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**Animal Risk of Produced Water  
Surface Discharges in Wyoming**

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**The issue: are current effluent limits  
protective of wildlife and livestock?**

	<b>Barium (mg/L)</b>	<b>Sulfate (mg/L)</b>	<b>TDS (mg/L)</b>
Current Limit:	None	3,000	5,000
Proposed Limit:	0.2	500	2,000

*Note: Sulfate is a component of TDS but is addressed by a separate regulatory limit. CBNG water is typically sodium-chloride or sodium-bicarbonate dominated. Therefore, discussion of TDS components is exclusive of sulfate.*

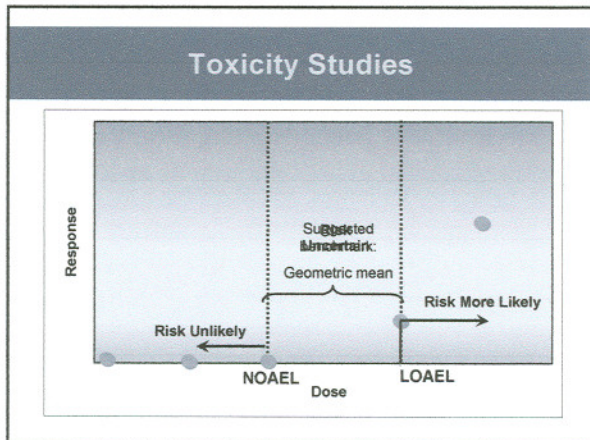
- Petitioners' Reasons:**
- **Petitioners claim that current EL are not "protective of stock and wildlife"**
  - Support for barium @ 0.2 mg/L:
    - ✓ Utah Ext. Bull. → refs don't check out for 0.2 mg/L
    - ✓ CSU Ag. Ext. → revised its guidelines, none for Ba
  - Support for sulfate @ 500 mg/L:
    - ✓ Kober 1993 → recommends < 4,500 mg/L
  - Support for TDS @ 2,000 mg/L:
    - ✓ All references support a 5,000 mg/L limit except SD Ag Ext. (2002), which focuses on sulfate-dominated water (recommendation: up to 3,000 mg/L "safe")
- ➔ **Conclusion: petitioners' statements are not supported by references provided.**

- What are the risks of TDS, Sulfate, Ba?**
- Lines of evidence:**
1. Other published guidelines
  2. Literature-based toxicity studies
  3. Ranchers' and other Wyoming resident experiences

### Existing peer reviewed guidelines

- Barium:
  - ✓ 5 – 300 mg/L livestock WQ guideline (Canada)
  - ✓ 20 - 100 ppm livestock (NRC 1980, 2005)
- Sulfate:
  - ✓ 1,000 – 3,000 mg/L livestock WQ (Canada)
  - ✓ 2,500 mg/L feedlot cattle (NRC 2005)
- TDS:
  - ✓ 5,000 – 15,000 mg/L livestock (EPA 1976)
  - ✓ 5,000 mg/L livestock (NRC 1974)

➔ Existing guidelines are supportive of current limits, but do not support proposed changes to limits.



### Toxicity Studies

	Nonruminant mammal (rodent)	Ruminant (growing heifer)	Ruminant (adult steer)	Waterfowl (mallard)
Barium (mg/L)*	100	13	N/A**	360
Sulfate (mg/L)	5,070*	5,100	3,010	4,590
TDS (mg/L)	7,460	7,800	N/A**	5,680

\*Lowest concentration derived for each receptor shown.  
 \*\*N/A Not applicable. No toxicity studies exist for this type of receptor.

### Ranchers' experiences

Why is it important?

- Wyoming conditions differ from toxicity studies
  - ✓ Johnson and Patterson (2004)
- Adaptation / inc'd tolerance can occur w/o long-term adverse effects
  - ✓ NRC (1974), Spafford (1941), Ballantyne (1957)
- Toxicity study limitations (NOAEL vs LOAEL)


➔ Ranchers in Bighorn and Powder River basins weigh in

- ✓ Thanks to: Flitners, McCarty, Patterson, Shepperson, Schlaf, Mikie, and others

### Ranchers' experiences

Thanks to: Flitners, McCarty, Patterson, Shepperson, Schlaf, Mikie, and others

- No adverse effects on livestock (cattle, sheep, horses) that drank water containing:
  - ✓ Sulfates ≤ 3,100 mg/L
  - ✓ TDS ≤ 5,390 mg/L
- Adverse effects apparent when exposed to:
  - ✓ Sulfates ≥ 4,000 mg/L
  - ✓ TDS ≥ 7,000 mg/L



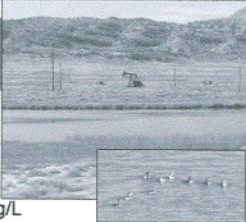
### Rancher's experiences

- Flitners: 7-year weaning rate averages as good or better on land w/ produced water (2,700 mg/L SO<sub>4</sub>, 5,000 mg/L TDS)
- Mr. McCarty: No adverse effects on land w/ produced water (3,100 SO<sub>4</sub>; 5,390 TDS); body condition, mortality, weaning rates/weights, breeding rate
- Meike, Schlaf, Shepperson: No adverse effects
- Letters- Garland, Grabbert, Mantle, Pattison, Shultz, Wilsons, Baird, McCarty, F.O.A.L, etc.

### Wildlife Effects

- Loch Katrine
  - ✓ No adverse effects on wildlife at Loch Katrine from produced water contributions of 5,000 mg/L TDS and 2,050 mg/L sulfate (Ramirez, USFWS 2002)
- Ranchers' observations
  - ✓ Wildlife observed utilizing produced water sources in greater densities than natural sources, without adverse effects.

➔ Experiences in the field are supportive of current limits, but do not support proposed changes to limits.



### Recommended water quality benchmark

<u>Benchmark/Limit</u>	<u>Barium</u> mg/L	<u>Sulfate</u> mg/L	<u>TDS</u> mg/L
<b>Recommended benchmark:</b>	<b>13</b>	<b>3,010</b>	<b>5,600</b>
<b>Current effluent limit:</b>	<b>None</b>	<b>3,000</b>	<b>5,000</b>
<b>Petition proposed limit:</b>	<b>0.2</b>	<b>500</b>	<b>2,000</b>



## Social and economic value of produced water surface discharge

- Letters of beneficial use by Wyoming residents
  - ✓ Cattle, sheep herds largely maintained by produced water sources in areas of Bighorn and Powder River basins;
  - ✓ Increased capacity for irrigated crop and pasturelands attributed to produced water sources;
  - ✓ Wild horse populations supported in Bighorn basin (F.O.A.L).
- Use attainability analyses<sup>1</sup>
  - ✓ Salt Creek discharges support >4,500 head of cattle and 3,300 head of sheep;
  - ✓ Cottonwood Creek discharges support 2/3rds of all crop production in the area;
  - ✓ Wildlife: game species abundant in discharge areas – supports tourism;
  - ✓ Loch Katrine enhanced by produced water supports sensitive/threatened species.

<sup>1</sup> Gene R. George 2005, RETEC 2004, SWWRC et al. 2002

## Effects of eliminated produced water surface-discharge

- Cottonwood Creek: 15 – 20% loss of cattle (\$2 million)
- Dry Creek: 30 – 50% loss of cattle (~\$0.6 million)
- Salt Creek: 20 – 40% loss of cattle (\$0.6 – 1.1 million)
- Hot Springs County – loss of cattle results in:
  - ✓ \$3.3 million total economic output,
  - ✓ \$645,000 annual labor income
  - ✓ 8% loss of pasture
- Additional costs to ranchers to develop alt water sources
- Lost revenue from tourism, hunting, fishing
- Lost access to federal funding for Loch Katrine

## Effects of eliminated produced water surface-discharge

### Effects of reduced exploration and development:

- Lost tax and export revenue to counties
  - ✓ Hot Springs County (Hamilton Dome) = \$28.7 million (1997 dollars);
  - ✓ Natrona County (S. Casper Creek) = \$3 million (2002 dollars).
- Lost jobs
  - ✓ Hot Springs (Hamilton Dome) = 136 jobs, \$4.1 million annual labor;
  - ✓ Natrona & Johnson counties (Salt Creek fields) = \$4.6 million ann. labor.
- Lost contributions to social programs
  - ✓ Hot Springs (Hamilton Dome) = \$1.4 million for schools, etc
  - ✓ Natrona & Johnson counties (Salt Creek fields) = \$2.9 million property and severance tax.

## Study Conclusion:

***Geomega's analysis shows that current WDEQ effluent limits pose no measurable adverse effect to the health and well-being of domestic livestock and wildlife, and there would be no incremental reduction in wildlife or livestock injury if limits were changed to the petitioners' requested limits. In addition, associated social and economic impacts of reduced water discharges and/or reduced exploration and development would be harmful to Wyoming residents.***

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