HESA and GIS-Based Groundwater Resources Evaluation Delta County, Colorado

OAK MESA AREA

Kenneth E. Kolm, Ph.D.
Paul K.M. van der Heijde
for
Integral Consulting Inc

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What did we do?

- Performed a **HESA** (Hydrologic and Environmental System Analysis) and formulated conceptual models of representative hydrogeologic subsystems of the Oak Mesa area

- Developed GIS maps and data bases of hydrological and hydrogeological characteristics from existing data for use in the HESA and as a cost-effective planning/management/ educational tool

Why do this?

- Source water assessment and protection (municipal and communal water supply systems)
- Sustainability of water supply sources
- Adequate water quantity and quality to sustain land development
- Effects of coal mining
- Effects of gas and oil development
- ISDS and well setbacks
- Protection of groundwater-fed wetlands.
- Groundwater contribution to in-stream flows and water quality
- Effects of land use changes (agriculture to mining and urbanization)

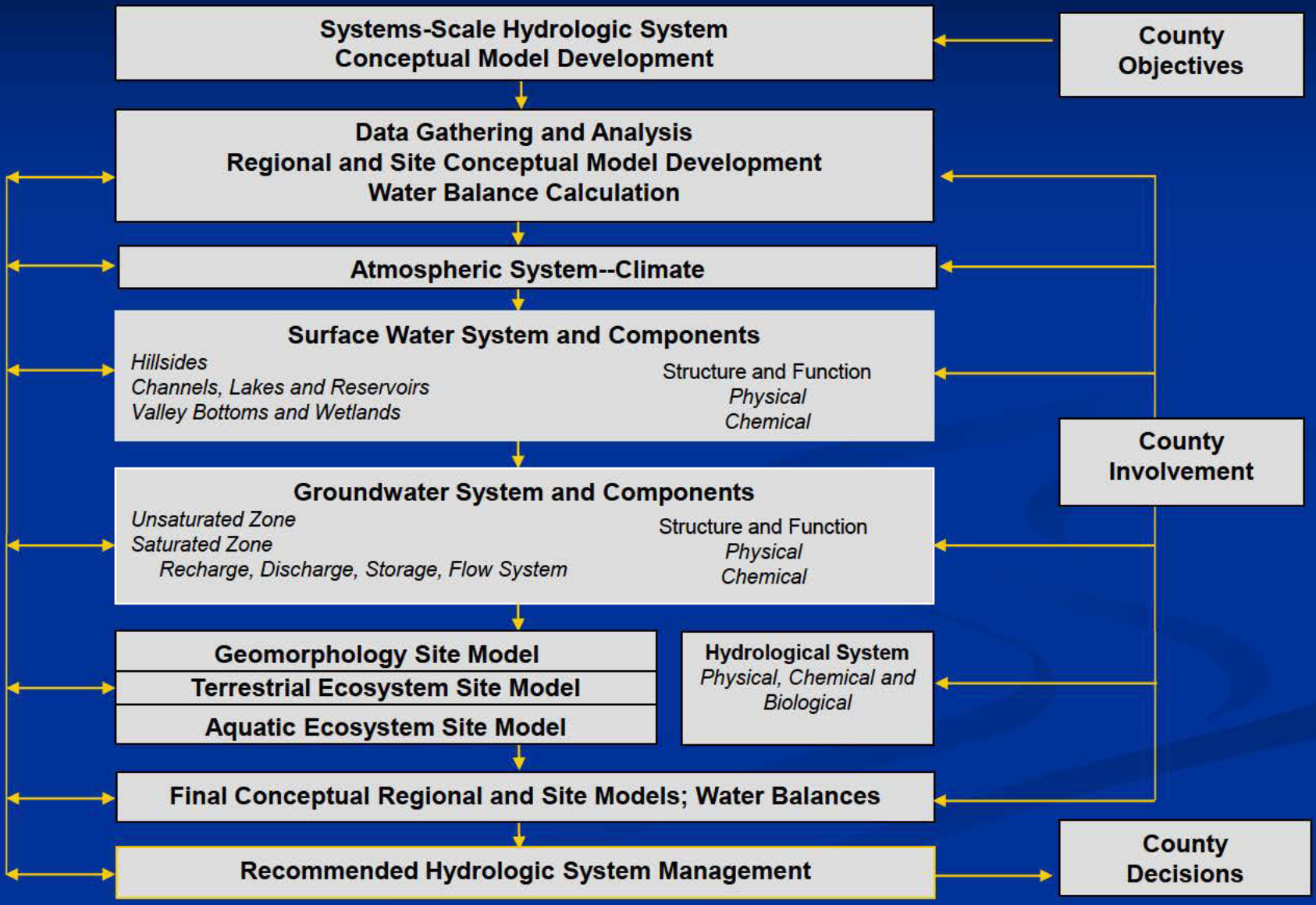
What is HESA?

Hydrologic and Environmental Systems Analysis

- HESA is an approach used to conceptualize and characterize relevant features of hydrologic and environmental systems, integrating relevant considerations of climate, topography, geomorphology, groundwater and surface water hydrology, geology, ecosystem structure and function, and the human activities associated with these systems into a **holistic, three-dimensional dynamic conceptual site model** (CSM).

- Using HESA, all relevant controlling factors of a particular environment can be identified at the planning/characterization stage, leading to more **focused, cost effective strategies and better decision-making** throughout water resources related management

HESA Flowchart

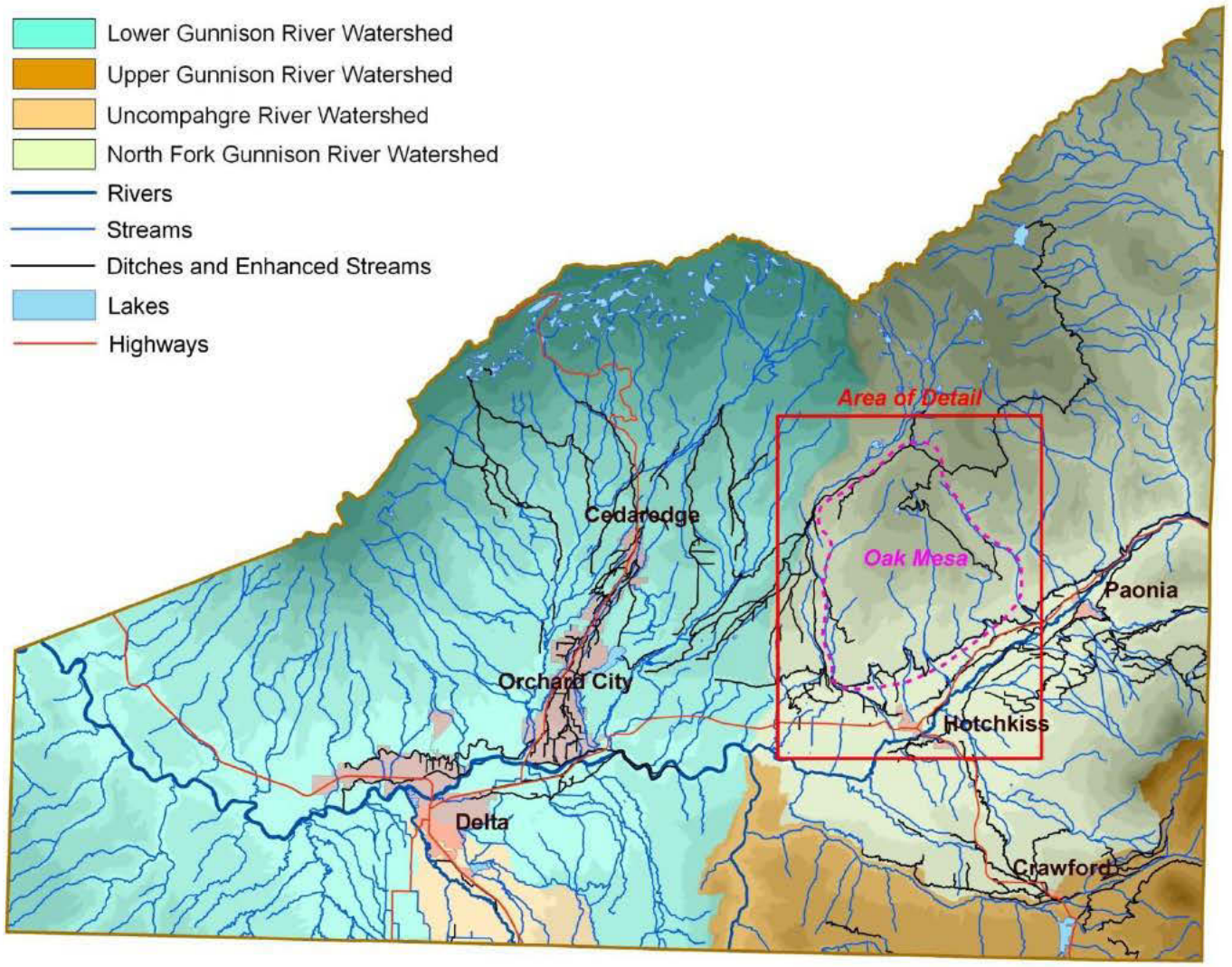


HESA Elements in Oak Mesa Study

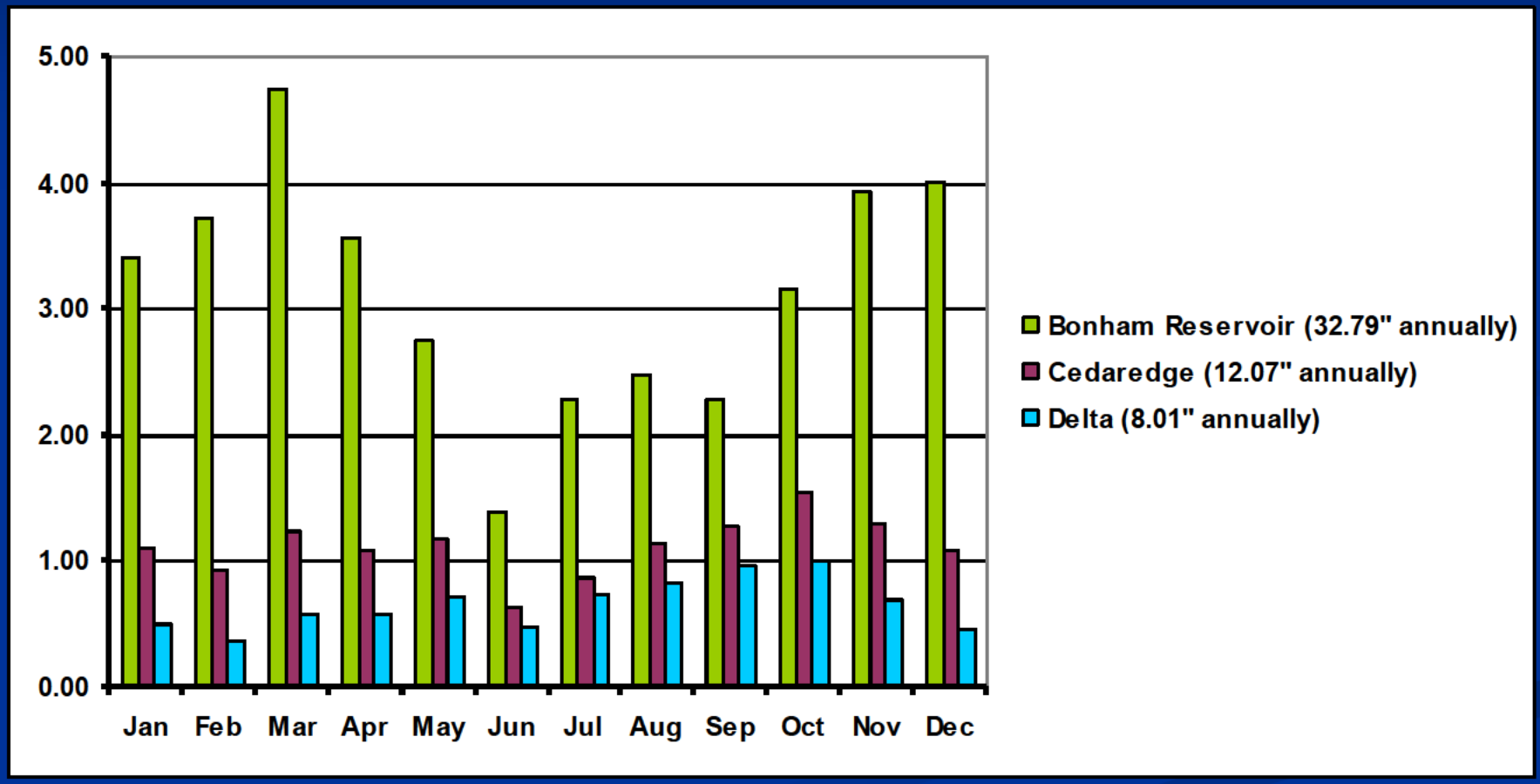
- **Surface characterization**
  - Climate, vegetation, soils, geomorphology, topography, surface water, and land use and other anthropogenic elements
- **Subsurface characterization**
  - Geologic framework, hydrogeologic framework, hydrogeologic properties
- **Groundwater flow system characterization**
  - Flow paths, velocities, recharge, discharge, water budget

- **[Ground water quality/chemistry characterization]**
- **[Ground water modeling]**

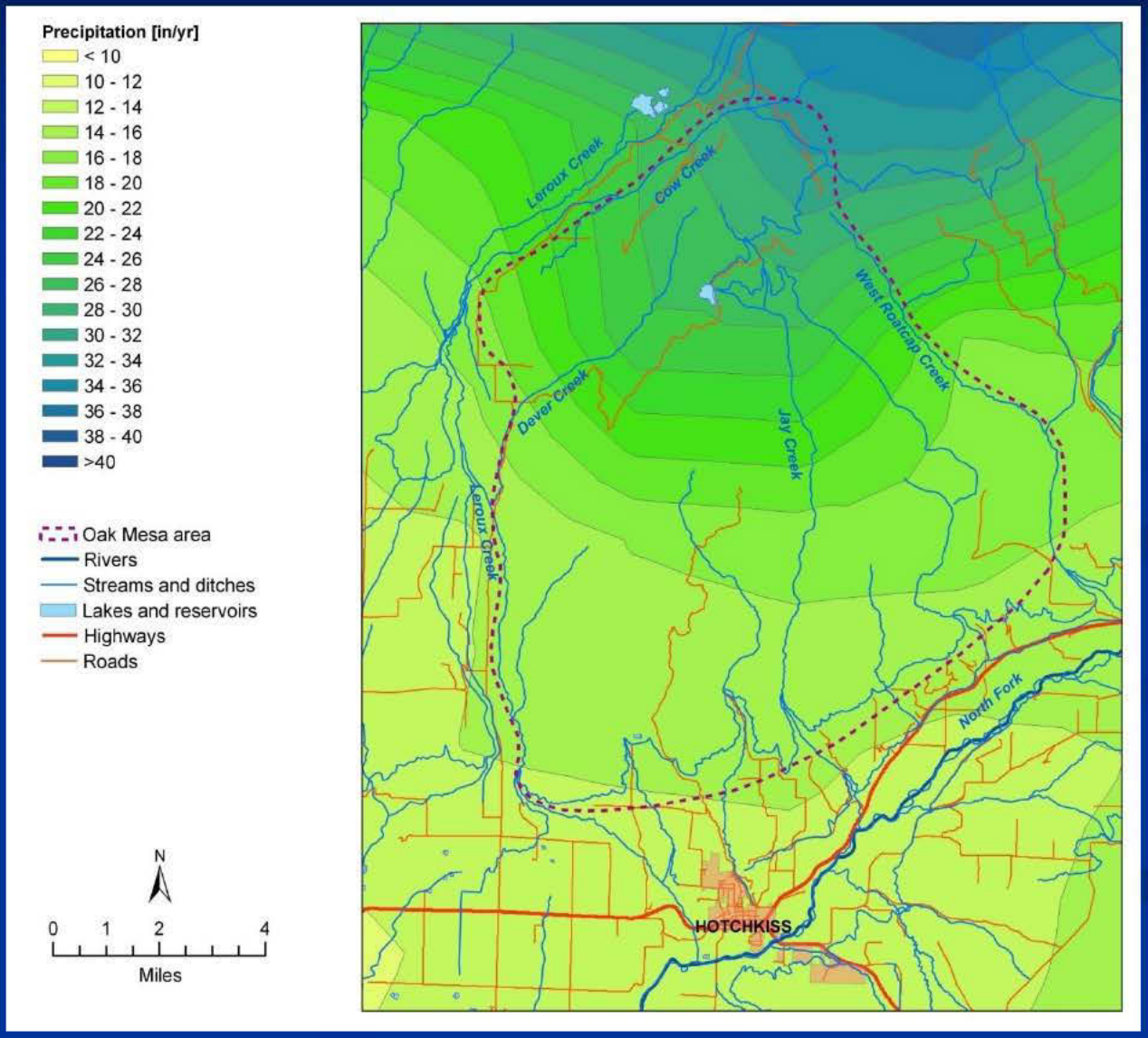
Study Area Location



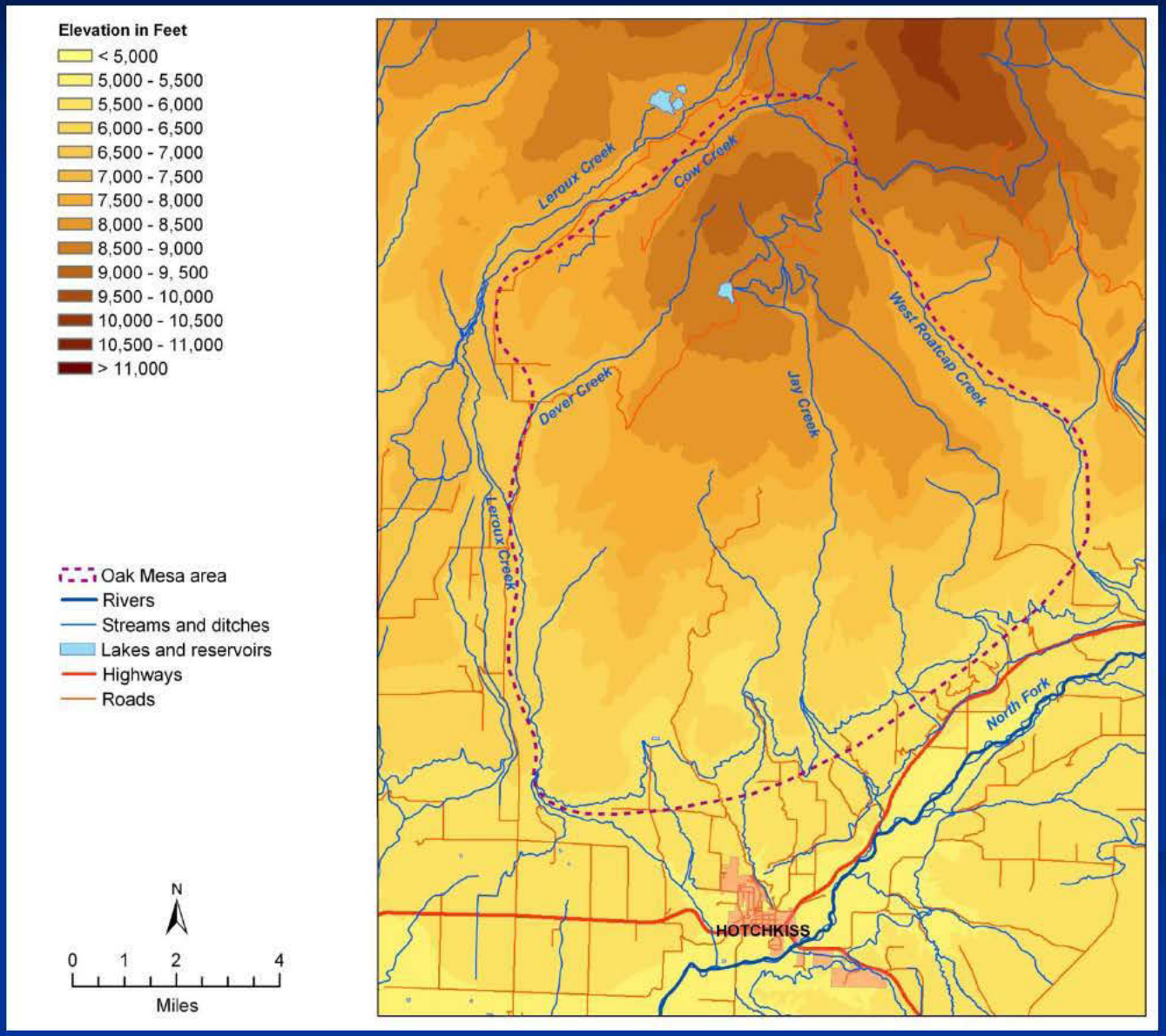
Climate


5.00
4.00
3.00
2.00
1.00
0.00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Bonham Reservoir (32.79" annually)
Cedaredge (12.07" annually)
Delta (8.01" annually)

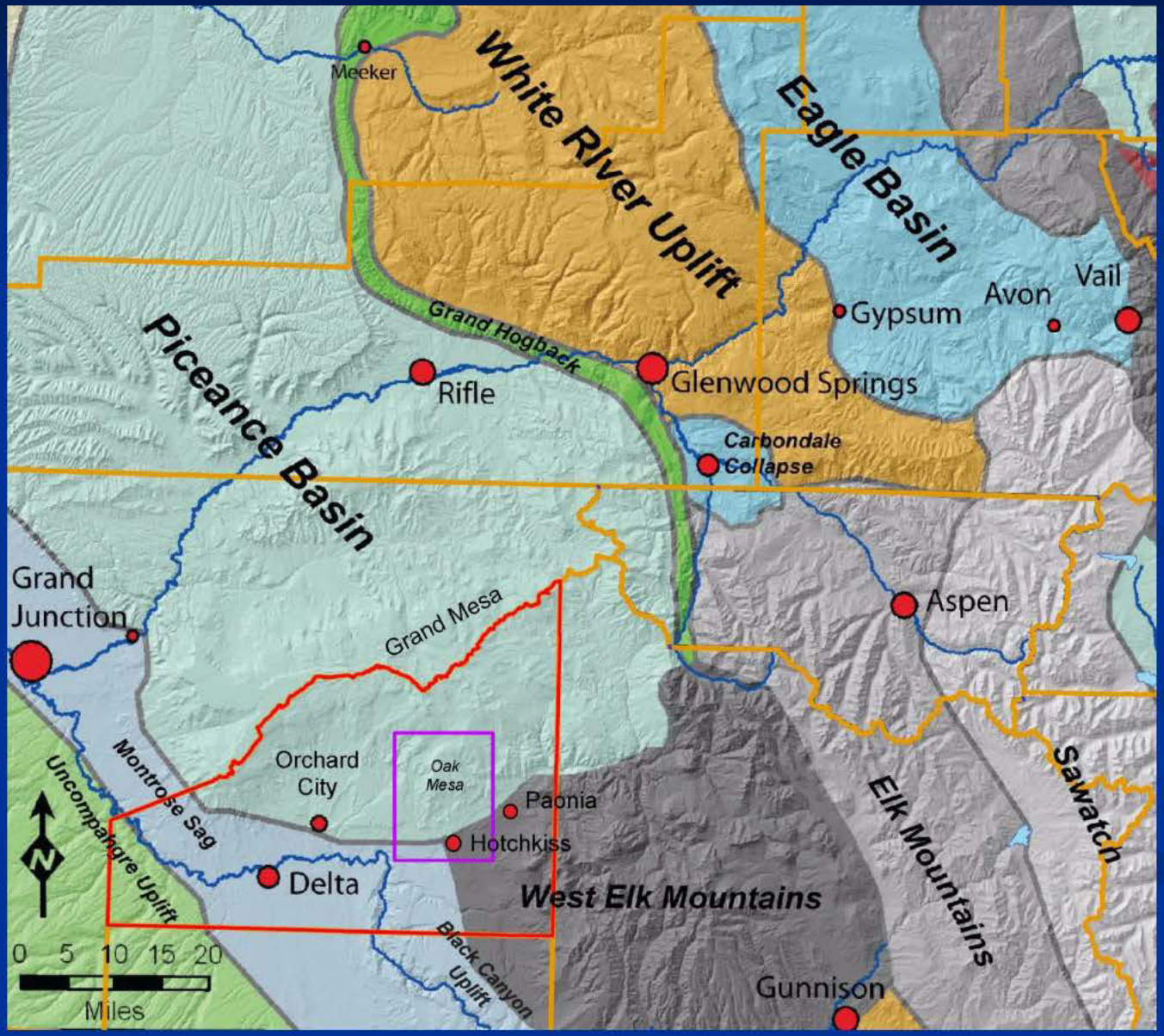
Climate


Precipitation [in/yr]
< 10
10 - 12
12 - 14
14 - 16
16 - 18
18 - 20
20 - 22
22 - 24
24 - 26
26 - 28
28 - 30
30 - 32
32 - 34
34 - 36
36 - 38
38 - 40
>40
Oak Mesa area
Rivers
Streams and ditches
Lakes and reservoirs
Highways
Roads
N
0 1 2 4
Miles
Leroux Creek
Cow Creek
West Rollcap Creek
Dever Creek
Jay Creek
Leroux Creek
North Fork
HOTCHKISS

Topography and Surface Water



Regional Geologic Setting



Correlation of Geological and Hydro-geological Units in Delta County - 1

Geological Unit	*Geological Subunit*	*Hydrogeological Unit*	*Hydro-geological Unit Symbol*	*Composition*	*Hydrogeological Characteristics*	*Permeability/Storativity*	*Depth to Water* (small/ moderate/ large/ highly fluctuating)	*Extent* (local/ sub-regional/ regional)	*Recharge Type* (natural/ anthropogenic)
Alluvium (Qa); alluvium and eolian deposits (Qae)		Alluvium	Qal	Poorly sorted riverine gravel, sand and silt deposited mainly in stream channels and floodplains in major stream valley bottoms; moderately to well bedded deposits	Generally good local phreatic aquifer with matrix based permeability; limited variations in groundwater levels; often sustained by local and sub-regional discharge to adjacent stream or directly by stream.	high matrix-permeability; high storativity	small	local	natural
Younger gravel (Qg, Qgy)		Younger valley gravels	Qgy	Poorly sorted sands and gravels; pebbles and cobbles in sand to silt matrix	Potentially good, spatially continuous phreatic aquifer with high matrix based permeability; may be supported by underlying bedrock.	high matrix-permeability; high storativity	highly fluctuating	local	natural and anthropogenic
Glacial drift, till, moraine (Qd, Qm, Qpt)		Quaternary glacial deposits	Qd	Heterogeneous, poorly sorted deposits of boulders, gravel, sand, silt and clay	Potentially good local phreatic aquifer with variable matrix based permeability and high water table gradients.	high matrix-permeability; high storativity	highly fluctuating	local	natural and anthropogenic
Landslide deposits, colluvium, mudflow deposits, talus (Ql, Qcl, Qs, Qls, Qta); unconsolidated deposits derived from the Wasatch Formation and Basalt cap on Grand Mesa (Quw)		Hillside (slope) deposits	Qs	Loose gravels and rock debris with mixed matrix composition (sand-clay) on valley sides, valley floors and hillslopes; deposited by gravitational processes	Potentially good, highly localized phreatic aquifer with high matrix based permeability and high water table gradients.	high matrix-permeability; high storativity	highly fluctuating	local	natural and anthropogenic
Old/older gravels (Qgo, Qgd)		Older mesa top gravels	Qgo	Poorly sorted sands and gravels; pebbles and cobbles in sand to silt matrix	Potentially good, spatially continuous phreatic aquifer with high matrix based permeability; may be prone to significant (seasonal) water table fluctuations; tends to recharge bedrock systems	high matrix-permeability; high storativity	moderate	local	natural and anthropogenic
Middle gravel (Qgm) and fans (Qf)		Fans and lower mesa gravels	Qgf	Poorly sorted sands and gravels; pebbles and cobbles in sand to silt matrix	Although having high matrix based permeability, location in topography precludes any significant groundwater presence.	high matrix-permeability; high storativity	highly fluctuating	local	natural and anthropogenic
High level alluvium (Qat); younger terraces (Qad); alluvial gravels (Qga)		Younger river terraces	Qat	Poorly sorted sands and gravels; pebbles and cobbles in sand to silt matrix; forms terraces above current North Fork level	Potentially good, spatially continuous phreatic aquifer with high matrix based permeability.	high matrix-permeability; high storativity	highly fluctuating	local	natural and anthropogenic

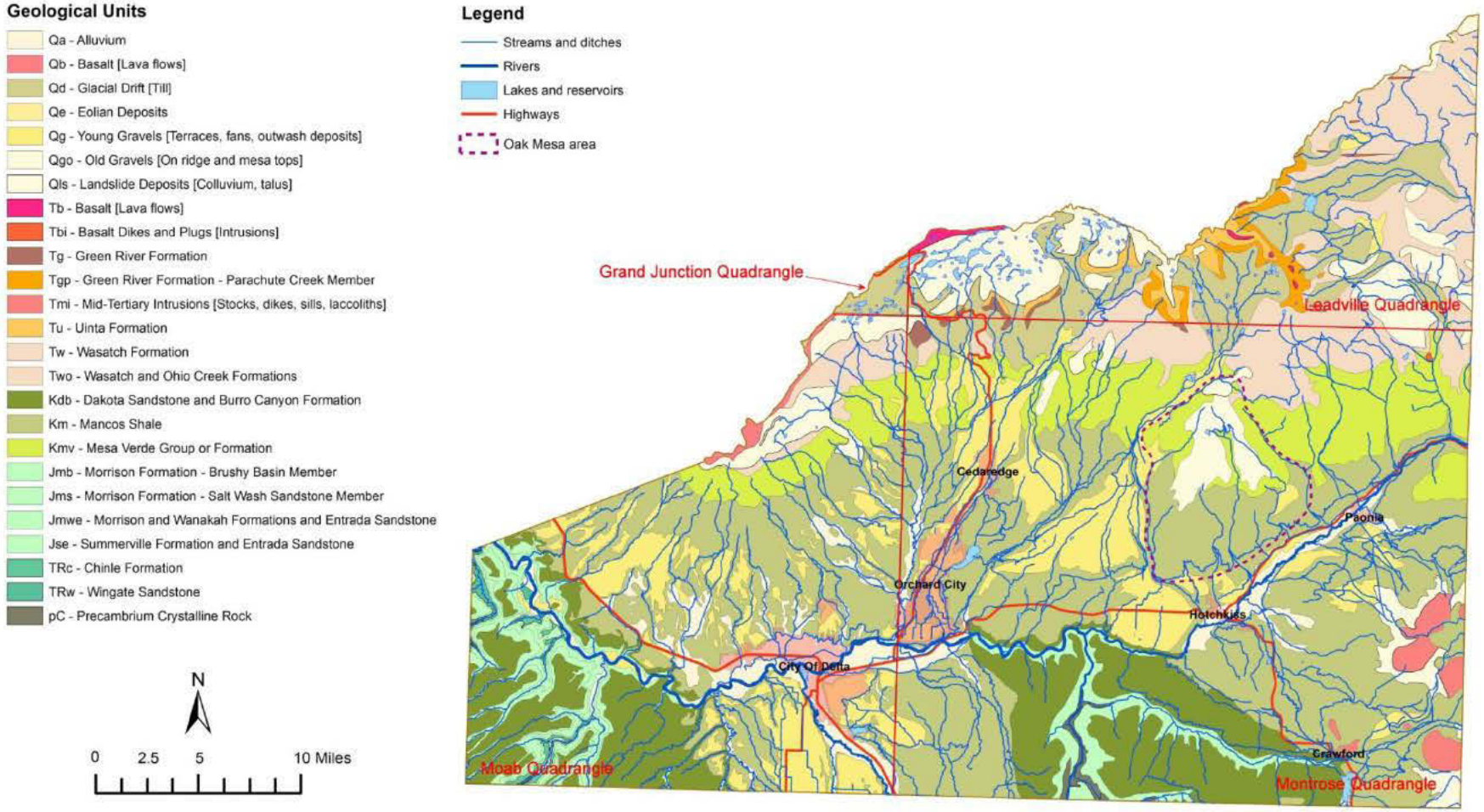
Correlation of Geological and Hydro-geological Units in Delta County - 2

Geological Unit	*Geological Subunit*	*Hydrogeological Unit*	*Hydro-geological Unit Symbol*	*Composition*
Alluvium (Qa); alluvium and eolian deposits (Qae)		Alluvium	Qal	Poorly sorted riverine gravel, sand and silt deposited mainly in stream channels and floodplains in major stream valley bottoms; moderately to well bedded deposits
Younger gravel (Qg, Qgy)		Younger valley gravels	Qgy	Poorly sorted sands and gravels; pebbles and cobbles in sand to silt matrix
Glacial drift, till, moraine (Qd, Qm, Qpt)		Quaternary glacial deposits	Qd	Heterogeneous, poorly sorted deposits of boulders, gravel, sand, silt and clay

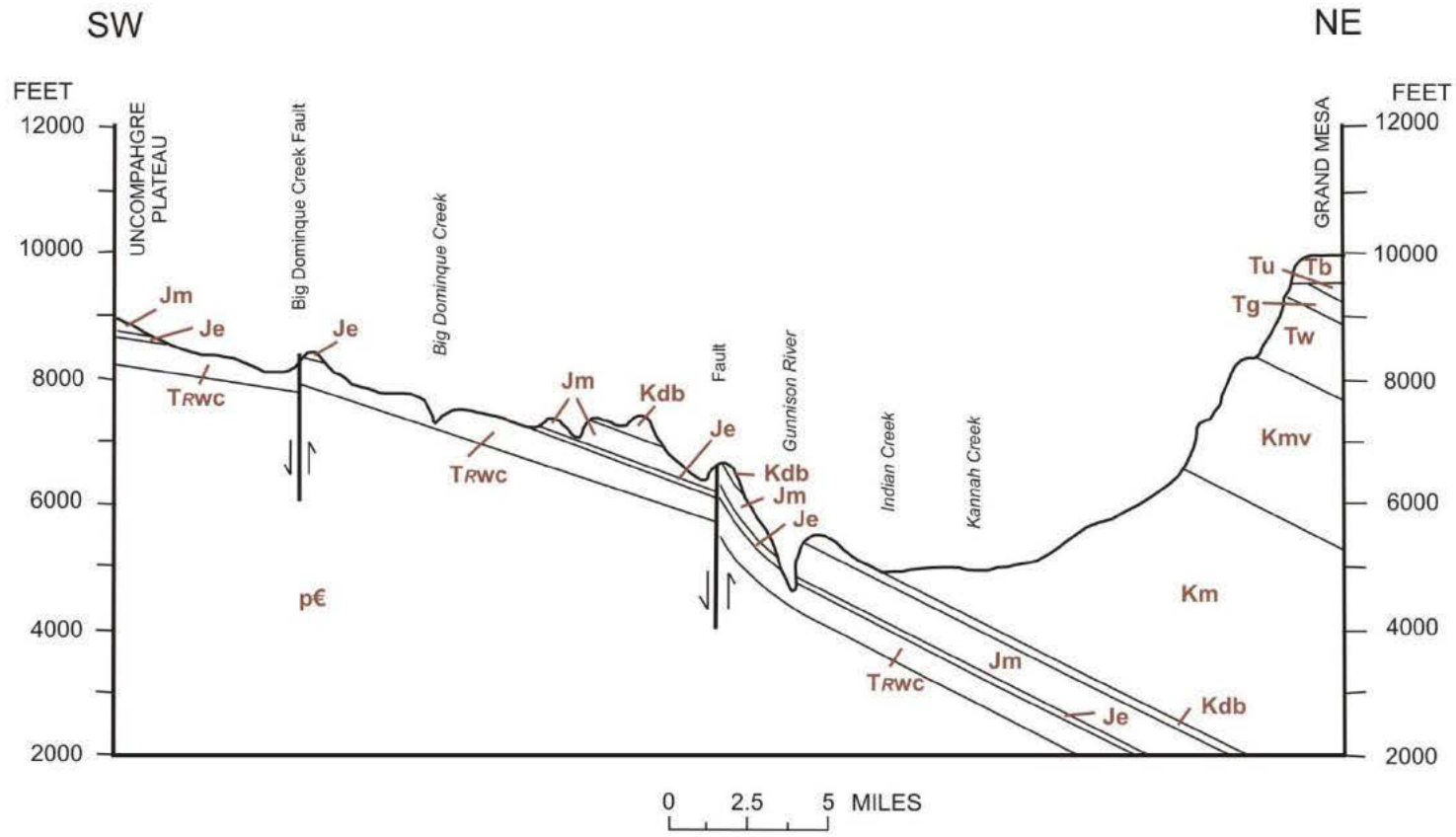
Correlation of Geological and Hydro-geological Units in Delta County - 3

Hydro-geological Unit Symbol	***Hydrogeological Characteristics***	***Permeability/Storativity***	***Depth to Water*** (small/ moderate/ large/ highly fluctuating)	***Extent*** (local/ sub-regional/ regional)	***Recharge Type*** (natural/ anthropogenic)
Qal	Generally good local phreatic aquifer with matrix based permeability; limited variations in groundwater levels; often sustained by local and sub-regional discharge to adjacent stream or directly by stream.	high matrix-permeability; high storativity	small	local	natural
Qgy	Potentially good, spatially continuous phreatic aquifer with high matrix based permeability; may be supported by underlying bedrock.	high matrix-permeability; high storativity	highly fluctuating	local	natural and anthropogenic
Qd	Potentially good local phreatic aquifer with variable matrix based permeability and high water table gradients; sustainability depends on local natural and/or anthropogenic recharge mechanisms.	high matrix-permeability; high storativity	highly fluctuating	local	natural and anthropogenic

Geological Map of Delta County



NE-SW Geological Cross Section

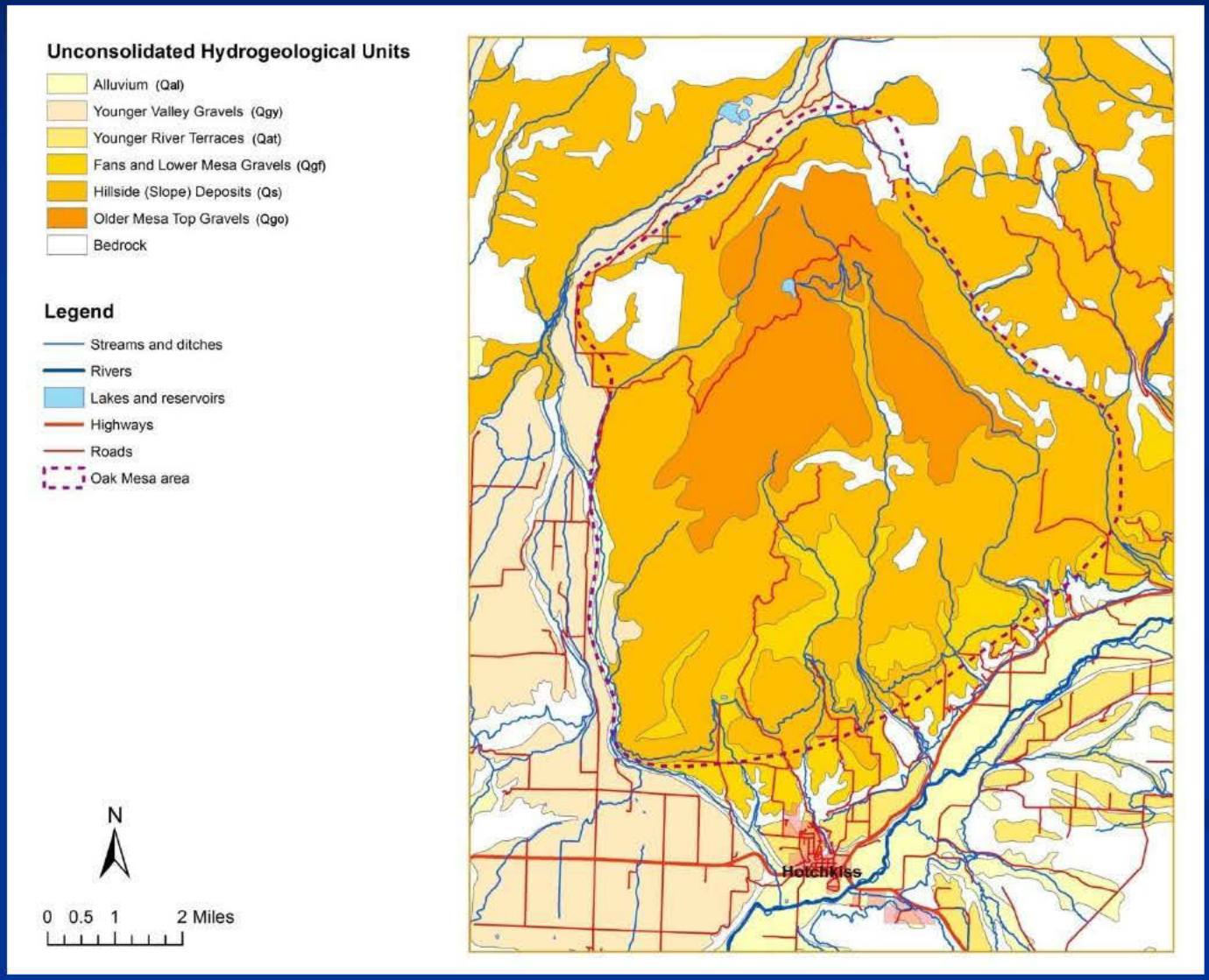


Tb - Tertiary Basalt
Tu - Uinta Formation
Tg - Green River Formation
Tw - Wasatch Formation
Kmv - Mesaverde Formation
Km - Mancos Shale

Kdb - Dakota Sandstone and Burro Canyon Formation
Jm - Morrison Formation
Je - Entrada Sandstone
Trwc - Wingate Sandstone and Chinle Formation
p€ - Precambrian

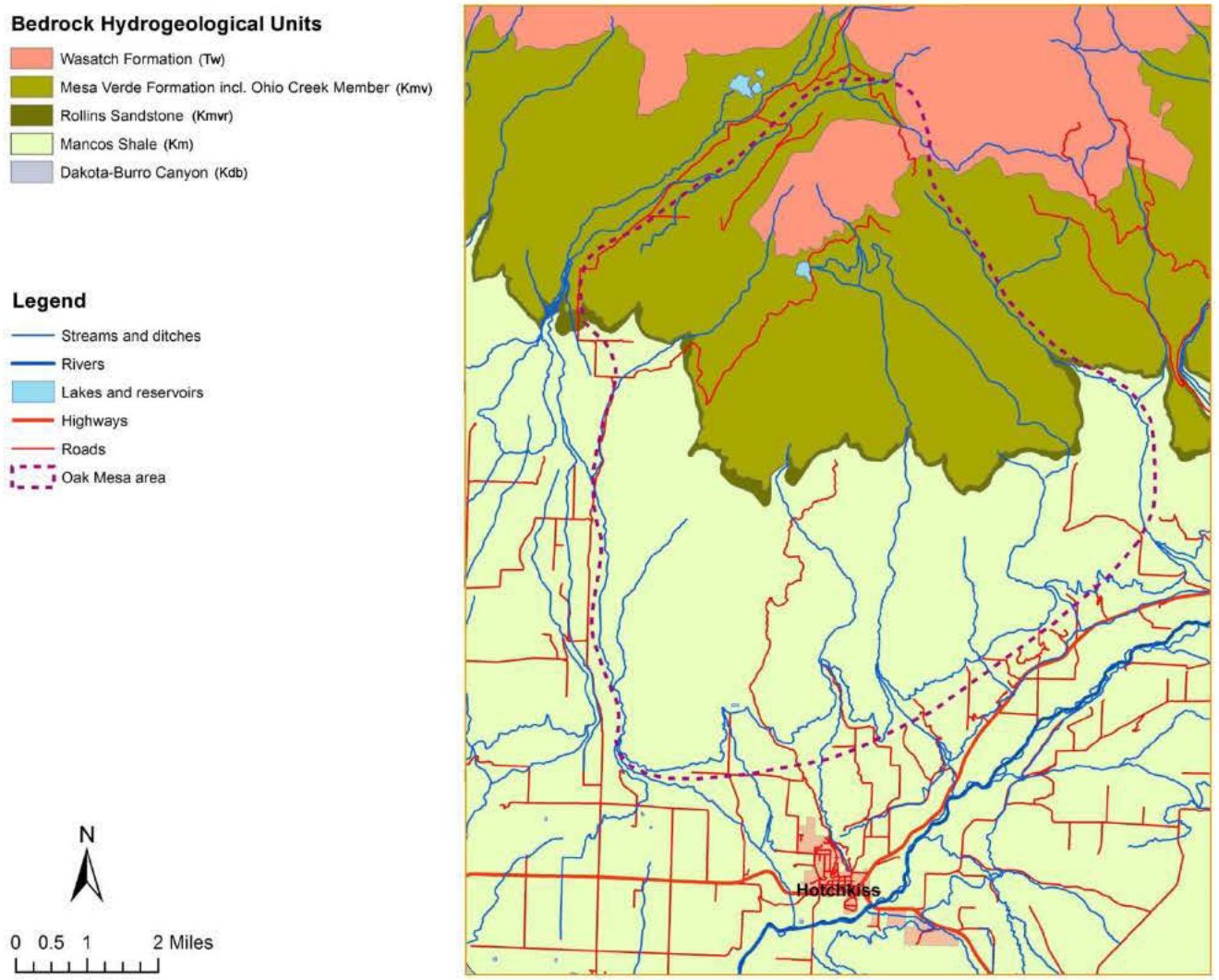
Hydrogeology of Oak Mesa Area

Shallow Unconsolidated Units



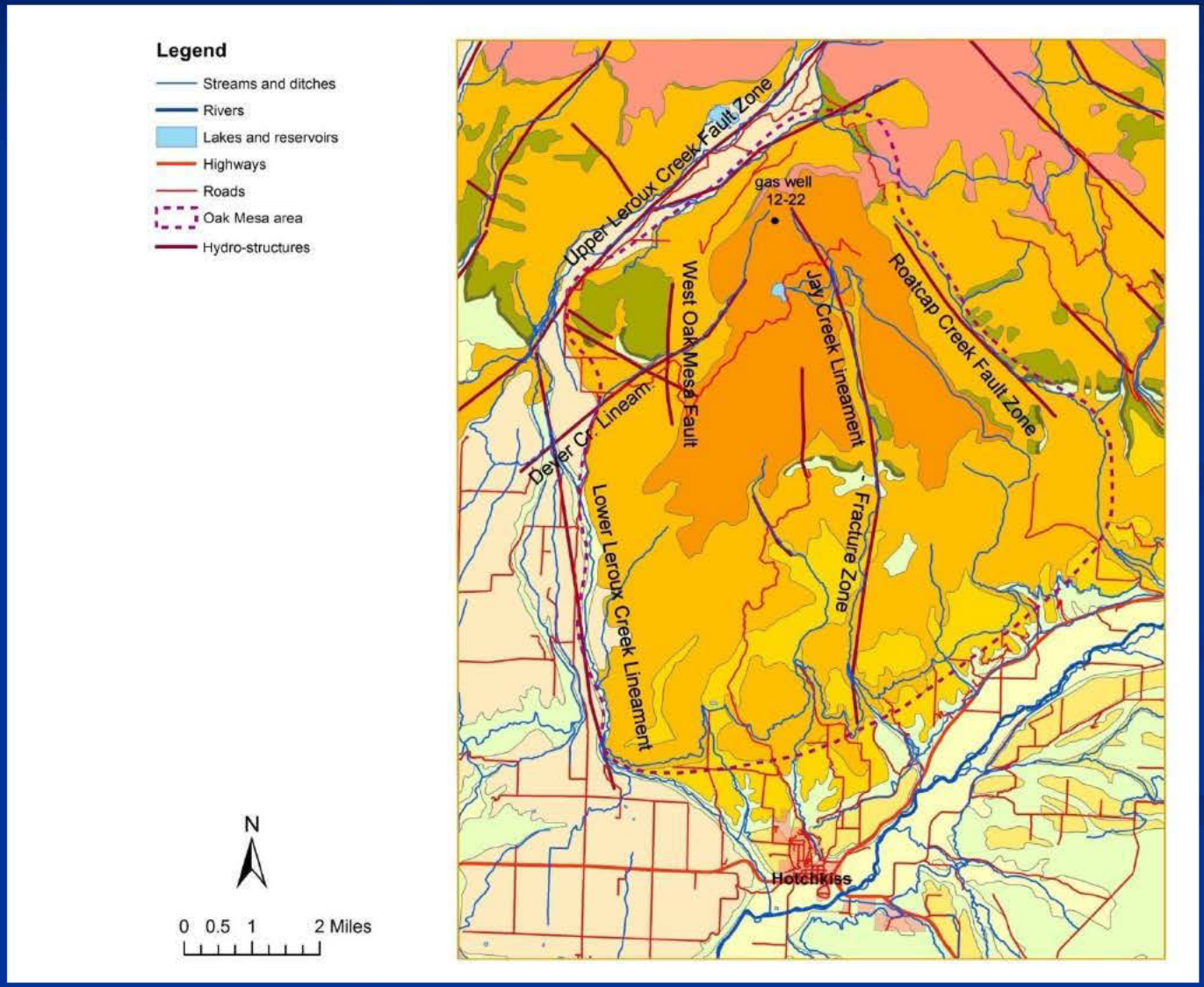
Hydrogeology of Oak Mesa Area

Bedrock Units



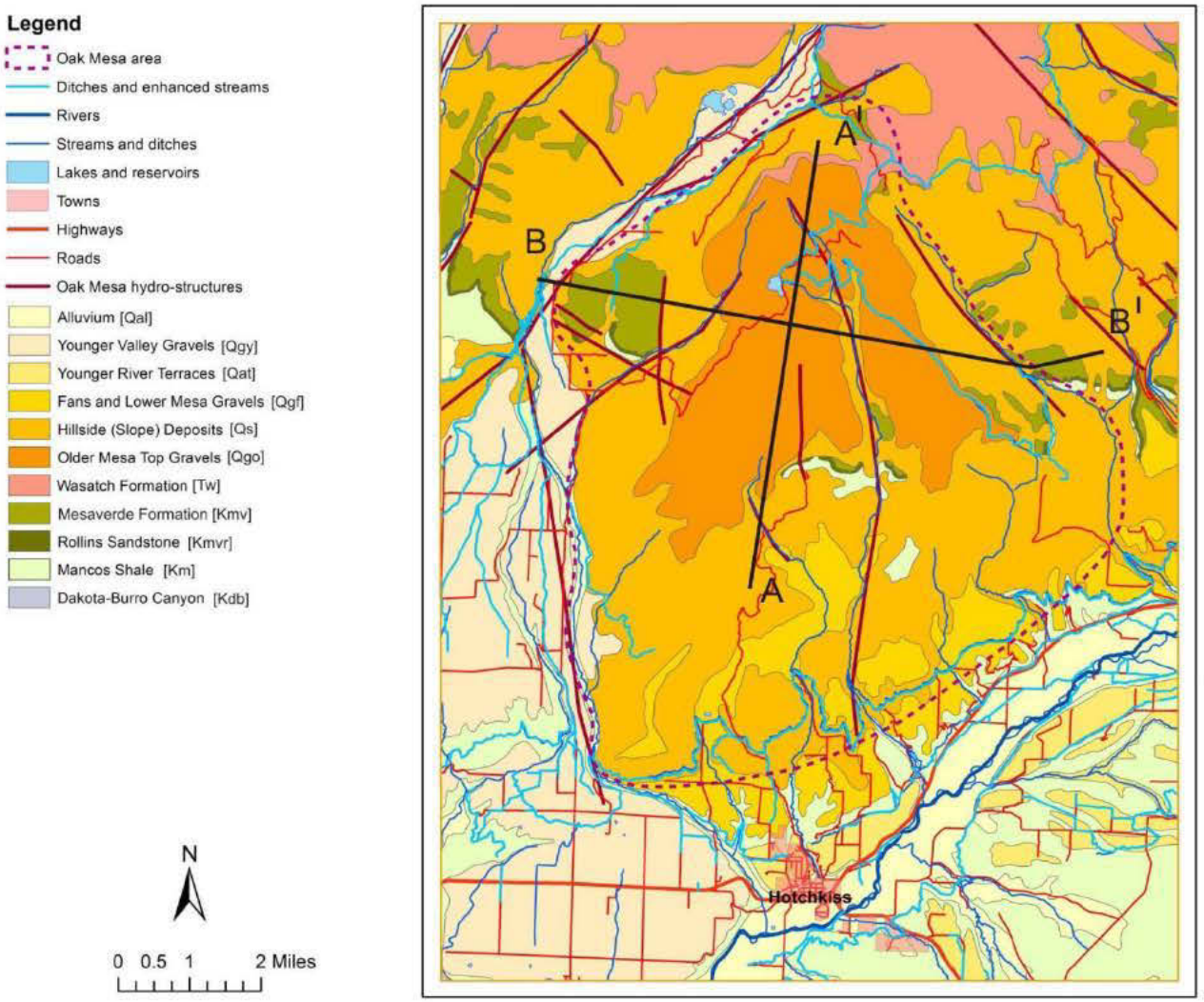
Hydrogeology of Oak Mesa Area

Hydrostructures



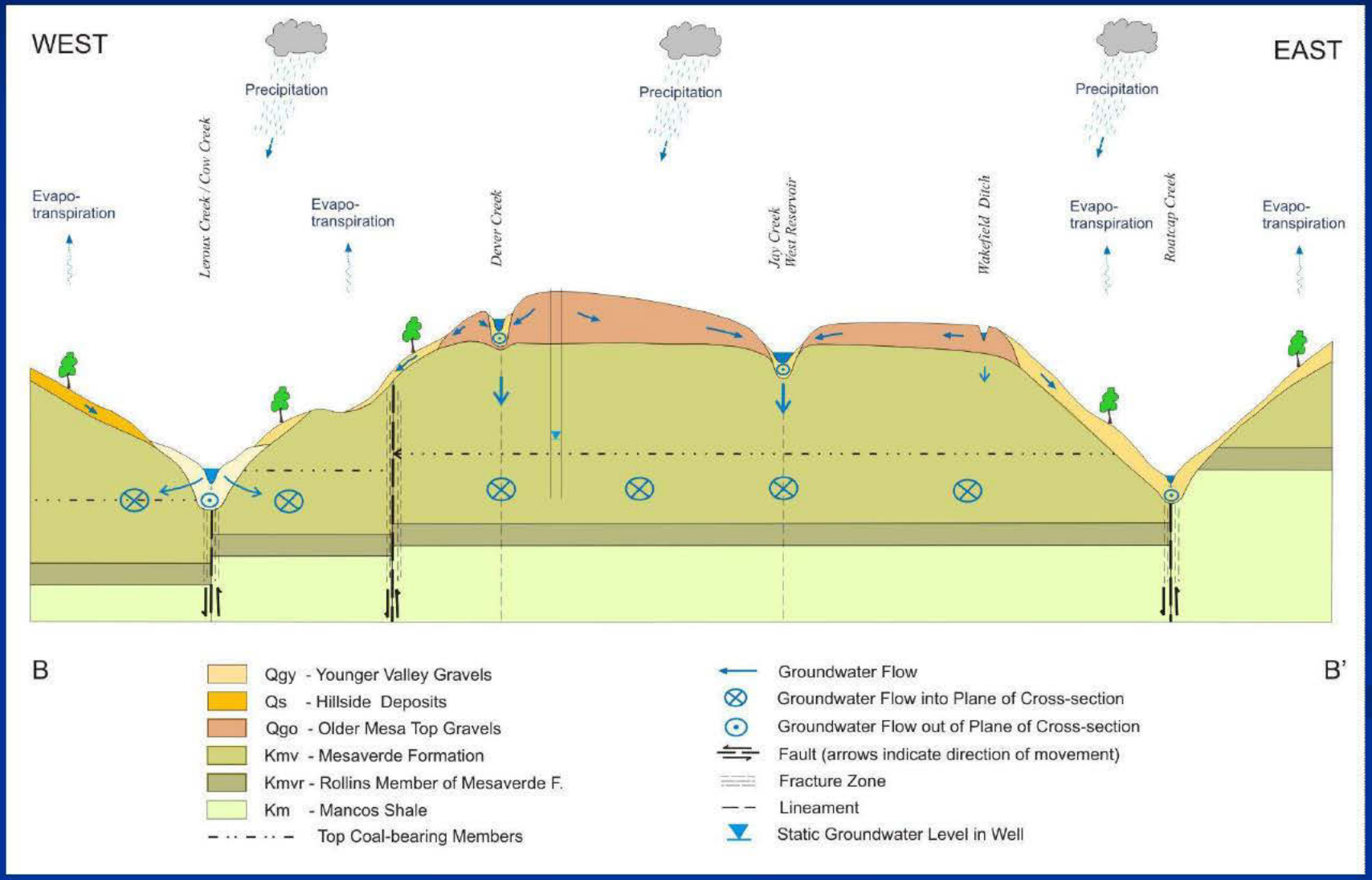
Hydrogeology of Oak Mesa Area

Location of CSM Cross Sections



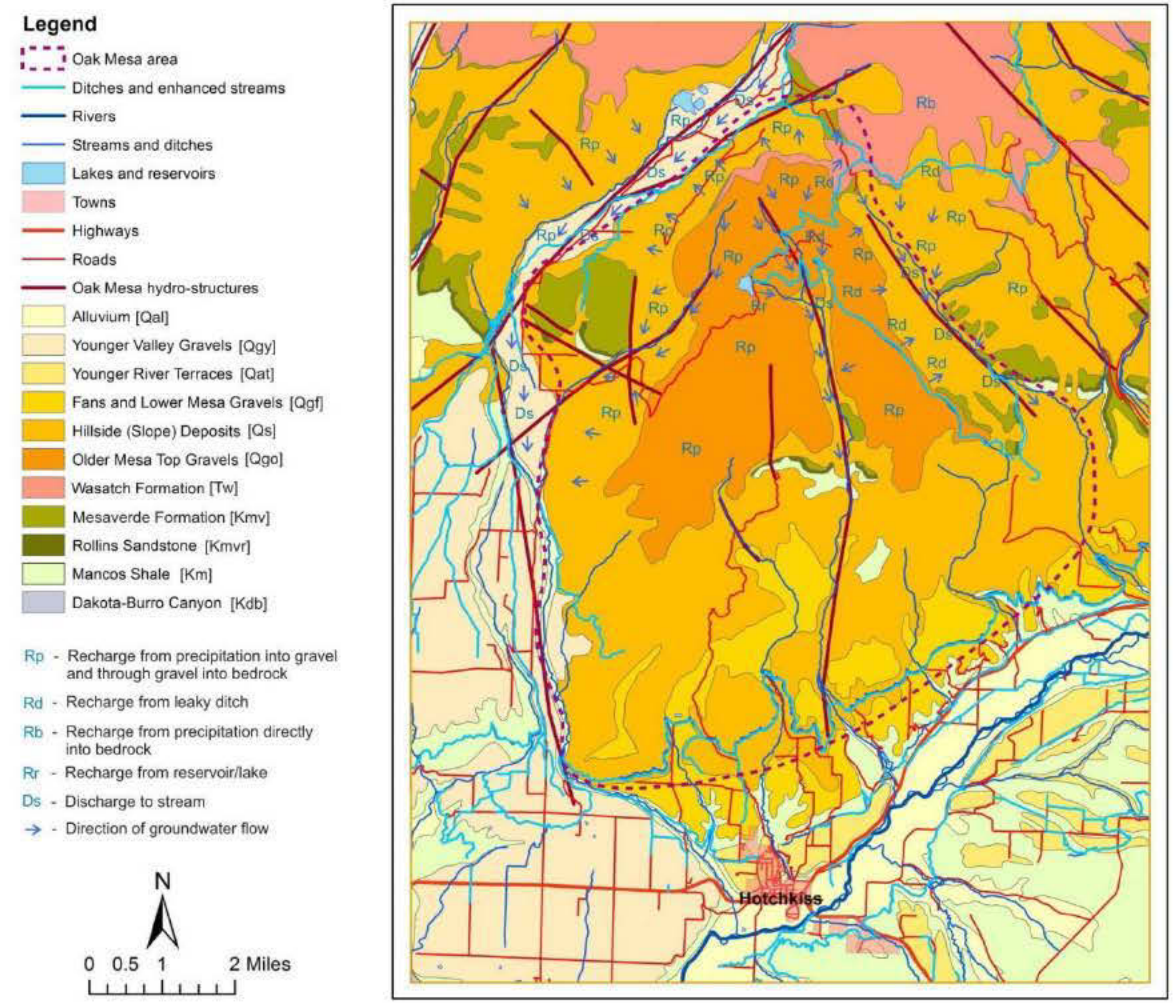
Hydrogeology of Oak Mesa Area

Shallow Aquifer Subsystem – X-section



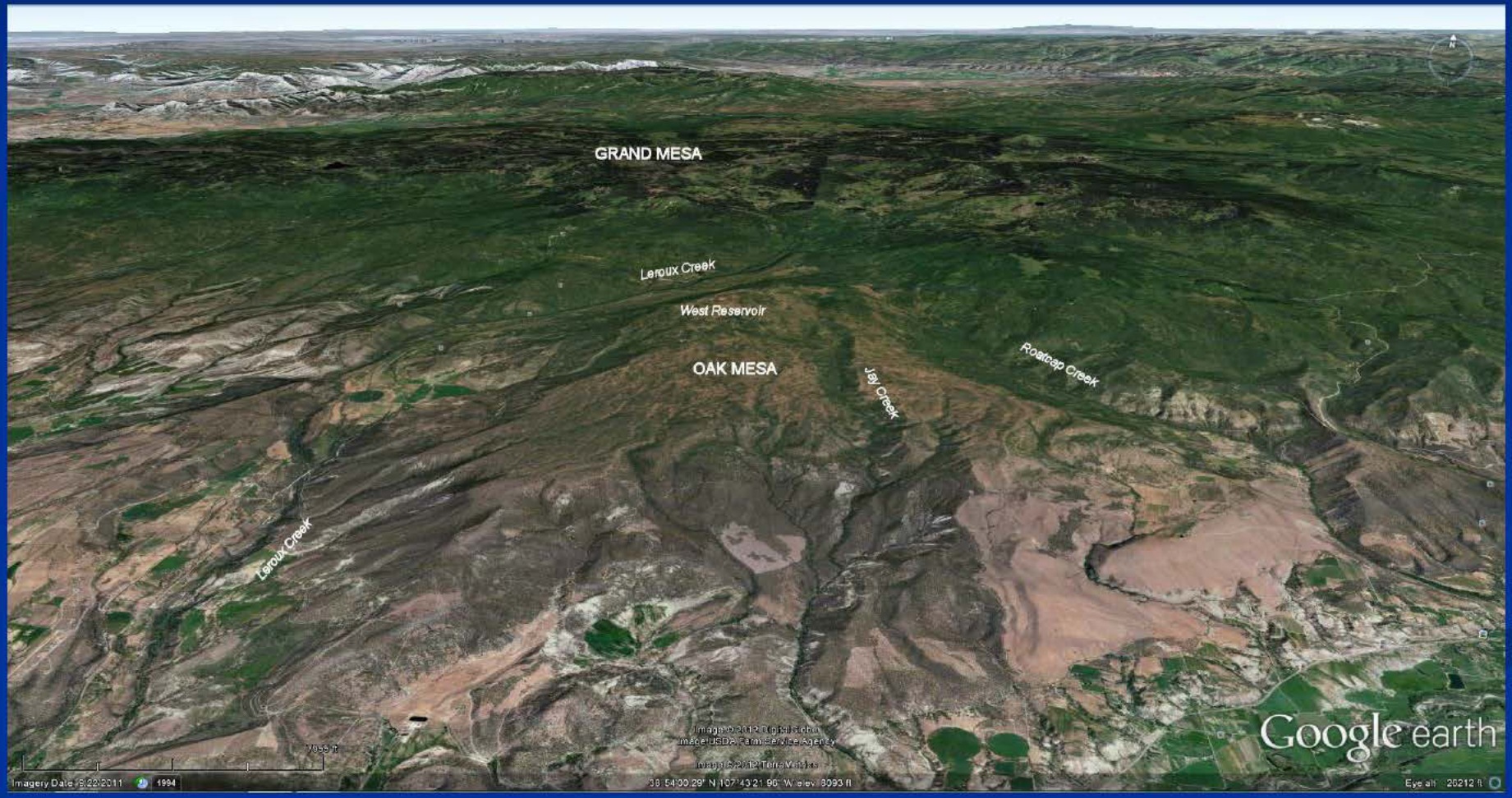
Hydrogeology of Oak Mesa Area

Shallow Aquifer Subsystem – Plan View



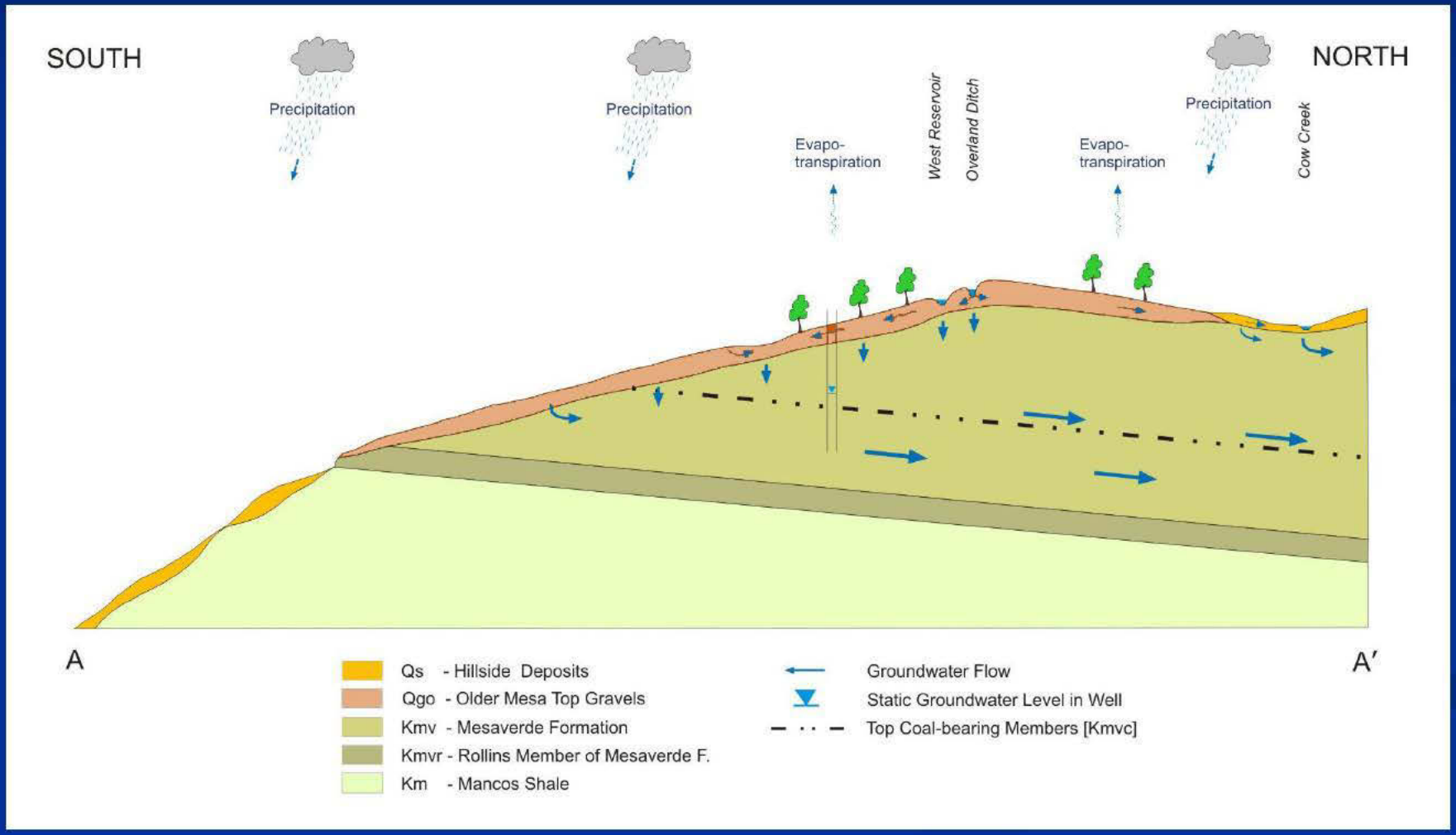
Hydrogeology of Oak Mesa Area

Shallow Aquifer Subsystem – Google Earth View



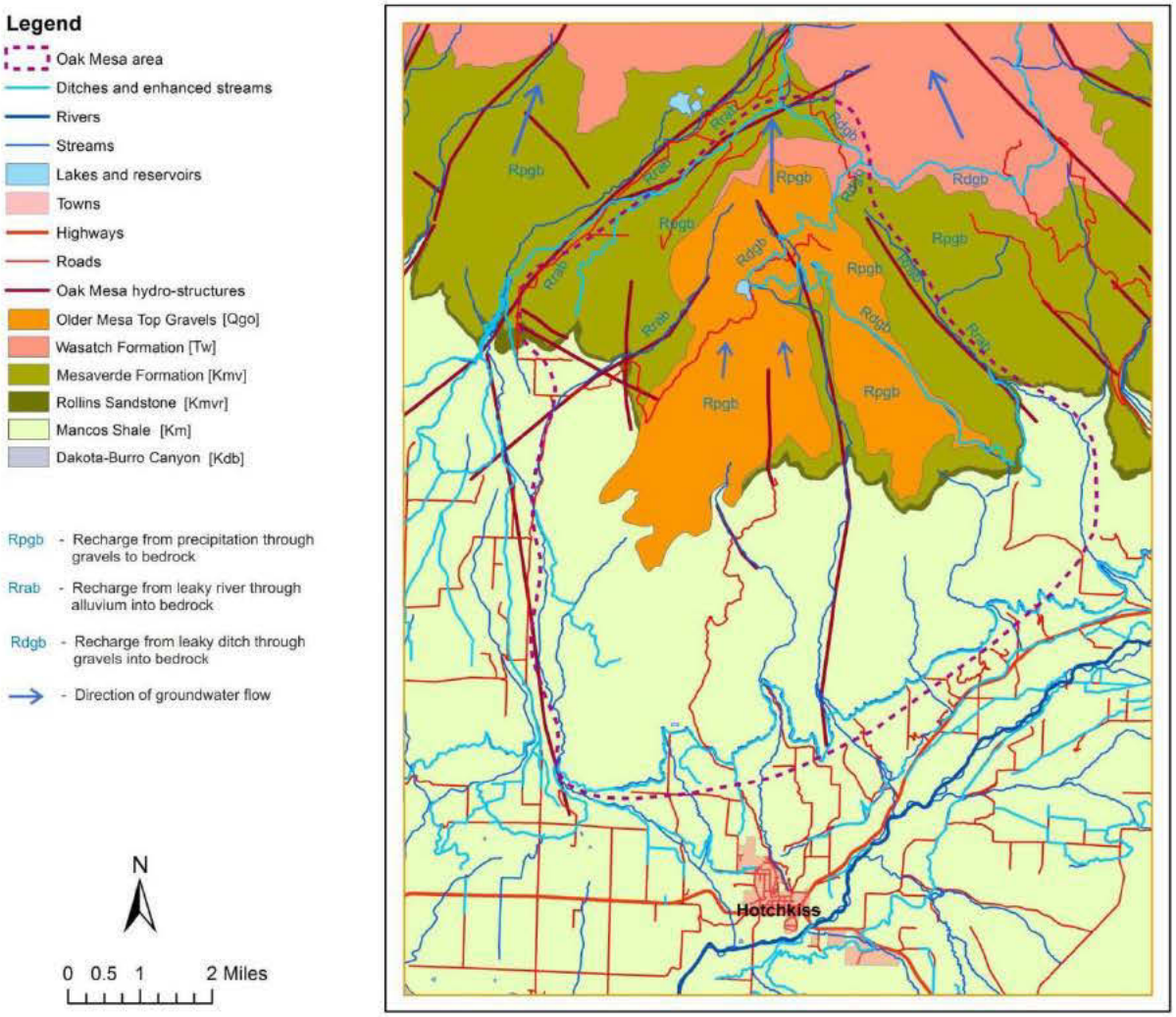
Hydrogeology of Oak Mesa Area

Regional Bedrock Subsystem – X-section



Hydrogeology of Oak Mesa Area

Regional Bedrock Subsystem – Plan View

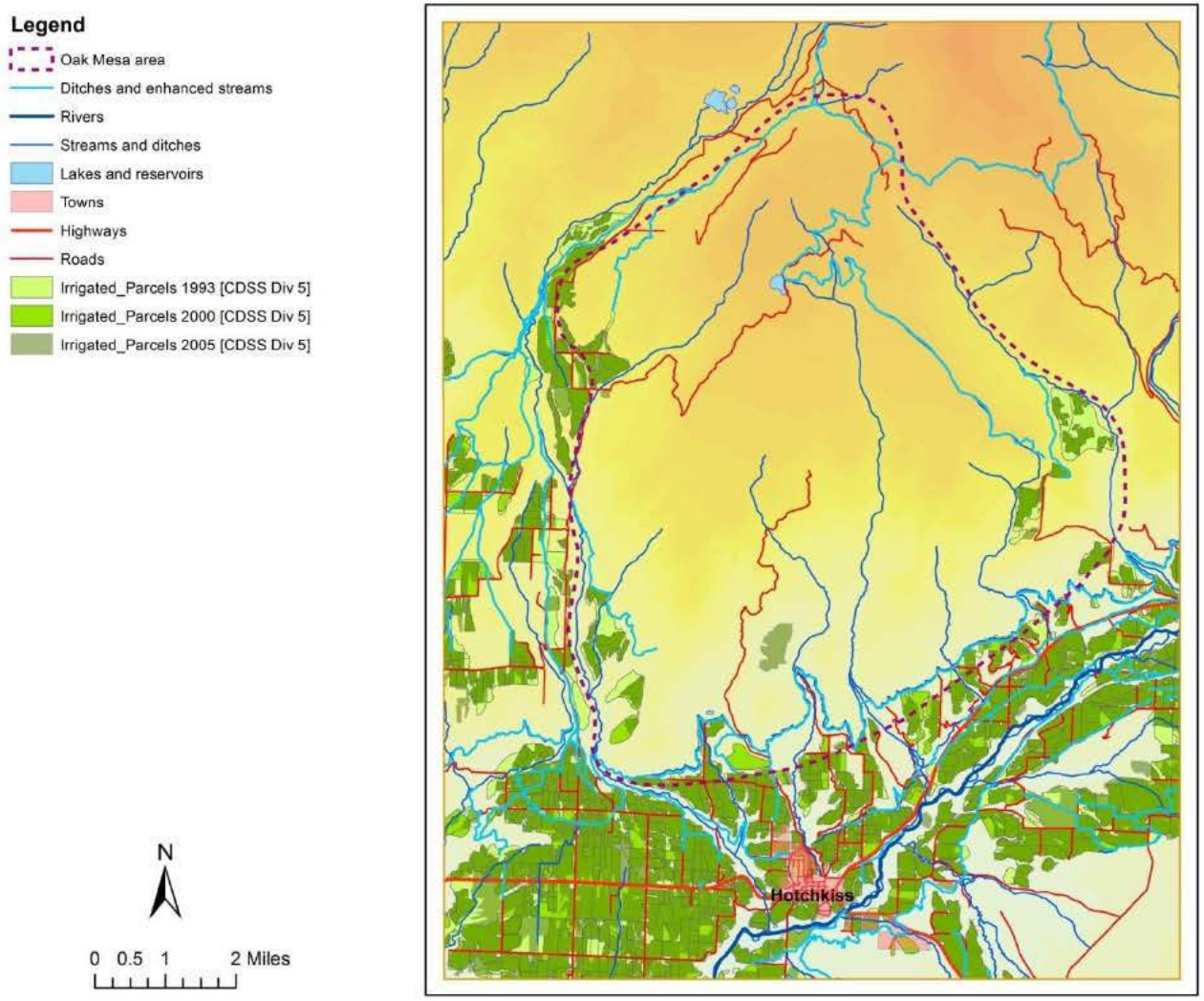


Hydrogeology of Oak Mesa Area

Anthropogenic Elements – Google Earth View

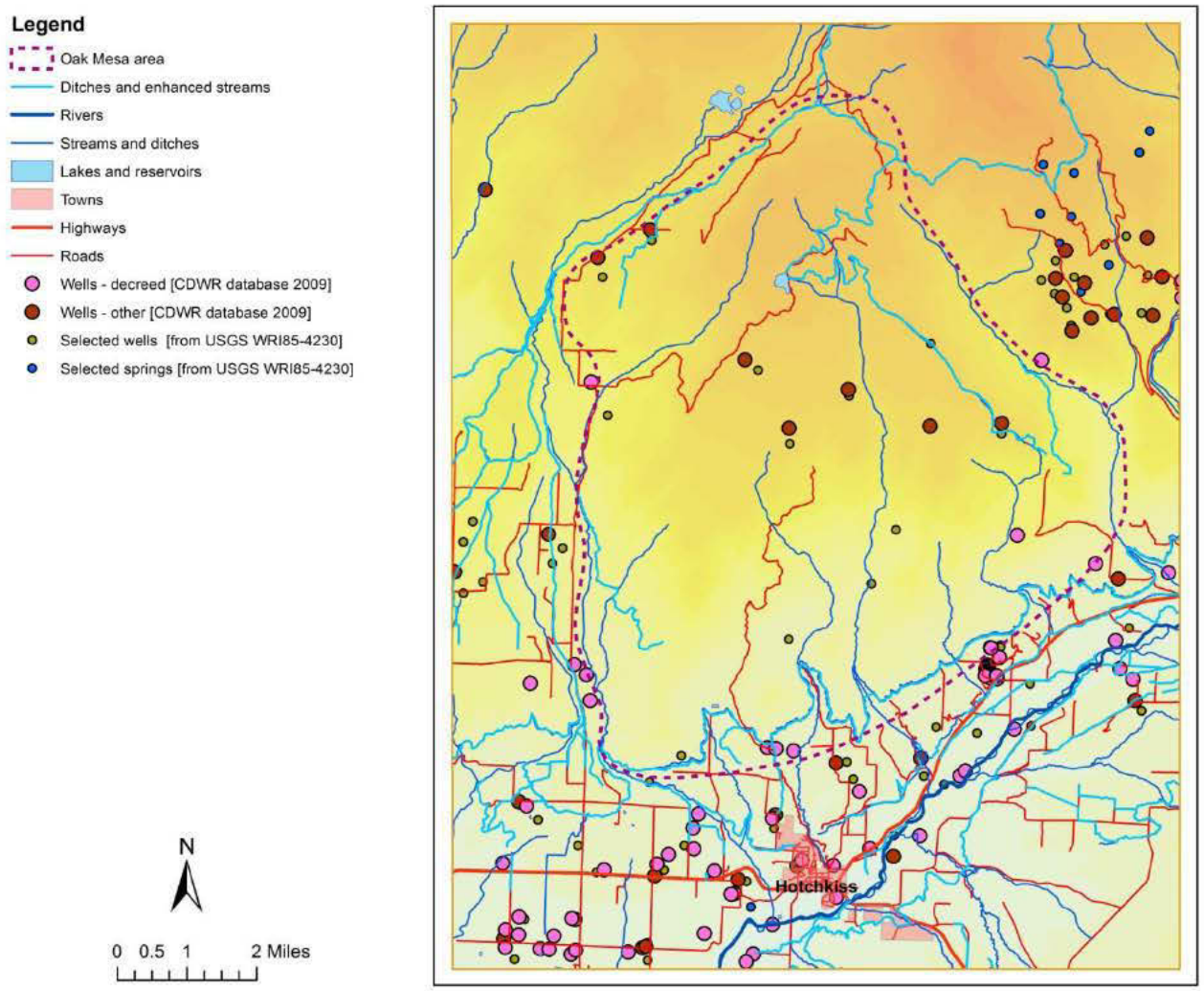
Hydrogeology of Oak Mesa Area

Anthropogenic Elements – Irrigation

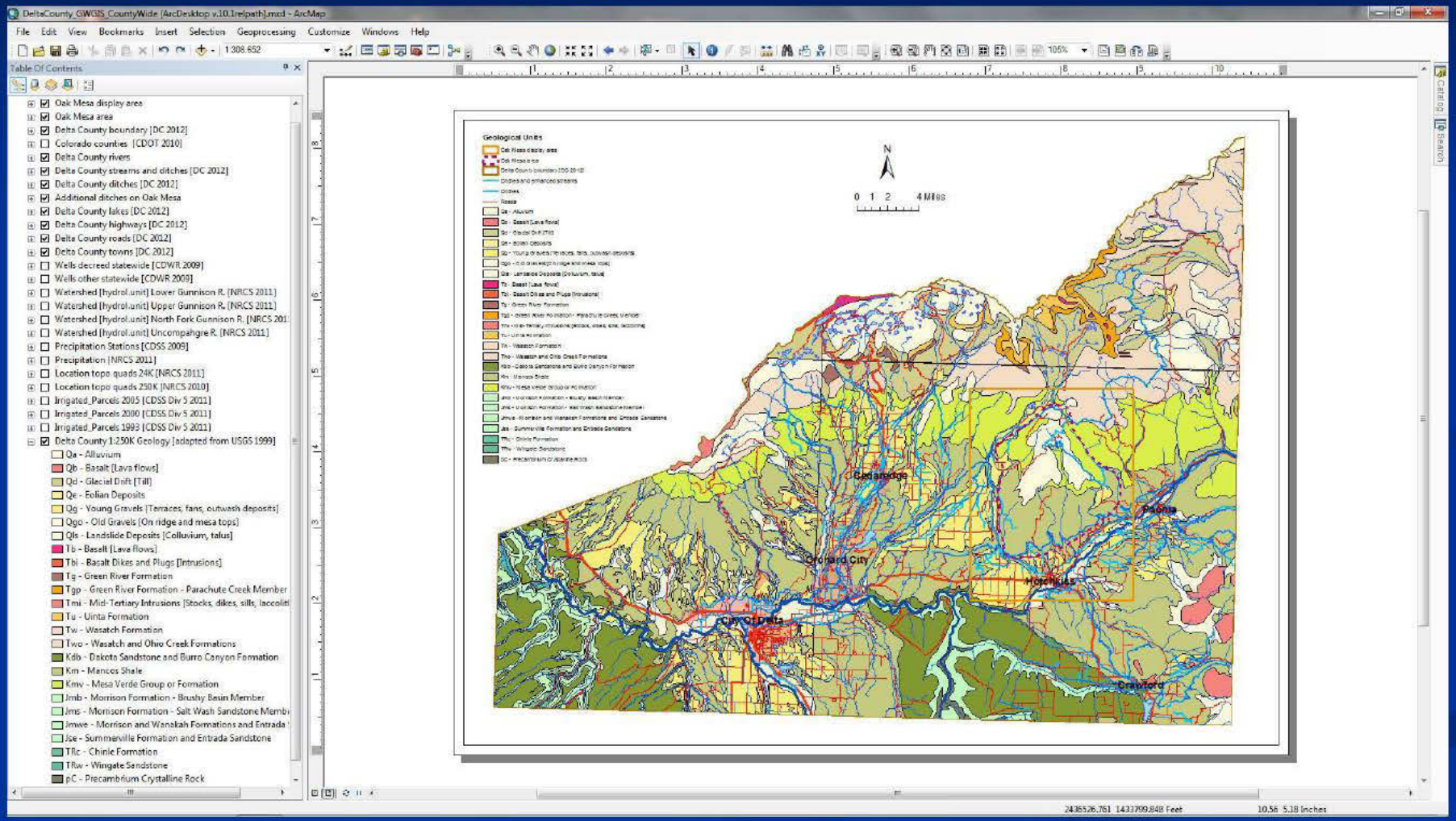


Hydrogeology of Oak Mesa Area

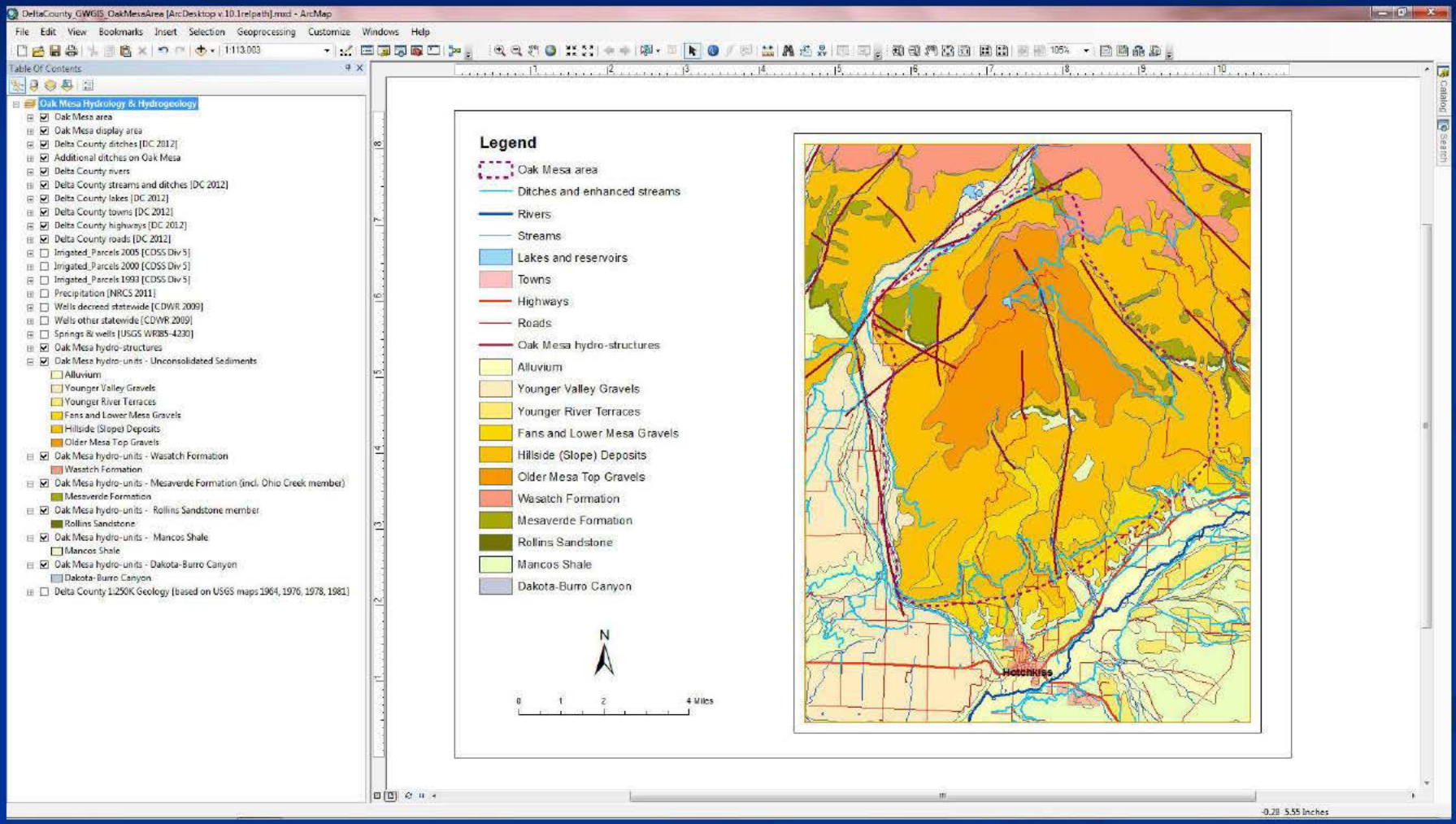
Anthropogenic Elements – Wells



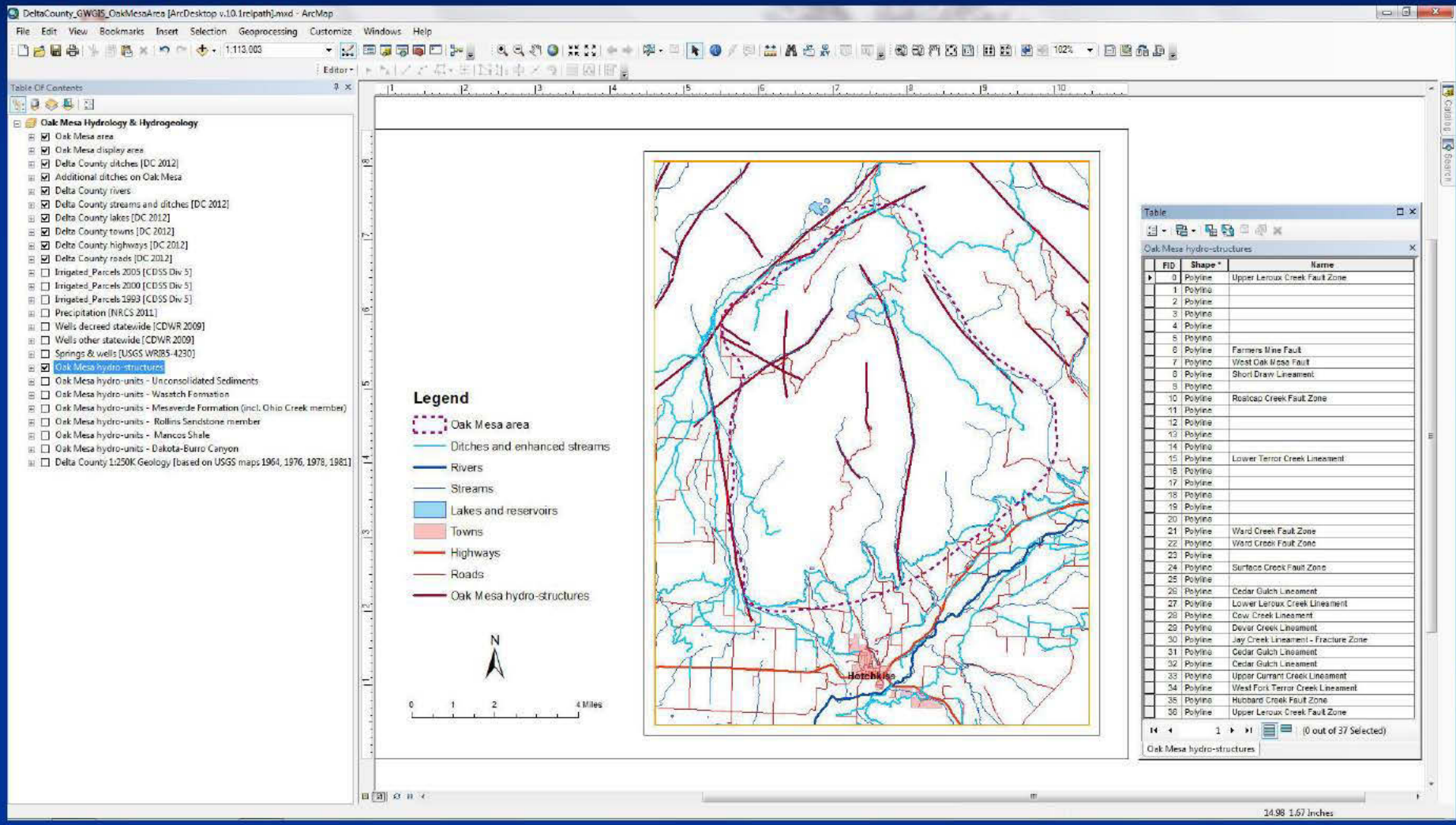
GIS MAPS: Delta County



GIS MAPS: Oak Mesa Area



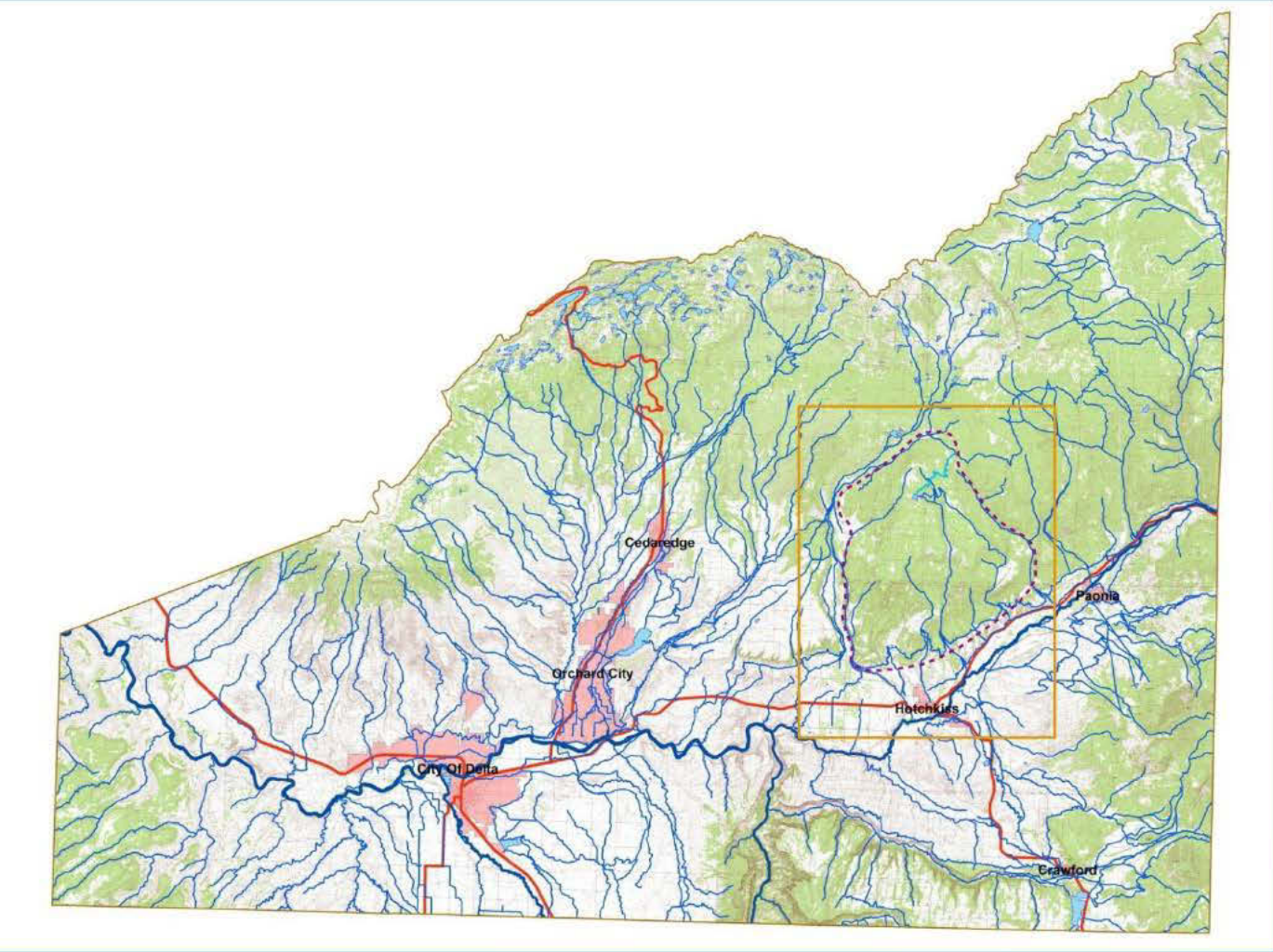
GIS MAPS: Database Detail



Summary

- Combining Hydrologic and Environmental Systems Analysis (HESA) with GIS provides an efficient, low cost approach to study and describe a county's hydrogeology and groundwater resources using existing data sources.
- Systematic, step-wise evaluation of groundwater resources, facilitated by the HESA/GIS approach, provides a quick assessment of presence, sustainability, and vulnerability of local groundwater resources.
- The HESA/GIS methodology provides a solid basis for planning and decision-making regarding local groundwater resources.

Future HESA Analysis



What Other Applications?

- Groundwater-surface water interaction
- Groundwater and wetlands, discharge zones
- Groundwater quality evaluations
- Groundwater and snow hydrology
- Groundwater levels, water table, depth to water
- Groundwater budget/balance
- Hydrogeologic parameters, models


QUESTIONS?


THANK YOU
Delta County
Canyons
Rivers
Mountains