From:	Lister, Joel
To:	Mayerson, David, NMENV
Cc:	Alan Kuhn
Subject:	FW: one more time!
Date:	Tuesday, February 03, 2015 12:30:07 PM
Attachments:	SUYW Rio Grande Resources Mt Taylor Mine.pdf

Dave,

I am waiting for several other companies to get back with RGR on other treatment methods. I want to go ahead and provide this to you to demonstrate that SE and MO can be removed from Mt Taylor discharge. We will continue to talk with the companies to research best technologies available. I would assume that this report would answer the question on treatment for SE and MO.

regards,

Joe Lister

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MAR SYSTEMS

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Date	Title	Client	Contact
1/22/2015	Mt. Taylor: Sorbster® Sorbent Studies for the Removal of Selenium and Molybdenum	Rio Grande Resources	Lupe Rocha Chief Engineer

GOAL: Removal of selenium and molybdenum from a mine shaft dewater project at Mt. Taylor uranium mine in New Mexico to allow mine startup. The project is projected to initially process 10,000 GPM for two years, then 5,000 GPM for several years. Objectives of treatment program are to remove selenium and molybdenum to drinking water standards. The EPA enforceable limit for selenium is 50 ppb maximum in drinking water. Molybdenum is not regulated in drinking water however, the State of New Mexico has a groundwater enforcement standard of 40 ppb and some states have an interim health advisory level for molybdenum at 90 ppb, so the MAR target was < 40-90 ppb. In the water sample, molybdenum was found to be present, measured at 530 µg/L. However, selenium was found at less than 1 µg/L which is far below the historical data provided to MAR for the site. In order to accurately gauge the treatability of the water, selenate, approximately 90 µg/L, was added to be consistent with average concentrations provided by Rio Grande Resources. Selenate is typically the most difficult selenium species to remove and is typically the species form in mining water. The selenate spiked sample was pumped through columns of Sorbster media at a 30 minute contact time to evaluate removal performance.

EVALUATION CONDITIONS:

Two column studies completed January 6-7, 2015 using Mt. Taylor water sample after spiking with selenate.

Column Conditions	Test 1: MAR column with Sorbster® Si-1. Spiked with Selenate and Treated at pH 9.70	Test 2: MAR column with Sorbster® Si-1. Spiked with Selenate and Treated at pH 6.27
Column Dimensions	1" diameter x 36" high	1" diameter x 36" high
Media 1: Sorbster® Si-1	Lot # M-SA158J074	Lot # M-SA158J074
Media 1: Sorbster® Se-1	Lot# M-829128	Lot# M-829128
Inlet pH	9.70	6.27
Media Volume	461 cm^3 per media type	461 cm^3 per media type
1 Empty Bed Volume	461 mL per media type	461 mL per media type
Flow Rate	15.3 mL/minute	15.4 mL/minute
Bed Volumes Treated	17.4 (8000 mL)	17.4 (8000 mL)
Empty Bed Contact Time per media Column	30.1 minutes per media type	29.9 minutes per media type
Water Pretreatment	Water was analyzed for Se content and then spiked (1/5/2014) with 2.28 mL of 1000 ppm selenate standard* into 20 L of water sample	Same Water as Test 1 with HCl added to reduce pH to 6.27 prior to treatment. 3.5 mL of concentrated HCL* was added to 10 L of water

*Selenate standard is from Ricca Chemical Company (Catalog No R6699000-1A)

*Hydrochloric Acid is 34-37% and from VWR/BDH Aristar® Plus (Catalog No 87003-253)

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WATER SAMPLE DESCRIPTION:

- Water was received at MAR Labs on 12/23/2014
- pH: 9.77 (before addition of selenate standard)
- pH: 9.70 (after addition of selenate standard)
- Total alkalinity: 328 mg/L as $CaCO_3$
- Reactive silica: 8.2 mg/L
- Specific conductivity: 576 µmhos/cm (method E120.1)
- Metals (measured after spiking with selenate; ICP Method E200.7) by Precision Analytical, Cleveland OH
    - Al: 19.3 µg/L
    - Ca: 926 µg/L
    - Cu: 14.6 µg/L
    - Fe: 76.6 µg/L
    - Mg: 303 µg/L
    - Mn: 6.2 µg/L
    - Mo: 539 µg/L
    - K: 1400 µg/L
    - Silica (from ICP Si): 6.09 mg/L (as SiO_2)
    - Na: 139 mg/L
    - Zn: 195 µg/L
    - Se: 0.574 µg/L by ICP-MS with CRC (before spiking with selenate standard)
    - Se: 89.6 µg/L by ICP-MS with CRC (after spiking with selenate standard)

- Anions (Ion Chromatography Method E300.0) by Precision Analytical, Cleveland OH
    - Chloride: 10.1 mg/L
    - Fluoride: 5.04 mg/L
    - Nitrate: Not Detected
    - Ortho-phosphate: Not Detected
    - Sulfate: 21.6 mg/L

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PERFORMANCE GRAPHS AND RESULTS:

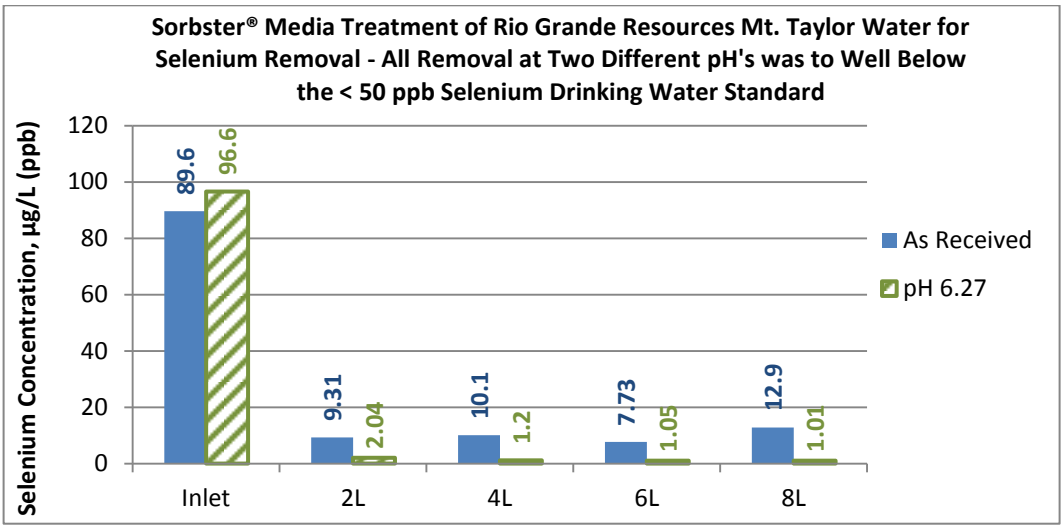

Figure 1: Selenium Concentrations in Sorbster Treated Mt. Taylor Water with pH Adjustment Averaged 1.4 ppb (98% Removal Rate). The Average Selenium Level for Non-pH Adjusted Water was 10 ppb (89% Removal Rate). Sorbster Media Provided Very Strong and Sustained Selenium Removal.

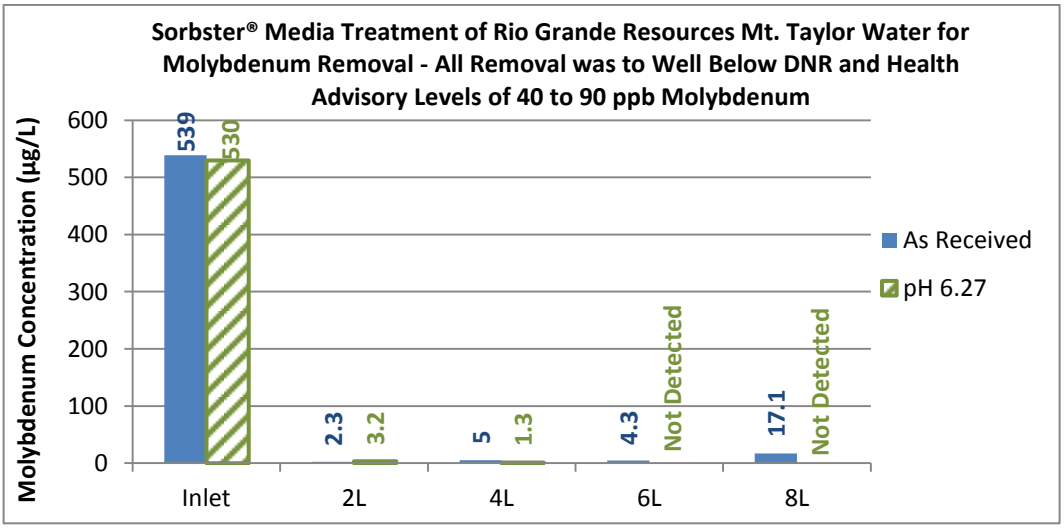

Figure 2: Molybdenum Concentrations in Mt. Taylor Water with pH Adjustment Averaged 3 ppb (99% Removal Rate). The Average Molybdenum Level for Non-pH Adjusted Water was 7 ppb (98% Removal Rate).

Table 2: Performance Summary of Sorbster Media for Tests Performed on Mt. Taylor Water Spiked with Selenate.

	Concentrations; µg/L (% removal)					
	Inlet Test 1	**Average**	**at 8L**	**Inlet Test 2**	**Average**	**at 8L**
Molybdenum	539	7.2 (98.7%)	17.1 (96.8%)	530	1.1 (99.8%)	ND (~100%)
Selenium	89.6	10.0 (88.8%)	12.9 (85.6%)	96.6	1.3 (98.6%)	1.01 (99.0%)
Silica	6.1	-	0.01 (99%)	6.0	-	0.05 (99.0%)

Comments and Recommendations:

- The Sorbster® Si-1 + Sorbster® Se-1 media system was found to be highly effective in treating Mt. Taylor water for selenium and molybdenum removal. Selenium (selenate) was reduced to 1.3 ppb and molybdenum to 1.1 ppb when the pH was reduced to 6.27. This removal was sustained throughout the 17 empty bed volumes treated, which is a good indicator of removal rate trend and high media capacity.
- pH adjustment to 6.27 provided the maximum removal. Removal efficiency for the water "as received" without pH adjustment was also very high at an average selenium reduction of around 89% and an average molybdenum reduction of around 98%.
- In all cases, selenium was removed by Sorbster to well below the drinking water standard of 50 ppb and molybdenum was removed to well below the State of New Mexico and health advisory levels of 40 to 90 ppb.
- The silica in the system was removed at 99% from the influent making the inclusion of Sorbster Si-1 pretreatment likely to be beneficial in extending the change-out rate/capacity of the metals removal media for selenium performance.
- MAR recommends a 500 GPM (or a flow rate representative of the total treatment flow) field demonstration to validate the results (when/if the State of New Mexico requires this step) with the following goals:
    - Optimize contact time required to meet treatment goals – System could potentially be scaled smaller.
    - Establish a media lifetime/capacity for this water to determine change-out frequency
    - Optimize the pH needed to meet treatment goals – System could potentially be operated at a higher pH in order to reduce the amount of acid needed. Acid demand in this water sample would equate to around 3.5 gallons of concentrated acid required per minute to reduce 10,000 GPM to a pH of around 6.3. If operated 24/7, this equates to ~1.84 M gallons/yr of concentrated acid
    - Optimize the ratio of Sorbster® Si-1 to Sorbster® Se-1 volumes to minimize media costs and change out frequency – This test operated at 1 to 1 volume ratios whereas a system with reduced Sorbster® Si-1 might perform as well and minimize cost without increasing the Si-1 change out frequency.
- MAR recommends organizing a meeting to discuss Sorbster® Technology, establish treatment criteria and define project scope/timeline