



Strategies, Monitoring and Data Needs for Assessing and Preventing Impacts from CBM Produced Water to Crop and Forage Production in Wyoming

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**November 5, 2010
Presented before the Wyoming Coal Bed Methane
Produced Water Working Group**

Role and Scope of TAT Review

- Provide advice and recommendations on soil and irrigation aspects of WDEQ's permitting policies for CBM water in the PRB
- Recommend options regarding agricultural uses of CBM produced waters
- Provide guidance to CBM Working Group and WDEQ on broad scientific monitoring programs
- Identify potential CBM water quality and quantity issues that could degrade soil, water, and plant communities

Rationale

- **CBM water quality varies**
- **Without proper management, some CBM water may harm crops/forages due to:**
 - **Chemical changes (EC, SAR, etc.)**
 - **Sustained flooding**
 - **Salinization/sodification**
- **Some CBM waters not suitable for agricultural use due to unsuitable water quality and/or soil properties**
- **Soils with high EC or SAR, flooding and high water tables can also occur naturally throughout the PRB**
- **The challenge is to determine where soil changes are caused by CBM water**

Approach

- Reviewed the Working Group's recommendations and DEQ's current methodology for setting CBM permit limits
- Developed a monitoring and contingency plan in conjunction with WDEQ-Water Quality Division
- Specified monitoring strategies for surface and groundwater, soils and crop/forage production
- Suggested recommendations to the Working Group for its consideration
- Completed matrix sought by WDEQ.

The Matrix

Monitored Substrate	Siting Guidelines (sample locations and densities)	Chemical/ Physical parameters to be monitored	Frequency and timing of sampling	Action Thresholds (At what chemical/ physical point does the alarm go off)	Corrective Action (What should the permit do about it, in order to avoid damage to crops)
Outfall (end-of-pipe)	N/A (Known)				
Reservoir water					
Instream surface water (IMP)					
Soils					
Groundwater					
Crop					

Approach

- Reviewed the Working Group's meeting summaries and Hendrickx and Buchanan reports
- Had several teleconferences and multiple e-mail correspondences
- Met 2 full days in Cheyenne and Laramie
- Completed matrix with assistance of Jason Thomas
- Drafted report
- Final teleconference
- Report distributed to the Working Group
- Presentation given to Working group

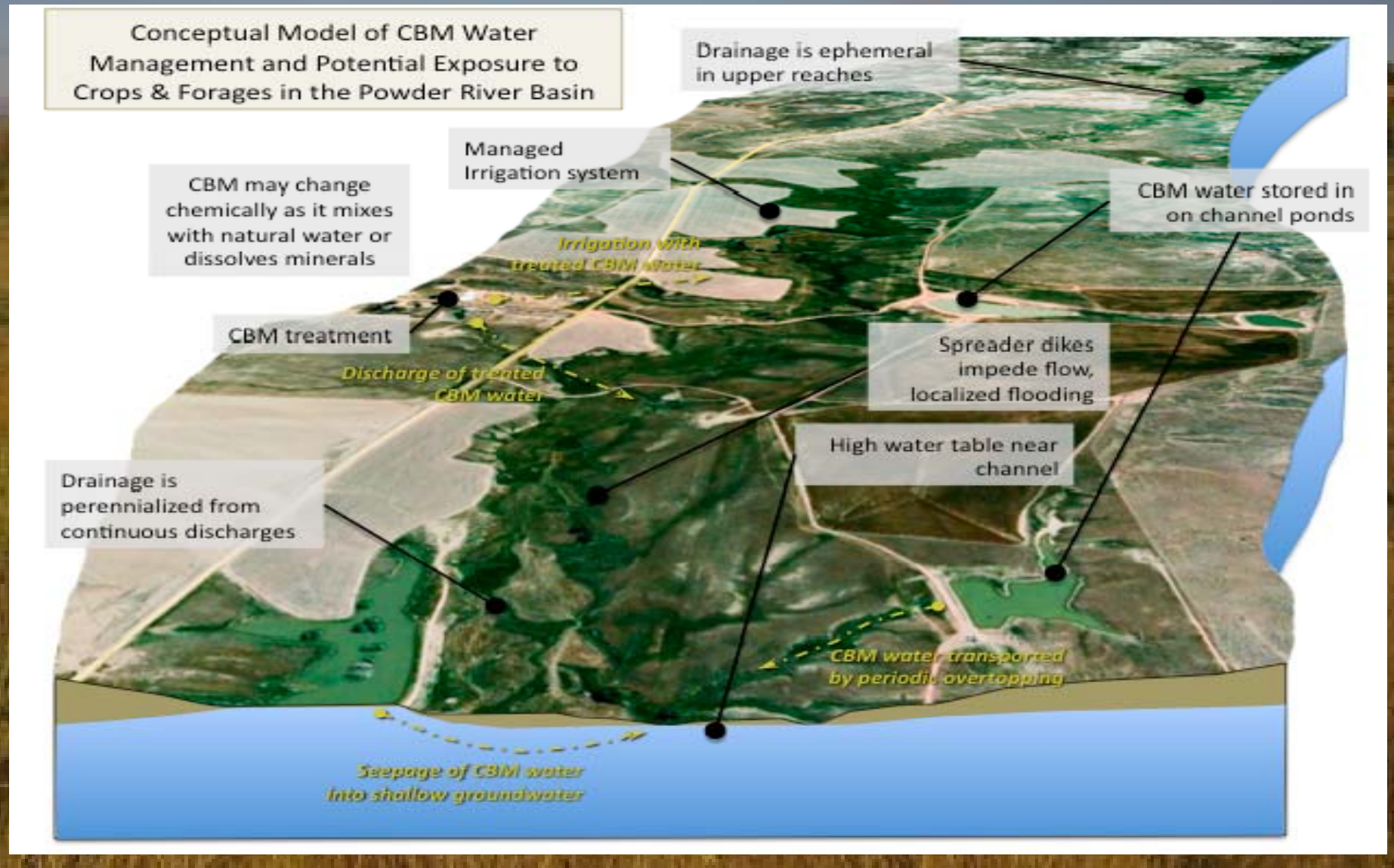
Challenges

- **Comprehensive monitoring program must be able to identify CBM-caused changes to water, soils and crops/forages**
- **Challenge is determining whether changes detected by the monitoring program are caused by CBM water**
- **Another challenge in interpreting monitoring data is the fact that “correlation does not imply causation”**
- **Must derive early warning systems that help prevent crop/forage losses**
- **Decreased yield may also result from drought or increased stand age in case of alfalfa**

Watershed Monitoring & Contingency Plan

- **Monitoring plans of individual permits must be coupled with watershed-based plans**
- **Permits should not be issued until WMCPs are developed**
- **Need broad watershed scale planning, coordination among stakeholders**
- **Require data collection, management and interpretation**
- **Contingency actions are a component of the plan, e.g., a watershed monitoring and contingency plan**

Conceptual Model of CBM waters Impacts on Crop/Forage Production



Direct Application of CBM Water – Managed Irrigation

- Use of CBM water for managed irrigation systems is exempt from discharge permits in Wyoming
- Managed irrigation requires utmost care in selecting suitable soils and crops or forages
- Needs consistent irrigation scheduling
- Properly sited and managed, irrigation is unlikely to cause extensive offsite impacts
- Any potential impact should be addressed prior to implementation of a managed irrigation operation.
- May necessitate soil reclamation to correct sodic conditions after irrigation ceases

Soil Monitoring

Managed irrigation (land application)

Sampling Guidelines - Siting and management guidelines based on land use

Frequency and timing of sampling

- Monitoring should be tied to site specific irrigation scheduling and chemical amendment plan
- Need to consider transition from irrigation back to dryland

Chemical/Physical parameters to be monitored - Texture, mineralogy, EC, SAR.

Action Thresholds

- Need to create a separate designated use for water on upland sites
- Coarse loamy and sandy soils best suited for managed irrigation
- Clay minerals should consist of less than 50% smectite clays

Corrective Action

- CBM irrigated soils may become saline/sodic
- After CBM water is no longer applied, soils may become sodic
- Amelioration of saline/sodic or sodic soils must be addressed

Watershed Monitoring Approaches

- Risk due to water quality and quantity impacts can be different for diverse water management strategies
- Monitoring needs to assess watershed processes from the point of CBM discharge to the potentially affected crop or forage
- Monitoring could involve sampling at the outfall, in ponds, in surface water, in groundwater, and in soil and crops/forage
- Crop/forage impacts need to be verified through multi-media sampling and monitoring

Outfall Monitoring

On-channel and 50-yr Headwater Reservoirs and 50-yr Off-channel pits

Sampling Guidelines - Outfall

Frequency and timing of sampling

- **On-channel** - 1st yr. monthly, then quarterly if within thresholds
- **50-yr Headwater Reservoirs and 50-yr Off-channel pits** - **Annually**

Chemical/Physical parameters to be monitored - pH, EC, SAR, HCO₃, metals, trace elements (F, Ba, As, Se, Fe, others as appropriate)

Action Thresholds

- End of pipe limits to protect livestock use

Corrective Action

- WDEQ enforcement policy to apply

Outfall Monitoring

Direct Discharge to Natural Perennial Channels

Sampling Guidelines - Outfall

Frequency and timing of sampling - 1st yr. monthly, then quarterly if within thresholds

Chemical/Physical parameters to be monitored - pH, EC, SAR, HCO₃, metals, trace elements (F, Ba, As, Se, Fe, others as appropriate)

Action Thresholds

- Permit limits not to exceed waste load allocation for designated uses
- Agricultural use limits should apply to median growing season flow
- Instantaneous maximum limits apply year-round

Corrective Action

- WDEQ enforcement policy to apply

Outfall Monitoring

Direct Discharge to Ephemeral Channels

Sampling Guidelines - Outfall

Frequency and timing of sampling - 1st yr. monthly, then quarterly if within thresholds

Chemical/Physical parameters to be monitored - pH, EC, SAR, HCO₃, metals, trace elements (F, Ba, As, Se, Fe, others as appropriate)

Action Thresholds

- Prevent flooding.
- End of pipe limits must maintenance instream water quality

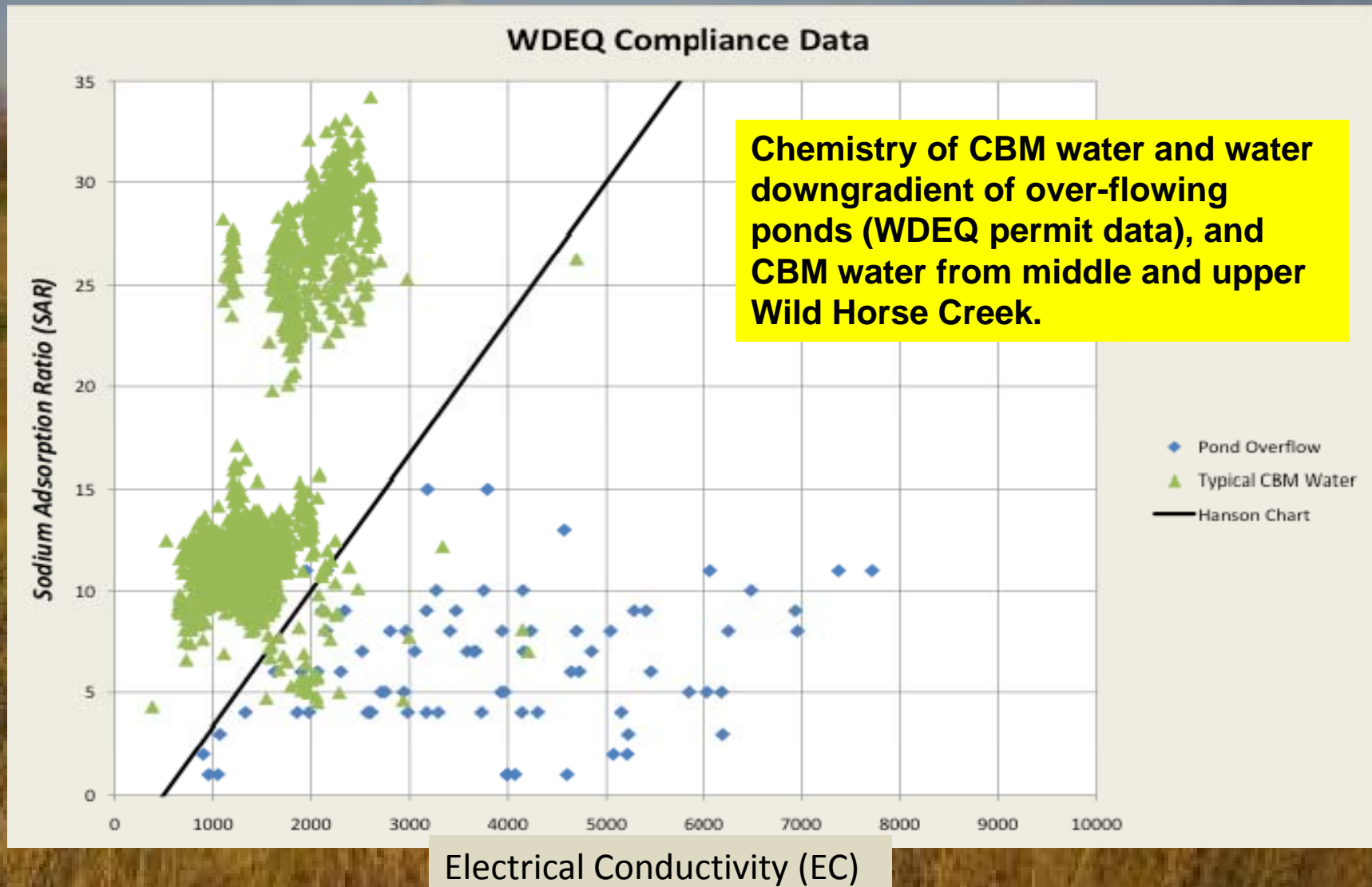
Corrective Action

- Curtail direct discharges if flooding due to CBM discharges
- Change end-of-pipe limits to preserve downstream water quality

Intermittent Surface Water Discharge – Reservoir Overtopping

- On-channel ponds are the most common management of CBM water
- Ponds designed so CBM water evaporates or infiltrates into the groundwater system that does not have a hydrologic connection to surface water
- Storms may result in over-topping of the reservoir for 24 hour period
- Over-topped waters lower in SAR than CBM waters, but EC (due to natural salt loads) can exceed general limits for irrigation of salt intolerant crops/forages

Intermittent Surface Water Discharge – Reservoir Overtopping



Reservoir Monitoring

50-yr Headwater Reservoirs and 50-yr Off-channel pits

Sampling Guideline - Minimum 5 ft. from shore and 50 ft. from inlet

Frequency and timing of sampling

- Effluent: Effluent: 1st yr. monthly, then quarterly if within thresholds
- Seepage monitoring: monthly/quarterly (as above)
- Stage monitoring: monthly/quarterly (as above)

Chemical/Physical parameters to be monitored - pH, EC, SAR, HCO_3 , metals, trace elements (F, Ba, As, Se, Fe, others as appropriate) + SO_4 .

- Seepage monitoring
- WDEQ may require stage monitoring within 0.1 feet

Action Thresholds

- Leakage: Visible surface seepage flow attributable to reservoir leakage
- Consider using EM to detect subsurface migration of saline water

Corrective Action

- Leakage: cease discharge; repair reservoir

Reservoir Monitoring

On-channel Reservoirs

Sampling Guidelines - Minimum 5 ft. from shore and 50 ft. from inlet

Frequency and timing of sampling

- Effluent: 1st yr. monthly, then quarterly if within thresholds
- Seepage monitoring: monthly/quarterly (as above)
- Stage monitoring: monthly/quarterly (as above)

Chemical/Physical parameters to be monitored - pH, EC, SAR, HCO₃, metals, trace elements (F, Ba, As, Se, Fe, others as appropriate) + SO₄.

- Seepage monitoring
- WDEQ may require stage monitoring within 0.1 feet

Action Thresholds

- Reservoir water EC is 150% of outfall water
- Visible surface seepage flow attributable to reservoir leakage
- Consider EM methods to detect subsurface migration of saline water
- Water release permitted if load credits are available and not detrimental to downstream agricultural uses
- Advance notice to downstream landowners required

Corrective Action

- Leakage: cease discharge; repair reservoir
- Close reservoir or increase freeboard to 50-yr level

Surface Water Discharge

- Direct discharge may occur if CBM water quality is better than background conditions or water is treated
- Permit effluent limits based on Clean Water Act
- Effluent limits calculated so water quality is protected at or above some critical flows
- For constituents such as EC and SAR, effluent limits should be protective for “average” flow conditions
- Mean or median stream flow measurements can be strongly skewed
- EPA recommends use of harmonic mean flows

Surface Water Monitoring

Instream surface water (IMP)

Sampling Guideline - Perennial streams

Frequency and timing of sampling - Continuous/monthly streamflow

Chemical/Physical parameters to be monitored

- Flow
- Water Quality - always monitor the following: pH, EC, Ca, Mg, Na. Monitor the following as appropriate: K, SO₄, HCO₃, Cl, ¹³C, and/or other isotopes.

Action Thresholds

- Water Quality - statistical trend analysis or if EC limit is exceeded
- Use USDA Salinity Tolerance Database EC or background levels
- Trend analysis needs to account for seasonality, flow-chemistry variation, and non-normal distributions
- Surface irrigation – limit SAR to <10 with appropriate EC
- Smectitic soils are of particular concern

Corrective Action

- Increase evaluation of cause if thresholds exceeded
- If due to CBM water, then curtail discharge or otherwise mitigate

Surface Water Monitoring

Ephemeral Streams

Sampling Guideline - Locate stations within WS to characterize contributions from sub-basins and on mainstem. Also have stations near discharge and close to beneficial use

Frequency and timing of sampling - Monthly Water Quality

Chemical/Physical parameters to be monitored

- Flow
- Water Quality - always monitor the following: pH, EC, Ca, Mg, Na. Monitor the following as appropriate: K, SO₄, HCO₃, Cl, ¹³C, and/or other isotopes.

Action Thresholds

- Presumptive agricultural use is surface overflow onto hay & native grass or subirrigation
- Prevent or mitigate flooding
- If flow becomes perennial – need to monitor groundwater level and use water quality triggers as for perennial drainages
- For ephemeral drainages, triggers may have limited value due to inherent variability - need to rely on soil/crop monitoring and trends

Corrective Action

- Intensify evaluation of cause if flow becomes perennial
- Curtail discharge or otherwise mitigate if CBM is the presumptive cause of surface water degradation that impairs crop/forage production

Groundwater

- Continuous discharge into ephemeral drainages may result in perennial flows due to alteration in the alluvial groundwater levels
- Impacts may occur when shallow groundwaters affect irrigated lands
 - Water tables <3 ft may result in surface salinization
 - Water tables <1 ft for extended periods may kill portions of the crop/forage plants due to lack of O₂
- Groundwater monitoring programs should be developed for each watershed
- A separate WDEQ program is designed to ensure aquifer protection beneath reservoirs

Groundwater Monitoring

Leakage from ponds

Sampling Guideline – Select highest risk reservoirs for sampling

Frequency and timing of sampling

- Monthly water level and water quality monitoring May, June, and July, quarterly otherwise
- Continuous if threshold is triggered
- Quarterly water quality

Chemical/Physical parameters to be monitored

- Water levels
- Water Quality - pH, EC, Ca, Mg, Na [K, SO₄, HCO₃, Cl, ¹³C, and/or other isotopes as appropriate]

Action Thresholds

- Evidence of surface leakage and/or lateral migration into stream channels.

Corrective Action

- Investigation is needed to determine cause and corrective actions
- Cessation of contributing discharges
- Underlying aquifer protected under the Groundwater Pollution Control Program

Groundwater Monitoring

Shallow groundwater near fields

Sampling Guidelines - Transect arrays of piezometers and wells - at least one array per field oriented normal to channel

Groundwater monitoring array co-located with soil, crop, and surface water monitoring

Frequency and timing of sampling

- At least one continuous water level monitoring station per site, otherwise quarterly
- Quarterly water quality

Chemical/Physical parameters to be monitored

- Water levels
- Water Quality - pH, EC, Ca, Mg, Na [K, SO₄, HCO₃, Cl, ¹³C, and/or other isotopes as appropriate]

Action Thresholds

- Depth between 3' and 6'
- Depth less than 3' and attributable to CBM
- Water quality parameters

Corrective Action

- Investigation is needed to detect cause and develop corrective actions
- Cessation of contributing discharges

CBM waters Impacts on Soils and Crop/Forage Production

- The amount and duration of exposure to CBM water may differ for each water management method
- Application of CBM water may impair soils due to increases in salinity and/or sodicity
- Changes in surface or groundwater system that are due to CBM water may impact soils that receive these waters
- High water tables created by CBM waters in some stream channels have altered soil characteristics of adjacent lands

Hanson Chart

- Hanson Chart is generally applicable for assessing water infiltration except for smectite soils
- Being specific to soil infiltration only, HC may provide a reasonable assessment of the interaction of SAR and EC at EC levels of 1-2 dS/cm (SAR 3-10)
- HC not applicable to waters with EC less than 1 dS/m
- Should not be used to permit direct discharge of water with SAR >10
- Higher water ECs may contribute to changes in plant communities
- Crop/forage tolerances to soil and water salinity must also be taken into consideration

Soil Monitoring

Sampling Guideline

- Detailed Monitoring: Fields should be segmented according to differences in soil characteristics or depth to groundwater (e.g., evidenced by distinct differences in vegetation)
- Minimum of 1 subsample per acre, but not less than 5 and not more than 15 subsamples per soil unit
- Survey Monitoring: As above for one sample location

Frequency and timing of sampling

- Annual fall sampling
- Composite within similar soil/groundwater systems using co-located composited samples
- Depth 0-6", 6-12", ea 12" to 6 ft or less in high water table areas
- Evaluate geophysical electromagnetic surveys (GEM) to partially offset soil sampling with ground truthing – could also assess restoration performance

Chemical/Physical parameters to be monitored

- **Initial** – texture, clay mineralogy, ESP, pH, EC, SAR, SO_4 , HCO_3 , lime, OC (N, P, K for alfalfa or irrigated grass)
- **Resampling** - pH, EC, SAR, N, P, K [SO_4 , HCO_3 , Cl]
- Provide for less detailed and more detailed monitoring as needed – not all fields in a watershed need detailed monitoring
- Alfalfa = 6 ft Grass=4 ft
- Recommend using GEM tool along with sampling to correlate results

Soil Monitoring

Action Thresholds

- Separating trends from cause and effect is challenging
- Trend of >40% increase in EC or SAR in 1 year, >15% over 2 yrs or more
- Trend analysis may not always identify CBM impacts where development pre-dates watershed monitoring. Other site specific evaluations will be required.
- Focus on groundwater-soil water pathway
- Regardless of trend, ESP > 10% or EC > 4 dS/m from 0"-12" is a trigger for more frequent soil monitoring
- If there is a trigger, the action is more detailed study to identify cause (e.g., assess climate, groundwater, soil water, agricultural management, watershed-wide trends)

Corrective Action

- If damage to soil is identified that is expected to impair crop/forage production and damage is due to CBM discharges, then
 - Curtail CBM discharges
 - Change discharge locations
 - Provide improved drainage
 - Add chemical amendments

CBM waters Impacts on Crop/Forage Production

- Application of CBM water may impair plant growth and species composition
- CBM waters can alter the chemistry of surface or groundwaters that are used by plants
- Higher ECs may contribute to changes in plant communities
- High water tables created by CBM waters can altered vegetation communities
- Only plants tolerant of wet conditions will grow where water tables are close to the soil surface

Crop and Forage Monitoring

Sampling Guidelines

- Detailed Monitoring: Fields should be segmented according to differences in soil characteristics or depth to groundwater (e.g., evidenced by distinct differences in vegetation). Minimum of 1 subsample per acre, but not less than 5 and not more than 15 subsamples per soil unit
- Survey Monitoring: As above for one sample location.

Frequency and timing of sampling

- Annual peak standing crop (late June-early July).
- Or pre-cutting for hayed fields – (can also use field harvest)

Chemical/Physical parameters to be monitored

- Yield/production at soil sampling locations
- Forage quality – bulk sample
- CP (crude protein), Ca, P, K, Na [trace elements not an intrinsic CBM issue relative to forage quality, but mobilization of naturally occurring trace elements could be issue, e.g., Se)

Action Thresholds

- Statistically significant decrease that correlates with causative mechanism such as soil water or groundwater impacts

Corrective Action

- Other monitoring programs meant to prevent crop/forage degradation
- Corrective action will require reclamation of damaged fields

Intended Use of Monitoring Data

- Monitoring programs should be designed, implemented and interpreted in an integrated watershed-based manner
- Need to consider relationships among CBM water, natural surface water, groundwater, soils and crops/forage
- Pattern of change in surface water, groundwater and soil conditions should precede crop/forage impact evaluation/determination
- Suggest WDEQ consider conducting pilot watershed-scale monitoring programs prior to implementation of individual permits

Recommendations

- **Recommend formation of WMCP groups - landowners, Conservation District personnel, gas/petroleum industry, regulatory staff, others**
- **Prevent flooding by CBM waters**
- **For sites dominated with smectite soils - increase monitoring or eliminate from CBM water operations**
- **Develop an expert panel to estimate background water quality for individual watersheds or stream segments using scientific methods**
- **Advise WDEQ to develop an effective enforcement program**

Recommendations

Suggested Elements of WMCP Working Groups

- Develop WGs for each watershed-wide monitoring program.
- Get assistance from UW SER, NRCS, WDA, CES, and/or conservation district for monitoring programs and to provide guidance to landowners
- Obtain expert(s) to assist in interpreting monitoring data
- Annually review and discuss monitoring results (locations, frequency, and constituents) for issues and concerns
- Recommend options for further CBM water use

A wide-angle photograph of a vast, flat landscape. The foreground is dominated by tall, golden-brown grasses. The middle ground shows a flat expanse of land with some scattered green bushes and a single utility pole. In the distance, there are rolling hills under a clear blue sky with a few wispy clouds. The overall scene is bright and open.

Questions?



A wide-angle photograph of a vast, flat landscape. The foreground and middle ground are covered in golden-brown grass, suggesting a dry or late-harvest season. In the distance, there are low, rolling hills or mounds of earth. The sky is a clear, deep blue with a few wispy clouds. The overall scene is open and expansive.

Response to Working Group Summary

Response to Working Group Summary

Permitting Basis

Permits shall protect historically existing (pre-CBM) indigenous plant or crop communities. Such communities shall remain capable of survival and maintenance under the conditions of increased soil moisture, salinity, and alkalinity from CBM discharge.

The concern expressed by the Working Group about ensuring that the native plant species are maintained in the areas impacted by CBM discharge water is legitimate. Large increases in water flows in an ephemeral stream that bring the water table to within three feet of the surface, or sustained overland flow onto a flat drainage bottom, will result in a change in the plant species present. Continued high flows that inundate a land area or cause a near surface high water table will cause a major shift in the plant community from one of native species such as western wheatgrass, blue grasses (Poa sp.), bluegrama, etc., to species such as foxtail barley, rabbitfoot grass, general sedge species, cattails, etc. These replacement species will be those that desire or can tolerate a high water table/flooding and salt/sodium buildup and are not palatable or nutritious like the native species. When CBM water discharge ends or is terminated these species will not be sustainable. With time after water removal these species will die and the area likely invaded with weedy species such as kochia, Canada thistle, Russian thistle and other noxious weeds found in the area. These conditions should be prevented and areas impacted reclaimed back to native species. Such reclamation may require soil amendments to correct sodium accumulation, leaching of salts and seeding along with associated seedbed preparations.

Response to Working Group Summary

Permitting Basis

Permits shall be based on drainage-specific factors, such as soils, water quality, crop species, irrigation method/amount, channel capacity, multiple operators, flow conditions, topography and water table factors.

1. **Permits should require monitoring of the following parameters for both perennial and ephemeral streams:**
 - a. **Flow: flow rates should be monitored continuously.**
 - b. **Water Quality: Always monitor the following: pH, EC, Ca, Mg, and Na. Other parameters that should be monitored when appropriate include: K, SO₄, HCO₃, Cl, ¹³C, and/or other isotopes.**
2. **Action thresholds for perennial streams:**
 - a. **Water quality triggers - statistical trend analysis or exceedence of the EC limit.**
 - b. **USDA Salinity Tolerance Database EC, background or statistically increasing trends (though upward trend not necessarily a compliance issue). Trend analysis needs to account for seasonality, flow-chemistry variation, and non-normal distributions.**
 - c. **Hanson Chart – primary utility for surface irrigation, not useful for subsurface water that may be subirrigating a field. Limit the Hanson Chart domain to >3 SAR, which corresponds to 1.0 dS/m EC. For default limits, also limit Hanson Chart to <10 SAR, which corresponds to 2.0 dS/m EC. Hanson Chart does not apply to high smectitic clay soils (e.g., these soils require more scrutiny). Smectitic soils are defined as having more than 50% smectite measured within the clay fraction.**
3. **Action thresholds for ephemeral streams:**
 - a. **Presumptive agricultural use is surface overflow onto hay and native grass or subirrigation.**
 - b. **If flow becomes perennial, need to monitor groundwater levels. Use water quality triggers as for perennial drainages.**
 - c. **For ephemeral drainages, triggers may vary due to inherent variability, so we also need to rely on soil/crop monitoring and trends.**
4. **Action to be taken when thresholds are exceeded in perennial and ephemeral streams:**
 - a. **Expand water quality parameters and constituents to be monitored.**
 - b. **Failure of criterion triggers more intensive evaluation of CBM activities as the presumptive cause of surface water degradation that impairs crop/forage production, then curtail discharge or otherwise mitigate.**

Response to Working Group Summary

Permitting Basis

Permits shall be based on vetted, credentialed science, be preventative, not reactive and include meaningful and timely enforcement. Permits should prevent harm to lands and require the permittee to demonstrate compliance.

A coordinated surface water, groundwater, soil and crop/forage monitoring plan is proposed that will provide the necessary information to develop appropriate enforcement. Monitoring of outfalls, reservoirs, channels, soils and groundwater is intended to prevent degradation of soil and crop/forage production.

If the quantity of the water is causing unacceptable water quality or has the potential to cause unacceptable water quality, then the EQA gives DEQ the authority to regulate water quantity. (AG Formal Opinion No. 2006-001)

The technical recommendations distinguish between water quality and water quantity impacts to crop/forage production. In regard to water quantity: (a) overland flooding caused by discharges should be prevented; (b) perennialization of flow occurring in the absence of flooding should not be allowed to cause an unacceptable increase in the water table.

Response to Working Group Summary

Permitting Basis

Within each drainage, where no economically feasible technical solutions exist to prevent salt loading and flooding problems, the permit shall require a water management or irrigation plan jointly developed by landowners and the permittee.

We agree that effective water management is the most critical element in preventing impacts to crop/forage production. Water management plans need to be tailored to site-specific conditions. A coordinated watershed monitoring and contingency plan, as proposed by the TAT, will help determine the effectiveness of CBM water management. The monitoring plan needs to measure performance of the water management plan. Review of monitoring results needs to identify trends and distinguish cause/effect. In addition, the TAT made recommendations on managed irrigation programs including the transition from irrigation back to dryland conditions.

Response to Working Group Summary

Definitions

Define what constitutes a measurable decrease in crop or livestock production due to CBM discharged water. (This would involve development of the metrics and methodology for measuring whether or not such a decrease has occurred or would be likely to occur due to CBM discharged water.)

Monitor crop/forage yield at soil sampling locations.

Need to account for factors that affect crop/forage yields that are not related to CBM produced water such as climatic factors, disease, insects, soil fertility, stand age, etc.

TAT recognizes that crop yields are highly variable and that variations of 10-30% or more can occur absent CBM water influences. Crop yield monitoring alone is not the most effective means of identifying CBM impacts. Therefore the TAT recommends reliance on early warning monitoring such as described in the surface water, soils, and groundwater monitoring of their report

Response to Working Group Summary

Monitoring

Require baseline measurements of soil quality, plant communities, and shallow groundwater quality & depth before issuing a discharge permit. In the absence of baseline data on plants and soils due to CBM discharges, certification or documentation of baseline plant and soil inventories from landowners, aerial surveys, NRCS data, or other historical information should be used.

Require monitoring of surface water quality & flow and shallow groundwater quality & depth to ensure compliance with Chapter 1 – Section 20.

Require on-going monitoring of soils, crop yields, etc. at the point of use during the period of CBM discharge.

The TAT fully specified a watershed monitoring regime, thresholds, and contingent corrective actions for outfalls, surface water, groundwater, soils, and crops and forage for CBM permits in the Powder River Basin.

Response to Working Group Summary

Require baseline measurements of soil quality, plant communities, and shallow groundwater quality & depth before issuing a discharge permit. In the absence of baseline data on plants and soils due to CBM discharges, certification or documentation of baseline plant and soil inventories from landowners, aerial surveys, NRCS data, or other historical information should be used.

- Require monitoring of surface water quality & flow and shallow groundwater quality & depth to ensure compliance with Chapter 1 – Section 20.
- Require on-going monitoring of soils, crop yields, etc. at the point of use during the period of CBM discharge.

The TAT fully specified a watershed monitoring regime, thresholds, and contingent corrective actions for outfalls, surface water, groundwater, soils, and crops and forage for CBM permits in the Powder River Basin.