Rec'd 1-18-07

Critical Review of the Scientific Literature Relating to Water Quality for Wyoming Livestock and Wildlife

Research Update presented to Wyoming Environmental Quality Council, 1/17/07

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Background

Water is a simple compound, yet it is arguably the nutrient *most* essential to life. It is responsible for movement of nutrients, metabolites and waste products between body compartments and into/out of the body as a whole. It plays a central role in mammalian thermoregulation. Loss of between 10-20% of the body's water content is fatal in most higher animals. Most mammals, especially those species economically important in Wyoming, derive the vast majority of their daily water requirement by drinking. None of our livestock or big game species can survive more than a few days without access to some form of water. However, because water is also an excellent solvent, it represents a potential source of excess minerals and other toxicants. In an arid state like Wyoming animals often don't have much choice about the water they drink. As noted by a WGF biologist in the Red Desert "...its wet ain't it? That's a damn sight better than the alternative." Thus, livestock producers, wildlife managers and regulatory officials need reliable data about the likely health effects of various water contaminants on livestock and wildlife.

Conservative water quality standards exist for human consumption. A somewhat looser set of standards and effluent limits has been adopted for livestock (and by inference, wildlife) consumption by various authorities based largely upon a review published in 1974 (NRC, 1974). While there was good science underlying many of the recommendations, the simple fact is that many of today's recommendations are based upon science that is at least 30 years old - or upon the best guess of the nearest expert available when they were written. In addition, the advent of the internet has created a volume of hearsay and urban legend that would have been impossible even 20 years ago. The latter, especially, lends itself to constant challenges of any regulation and can only be countered by solid data.

Objective

The objective of this project is a thorough review of the scientific knowledge base re: water quality for the classes of livestock and economically important wildlife species common in Wyoming. It is *not* an attempt to write or re-write regulatory standards as doing so is properly the province of the political and/or regulatory communities. Rather our goal is to provide a sound scientific basis for decisions by all persons interested in animal health.

Methodology

We have assembled a team with expertise in water chemistry (Dr. Reddy), range science and livestock production (Dr. Smith), wildlife health (Dr. Tate), veterinary toxicology (Dr. Raisbeck) and regulatory affairs (Ms. Zygmunt). Given the very short time frame available, we've also hired a post-doc in water chemistry (Rich Jackson) and a technician with a BS in Veterinary Sciences and experience in livestock and wildlife health (Sarah Riker) to do the the leg-work of accumulating and assimilating data. Although this project is not targeted at produced waters *per se*, we are very cognizant of the potential impact our final report may have in this arena and have tried to focus, at least initially, on contaminants typical of produced waters. To this end, our initial list of contaminants to review is based, in large part, upon data Dr. Reddy has accumulated working with various Powder River Basin waters over the last 10-15 years.

Once our list of contaminants was drawn up and prioritized we began a typical scientific literature search for each utilizing the common databases such as Medline, Toxline, CAB, Biosis, etc. To the extent possible, we have tried to go back to original sources to validate conclusions of earlier reviews such as the NRC document mentioned above, *as well as* searching for more recent data. We are also reviewing source data from other recent guidelines, such as the Australia New Zealand Conservation Council chapter 3 (ANZECC, 2000), where there is an adequate bibliography. Finally, we have solicited anecdotal information from other animal health agencies, such as diagnostic laboratories, in the upper Great Plains and Rocky Mountains for input that may not have made it into the computerized bibliographic databases. Examples of this category might include, but are not limited to, unpublished theses, industrial or governmental reports and searches of diagnostic lab databases. It also includes first hand reports of poisoning by diagnosticians, wildlife biologists, etc., so long as the story can be corroborated by ancillary data (lab reports, etc.) and fits good diagnostic practices (e.g. Koch's Postulates). Obviously, the latter category of information requires very careful scrutiny *vis-a-vis* its reliability and accuracy, but *it is* a resource that should not be ignored. For example, there is nothing in the peer-reviewed literature re: Ba toxicity in ruminants, but, utilizing the "grapevine" we were able to come up with 2 believable reports of Ba toxicity in cattle. Non-academic organizations often commission or conduct relatively well-funded and rigorous research projects to address specific issues, but the investigators have no incentive to publish anything beyond technical reports to the funding organization.

Each report is abstracted and entered into a shared bibliographic database and an electronic copy archived to a shared directory. Each is assigned keywords reflecting the nature of the publication (e.g. primary or secondary source; clinical or experimental data), species involved (the intent is to focus economically important species such as sheep, cattle, elk, deer or pronghorn), the nature of toxic effects, chemical form of the contaminant, etc. All papers are evaluated for reliability and accuracy by the full-time employees. *The objective of this process is to wind up with an extensive collection of **reliable, first-hand** field reports of intoxication and/or experiments that demonstrated No Observable Effect Levels (NOELs), **not** secondary citations.*

Working in conjunction with the full-time employees, the faculty investigators then extract the relevant information for inclusion in the report. This is where the expertise and experience of the investigators comes in. For example, S has been demonstrated to be toxic to ruminants both experimentally and under field conditions. Various papers describe poisoning in cattle and sheep, but attribute it to water SO_4 concentrations as low as 2000 mg/L (McAllister et al., 1997) while others indicate NOELs greater than 5000 mg/L (Digesti and Weeth, 1976). Still others reported "no effects", then described animals exhibiting signs typical of polioencephalomalacia. The validity of the reported lethal dose needs to be determined in light of the basic design of the report and any analysis done (toxicology and chemistry, Raisbeck and Reddy) and ancillary factors such as other dietary components (toxicology and management, Raisbeck and Smith). Interactions with other dietary components, common to Wyoming environments, which might potentiate or inhibit toxicity need to be evaluated (toxicology and chemistry, Raisbeck, Smith and Reddy). Since virtually nothing is known about the toxicology of S in antelope, deer, etc. extrapolation of dose from (e.g. cattle) represents a combined effort of wildlife physiology and toxicology (Raisbeck and Tate).

Of necessity, we have made some assumptions re: target species and environmental conditions in our deliberations. Many water contaminants, e.g. Se and S, are additive with the same or other elements in the diet. Obviously, the toxicity of any given contaminant in water will then depend upon the concentration in the rest of the animal's diet. With the exception of issues like palatability, the hazard of any given concentration in water will depend upon the amount of water consumed. For the first, we have are basing recommendations upon "normal" concentrations of various elements in common Wyoming forages that animals are likely to encounter. For the latter, we have chosen a worst case scenario, a young, rapidly growing ruminant animal under conditions (environmental temperature 30 C) that are likely in Wyoming.

Another area where the expertise of this group comes into play is where there is insufficient data in the target species to make a recommendation. This is especially important in the case of wildlife as there has been relatively little such research done with these species. In other instances, the only research available has been focused upon non-ruminant species such as humans and laboratory rodents. Obviously, in either case, any extrapolations, re: cattle, sheep, elk, deer, antelope, etc. are, of necessity, an educated guess. However, the team we've assembled is as well qualified to make, and defend, such extrapolations as anyone in North America. For example, relatively little has been done with F in ruminants since the 1970's, but there has been a ground swell of claims attributing everything from neurotoxicity to cancer in humans to relatively small F concentrations. We're reviewing this literature and trying to determine, from theoretical, physiological perspectives, which, if any are of relevance to large ungulates.

Progress to date

We have identified and abstracted 421 scientific papers deemed relevant to water quality for livestock and big game animals. We've also made contacts with several other experts at land-grant schools in states with similar geology and agriculture. Selenium, Ba and S chapters are virtually complete and the material is collected to finalize TDS, F and N (note: none of these will be released until the entire study is complete as materials continue to trickle in). We're a bit behind schedule because of conflicts with PIs' other commitments this Fall and the time it took to get the staff up to speed on what we need, but we still anticipate having a completed document by July 1, 2007.