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Date: July 22, 2009

From: Larry C. Munn, Professor of Soil Science

To: Dr. Jan Hendrickx and Dr. Bruce Buchanan

c. Wyoming EQC, Wyoming DEQ, Dr. Paige, Dr. Vance, PRBRC, EPA Region 8

Re: Comments on the Expert Scientific Opinion on the Tier-2 Methodology.

The DEQ website said to format comments on this document (docket 09-1101) as questions to you and so I am submitting this correspondence to you directly with copies to DEQ and others to insure that it is entered into public record. I understand that you were given an over-flight of part of the Powder River Basin by Wyoming DEQ earlier this month and a brief visit to several sites on the ground. I am sure that this provided an opportunity for you to see the scale of the ongoing gas development in the Basin. Approximately 80,000 acre-feet of produced water per year is being discharged now (Wyoming Geological Survey Exploration Memoir No.2, 2008). What might not have been readily apparent from your short visit is that quite a lot of the "green line" along the now perennial flowing channels is new vegetation, adapted to wet saline conditions, that has replaced the natural vegetation that grew in the ephemeral channels before discharge of produced water. Much of the new "green line" vegetation is comprised of Baltic rush (*Juncus balticus*) and foxtail (*Hordeum jubatum*) and this lush appearing growth actually represents a reduction in the value of the channels to the forage base for the livestock industry. It also begs the question of what will happen when water flow ceases and the channels revert to ephemeral flow of natural surface water.

Your report well identified the core problems with the Tier-2 methodology. You documented clearly that the assumption in Tier-2 of a consistent, direct relationship between soil salinity and background water quality does not exist. This in itself means that the Tier-2 methodology, as it is being applied, is scientifically invalid, as you specifically said in Scientific Expert Opinion A. I agree with your conclusion on this and I further conclude that no adjustment, calibration or other tweaking is possible that would make the Tier-2 methodology scientifically valid. The concerns that you expressed later in the report about the sampling methodology (which does not provide an objective, repeatable outcome) are basically rendered moot by the fact that the core assumption of the methodology (that background water quality alone determines soil salinity) is wrong. I also agree with your statement in Scientific Expert Opinion B that the Tier 2 methodology will not support the establishment of

effluent limits for discharge permits that will not cause measurable decrease in crop production. Tier 2, as it is being applied, is simply scientifically invalid.

I find two aspects of the present condition in the Powder River Basin (PRB) particularly worrisome. The first is the high sodicity of much of the produced water in the middle and northern parts of Wyoming's portion of the PRB. Data collected by the US Geological survey in cooperation with Wyoming DEQ, and published on the DEQ website (U.S. Geological Survey Scientific Investigations Report 2007-5146) shows almost all measured water from ephemeral streams to have SAR's of 10 or less, much lower than some of the derived SAR values calculated from the (scientifically invalid) Tier 2 methodology and now being permitted by DEQ. With these discharges, a large area of landscape will be converted to sodic and saline-sodic soil conditions during the period of water discharge. The second issue, and overall the most potentially damaging, is the desire by Wyoming DEQ to write end-of-pipe discharge permits and to disclaim any responsibility for negative impacts that occur as the water interacts with the soils and geology as it flows down the channels. The long history of irrigated agriculture has clearly demonstrated that irrigation without management in arid/semi-arid climates is doomed to be unsustainable.

You specifically point out in your report that un-managed discharge can cause damage to the soil-plant system even with water that meets Tier-1 quality standards. I urge you to stress this to Wyoming DEQ in your consultations. Wyoming DEQ does require in the WYPDES permits it issues for wastewater that the amount of water applied to a particular land area "not exceed the agronomic rate" for that site. If they included similar provisions in CBM discharge permits to insure application rates for the water that would truly provide beneficial use, it would alleviate issues of damage both due to wetness and to salinity/sodicity.

Your suggestion to use electromagnetic induction (EI) to assess soil salinity before, during and after discharge is worthy of further consideration. However, what you suggest would require a major policy change by DEQ (i.e. management and monitoring of the produced water) beyond their present action of simply writing end-of-pipe discharge standards. Simply substituting EI for conventional soil sampling to establish background water quality would not address the false assumption at the core of Tier 2. You have wide experience with irrigation and I note that you have expressed several times in the report the need for management and monitoring of the drainage systems to which the water is applied if damage is really to be avoided. Please try to impress DEQ with this necessity.

It is my hope that Wyoming DEQ and the Environmental Quality Council take your report very seriously. Your recommendation that the way forward is to scrap the Tier-2 methodology and require management for discharge resulting in surface application of water that exceeds Tier-1 standards is, in my professional judgment, exactly correct and I support that course of action. The major points in your report are in agreement with testimony and written comments which I, and others, have provided to DEQ and the Environmental Quality Council in the past. Wyoming DEQ's Tier -2 Methodology which attempts to estimate background water quality from soil samples will always over estimate the salinity and sodicity of the background water. Combined with DEQ's end-of-pipe permitting approach, its continued application will cause significant damage to soils and plant systems in the Powder River Basin.