Montana Regional Ground – Water Monitoring Program

Montana Bureau of Mines and Geology
Bureau of Land Management
MT Department of Natural Resources
Conservation Districts

Purpose:

- Third - party information -- available on the Internet
- Specific to CBM
- Water levels and water quality
- Identifies impacts and non – impacts
- Helps plan water management
- Confirm and improve predictive capabilities
- Continued funding is an ongoing challenge

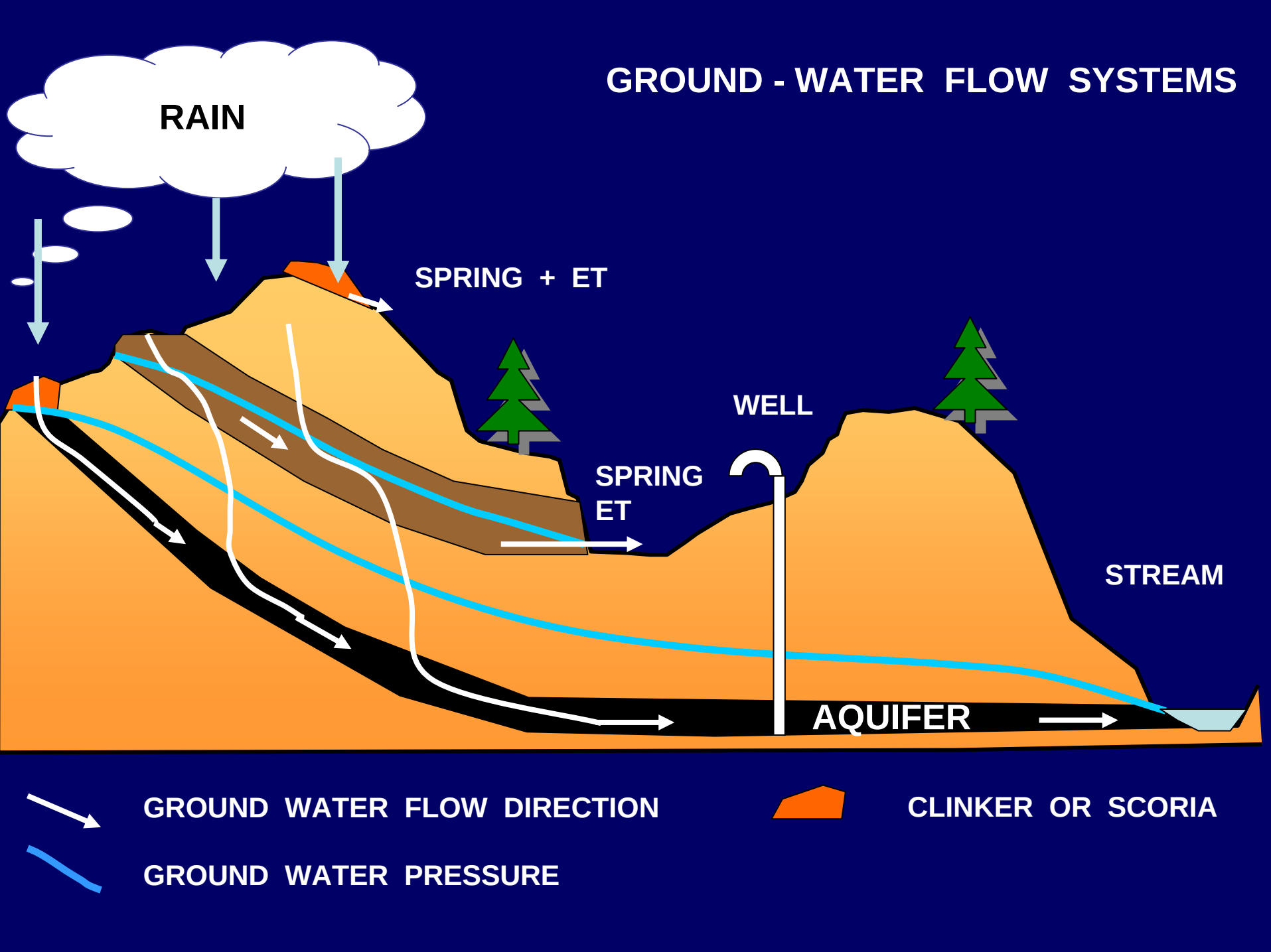
A Reminder:

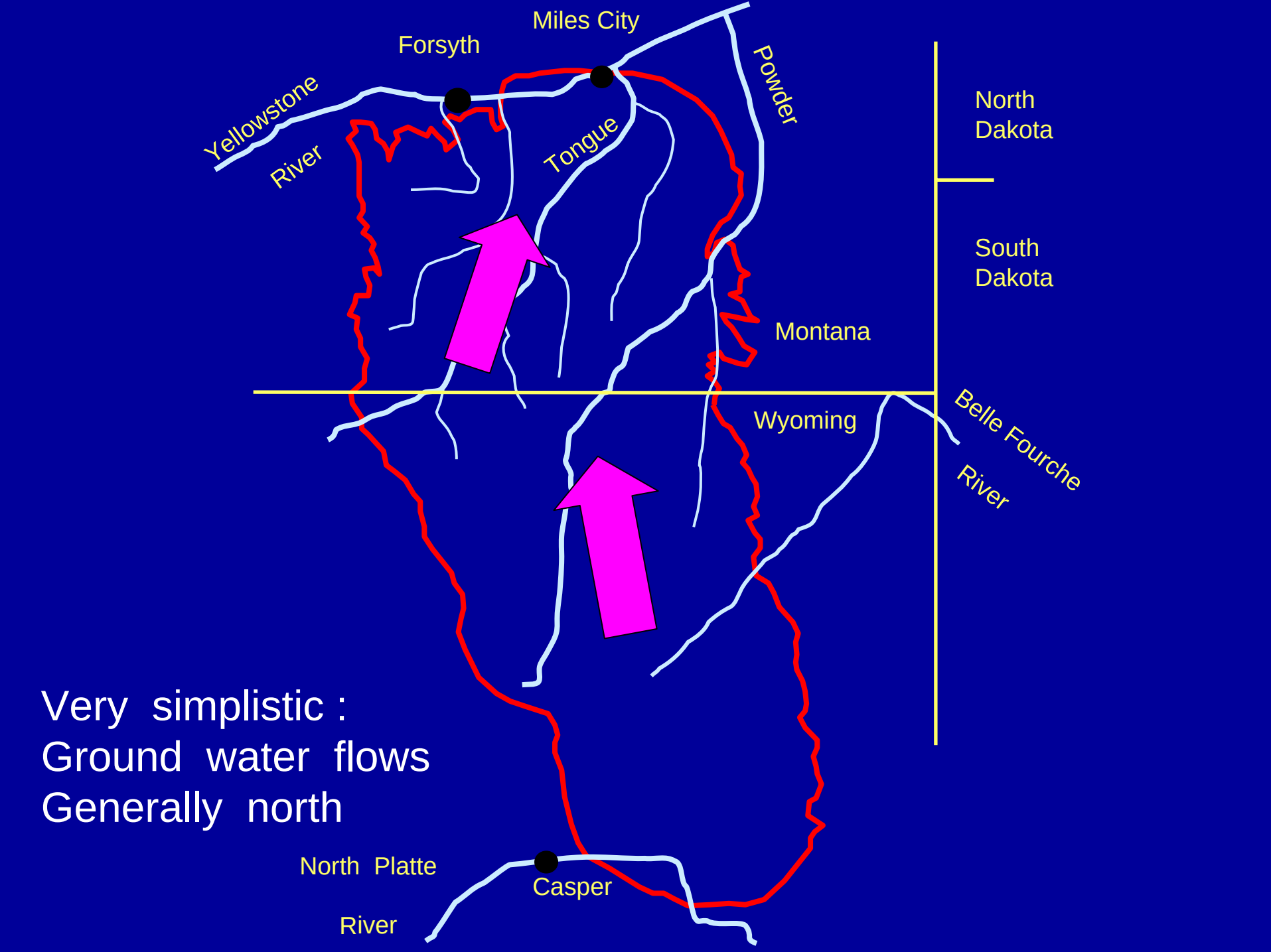
CBM development, regulatory decisions and opinions are based in part on predictions (or models) of impacts.

Predictive models **must** be based on data.

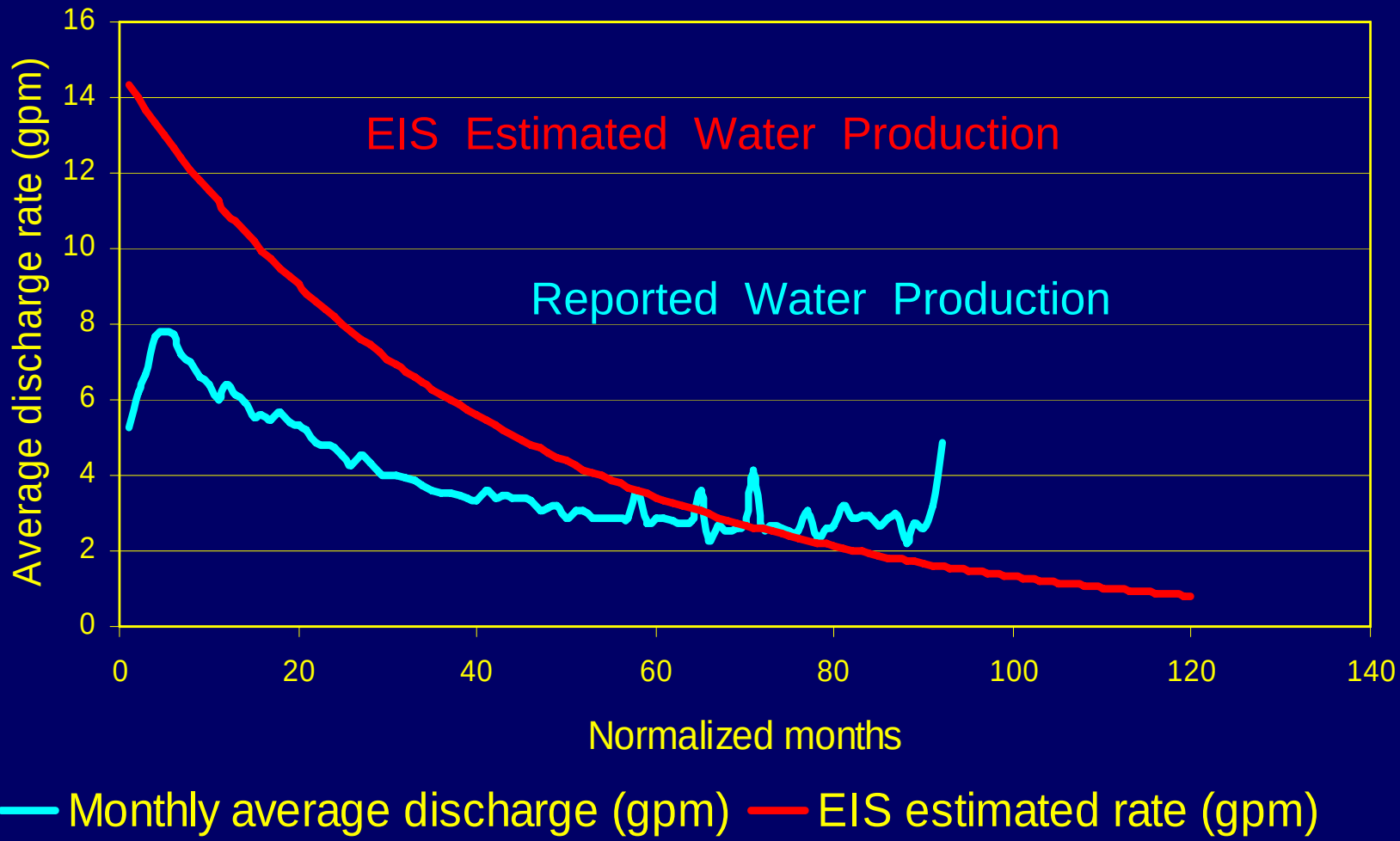
Whistles and bells do not make better science.

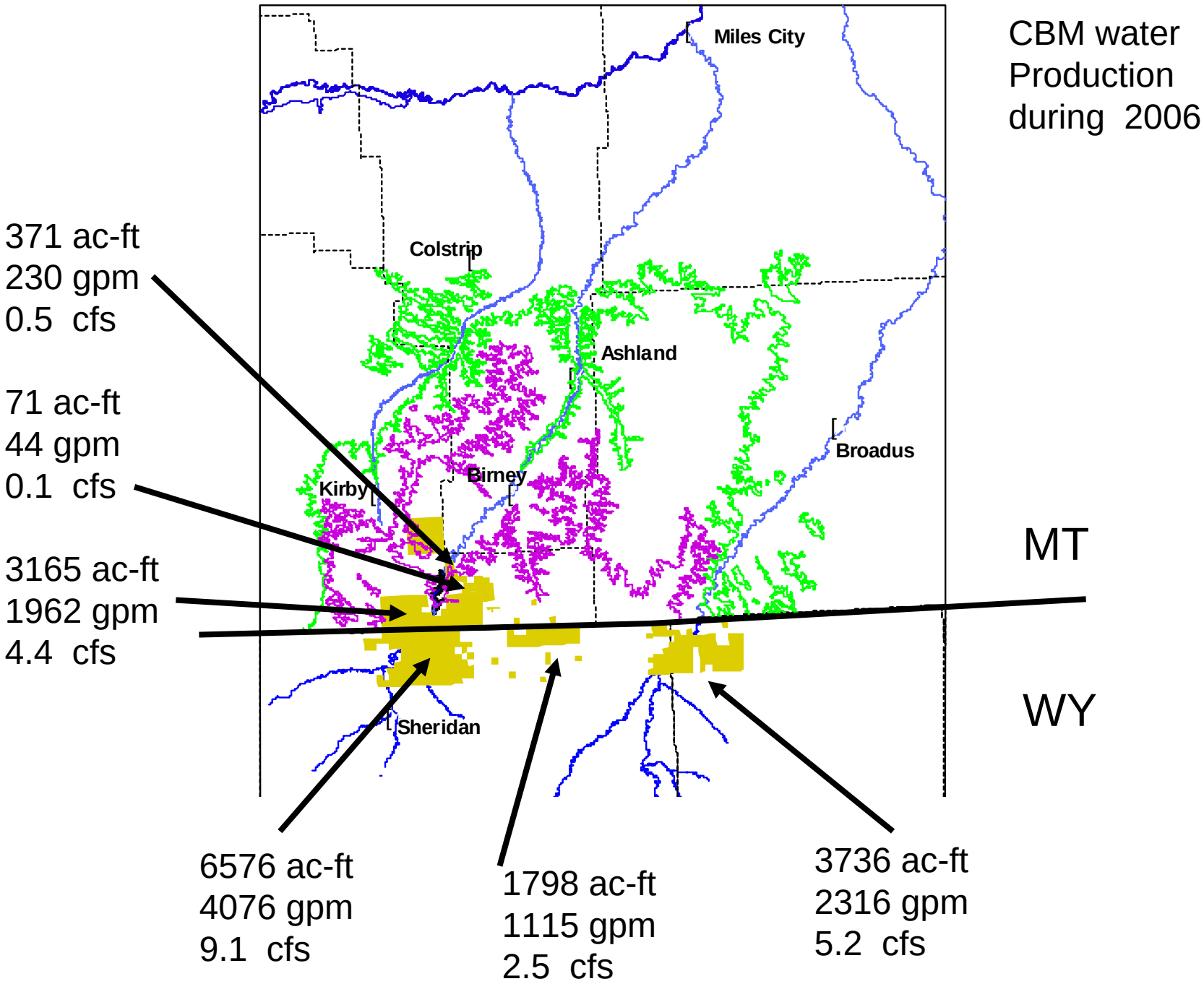
Data make better science.

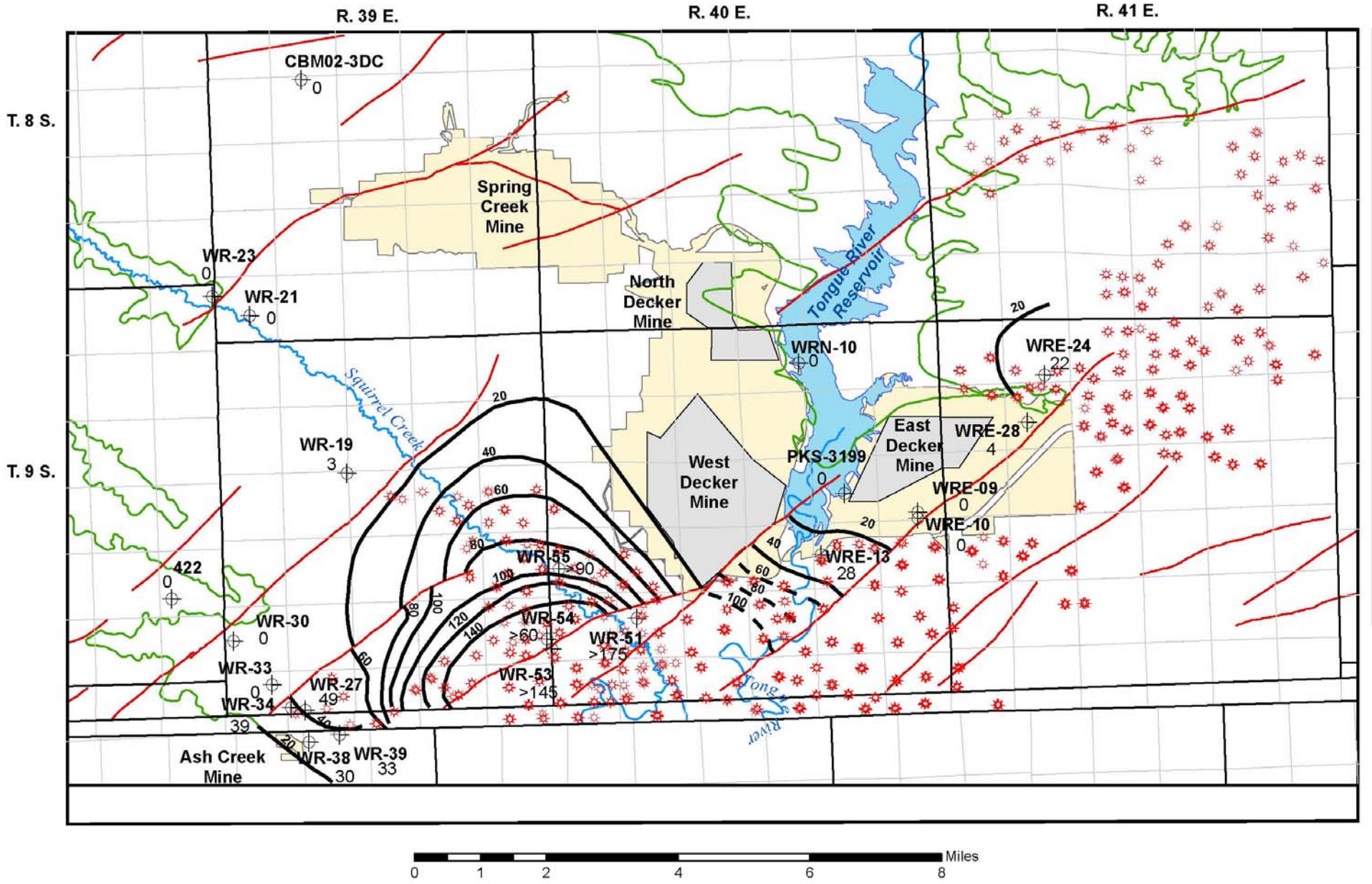

GROUND - WATER FLOW SYSTEMS
RAIN
SPRING + ET
WELL
SPRING
ET
STREAM
AQUIFER
GROUND WATER FLOW DIRECTION
CLINKER OR SCORIA
GROUND WATER PRESSURE

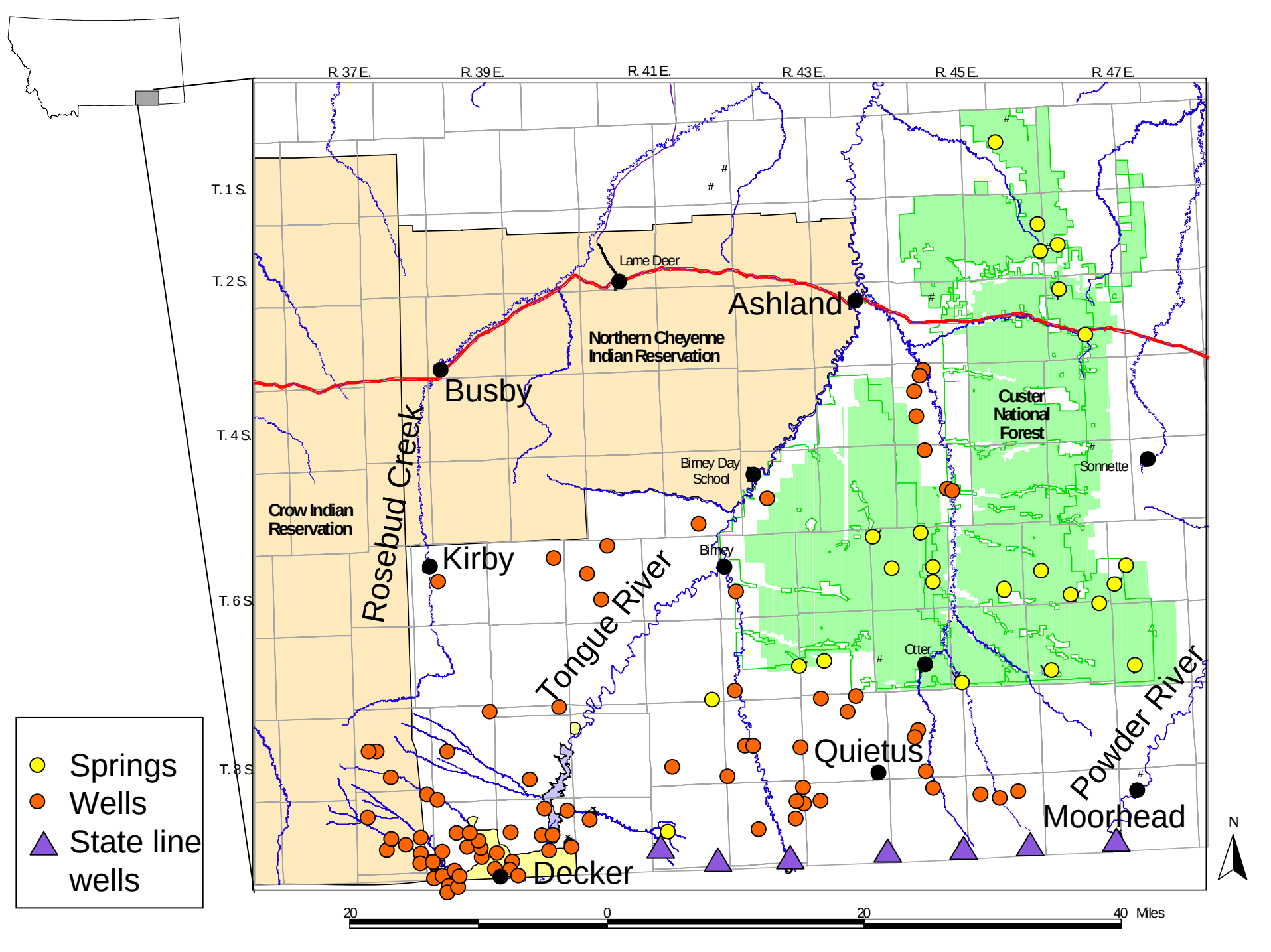

Miles City
Forsyth
Yellowstone
River
Tongue
Powder
North
Dakota
South
Dakota
Montana
Wyoming
Belle Fourche
River
Very simplistic :
Ground water flows
Generally north
North Platte
River
Casper

Montana Water Production
CBM Produced - water discharge rate, normalized per month

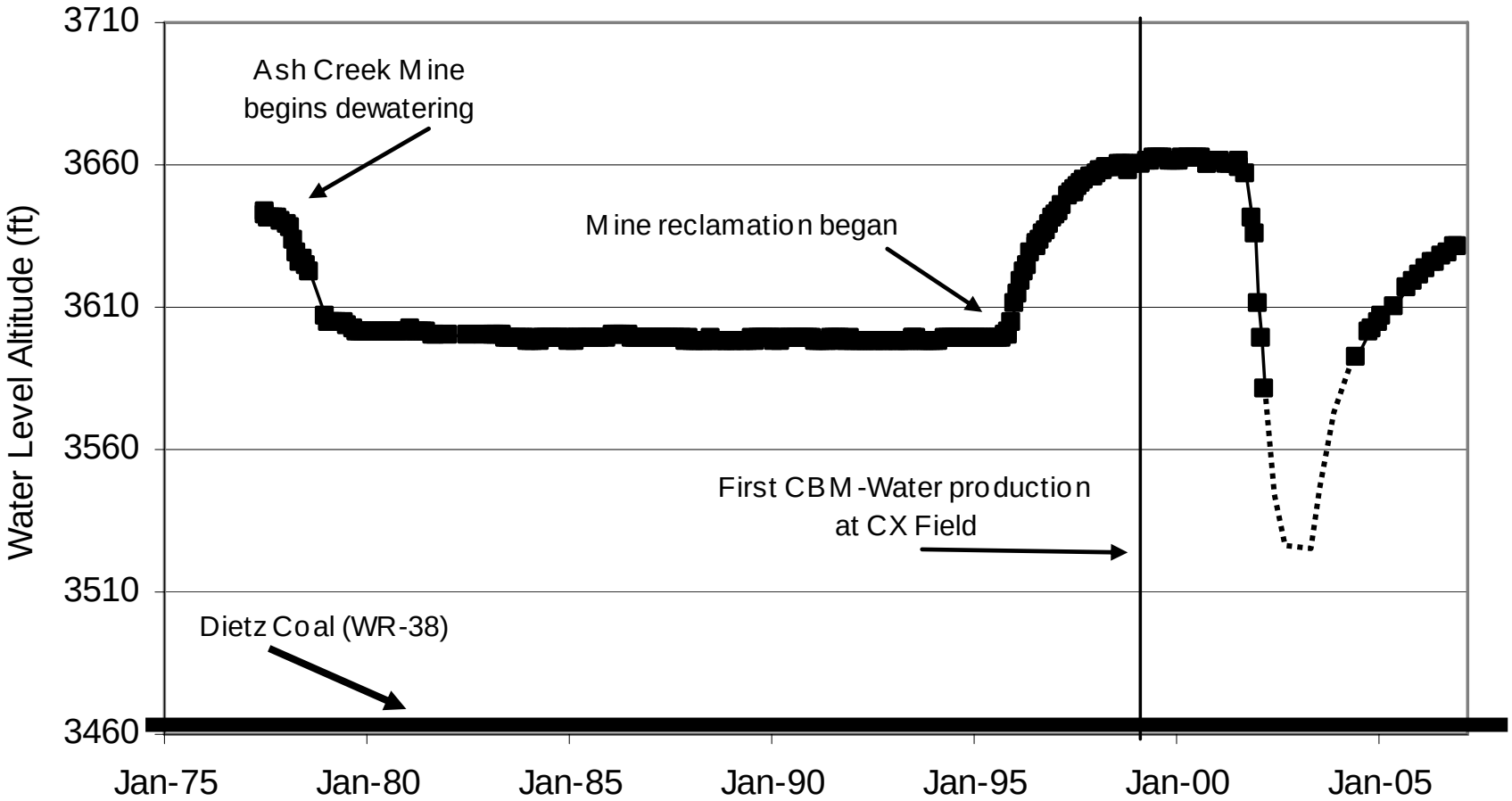


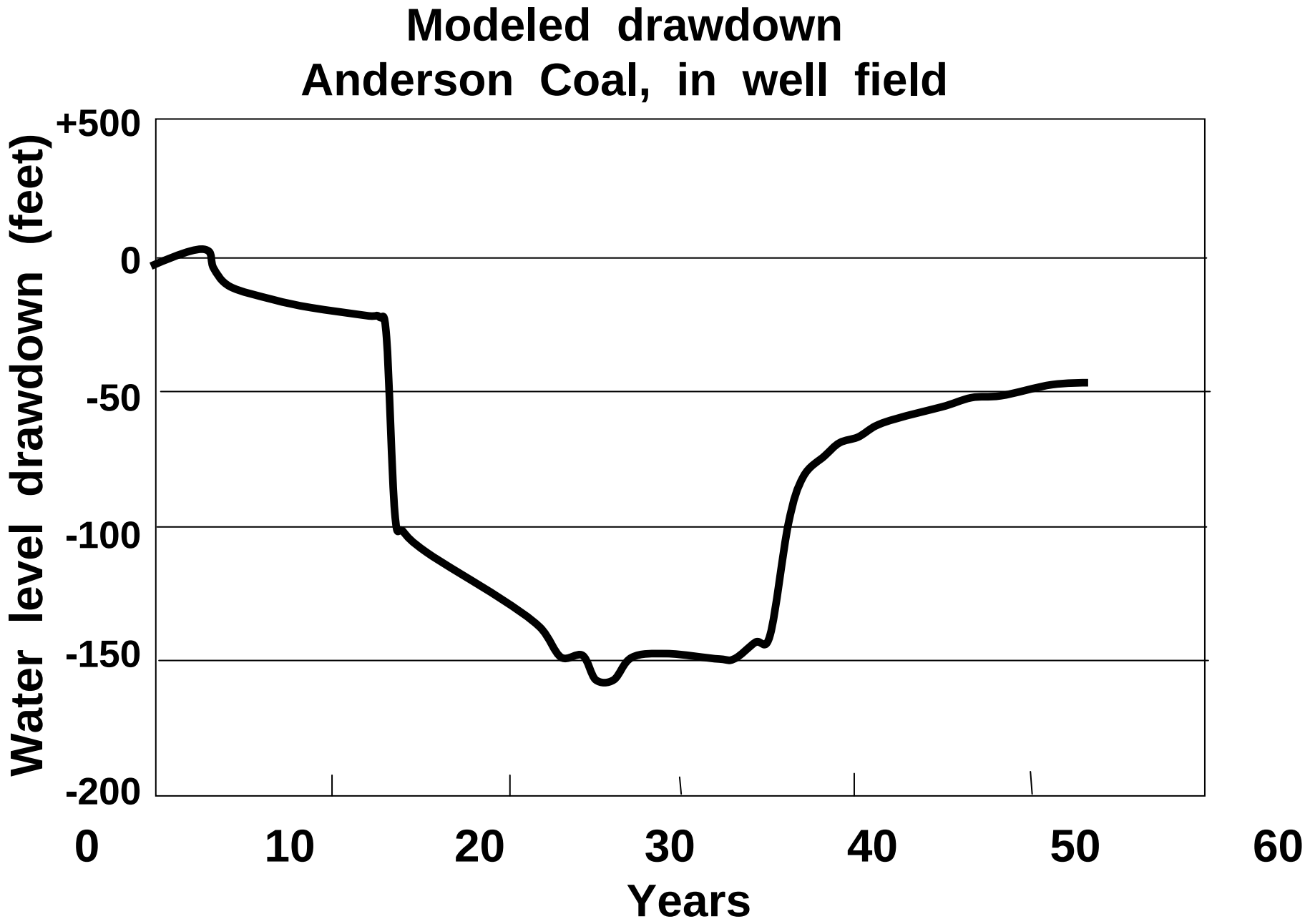

CBM water Production during 2006
Miles City
Colstrip
Ashland
Broadus
Birney
Kirby
Sheridan
MT
WY
371 ac-ft
230 gpm
0.5 cfs
71 ac-ft
44 gpm
0.1 cfs
3165 ac-ft
1962 gpm
4.4 cfs
6576 ac-ft
4076 gpm
9.1 cfs
1798 ac-ft
1115 gpm
2.5 cfs
3736 ac-ft
2316 gpm
5.2 cfs

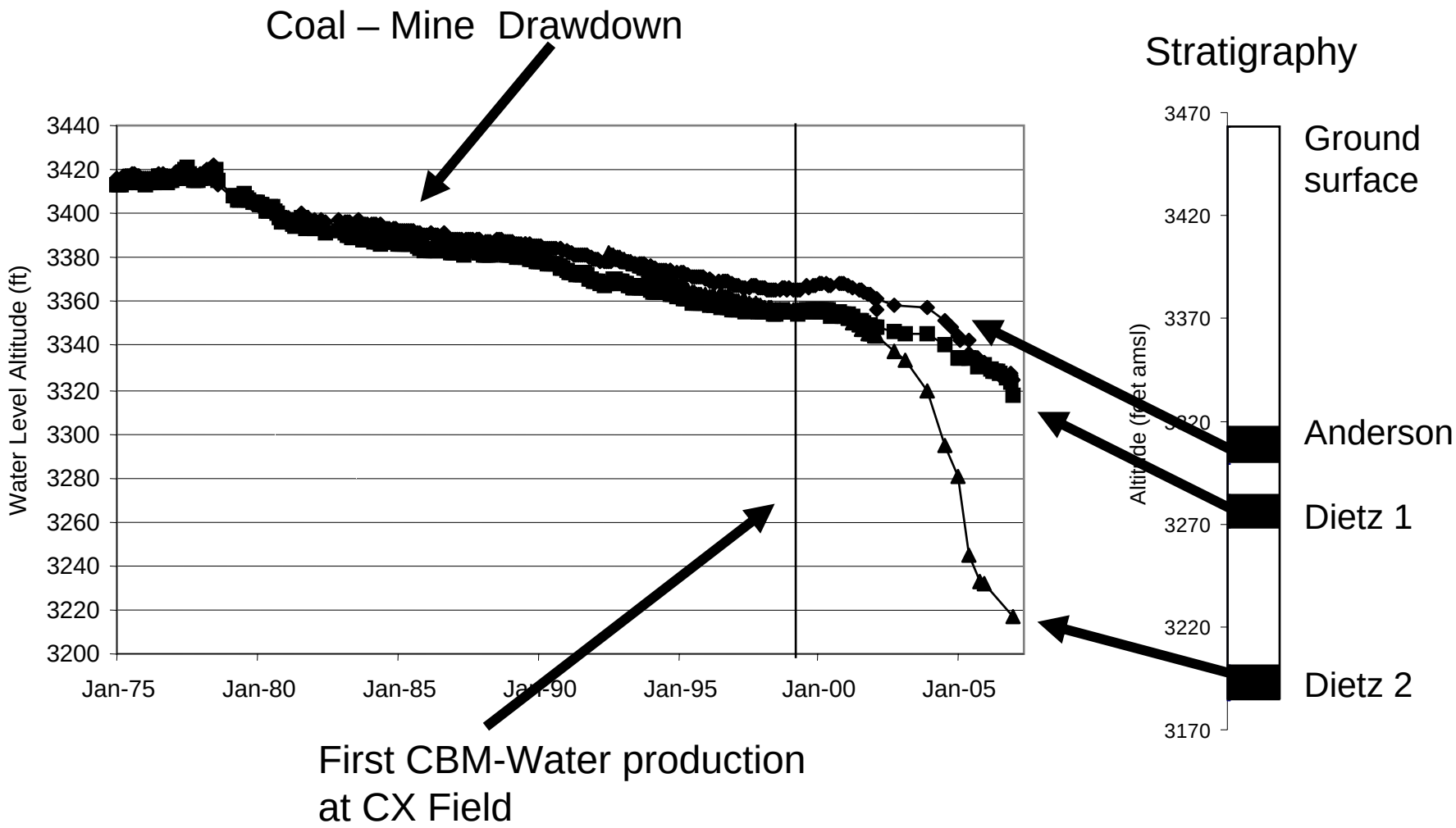

R. 39 E.
R. 40 E.
R. 41 E.
T. 8 S.
T. 9 S.
CBM02-3DC
0
Spring Creek Mine
North Decker Mine
West Decker Mine
East Decker Mine
Tongue River Reservoir
WR-23
0
WR-21
0
WR-19
3
422
0
WR-30
0
WR-33
0
WR-34
39
WR-27
49
WR-38
30
WR-39
33
Ash Creek Mine
WR-55
>90
WR-54
>60
WR-51
>175
WR-53
>145
WRN-10
0
PKS-3199
0
WRE-24
22
WRE-28
4
WRE-09
0
WRE-10
0
WRE-13
28
Squirrel Creek
Tongue River
20
40
60
80
100
120
140
Miles
0
1
2
4
6
8

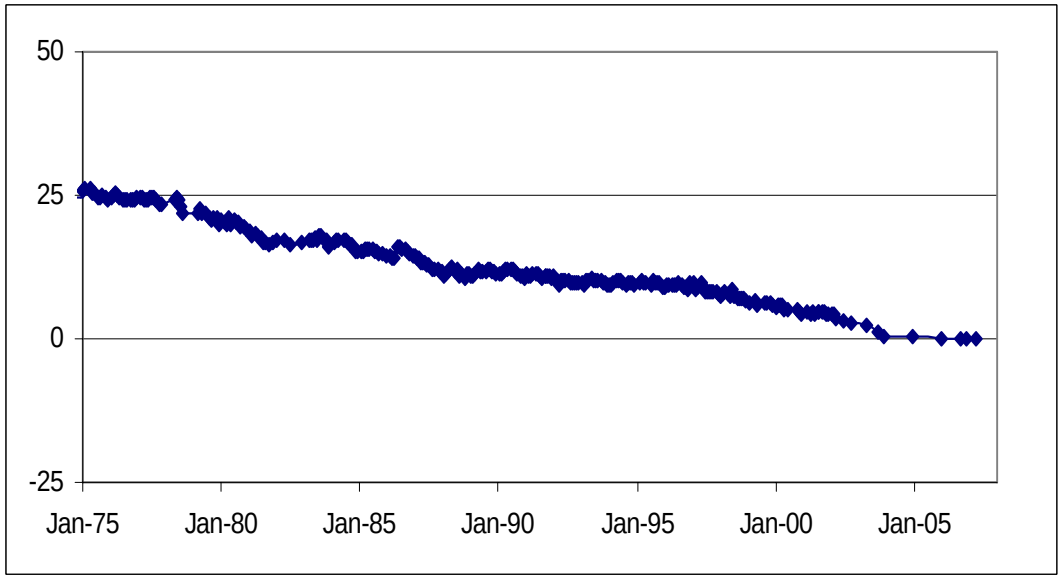

R. 37 E.
R. 39 E.
R. 41 E.
R. 43 E.
R. 45 E.
R. 47 E.
T. 1 S.
T. 2 S.
T. 4 S.
T. 6 S.
T. 8 S.
Lame Deer
Ashland
Busby
Northern Cheyenne Indian Reservation
Custer National Forest
Birney Day School
Sonnette
Crow Indian Reservation
Rosebud Creek
Kirby
Birney
Tongue River
Otter
Powder River
Quietus
Moorhead
Decker
Springs
Wells
State line wells
20
0
20
40 Miles
N

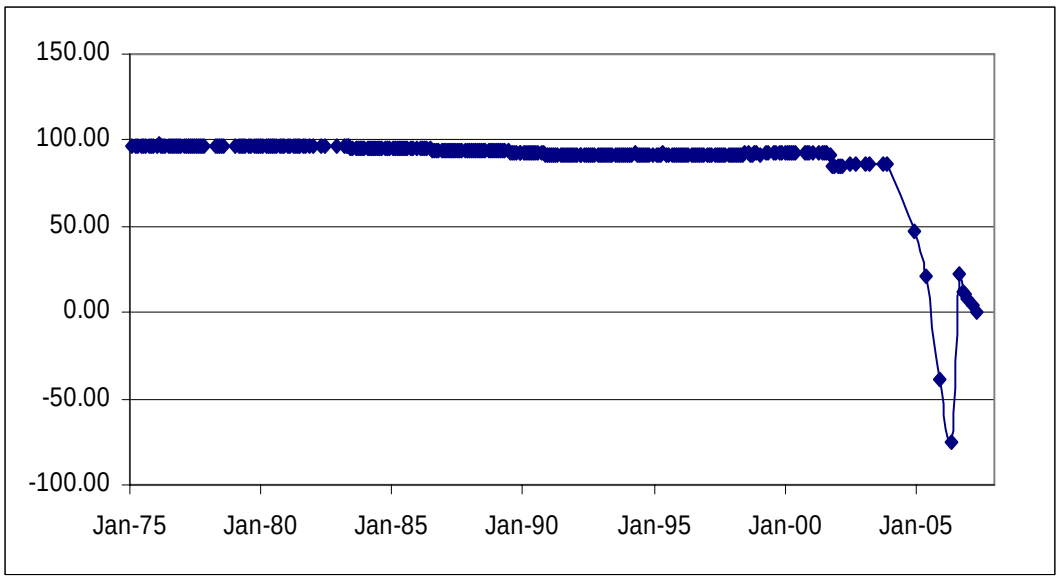
Idealized water level response

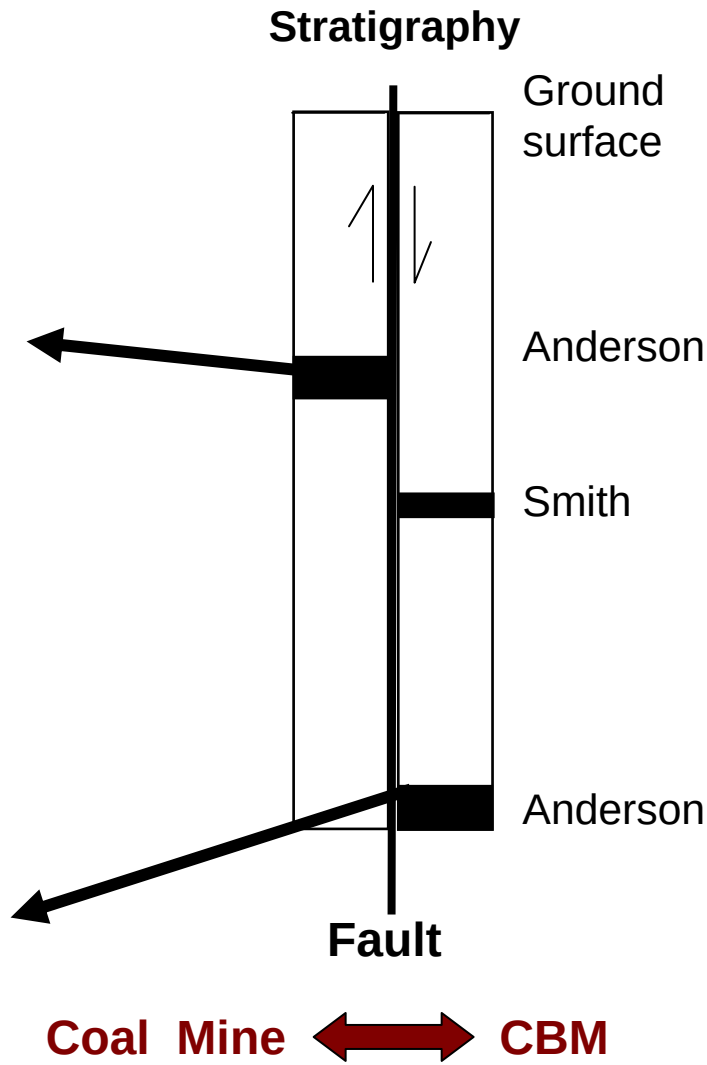



Modeled drawdown
Anderson Coal, in well field
Water level drawdown (feet)
+500
0
-50
-100
-150
-200
0
10
20
30
40
50
60
Years

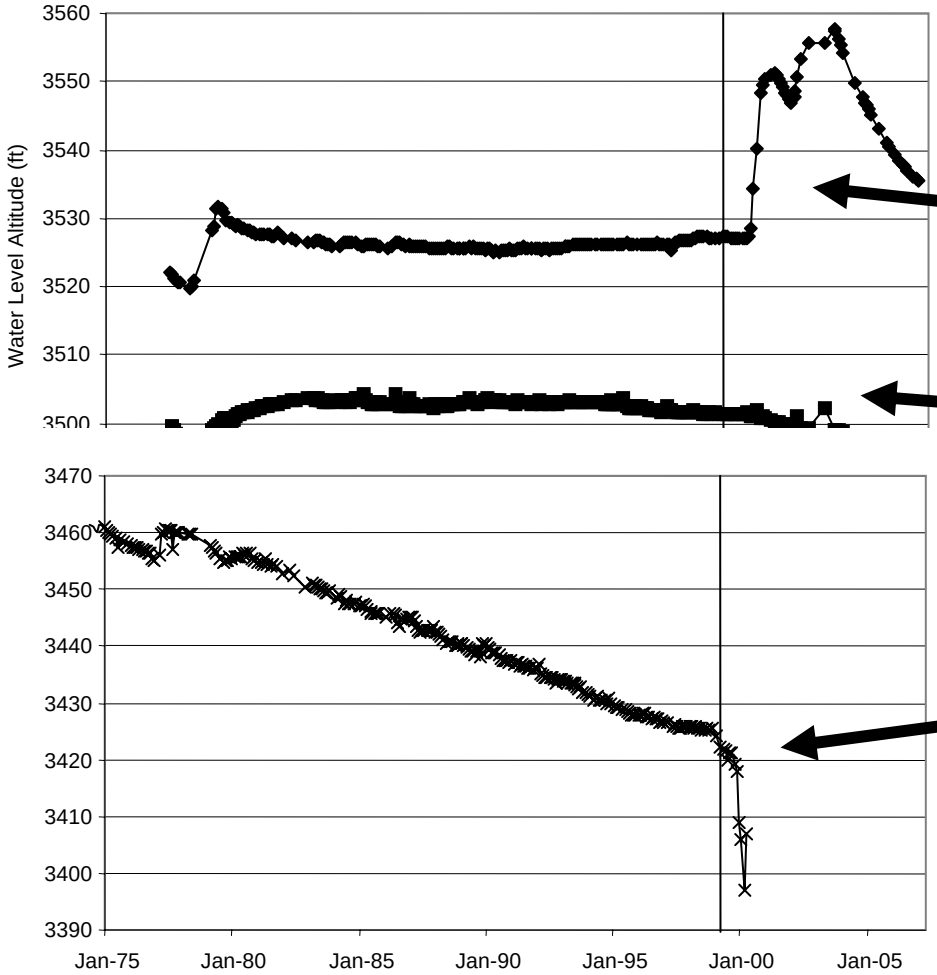

Coal – Mine Drawdown
Stratigraphy
Water Level Altitude (ft)
3440
3420
3400
3380
3360
3340
3320
3300
3280
3260
3240
3220
3200
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Jan-00
Jan-05
3470
3420
3370
3320
3270
3220
3170
Ground surface
Anderson
Dietz 1
Dietz 2
First CBM-Water production at CX Field

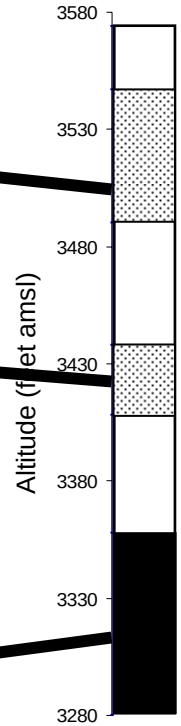

50
25
0
-25
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Jan-00
Jan-05


150.00
100.00
50.00
0.00
-50.00
-100.00
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Jan-00
Jan-05


Stratigraphy
Ground surface
Anderson
Smith
Anderson
Fault
Coal Mine
CBM

Stratigraphy



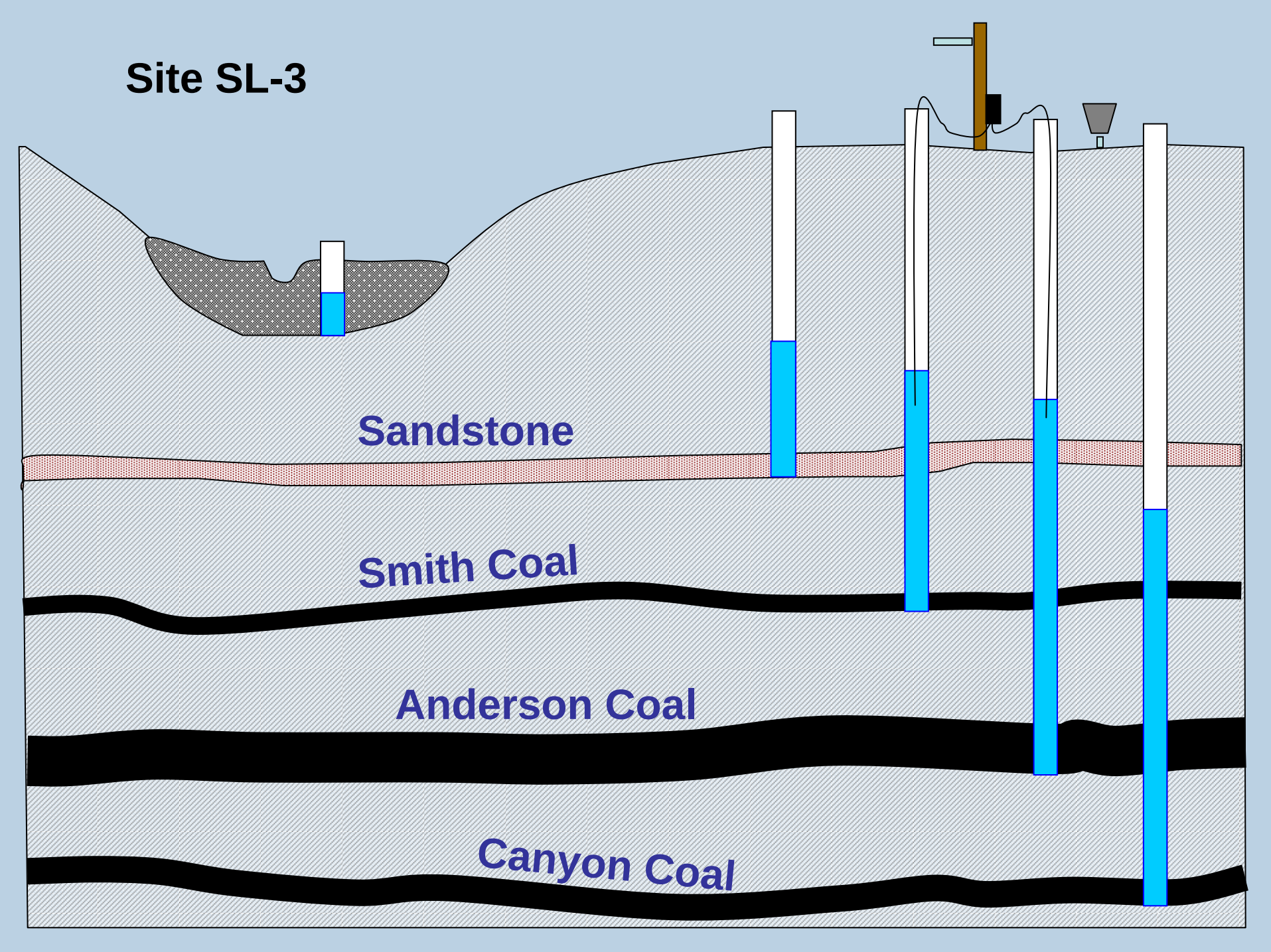


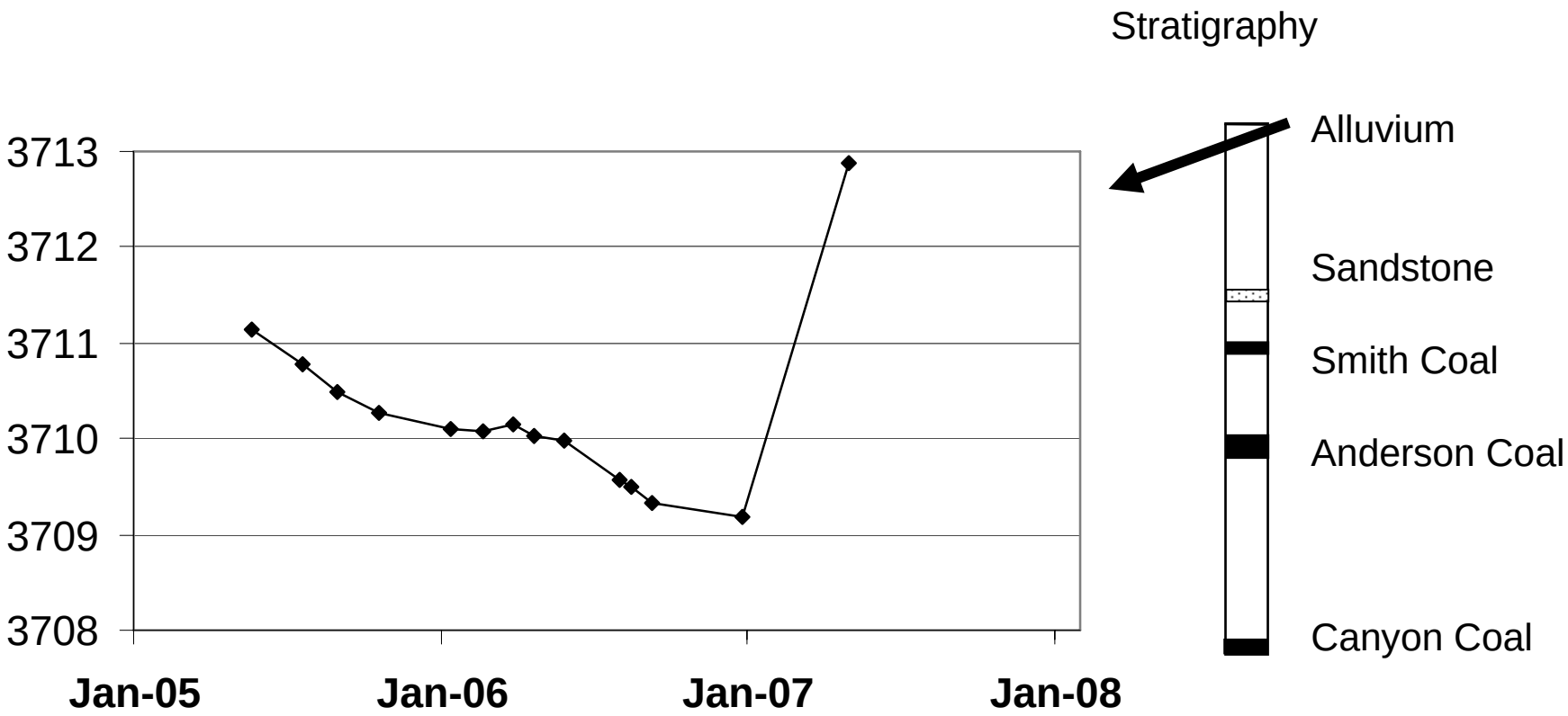
Ground surface

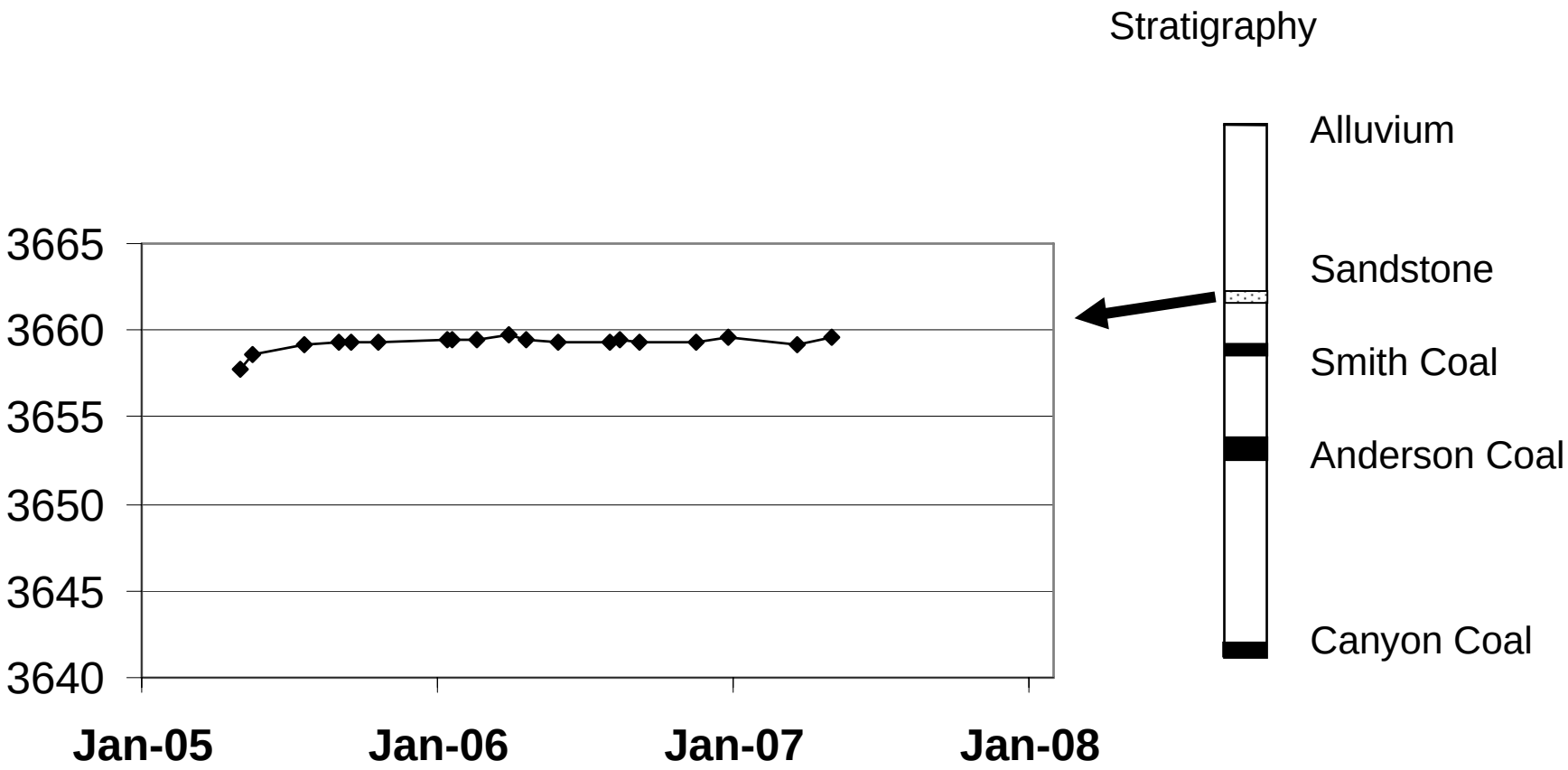
Shallow sandstone

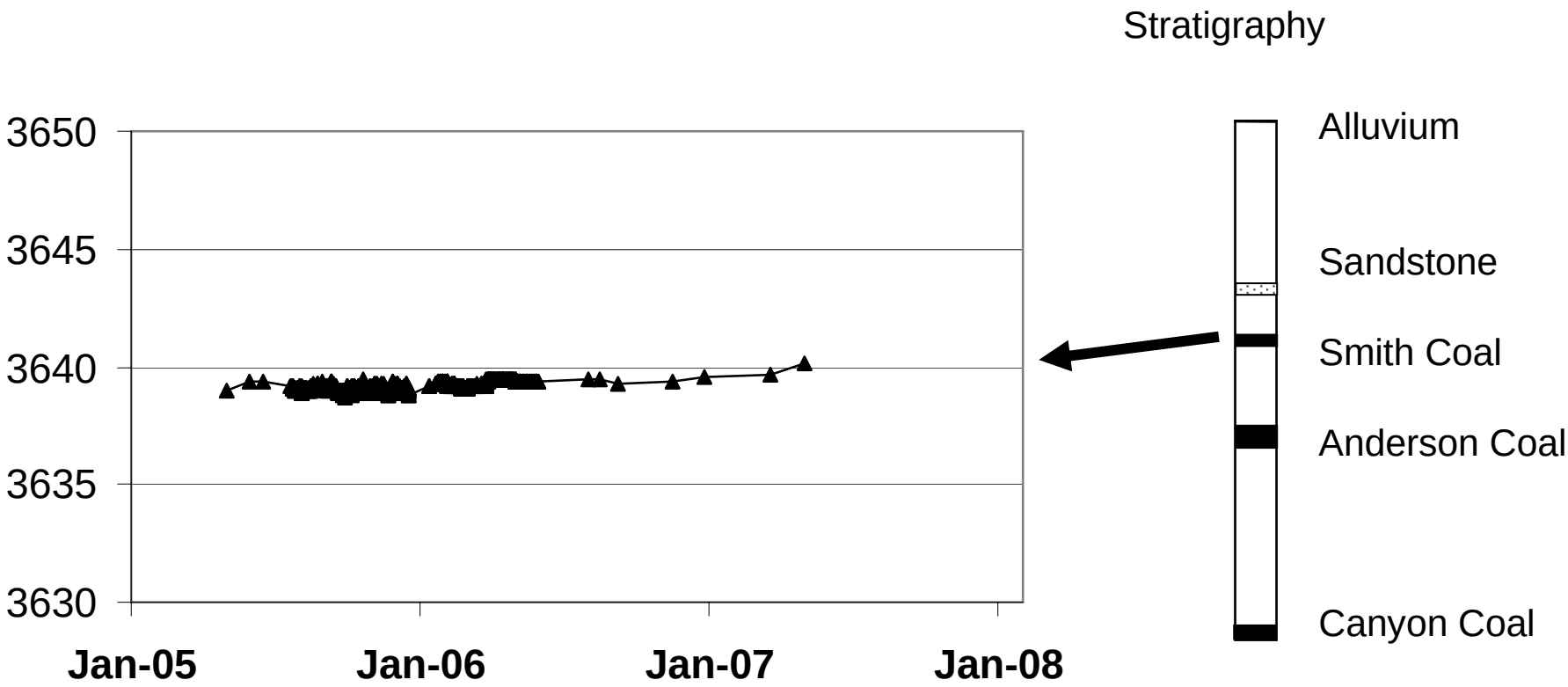
Anderson-Dietz overburden

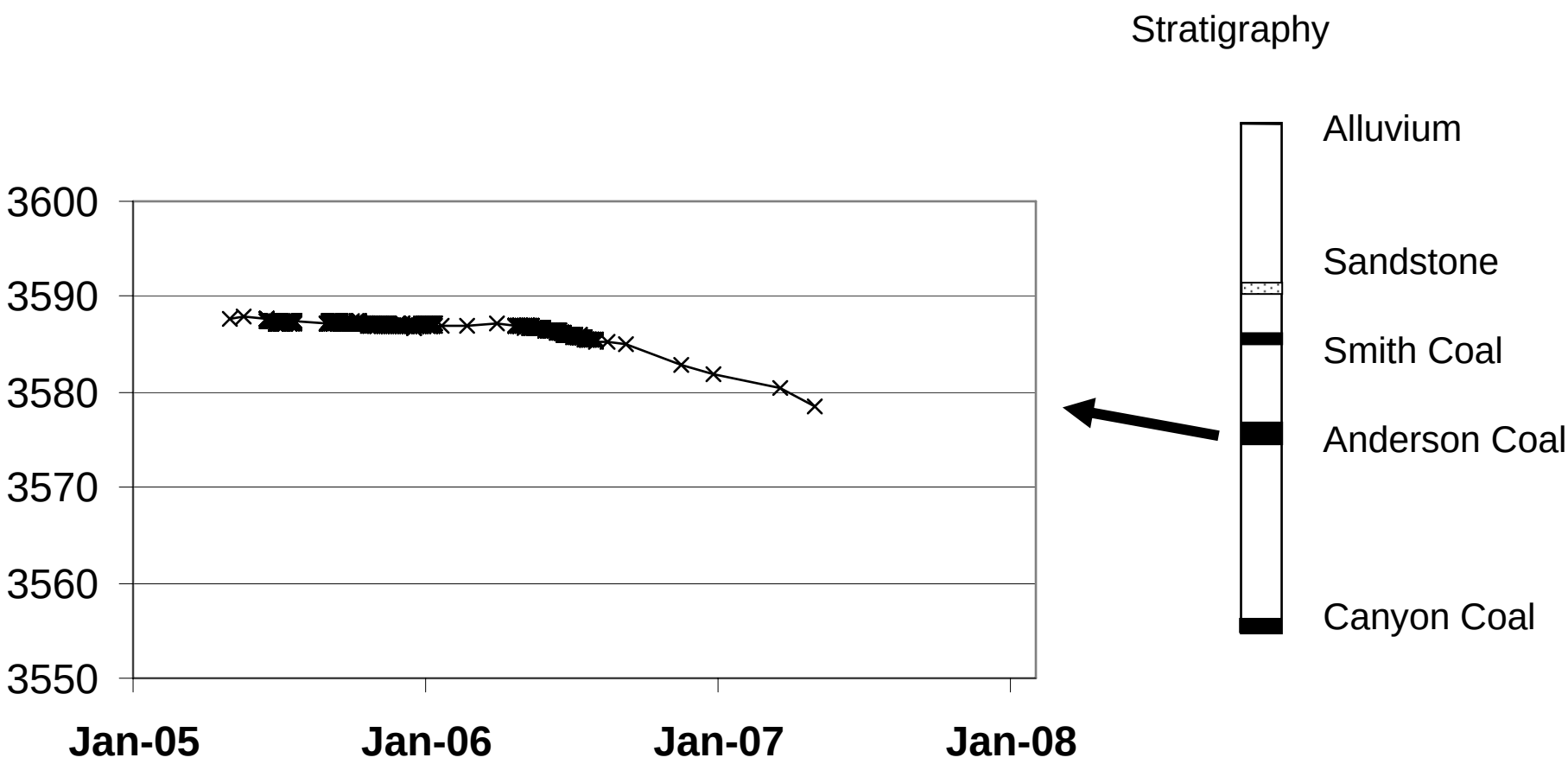
Anderson-Dietz Coal

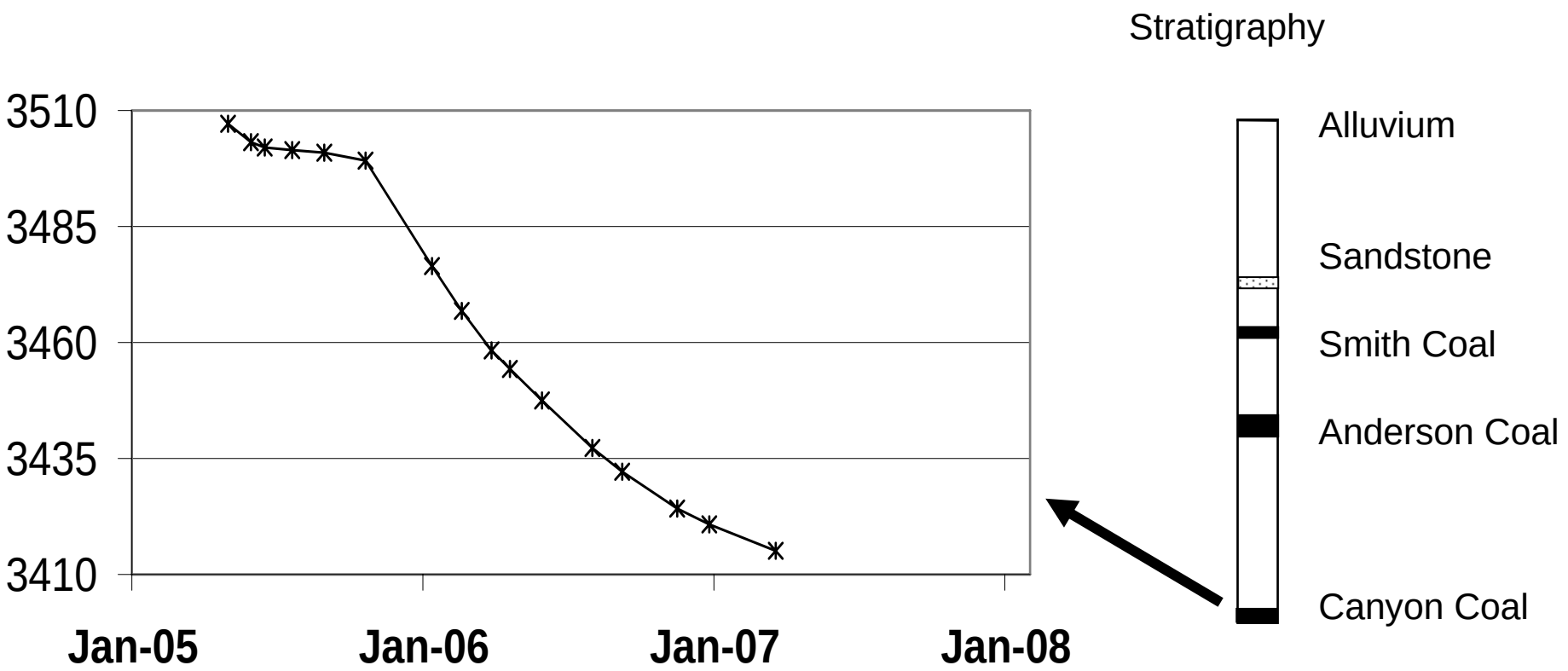

Site SL-3
Sandstone
Smith Coal
Anderson Coal
Canyon Coal


Stratigraphy
3713
3712
3711
3710
3709
3708
Jan-05
Jan-06
Jan-07
Jan-08
Alluvium
Sandstone
Smith Coal
Anderson Coal
Canyon Coal


Stratigraphy
Alluvium
Sandstone
Smith Coal
Anderson Coal
Canyon Coal
3665
3660
3655
3650
3645
3640
Jan-05
Jan-06
Jan-07
Jan-08


Stratigraphy
3650
3645
3640
3635
3630
Jan-05
Jan-06
Jan-07
Jan-08
Alluvium
Sandstone
Smith Coal
Anderson Coal
Canyon Coal


Stratigraphy
Alluvium
Sandstone
Smith Coal
Anderson Coal
Canyon Coal
3600
3590
3580
3570
3560
3550
Jan-05
Jan-06
Jan-07
Jan-08


Stratigraphy
3510
3485
3460
3435
3410
Jan-05
Jan-06
Jan-07
Jan-08
Alluvium
Sandstone
Smith Coal
Anderson Coal
Canyon Coal

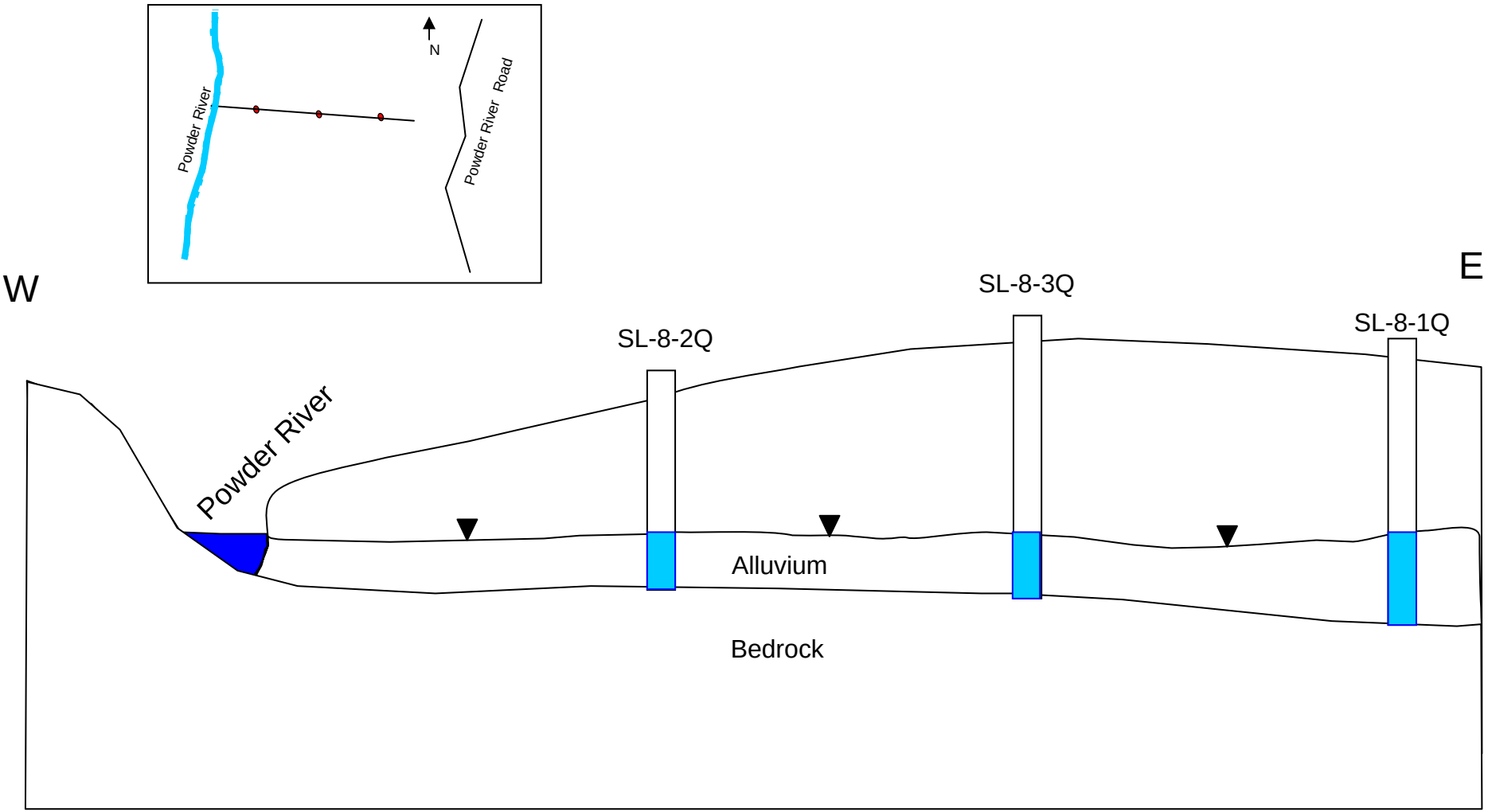


Figure 13. Cross section of alluvial wells south of Moorhead near the Powder River located in T09S R47E section 25. Ground water in the alluvium appear to flow parallel to the river. Water levels for this cross section were taken in January 2006. Vertical exaggeration is 58:1.

Powder River Alluvium

Alluvium Water Levels

Furthest

Middle

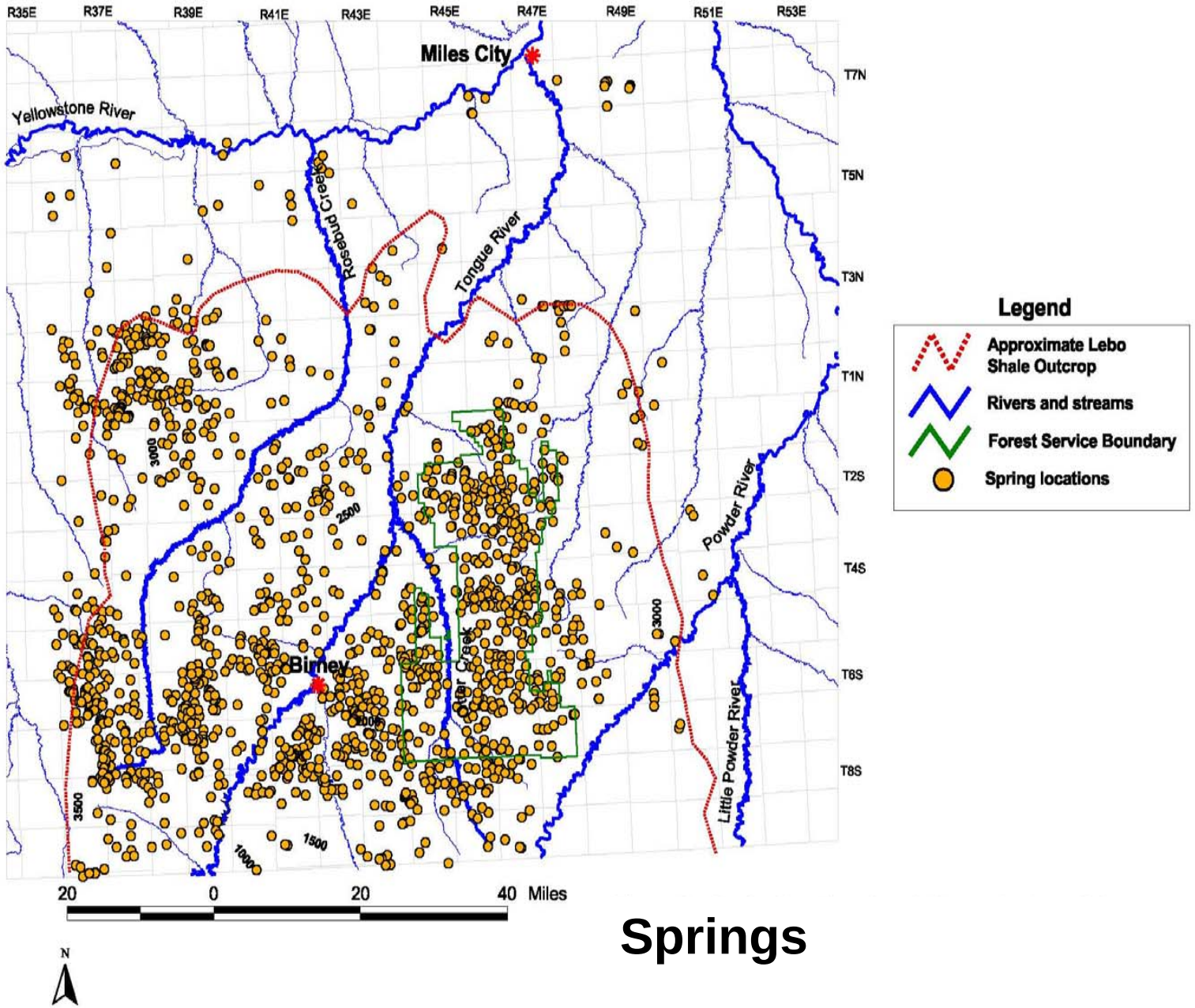
Nearest To River

Estimated River Flow

Coalbed Methane Regional Ground – Water Monitoring Network

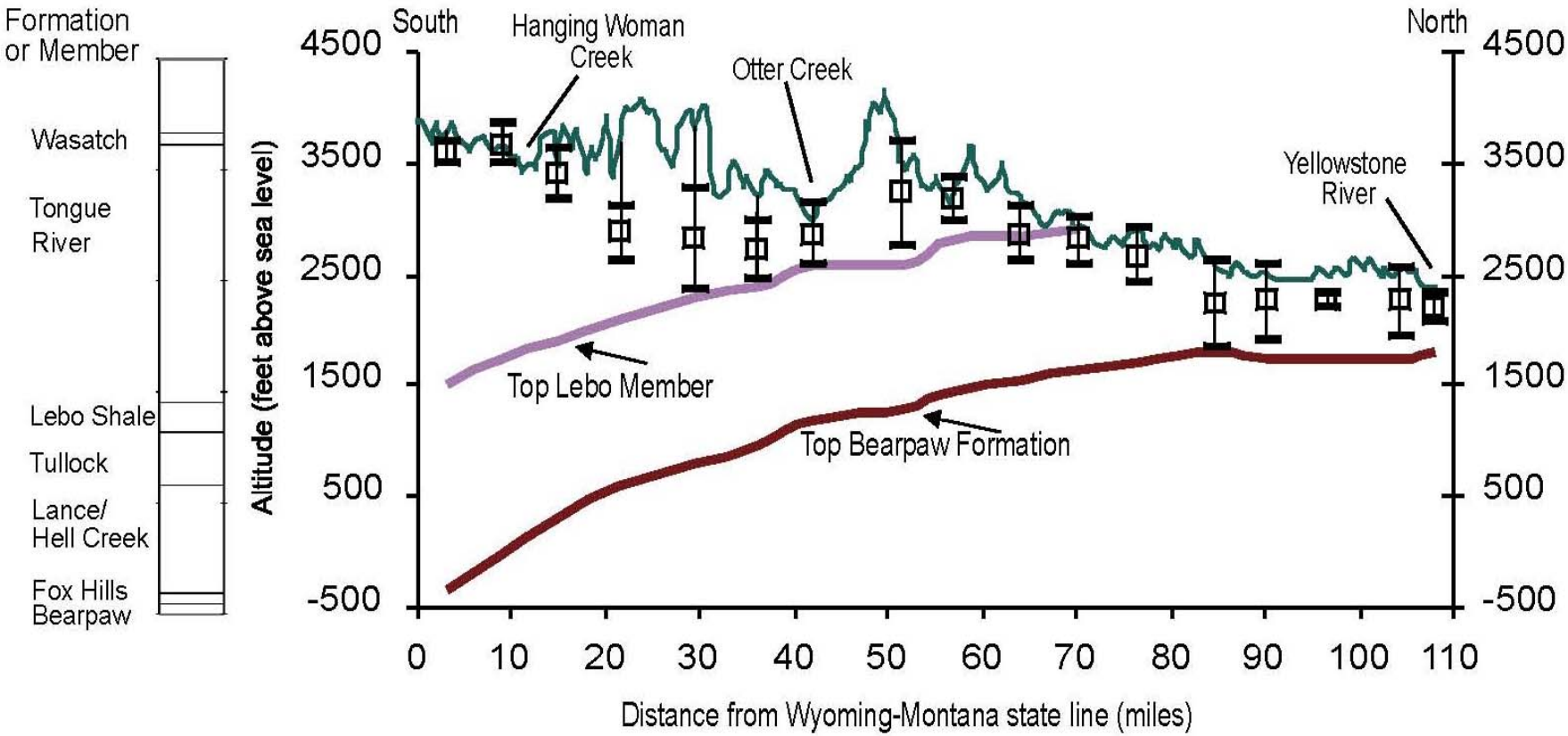
Use of results and data:

- **Annual update on ground – water impacts (and lack of impacts)**
- **Regulatory permitting assessments**
- **Exploration data (sodium bicarbonate)**
- **Public knowledge**
- **http://mbmggwic.mtech.edu/**


R35E
R37E
R39E
R41E
R43E
R45E
R47E
R49E
R51E
R53E
T7N
T5N
T3N
T1N
T2S
T4S
T6S
T8S
Miles City
Yellowstone River
Rosebud Creek
Tongue River
Powder River
Little Powder River
Otter Creek
Birney
3000
2500
3500
1500
1000
20
0
20
40 Miles
N
Legend
Approximate Lebo Shale Outcrop
Rivers and streams
Forest Service Boundary
Spring locations

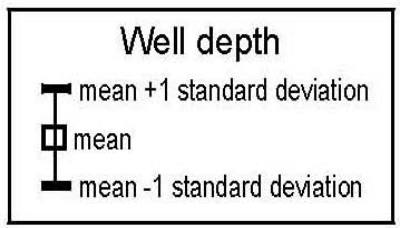
Springs

Stratigraphic intervals for water supply wells

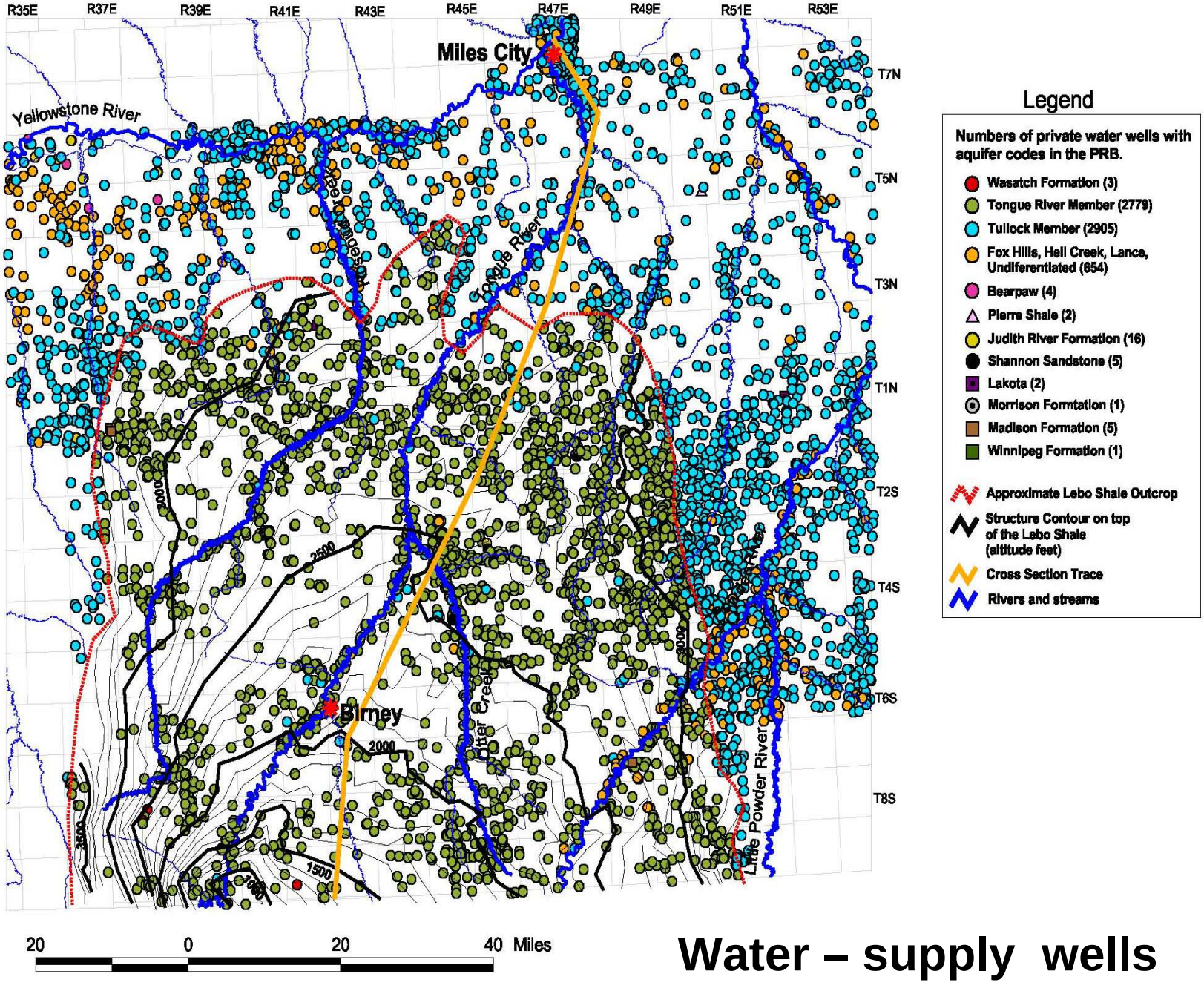


2,779 supply wells in the Tongue River Mbr

10 - 15 gpm typical

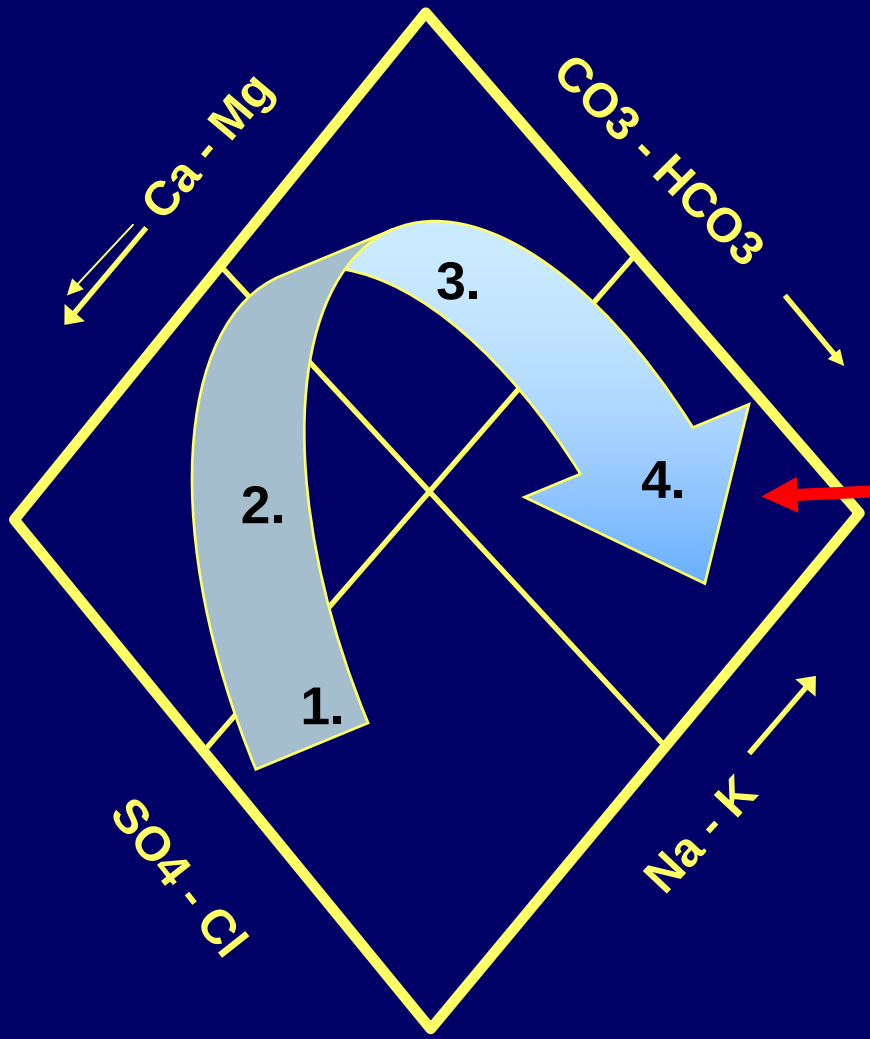


Vertical exaggeration 53x



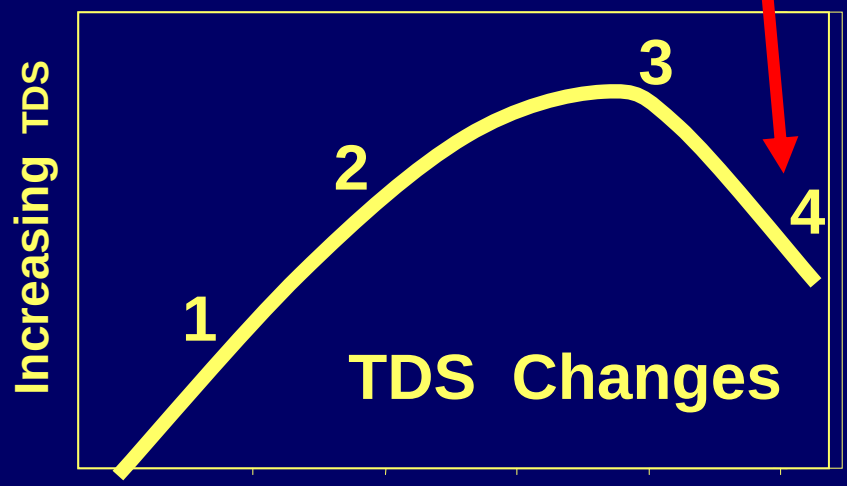
Water – supply wells

Primary changes on ground - water quality in the Fort Union Formation

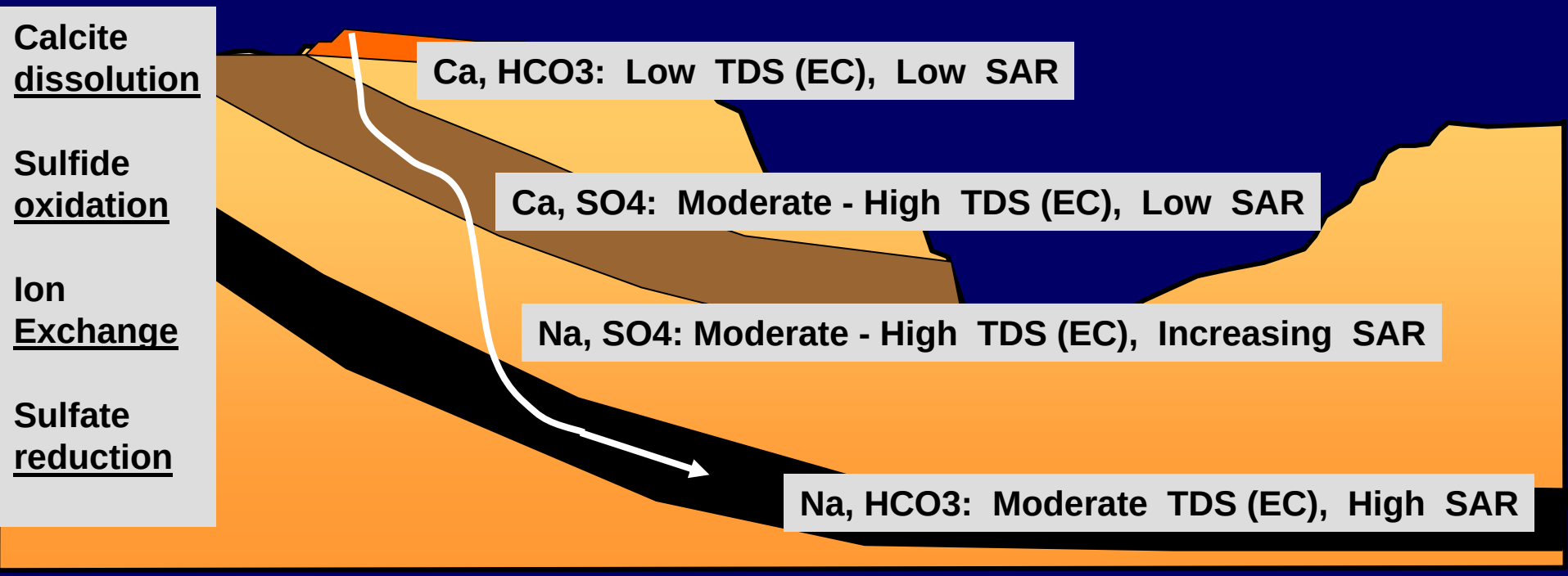


1. Salt Dissolution
2. FeS_2 Oxidation
3. Cation Exchange
4. Sulfate Reduction

CBM Produced Water



GROUND - WATER QUALITY ALONG FLOW PATHS IN THE FORT UNION FORMATION



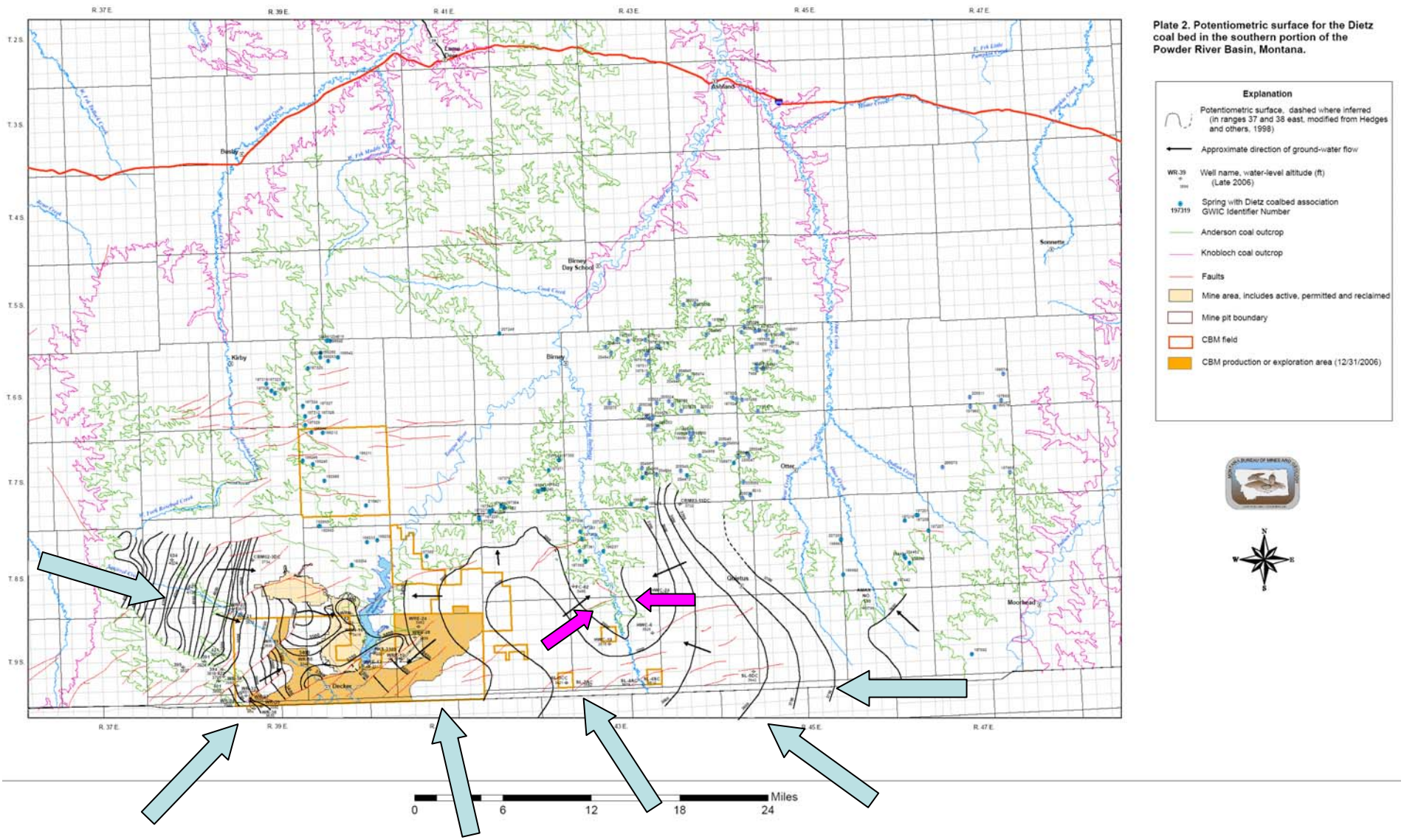
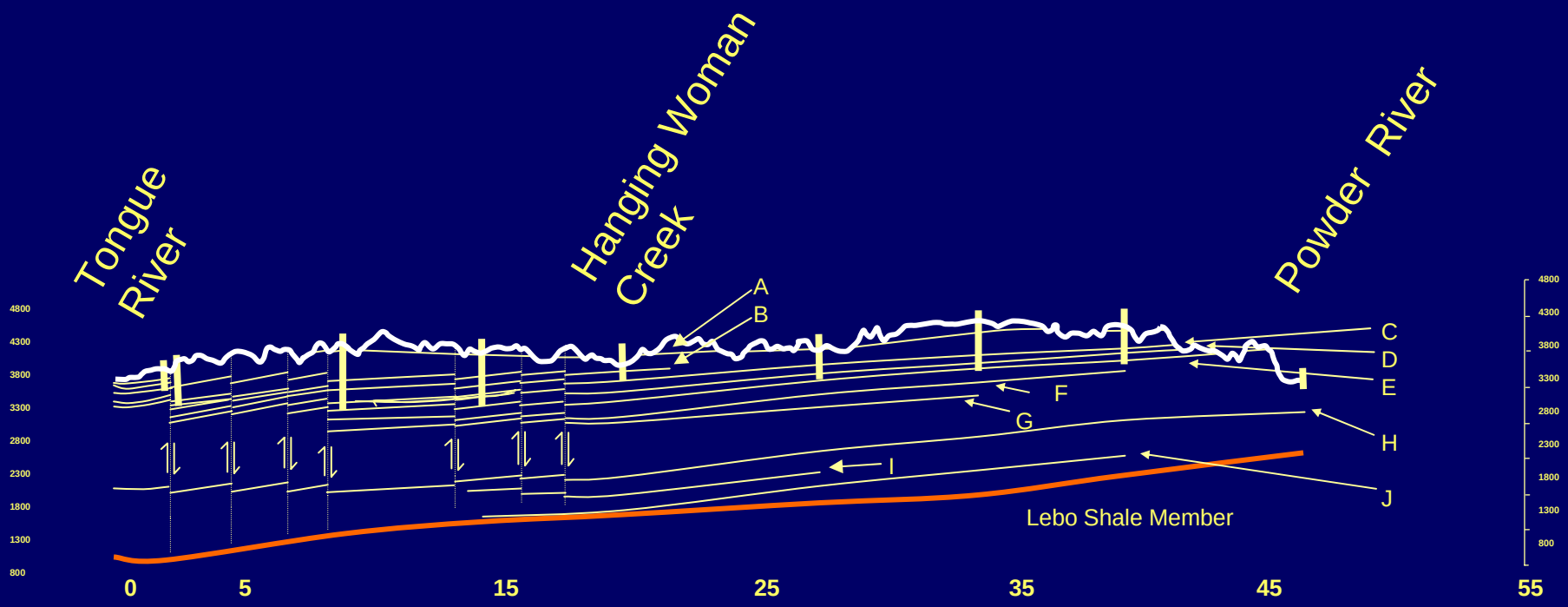


Plate 2. Potentiometric surface for the Dietz coal bed in the southern portion of the Powder River Basin, Montana.

Explanation

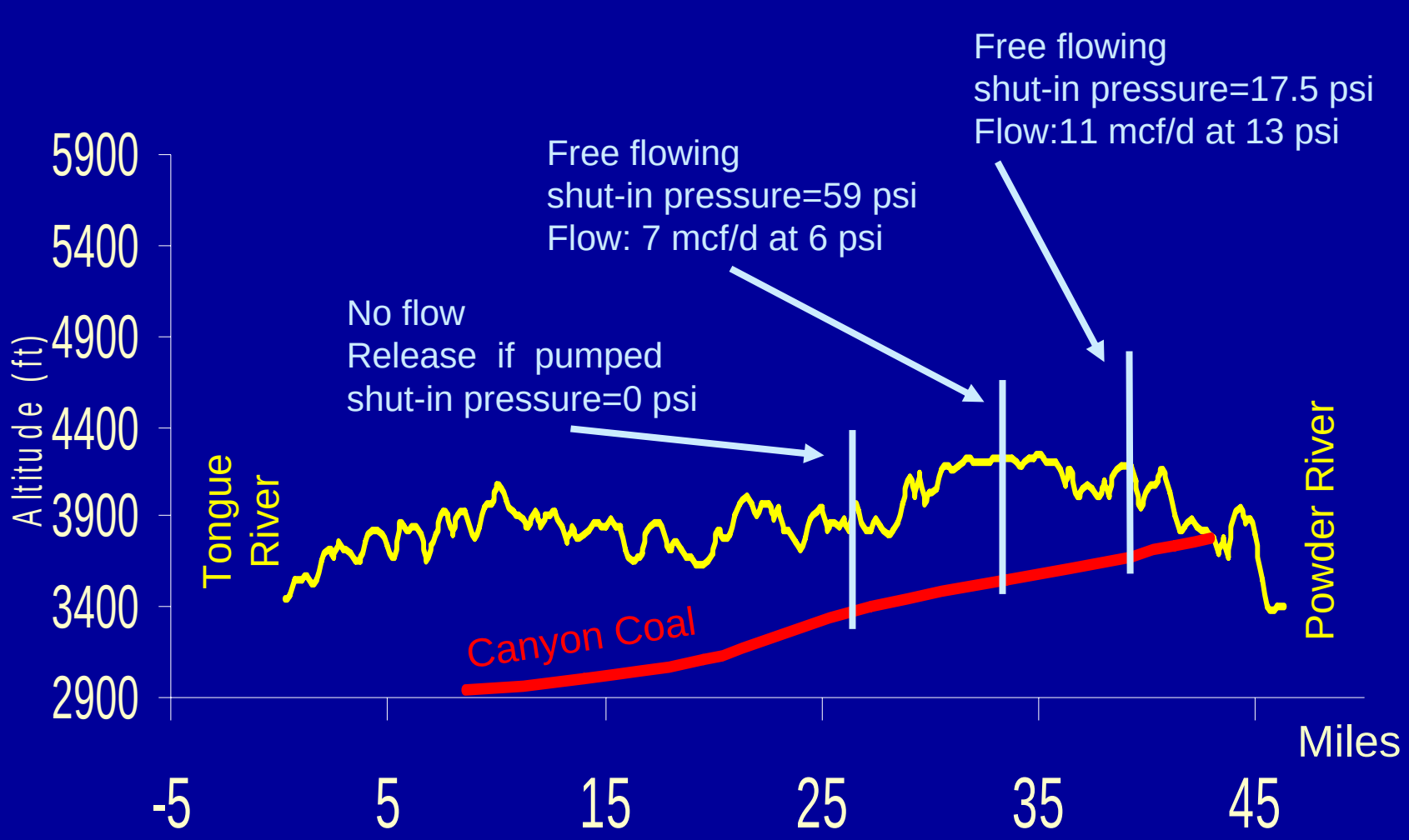
- Potentiometric surface, dashed where inferred (in ranges 37 and 38 east, modified from Hedges and others, 1998)
- Approximate direction of ground-water flow
- WR-39 — Well name, water-level altitude (ft) (Late 2006)
- 197319 — Spring with Dietz coalbed association GWIC Identifier Number
- Anderson coal outcrop
- Knobloch coal outcrop
- Faults
- Mine area, includes active, permitted and reclaimed
- Mine pit boundary
- CBM field
- CBM production or exploration area (12/31/2006)

Cross section along the Montana – Wyoming state line

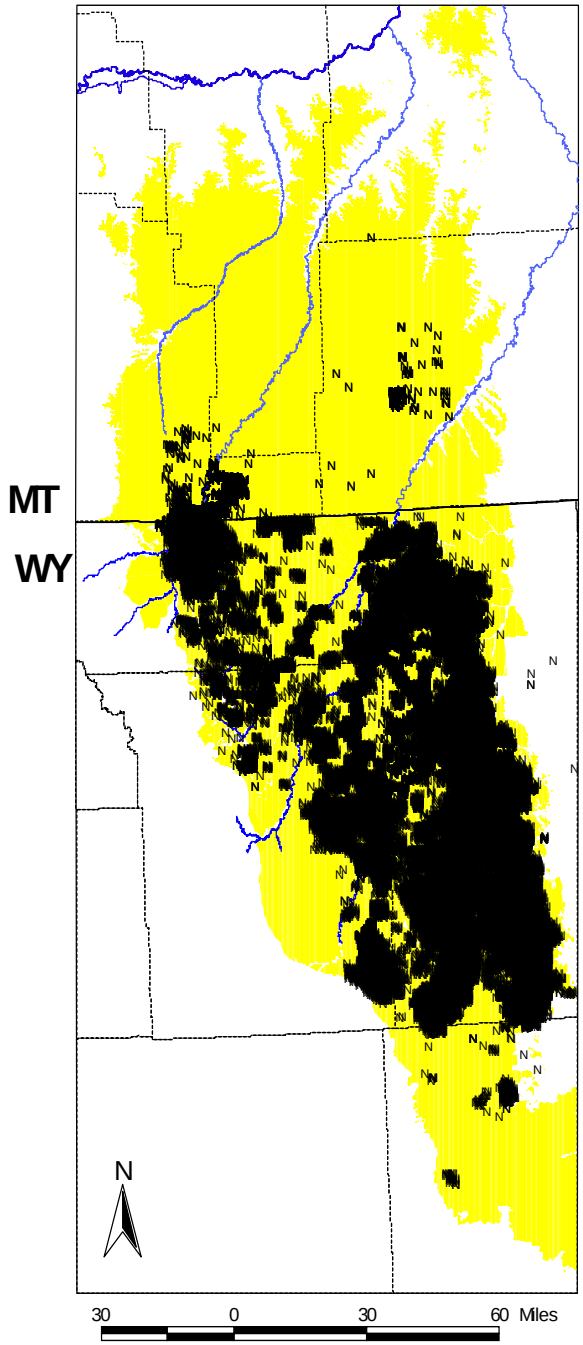


Coal beds identified in cross section

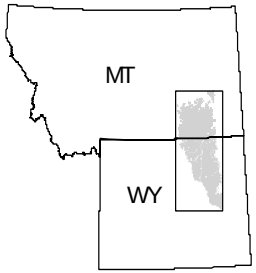
A Roland
B Smith
C Anderson
D Dietz
E Canyon
F Carney Coal
G Wall Coal
H Knobloch
I Roberts Coal
J Kendrick



Cross section along the MT-WY state line.
Freely flow methane gas from monitoring wells.
Gas pressure decreases toward the outcrop.
Gas flow rate increases towards the outcrop.



N Location of CBM wells and permits in the Powder River Basin




Miles City
Locate
Yellowstone
Tongue River
Powder River
Lebo Shale
Ashland
Flowers-
Goodale
Broadus
Birney
King
Knobloch
Broadus
Wall
Pawnee
Cache
Dietz
Canyon
Anderson
Smith
Cook
Moorhead
Montana
Wyoming
Decker
Roland

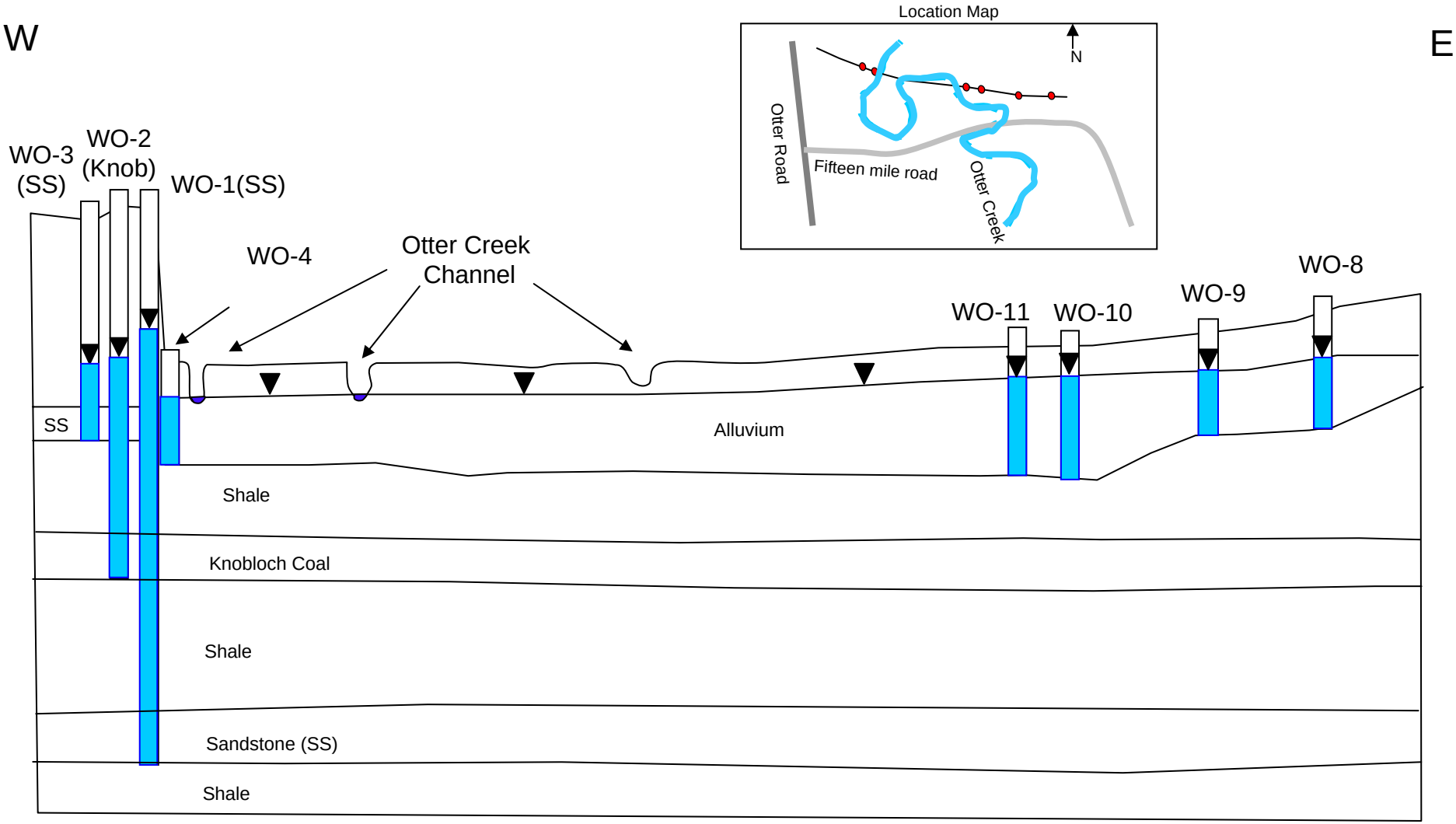


Figure 8. Geologic cross section for the Otter Creek alluvium and bedrock wells located in T05S R45E sec 23. Water levels in the alluvium are lower than the underlying bedrock aquifers. The water levels in the bedrock wells completed in stratigraphically deeper units are higher than those in shallower units. The water levels for this cross section were taken in December, 2006. Vertical exaggeration is 9.6:1.

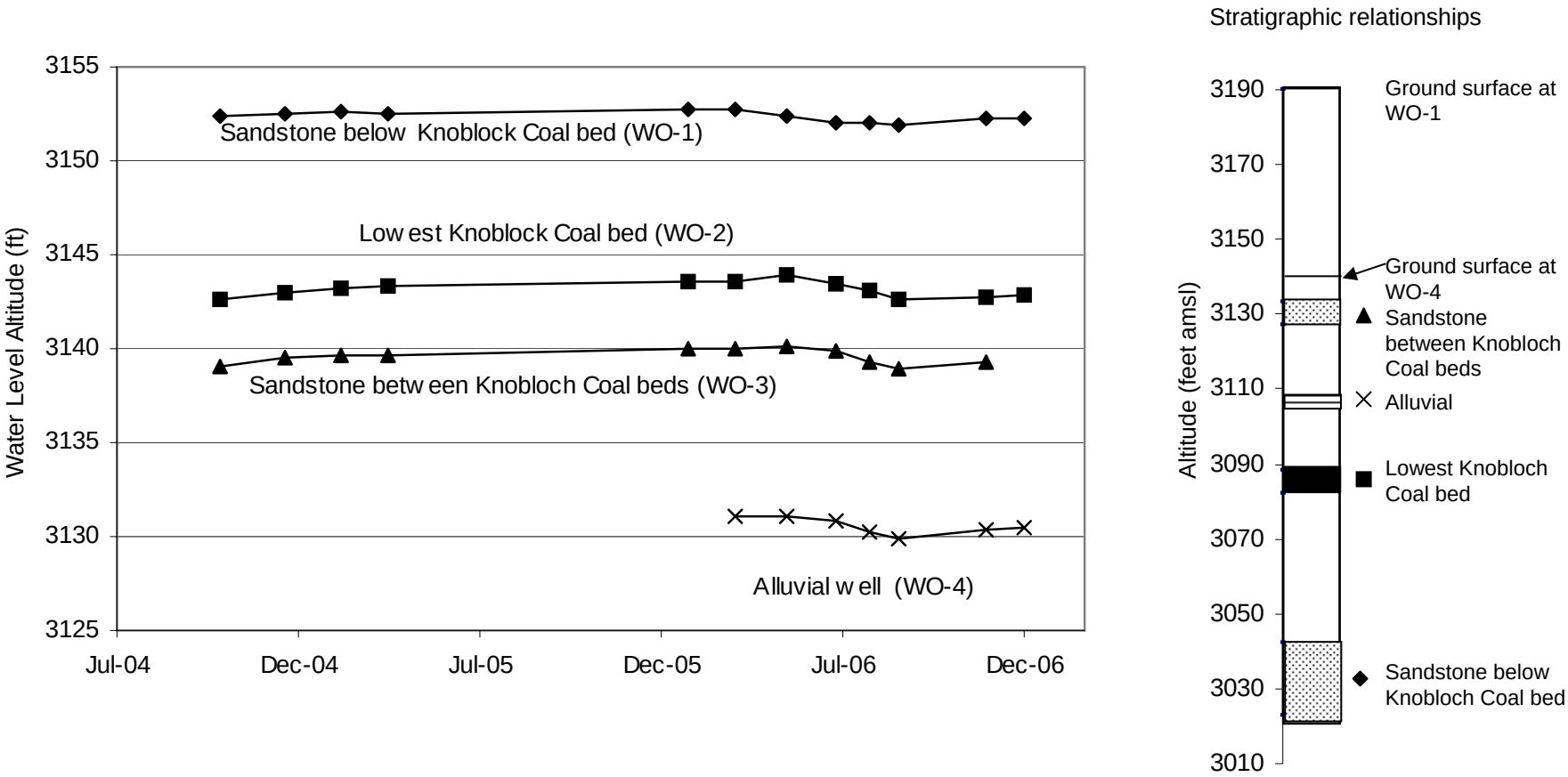


Figure 9. Bedrock aquifers at the Otter creek area have an upward vertical gradient, flowing wells are common in the area. The alluvial well appears to show the general seasonal water year cycle.

Note the vertical scales of the stratiographic relationship and the hydrograph are different.

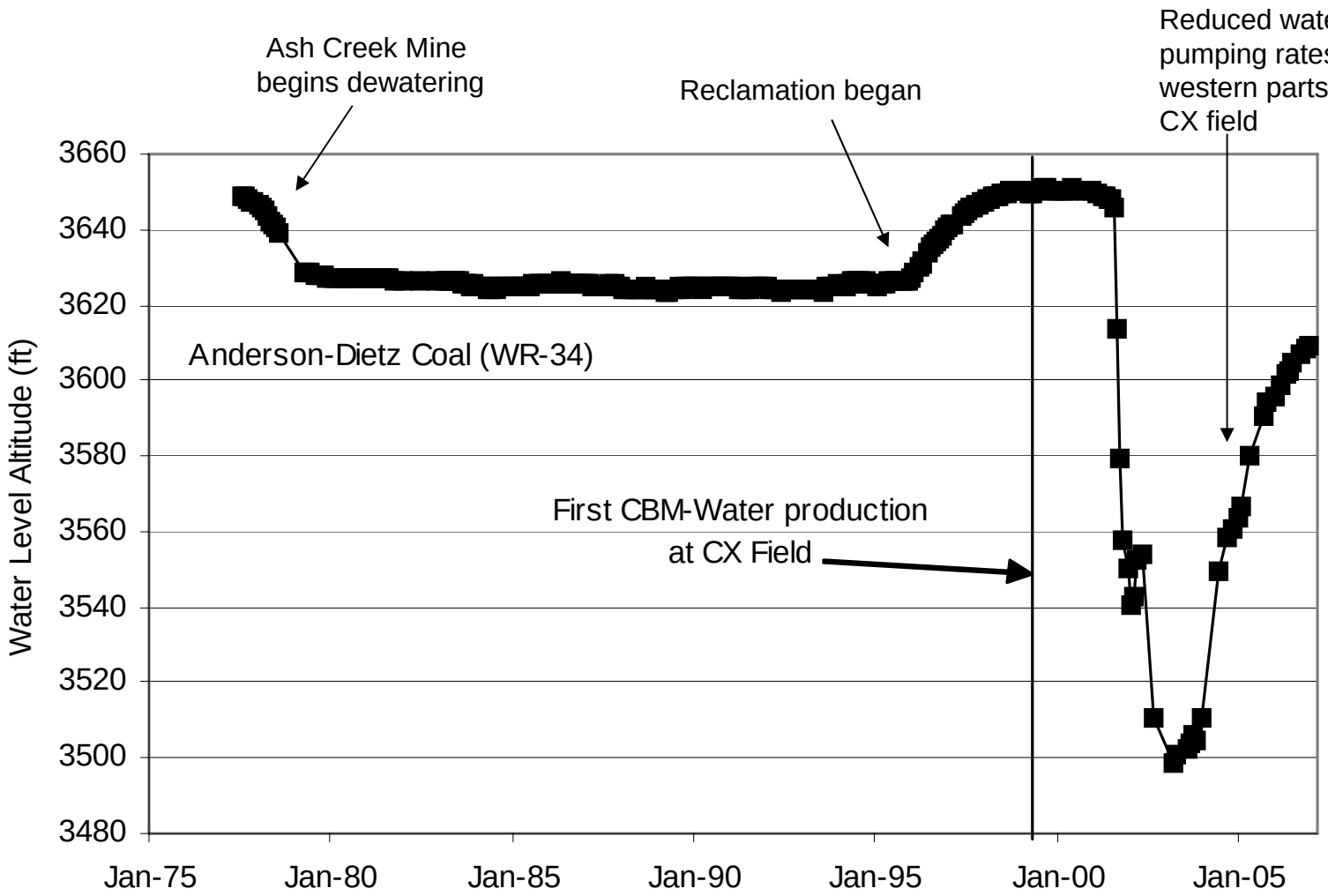
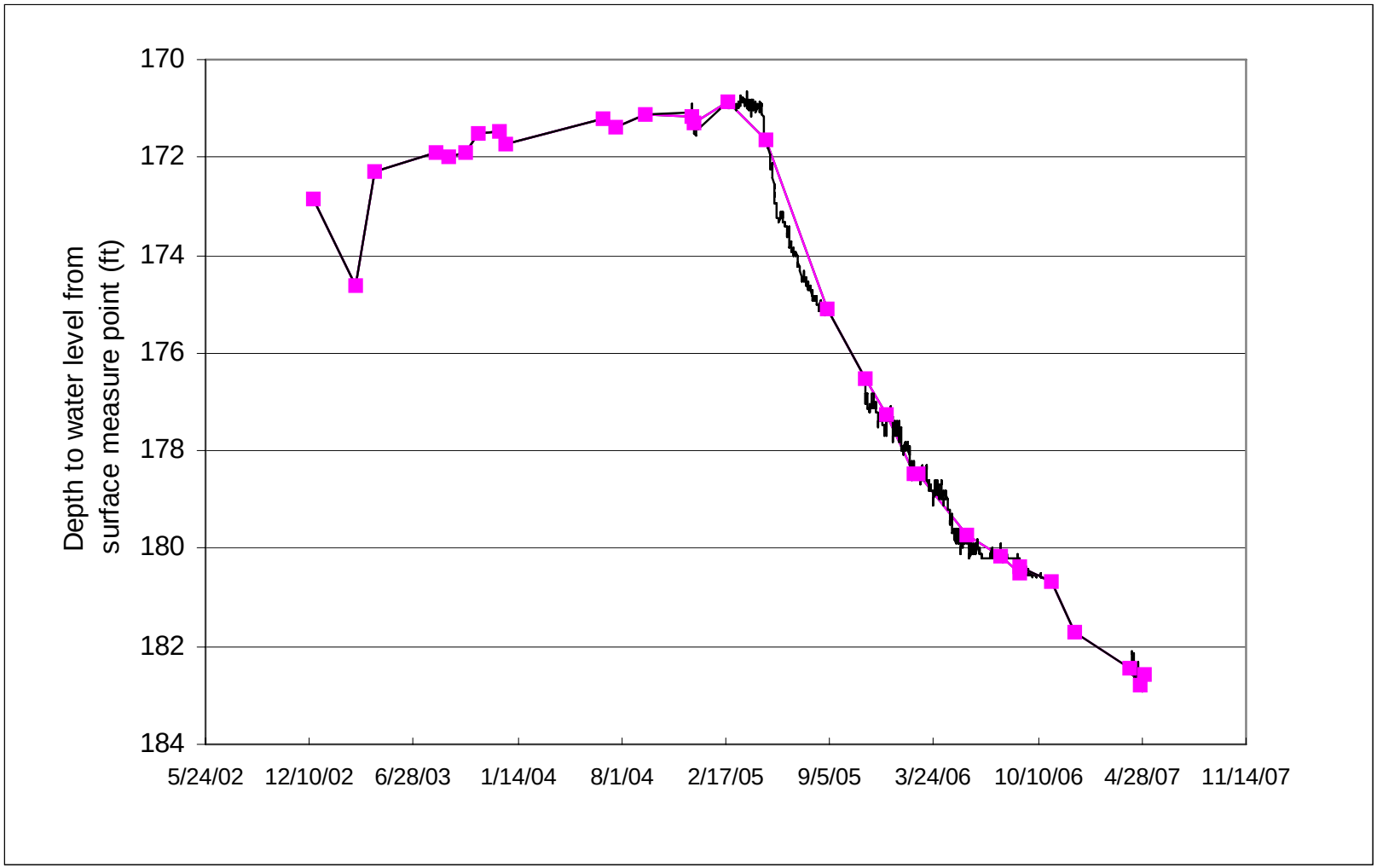


Figure 22. Water levels in the combined Anderson and Dietz coal (WR-34) in the Squirrel Creek area respond to both coal mining and coalbed methane production. The water level recovered during 2004 in response to water production decreases in this portion of the CX field.

Wall Coal well CBM02-4WC

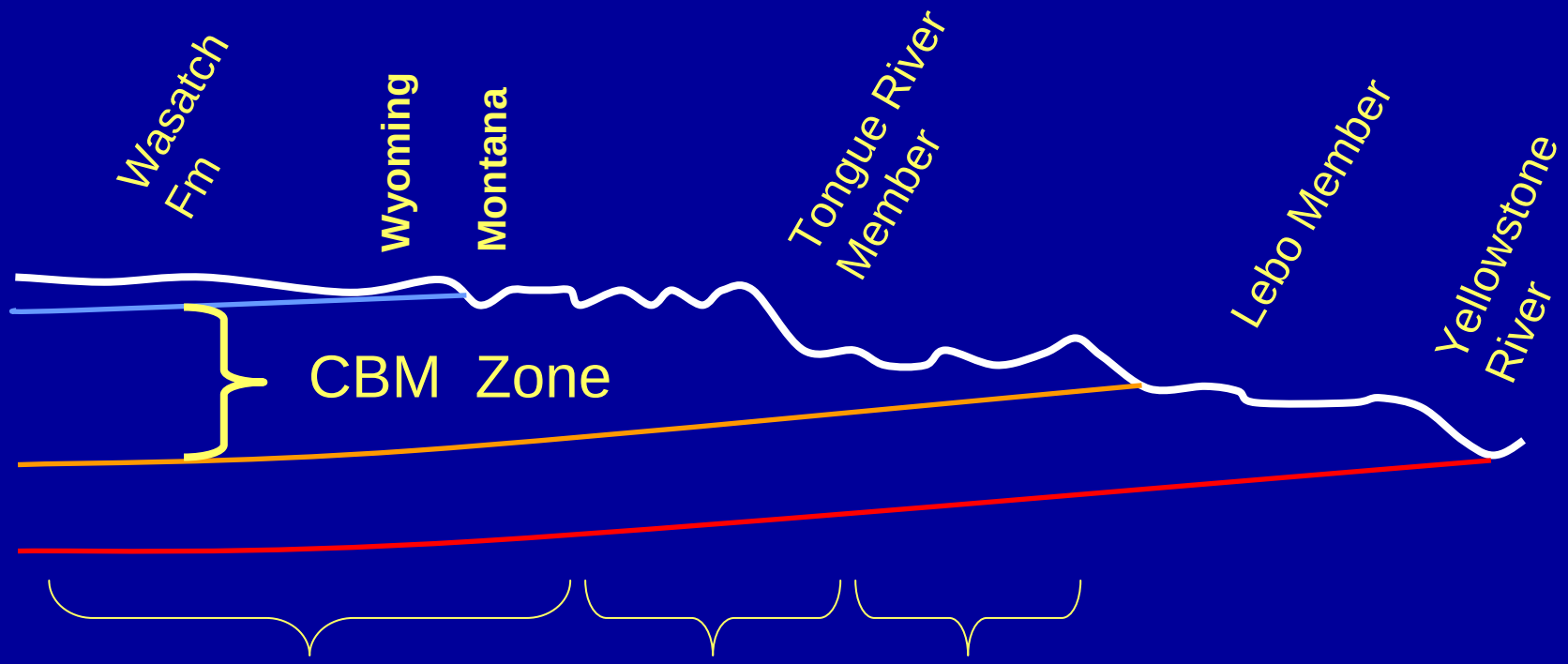


Powder River Basin, Montana

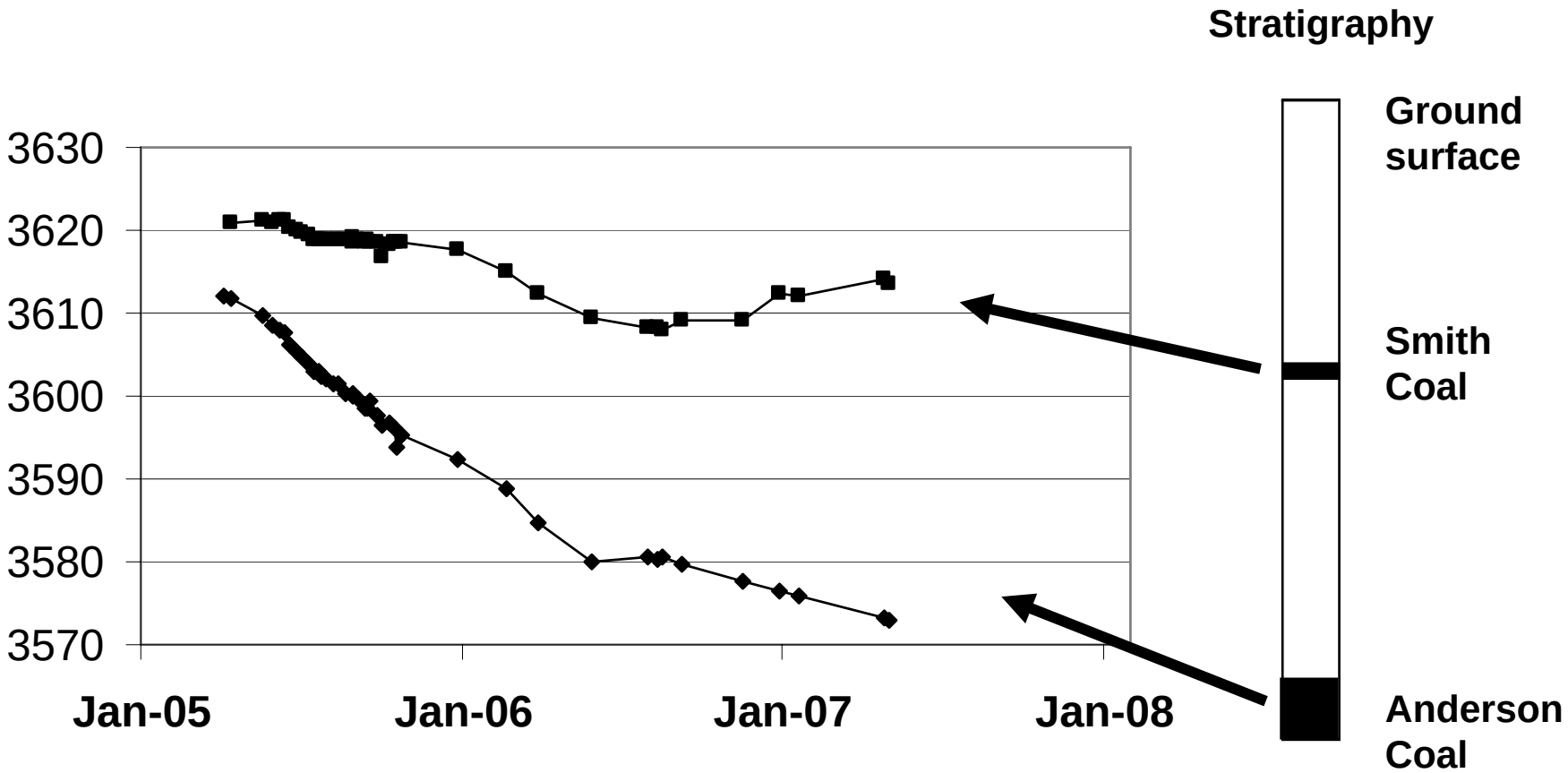
Cross Section 3 South to North

South

North



Potential for CBM Development


Stratigraphy
Ground surface
Smith Coal
Anderson Coal
3630
3620
3610
3600
3590
3580
3570
Jan-05
Jan-06
Jan-07
Jan-08

Montana Coalbed Methane Regional Ground – Water Monitoring Network

Regular site visits and measurements at -

Springs : 28

Monitoring Wells : 200

All data available to you at

http://mbmggwic.mtech.edu/