WWDC Platte River Basin Plan, Groundwater Study (Level I)

WSGS – USGS – WRDS

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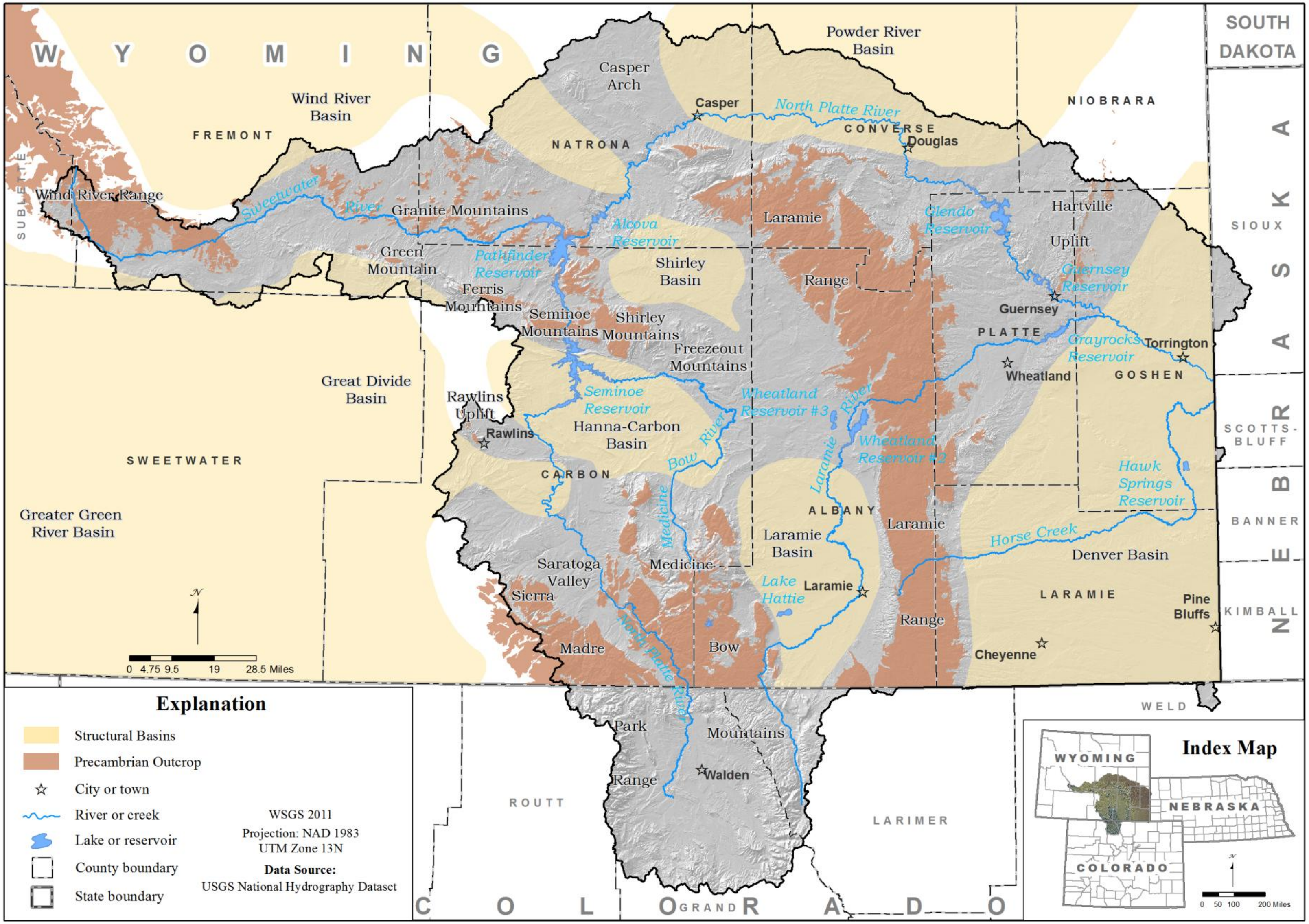
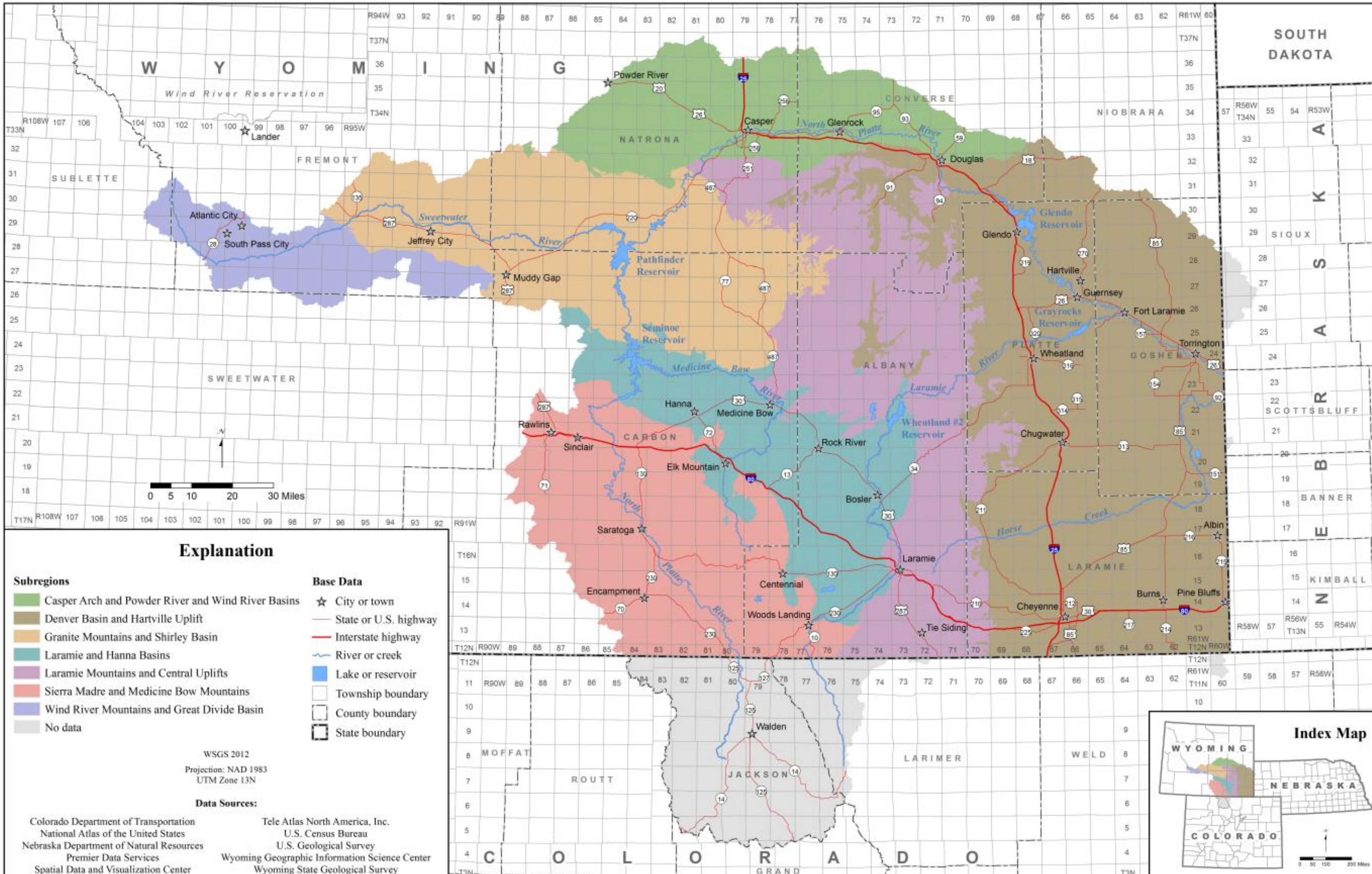
Platte River Drainage Basin



Geologic Areas



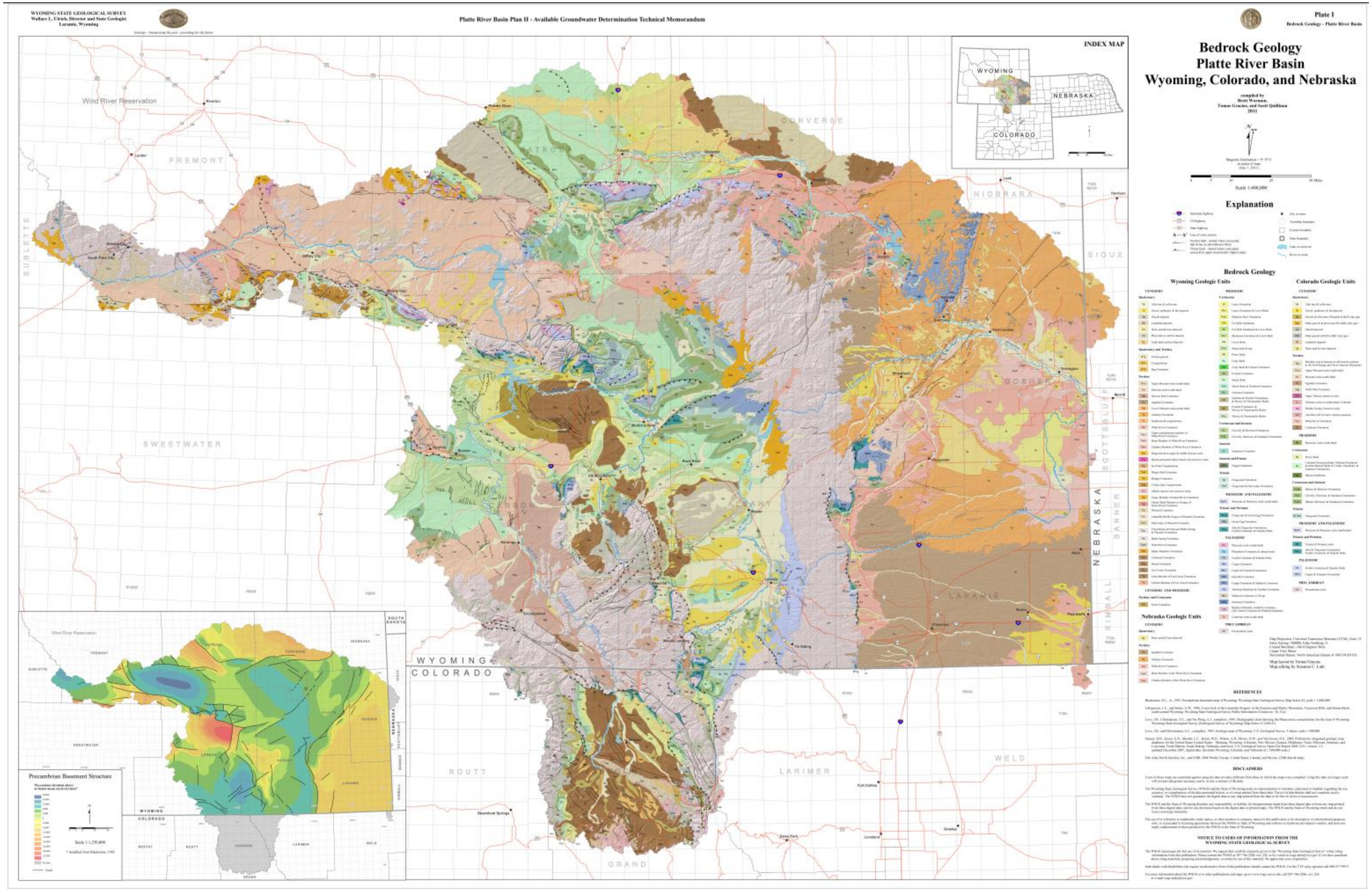
Tasks

- Identify major aquifers
- Define the three dimensional extents of the aquifers
- Describe aquifer hydrogeologic and chemical properties
- Describe aquifer recharge areas and rates
- Estimate water quantity and safe yield
- Identify and describe existing studies/models
- Identify water development opportunities

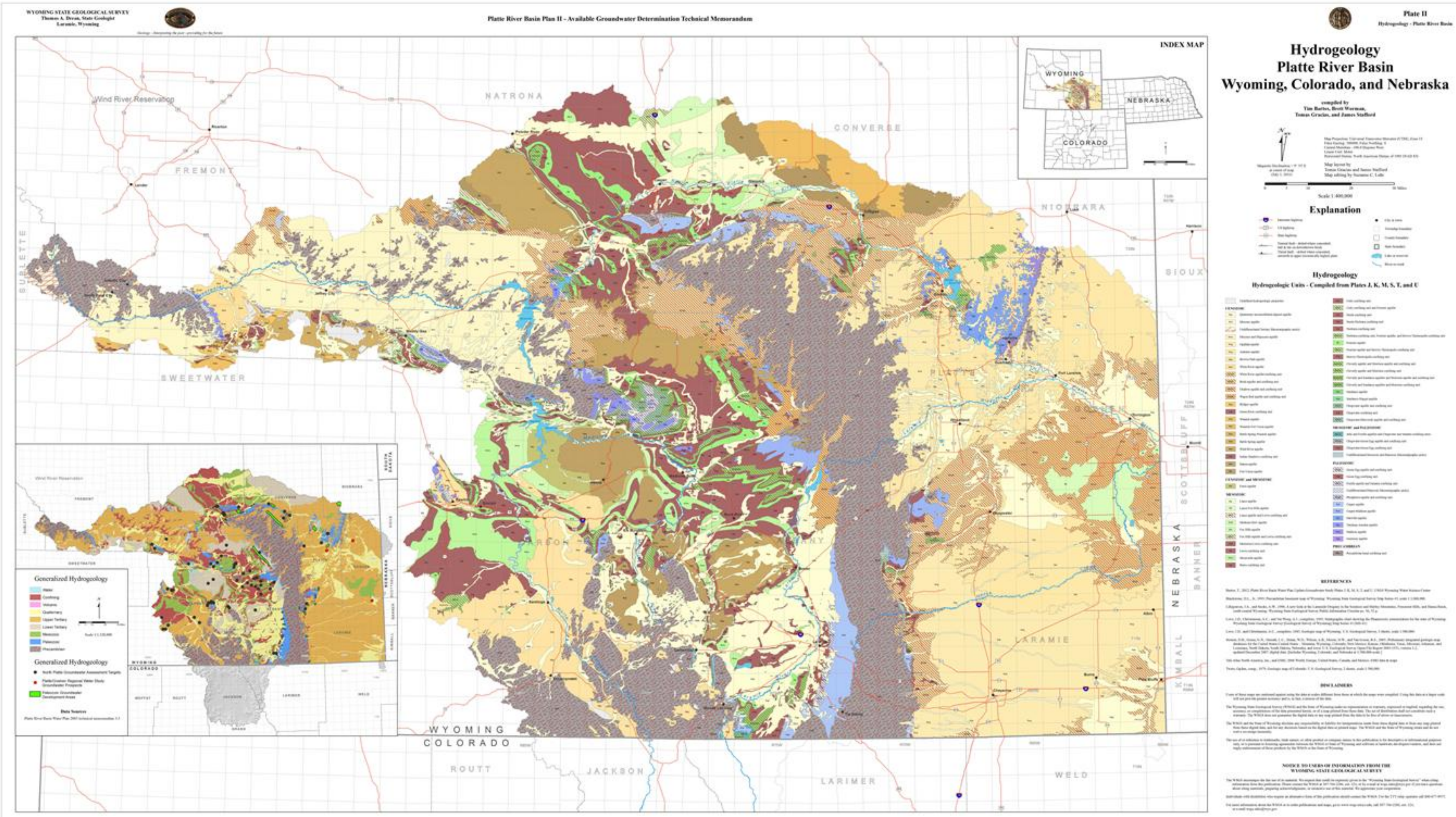
Identify the Major Aquifers and Their Extents

- Geologic formations
- Hydrogeologic units (aquifers and confining units)
- Formation thickness
  - Cross section figures (18)
  - Potentiometric surfaces/water table maps (8+)

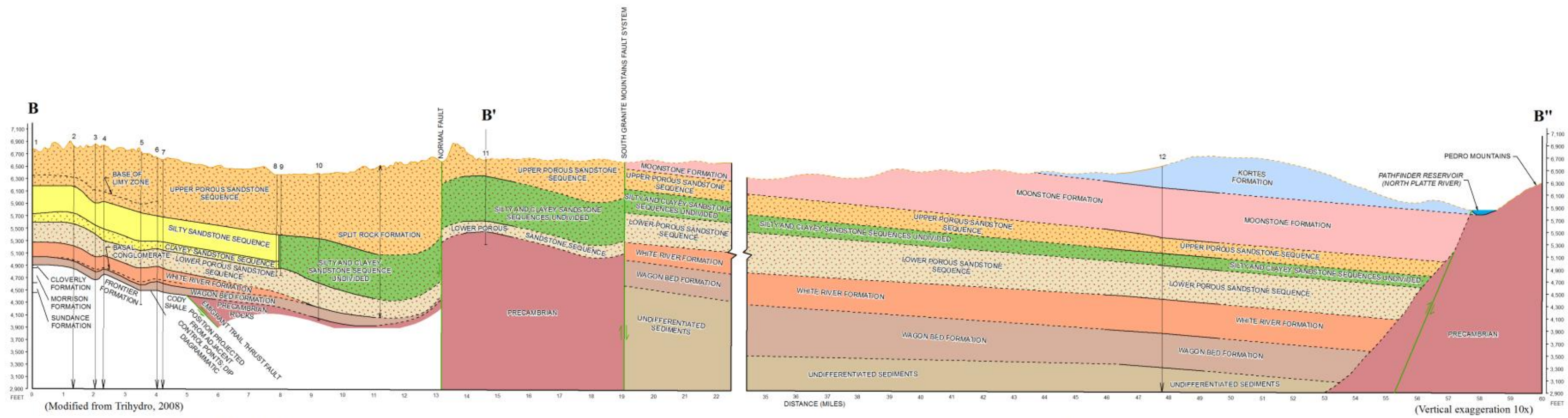
Bedrock Geology

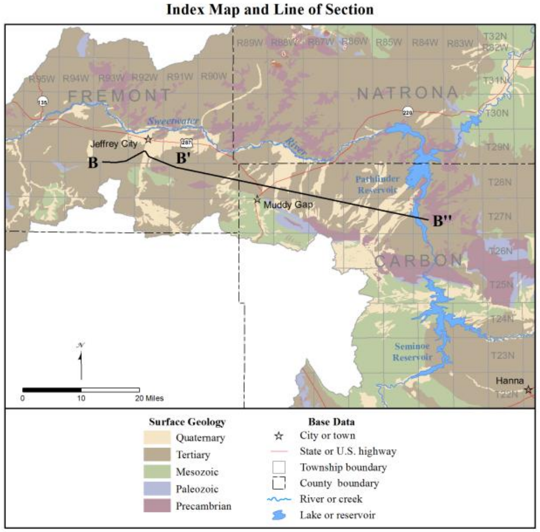


Hydrogeology Plate



Cross Section





Well Information

Well/Core Hole #	API #	Well/Core Hole Name	Location (Section-Township-Range)	Elevation† (feet)	Depth (feet)	Bottom Formation	Spud Date
1	N/A	Sinclair, CH 19	32-29N-93W	6,780 T	2,326	Sundance	N/A
2	49-013-05223	Govt 33-1	33-29N-93W	6,828 KB	4,700	Chugwater	1953
3	49-013-05224	Govt 34-1	34-29N-93W	6,865 G	3,153	Cloverly & Morrison, undiff.	1953
4	49-013-05225	Govt 2	34-29N-93W	6,840 T	3,035	Cloverly & Morrison, undiff.	1956
5	49-013-60025	Sinclair, CH 6-B	35-29N-93W	6,738 G	2,470	Frontier	1956
6	49-013-08381	Sinclair, CH 4-B	36-29N-93W	6,640 T	2,620	Frontier	1956
7	49-013-08380	Sinclair, CH 2-B	36-29N-93W	6,615	2,660	Frontier	1956
8	N/A	Sinclair, CH 5-A	21-29N-92W	6,372 T	1,635	Split Rock	N/A
9	N/A	Sinclair, CH 5	21-29N-92W	6,375 T	1,635	Split Rock	N/A
10	N/A	Sinclair, CH 25	27-29N-92W	6,390 T	2,378	Precambrian	N/A
11	49-013-60062	Split Rock 1	5-28N-91W	6,620 T	1,350	Precambrian	1955
12*	49-007-07151	Test Boring SR-2	9-27N-86W	6,555 GPS	3,820	N/A	N/A

† T = Topographic Map; KB = Kelly Base on drill rig; G = Ground elevation at well site; GPS = Global Positioning System; no modifier = no data available or unknown
API # and Spud Date provided by Wyoming Oil and Gas Conservation Commission
* Data (except API #) from 2008 Split Rock Groundwater Development Project by Trihydro

Figure 9-3. Geologic cross section B-B'-B"

Potentiometric Surface

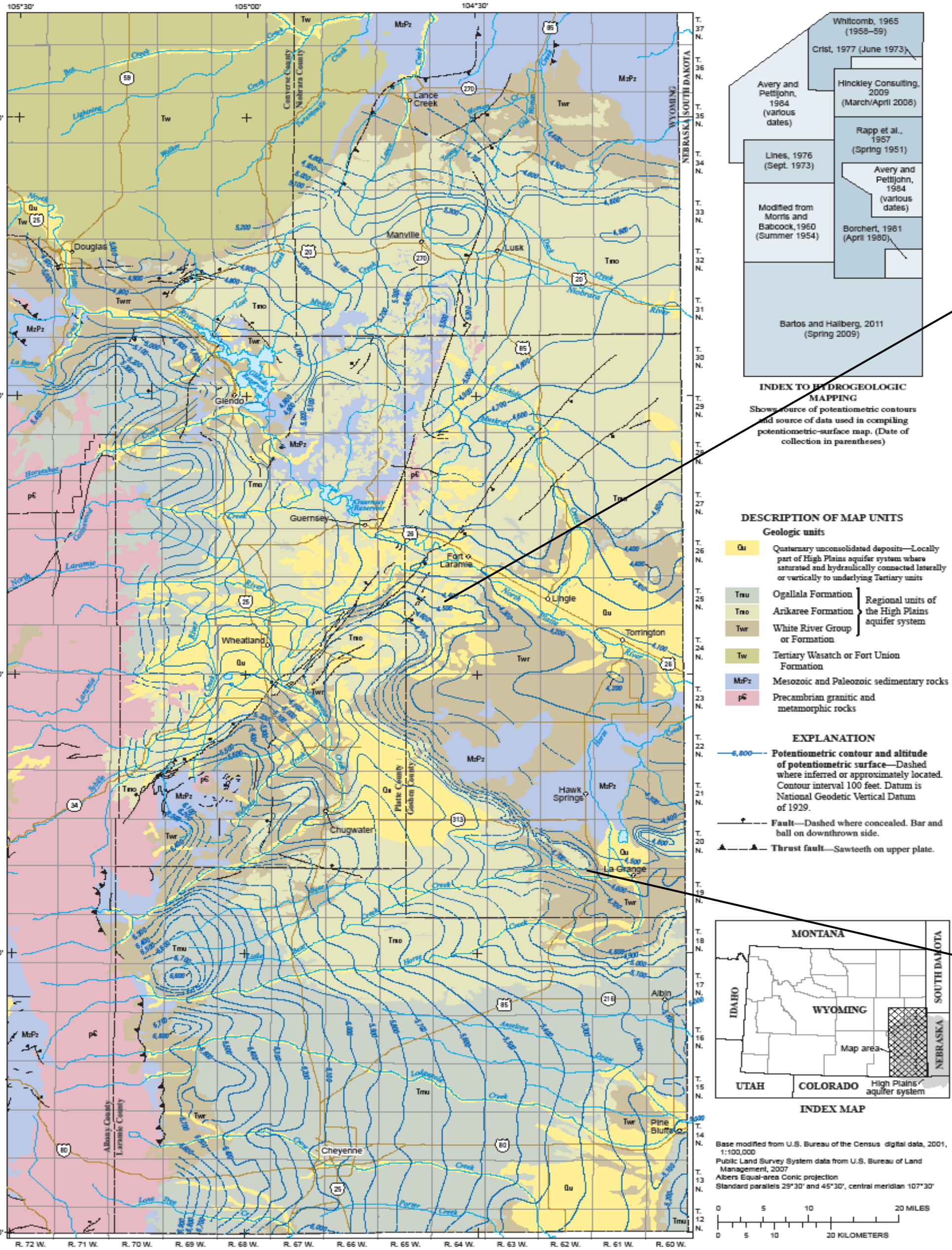
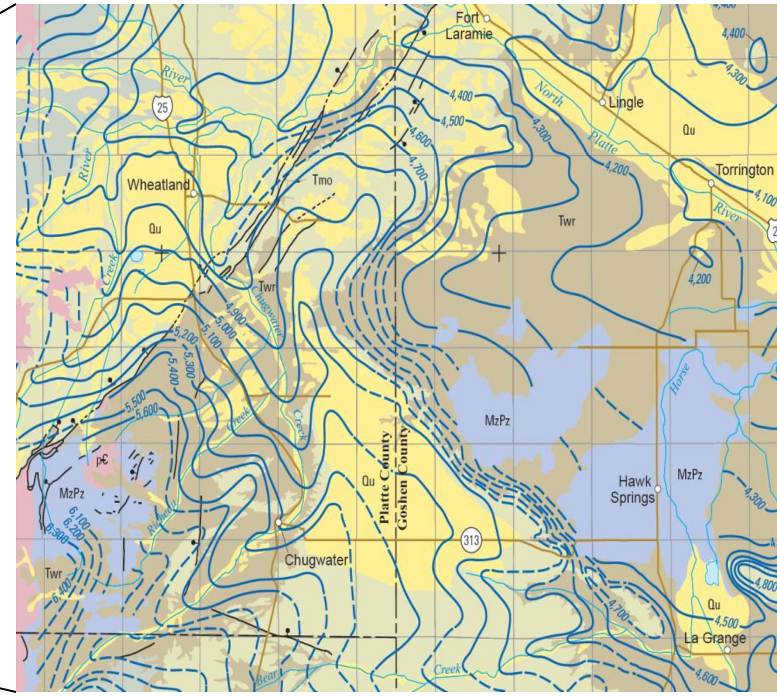


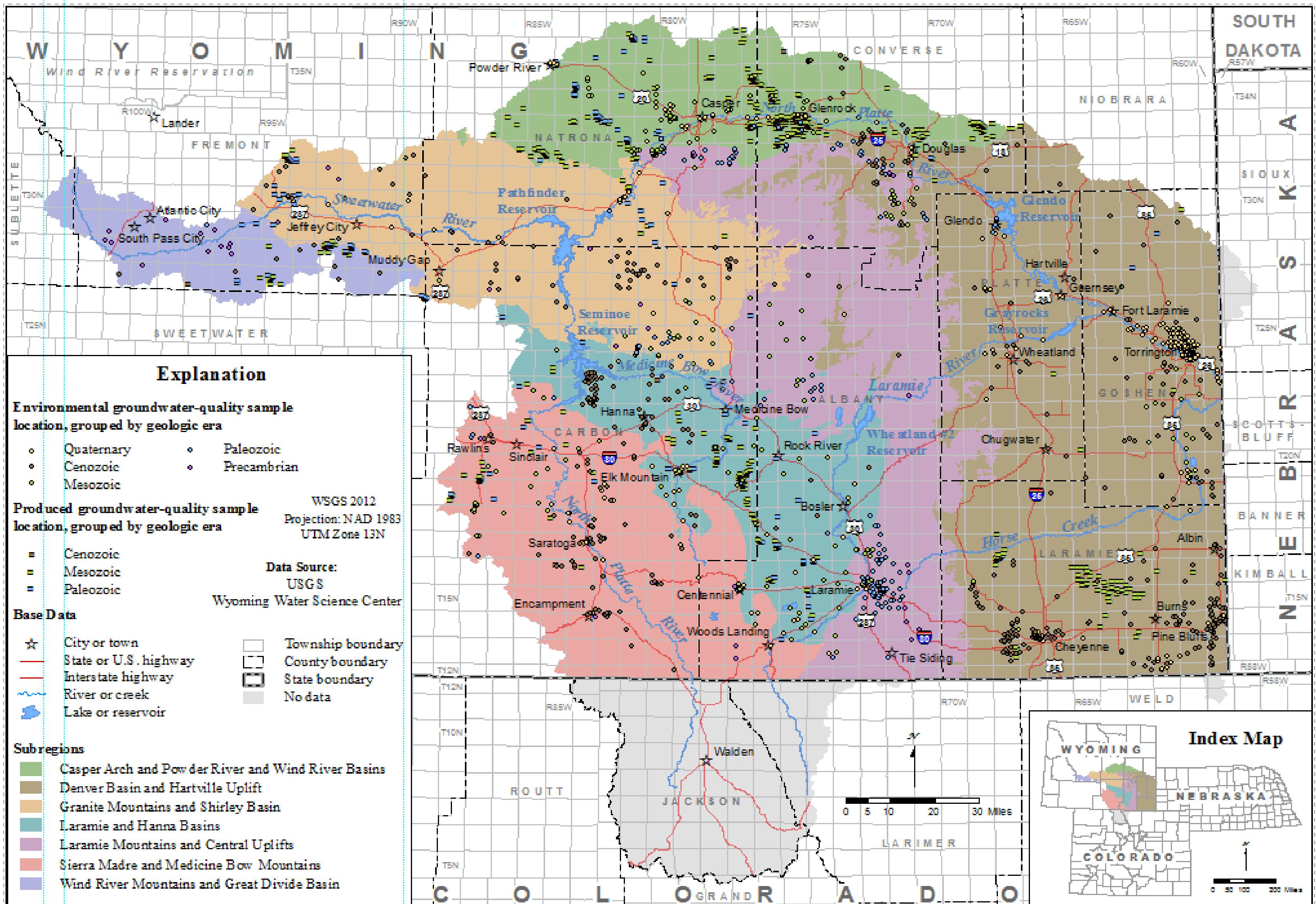
Figure 5. Generalized potentiometric-surface map of the High Plains aquifer system in southeastern Wyoming.



Identify Aquifer Hydrogeologic Properties

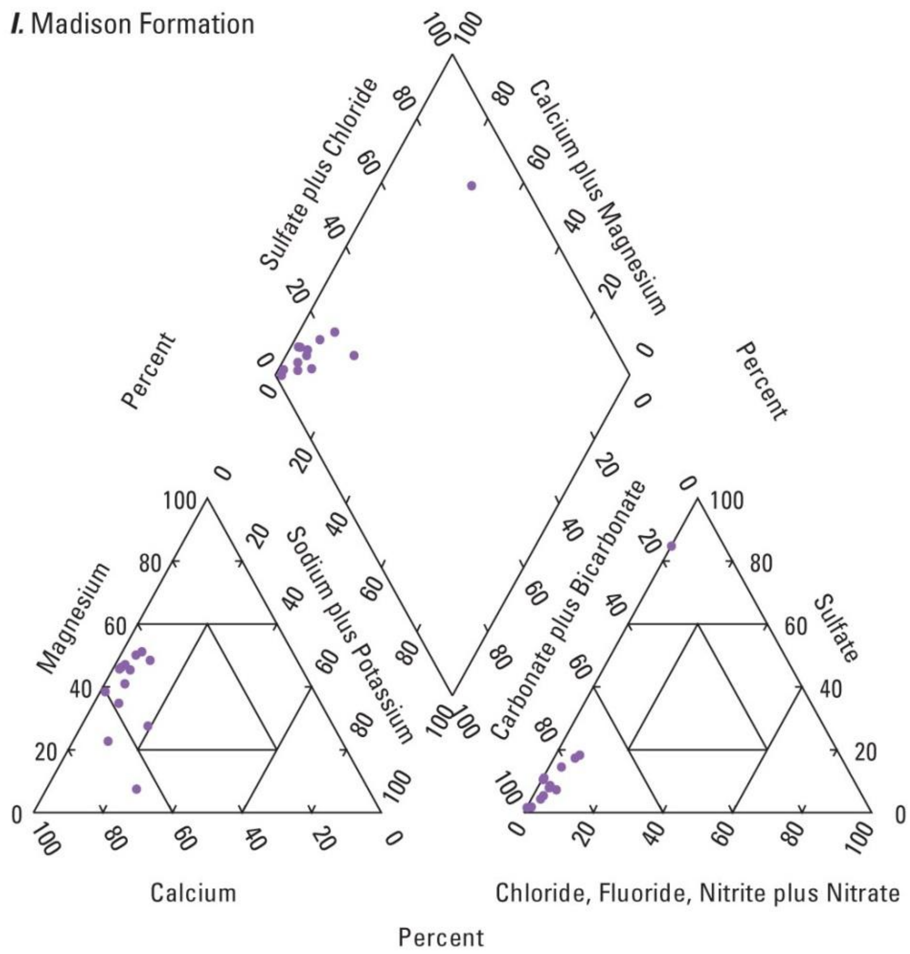
- USGS examined physical hydrogeologic properties in Chapter 7
- Statistical analysis of water quality from over 2100 water samples
- Mapped and describe potential contaminant sites identified from WDEQ and WOGCC data.

Environmental and Produced Water Samples



Water Quality

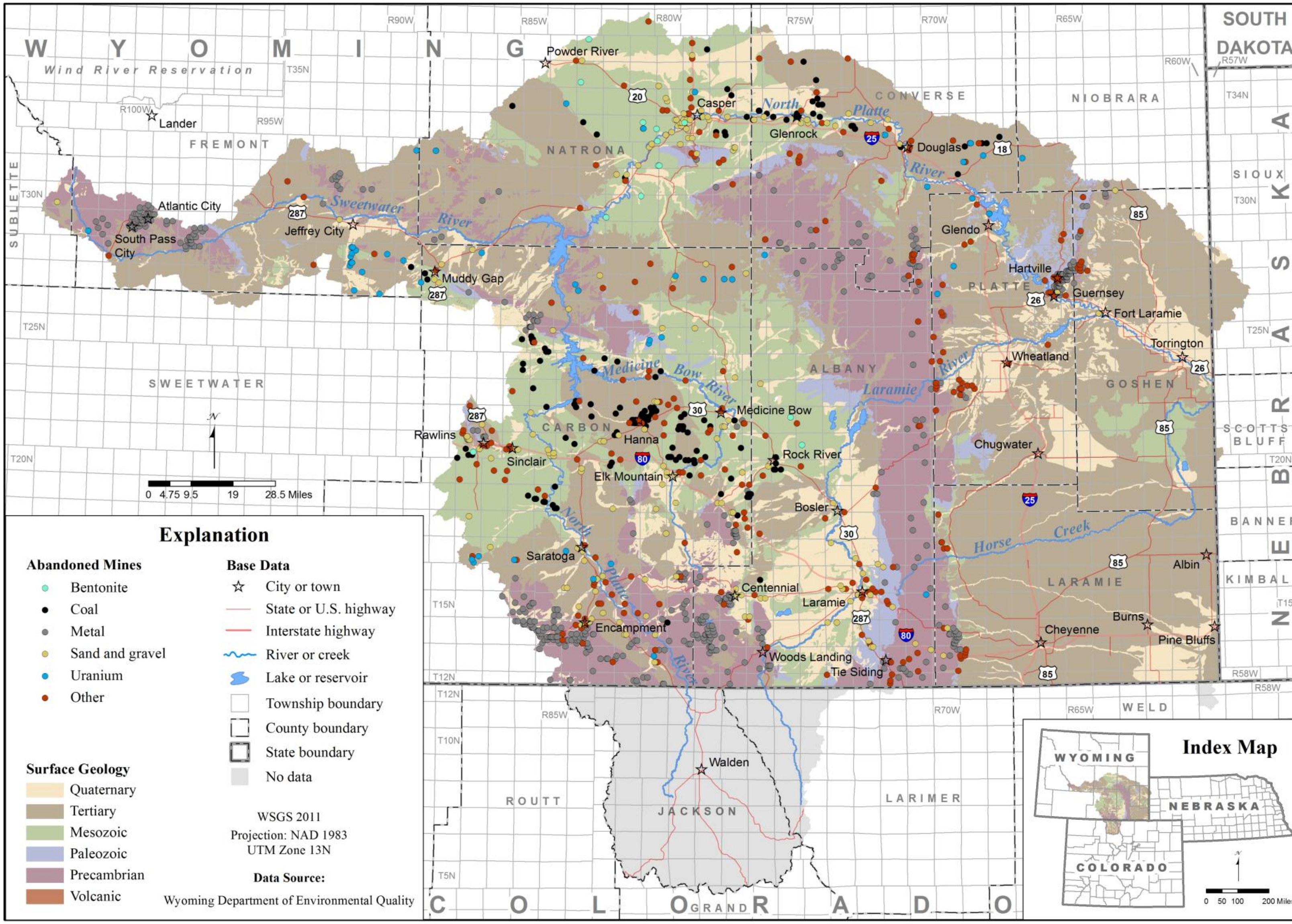
- Compare water quality to state and federal regulatory standard
- 49 Trilinear Diagrams
- 2 Statistical Appendices



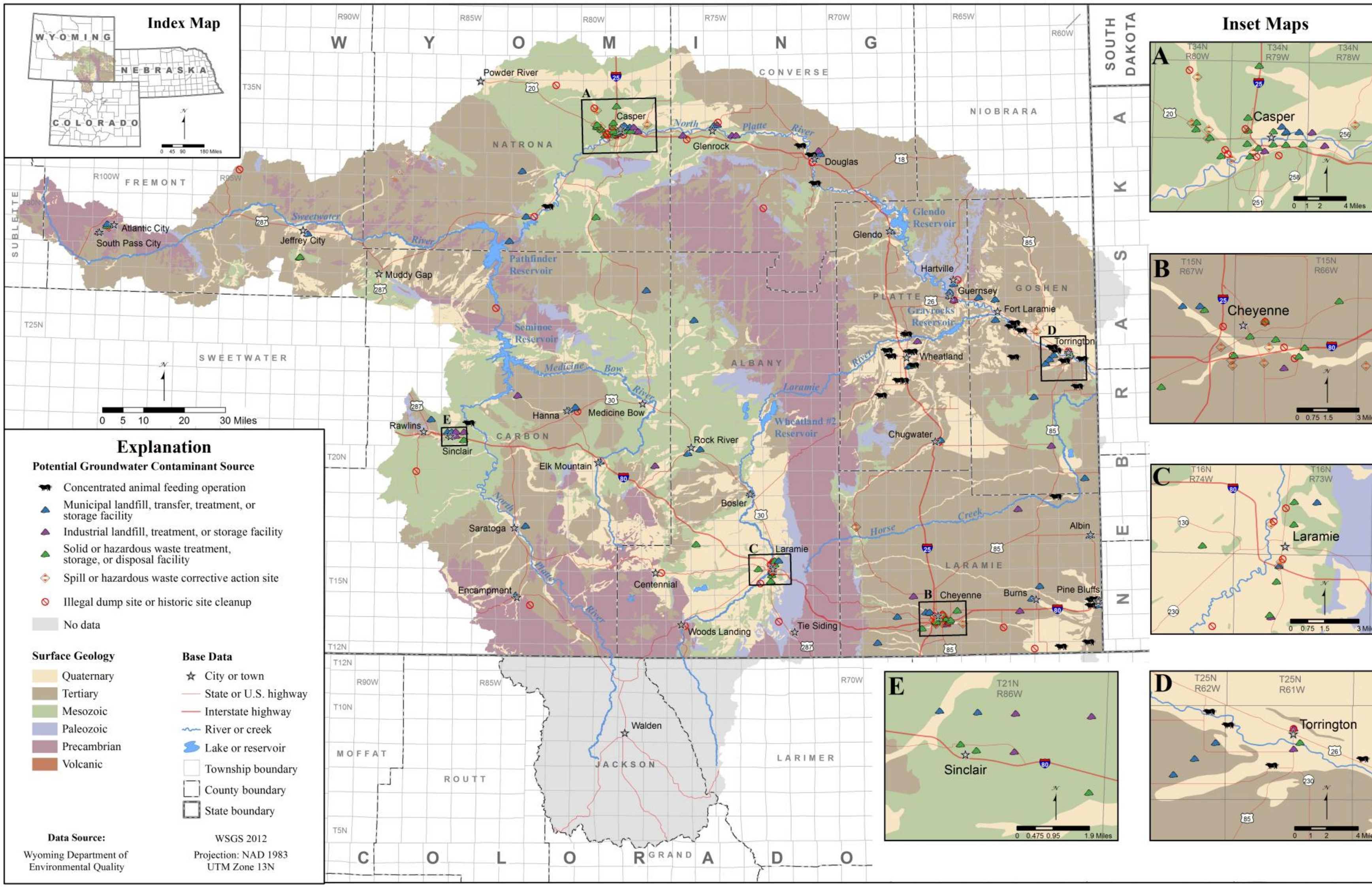
[--, not applicable; µS/cm, microsiemens per centimeter. Values in black are in milligrams per liter unless otherwise noted; values in blue are in micrograms per liter]

Geologic unit	Constituent	Minimum	25th percentile	Median	75th percentile	Maximum	Sample size
Madison Formation—Continued	Silica	7.5	8.6	10.3	20.0	24.0	12
	Sulfate	3.3	9.3	17.0	27.0	560	13
	Dissolved solids	181	209	216	245	920	13
	Ammonia (as N)	--	0.020	0.020	0.030	--	5
	Nitrate+nitrite (as N)	--	0.080	0.20	0.92	--	11
	Phosphorus, unfiltered (as P)	--	0.006	0.009	0.020	--	8
	Boron	--	14.4	20.0	27.8	--	7
	Iron	--	3.0	60.0	140	--	7
	Manganese	--	0.85	20.0	80.0	--	7
	Alpha radioactivity (picocuries per liter)	--	1.2	2.7	6.8	--	6
	Gross beta radioactivity (picocuries per liter)	--	2.0	4.0	6.3	--	5
	Radium-226 (picocuries per liter)	--	0.92	1.2	2.7	--	4
	Uranium, natural	--	1.3	2.1	2.8	--	4

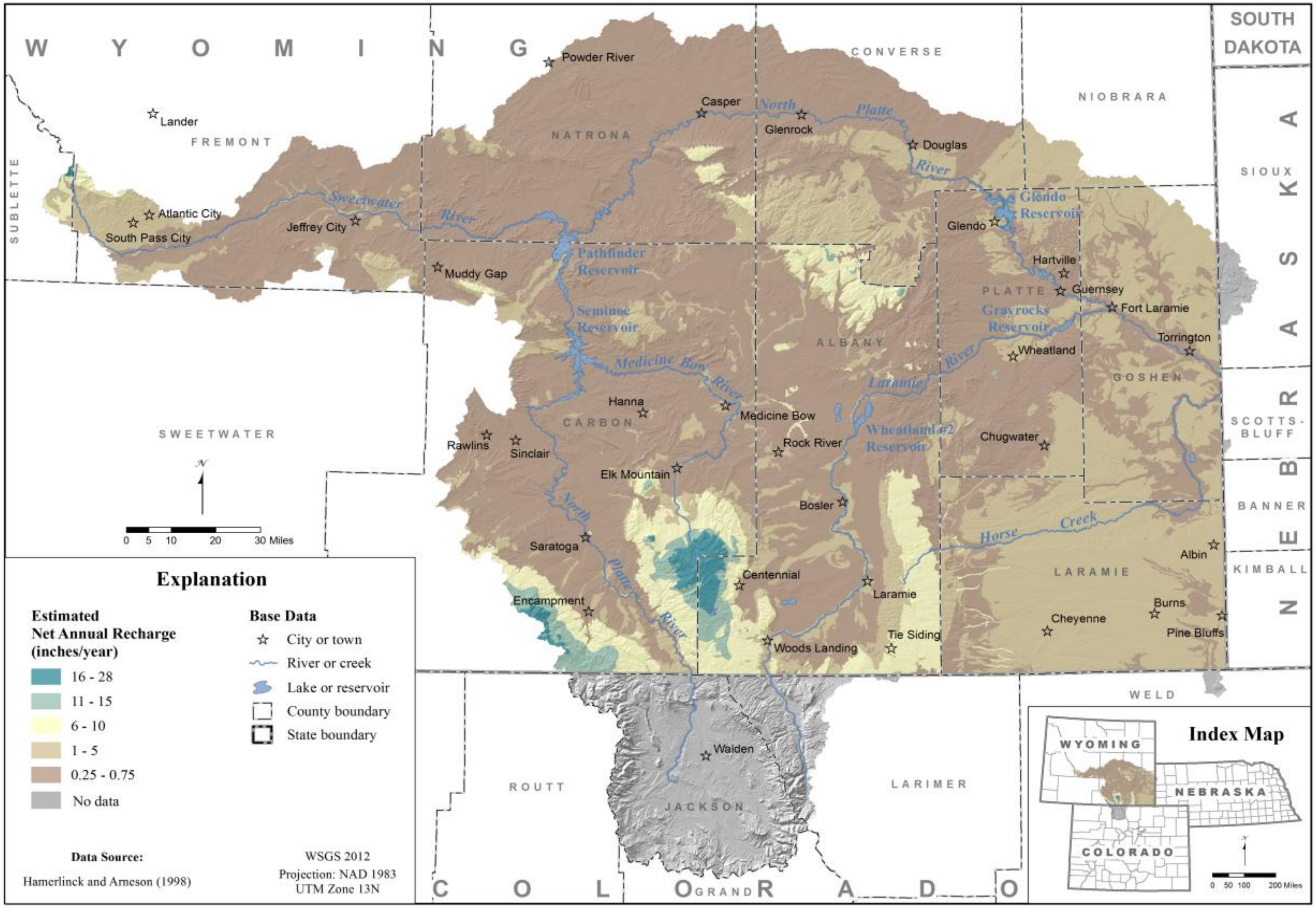
Abandoned Mine Lands



Concentrated Animal Feeding Operations and Landfills



Identify Aquifer Recharge Areas and Rates

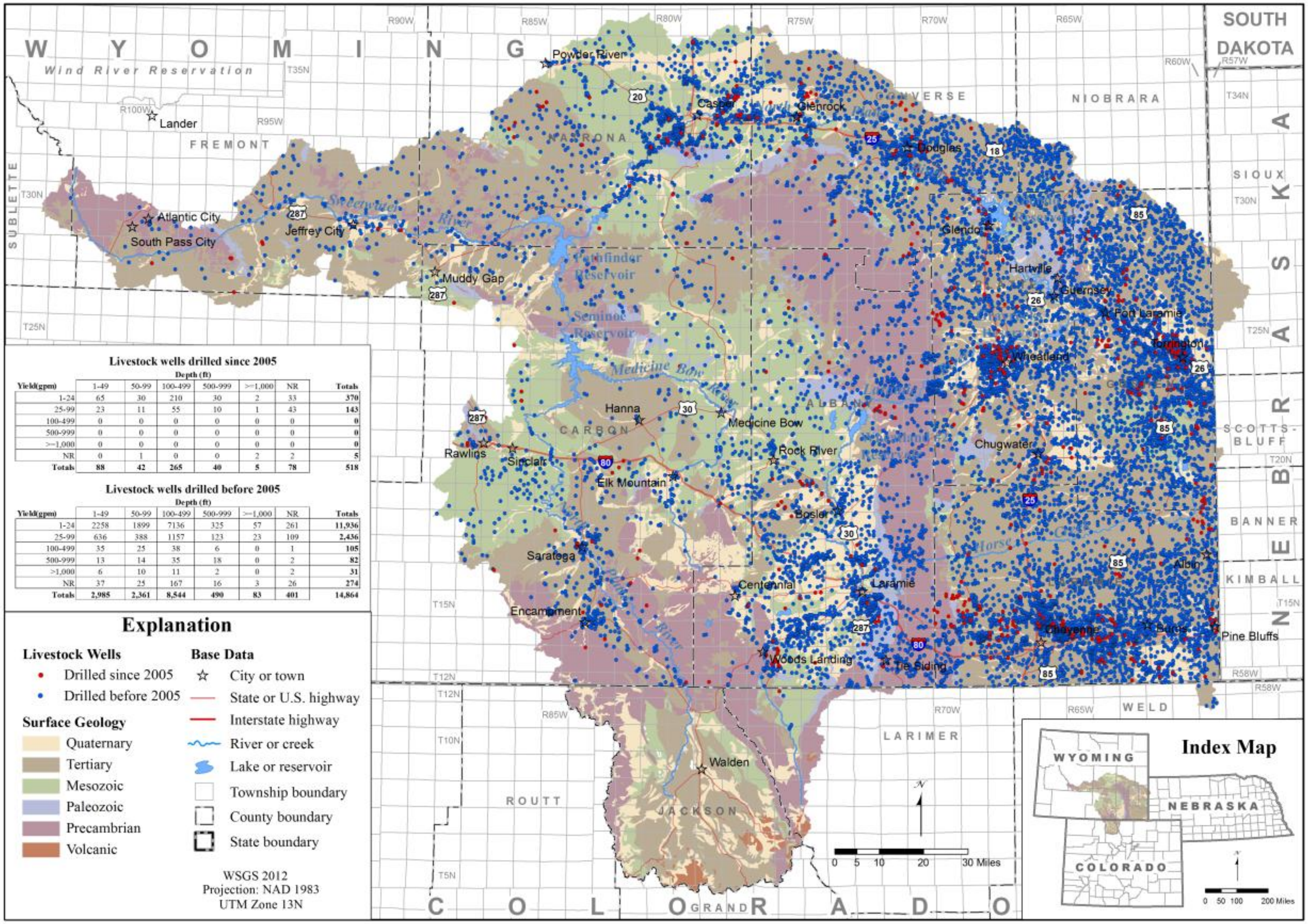


Estimate Water Quantity and Safe Yield

- Provide a basin wide water balance (mass balance model)
- Maps of basin groundwater uses
- Discussion of "safe" vs "sustainable" yield

Water balance statistics		Volume (ac-feet)	% Precip.
[1] Average annual precipitation (1981 - 2010)		19,678,000	---
Net surface water outflows	-	812,000	4.1 %
[2] Total consumptive use (surface water and groundwater)	-	1,131,000	5.8 %
[3] Estimated recharge volume	-	1,045,000	5.3 %
Remaining precipitation lost to evapotranspiration	=	16,690,000	84.8 %
[1] PRISM, 2012			
[2] Harvey Economics, 2005			
[3] Table 6-2			

WSEO Wells – Livestock



Livestock wells drilled since 2005

Yield(gpm)	Depth (ft) 1-49	50-99	100-499	500-999	>=1,000	NR	Totals
1-24	65	30	210	30	2	33	370
25-99	23	11	55	10	1	43	143
100-499	0	0	0	0	0	0	0
500-999	0	0	0	0	0	0	0
>=1,000	0	0	0	0	0	0	0
NR	0	1	0	0	2	2	5
Totals	88	42	265	40	5	78	518

Livestock wells drilled before 2005

Yield(gpm)	Depth (ft) 1-49	50-99	100-499	500-999	>=1,000	NR	Totals
1-24	2258	1899	7136	325	57	261	11,936
25-99	636	388	1157	123	23	109	2,436
100-499	35	25	38	6	0	1	105
500-999	13	14	35	18	0	2	82
>1,000	6	10	11	2	0	2	31
NR	37	25	167	16	3	26	274
Totals	2,985	2,361	8,544	490	83	401	14,864

Explanation

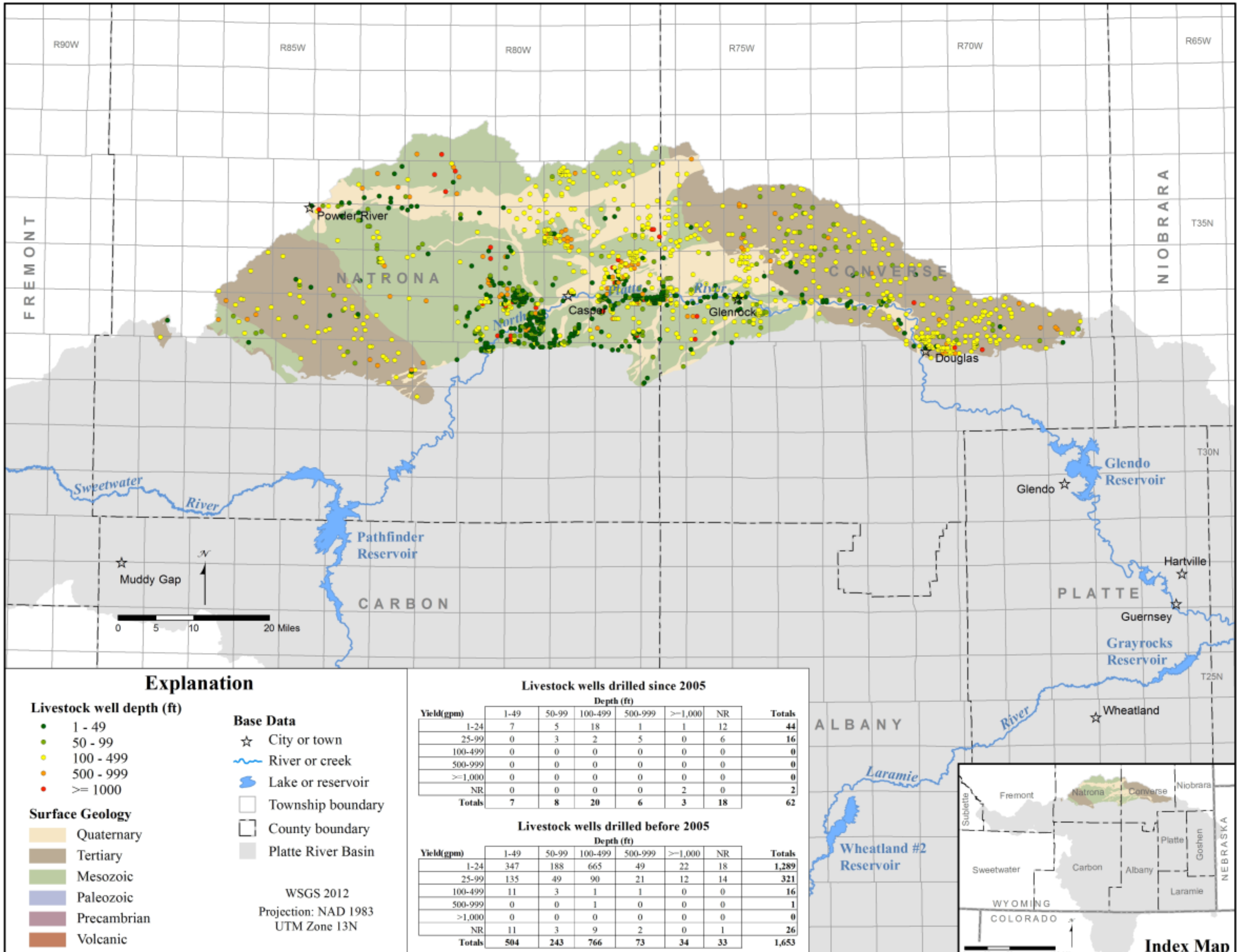
Livestock Wells
- Drilled since 2005
- Drilled before 2005

Surface Geology
- Quaternary
- Tertiary
- Mesozoic
- Paleozoic
- Precambrian
- Volcanic

Base Data
- City or town
- State or U.S. highway
- Interstate highway
- River or creek
- Lake or reservoir
- Township boundary
- County boundary
- State boundary

WSGS 2012
Projection: NAD 1983
UTM Zone 13N

WSEO Wells – Livestock - Geologic Area



Livestock wells drilled since 2005

Depth (ft)

Yield(gpm)	1-49	50-99	100-499	500-999	>=1,000	NR	Totals
1-24	7	5	18	1	1	12	**44**
25-99	0	3	2	5	0	6	**16**
100-499	0	0	0	0	0	0	**0**
500-999	0	0	0	0	0	0	**0**
>=1,000	0	0	0	0	0	0	**0**
NR	0	0	0	0	2	0	**2**
Totals	**7**	**8**	**20**	**6**	**3**	**18**	**62**

Livestock wells drilled before 2005

Depth (ft)

Yield(gpm)	1-49	50-99	100-499	500-999	>=1,000	NR	Totals
1-24	347	188	665	49	22	18	**1,289**
25-99	135	49	90	21	12	14	**321**
100-499	11	3	1	1	0	0	**16**
500-999	0	0	1	0	0	0	**1**
>1,000	0	0	0	0	0	0	**0**
NR	11	3	9	2	0	1	**26**
Totals	**504**	**243**	**766**	**73**	**34**	**33**	**1,653**

“Safe Yield” – An Evolving Concept

Lee (1915): “the limit to quantity of water that can be withdrawn regularly and permanently without dangerous depletion of the storage reserve.”

Meinzer (1923): “the rate at which ground water can be withdrawn from an aquifer for human use without depleting the supply to such an extent that withdrawal at this rate is no longer economically feasible.”

Misconceptions Related to "Safe Yield"

- Groundwater withdrawals from wells and springs are "safe" as long as they do not exceed the amount of annual recharge.
- Safe yield (average annual recharge) can be determined by developing a water balance.

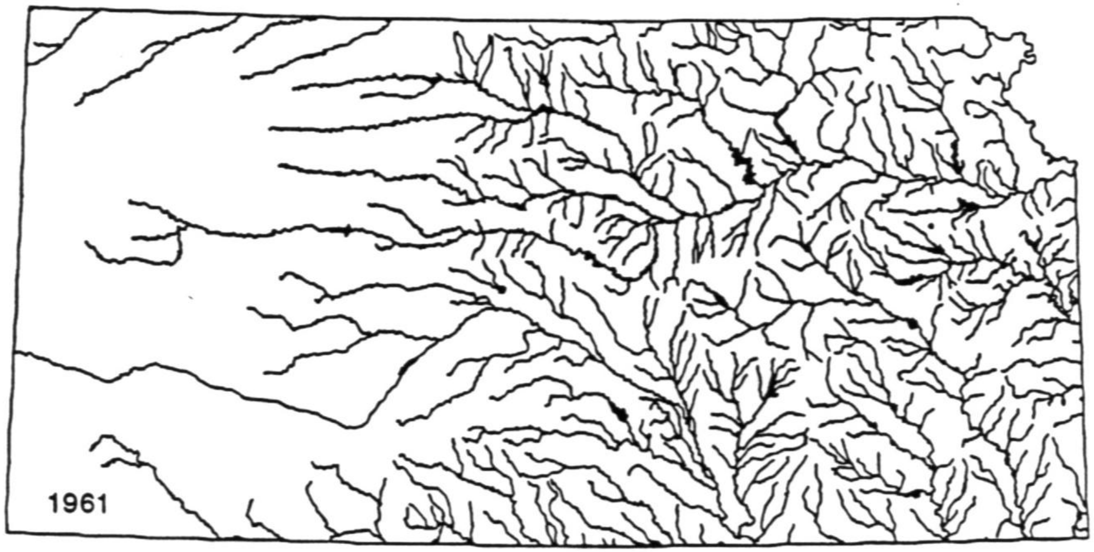
Water in (Recharge) = Water out (Discharge) + Change in aquifer storage (long term assumed to be 0)

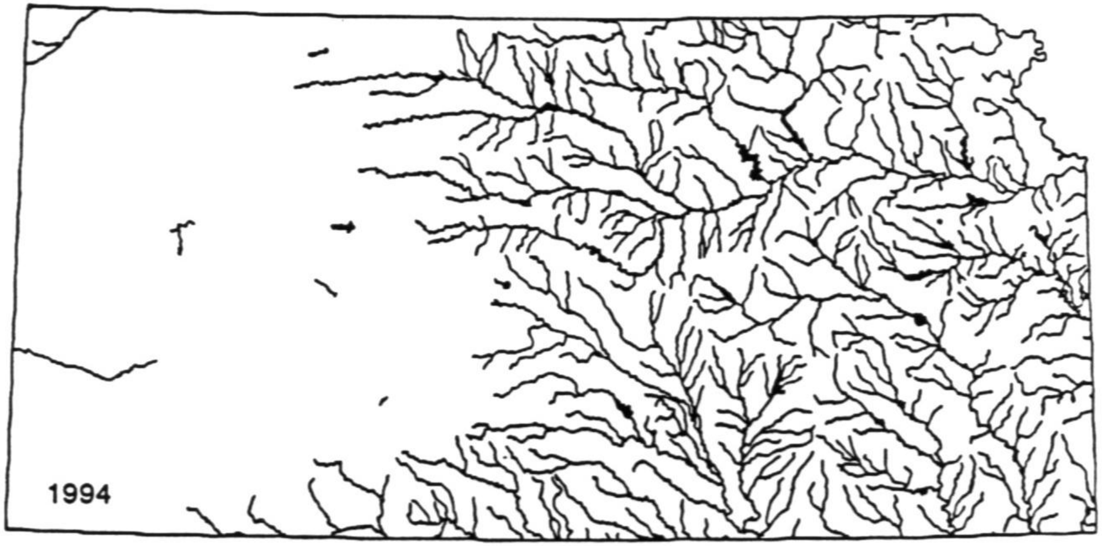
Or, simply

Recharge = Discharge

Pre-development: Natural discharges to springs and streams reach dynamic equilibrium with recharge volumes.

Under development: Groundwater volumes extracted from wells and developed springs result in reduced natural discharges to streams.





Perennial streams in Kansas

1961 and 1994

(Angelo, 1994)

It’s unlikely that a basin scale value of safe yield can be calculated accurately, because:

- Heterogeneity – Any drainage basin is a complex system of aquifers and confining units that possess high levels hydrogeologic heterogeneity.
- Scale - A regional water balance analysis may mask unacceptable groundwater depletions on the local level.

Sustainable water systems

- American Society of Civil Engineers - "… those designed and managed to fully contribute to the objectives of society, now and in the future, while maintaining their ecological, environmental and hydrological integrity."

Estimating Sustainable Yields

Mandel and Shiftan (1981)

1. Determine mean annual recharge.
2. Identify the first unacceptable affect that will occur as water levels are lowered.
3. Define the quantitative relationship between water levels and the timing and extent of the unacceptable affect(s).
4. Determine minimal acceptable water levels for the aquifer.
5. Calculate the rate of natural discharge that will result when a new state of dynamic equilibrium consistent with the minimal water levels is established.
6. The sustained yield is the difference between Steps 1 and 5.
7. *Monitor, review and reevaluate frequently.*

Identify Water Development Opportunities

Future water development opportunities in the Platte River Basin are subject to the provisions of the 2001 Modified North Platte River Decree, the Laramie River Decree and the Platte River Recovery Implementation Program (PRRIP).

WSGS reviewed WWDC water development projects (2005 and later) for 13 towns, cities and geographic areas in the basin.

Identify Existing Studies

- The USGS identified over 240 previous studies in their hydrostratigraphy plates and in Chapter 7.
- WSGS reviewed 107 WWDC studies in Appendix B

Summary

The Platte River Basin groundwater report can be accessed online:

WWDC website

http://waterplan.state.wy.us/plan/platte/2013/finalrept/gw_toc.html

WSGS website

http://www.wsgs.uwyo.edu/Research/Water-Resources/PtRB/Default.aspx

Or search "Platte River Basin Report"

Thank you, Questions?

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