

Coalbed Methane: Evaluation of Produced Water Infiltration Ponds

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General Concepts:

- **Infiltrated water flows through weathered overburden material**
- **TDS load increases due to dissolution, ion exchange and oxidation reactions**
- **With time, salt load decreases as soluble minerals are flushed**
- **Knowing these changes is critical for siting ponds**

KNOWN REACTIONS ALONG FLOW PATHS IN THE FORT UNION FORMATION

Calcite
dissolution

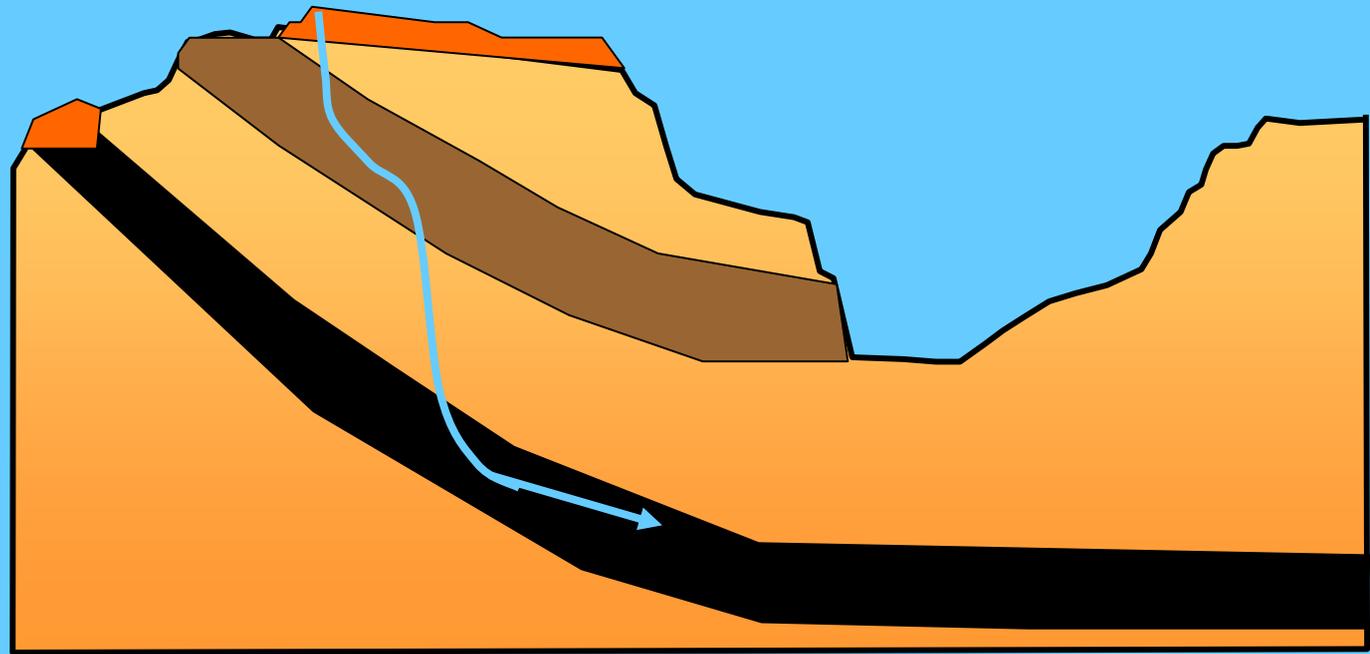
Gypsum
dissolution

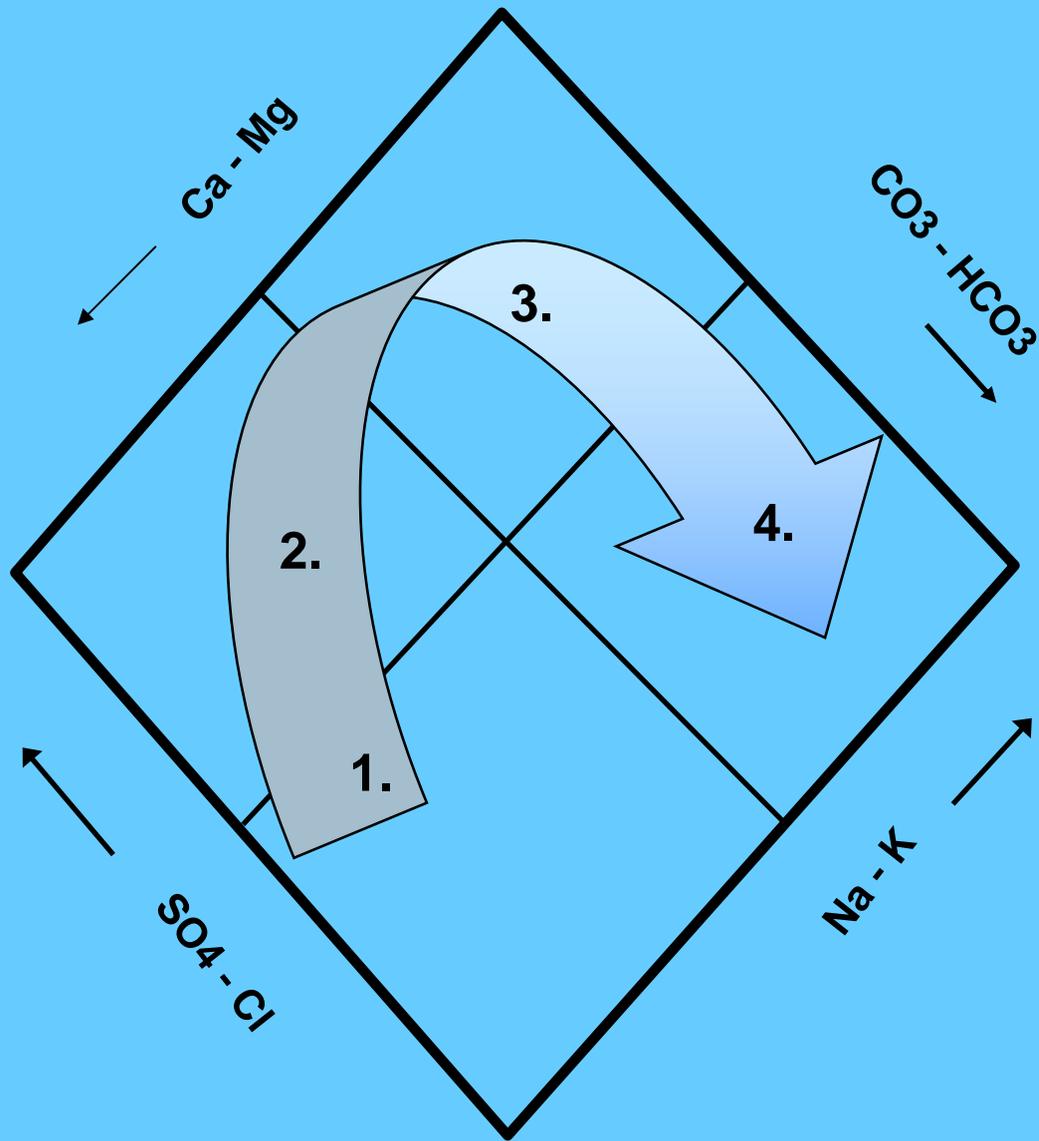
Sulfide
oxidation

Ion
Exchange

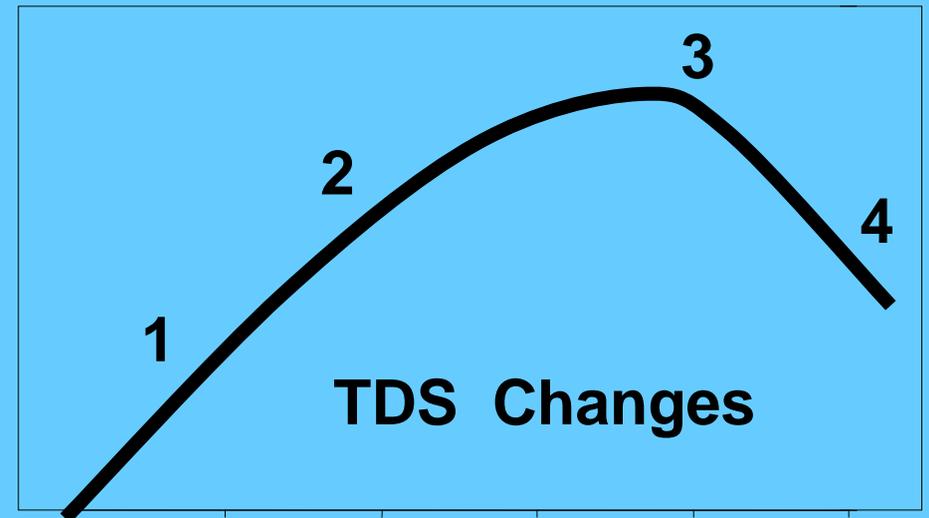
Sulfate
reduction

Calcite
precipitation





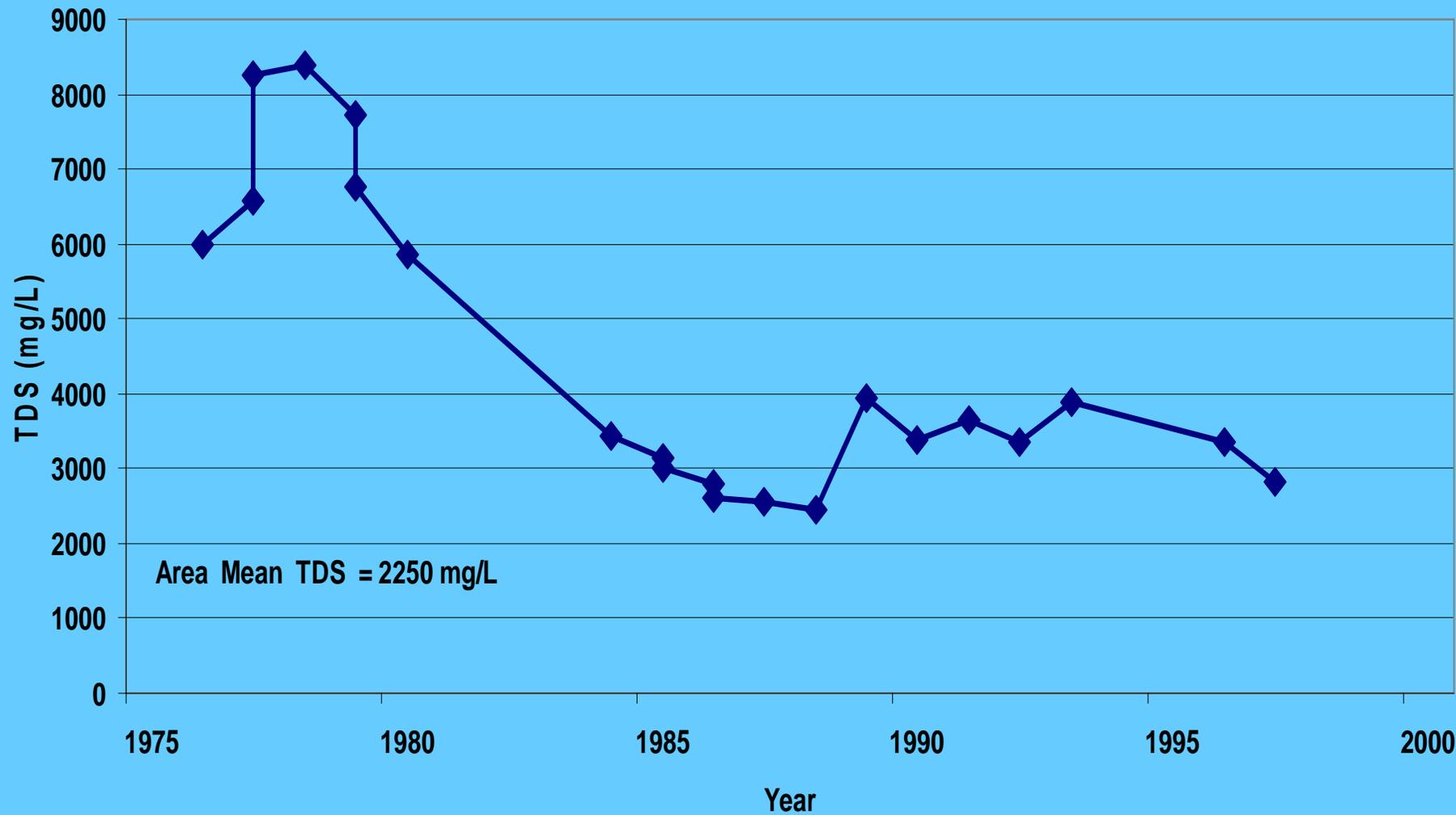
1. Salt Dissolution
2. FeS₂ Oxidation
3. Cation Exchange
4. Sulfate Reduction



Other changes in impacted water Quality

- Flushing salts will reduce TDS with time.
- In coal mines, 1 or more pore volumes is needed prior to significant decreases in TDS.

DS03
Coal - Mine Spoils, Decker, Montana



Hypothesis:

- **Changes in water quality in underlying aquifers will result from mixing with CBM water and chemical reactions with geologic material**
- **Changes will follow known series of reactions**
- **Using solid phase data SAR can be predicted, TDS may be estimated but not with accuracy**

Methods:

- Compare Saturated Paste Extract (SPE) data to water quality changes at existing sites
- Use flowing wells with Na – HCO₃ water as test sites
- Establish relationship between SPE and water quality changes for test sites

CX - 50

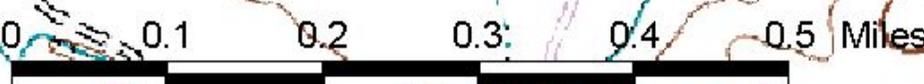
**Saturated Paste Extract
Data Point**

**Montana
CBM Pond
Example**

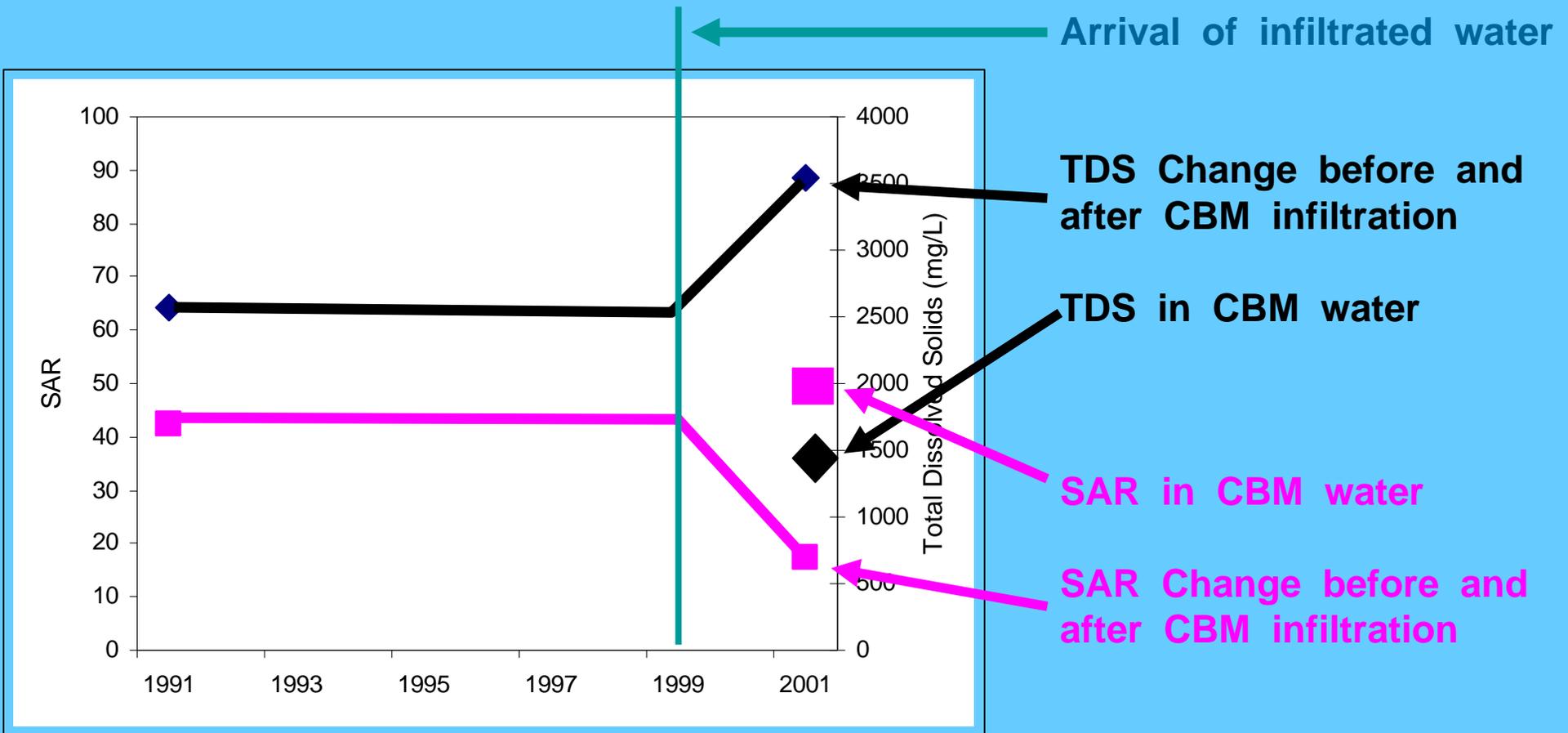
CBM Infiltration Pond

WR-17A

**WR-17A Water Quality
Overburden Sandstone,
TD = 88 feet**

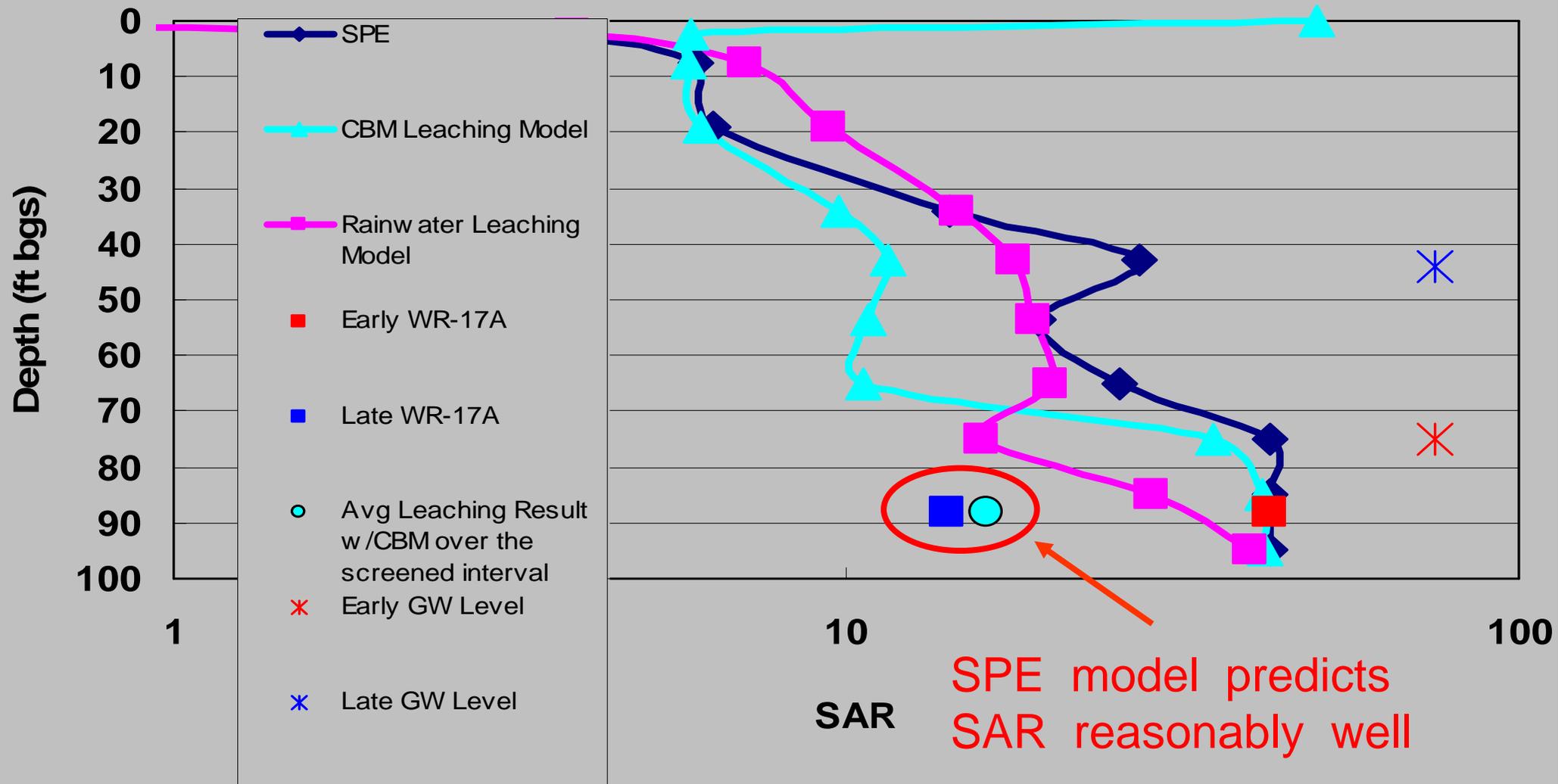


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Simple Mixing Model does not Work

Comparison of SPE Data with Simulated Leaching with CBM Water for WR-17A

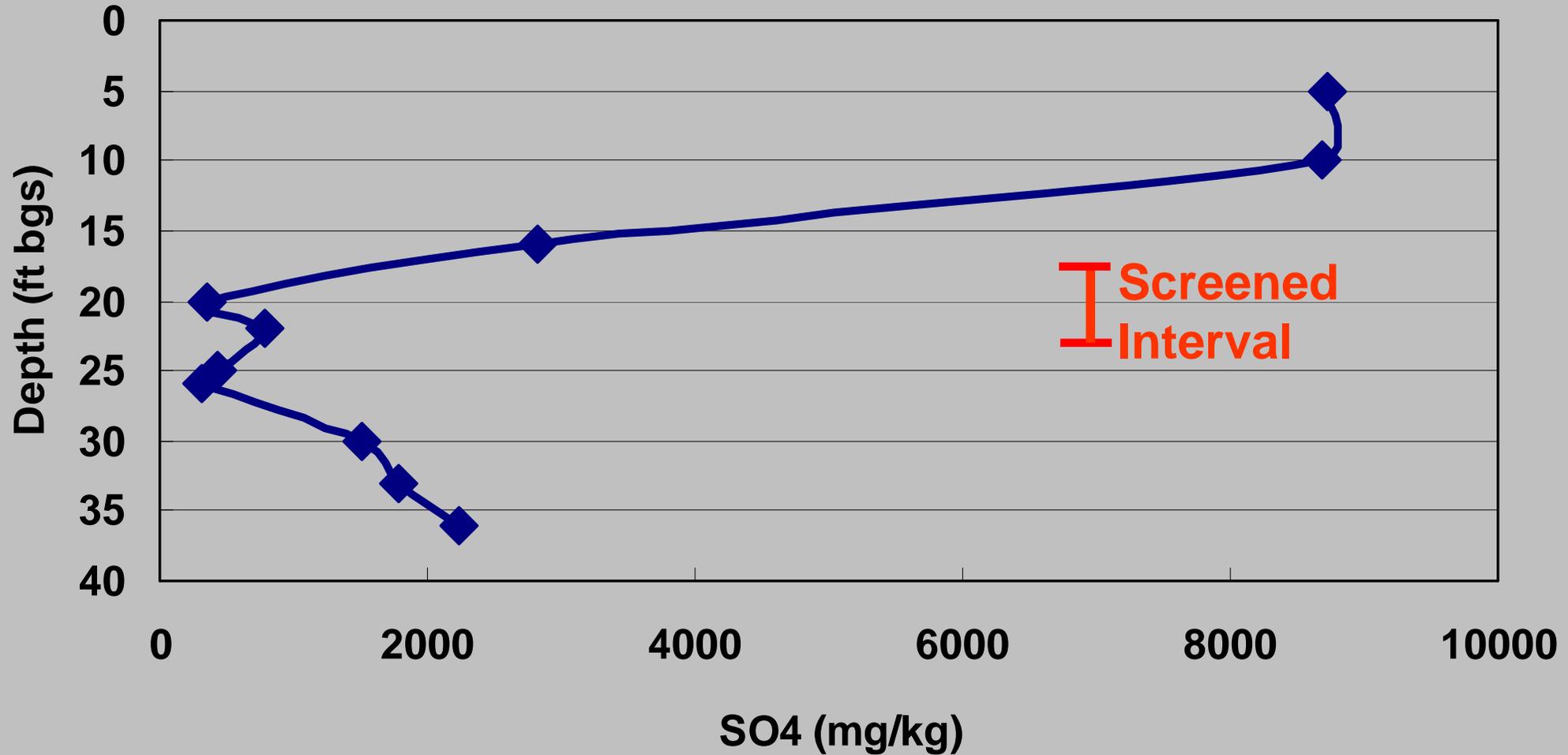


Coal Creek, Wyoming

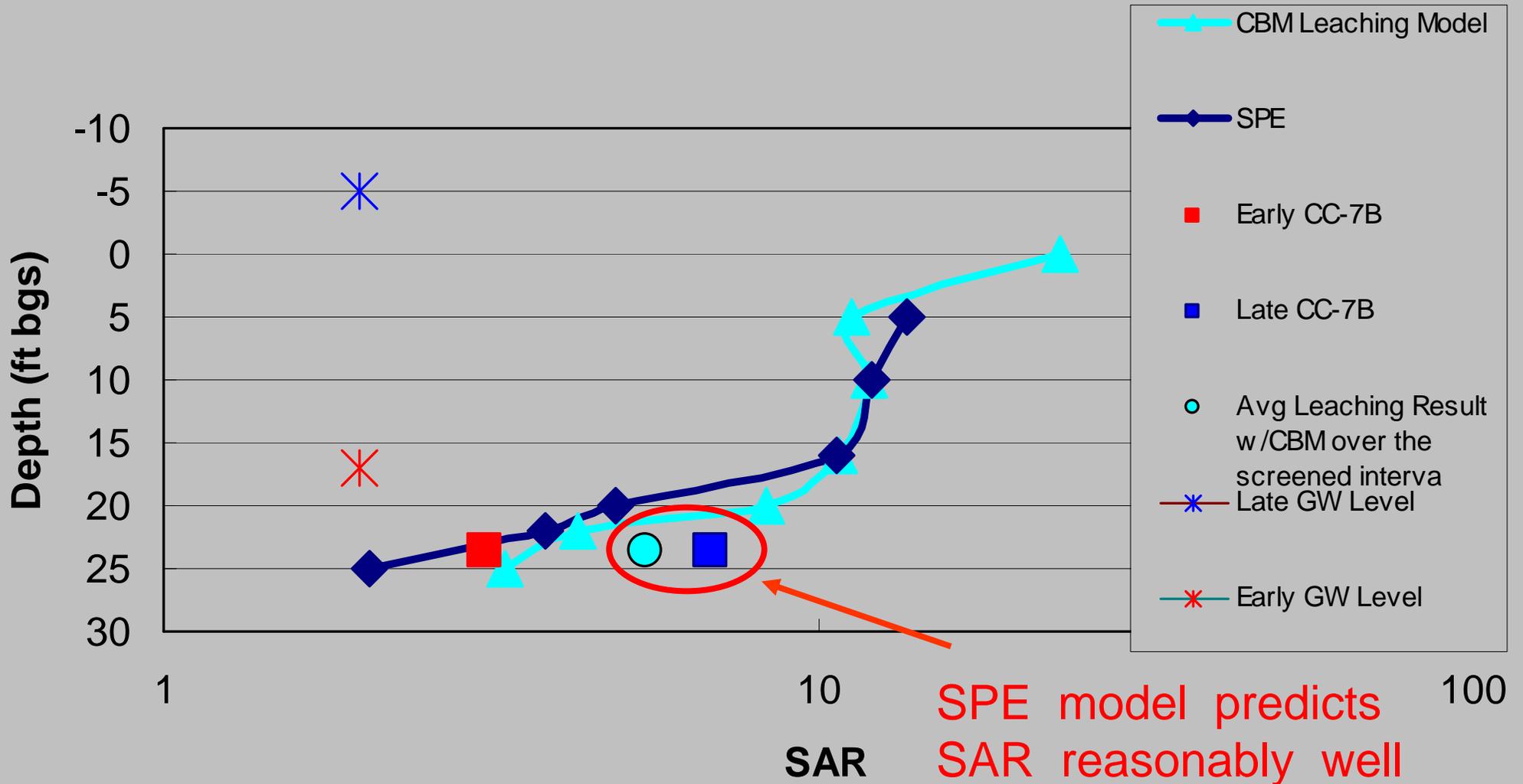


SPE SO4 Data for CC-7B

Increase in SO4 at this site must come from the shallow material



Comparison of SPE Data with Simulated Leaching with CBM Water for CC-7B (23 feet deep)



Ongoing Additional Confirmatory Field Work

- Compare shallow ground – water quality to solid phase at flowing well test sites
- Conduct detailed geochemical modeling to test hypotheses

Flowing
Well
Discharge

Overland
Flow

Test
Drilling
Locations



Water Quality from Flowing – Wells at Test Sites are like CBM Discharge

	<u>Ca</u>	<u>Mg</u>	<u>Na</u>	<u>SO4</u>	<u>HCO3</u>	<u>SAR</u>	<u>TDS</u>
Minimum	1.2	0.3	226.0	0.0	462.1	44.2	585.3
Maximum	2.5	1.0	489.0	488.0	1192.3	74.5	1346.3
Average	1.8	0.7	398.2	165.3	788.9	63.6	994.7

Solid - phase data is not yet available

Preliminary Conclusions

- Water quality is changing due to the dissolution of soluble minerals, cation exchange with clays, and pyrite oxidation within the previously unsaturated zone
- The quality of the water that infiltrates is less of a factor than the minerals that it dissolves
- The existing and additional saturated paste extract data will be valuable in selecting appropriate pond sites

Preliminary Conclusions (cont.)

- Water-quality concepts developed during coal-mine spoils studies apply well to CBM ponds
- Sulfate reducing bacteria may reduce TDS in certain settings



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