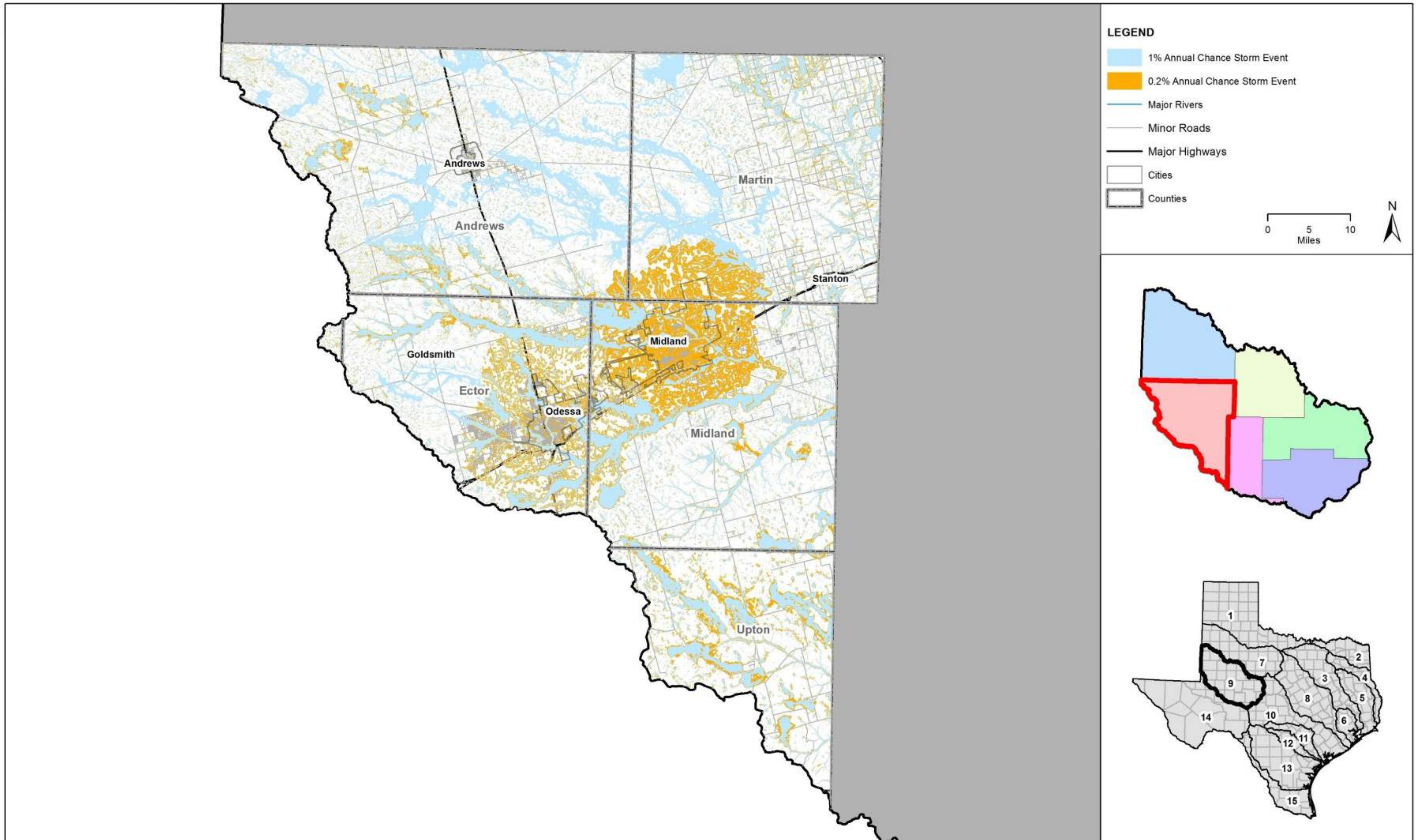
REGION 9 UPPER COLORADO - LOWER MID BASIN - MAP 7: EXISTING CONDITION VULNERABILITY AND CRITICAL INFRASTRUCTURE

FIGURE 5


LEGEND
Critical Facilties With SVI Over 0.75
SVI
0.75 - 0.80
0.80 - 0.84
0.84 - 0.92
Low Water Crossings
Major Rivers
Minor Roads
Major Highways
Cities
Region9_DDP
Region 9 Boundary
Counties
N
0 5 10
Miles
San Angelo
Tom Green
Paint Rock
Concho
Irion
Mertzon
Schleicher
Eldorado
North Concho River
Middle Concho River
South Concho River
Concho River
REGION 9 UPPER COLORADO - LOWER BASIN - MAP 7: EXISTING CONDITION VULNERABILITY AND CRITICAL INFRASTRUCTURE
FIGURE 6

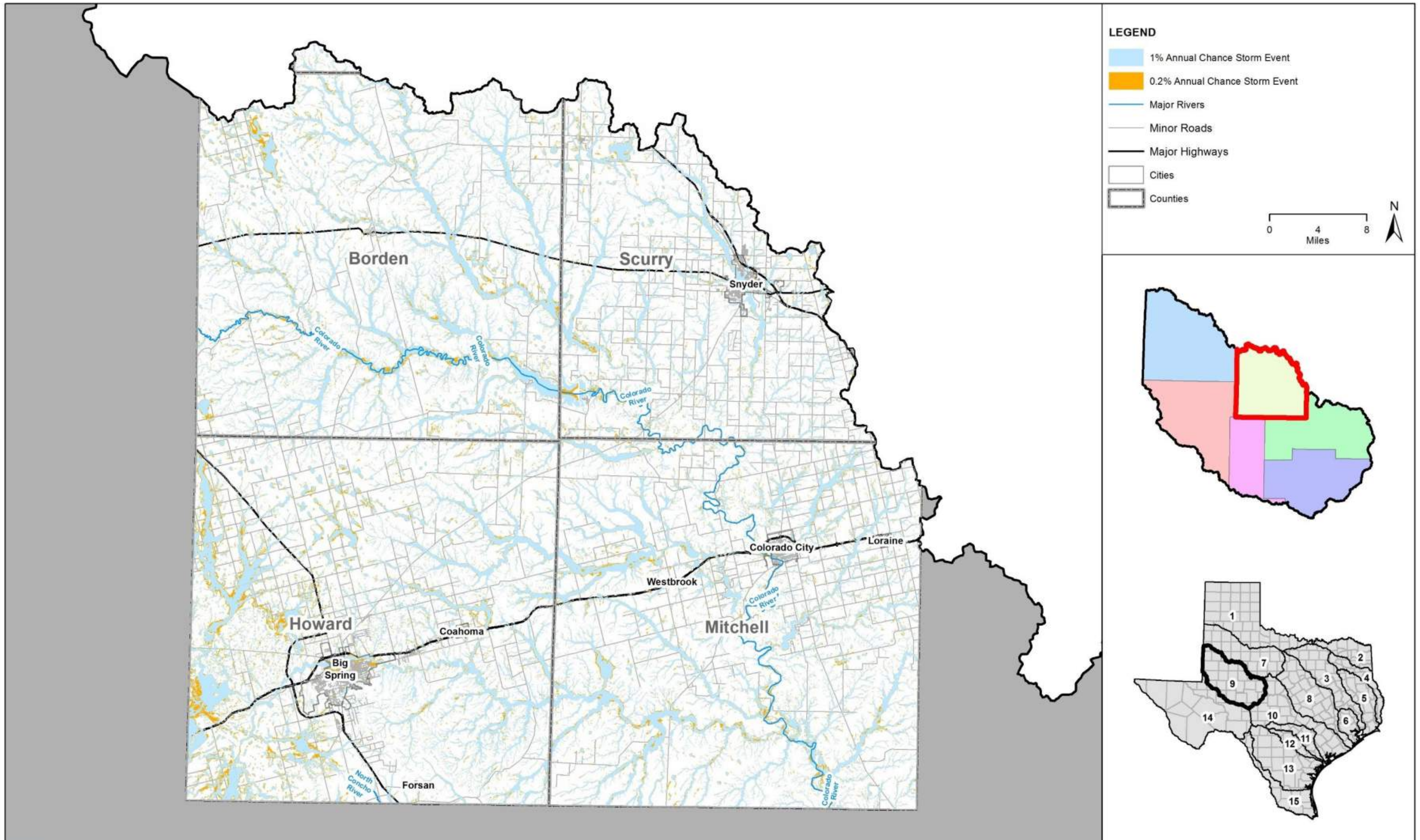
Map 8: Future Condition Flood Hazard (2.2.B.1 Future condition flood hazard analysis)





REGION 9 UPPER COLORADO - UPPER MID BASIN - MAP 8: FUTURE CONDITION FLOOD HAZARD

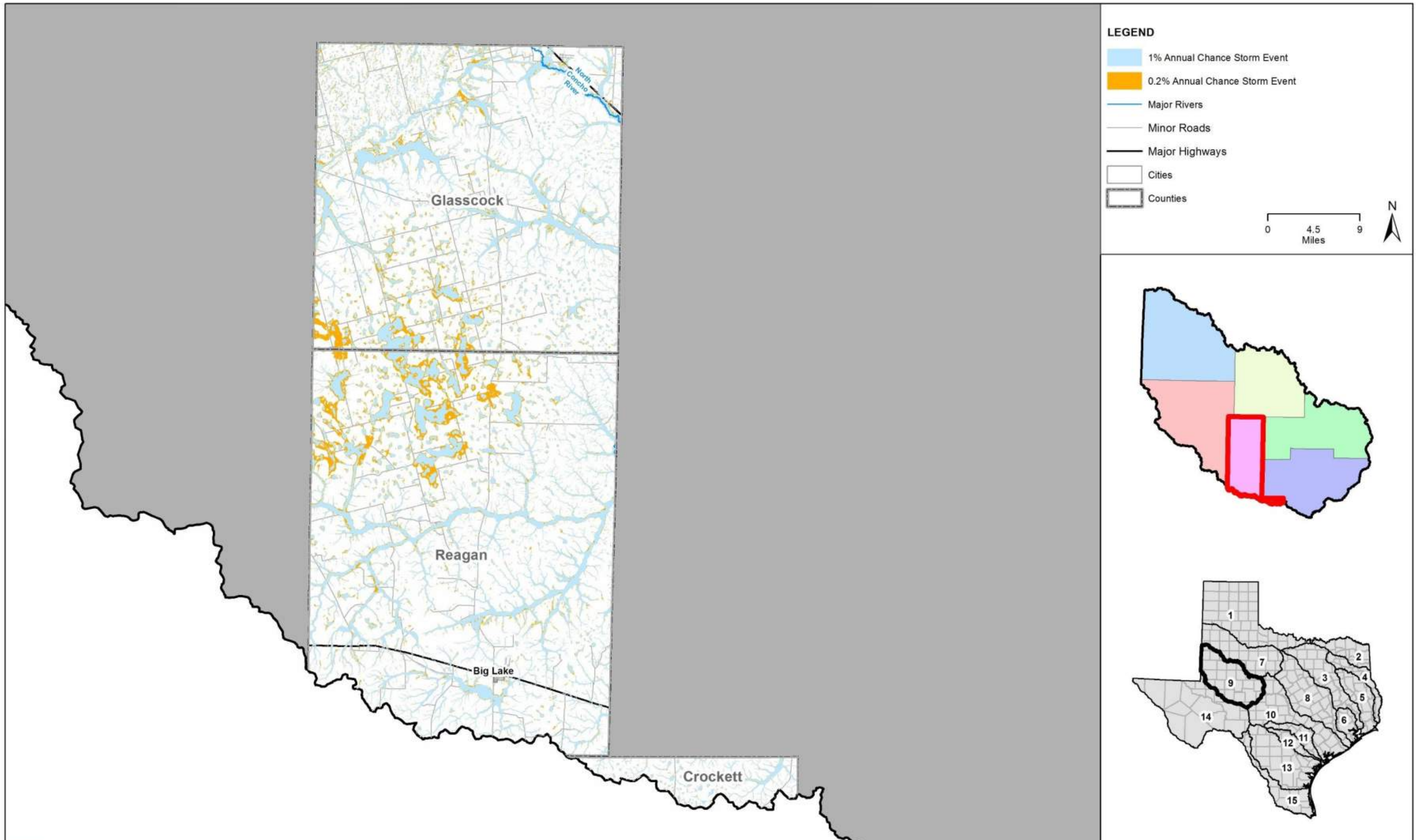
FIGURE 2



REGION 9 UPPER COLORADO - MID UPPER BASIN - MAP 8: FUTURE CONDITION FLOOD HAZARD

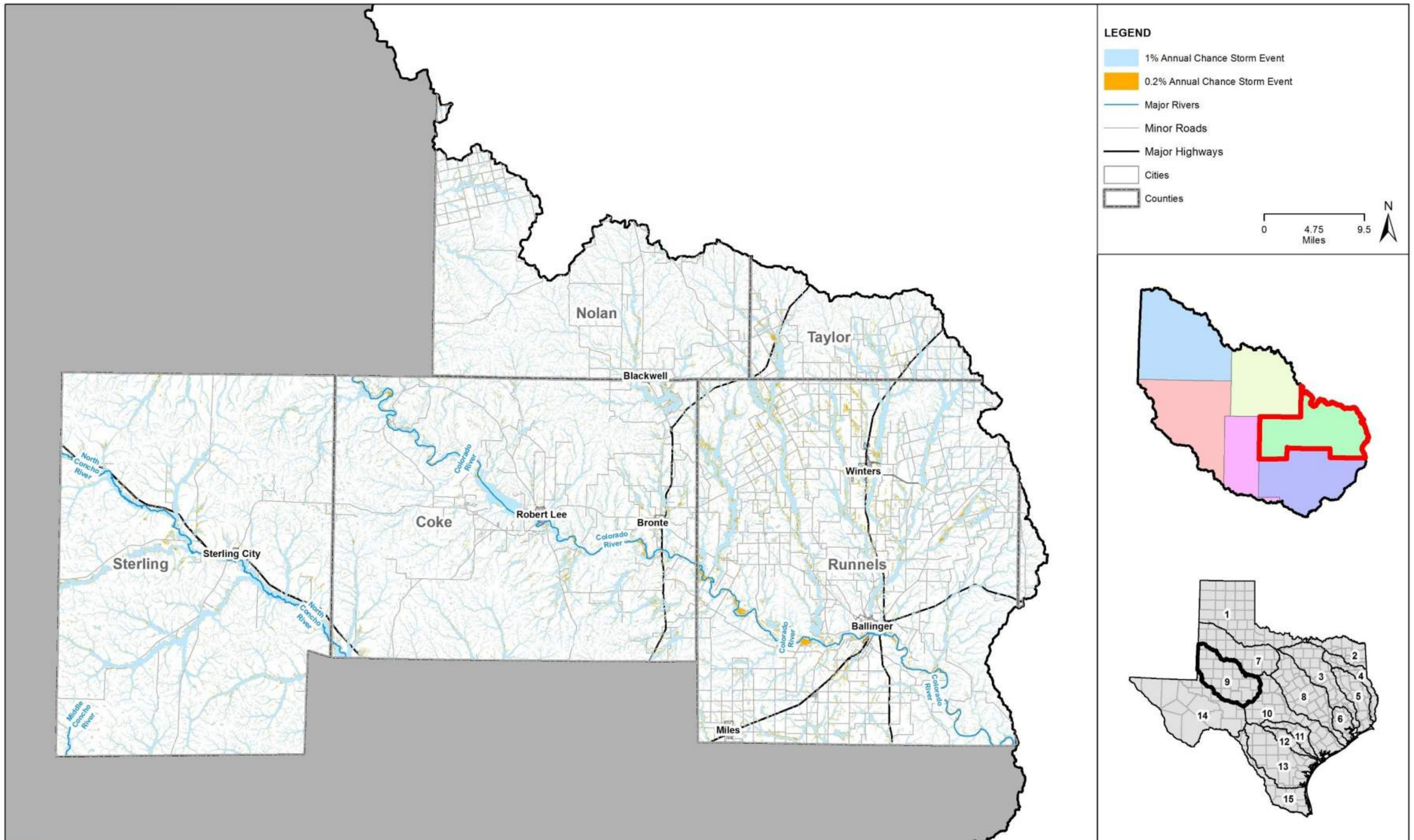
FIGURE 3

PATH: \\DALCTXSRV01\TEXAS_GIS_PROJECTS\10310495_10189_COSANANGELO_UPPERCOLORADOFP\MAP_DOCS\FIGURES\SUBMISSION_AUG22\MAP8FUTURECONDITIONFLOODHAZARD_SA22_.MXD - USER: KJAVVAJI - DATE: 7/14/2022



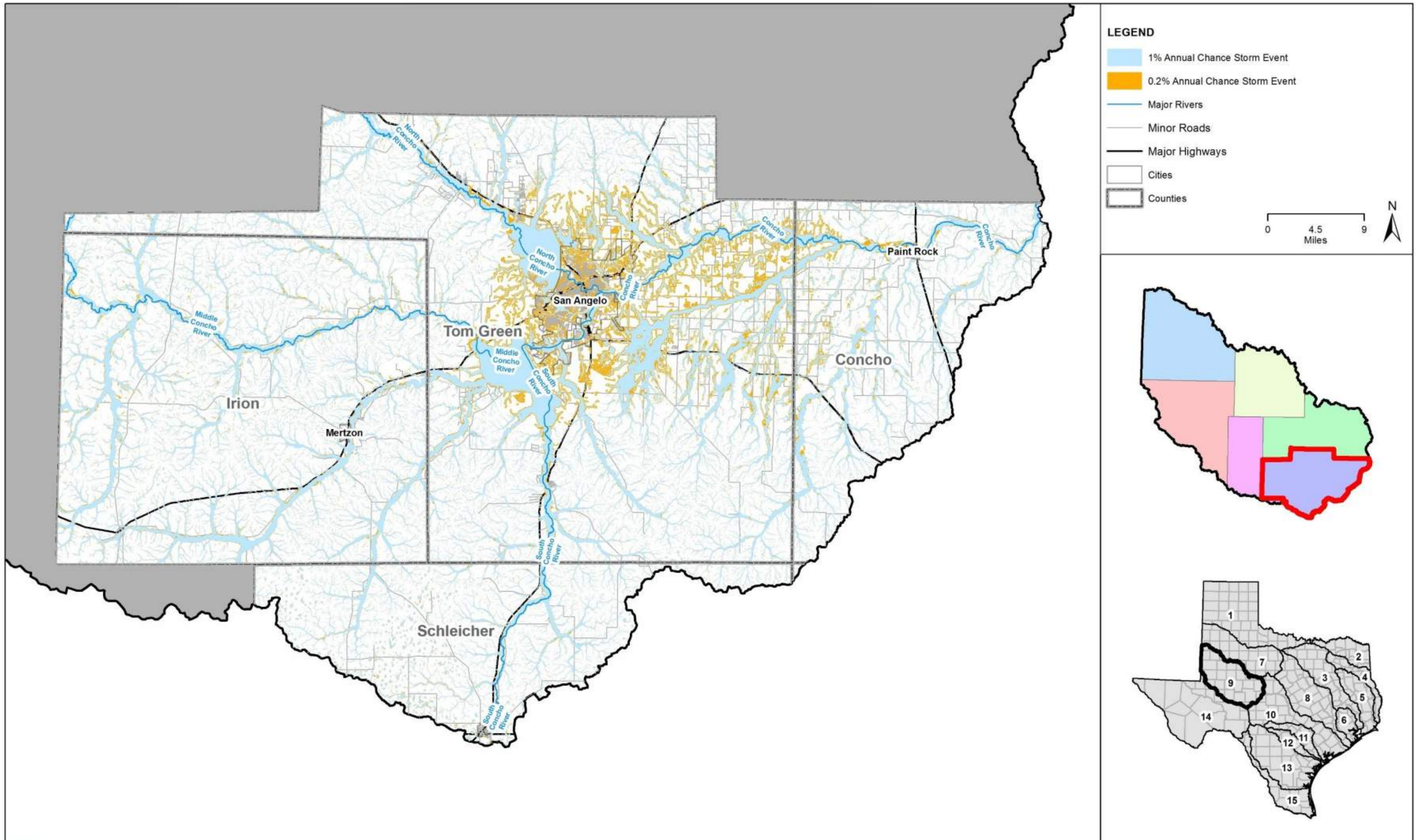
REGION 9 UPPER COLORADO - MID LOWER BASIN - MAP 8: FUTURE CONDITION FLOOD HAZARD

FIGURE 4



REGION 9 UPPER COLORADO - LOWER MID BASIN - MAP 8: FUTURE CONDITION FLOOD HAZARD

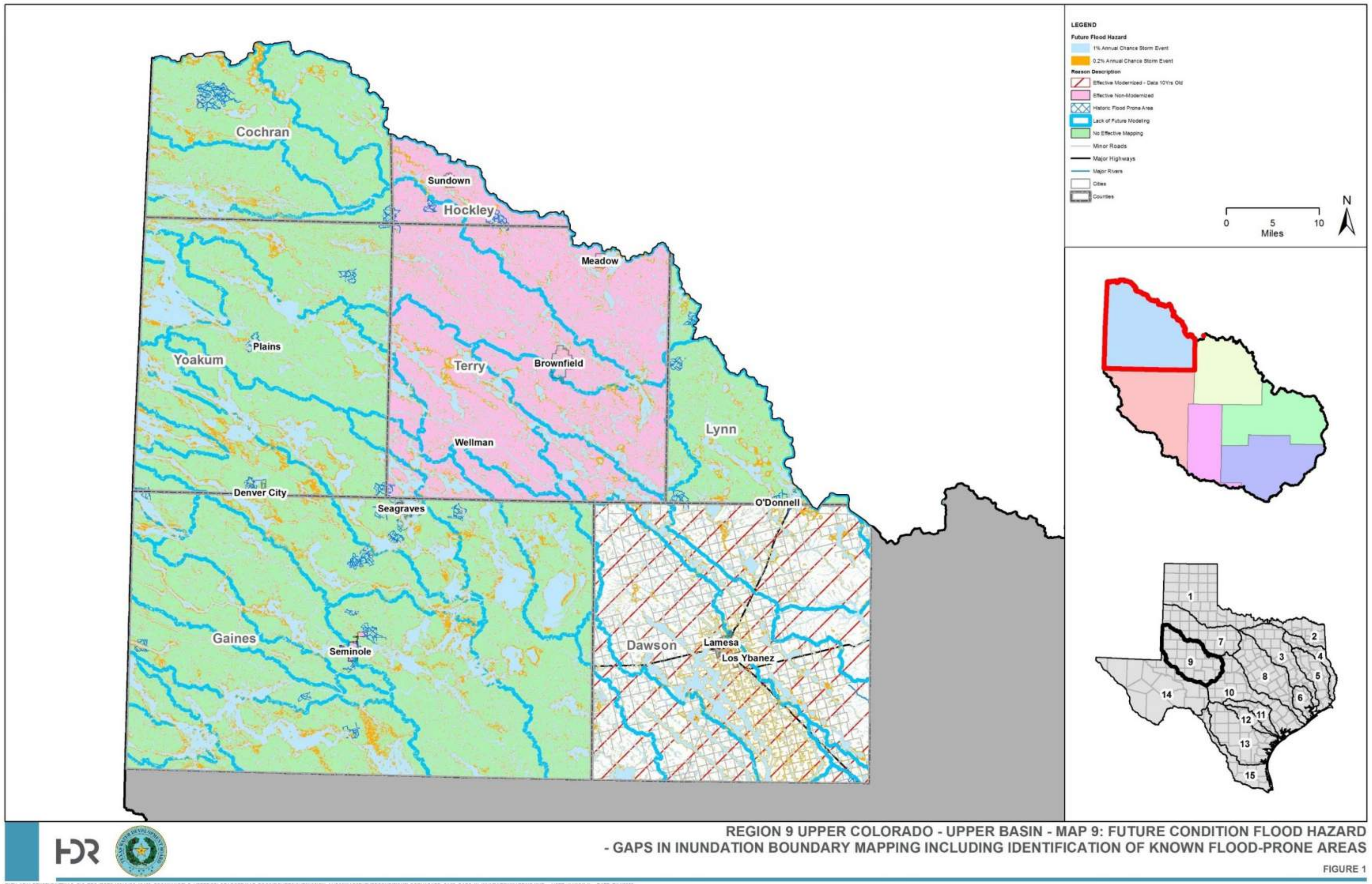
FIGURE 5

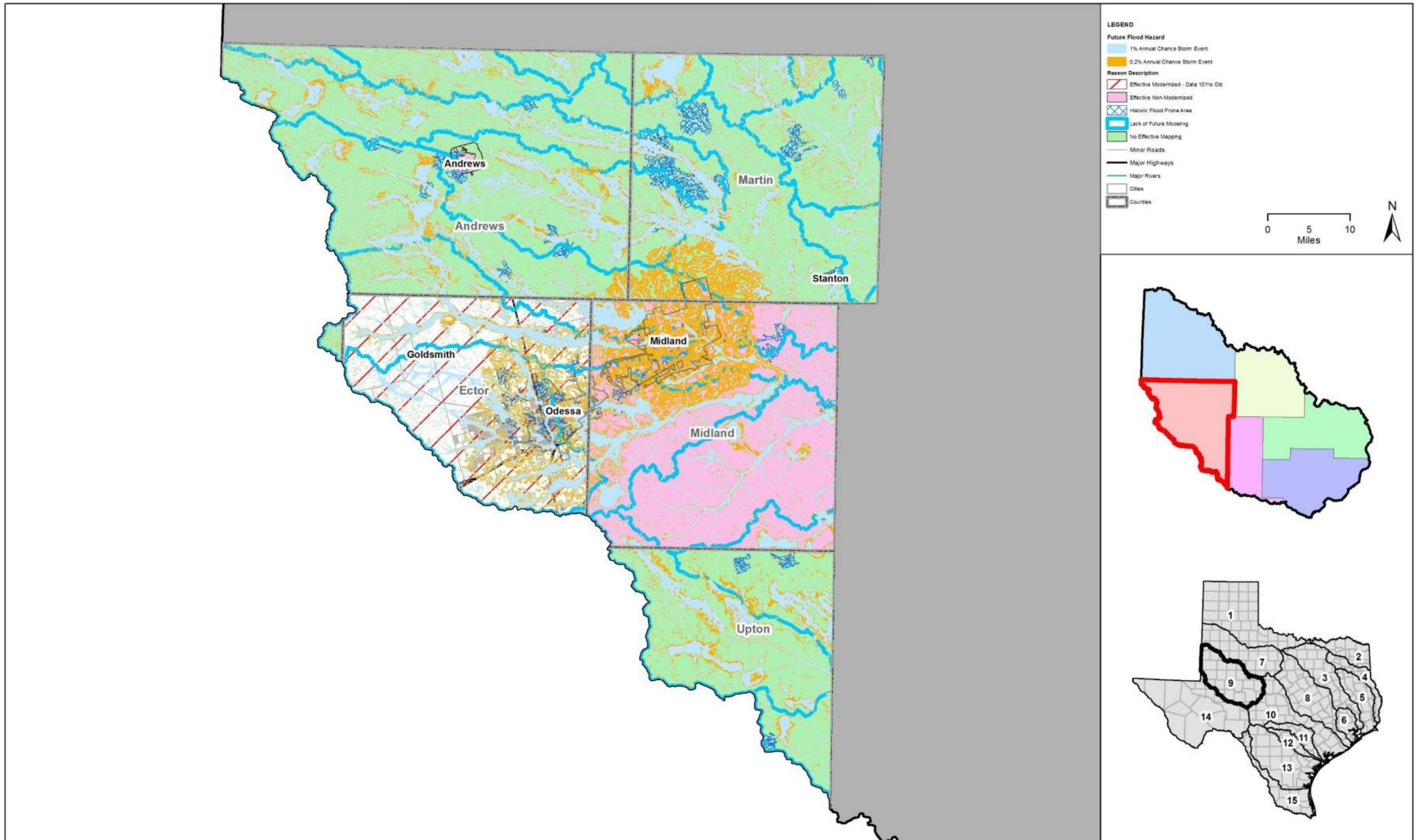


REGION 9 UPPER COLORADO - LOWER BASIN - MAP 8: FUTURE CONDITION FLOOD HAZARD

FIGURE 6

Map 9: Future Condition Flood Hazard - Gaps in Inundation Boundary Mapping including Identification of Known Flood-Prone Areas (2.2.B.1 Future condition flood hazard analysis)

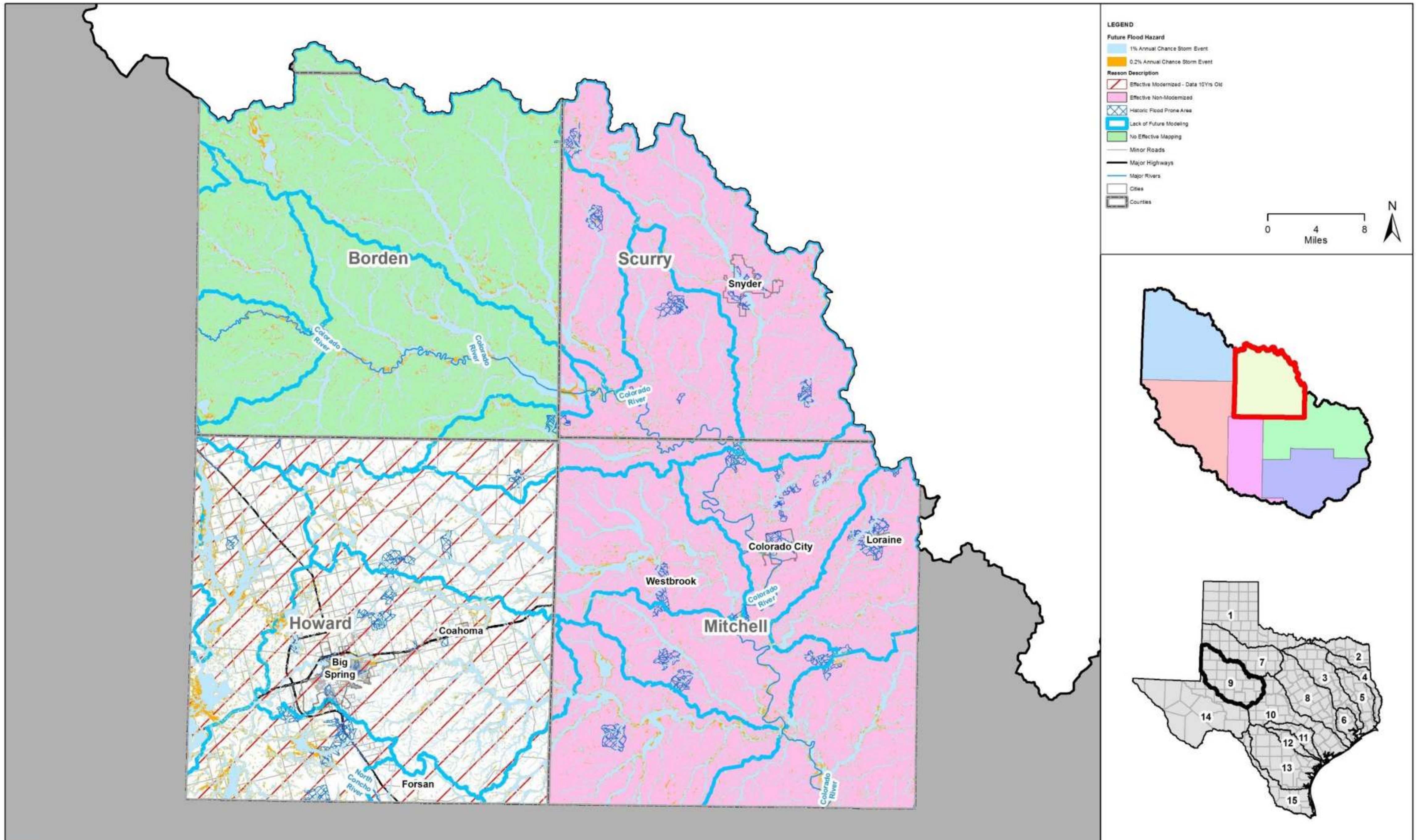




REGION 9 UPPER COLORADO - UPPER MID BASIN - MAP 9: FUTURE CONDITION FLOOD HAZARD - GAPS IN INUNDATION BOUNDARY MAPPING INCLUDING IDENTIFICATION OF KNOWN FLOOD-PRONE AREAS

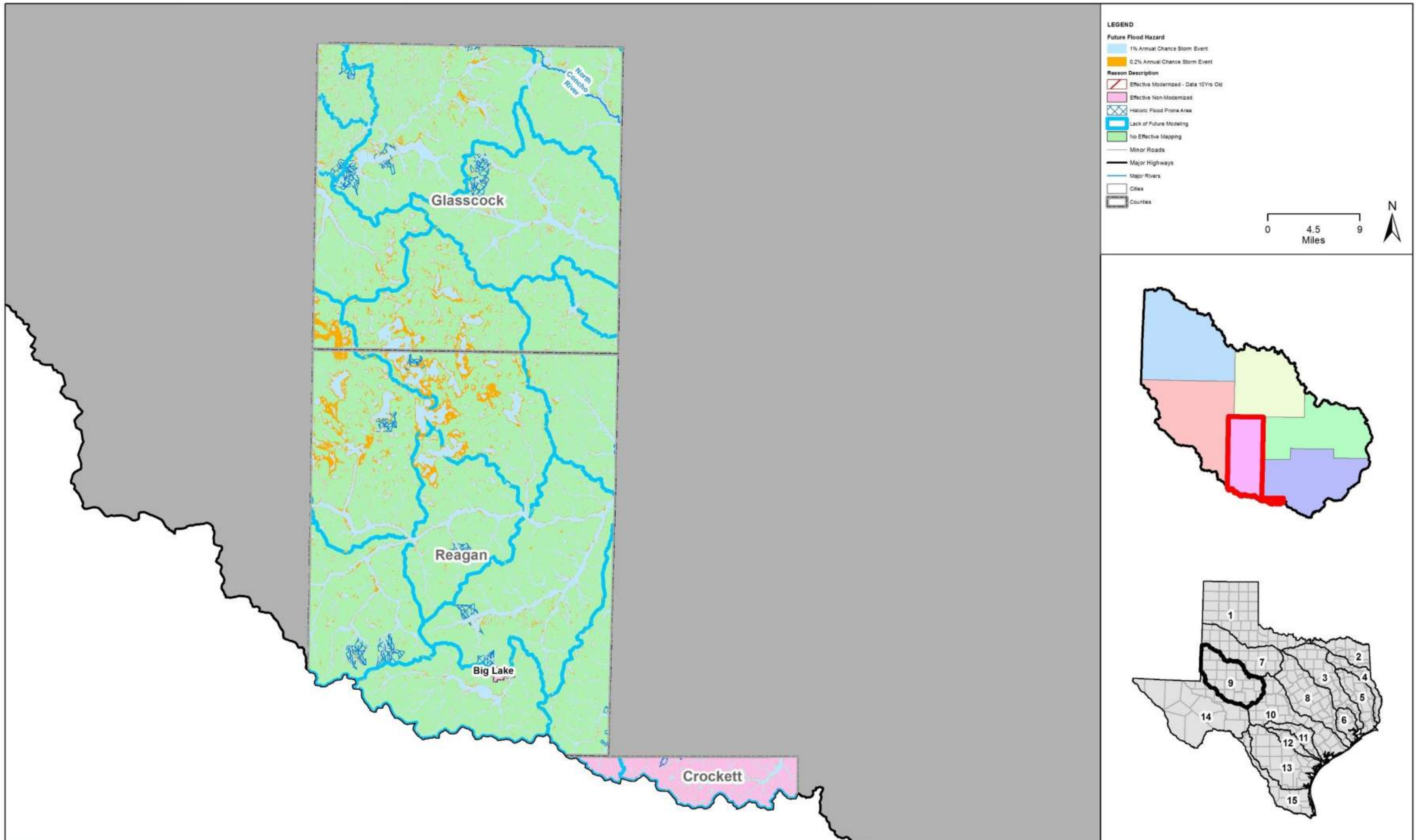
FIGURE 2

PATH: \\DALCTXSRV01\TEXAS_GIS_PROJECTS\10310495_10189_COSANANGELO_UPPERCOLORADOFP\MAP_DOCS\FIGURES\SUBMISSION_AUG22\MAP9FUTURECONDITIONFLOODHAZARD_SA22_GAPS_IN_INUNDATIONMAPPING.MXD - USER: KJAVVAJI - DATE: 7/14/2022



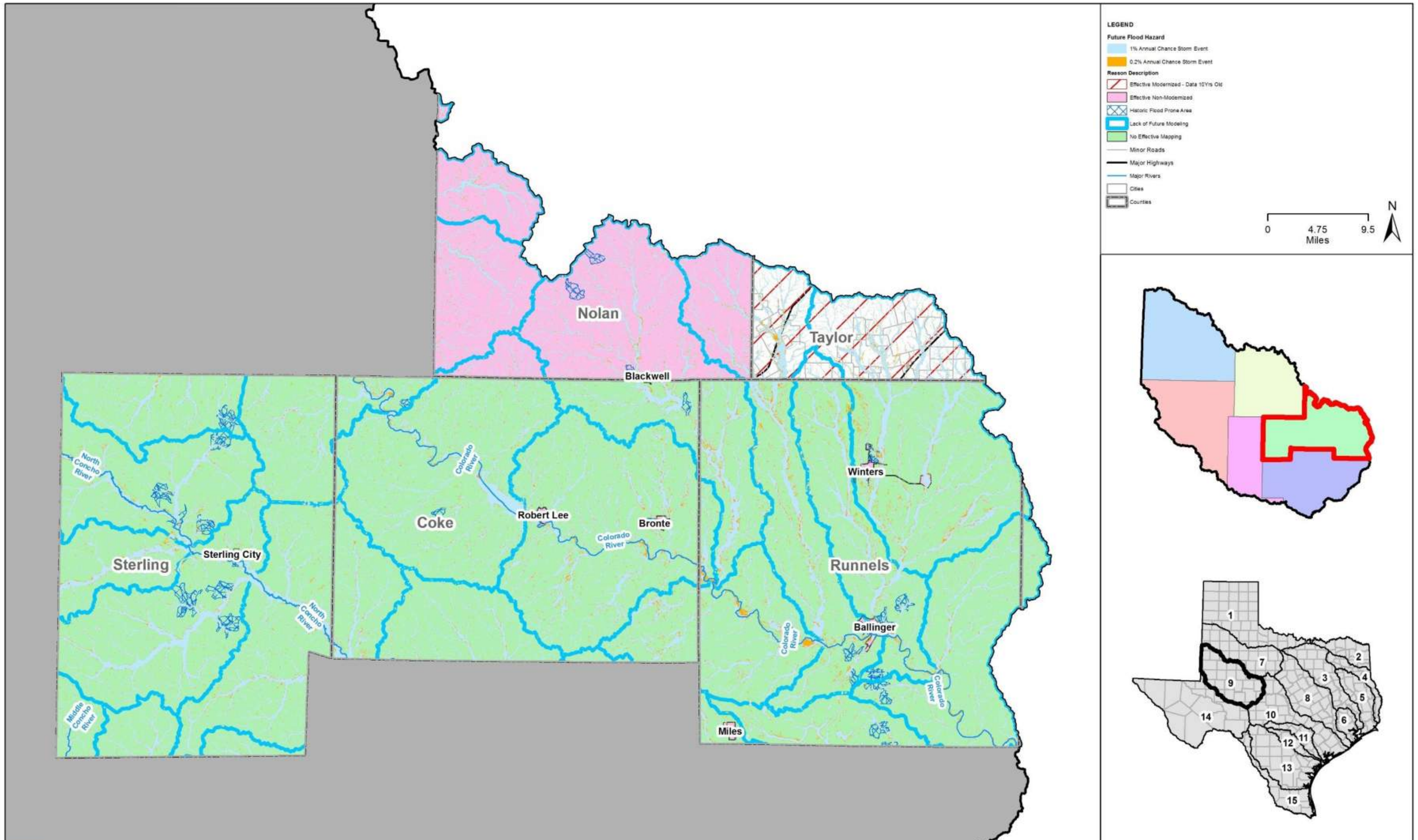
REGION 9 UPPER COLORADO - MID UPPER BASIN - MAP 9: FUTURE CONDITION FLOOD HAZARD - GAPS IN INUNDATION BOUNDARY MAPPING INCLUDING IDENTIFICATION OF KNOWN FLOOD-PRONE AREAS

FIGURE 3



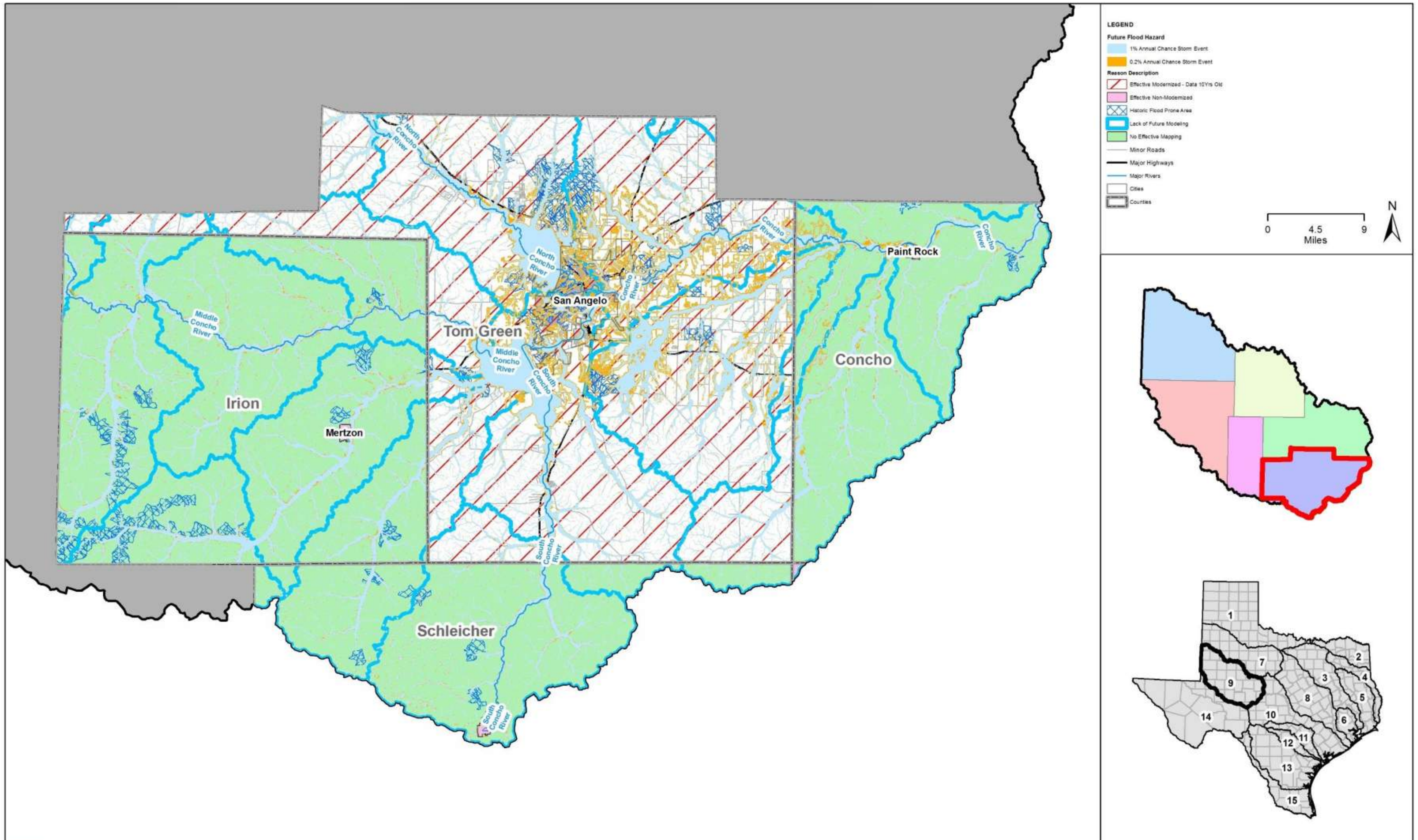
REGION 9 UPPER COLORADO - MID LOWER BASIN - MAP 9: FUTURE CONDITION FLOOD HAZARD - GAPS IN INUNDATION BOUNDARY MAPPING INCLUDING IDENTIFICATION OF KNOWN FLOOD-PRONE AREAS

FIGURE 4



REGION 9 UPPER COLORADO - LOWER MID BASIN - MAP 9: FUTURE CONDITION FLOOD HAZARD - GAPS IN INUNDATION BOUNDARY MAPPING INCLUDING IDENTIFICATION OF KNOWN FLOOD-PRONE AREAS

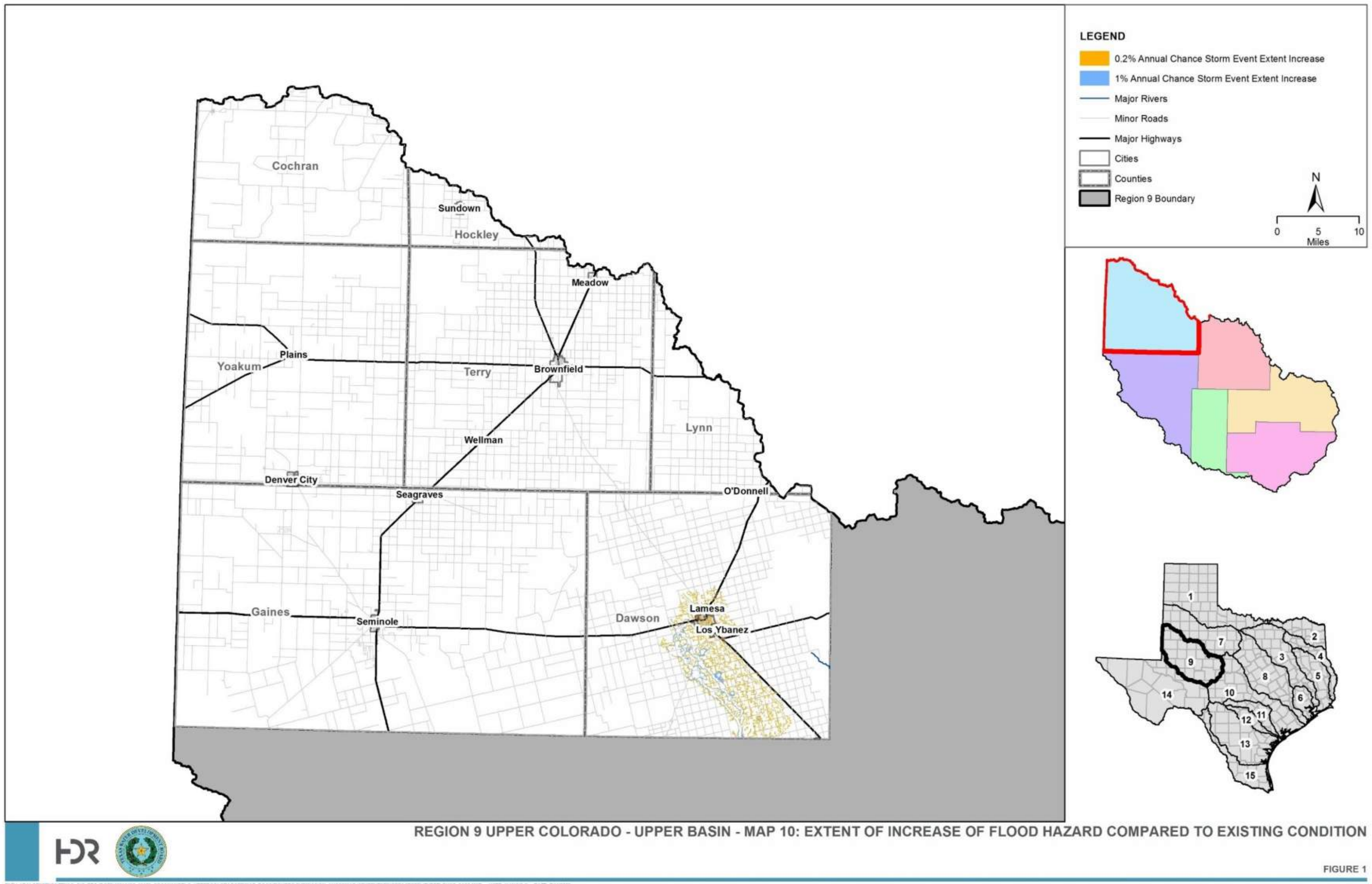
FIGURE 5

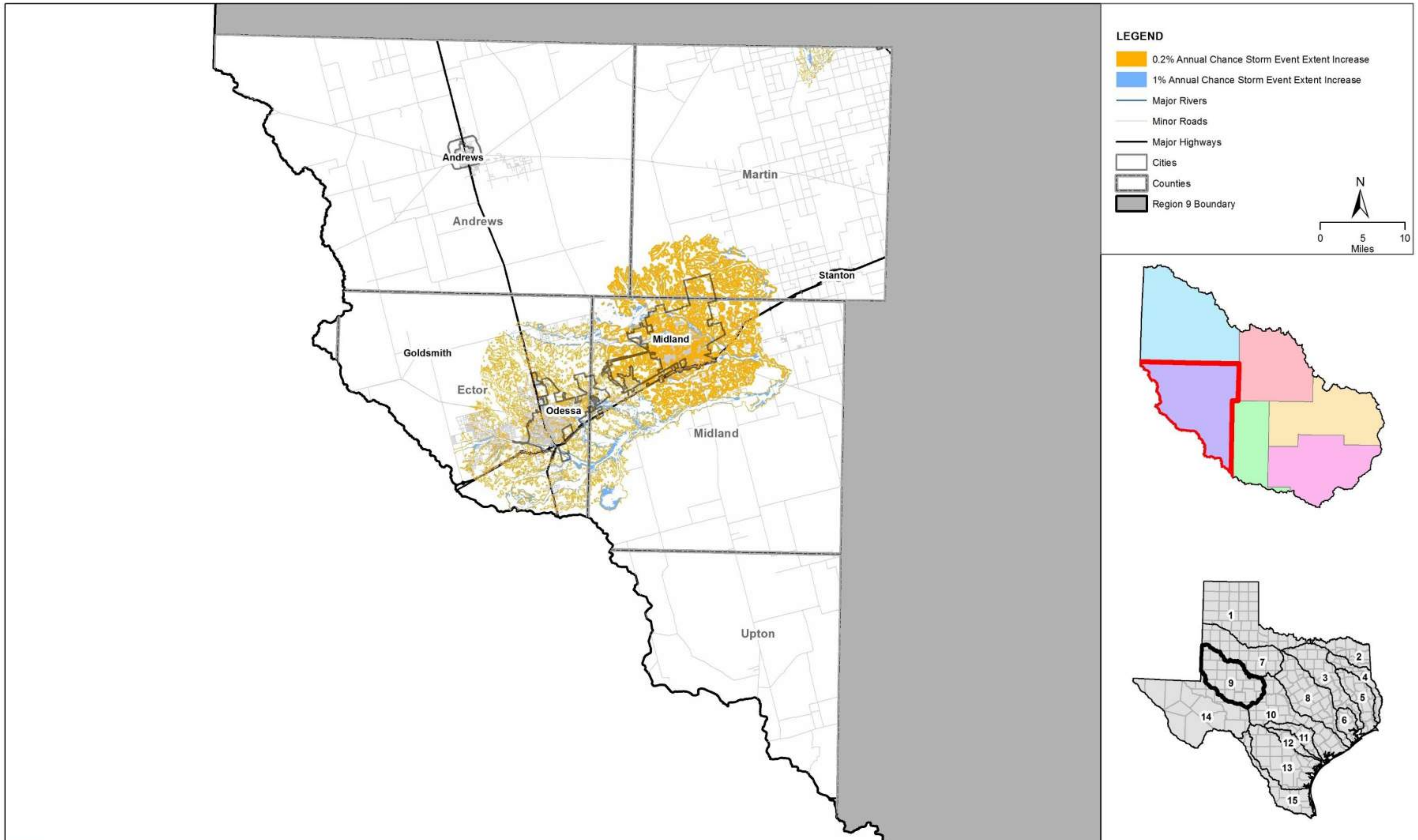


REGION 9 UPPER COLORADO - LOWER BASIN - MAP 9: FUTURE CONDITION FLOOD HAZARD - GAPS IN INUNDATION BOUNDARY MAPPING INCLUDING IDENTIFICATION OF KNOWN FLOOD-PRONE AREAS

FIGURE 6

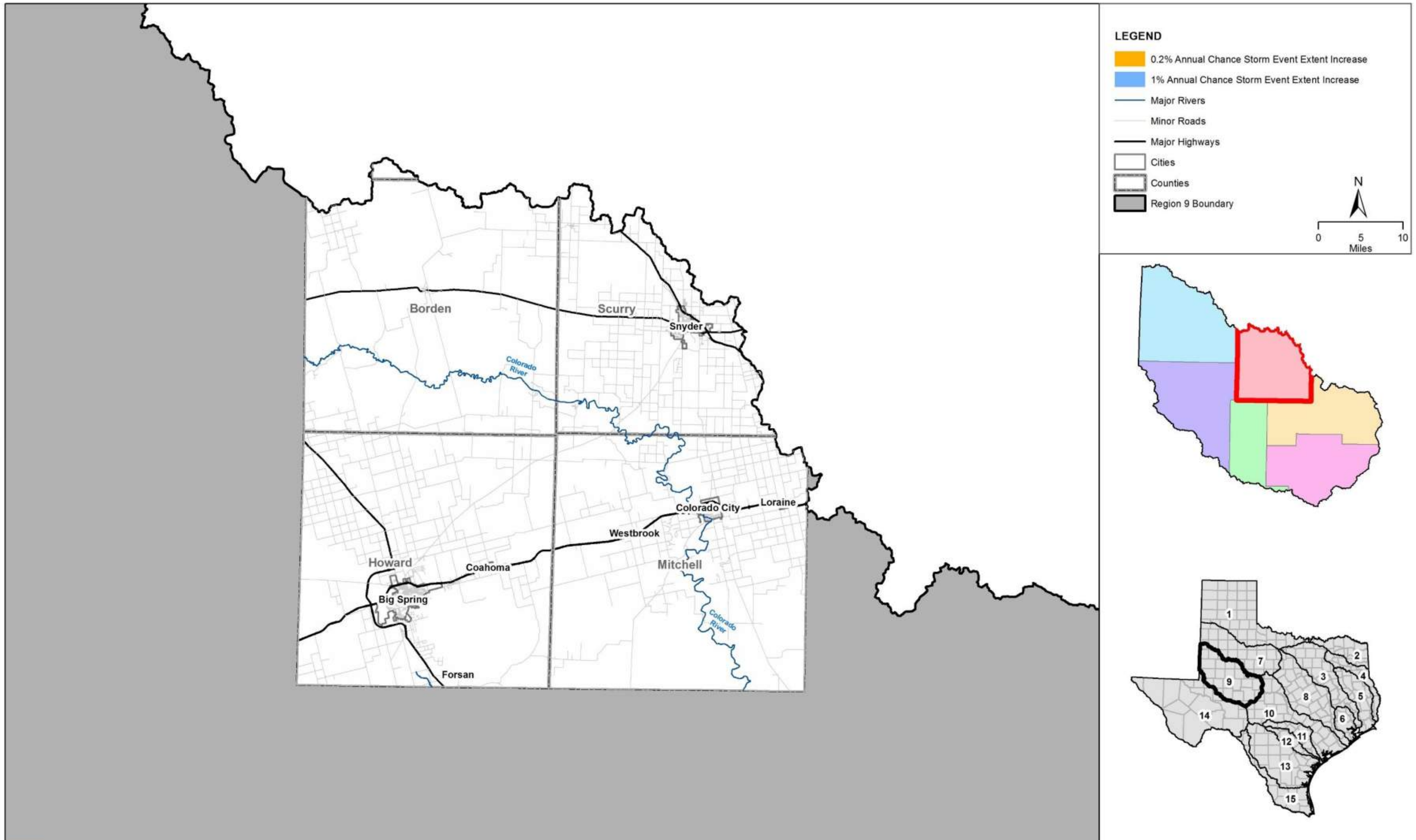
Map 10: Extent of Increase of Flood Hazard Compared to Existing Condition (2.2.B.1 Future condition flood hazard analysis)





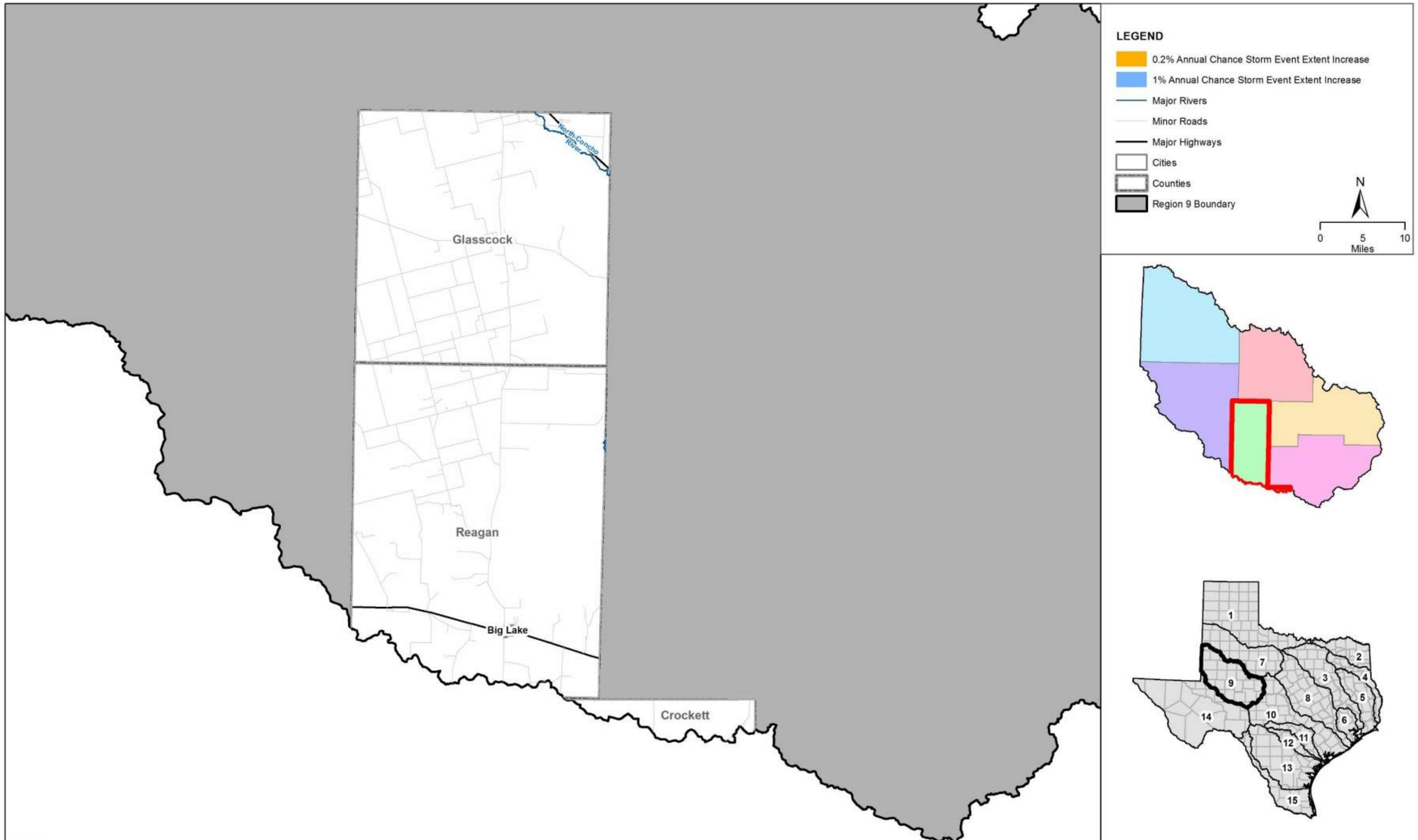
REGION 9 UPPER COLORADO - UPPER MID BASIN - MAP 10: EXTENT OF INCREASE OF FLOOD HAZARD COMPARED TO EXISTING CONDITION

FIGURE 2



REGION 9 UPPER COLORADO - MID UPPER BASIN - MAP 10: EXTENT OF INCREASE OF FLOOD HAZARD COMPARED TO EXISTING CONDITION

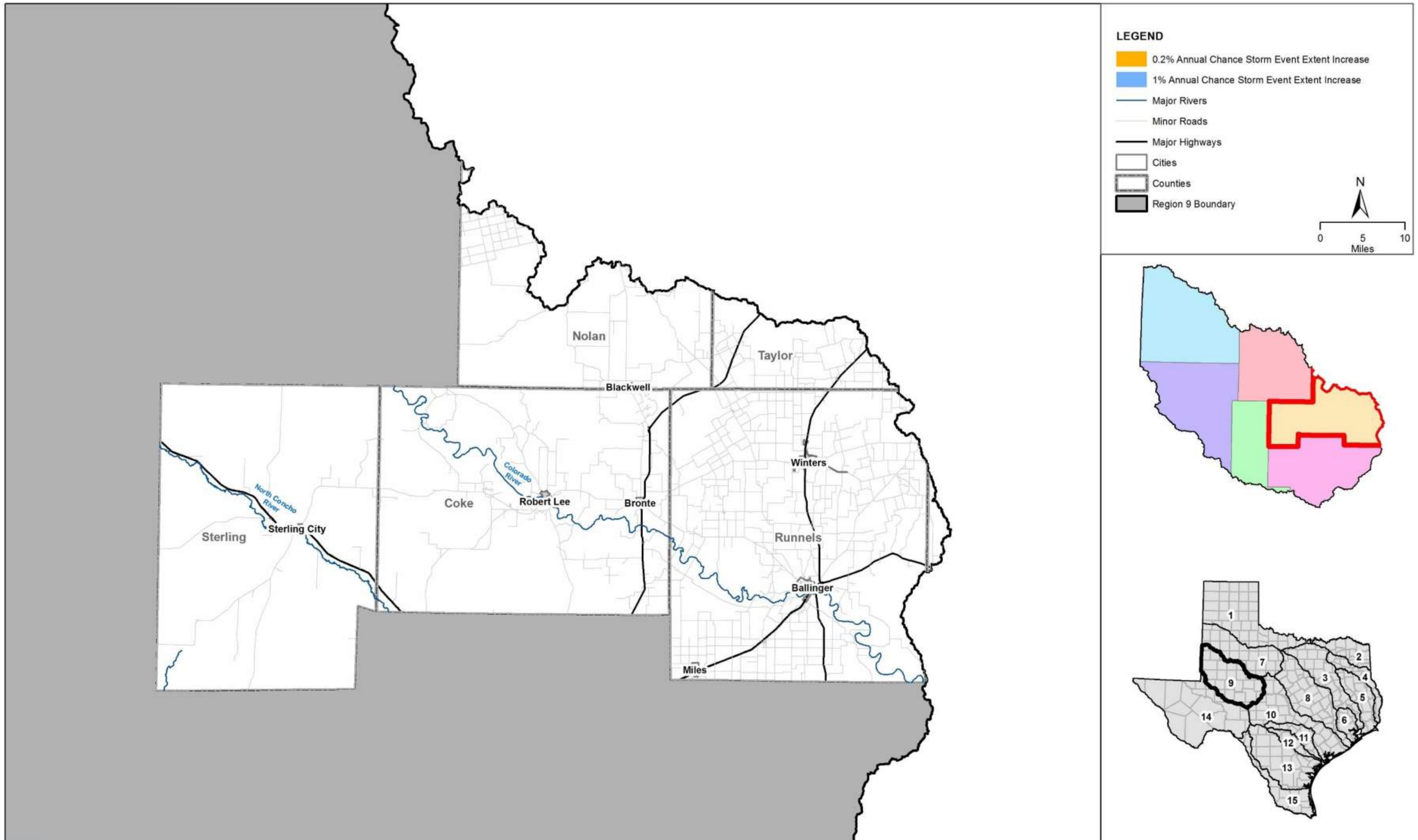
FIGURE 3



REGION 9 UPPER COLORADO - MID LOWER BASIN - MAP 10: EXTENT OF INCREASE OF FLOOD HAZARD COMPARED TO EXISTING CONDITION

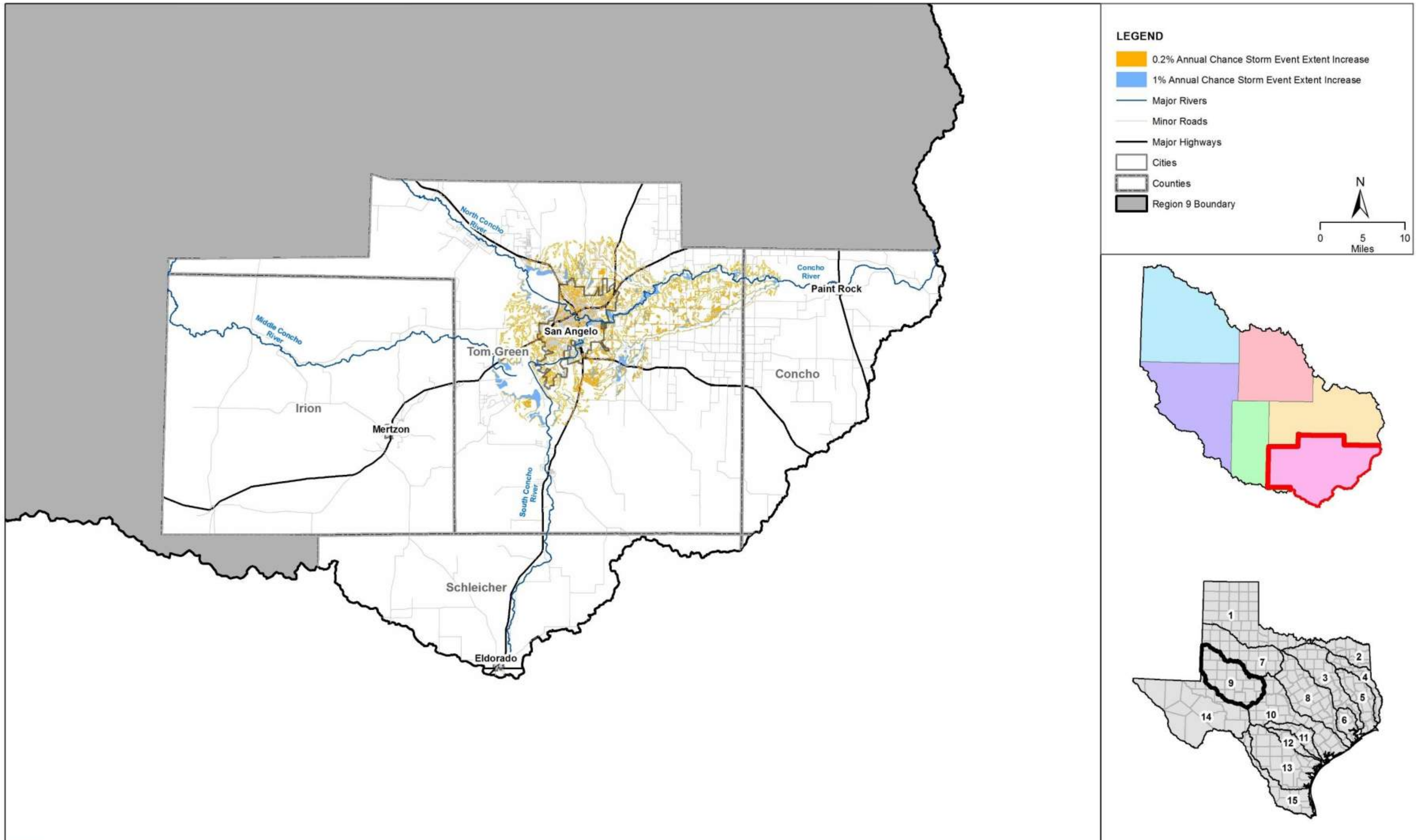
FIGURE 4

PATH: \\DALCTXSRV01\TEXAS_GIS_PROJECTS\10310495_10189_COSANANGELO_UPPERCOLORADOFP\MAP_DOCS\FIGURES\SUBMISSION_AUG22\MAP10EXTENTOFINCREASEOFFUTUREFLDHAZ_9A22.MXD - USER: KJAVVAJI - DATE: 7/14/2022



REGION 9 UPPER COLORADO - LOWER MID BASIN - MAP 10: EXTENT OF INCREASE OF FLOOD HAZARD COMPARED TO EXISTING CONDITION

FIGURE 5

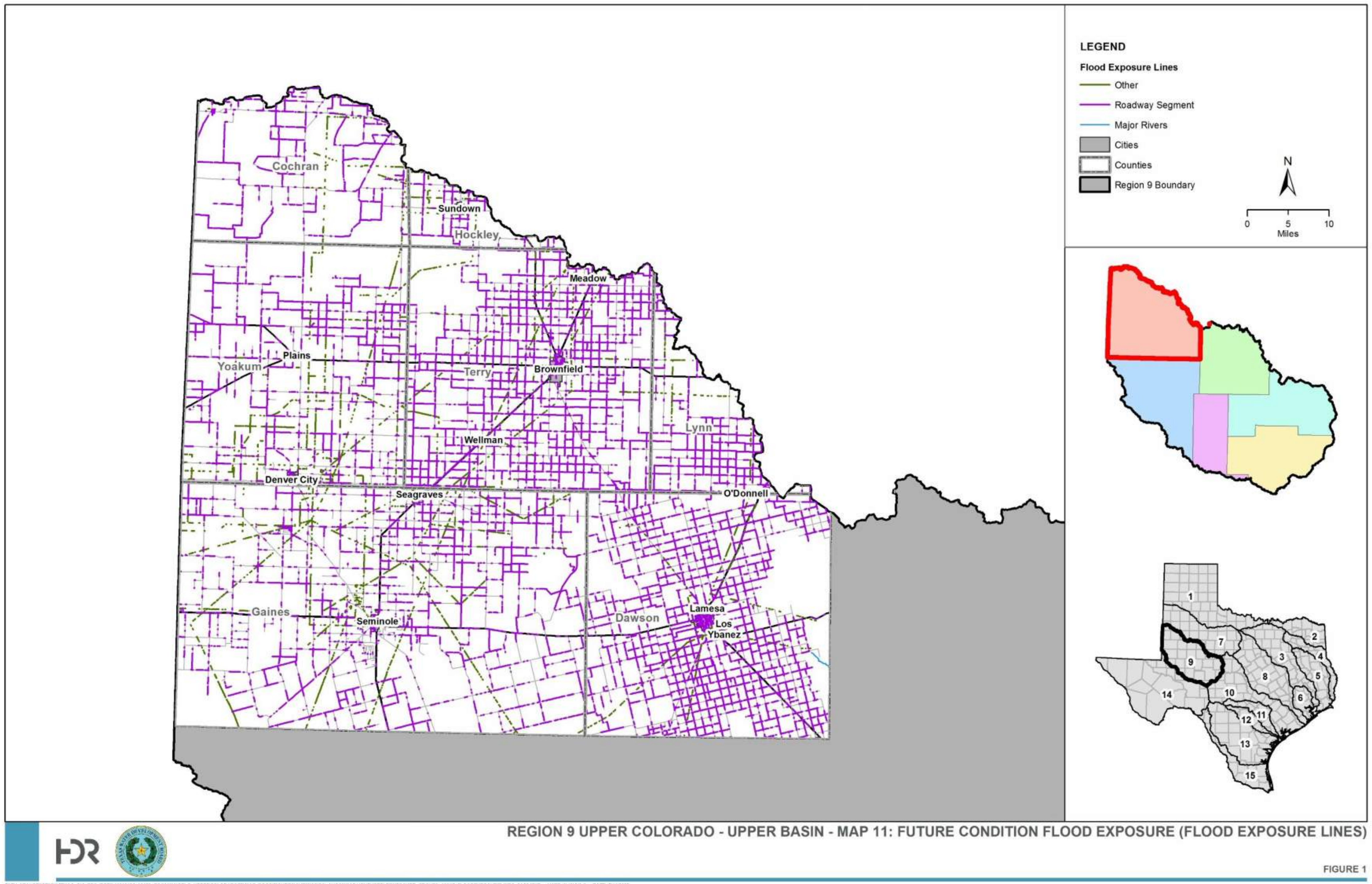


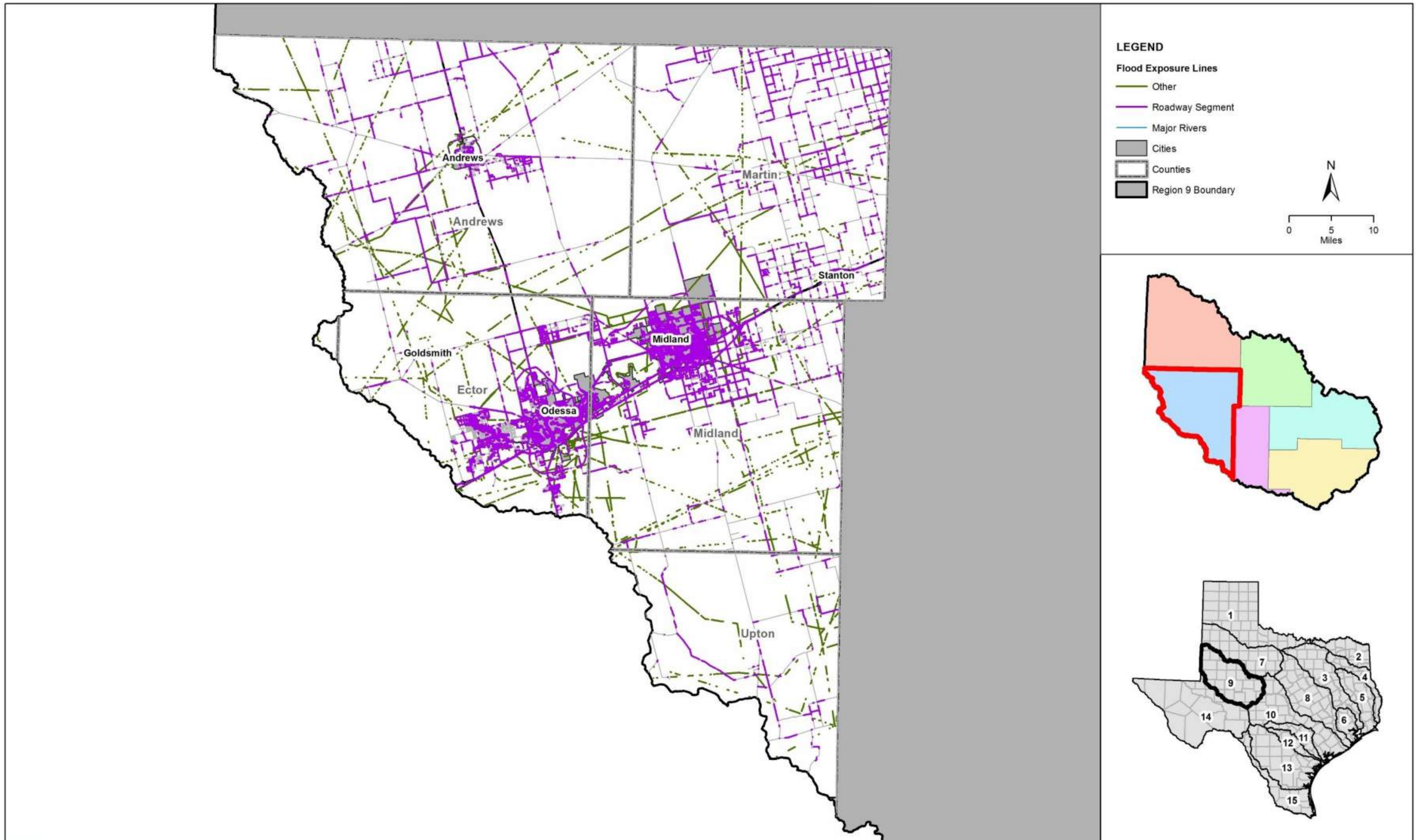
REGION 9 UPPER COLORADO - LOWER BASIN - MAP 10: EXTENT OF INCREASE OF FLOOD HAZARD COMPARED TO EXISTING CONDITION

FIGURE 6

PATH: \\DALCTXSRV01\TEXAS_GIS_PROJECTS\10310495_10189_COSANANGELO_UPPERCOLORADOFP\MAP_DOCS\FIGURES\SUBMISSION_AUG22\MAP10EXTENTOFINCREASEOFFUTUREFLDHAZ_SA22.MXD - USER: KJAVVAJI - DATE: 7/14/2022

Map 11: Future Condition Flood Exposure (2.2.B.2 Future condition flood exposure analysis)

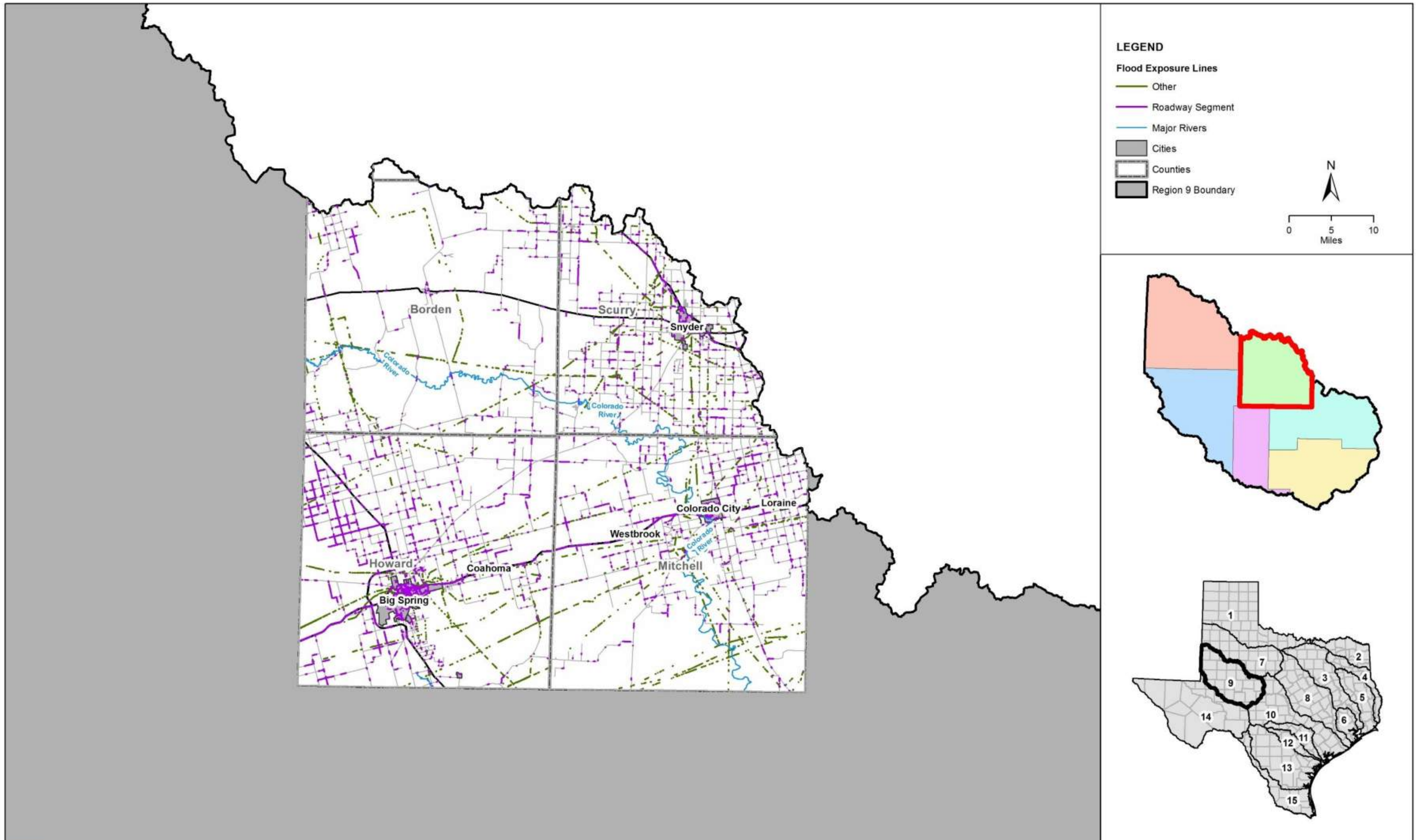




REGION 9 UPPER COLORADO - UPPER MID BASIN - MAP 11: FUTURE CONDITION FLOOD EXPOSURE (FLOOD EXPOSURE LINES)

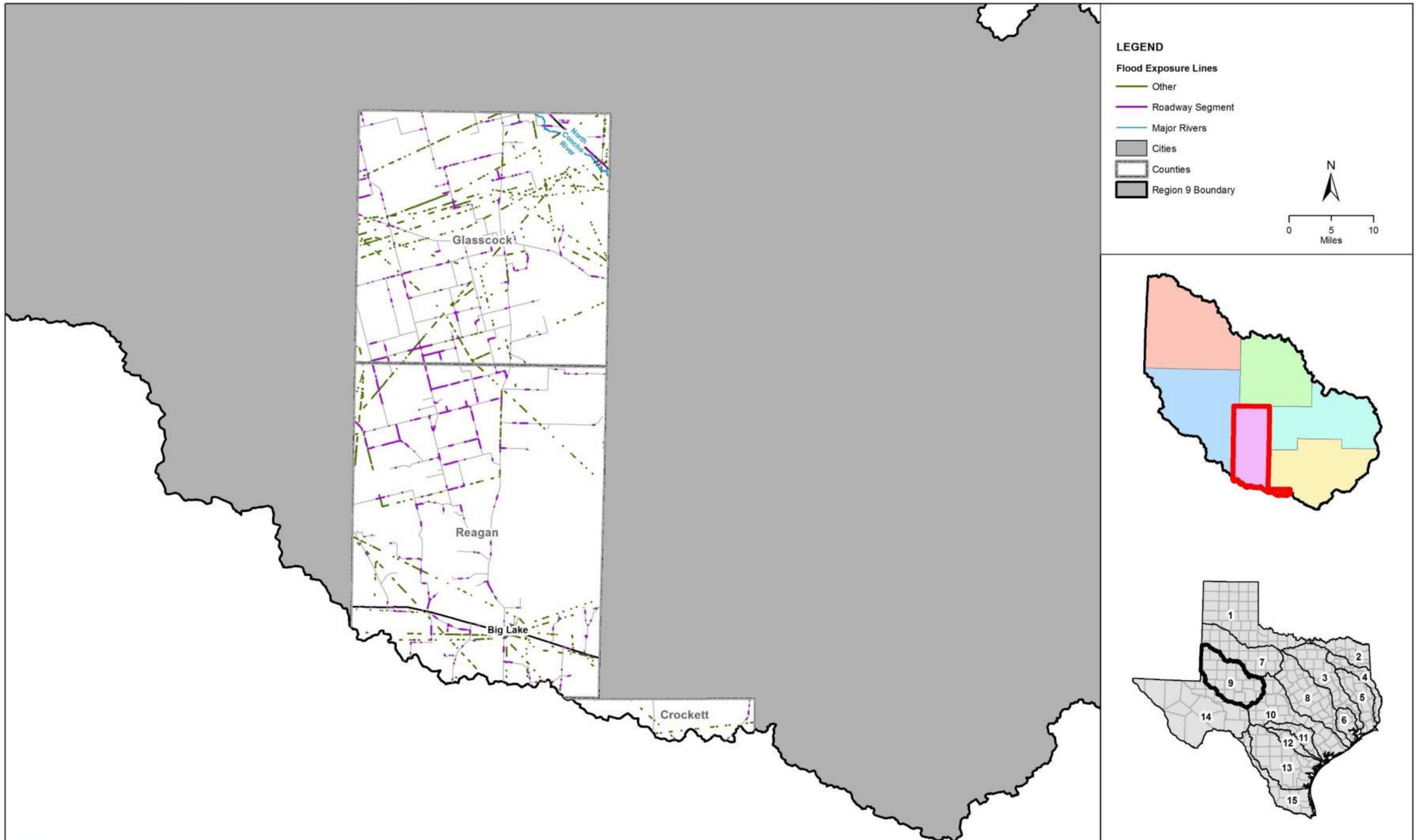
FIGURE 2

PATH: \\DALCTXSRV01\TEXAS_GIS_PROJECTS\10310495_10189_COSANANGELO_UPPERCOLORADOFP\MAP_DOCS\FIGURES\SUBMISSION_AUG22\MAP11FUTUREFLDEXPOSURE_GROUPA_11X17_FLOODEXPOSURELINES_SA22.MXD - USER: KJAVVAJI - DATE: 7/14/2022



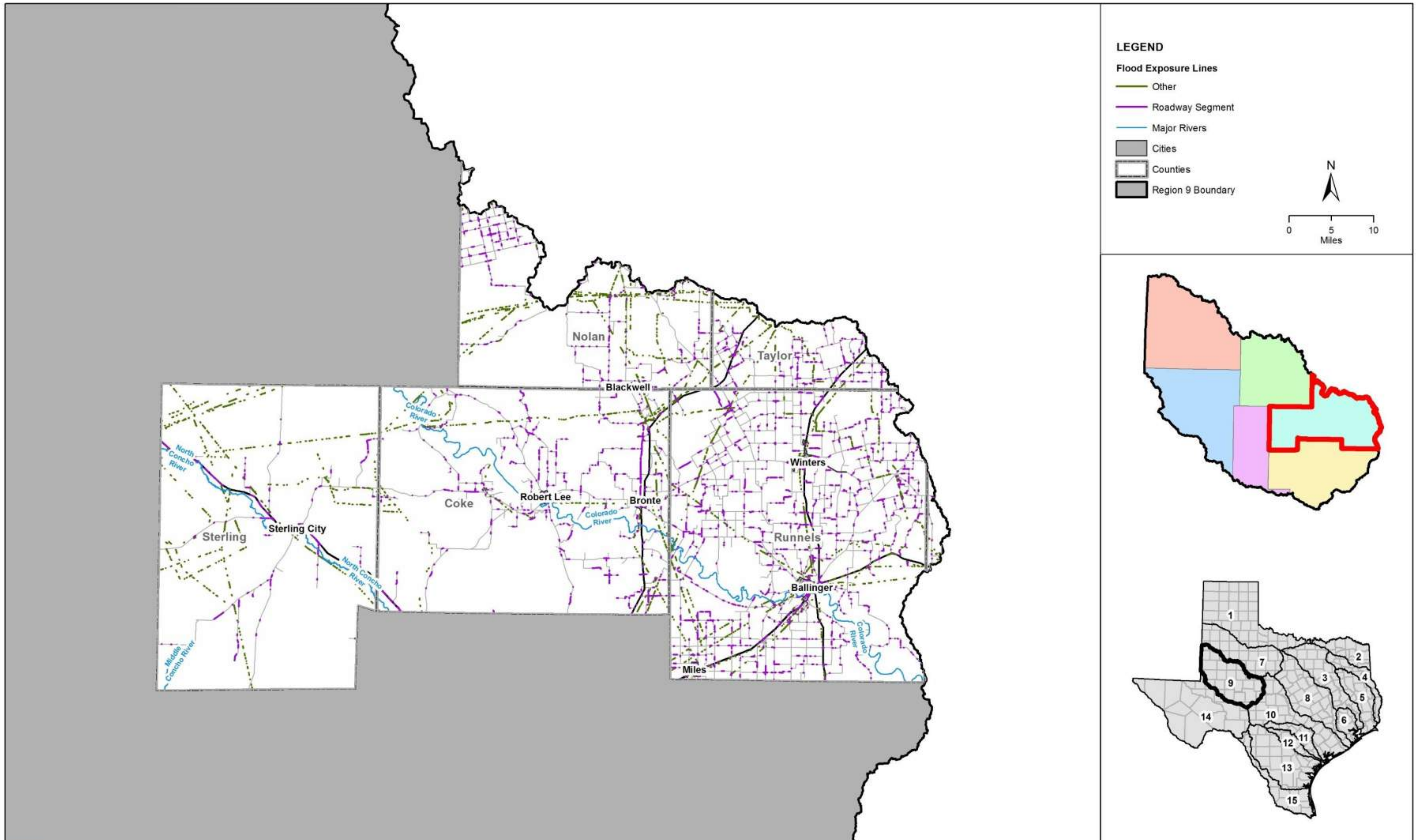
REGION 9 UPPER COLORADO - MID UPPER BASIN - MAP 11: FUTURE CONDITION FLOOD EXPOSURE (FLOOD EXPOSURE LINES)

FIGURE 3



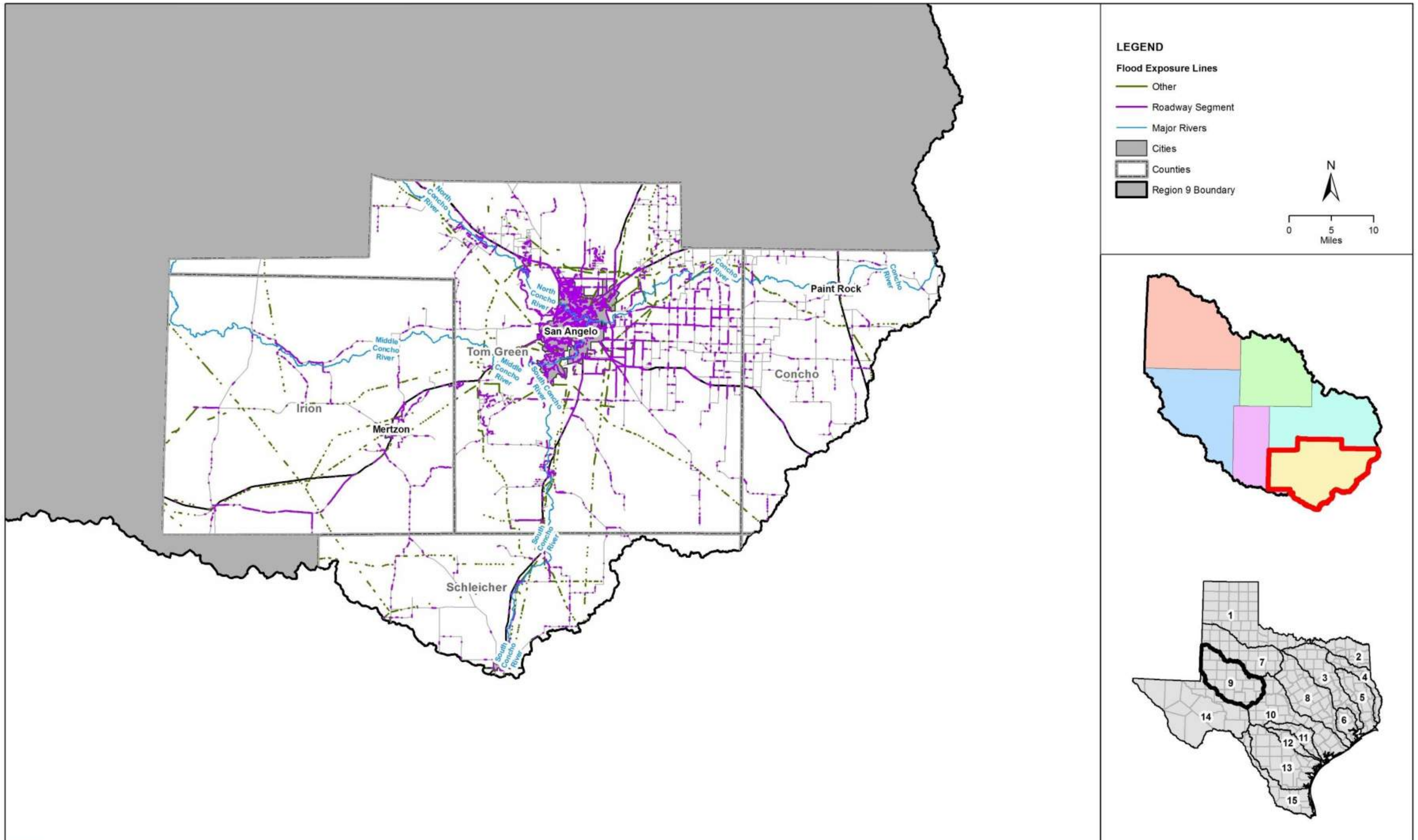
REGION 9 UPPER COLORADO - MID LOWER BASIN - MAP 11: FUTURE CONDITION FLOOD EXPOSURE (FLOOD EXPOSURE LINES)

FIGURE 4



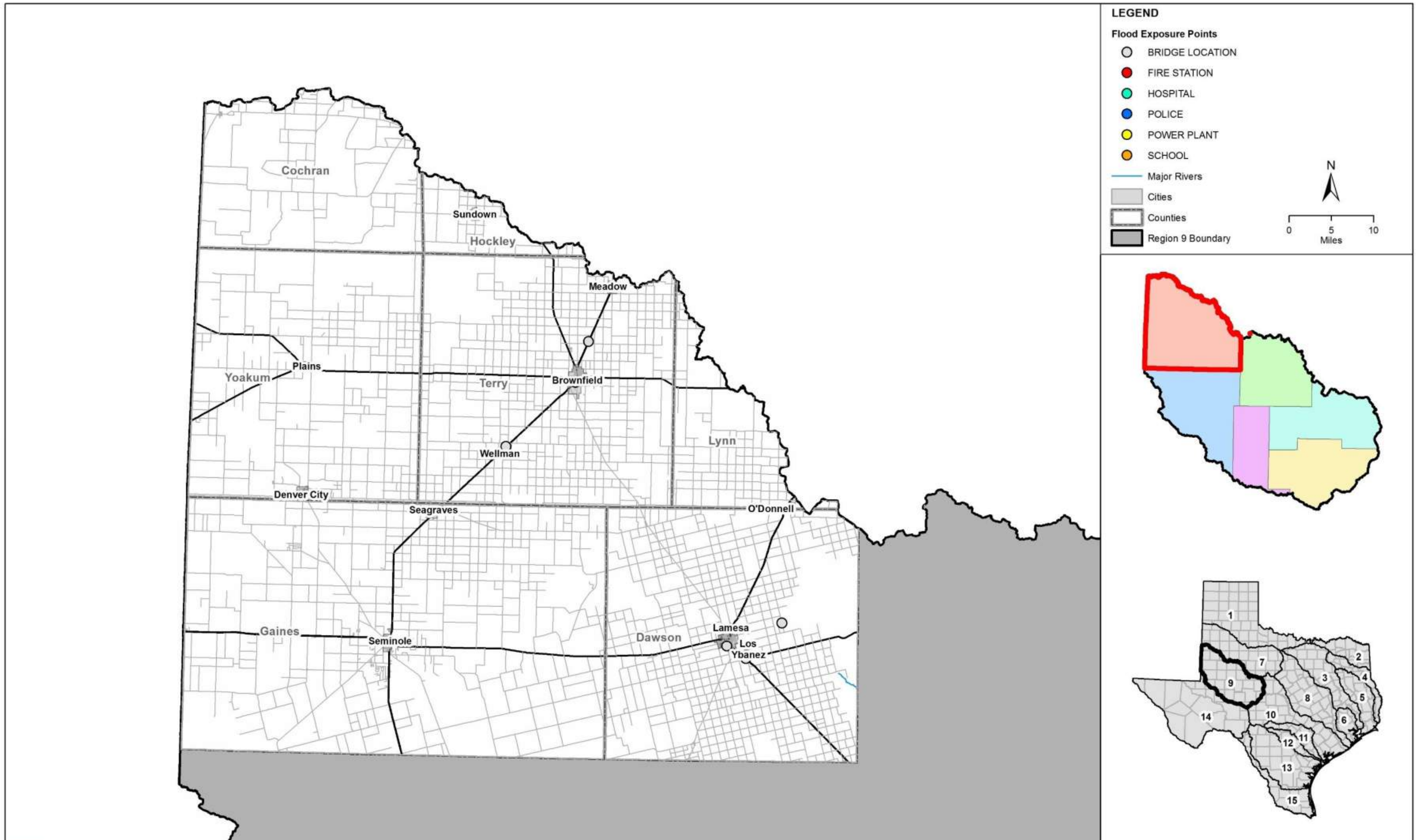
REGION 9 UPPER COLORADO - LOWER MID BASIN - MAP 11: FUTURE CONDITION FLOOD EXPOSURE (FLOOD EXPOSURE LINES)

FIGURE 5



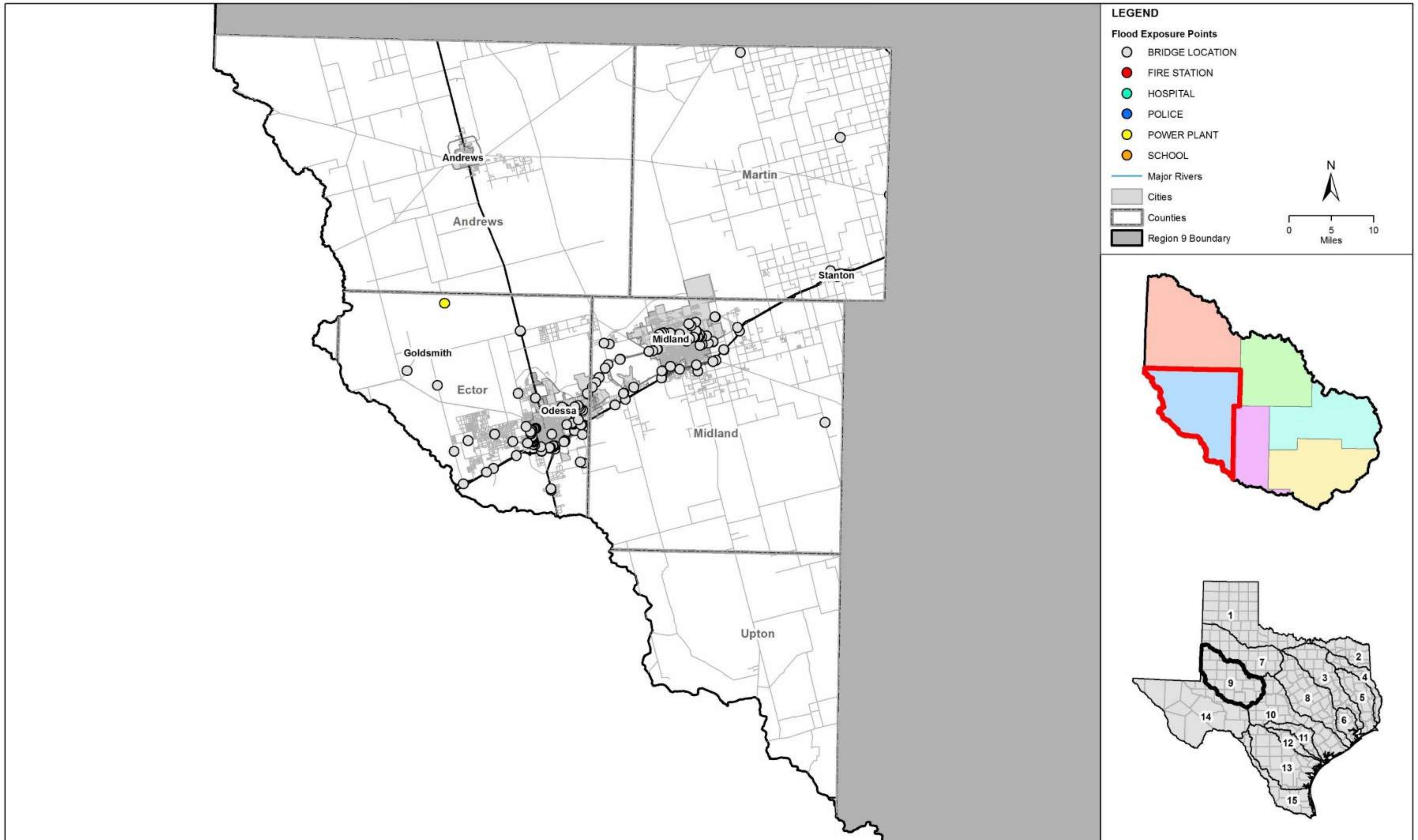
REGION 9 UPPER COLORADO - LOWER BASIN - MAP 11: FUTURE CONDITION FLOOD EXPOSURE (FLOOD EXPOSURE LINES)

FIGURE 6



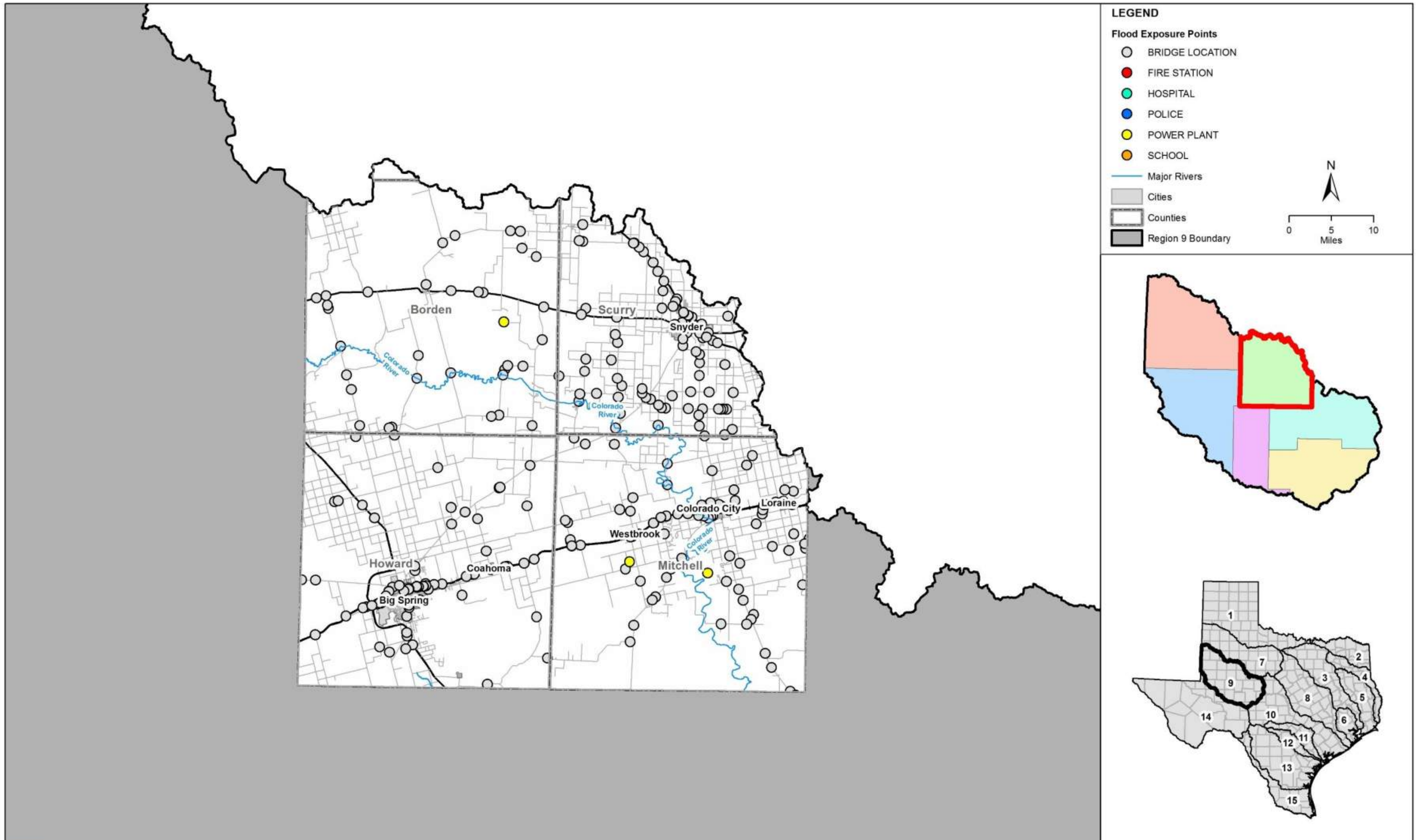
REGION 9 UPPER COLORADO - UPPER BASIN - MAP 11: FUTURE CONDITION FLOOD EXPOSURE (FLOOD EXPOSURE POINTS)

FIGURE 1



REGION 9 UPPER COLORADO - UPPER MID BASIN - MAP 11: FUTURE CONDITION FLOOD EXPOSURE (FLOOD EXPOSURE POINTS)

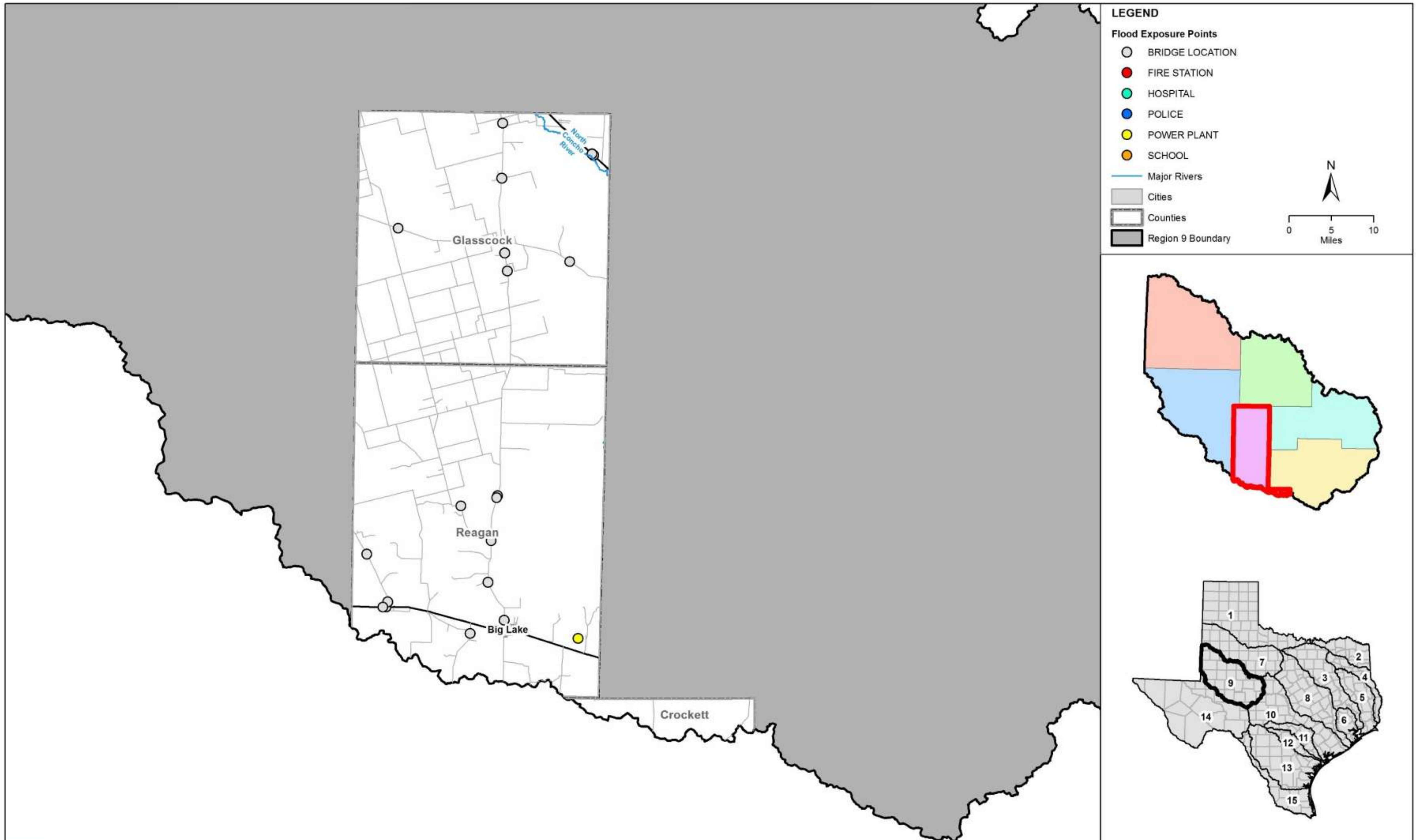
FIGURE 2



REGION 9 UPPER COLORADO - MID UPPER BASIN - MAP 11: FUTURE CONDITION FLOOD EXPOSURE (FLOOD EXPOSURE POINTS)

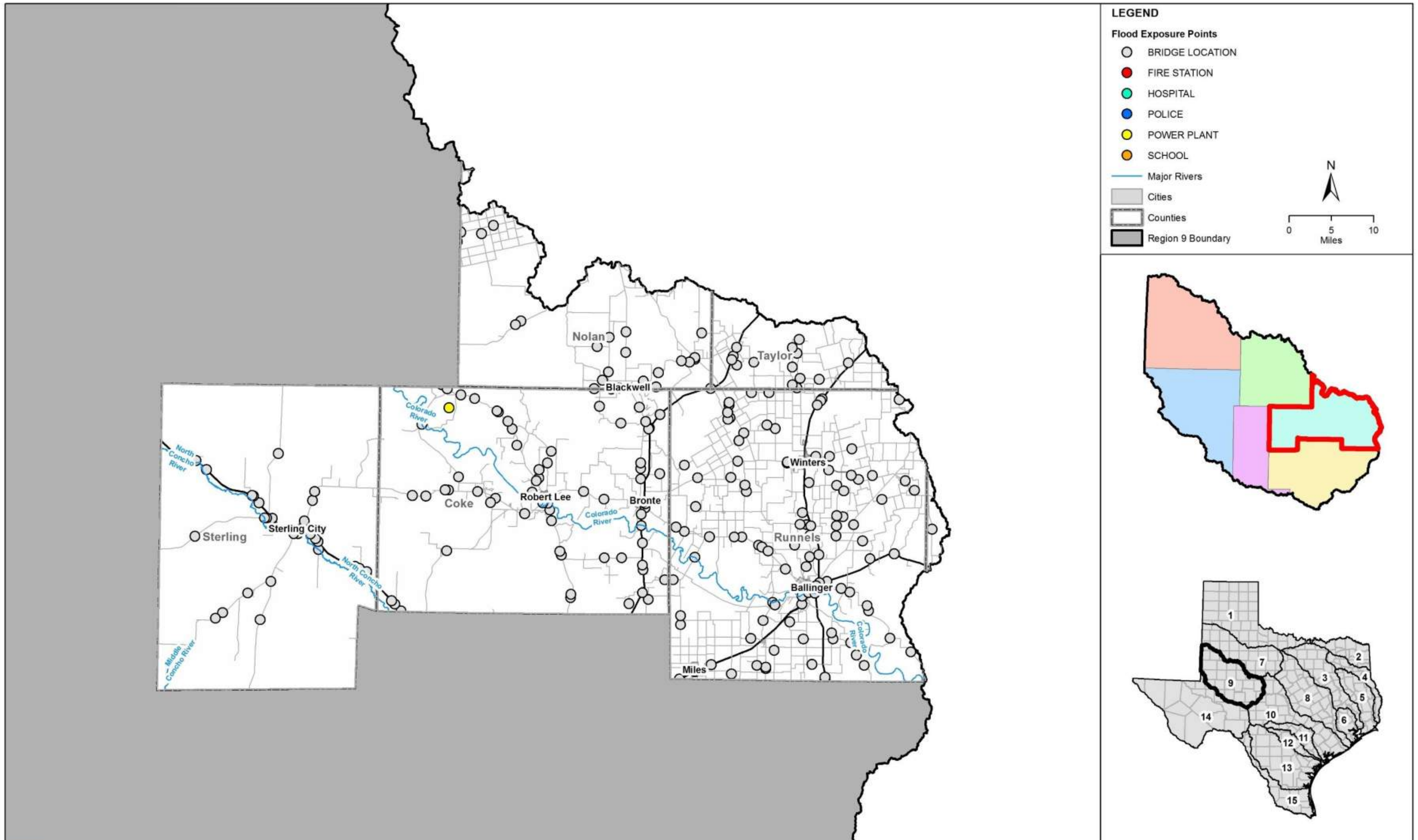
FIGURE 3

PATH: \\DALCTXSRV01\TEXAS_GIS_PROJECTS\10310495_10189_COSANANGELO_UPPERCOLORADOFP\MAP_DOCS\FIGURES\SUBMISSION_AUG22\MAP11FUTUREFLDEXPOSURE_GROUPA_11X17_FLOODEXPOSUREPOINTS_SA22.MXD - USER: KJAVVAJI - DATE: 7/14/2022



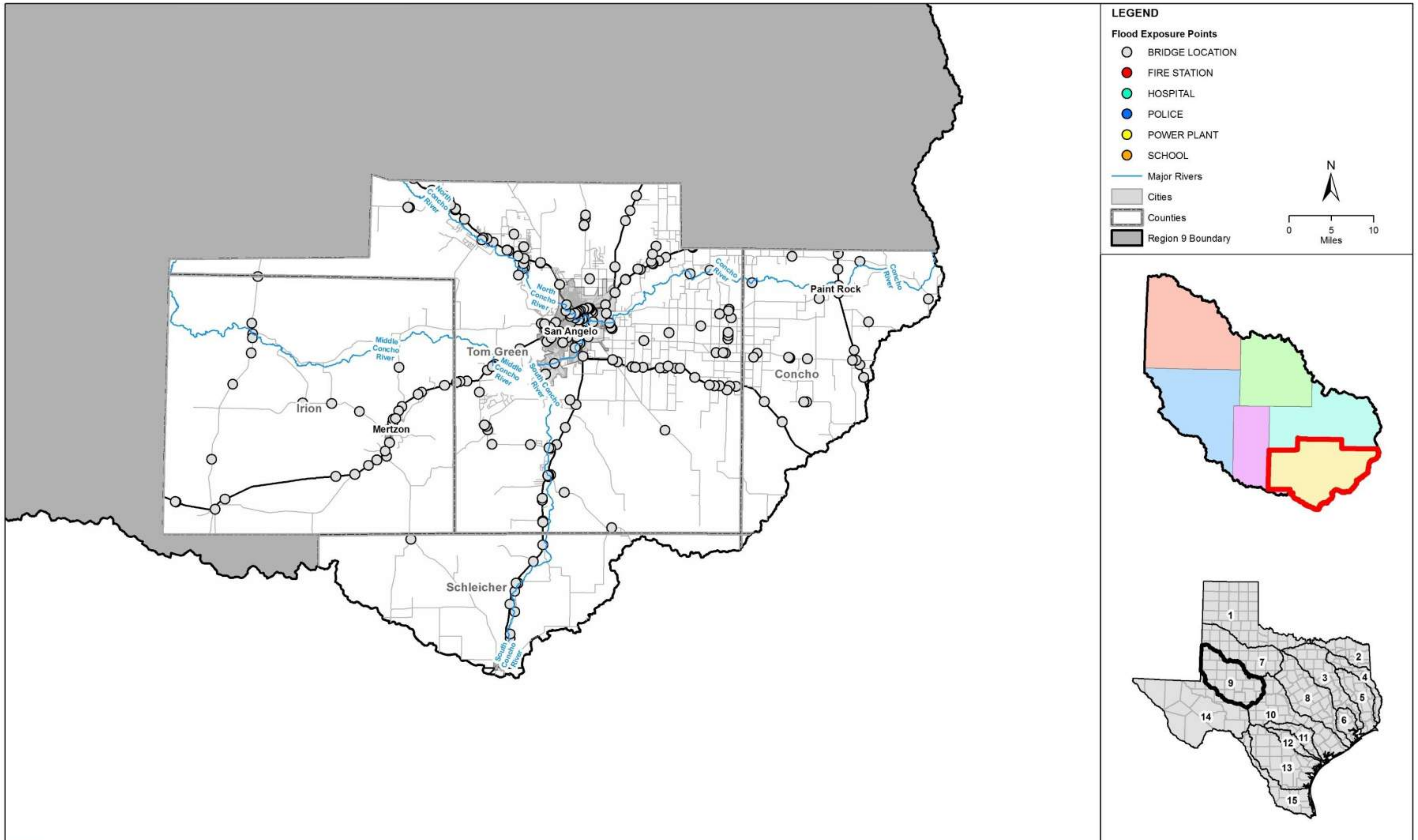
REGION 9 UPPER COLORADO - MID LOWER BASIN - MAP 11: FUTURE CONDITION FLOOD EXPOSURE (FLOOD EXPOSURE POINTS)

FIGURE 4



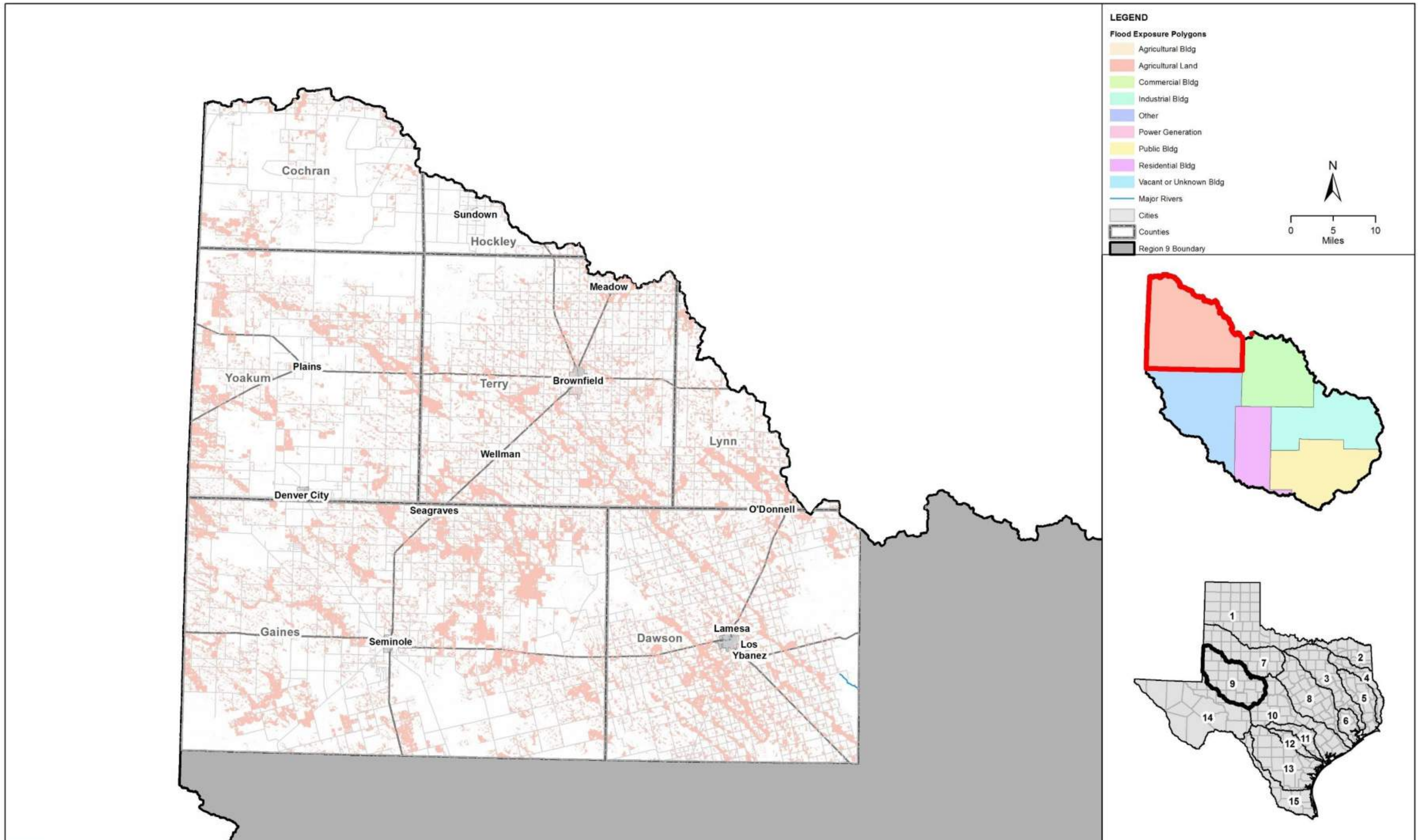
REGION 9 UPPER COLORADO - LOWER MID BASIN - MAP 11: FUTURE CONDITION FLOOD EXPOSURE (FLOOD EXPOSURE POINTS)

FIGURE 5



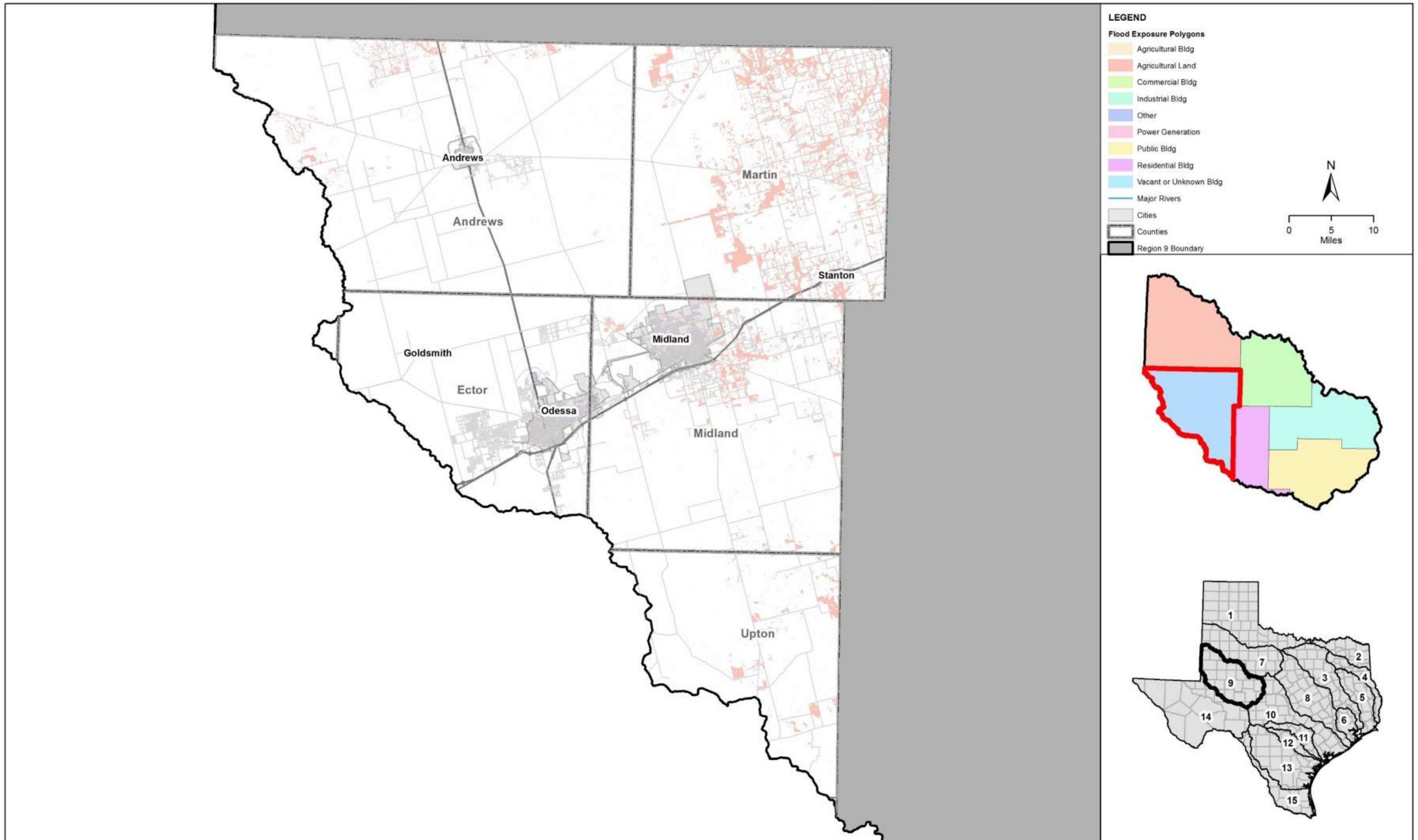
REGION 9 UPPER COLORADO - LOWER BASIN - MAP 11: FUTURE CONDITION FLOOD EXPOSURE (FLOOD EXPOSURE POINTS)

FIGURE 6



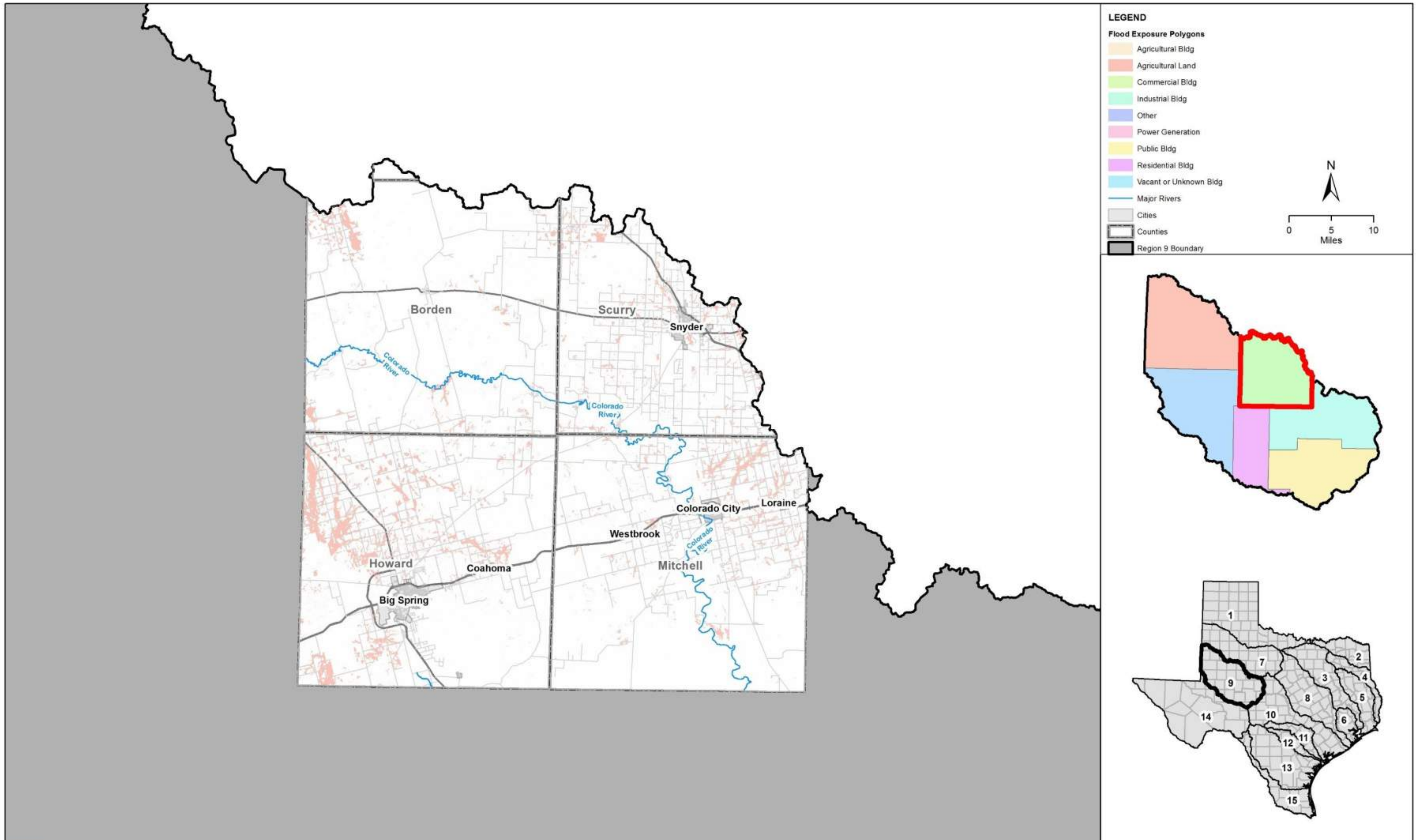
REGION 9 UPPER COLORADO - UPPER BASIN - MAP 11: FUTURE CONDITION FLOOD EXPOSURE (FLOOD EXPOSURE POLYGONES)

FIGURE 1



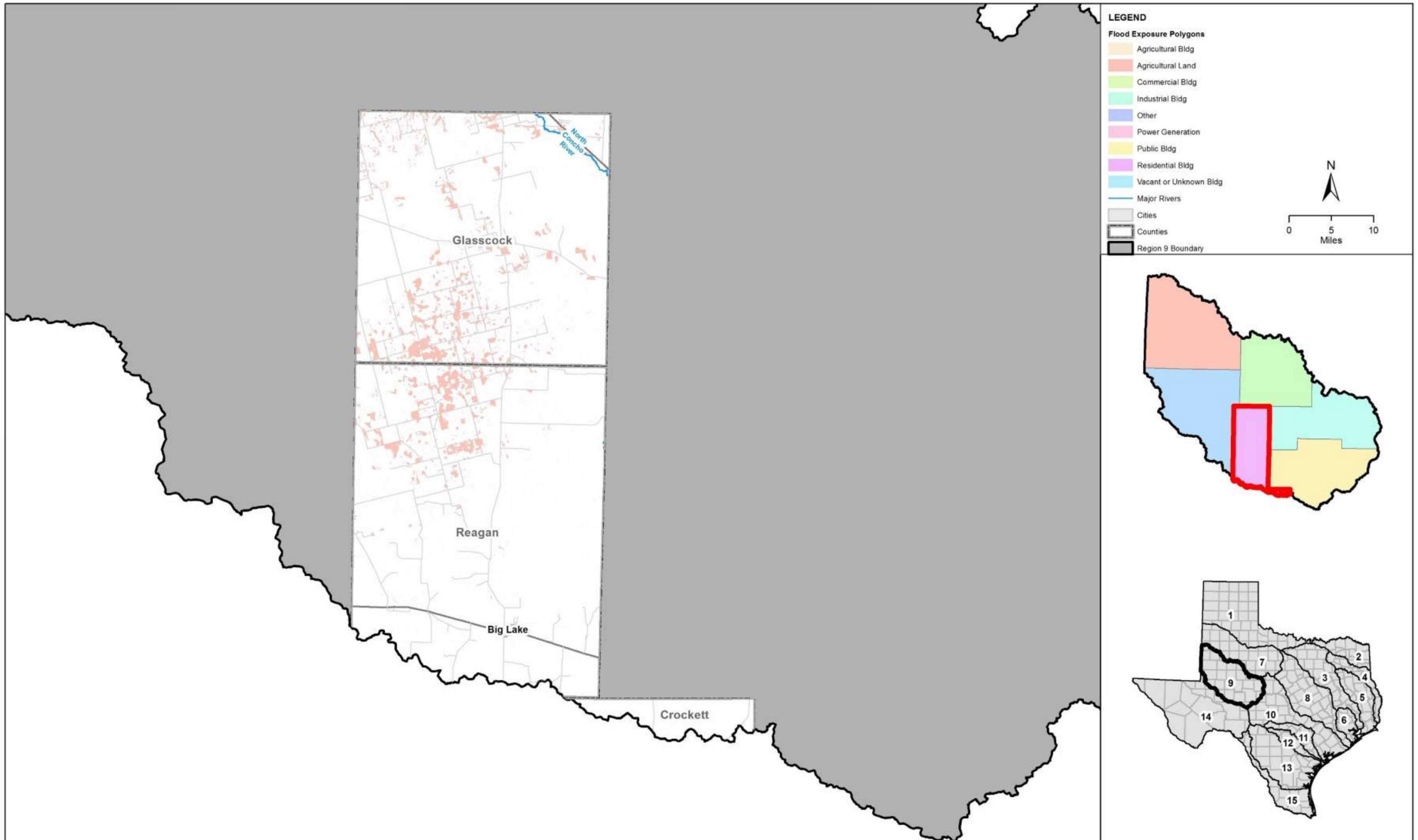
REGION 9 UPPER COLORADO - UPPER MID BASIN - MAP 11: FUTURE CONDITION FLOOD EXPOSURE (FLOOD EXPOSURE POLYGONES)

FIGURE 2



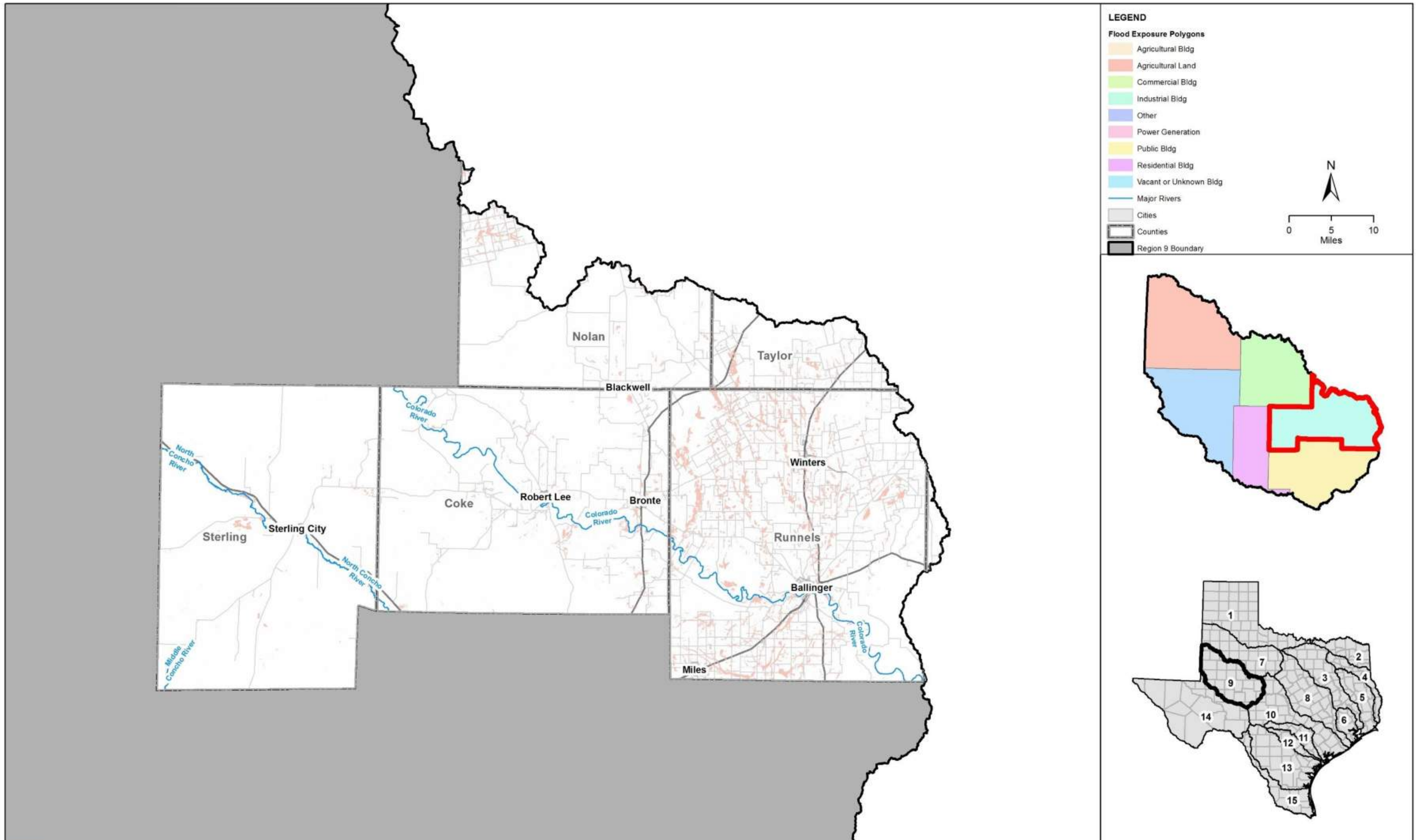
REGION 9 UPPER COLORADO - MID UPPER BASIN - MAP 11: FUTURE CONDITION FLOOD EXPOSURE (FLOOD EXPOSURE POLYGONES)

FIGURE 3



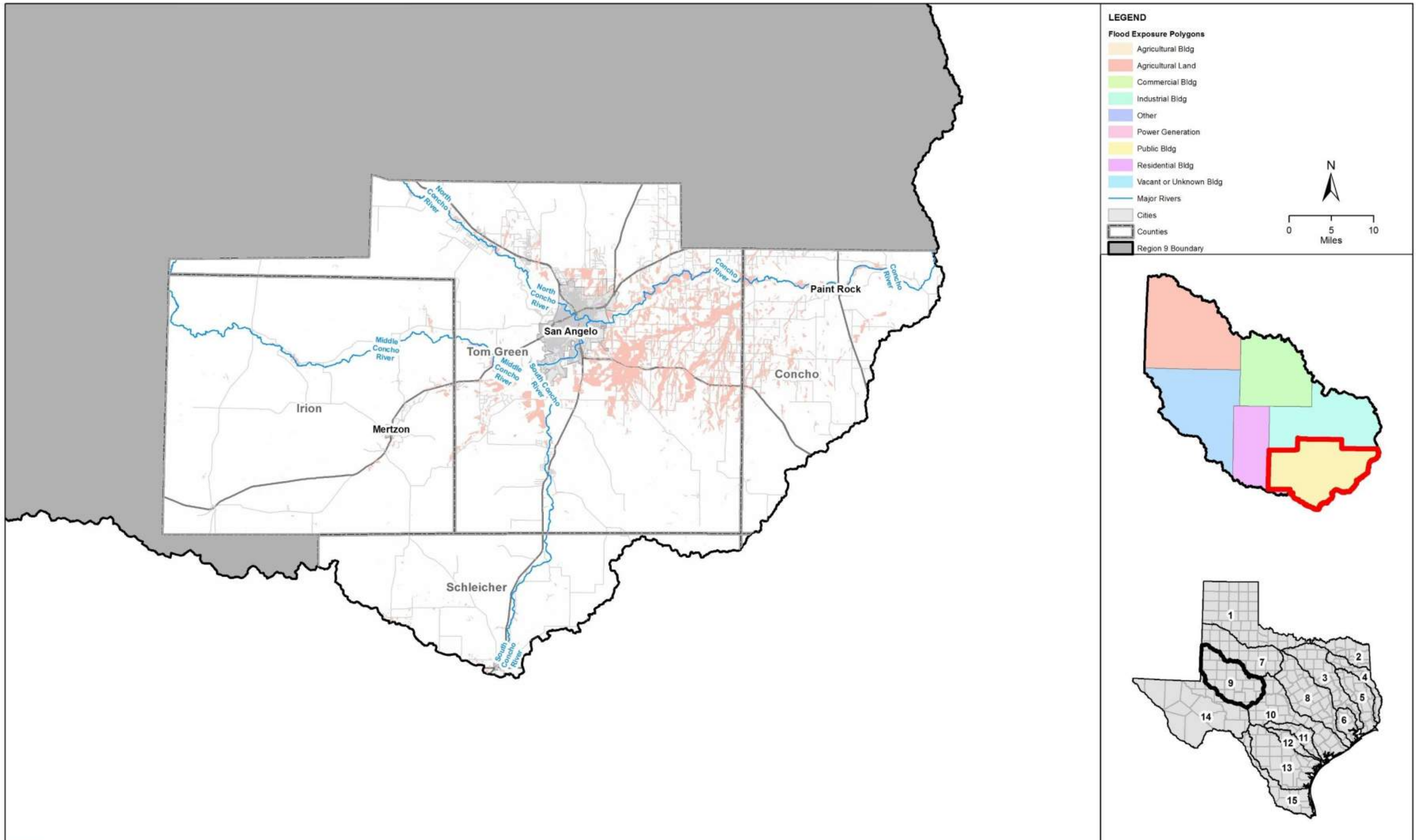
REGION 9 UPPER COLORADO - MID LOWER BASIN - MAP 11: FUTURE CONDITION FLOOD EXPOSURE (FLOOD EXPOSURE POLYGONES)

FIGURE 4



REGION 9 UPPER COLORADO - LOWER MID BASIN - MAP 11: FUTURE CONDITION FLOOD EXPOSURE (FLOOD EXPOSURE POLYGONES)

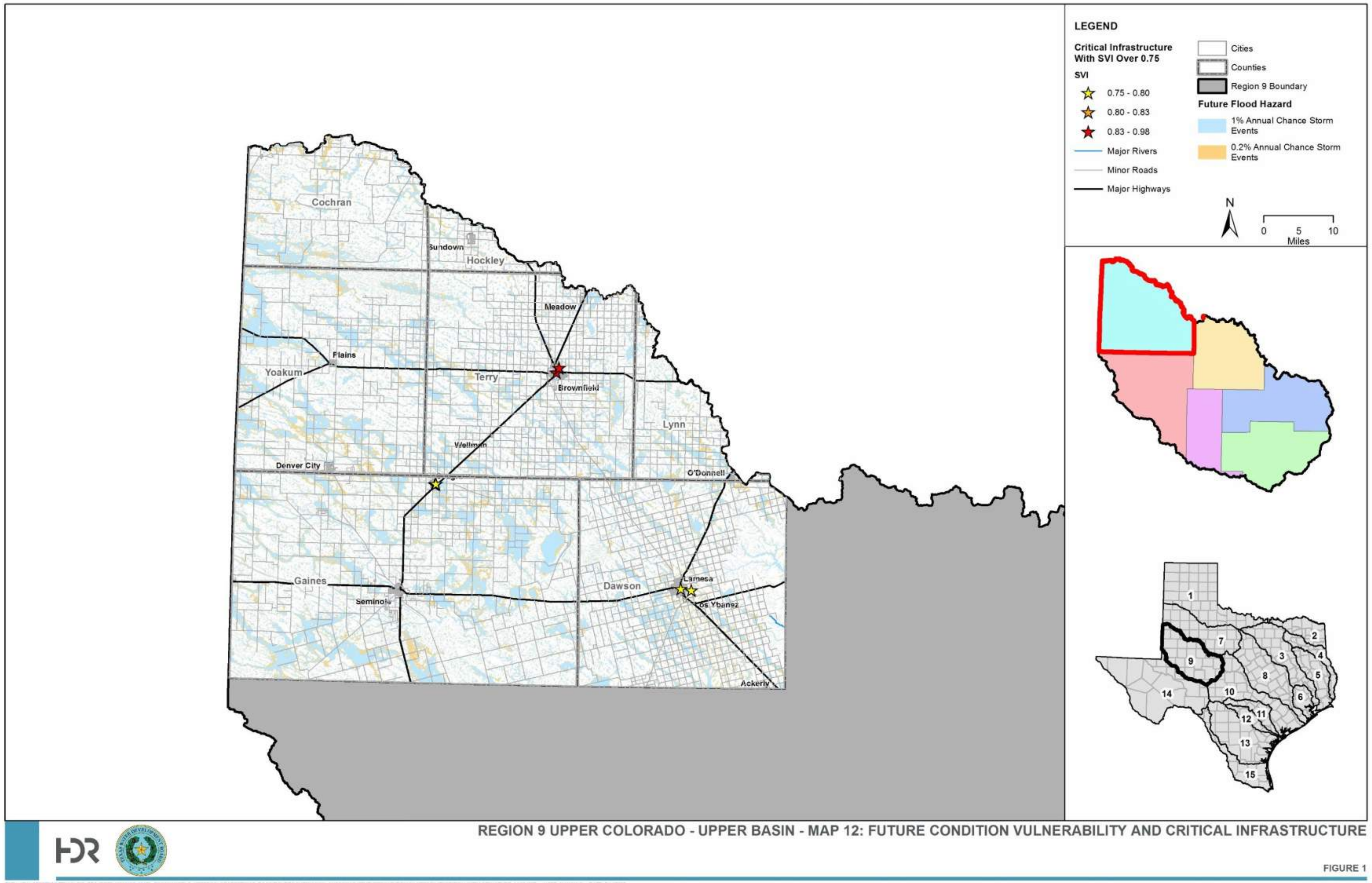
FIGURE 5

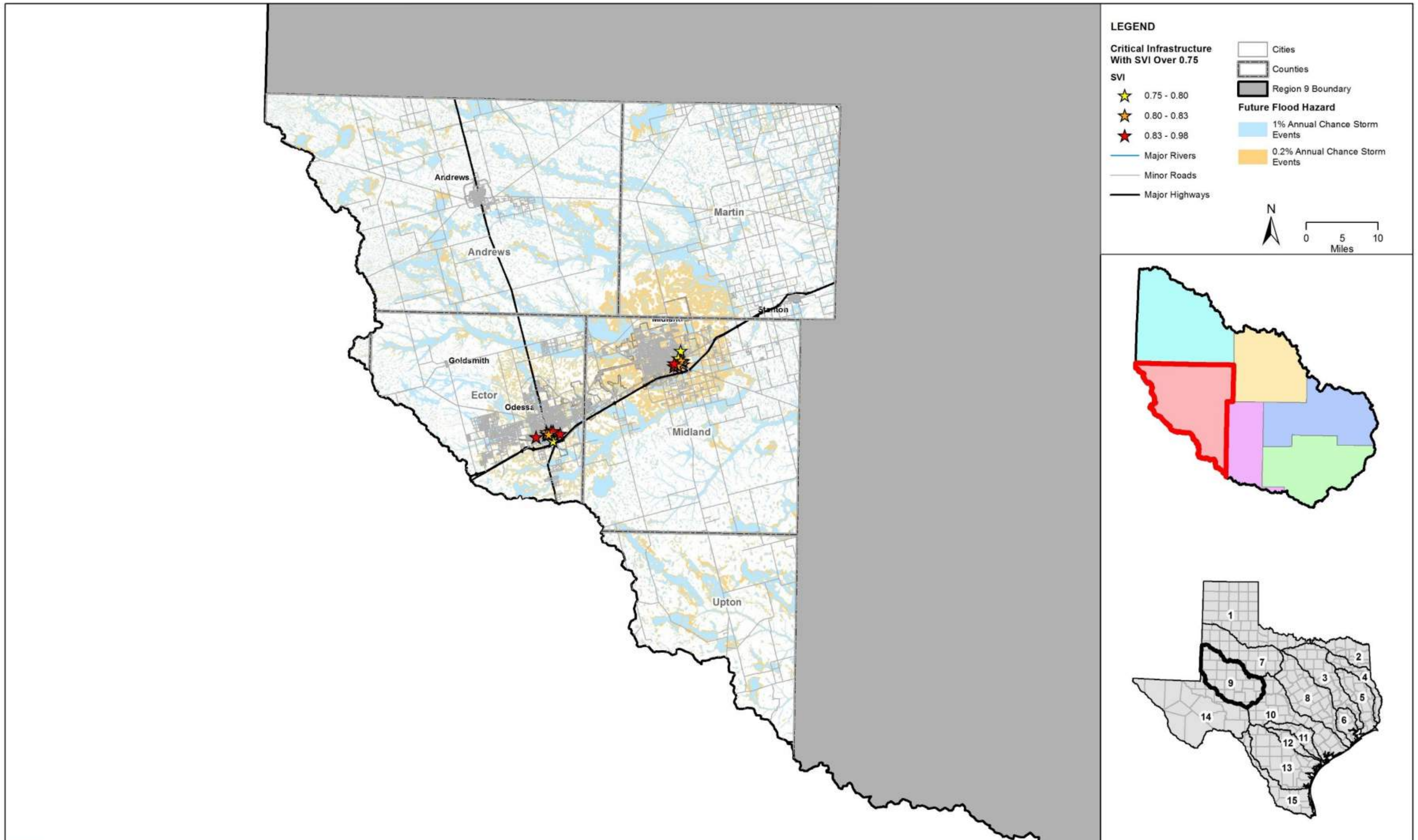


REGION 9 UPPER COLORADO - LOWER BASIN - MAP 11: FUTURE CONDITION FLOOD EXPOSURE (FLOOD EXPOSURE POLYGONES)

FIGURE 6

Map 12: Future Condition Flood Vulnerability including Critical Infrastructure (2.2.B.3 Future condition vulnerability analysis)

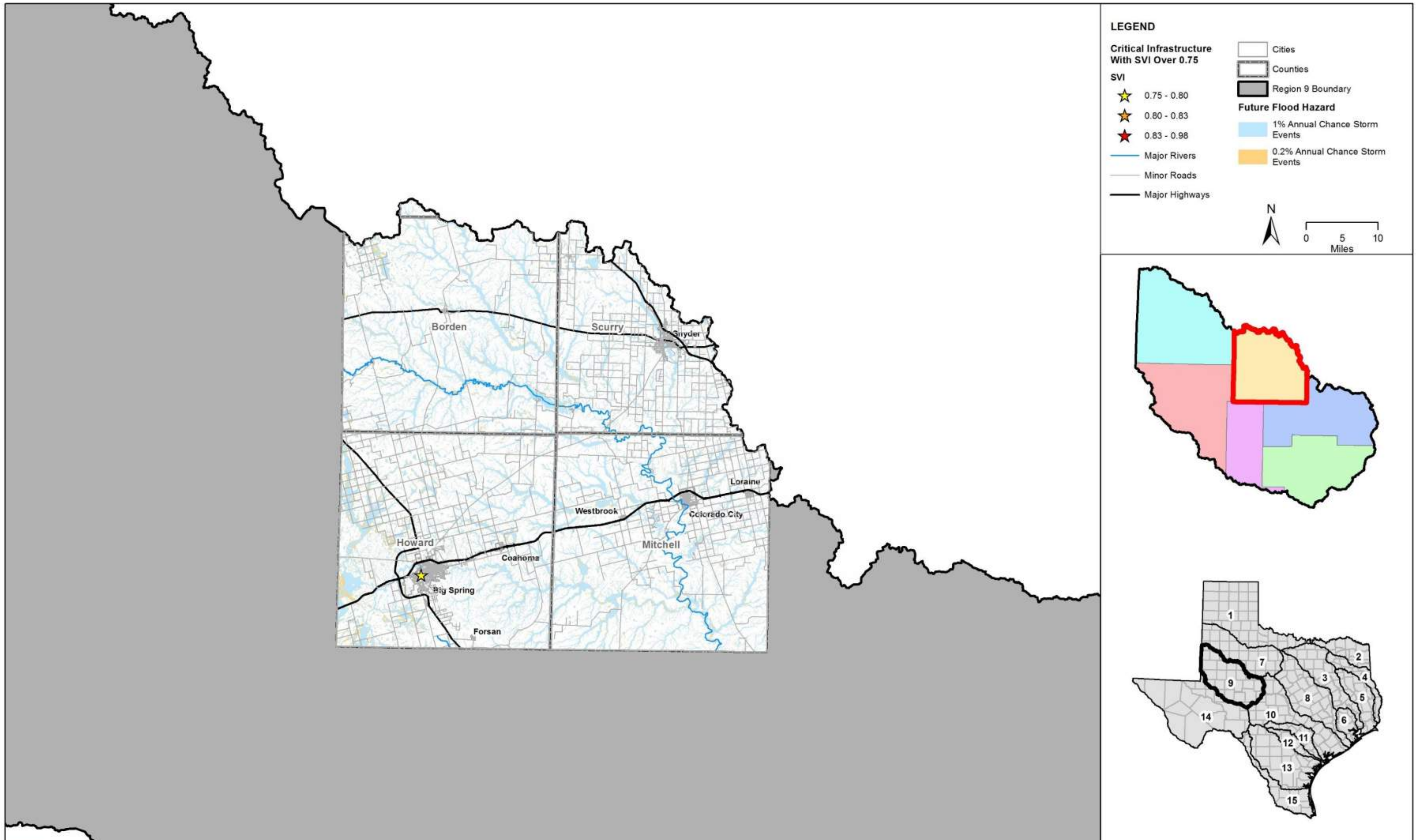




REGION 9 UPPER COLORADO - UPPER MID BASIN - MAP 12: FUTURE CONDITION VULNERABILITY AND CRITICAL INFRASTRUCTURE

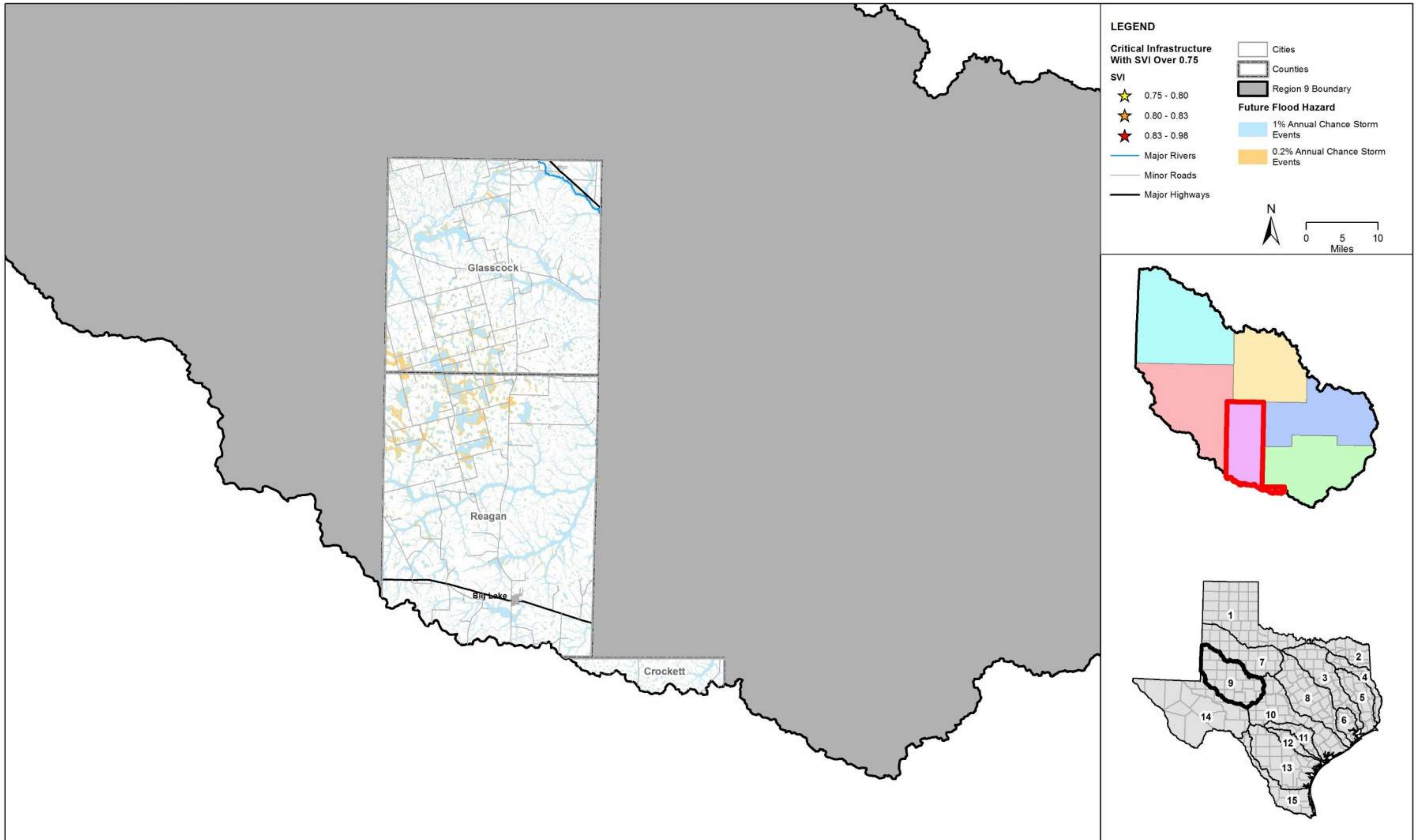
FIGURE 1

PATH: \\DALCTXSRV01\TEXAS_GIS_PROJECTS\10310495_10189_COSANANGELO_UPPERCOLORADOFP\MAP_DOCS\FIGURES\SUBMISSION_AUG22\MAP12FUTURECONDITIONVULNERABILITYCRITICALINFRASTRUCTURE_SA22.MXD - USER: KJAVVAJI - DATE: 7/14/2022



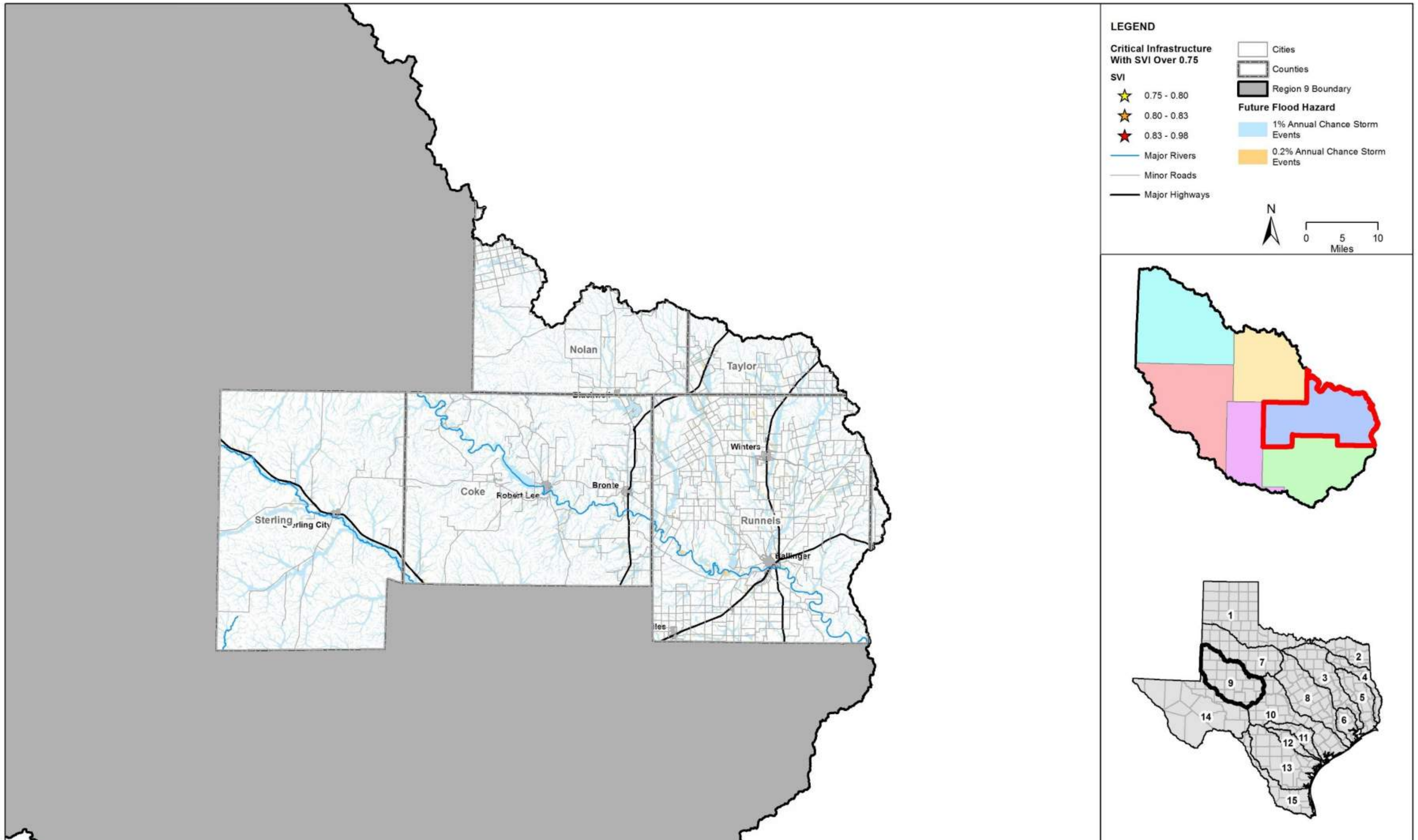
REGION 9 UPPER COLORADO - MID UPPER BASIN - MAP 12: FUTURE CONDITION VULNERABILITY AND CRITICAL INFRASTRUCTURE

FIGURE 1



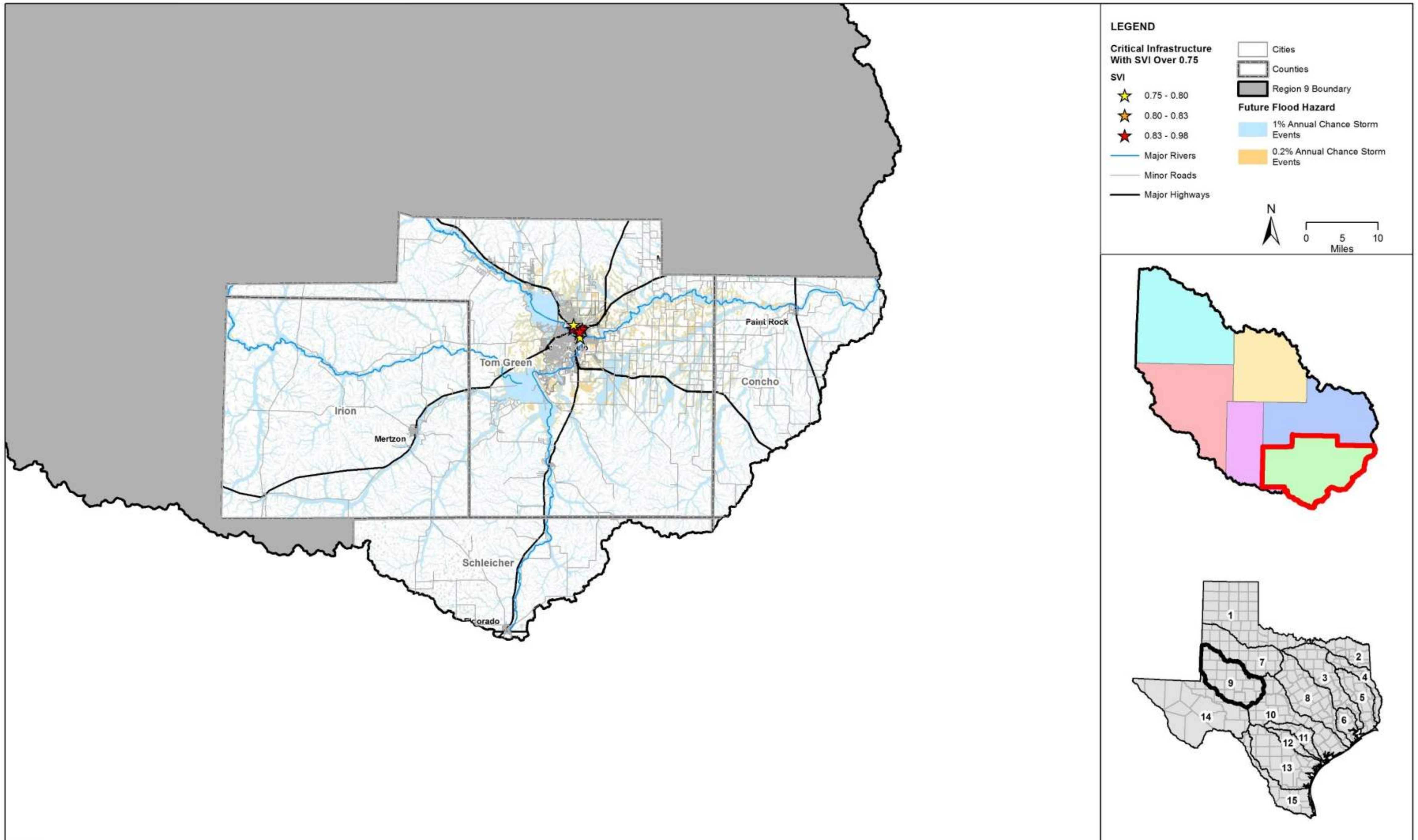
REGION 9 UPPER COLORADO - MID LOWER BASIN - MAP 12: FUTURE CONDITION VULNERABILITY AND CRITICAL INFRASTRUCTURE

FIGURE 1



REGION 9 UPPER COLORADO - LOWER MID BASIN - MAP 12: FUTURE CONDITION VULNERABILITY AND CRITICAL INFRASTRUCTURE

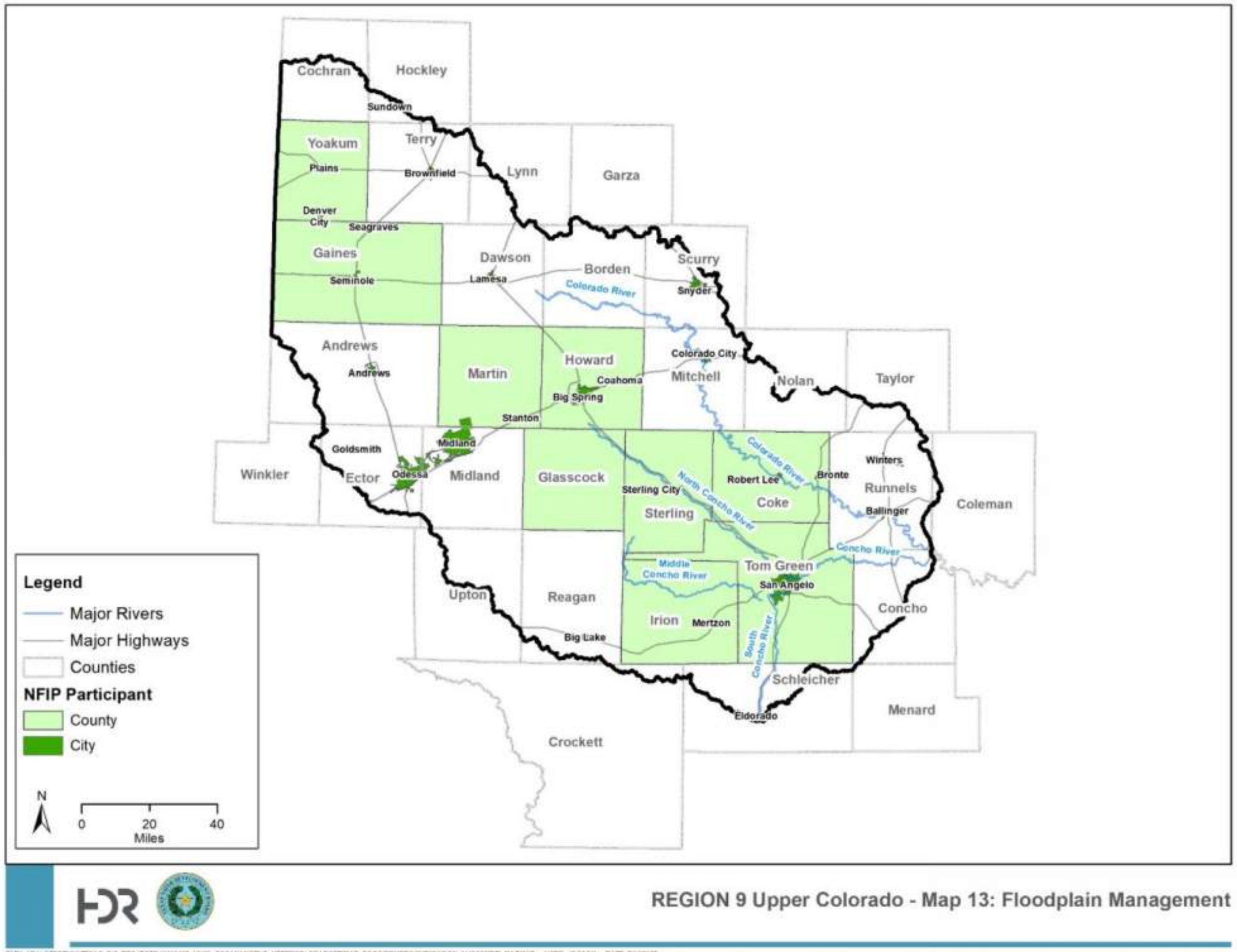
FIGURE 1



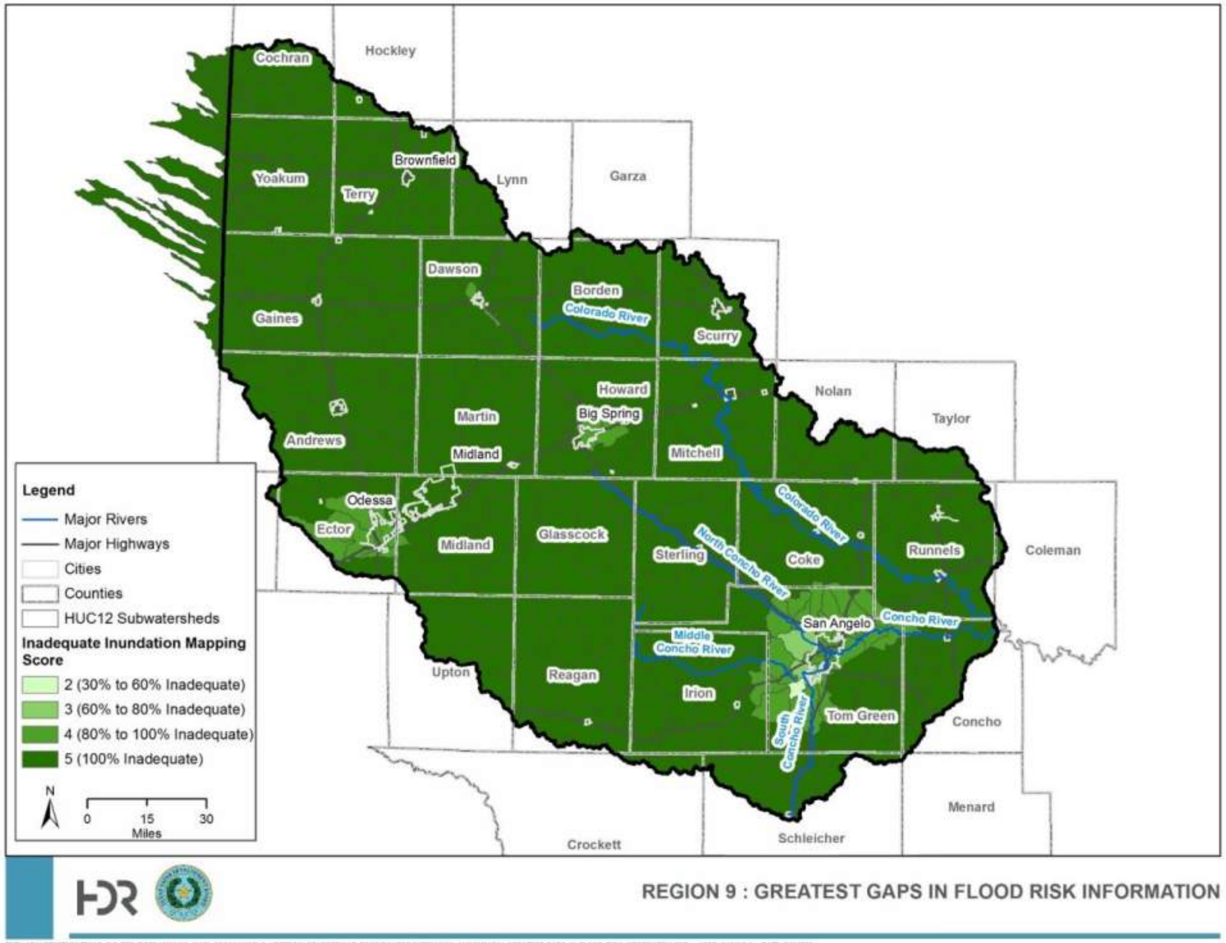
REGION 9 UPPER COLORADO - LOWER BASIN - MAP 12: FUTURE CONDITION VULNERABILITY AND CRITICAL INFRASTRUCTURE

FIGURE 1

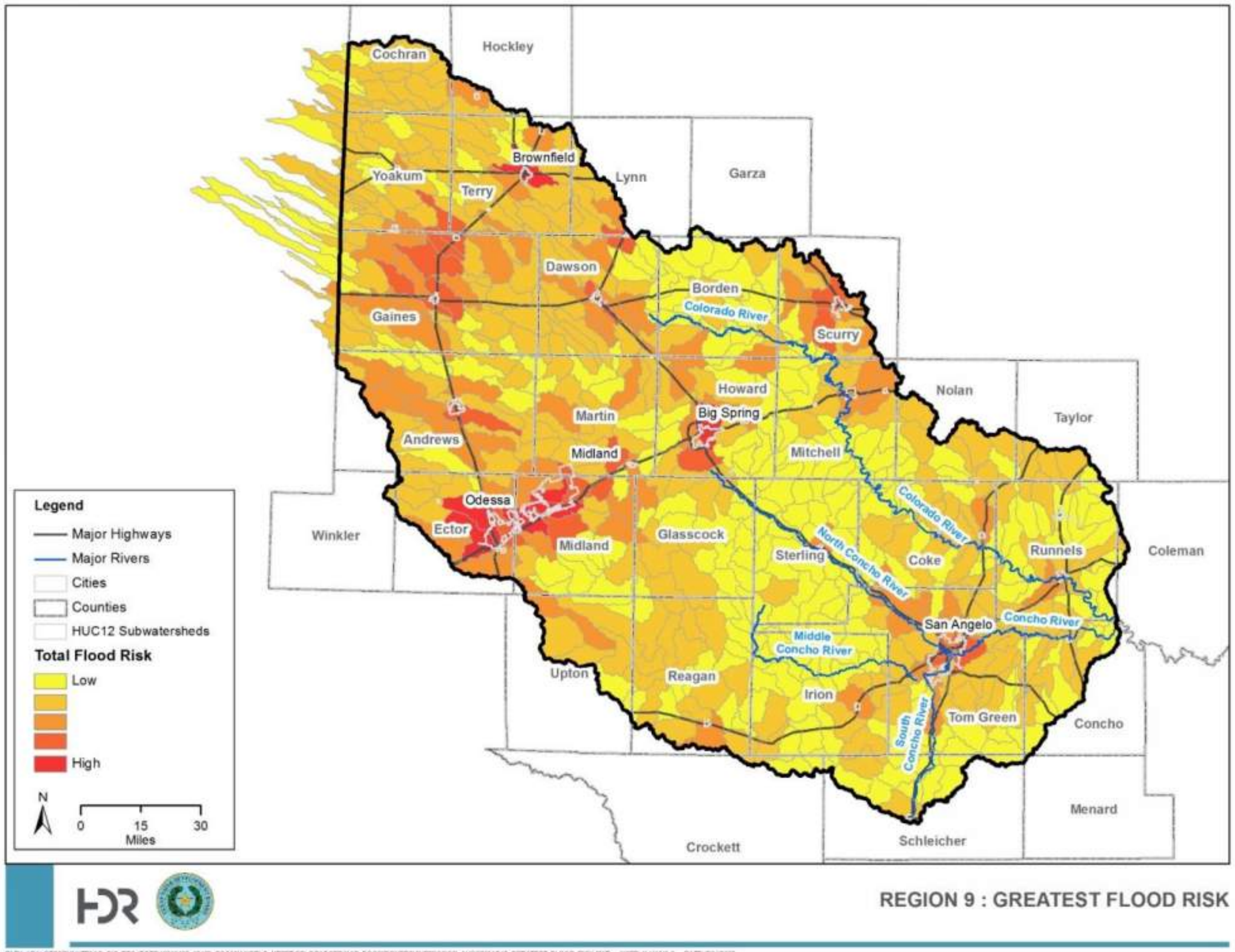
Map 13: Floodplain Management (2.3.A Task 3A – Evaluation and Recommendations on Floodplain Management Practices)



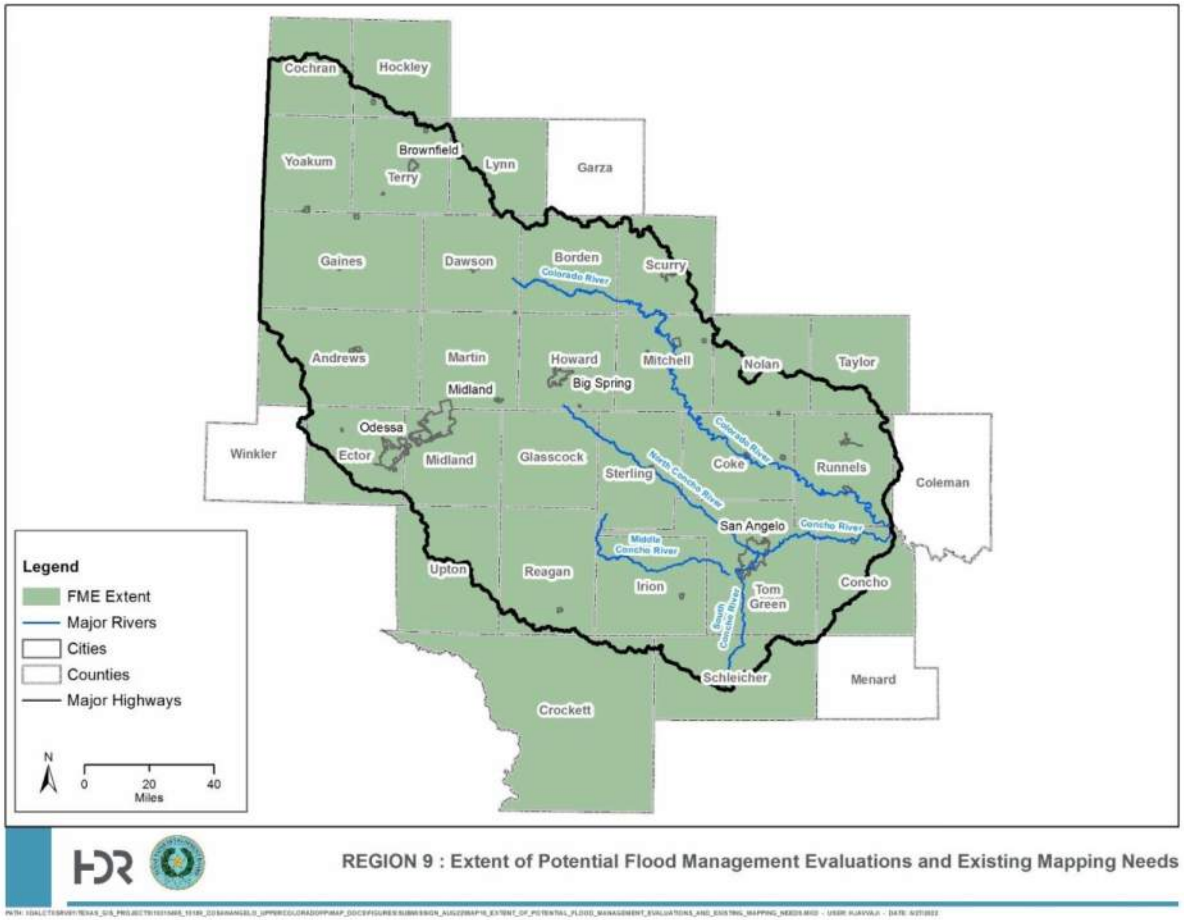
Map 14: Greatest Gaps in Flood Risk Information (2.4.A Task 4A – Flood Mitigation Needs Analysis)



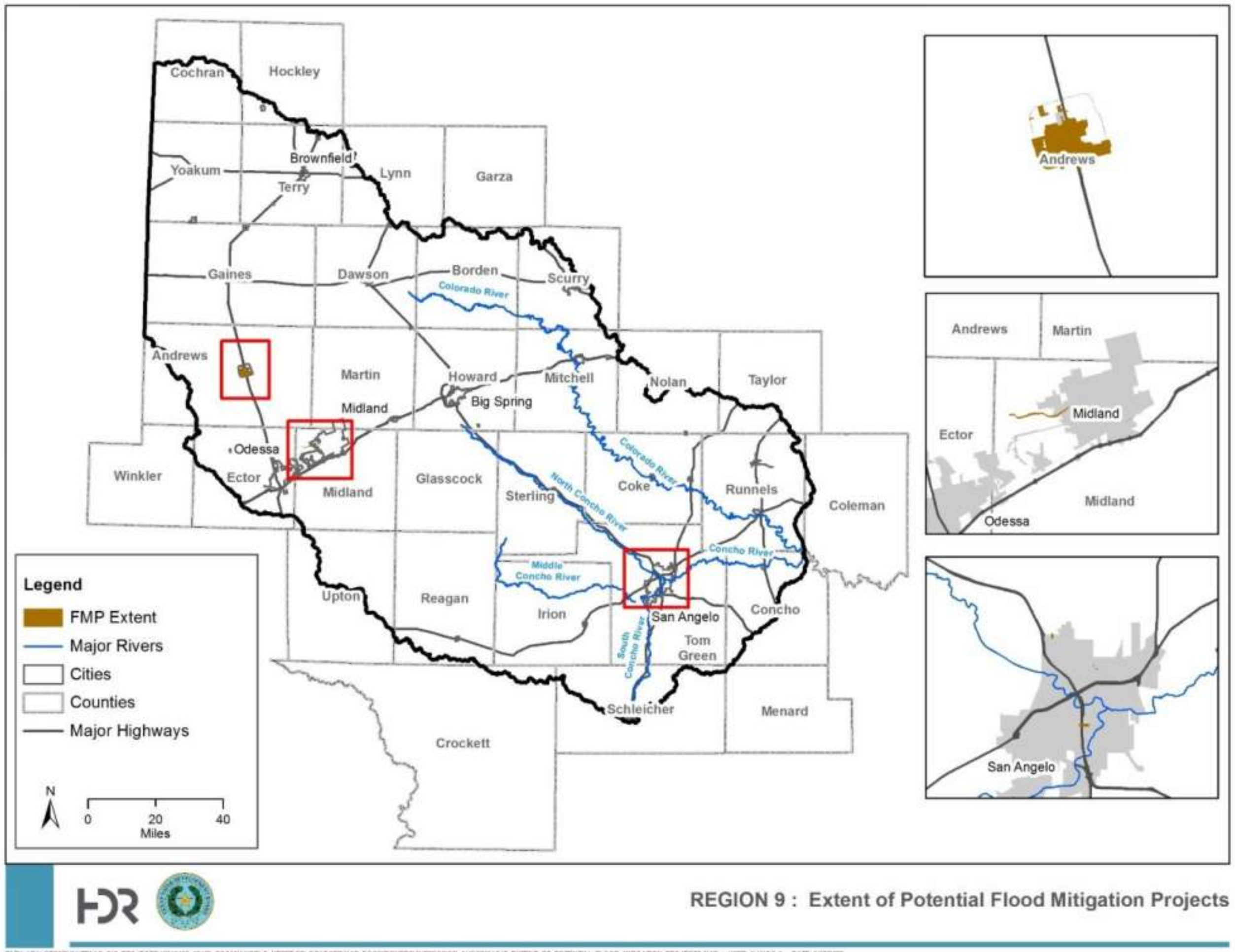
Map 15: Greatest Flood Risk (2.4.A Task 4A – Flood Mitigation Needs Analysis)



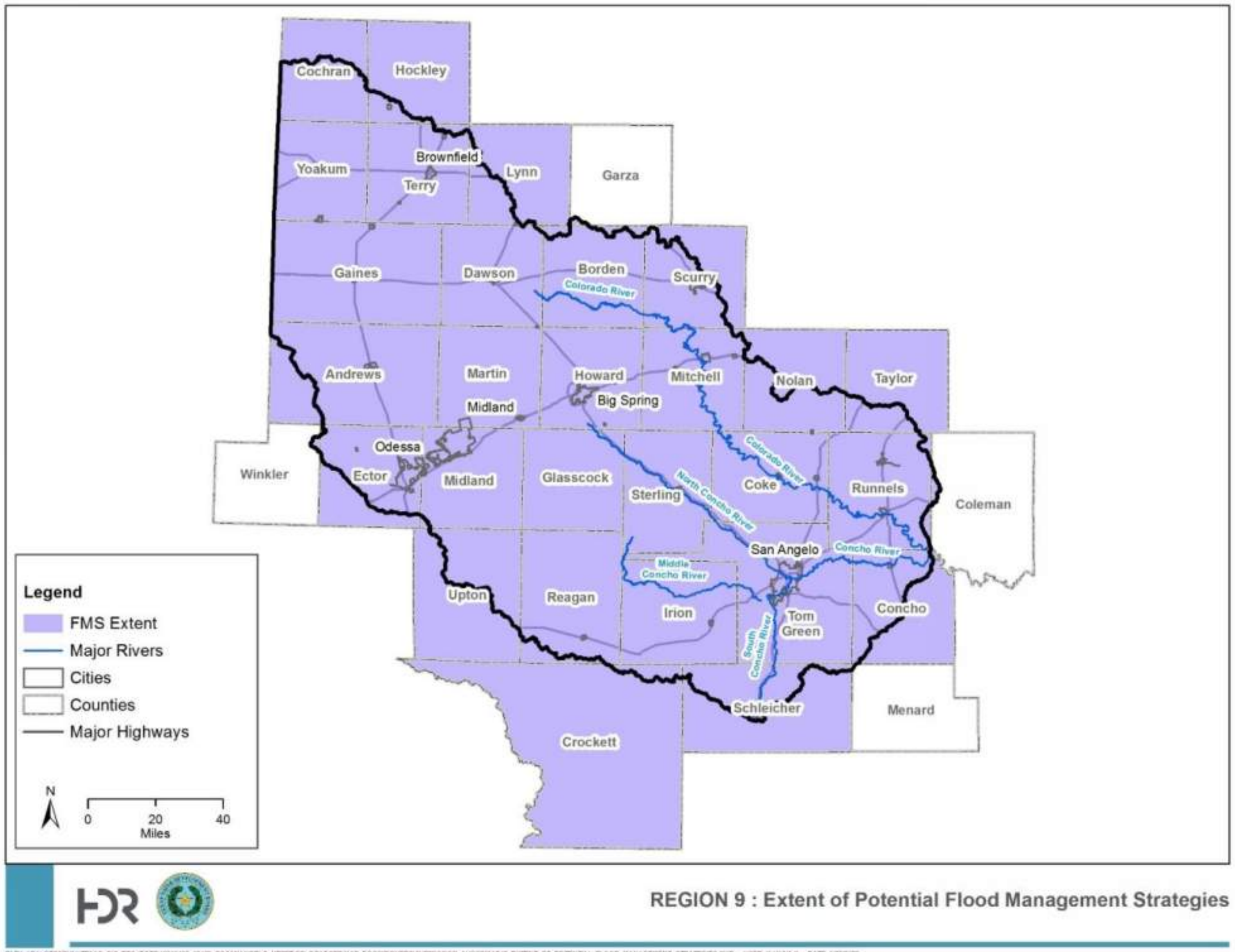
Map 16: Extent of Potential Flood Management Evaluations and Existing Mapping Needs (2.4.B Task 4B– Identification and Evaluation of Potential Flood Management Evaluations and Potentially Feasible Flood Management Strategies and Flood Mitigation Projects)



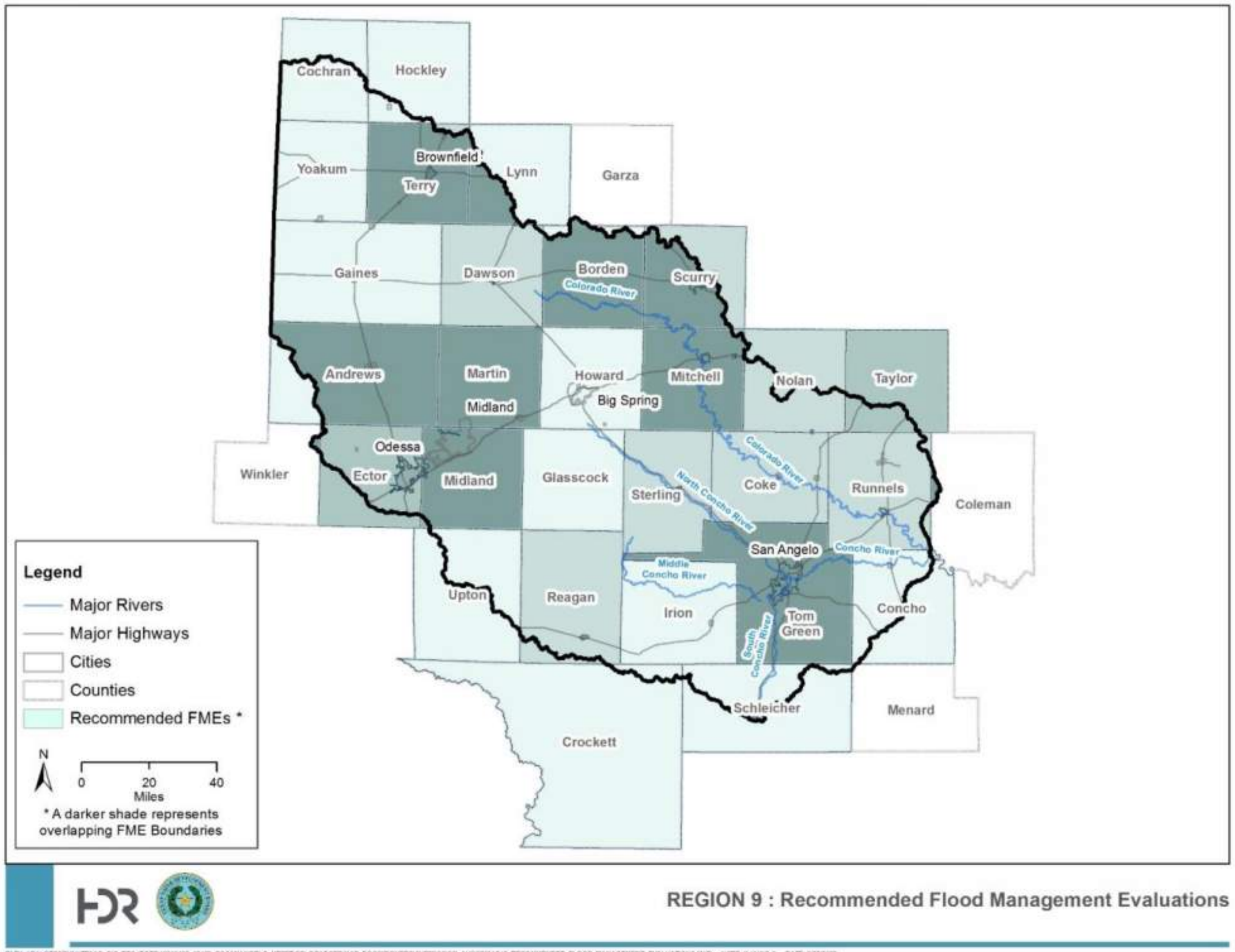
Map 17: Extent of Potential Flood Mitigation Projects (2.4.B Task 4B)



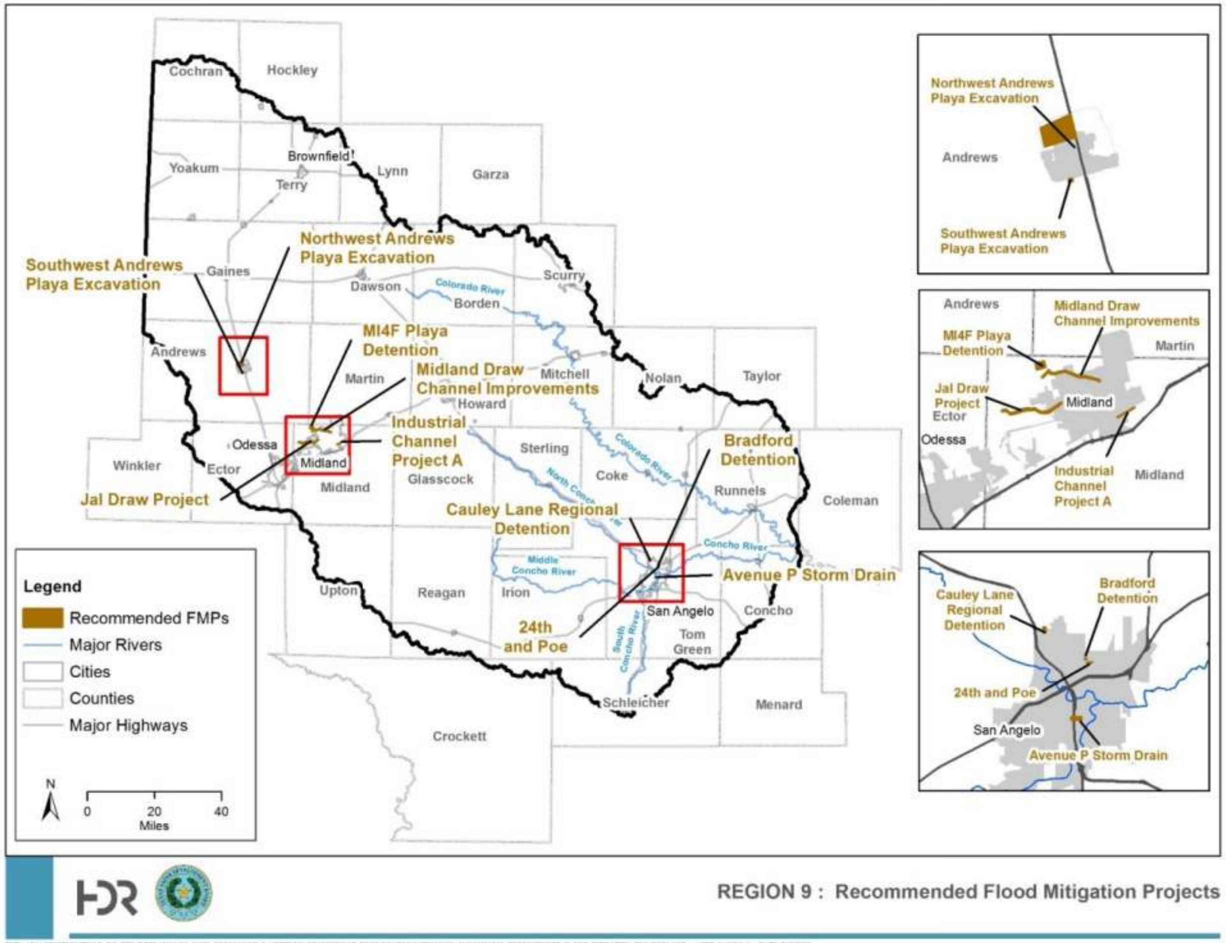
Map 18: Extent of Potential Flood Management Strategies (2.4.B Task 4B)



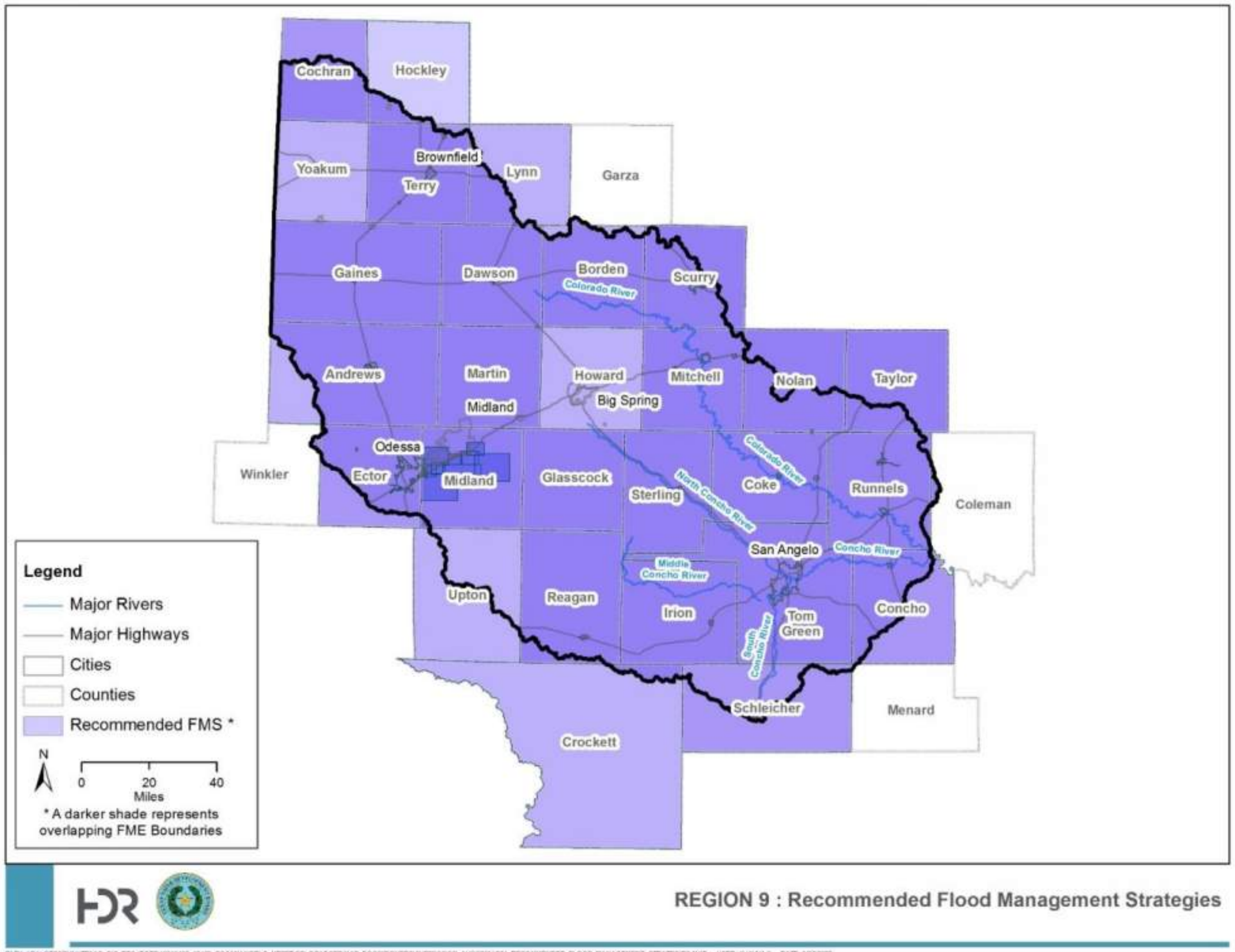
Map 19: Recommended Flood Management Evaluations (2.5.A Flood Management Evaluations)



Map 20: Recommended Flood Mitigation Projects (2.5.B Flood Mitigation Projects)



Map 21: Recommended Flood Management Strategies (2.5.C Flood Management Strategies)



Map 22: Model Coverage (2.4.C Task 4C – Prepare and Submit Technical Memorandum)