James Bauder, Department of Land Resources and Environmental Sciences, Montana State University-Bozeman.

The Montana Energy Symposium:
The Energy Future of the West

October 19, 2005
Montana State University

CBM (coalbed methane) and the issue of water management associated with CBM extraction.

Some facts about CBM co-produced water within the Powder River Basin and other locations of significance to the West

Our partners in CBM water management investigations:

Montana Department of Commerce-Technology Transfer, U.S Departments of Energy, Interior and Agriculture, Northern Cheyenne Tribe, Prairie County Conservation District, Buffalo Rapids Irrigation District, the U.S. Environmental Protection Agency.

The Team

Kim Hershberger, Holly Sessoms, Suzanna Roffe, Adam Sigler, Amber Kirkpatrick, Linzy Browning, Adam Toivola

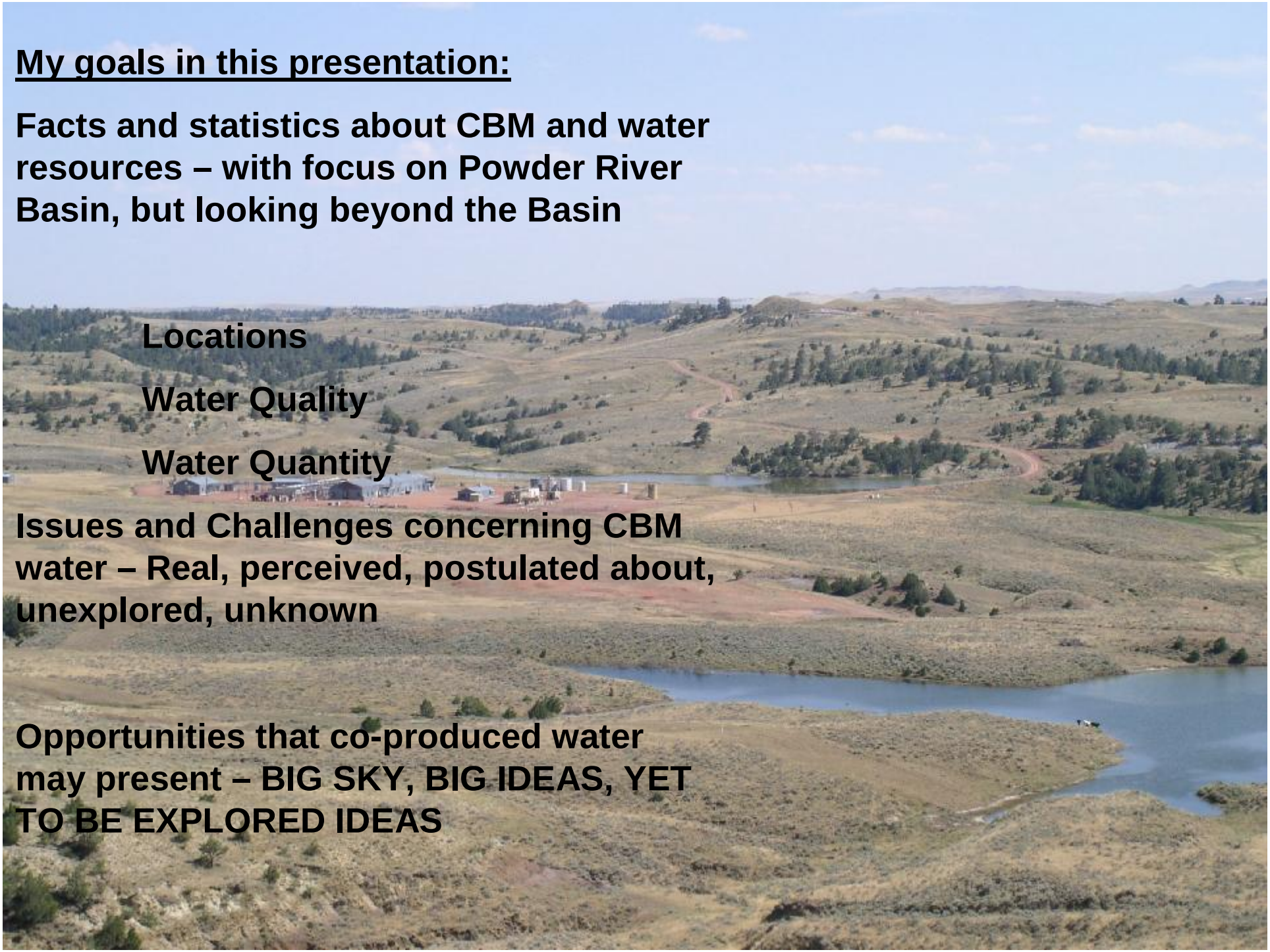
Research Associates

Shannon Phelps, Nikos Warrence, Keri Garver, Kristin Keith, Krista Pearson, Melissa Mitchem, Margaret Buchanan, Alison Todd, Jenny McCabe, Natalie McGowan, Jason Drake, Allison Levy

Faculty & collaborators

Jon Wraith, Doug Dollhopf, Dennis Cash, Ron and Vivian Drake, Tom Keck, Tom Blake, Suzanne Mickelson, John Wheaton, Kevin Harvey, Bill Schafer, Reagan Waskom, Matt Neibauer, Quentin Skinner, Katta J Reddy, Virginia Paige, Nancy Mesner, Grant Cardon

Our efforts focus on surface management of water associated with CBM extraction.



My goals in this presentation:

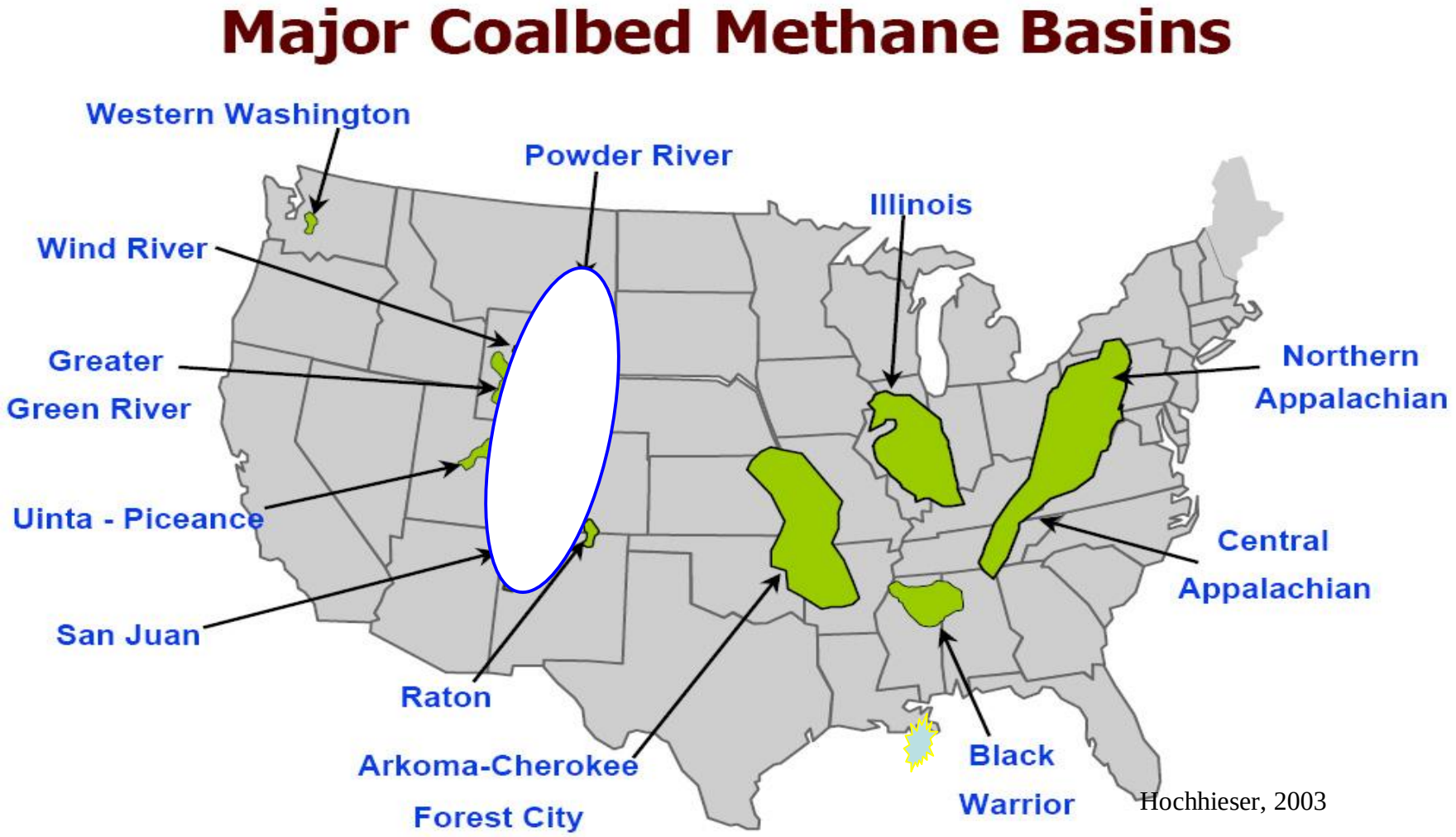
Facts and statistics about CBM and water resources – with focus on Powder River Basin, but looking beyond the Basin

- **Locations**
- **Water Quality**
- **Water Quantity**

Issues and Challenges concerning CBM water – Real, perceived, postulated about, unexplored, unknown

Opportunities that co-produced water may present – BIG SKY, BIG IDEAS, YET TO BE EXPLORED IDEAS

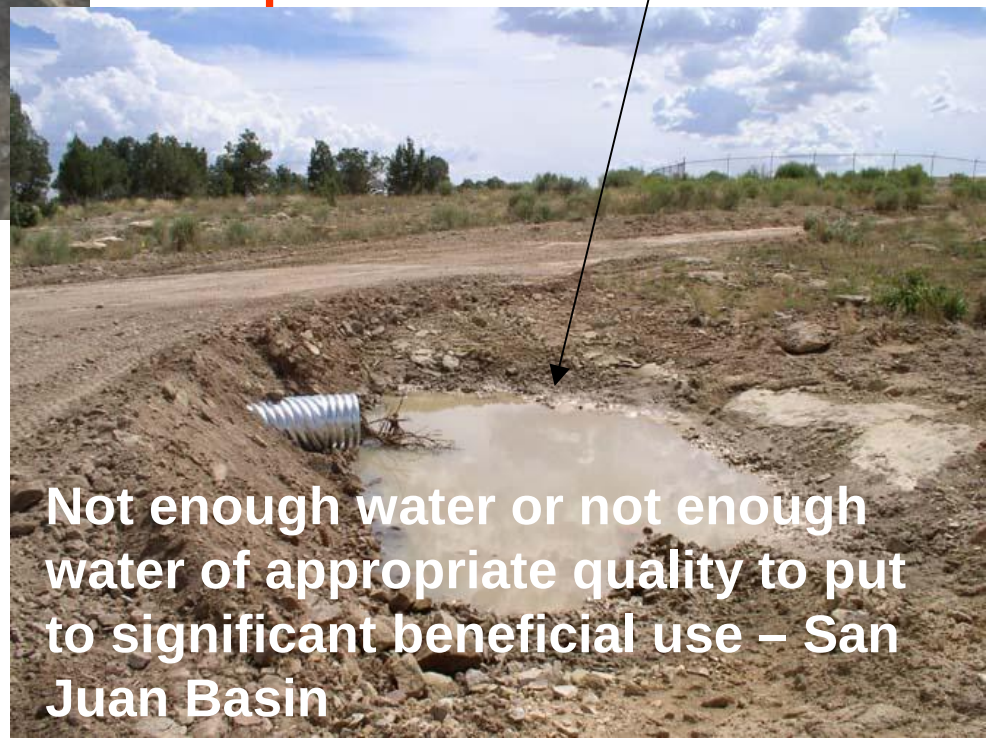
CBM development potential in U.S. as of 2004



Compliments of John Wheaton, MBMG

Fact: There are various ways to look at water and CBM development. Reality is that most CBM co-produced water is managed as a waste product. In some locations – disposal is probably the best option. In other locations….. water management is one of the biggest obstacles to CBM development.

The other situation: Too much water in too many different places, not collectively managed to put to significant beneficial use, either within localized region or interstate – example: Powder River Basin



Not enough water or not enough water of appropriate quality to put to significant beneficial use – San Juan Basin

How much water? CBM Produced Water in the Rocky Mountain Region

- More than 3.5 billion barrels of produced water in 2003.
- Wyoming = 1,901,087,161 bbl (63% of total) = 230,000 acre feet (equivalent to the total volume of Canyon Ferry reservoir). Collectively, it looks like

- New Mexico = 71,750 acre feet
- Colorado = 30,360 acre feet
- Utah = 17,560 acre feet
- Montana = 13,600 acre feet = ½ of 1% of water production. Collectively, it looks like….

Per Well Water, Gas and Water/Gas

North Central Montana Basin MT/AB/SK

?4000bbl/day 80Mcf/day 50bbl/Mcf?

Powder River MT/WY

400bbl/day 145Mcf/day 2.75bbl/Mcf

Uinta UT

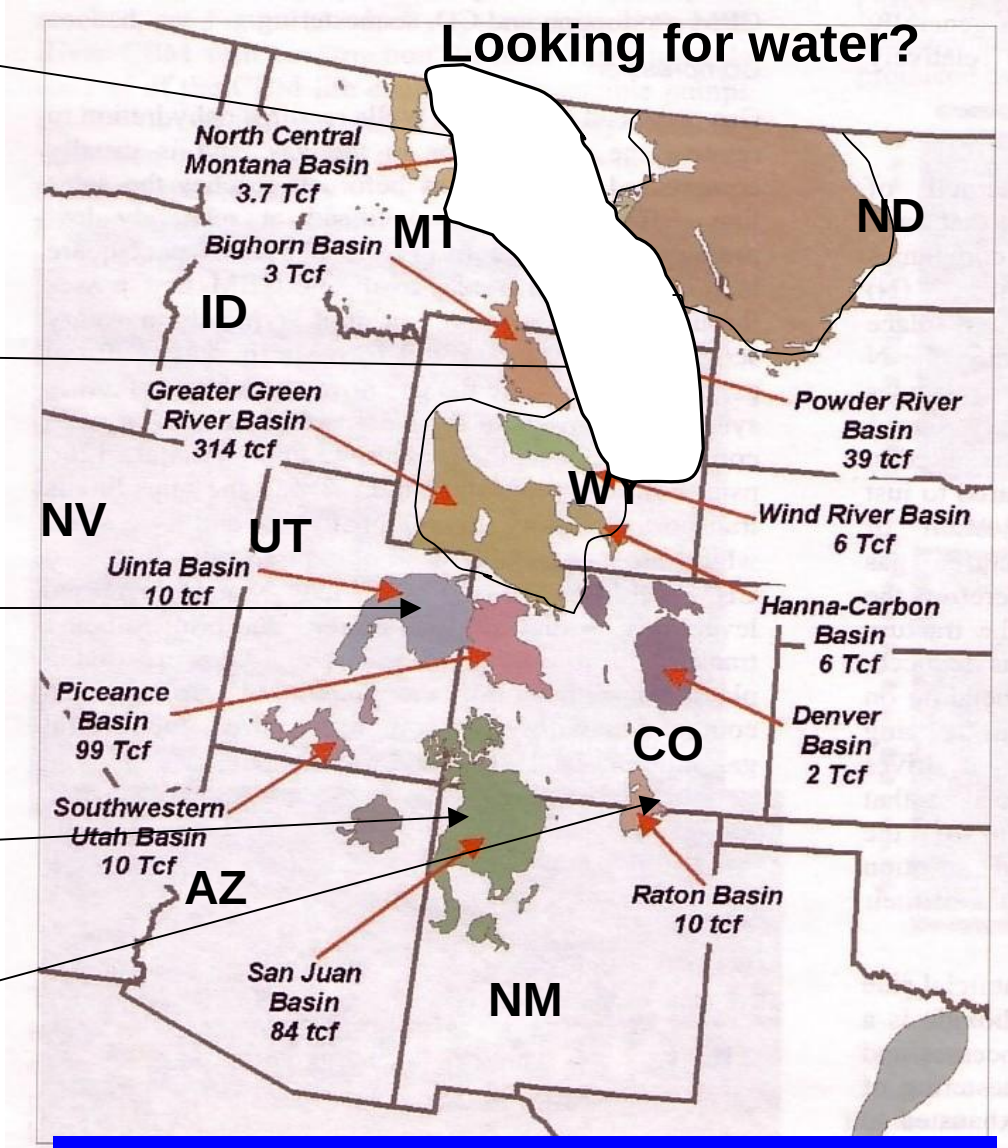
215bbl/day 625Mcf/day 0.34bbl/Mcf

San Juan NM/CO

25bbl/day 2000Mcf/day 0.03bbl/Mcf

Raton NM/CO

266bbl/day 200Mcf/day 1.34bbl/Mcf



Rocky Mountain Region Coal Basins and Estimated CBM Reserves (Nelson, 2000)

Per Well Water, Gas and Water/Gas

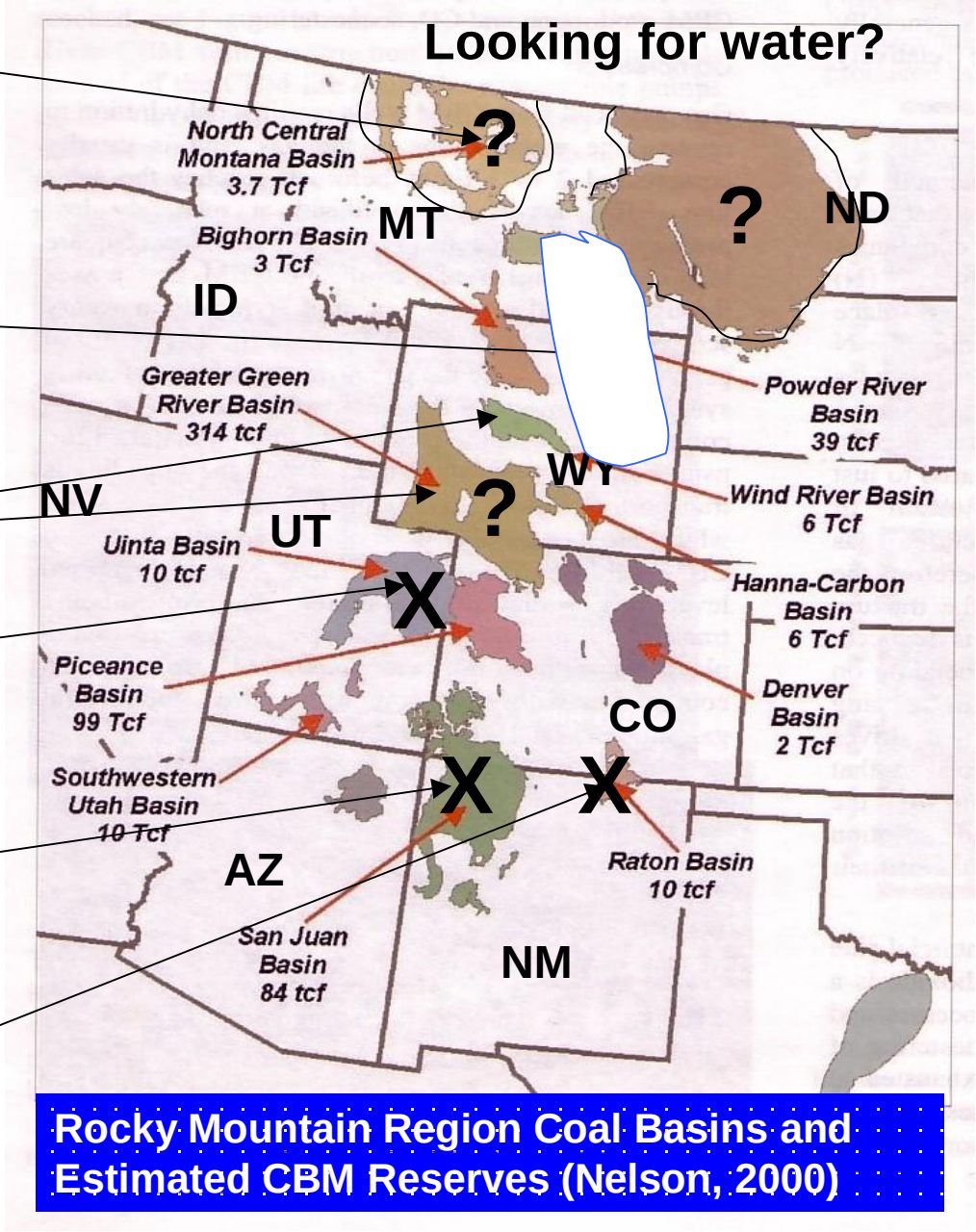
North Central Montana Basin MT/AB/SK: 50bbl/Mcf? Very saline, sulfates, chlorides, treatment needed

Powder River MT/WY: 2.75bbl/Mcf – slightly saline, variable sodicity, bicarbonates, relatively easy to treat and it's probably marketable

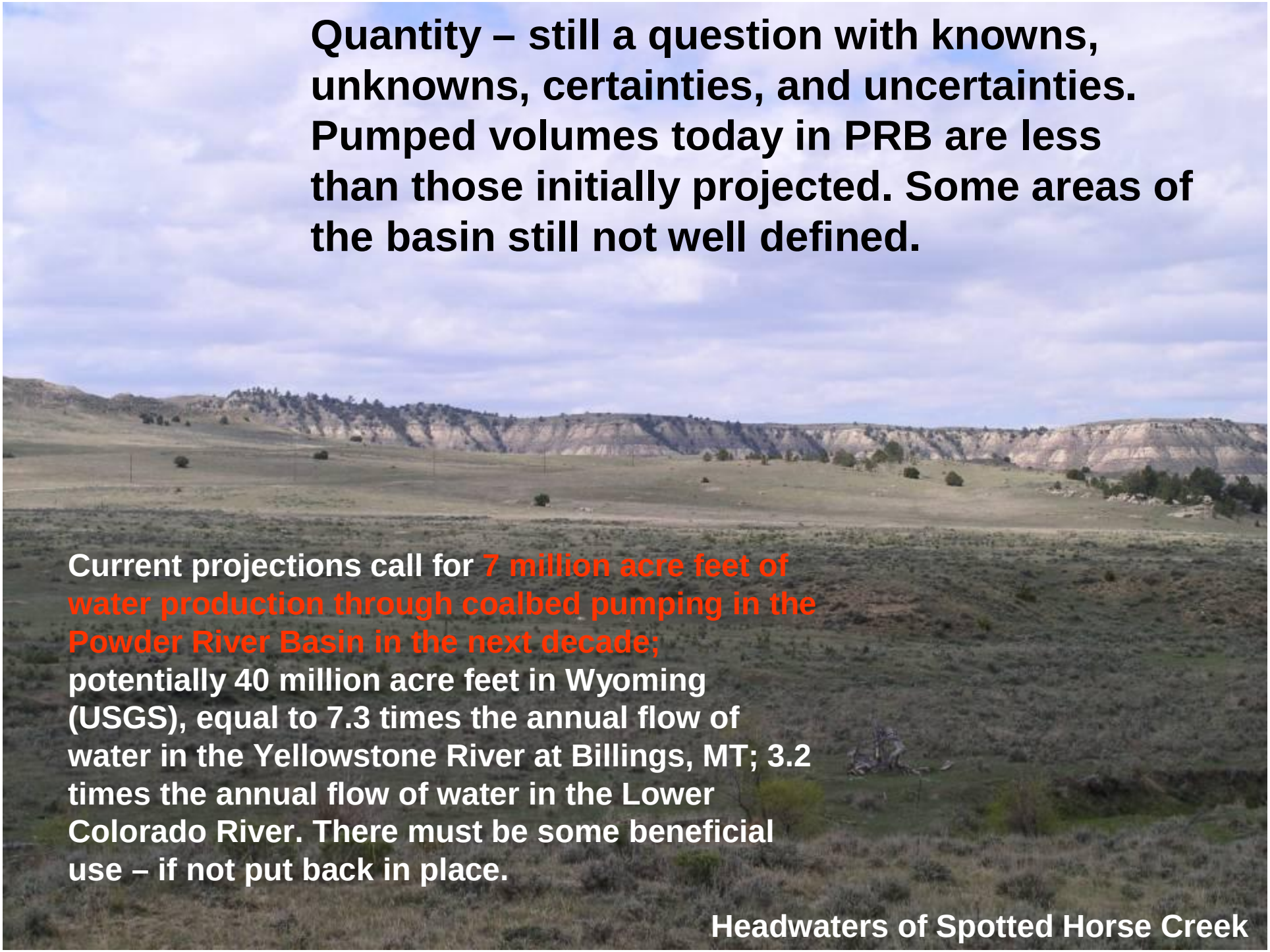
Uinta UT: 0.34bbl/Mcf – very saline, brackish, chlorides, sulfates

San Juan NM/CO: 0.03bbl/Mcf – very saline, brackish, chlorides, sulfates

Raton NM/CO: 1.34bbl/Mcf – very saline, brackish, chlorides, sulfates



Rocky Mountain Region Coal Basins and Estimated CBM Reserves (Nelson, 2000)

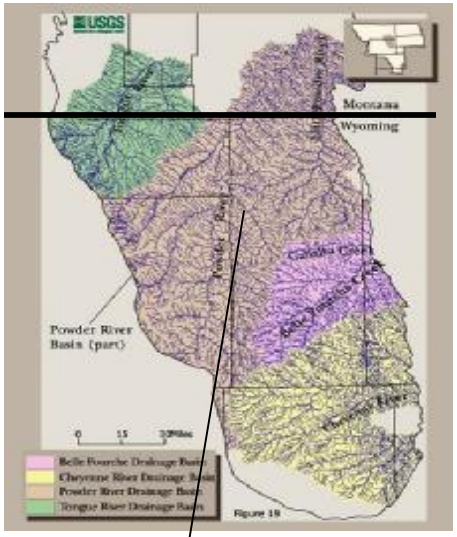


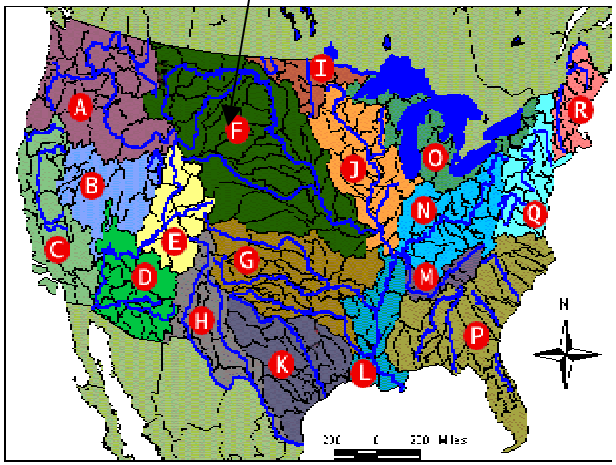
Quantity – still a question with knowns, unknowns, certainties, and uncertainties. Pumped volumes today in PRB are less than those initially projected. Some areas of the basin still not well defined.

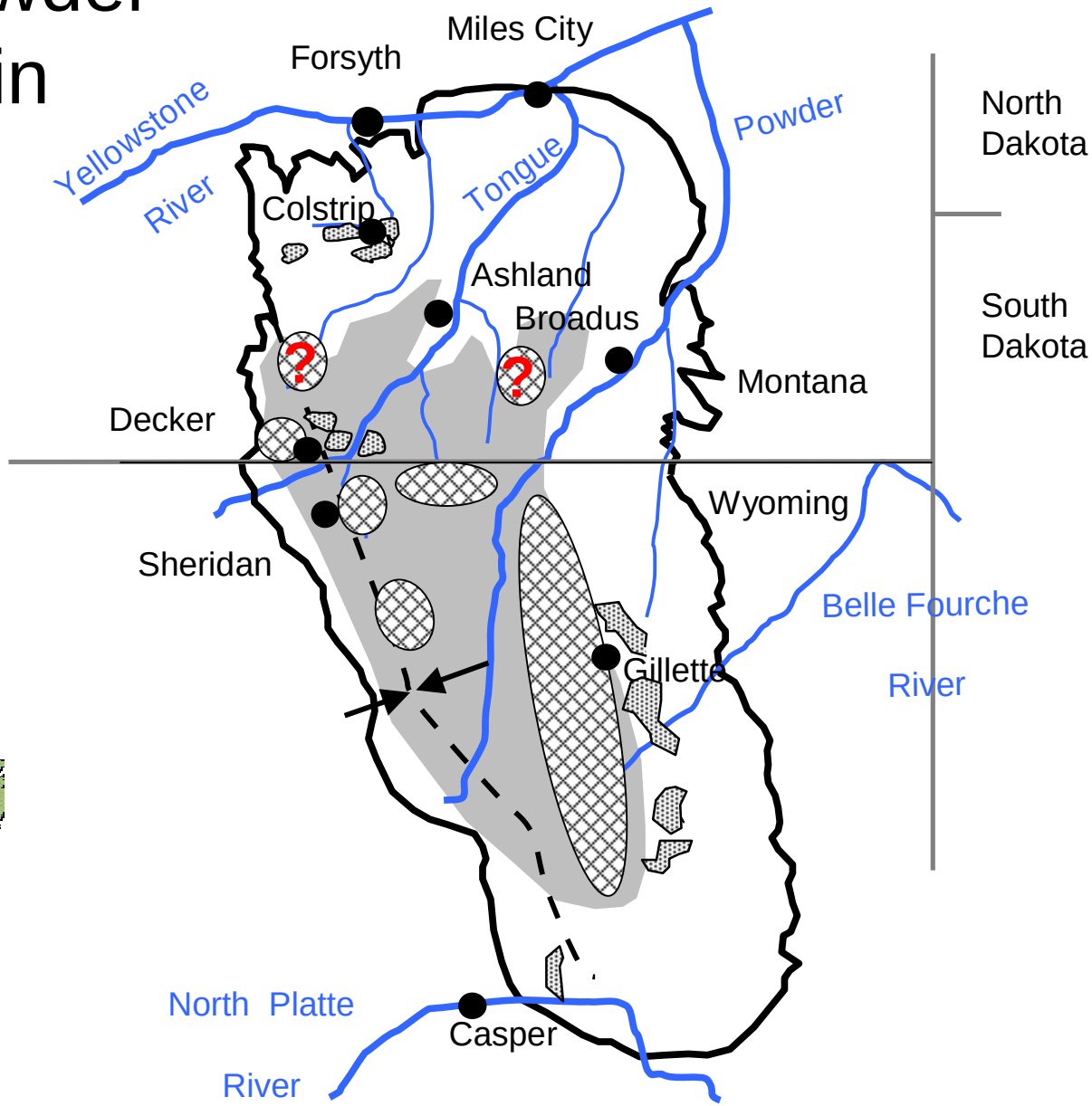
Current projections call for 7 million acre feet of water production through coalbed pumping in the Powder River Basin in the next decade; potentially 40 million acre feet in Wyoming (USGS), equal to 7.3 times the annual flow of water in the Yellowstone River at Billings, MT; 3.2 times the annual flow of water in the Lower Colorado River. There must be some beneficial use – if not put back in place.

Headwaters of Spotted Horse Creek

Focus on Powder River Basin







Each well produces gas and water. Water and gas from pods (clusters) of wells are gathered together in buried pipeline infrastructure.

Water Quantity – Generally, the water is being managed in close proximity to the wells, primarily due to the expense of moving water. This will remain such unless sufficiently large volumes of useable water can be gathered and managed on a watershed x interstate basis.

-Water Quality – chemistry and constituents - can be measured, but ‘usable quality’ is dictated by the intended use – and the most sensitive entity the water comes in contact with.

What does PRB CBM product water look like - in general?

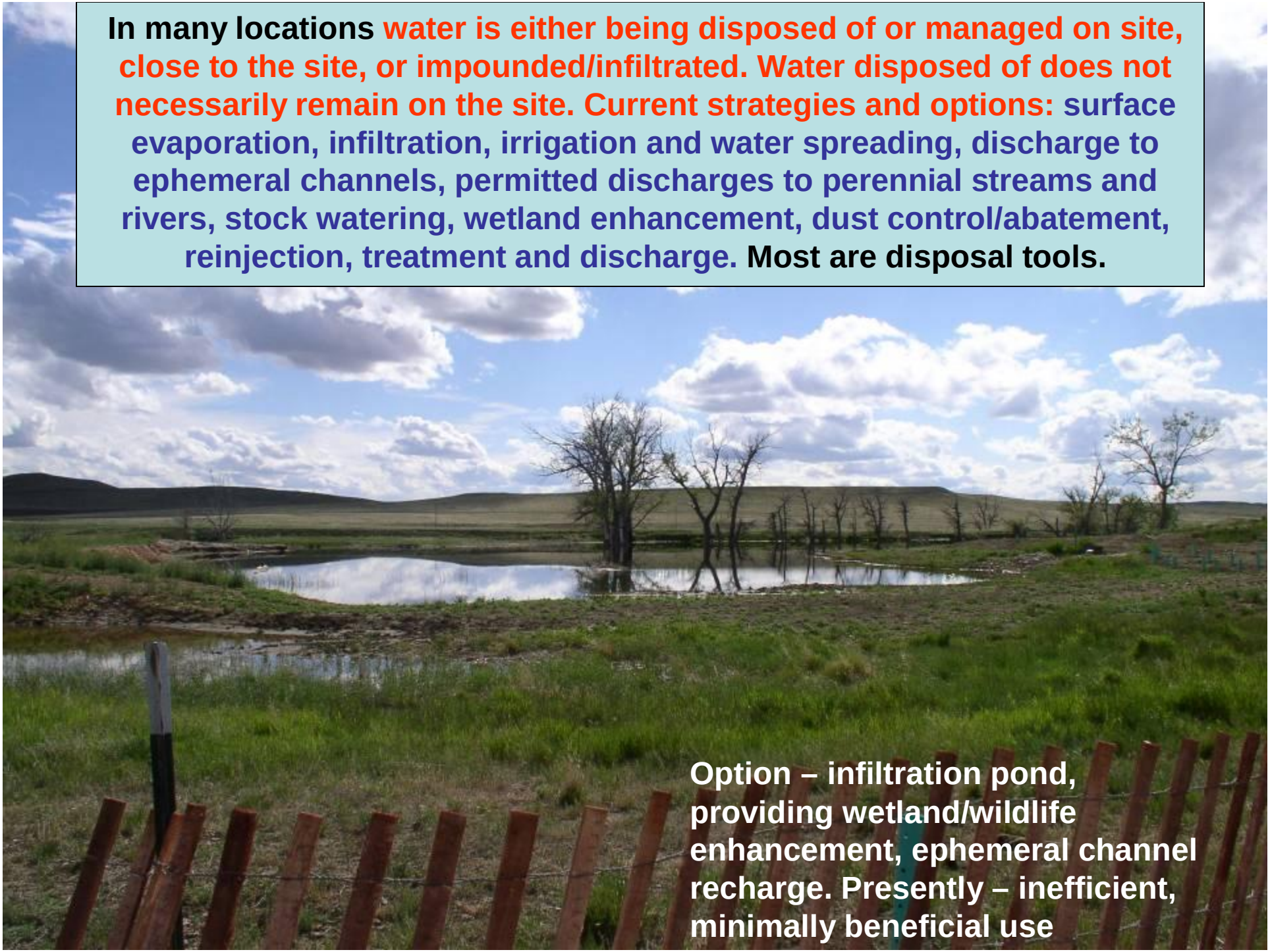
The common signature of PRB coal bed methane product water is low to modest salinity and low to very high sodicity

Primarily sodium bicarbonate.

In areas of thermogenic methane, chemistry is much different, more harsh.

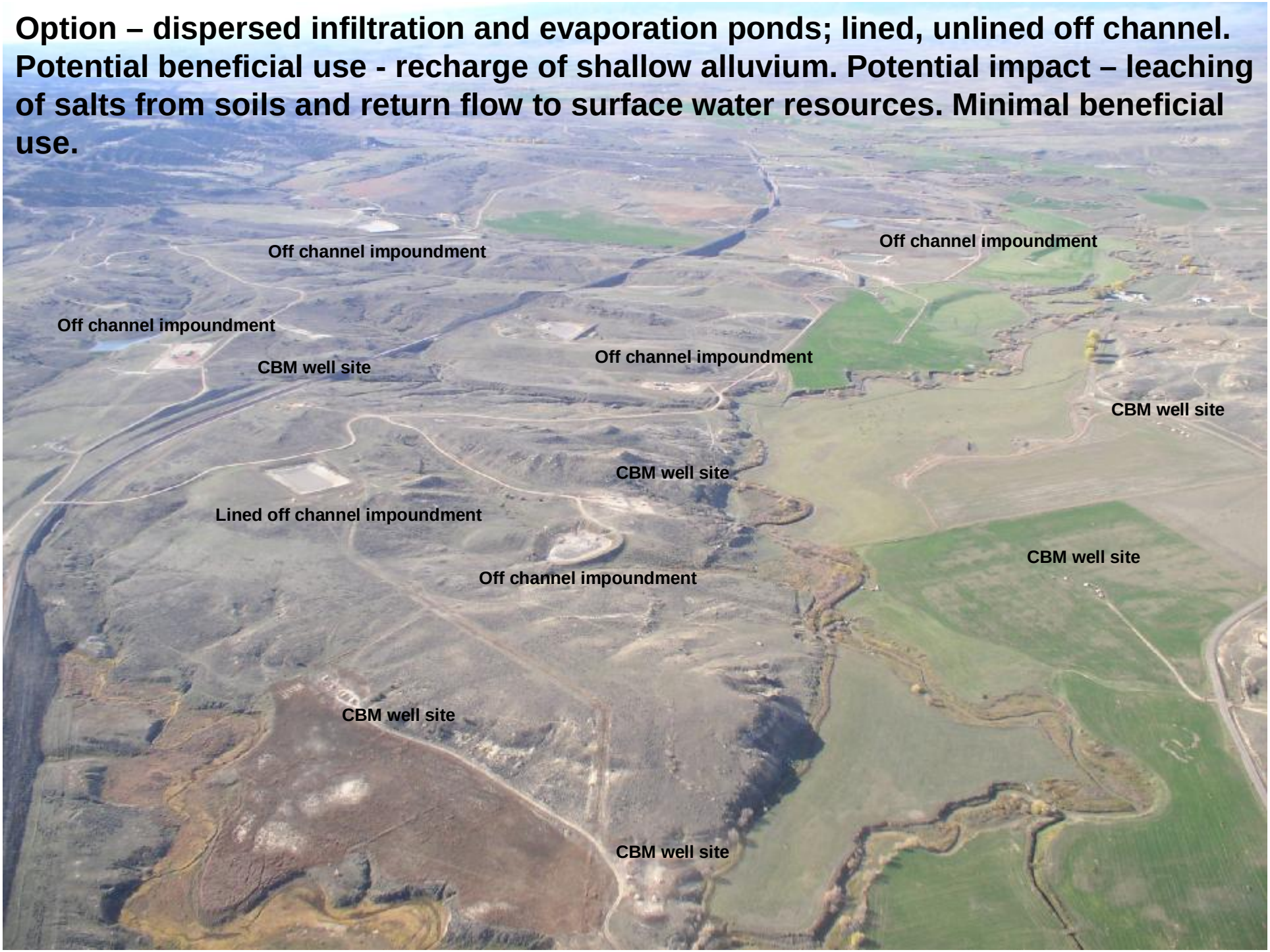
Sodic water is: 1) relatively high in sodium salt concentration compared to other salts – not the amount of sodium but ratio to other salts; 2) typical of most CBM produced water and most waters associated with coal.

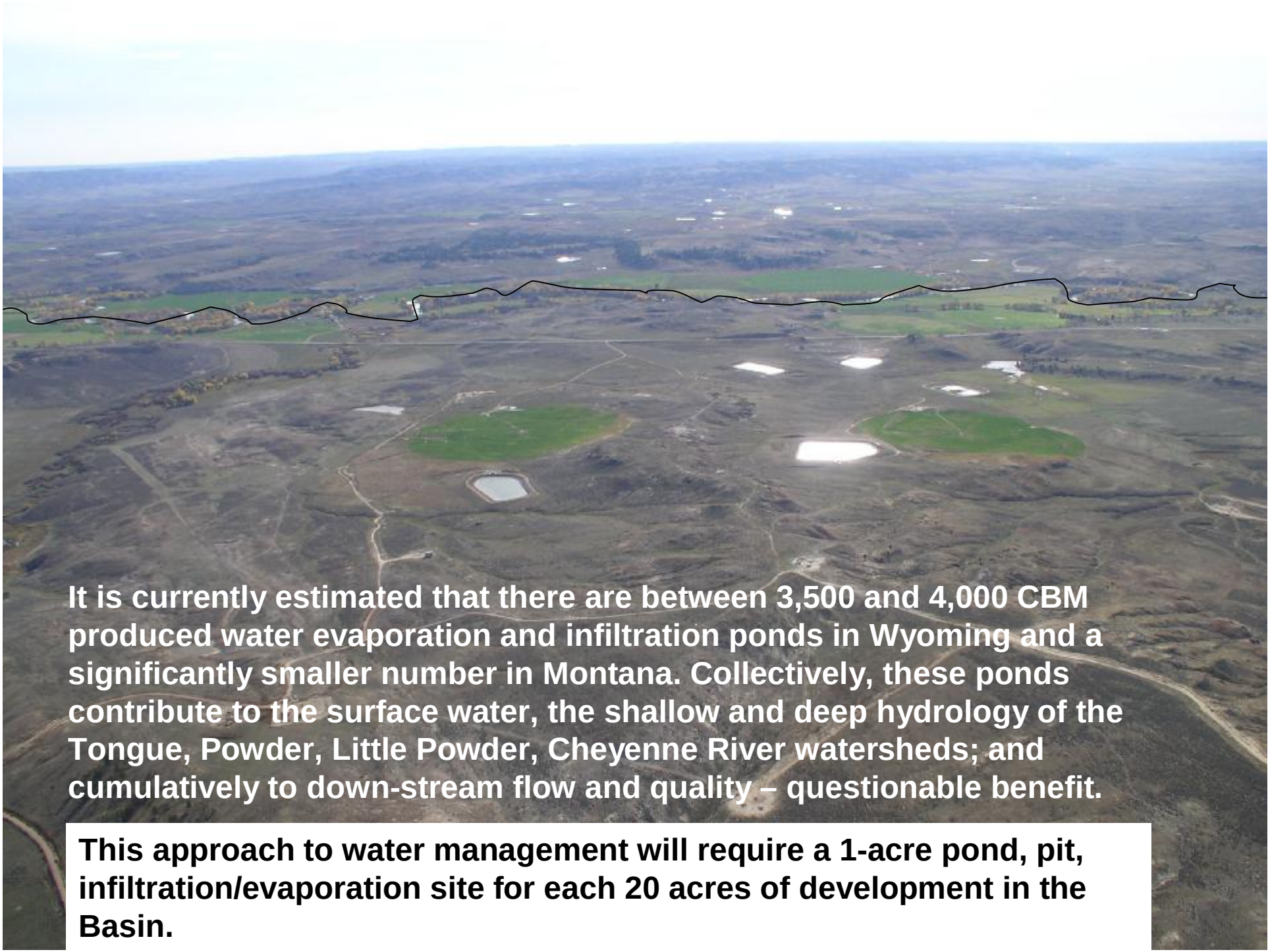
In many locations water is either being disposed of or managed on site, close to the site, or impounded/infiltrated. Water disposed of does not necessarily remain on the site. Current strategies and options: surface evaporation, infiltration, irrigation and water spreading, discharge to ephemeral channels, permitted discharges to perennial streams and rivers, stock watering, wetland enhancement, dust control/abatement, reinjection, treatment and discharge. Most are disposal tools.



Option – infiltration pond, providing wetland/wildlife enhancement, ephemeral channel recharge. Presently – inefficient, minimally beneficial use

Option – dispersed infiltration and evaporation ponds; lined, unlined off channel. Potential beneficial use - recharge of shallow alluvium. Potential impact – leaching of salts from soils and return flow to surface water resources. Minimal beneficial use.



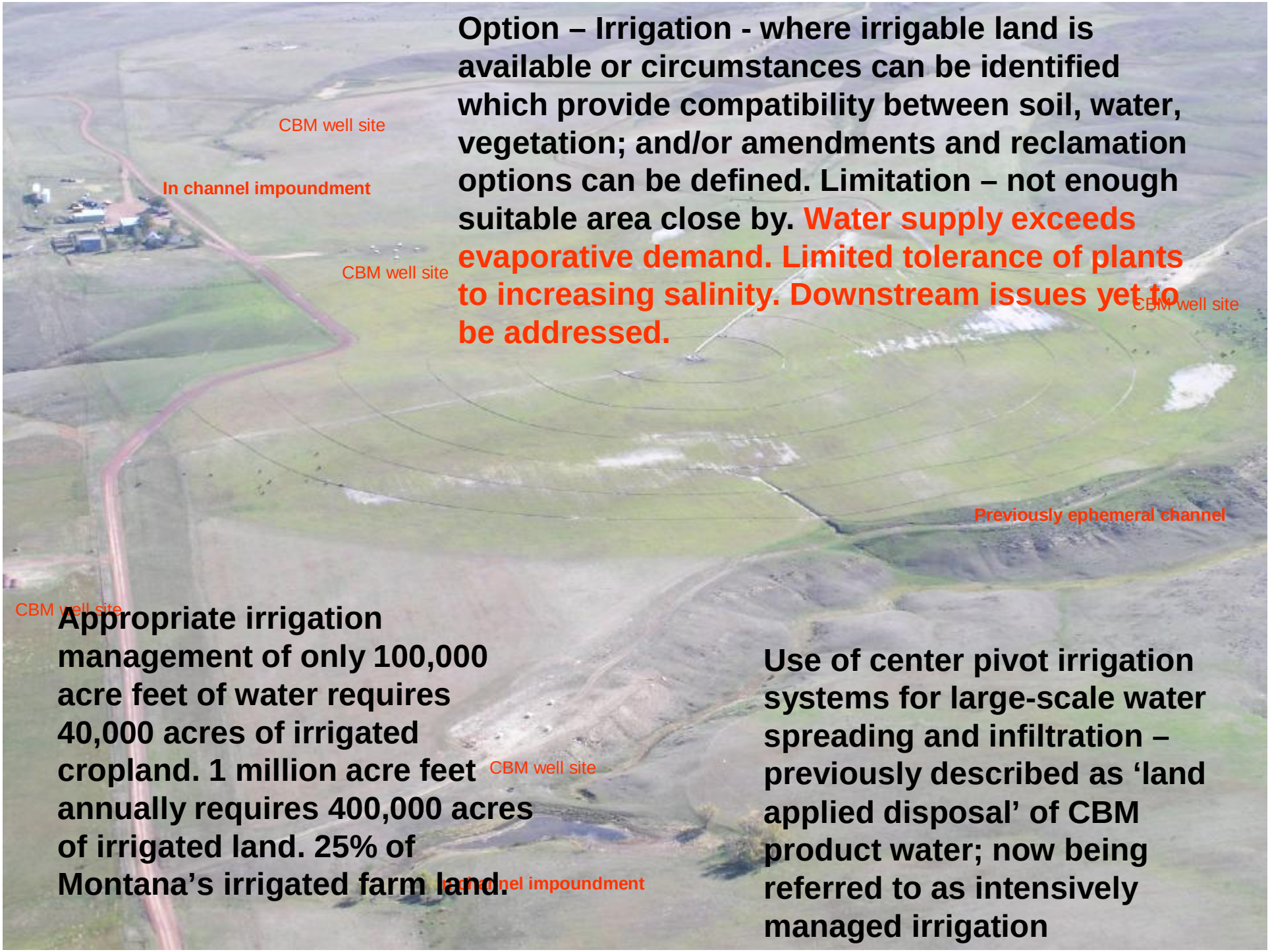


It is currently estimated that there are between 3,500 and 4,000 CBM produced water evaporation and infiltration ponds in Wyoming and a significantly smaller number in Montana. Collectively, these ponds contribute to the surface water, the shallow and deep hydrology of the Tongue, Powder, Little Powder, Cheyenne River watersheds; and cumulatively to down-stream flow and quality – questionable benefit.

This approach to water management will require a 1-acre pond, pit, infiltration/evaporation site for each 20 acres of development in the Basin.

Irrigating with CBM product water

- **In the Powder River Basin, most CBM discharge water in the eastern and southern portions of the basin would be suitable for irrigation on most soil types; in the northern portion of the basin, the salinity/sodicity combination makes it challenging for long-term irrigation and, in some cases, unsuitable for irrigation. Generally, there is not enough irrigable land in the development area to accommodate the projected CBM waters – on site.**



Option – Irrigation - where irrigable land is available or circumstances can be identified which provide compatibility between soil, water, vegetation; and/or amendments and reclamation options can be defined. Limitation – not enough suitable area close by. Water supply exceeds evaporative demand. Limited tolerance of plants to increasing salinity. Downstream issues yet to be addressed.

Appropriate irrigation management of only 100,000 acre feet of water requires 40,000 acres of irrigated cropland. 1 million acre feet annually requires 400,000 acres of irrigated land. 25% of Montana's irrigated farm land.

Use of center pivot irrigation systems for large-scale water spreading and infiltration – previously described as 'land applied disposal' of CBM product water; now being referred to as intensively managed irrigation

• About irrigation

- **All irrigation water – regardless of source – has some dissolved salt. All irrigation requires some type of salt management plan – moving the salt beyond the point of water application – into the soil profile, into the aquifer, into the drainage system. All irrigation requires drainage.**

- **Excess irrigation water will leach salts derived from CBM product water and salts geologically accumulated in the soil profile. (off-site)**

- **Salinity can be managed – managed leaching, dependable supplies of water; consideration for downstream consequences. Irrigation doesn't come without a price.**

- **Downstream considerations need to be attended to – must be dealt with on a far-reaching watershed basis. Examples: Lower Colorado River, New Fork River, Breede River, Tongue River, Powder River. The PRB is headwaters of the Missouri River watershed.**

Treatment or (re)injection of CBM product water as an option

What quality of water or cost is acceptable? What cost justifies reinjection? What happens to the treated water? After the water is treated – then what? Treatment options – several available and in place at present. At a price. Reinjection being tried and used in some locations. But, even after treatment – the water still needs to be dealt with – either disposed of, managed, or put to beneficial use.

The water issue – what are some of the expressed issues?

-**Too much water in too few places**

-**Too dispersed to easily manage collectively**

-**Debatable suitability of quality to be used exclusively as a sole source water supply**

-**Uncertainties of longer-term availability and consequences of long-term use on site**

-**Some people want the water; some people don't want the water – but both in the same watershed**

-**Questionable short and long-term cumulative impacts – to existing water resources and to down stream water rights holders, down stream water users**

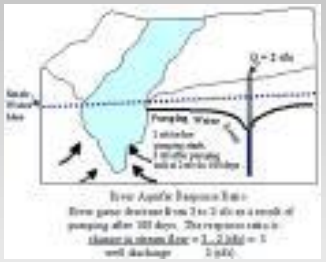
-**Externalities**

Other debated platforms and expressed issues

Weeds, invasive plants, noxious weeds

Water rights impairments, water marketing

Surface access issues, water trespass



Aquifer depletion

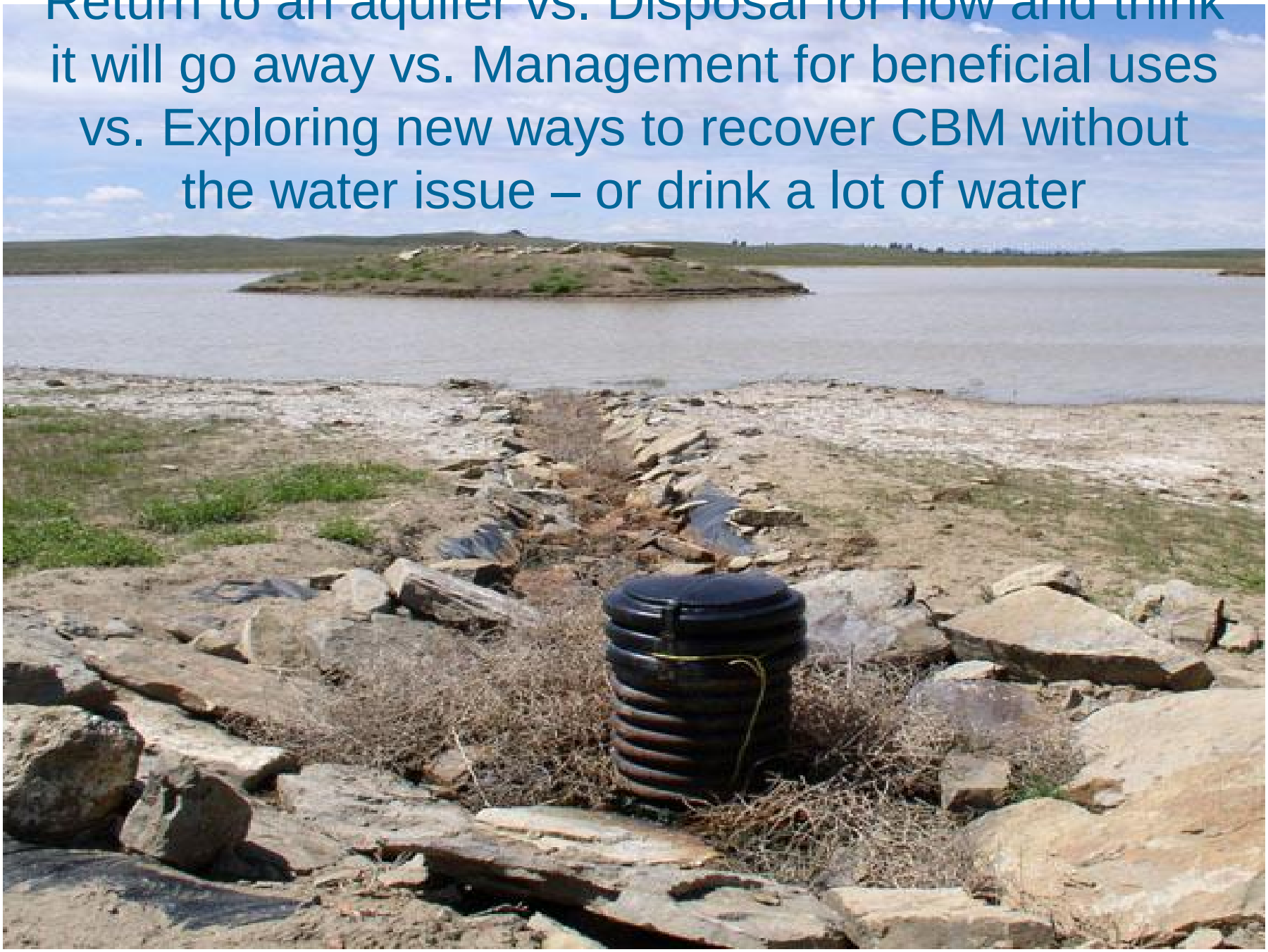
Aquifer interactions, wells, springs

Down gradient saline seeps, discharges

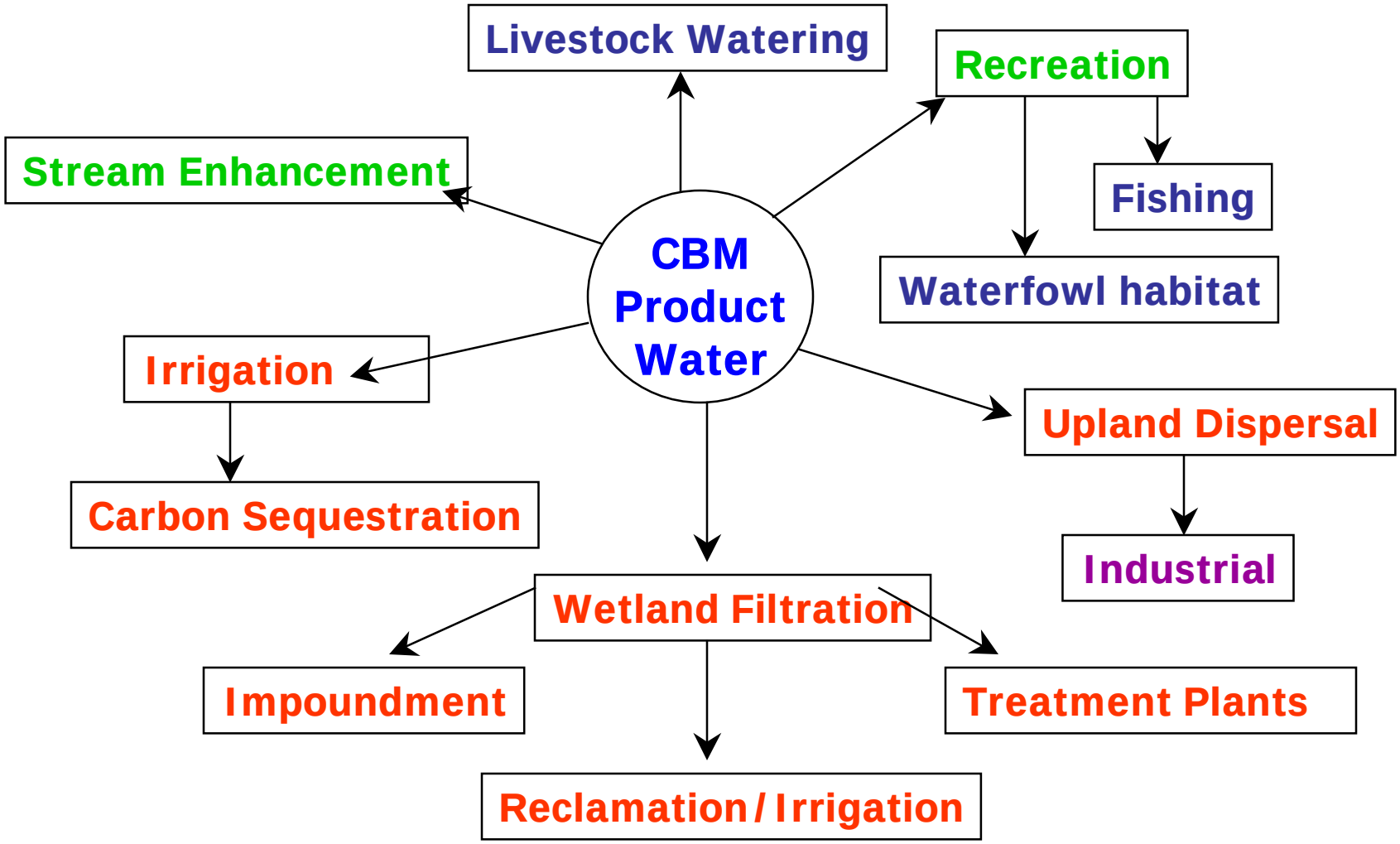
Fisheries and aquatic life

Resource waste/aquifer depletion

Return to an aquifer vs. Disposal for now and think it will go away vs. Management for beneficial uses vs. Exploring new ways to recover CBM without the water issue – or drink a lot of water



Beneficial Uses of CBM Product Water
Small Scale – Close to the Source



CBM Product Water
The Governor's Challenge
Thinking beyond traditional

Opportunities to be investigated – what can be done with this water

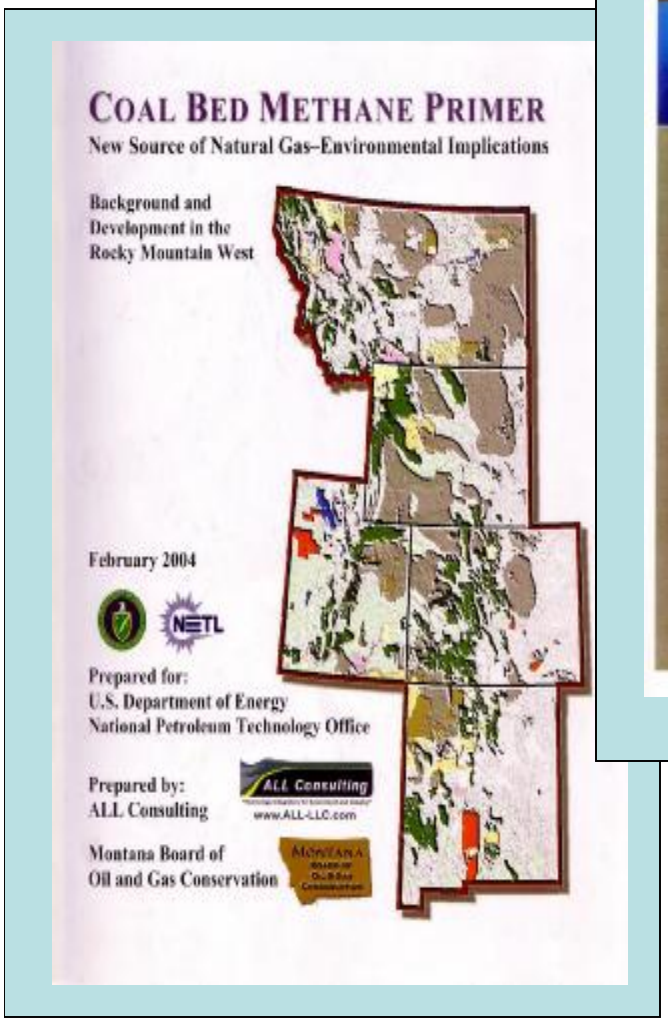
- **Biomass production – An Alternative energy source**
  - **Biofuel**
  - **Ethanol**
  - **Co-mingled energy source, i.e., coal x X fired power**
  - **Terrestrial carbon sequestration**
- **Geologic carbon sequestration**
- **Coalbed methane regeneration**
- **Agricultural Industry augmentation/support**
  - **Rangeland forage production and utilization**
  - **Site-specific livestock forage production**
  - **Supplemental/conjunctive water for irrigation**
- **Downstream irrigation supply enhancement**
- **Stream flow augmentation**
- **Wetland habitat enhancement/expansion**
- **Wildlife habitat enhancement**

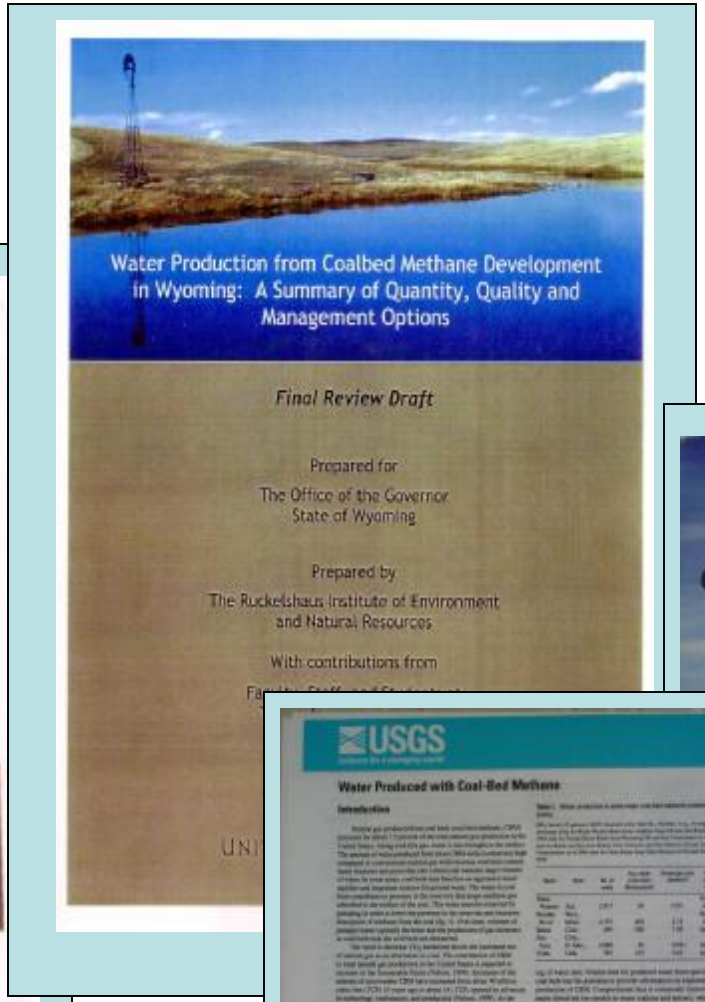
CBM Product Water
The Governor's Challenge
Thinking beyond traditional

Opportunities to be investigated – what can be done with this water

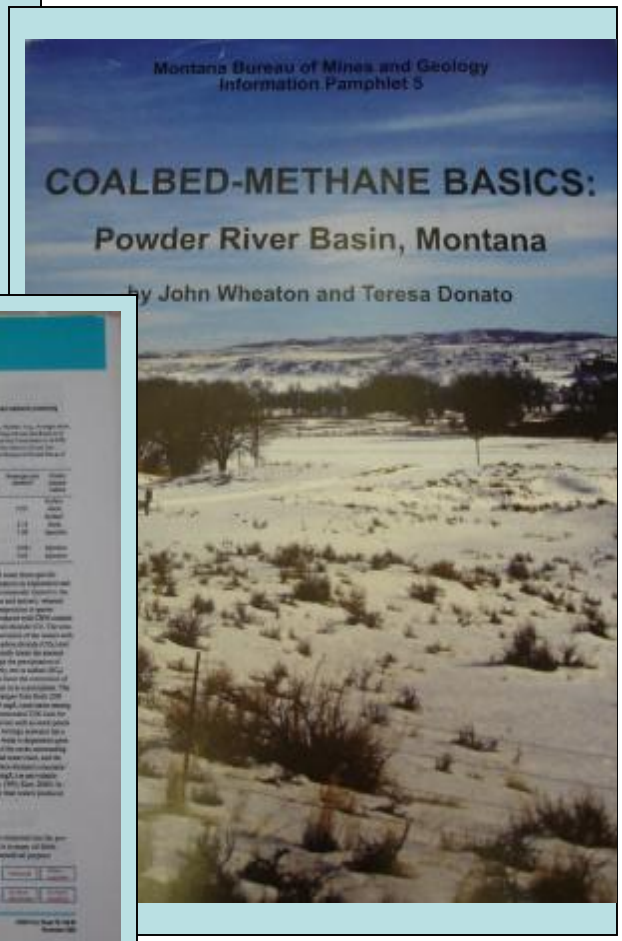
- **Coal slurry transmission**
- **Coal gasification**
- **Future water resource supply enhancement**
- **Aquifer enhancement/transfer and storage**
- **Downstream water marketing**

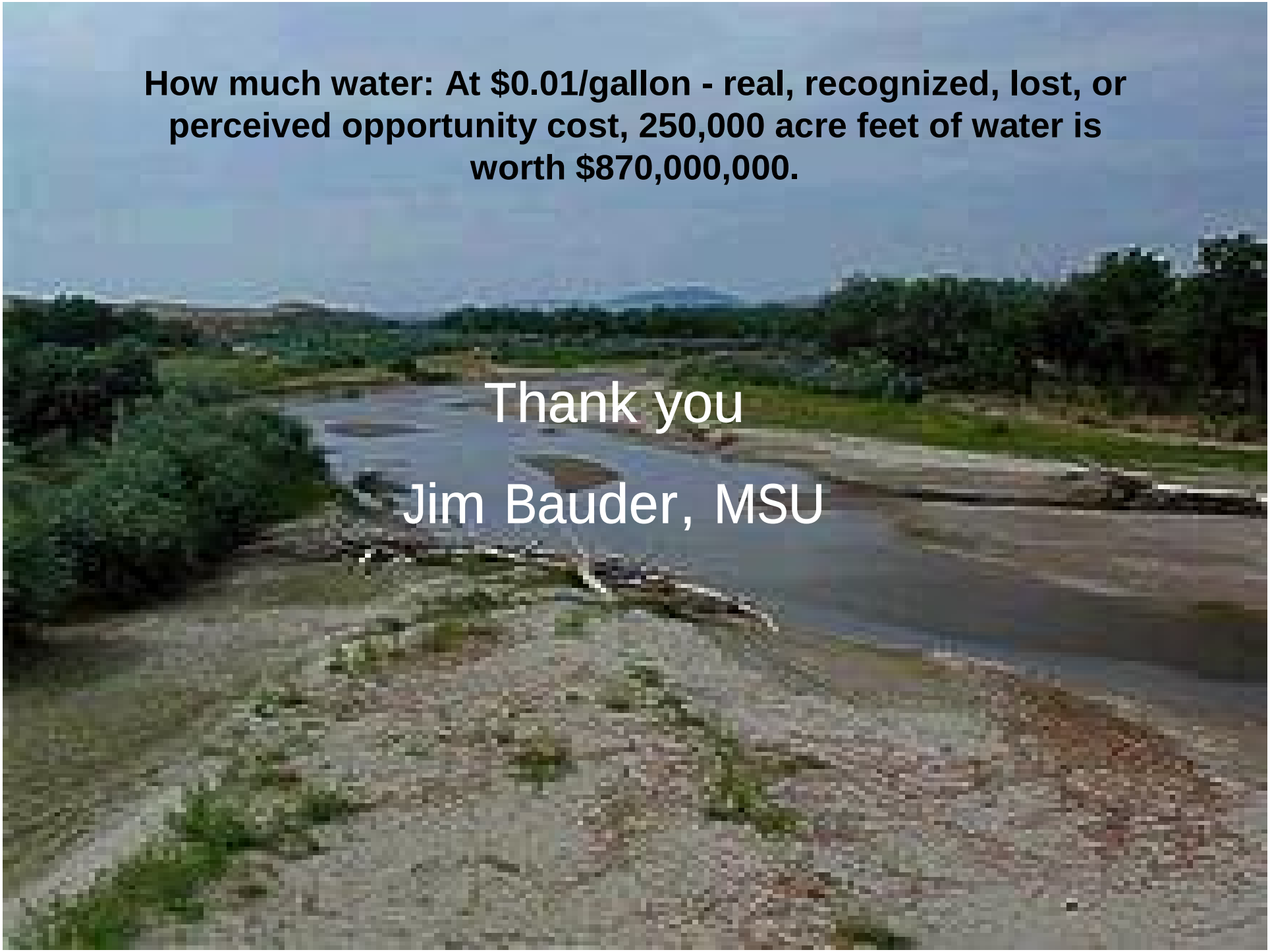
Presently, CBM co-produced water is viewed and treated as a waste product – dispose of at the least possible cost. CBM co-produced water is managed and dealt with either on a well-by-well, site-by-site, or development project-by-project basis. A well-conceived and regional plan, on a watershed x basin scale, with interstate collaboration (not just WY and MT) needs to be developed. CBM co-produced water needs to be managed as acomponent and an issue to be addresses in the plan for the Energy Future of the West. Either we deal with it now or we will use some of our 'energy' in the future to correct the aftermath.


COAL BED METHANE PRIMER
New Source of Natural Gas–Environmental Implications
Background and Development in the Rocky Mountain West
February 2004
NETL
Prepared for:
U.S. Department of Energy
National Petroleum Technology Office
Prepared by:
ALL Consulting
ALL Consulting
www.ALL-LLC.com
Montana Board of Oil and Gas Conservation
MONTANA


Water Production from Coalbed Methane Development in Wyoming: A Summary of Quantity, Quality and Management Options
Final Review Draft
Prepared for
The Office of the Governor
State of Wyoming
Prepared by
The Ruckelshaus Institute of Environment and Natural Resources
With contributions from


USGS
Water Produced with Coal-Bed Methane
Introduction
Volumes and Compositions of CBM Water


Montana Bureau of Mines and Geology
Information Pamphlet 5
COALBED-METHANE BASICS:
Powder River Basin, Montana
by John Wheaton and Teresa Donato


How much water: At $0.01/gallon - real, recognized, lost, or perceived opportunity cost, 250,000 acre feet of water is worth $870,000,000.
Thank you
Jim Bauder, MSU