

Defense-Related Uranium Mines Risk Scoring Assessment and Risk Ranking Results



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U.S. DEPARTMENT OF
ENERGY

Legacy
Management

Defense-Related Uranium Mines Risk Scoring Assessment and Risk Ranking Results

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2018 Long-Term Stewardship Conference Session

8.2 Environmental and Human Health Risk Screening of Abandoned Mines

DOE DRUM Program Overview



- The DRUM Program is a one time inventory and environmental sampling effort to fill data gaps identified in the report to congress on approximately 4,225 mines with U.S. Atomic Energy Commission (AEC)ore purchase records between 1947 and 1970
- One of the main goals of the program is to develop and implement a risk-based screening assessment to support partner agency decisions regarding the need for further site analysis or action



Risk Scoring Assessment Approach

- Evaluate the primary hazards (physical hazards and human health risks)
- Use modifying factors to adjust or clarify the primary hazard evaluation
- The three modifying factors are
 - Ecological and Environmental Risk Evaluation
 - Access and Suitability Evaluation
 - Complexity and Magnitude Evaluation
- Focus on the endpoint ranking (none, low, medium, or high)
 - not the numerical risk scores



Buckshot Mine, Club Mesa Area, CO

Physical Safety Hazards

- Injury or death from a site visitor falling into a mine feature or a mine feature collapsing on a site visitor
- Typical hazards include open shafts, open and unstable adits, subsidence features, and large mine structures, such as unstable ore chutes



Waste Rock Pile and Loadout at Buckshot Mine, CO



Recreational Use Scenario

- Federal Public Lands
- Recreationalist spends 2 weeks a year camping on site
- Relatively arid sites-majority of DRUM in southwest
- 26 years exposure duration (2 years as a child, 24 years adult exposure)
- Radiological and Chemical exposure pathways

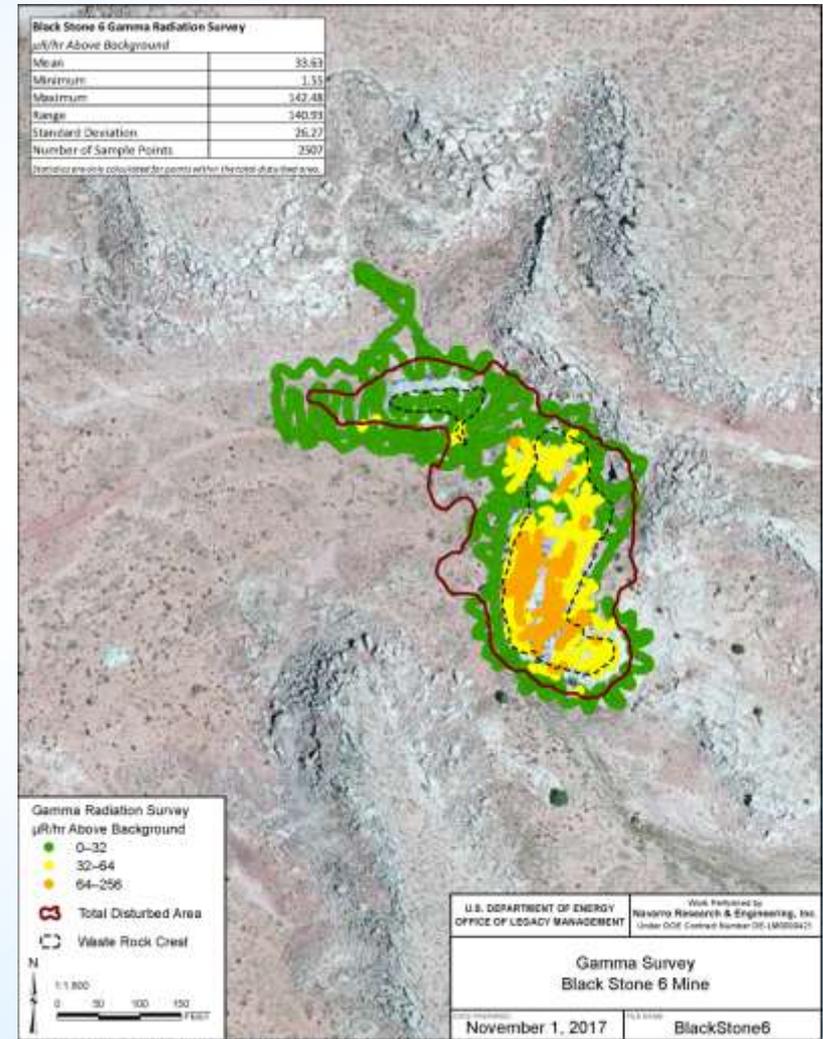


Spook Dee Mine, Red Canyon, UT



Radiological Screening Levels

- $256 \mu\text{R/hr} \cong 100 \text{ mrem/yr}$
 - 100 mrem/yr: DOE and NRC public exposure limit for nuclear facilities and ICRP 103 recommendation
- $64 \mu\text{R/hr} \cong 25 \text{ mrem/yr}$
 - 25 mrem/yr: NRC public exposure limit for D&D and license termination
- $32 \mu\text{R/hr} \cong 12 \text{ mrem/yr}$
 - 12 mrem/yr: EPA protective dose level recommendation
- Mean μR for the total disturbed area of the mine site is used for the Risk Scoring Assessment



Chemical Screening Levels

- Risk-based screening levels (RBSL) developed for inorganic chemicals commonly found at mine sites
- Chemical exposure pathways include:
 - Ingestion
 - Dermal Contact
 - Inhalation of windblown particulates
 - Dust from ATV riding not included in chemical exposure evaluation
- RBSL developed by BLM using EPA's on-line risk screening level calculator – updated regularly
- Risk results presented as ratio of site concentration to recreational RBSL (Risk Ratio)
 - Hazard index (HI) approach



Mineralization at Paradox Bell Mine, Long Park Area, CO

BLM Recreational Screening Levels (mg/kg)

Chemical	BLM Recreational SL	EPA Residential SL	EPA Industrial SL
Aluminum (Al)	>1,000,000	77,000	>1,000,000
Antimony (Sb)	782	31	470
Arsenic (As)	30.6	0.68	3
Barium (Ba)	390,000	15,000	220,000
Beryllium (Be)	3,910	160	2,300
Cadmium (Cd)	1,780	71	980
Chromium (III) (Cr)	>1,000,000	120,000	>1,000,000
Cobalt (Co)	586	23	350
Copper (Cu)	78,200	3,100	47,000
Iron (Fe)	>1,000,000	55,000	820,000
Lead (Pb)	800 ^a	400	800
Manganese (Mn)	46,700	1,800	26,000
Mercury (elemental) (Hg) ^b	271	11	46
Molybdenum (Mo)	9,780	390	5,800
Nickel (Ni)	39,000	1,500	22,000
Selenium (Se)	9,780	390	5,800
Silver (Ag)	9,780	390	5,800
Thallium (Tl)	19.6	0.78	12
Uranium (U) ^c	391	16	230
Vanadium (V)	9,850	390	5,800
Zinc (Zn)	587,000	23,000	350,000
Primary Exposure Assumptions	14 days/year, 26 years, adult/child	350 days/year, 26 years, adult/child	225 days/year, 25 years, adult

^aThe recreational SL for lead is based on EPA's industrial SL, which assumes regular and chronic exposure to soil, although not as frequently or extensively as the residential SL.

^bMercury is the only metal on the list whose SL is based on the inhalation pathway. EPA made some minor changes in their volatilization modeling in 2015 and the SL increased slightly. SLs for all populations may exceed the soil saturation concentration (C_{sat}), an estimate of the concentration at which the soil pore water, pore air, and surface sorption sites are saturated. Above this theoretical threshold concentration, mercury may be present in free-phase within the soil matrix.

^cUranium screening values updated per changes in EPA's oral toxicity value.



Risk Scoring Assessment Purpose and Objectives

- Designed to put mines into “bins” that pose similar hazards
- Provide sufficient flexibility to optimize risk evaluation
- Focus on primary hazards: physical hazards and human health risk
- Address all modifying factors
- Allow end user to tailor risk information to objectives
- Separate out mines that require some action from those that clearly do not require action



Open Shaft at Yellow Circle Mine, UT

Primary Hazards

Physical Safety Hazard
and Human Health
Risks

Score of 0 for both

No Known Hazards

↓ Low, Medium, or High
for Physical Hazards or
Human Health Risks

↓ T&E or special
species and physical
hazard present

Three Modifying Factors

Access and Suitability

- Accessibility by vehicle or hiking
- Visible from maintained road
- Signs of use at the site
- Suitability of the area for camping

Complexity and Magnitude

- Physical Hazards
 - Mine extent and complexity
- Human Health
 - Magnitude of the risk ratio

Ecological Impacts

- Threatened or endangered species
- Hazards that may entrap wildlife
- Sediment shed with elevated gamma
- Surface water nearby

Risk Ranking Summary Table



Potential Impacts of Modifying Factors

Primary Hazard Evaluation	Related Modifying Factors												Non-Related Modifying Factors		
	Access			Suitability			Complexity			Risk Magnitude			Ecological/Environmental Risk Evaluation		
	Low	Medium	High	Low	Medium	High	Low	Medium	High	Low	Medium	High	Low	Medium	High
Physical Hazards	-	0	+	Not Applicable			0	+	+	Not Applicable			0 0 +		
Human Health Evaluation	-	0	+	-	0	+	Not Applicable			0	+	+			

- May decrease the final ranking
- 0 Will likely not impact the final ranking
- + May increase the final ranking

Risk Scoring Example

Open Adit with Unstable Brow at Joe Bishop Mine, UT

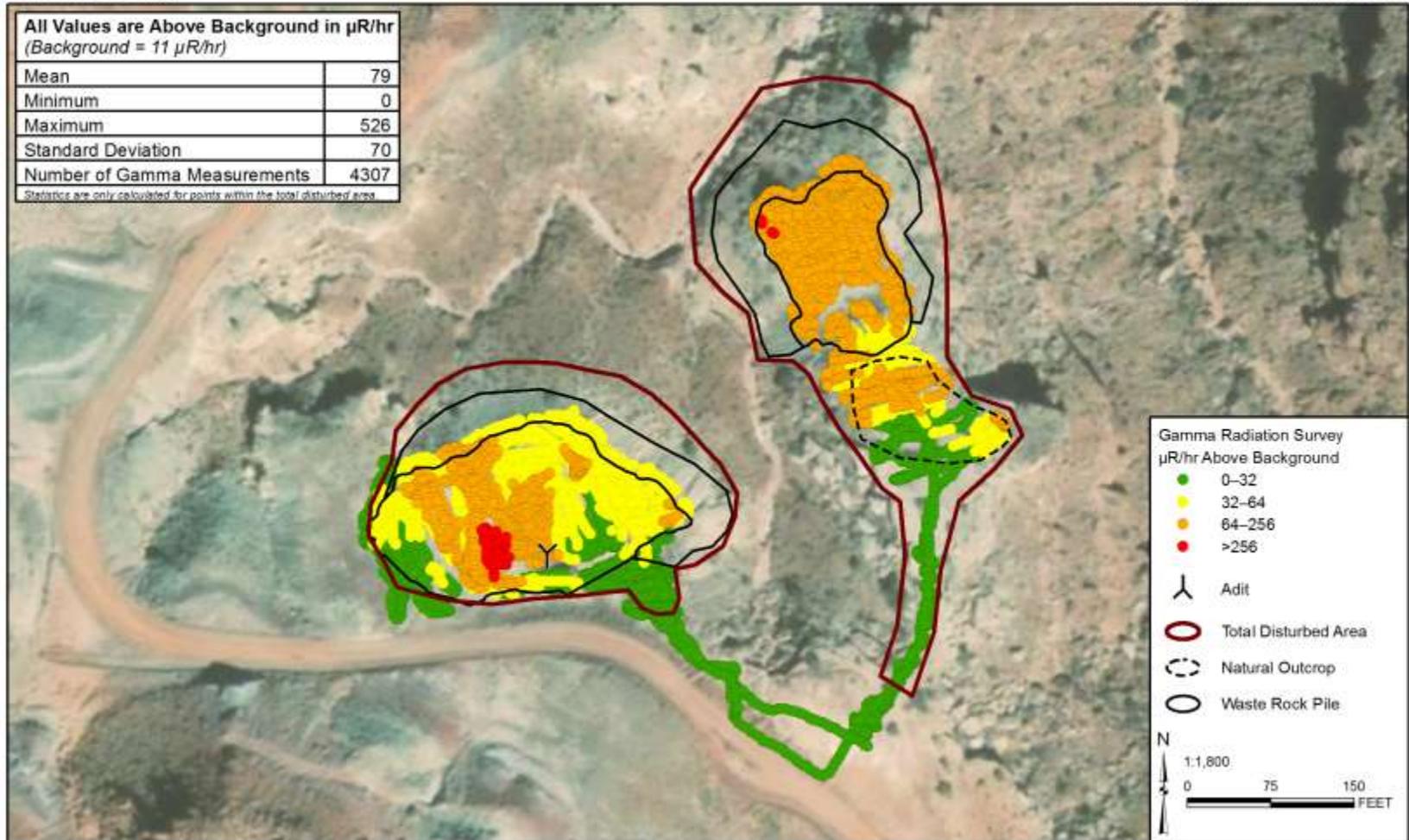


Risk Scoring Example

Gamma Radiation Survey for the Joe Bishop Mine, UT

Gamma Survey

Joe Bishop Mine – LMID 3155



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Risk Scoring Example

COI Soil Sample Results Joe Bishop Mine, UT

Analyte	Background Sample ^a	LQ	VQ	Recreational Screening Level ^b	Waste Rock Sample 1 ^c	LQ	VQ	Risk Ratios ^d	Waste Rock Sample 2 ^c	LQ	VQ	Risk Ratios ^d
Metals (mg/kg)												
Aluminum	8,000			>1,000,000	4570			0.00	3,700			0.00
Antimony	0.333	U		782	0.309	U		0.00	3.35	U		0.00
Arsenic	1.76			30.6	25.6			0.84	23.2			0.76
Barium	186			390,000	82.9			0.00	154			0.00
Beryllium	0.807			3,910	0.658			0.00	0.504			0.00
Cadmium	0.0381	B		1,780	0.0327	B		0.00	0.0565	B		0.00
Chromium	17.8		J	>1,000,000	9.08		J	0.00	8.29		J	0.00
Cobalt	7.98			586	13.2			0.02	12.8			0.02
Copper	38.2			78,200	3200			0.04	2,660			0.03
Iron	23,000			>1,000,000	16,500			0.02	21,200			0.02
Lead	12.4		J	800	27.3		J	0.03	28.1		J	0.04
Manganese	557		J	46,700	49.3		J	0.00	221		J	0.00
Mercury	0.0061	B, Q		271	0.00848	B, Q	J	0.00	0.00787	B, Q	J	0.00
Molybdenum	0.157	B		9,780	1.82			0.00	1.97			0.00
Nickel	18.7			39,000	11.4			0.00	10.3			0.00
Selenium	1.36			9,780	1.75			0.00	2.36			0.00
Silver	0.101	U	J	9,780	0.243	B	J	0.00	0.102	U	J	0.00
Thallium	0.146	B		19.6	0.493			0.03	0.972			0.05
Uranium	4.61			391	503			1.29	173			0.44
Vanadium	27.6			9,850	22.9			0.00	17.8			0.00
Zinc	33.9		J	587,000	20.1		J	0.00	23.2		J	0.00
Cumulative Risk Ratios								2.27				1.36
Radionuclide (pCi/g)^e												
Radium-226	4.94			37-147	147				47.1			
Soil pH												
pH	8.60	H, Q	J	none	6.84	H, Q	J		7.53	H, Q	J	



Risk Scoring Example

Risk Ranking Summary for the Joe Bishop Mine, UT

Primary Hazards		Risk Ranking	Comments
Physical Hazard Evaluation		High	Adit 2 is open with an unstable brow
Human Health Risk Evaluation	Radiological	Medium	Mean gamma radiation survey result is 79 μ R/hr above background
	Chemical	Low	The highest cumulative risk ratio is 2.27 and one COI has an individual risk ratio above 1
Modifying Factors		Risk Ranking	Comments
Ecological and Environmental Hazard Evaluation	Physical Hazards	None	There are no inherent physical hazards to wildlife
	Pathway Hazards	None	Vegetative foliar cover is below 10%
Access and Suitability Evaluation	Access	High	The mine is accessible by a four-wheel-drive road and is visible from Red Canyon Road
	Suitability	High	Two fire rings and tire tracks were found directly outside of the mine; the total disturbed area is 3 acres and includes areas suitable for camping
Complexity and Magnitude Evaluation	Complexity	Not applicable	No major mine features besides the open adit
	Magnitude	Not applicable	The highest cumulative risk ratio is 2.27

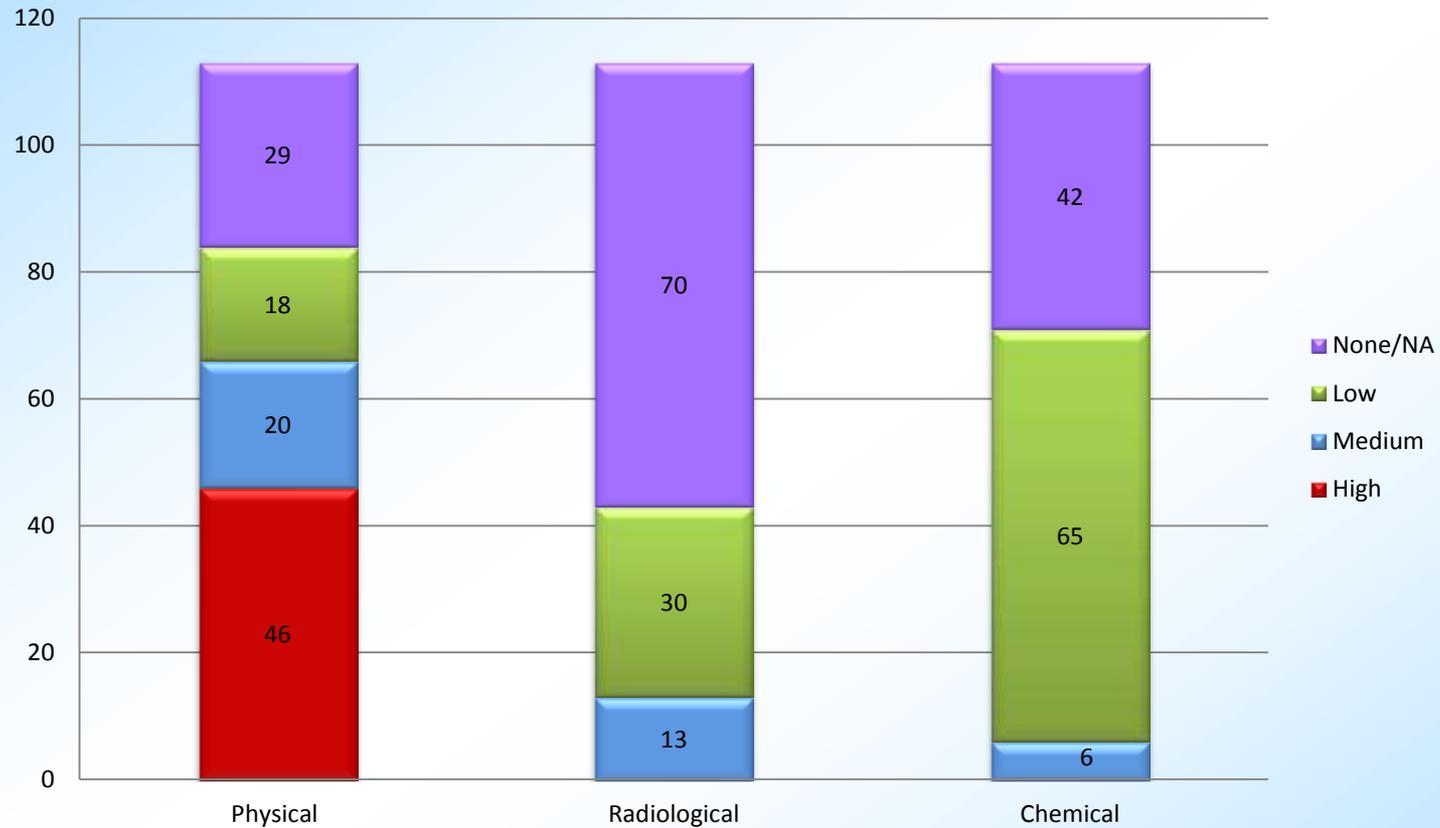


Risk Ranking Results

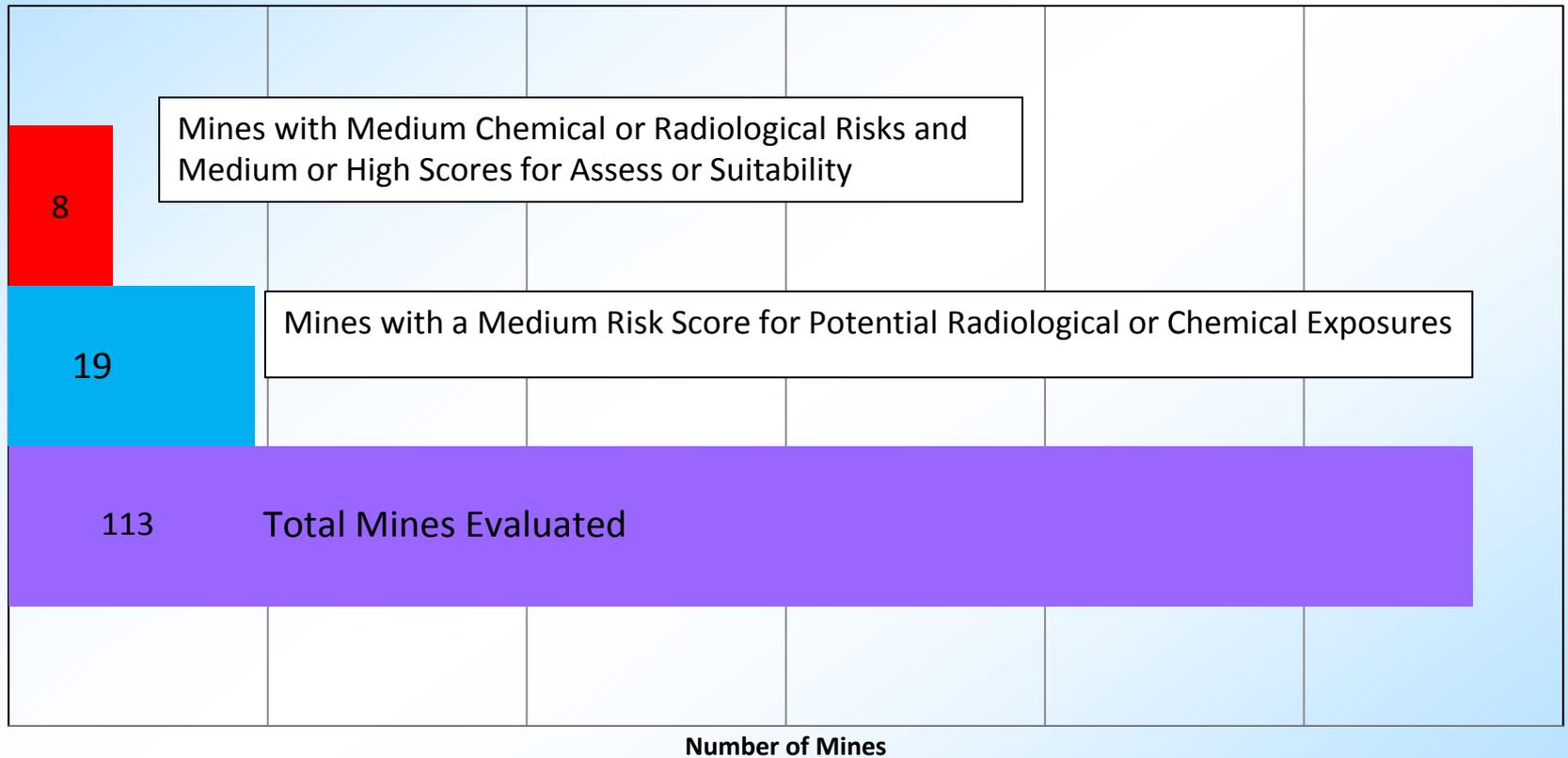
- Risk Scoring Assessment completed on 113 mines on BLM managed land in Colorado and Utah
- None of the mines ranked high for human health risk for either chemical or radiological hazards
- Approximately 35% of the mines evaluated ranked low or none/NA for all three of the primary hazards, and could be candidates for no further action
- Approximately 58% of the mines evaluated ranked high or medium for physical safety hazards, and may require some action.
- Based upon modifying factors such as site access or camping suitability, the mines that ranked medium for chemical or radiological risks could be candidates for further investigation



Risk Ranking Primary Hazards Results

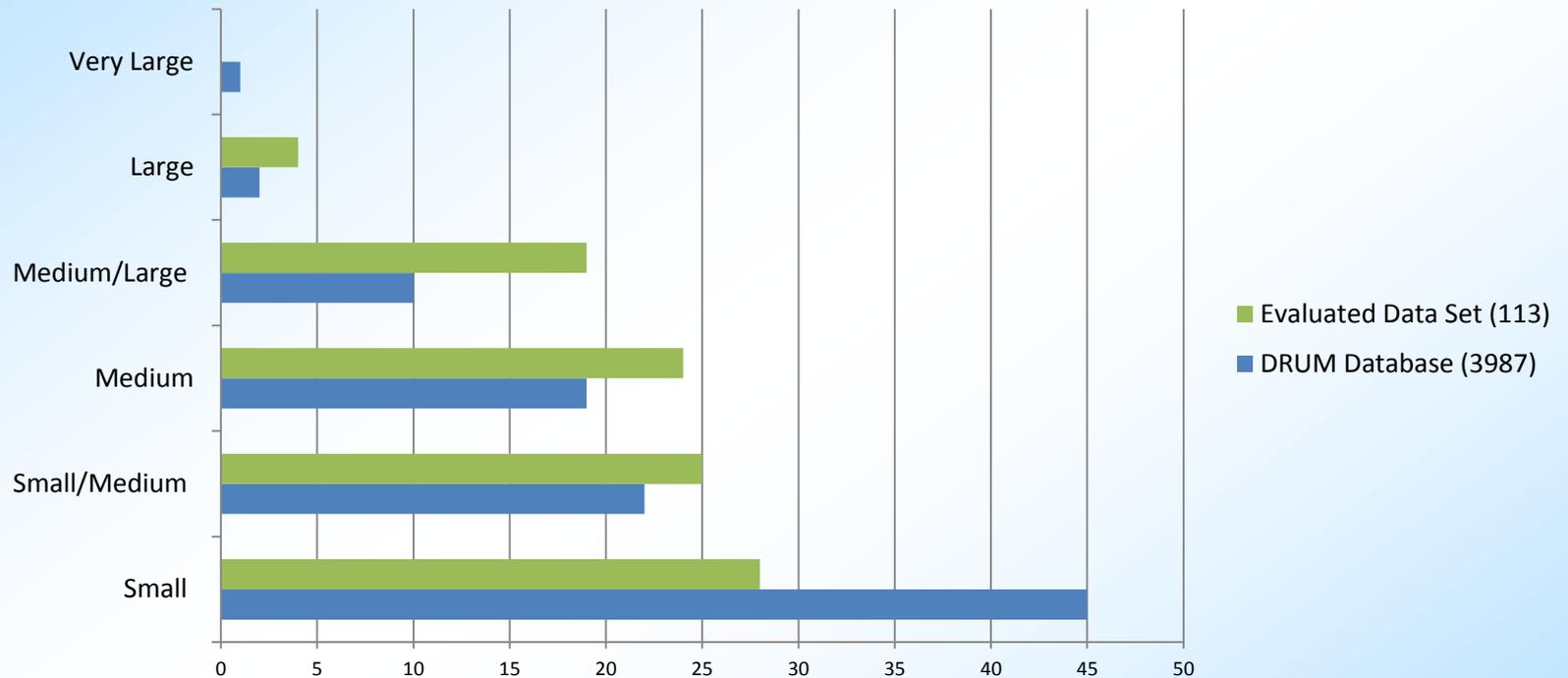


Risk Ranking Human Health Results



Evaluated Data Set vs. DRUM Database

The Percent of Mines by Size Category: Evaluated Data Set vs. DRUM Database

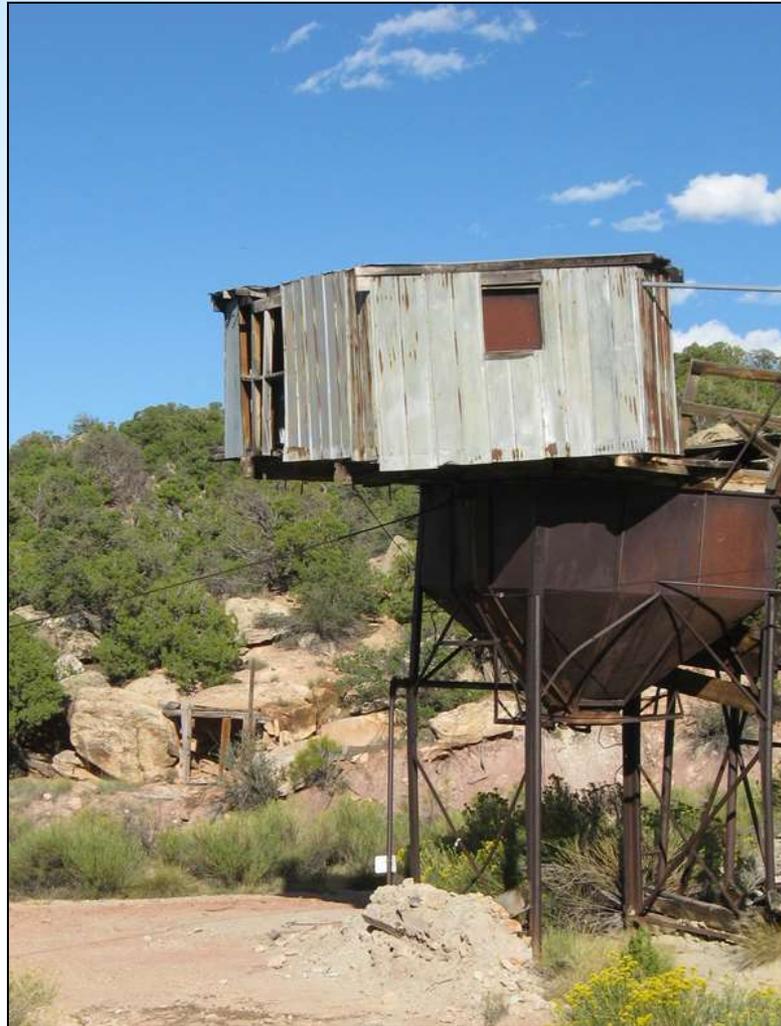


Conclusions

- The risk scoring approach has successfully organized the sites into the opposite ends of the hazard spectrum:
 - Those sites that pose no or minimal risks and can be likely candidates for no further action for physical or CERCLA hazards
 - Those sites that present hazards and may require some action by the land management agencies
- Physical hazards are the primary risk driver and only require a one-time instantaneous event (e.g., falling down an open shaft)
- Exposure to gamma radiation and mine-related chemicals results in much lower risks, and requires the fulfillment of a conservative recreational scenario



Questions?



Radium 10 Mine, Slick Rock, CO

