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Black Butte Copper Project

Zero Discharge LAD System
Black Butte Copper Project, Montana

with Comment on Select Historic LAD Systems

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Location
Black Butte Copper Project

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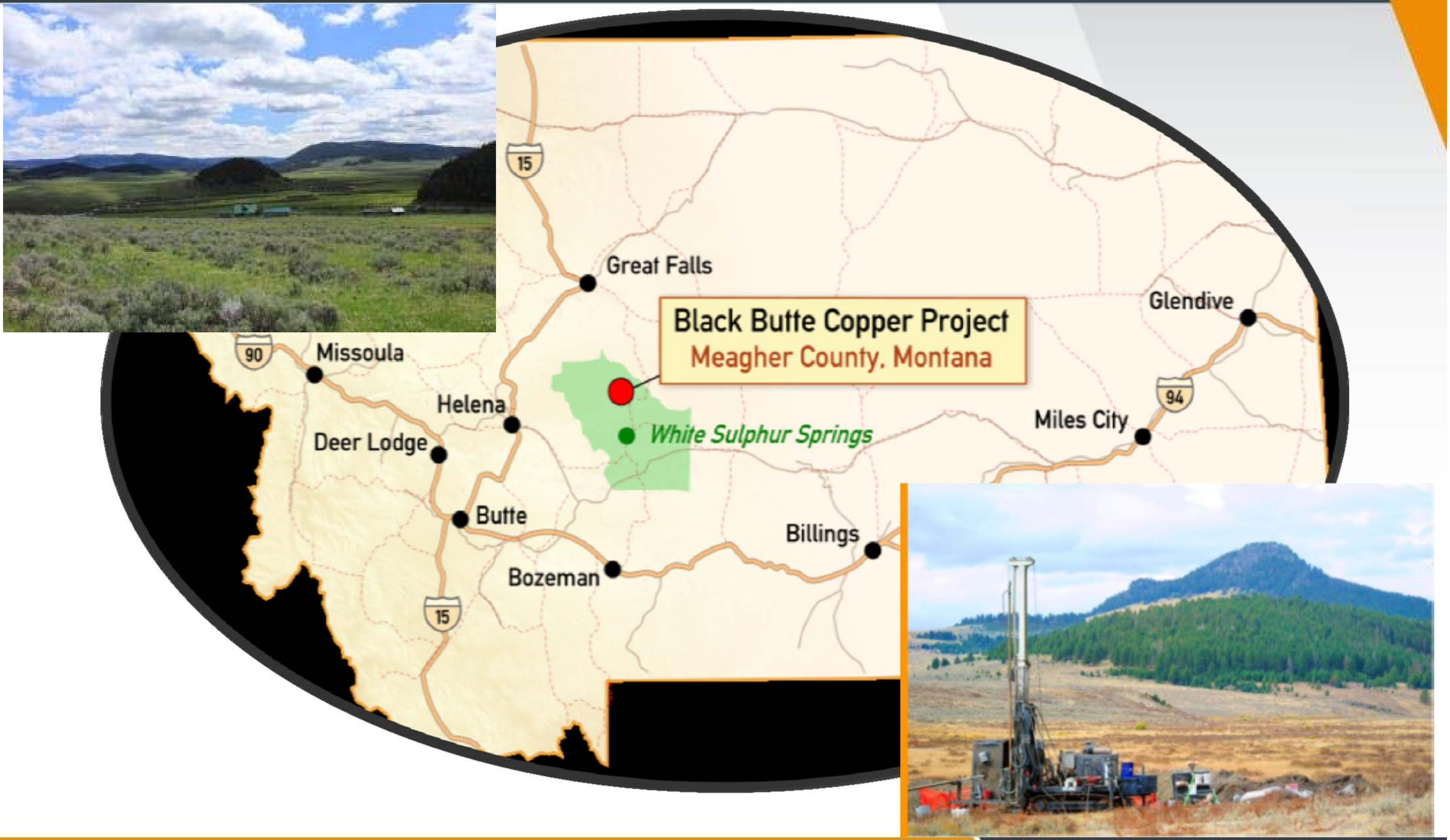

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Hydrologic Assessments - Objectives

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- Hydrologic Assessments objectives were to:
  - Determine aquifer characteristics of hydro-stratigraphic units and faults
    - vertical and horizontal connectivity of water flow between bedrock units, and between bedrock and alluvial systems
    - measure water flow volumes
  - Estimate inflow from units to be encountered in underground mine workings (declines, access ramps and mining stopes)
  - Collect baseline data and model groundwater flow in anticipation of submitting an Application for a Mine Operating Permit.

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Hydro-Stratigraphic Units
Cross Section of the Johnny Lee Deposit

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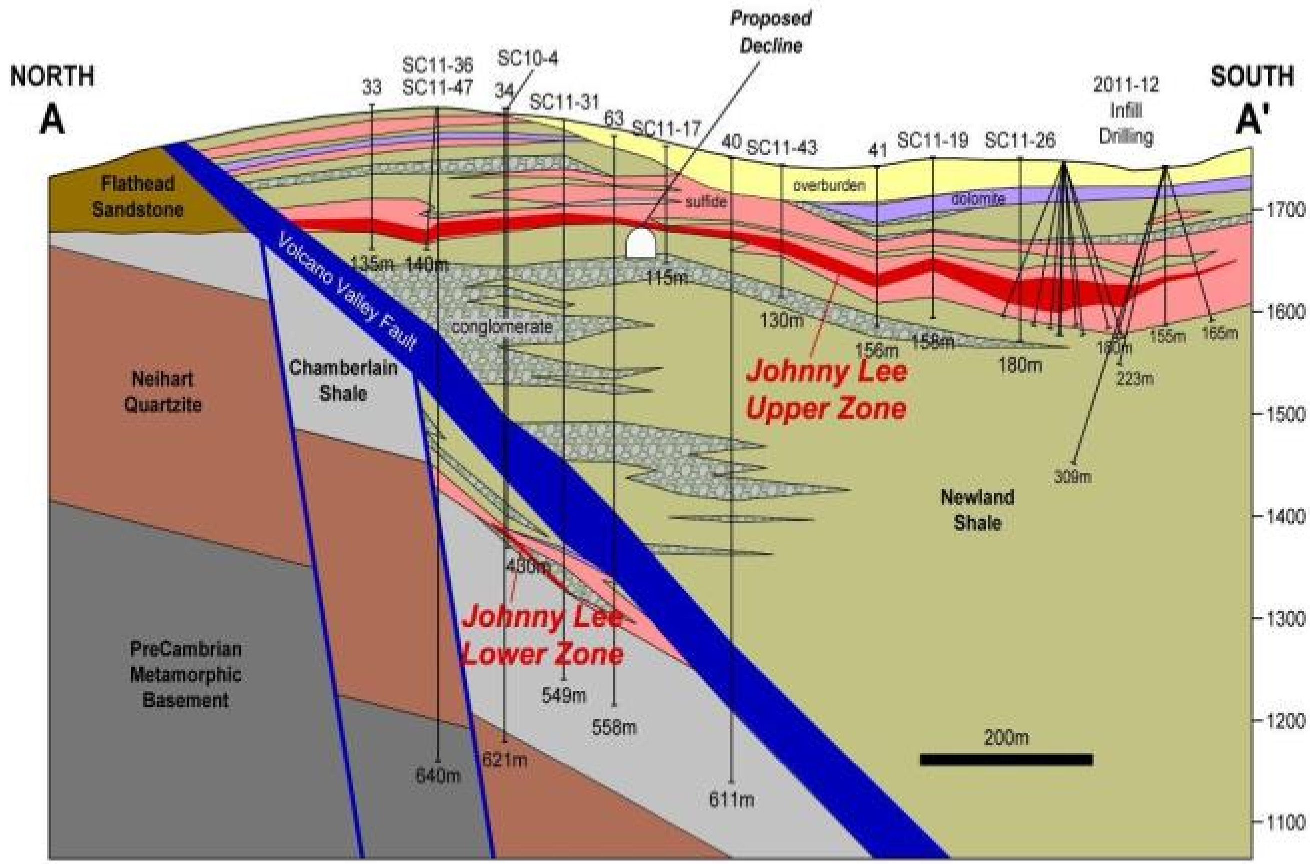
Hydro-Stratigraphic Units

- **Ynla – overlying Newland Fm.**
- **USZ – upper sulfide zone**
- **UCZ – upper copper zone**
- **Ynlb – underlying Newland Fm.**
- **Volcano Valley Fault**
- **Buttress Fault**
- **LCZ – lower copper zone**
- **Chamberlain Shale**
- **Neihart Quartzite**



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Hydrologic Assessment Components

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- Hydrologic Assessment Components
  - 4 previous pumping tests conducted (2011 - 2012)
  - Installation of 6 new pumping wells (2013 – 2014)
- Establishing monitoring program
  - 11 -GW monitoring/observation wells
  - 11 -SW sites
  - 13- springs
  - 12 -piezometers (wetlands and alluvium), and
  - 7 -lysimeters
  - --Exploration drill holes
- Conducting pumping / recovery aquifer tests.

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Pumping Wells and Monitoring Sites

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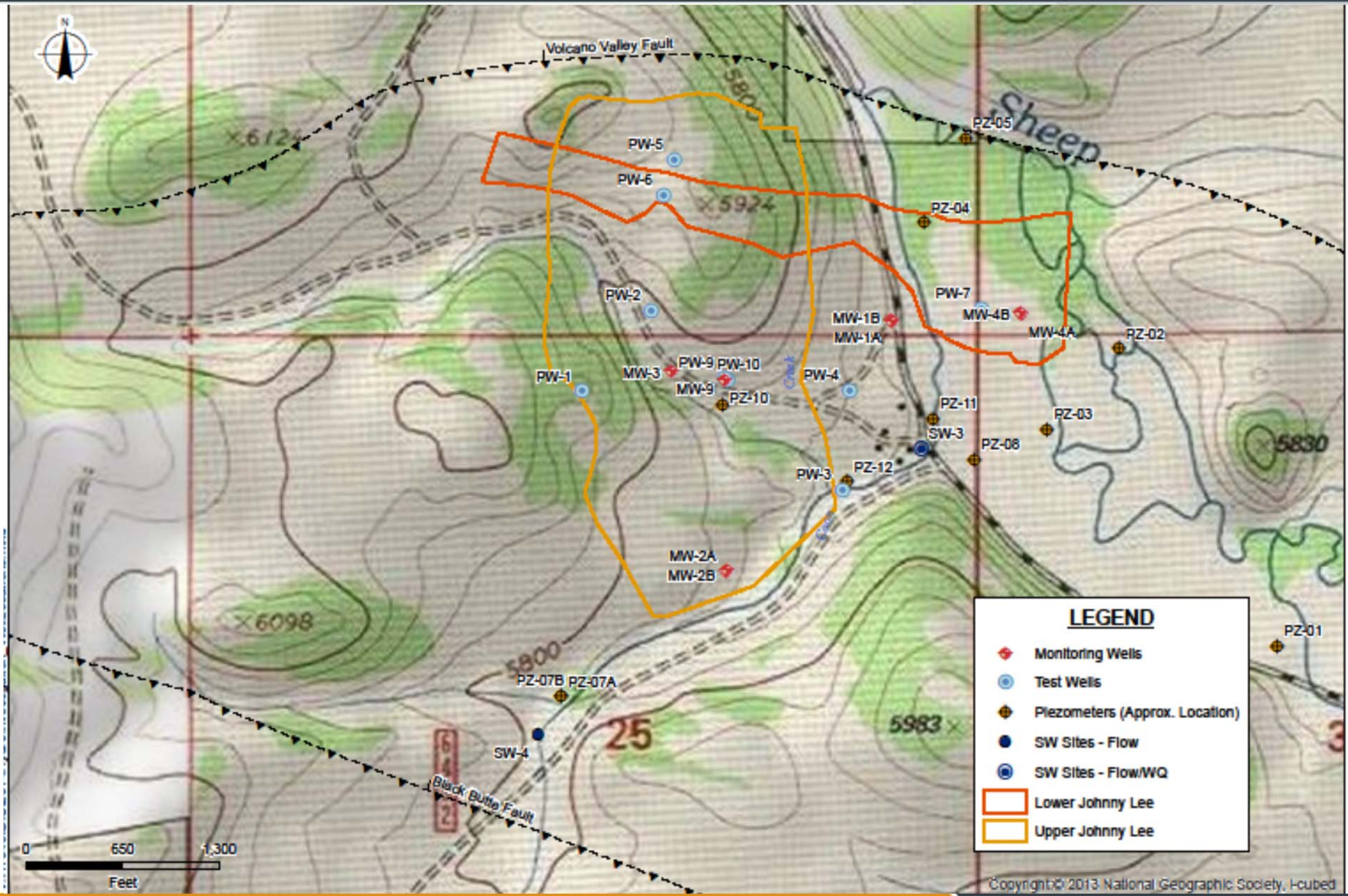

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Pumping Well Water Quality

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- Geochemistry in one of the earlier drilled pumping wells in upper sulfide zone exceeded human health standards
  - Arsenic - 0.067 mg/L (standard 0.010 mg/L)
  - Strontium - 9.3 mg/L (standard 4 mg/L)
  - Thallium - as much as 0.0048 mg/L (standard 0.0024 mg/L)
- Precluded permitting of direct discharge to groundwater via infiltration basins
- Led us to consider Land Application Disposal System

Land Application Disposal Systems

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- **Land Application Disposal Systems** –are a method of disposing of water using a water dispersal or irrigation system over a large area of vegetated land surface.
  - Alternative to waste water treatment and/or direct discharge to surface or groundwater
  - Water often does not meet water quality standards for direct discharge to surface or groundwater
  - Need to dispose of large volumes of water (i.e., 30-day pumping tests)
- Accomplishes water treatment through:
  - Evaporation
  - Agronomic uptake
  - Soil Attenuation/Adsorption
  - Reaction with organic materials
  - Microbial activity

LAD Contaminant Uptake

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- Factors effecting LAD contaminant uptake:
  - composition of the wastewater
  - site water balance (precipitation/evaporation/infiltration rates)
  - schedule and rate of land application (seasonal, climate, soil moisture limits)
  - area and topography of the land application site
  - climatic data and operational weather conditions
  - chemical/physical soil characteristics (infiltration rates and cation exchange capacity)
  - proximity to surface water
  - depth to and characteristics of underlying ground water resources
  - projected impacts on ground water quality
- Requires monitoring plan (wells, springs, lysimeters)

Reason for Designing a LAD System

- However test water produced would be:
  - Below the EPA's Recommended Limits for Constituents in Reclaimed Water for Irrigation (USEPA, 2006).
  - Applied at rates and quality that would maintain metal loading limits below those recommended by the EPA based on World Health Organization annual limits for metals applied to Agricultural Crop Land (Chang, et al., 1995).
- As a result a Zero Discharge Land Application Disposal (LAD) system was designed for discharge of pumping test water.

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Zero Discharge System Components

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Zero Discharge LAD System Designed that

- Application rates sufficient for agronomic/evaporative uptake to result in zero discharge to surface or groundwater.
- Water application maintained at less than 90% of the monthly net irrigations requirement for a normal year
- Daily discharge to the LAD system would not exceed the average daily ET minus precipitation in last 24 hours.
- LAD designed for aquifer test discharge rates of 30 gpm

- Water applications were:
  - Limited to a range of 1 to 6 hours a day (based on avg. daily ET)
  - Minimum drying period of 18 hours followed the application period
  - Applied at optimum time of day for agronomic/evaporative uptake
- Test water was applied to the 17 acre surface area of the LAD

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IWR Calculate Average Monthly Requirements for Pasture Grass

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Month	Total Monthly ET[3] inches	Normal Year 50% Chance[1]		Average Daily ET inches	Peak Daily ET inches
		Effective Precipitation inches	Net Irrigation Requirements inches[2]		
January	0.00	0.00	0.00	0.00	
February	0.00	0.00	0.00	0.00	
March	0.00	0.00	0.00	0.00	
April	0.69	0.19	0.00	0.06	
May	2.91	1.11	1.80	0.09	0.11
June	4.38	1.21	3.17	0.15	0.17
July	5.74	0.98	4.76	0.19	0.23
August	5.18	0.66	4.52	0.17	0.20
September	2.76	0.57	2.19	0.09	0.10
October	0.99	0.28	0.21	0.05	
November	0.00	0.00	0.00	0.00	
December	0.00	0.00	0.00	0.00	
Total	22.64	4.99	16.65		

(1) For 50 percent chance of occurrence, effective precipitation will be equaled 1 out of 2 years.

(2) Net Irrigation requirements are adjusted for carryover moisture used at the beginning of the season and carryover moisture used at the end of the growing season.

(3) Evapotranspiration (ET) is adjusted upwards 10% per 1000 meters above sea level.

Pasture Grass LAD Area

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LAD Design Parameters

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Parameter	August	September	Units
Irrigation Water Requirement (for Pasture grass)	4.52	2.19	in/month
90% of Irrigation Water Requirement (design basis)	4.07	1.97	in/month
Application Rate per hour	0.02	0.02	inches
Sprinkler Efficiency (per NRCS)	70%	70%	--
Sprinkler Flow Rate (@ 35 psi)	1.51	1.51	gpm
Sprinkler Radius (@ 35 psi)	36	36	feet
Maximum Daily Discharge minus precipitation	0.17	0.09	inches
Maximum Duration of LAD System (No Precip)	6	4	hours

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Maximum Dailey Discharge Rate and Total Volume to LAD

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Parameter	August	September	October
Average Daily ET (inches)	0.17	0.09	0.05
Max Daily Pumped (gallons)	37,500	22,500	11,250
Maximum Application (inches)	0.13	0.08	0.04
Percent of Average Daily ET	76%	89%	80%

Test Well	Pumping Days	Discharge Days	Total Volume Pumped to Tanks (gallons)	Total Volume Pumped to LAD (gallons)*	Variable Pumping Rate (gpm)
PW-8	30	20	410,682	401,250	5 to 10
PW-9	19	15	141,609	158,650	5 to 6
Total	49	35	552,291	559,500	

*Total Volume Pumped to tanks does not include step tests or PW-6 test.

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LAD Schematic

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Hydrometrics, Inc.
Consulting Scientists and Engineers

Figure 3-1
LAD Schematic
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Meagher County, Montana

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Monitoring and Pumping Wells MW-9, PW-9 and PW-10

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Monitoring Observation and Pumping Well

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Two of the 21,000 gallon, Short-Term Storage Tanks

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Pump with 6” Main Water Line to LAD

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Portion of 17-Acre LAD Area

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LAD Photographs

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LAD Lysimeters

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Discharge Water Quality and Arsenic Metal Load

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- Groundwater from wells had average arsenic concentrations of 0.014 mg/L to 0.086 mg/L (predicted 0.060 mg/L)

- Total arsenic load applied to the LAD area over the pumping test program was 0.021 lbs./acre (1/3 oz.)
  - less than 2% of EPA recommended load limit for arsenic 1.78 lbs./acre)

Test Well	Average Arsenic Concentration (mg/L)	Total Volume Pumped to LAD (gallons)	Application Area (acres)	Load (lb/acre)
PW-8	0.014	401,250	7.75	0.006
PW-9	0.086	158,650	7.75	0.015
			Total	0.021

LAD System Monitoring

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- LAD water resource monitoring:
  - conducted on a weekly basis
  - included seven LAD lysimeters
  - three springs, and
  - samples from LAD sprinkler discharge to evaluate:
    - the removal of arsenic from oxidation of the groundwater during transport and storage
    - average arsenic removal (see table) was 56%.

Date	PW-8	PW-9	Sprinkler Discharge	Percent Reduction
8/28/2014	0.014	--	0.005	64%
10/9/2014	--	0.082	0.062	24%
10/16/2014	--	0.082	0.016	80%
All concentrations in mg/L				

  - soil samples collected pre- and post-LAD operations

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Lysimeter Sampling results

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- The individual lysimeters produced insufficient water for field parameter measurements and laboratory analysis.
  - a composite of 3-4 lysimeter samples was used to measure field parameters and laboratory analysis for total metals.

  - Estimated Pore Water Volume from LAD Lysimeters

Date	LS-1	LS-2	LS-3	LS-4	LS-5	LS-6	LS-7
	(volume in ml)						
7/31/2014	0	100	100	N/A	100	N/A	N/A
8/7/2014	<10	N/A	N/A	N/A	N/A	N/A	N/A
8/26/2014*	30	200	225	<10	125	N/A	N/A
9/3/2014	<10	150	100	<30	100	<30	<30
9/10/2014	10	175	250	10-20	150	50-75	10-20
10/1/2014	50	200	200	100	150	100	50
10/8/2014	5	200	200	50	150	10	20
10/22/2014	5	200	200	50	200	50	50

* Precipitation 0.7 inches August 23 and 24.

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Spring Sampling results

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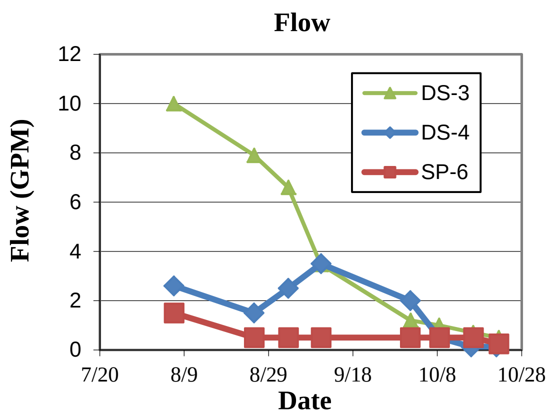

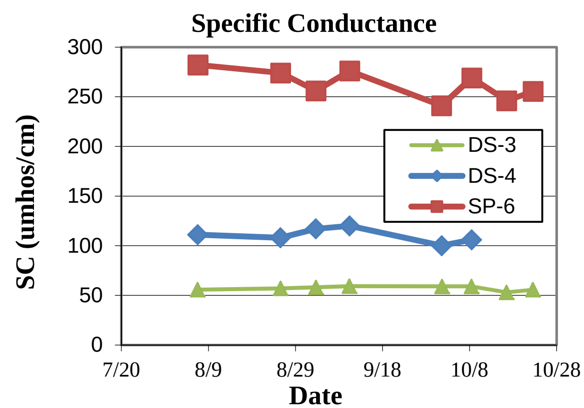

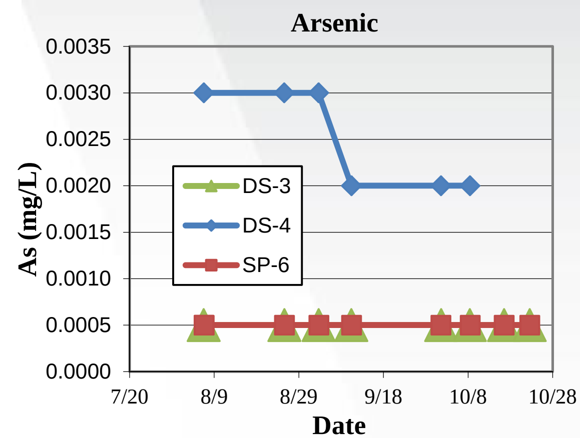

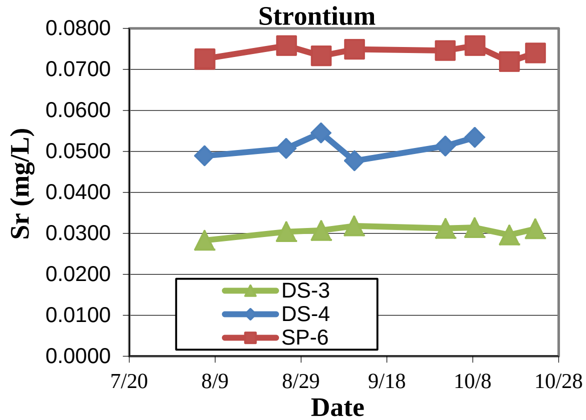

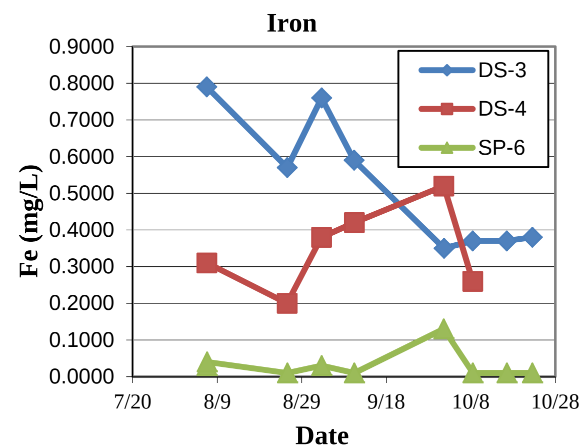

Soil Testing Results

- Soil samples were collected prior to and post LAD operation from depths of 0-6” and 6-12” intervals.
- Soil concentrations were below the detection limit for arsenic, selenium and thallium in all samples.
- largest increase and decrease in soil concentrations was seen in iron, with percent changes ranging from a 184% decrease to 474% increase in concentration
- Concentrations of barium, manganese, strontium, and zinc increased slightly or decreased between pre and post LAD discharge period.

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LAD Conclusions

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Conclusions

- LAD monitoring indicates that water distributed on the zero discharge LAD system did not impact surface or shallow groundwater resources.
- Loading to soils was substantially below EPA's recommended limits for arsenic and strontium.
- Tintina's successful implementation suggests zero discharge LAD systems can provide a viable alternative for disposal of excess water from hydrologic testing or other water sources.

Historic Use of LAD Systems in Emergency Situations

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Examples of Historic Use of LAD Systems under Emergency Circumstances

- Onset of Discharge of Water from Two Heap Leach Pad Facilities to LAD Systems
    - Beal Mountain Mine
    - Zortman-Landusky Mines
  - Chronology of Events
  - Emergency Situations
  - Conclusions

Beal Mountain Heap Leach Pad

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Beal Mountain Facility Map

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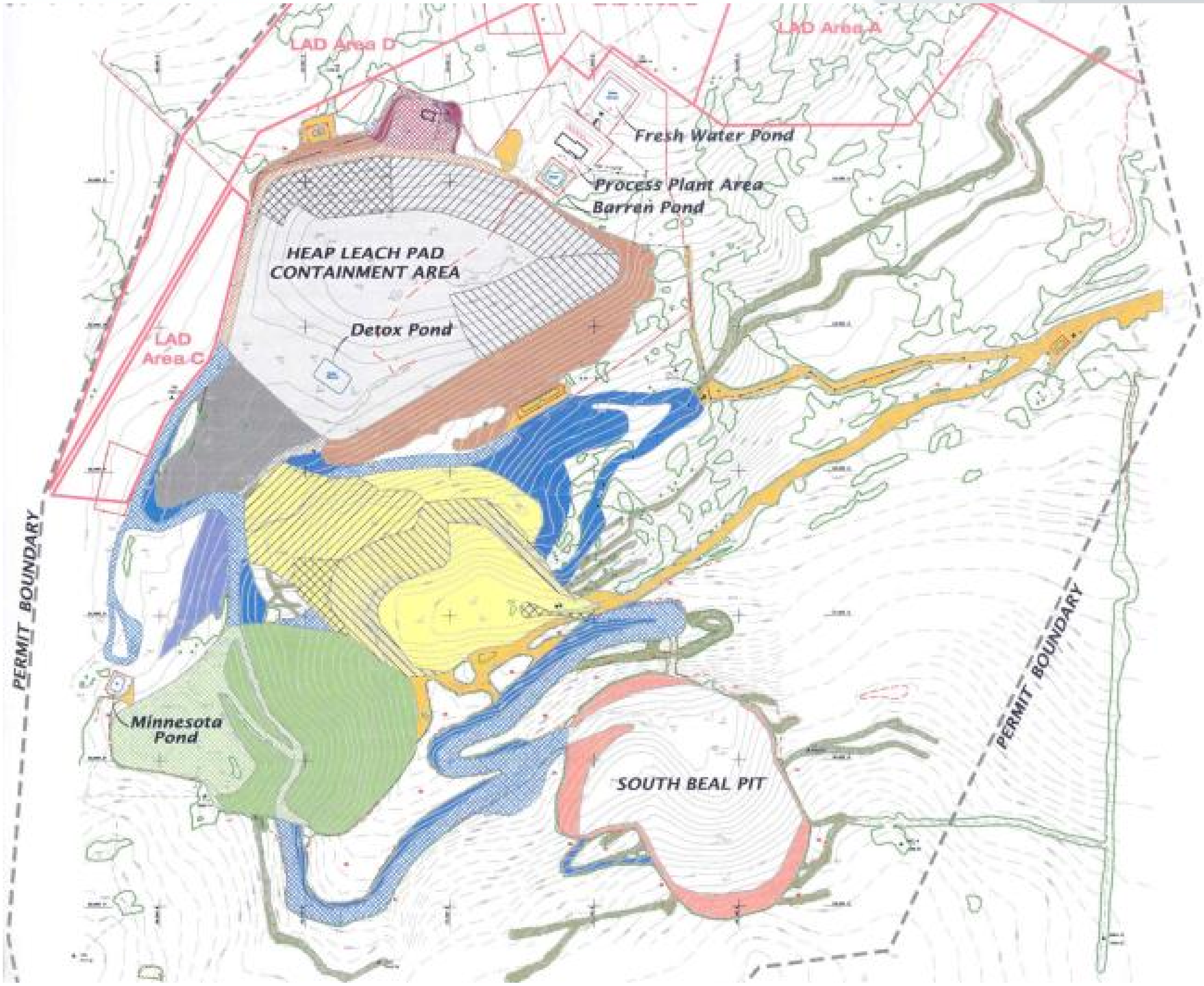

Zortman Landusky Mines with LAD System

Zortman LAD Layout at 210 acres

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Conclusions

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- Conclusions
  - LAD systems used at Zortman and Beal Mountain were not systems designed with the expectation that they could effectively treat large volumes of contaminated water, by evaporation and soil attenuation as is typical in most in LAD systems.
  - Instead, they were emergency releases of water to avoid overflow of heap leach pads containing significantly contaminated process water. thereby creating a direct discharge to surface or groundwater.
  - The LADs at Zortman and Beal Mountain Mines should not be compared with more typical LAD systems designed to treat water at other mines or agricultural sites.

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Well	Target	GPM	Time	Drawdown ft	comment
PW-5	VVF	1	20 min.	30'	deep water level 500 ft
PW-6	BF	3.5	2 hrs	225'	
PW-7	LCZ				artresian slug test only
PW-8	YNL-A	5.5	4 days		
		8	4 days		
		10	23 days	Total 30 days	
PW-9	UCZ	5.5	10 days		
		6	9 days	total 19 days	
PW-10	YNL-B	0			insufficient flow

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2011 - 2014 Pumping Well Completion Data

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WELL NAME	Northing (meters)	Easting (meters)	Ground Surface Elev. (feet amsl)	Measuring Point Elev. (feet amsl)	Borehole Total Depth (feet, bgs)	Well Total Depth (feet, bgs)	Perforated/ Screen Interval (feet, bgs)	Hydro-stratigraphic Unit	Year Drilled	Purpose
	UTM Zone 12 North									
PW-1	5180698.40	506301.42	5912.07	5913.74	213	211	140-211	YNL-A - Perched	2011	Previous Decline
PW-2	5180865.03	506443.15	5793.08	5794.88	215	212	132 - 212	USZ	2011	Previous Decline
PW-3	5180479.42	506846.43	5655.21	5657.42	131	127	90-127	YNL-A	2012	Exploration Decline
PW-4	5180701.75	506849.44	5678.13	5680.01	242	239	200-239	USZ	2012	Exploration Decline
PW-5	5181172.77	506490.68	5913.22	5915.49	555	500	515-555	Volcano Valley Fault	2013	Volcano Valley Fault Hydrologic Characteristics
PW-6	5181085.67	506477.44	5895.43	5897.40	1234	1204	1164-1204	Buttress Fault	2013	Buttress Fault Hydrologic Characteristics
PW-7	5180867.59	507122.89	5609.11	5611.15	1350	1346	1306-1346	LCZ	2013	Baseline LCZ Characterization
PW-8	5180695.53	506846.19	5679.12	5680.60	184	178.5	138.5-178.5	YNL-A	2014	Baseline YNL-A Characterization
PW-9	5180721.88	506598.38	5743.59	5745.05	255.5	255.5	215.5-255.5	UCZ	2014	Baseline UCZ Characterization
PW-10	5180721.88	506593.55	5743.57	5744.84	369.5	358.5	318.5-358.5	YNL-B	2014	Baseline YNL-B Characterization