Evaluation of Service Loss: Molycorp Terrestrial HEA Debit

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Terrestrial Data Included in Analysis

▸ Soil metals concentrations from mine, tailings, and riparian areas from Molycorp database

  ▫ Excluding scars, industrial dev't, roads

  ▫ Including riparian tailings spill data, all surface soils data in the database

▸ Vegetation metals data

  ▫ Used to calculate BAFs

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Use of Mammal Tissue Data?

▶ Following Molycorp's presentation, we evaluated use of the mammal tissue data as an alternative line of evidence

- ▫ Paired mammal samples with matching soil samples
- ▫ Sample size small (n= 67 total; n = 38 at impact sites)
- ▫ Low soil Mo concentrations at mammal collection sites (mean = 28 mg/kg, max = 152 mg/kg at impact sites)

▶ Conclusion: mammal data only collected from areas with relatively low soils Mo (< our injury threshold concentrations) and therefore are insufficient as a metric for use in service loss estimation

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Metals Driving Service Loss

▶ Initial screening of 10 metals, comparing soil concentrations to toxicological endpoints

  ▫ B, Cd, Cr, Co, Cu, Pb, Mn, Mo, V, Zn

▶ Mo exceeded toxicity thresholds by far more than other metals

  ▫ Pb is also a driver of service loss at certain areas within the mine

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Relating Soil [Mo] to Service Loss

▸ Evaluated toxicity relationships to relevant mammals based on literature review per discussion with H. Ohlendorf

▸ Used paired soil/vegetation samples to approximate a 2:1 ratio of Soil Mo to Plant Mo to convert dietary dose to soil concentrations /service loss levels

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Soil [Mo] → Service Loss

- RBSL = 2 mg/kg
- 0% SL below 63 mg/kg
- 20% SL at 200 mg/kg
- 50% SL at 700 mg/kg
- 100% SL at >5700 mg/kg

- Partitioned soil concentrations into SL bins

- Using these thresholds, there are no service losses in the reference areas
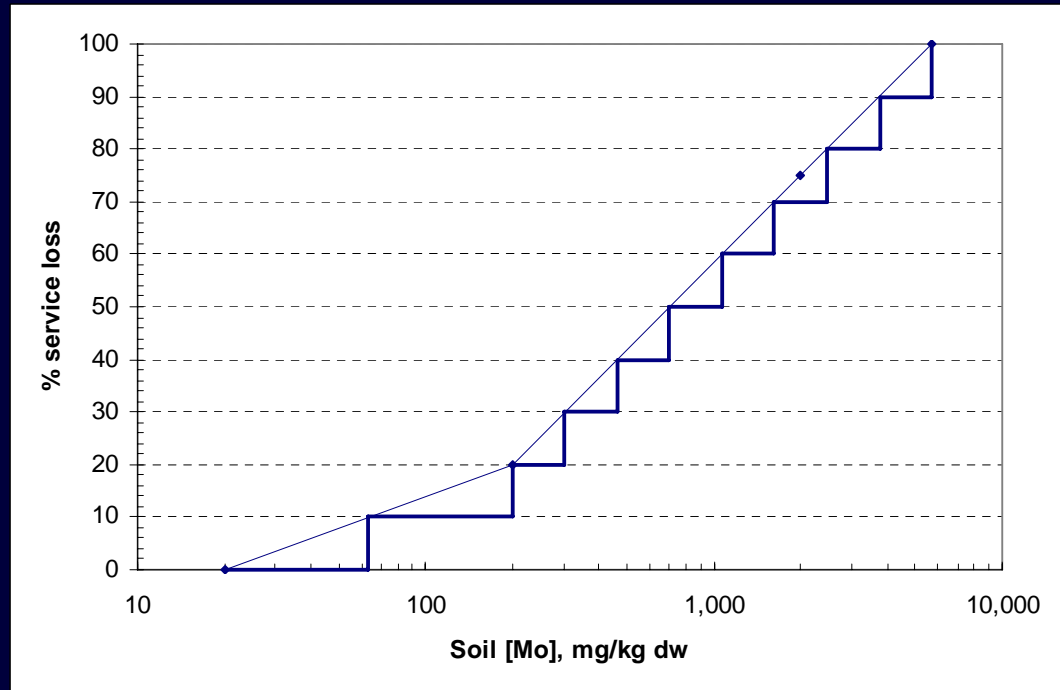
Relating Soil [Pb] to Service Loss

- As with Mo, developed toxicity relationships from literature

- Used paired soil/vegetation samples to approximate a 100:1 ratio of Soil Pb to Plant Pb

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Soil [Pb] → Service Loss Summary

- RBSL = 16 mg/kg
- 0% SL below 223 mg/kg
- 20% SL at 500 mg/kg
- 50% SL at 2000 mg/kg
- 100% SL at >20,000+ mg/kg

- Partitioned soil concentrations into SL bins

- At these thresholds, there are no service losses in the reference areas
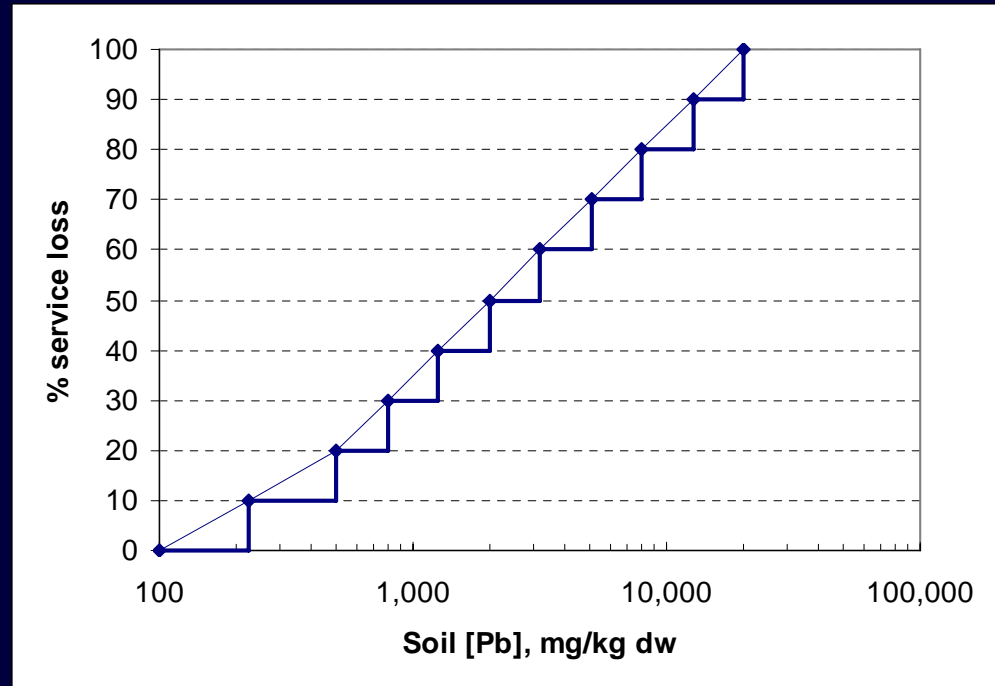
Mo & Pb Areal Coverage at Mine

▸ Kriging used to estimate areal distribution of metals in soils

- Excluded SS2, SS7, SS8, roads, scars
- Excluded mill site, but included habitat areas within SS1
- Low estimate = excludes western side of the mine not included in soil polygons
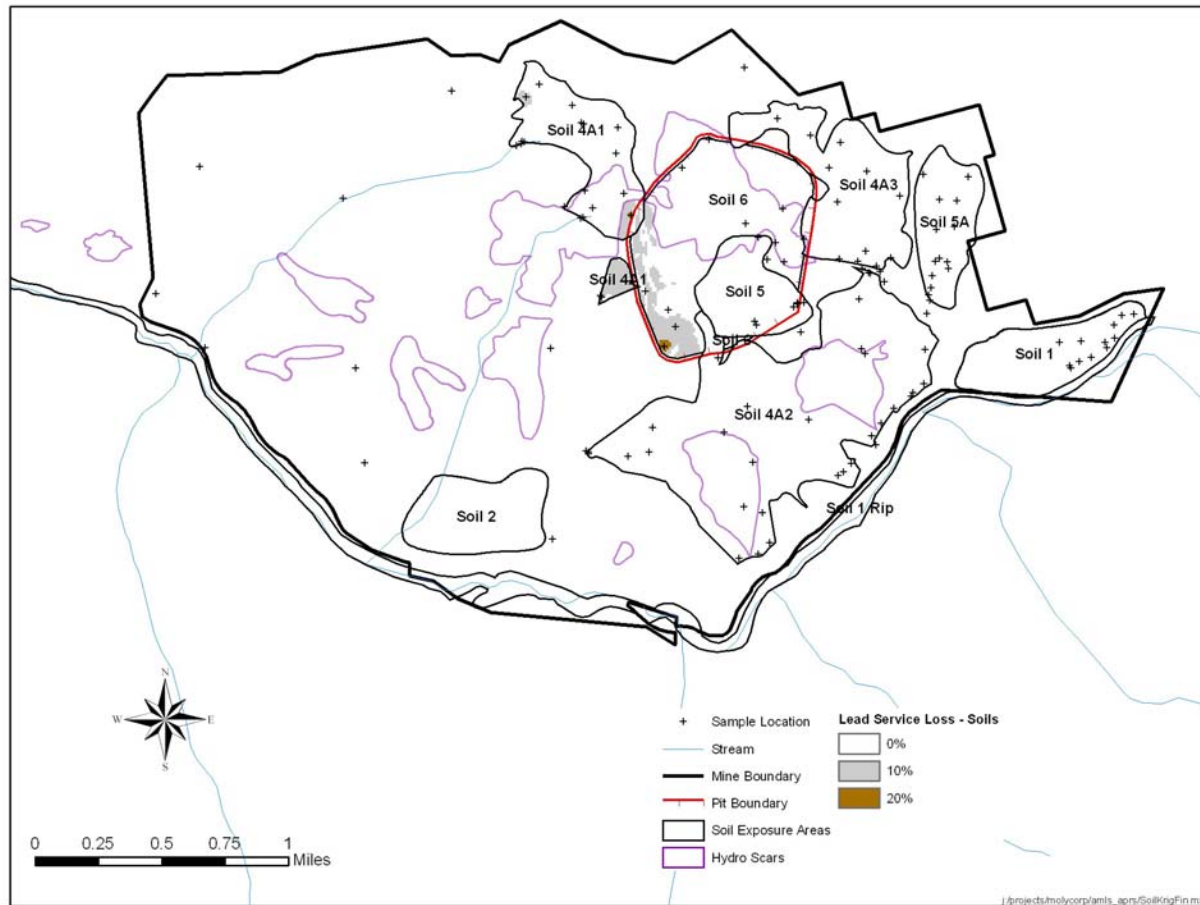- High estimate = includes all areas within the mine site boundary, except the exclusions listed above

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Mo & Pb Areal Coverage at Mine

▶ Mo and Pb kriged separately

▶ Selected maximum service loss per pixel to calculate final areal coverage of each 10% service loss bin
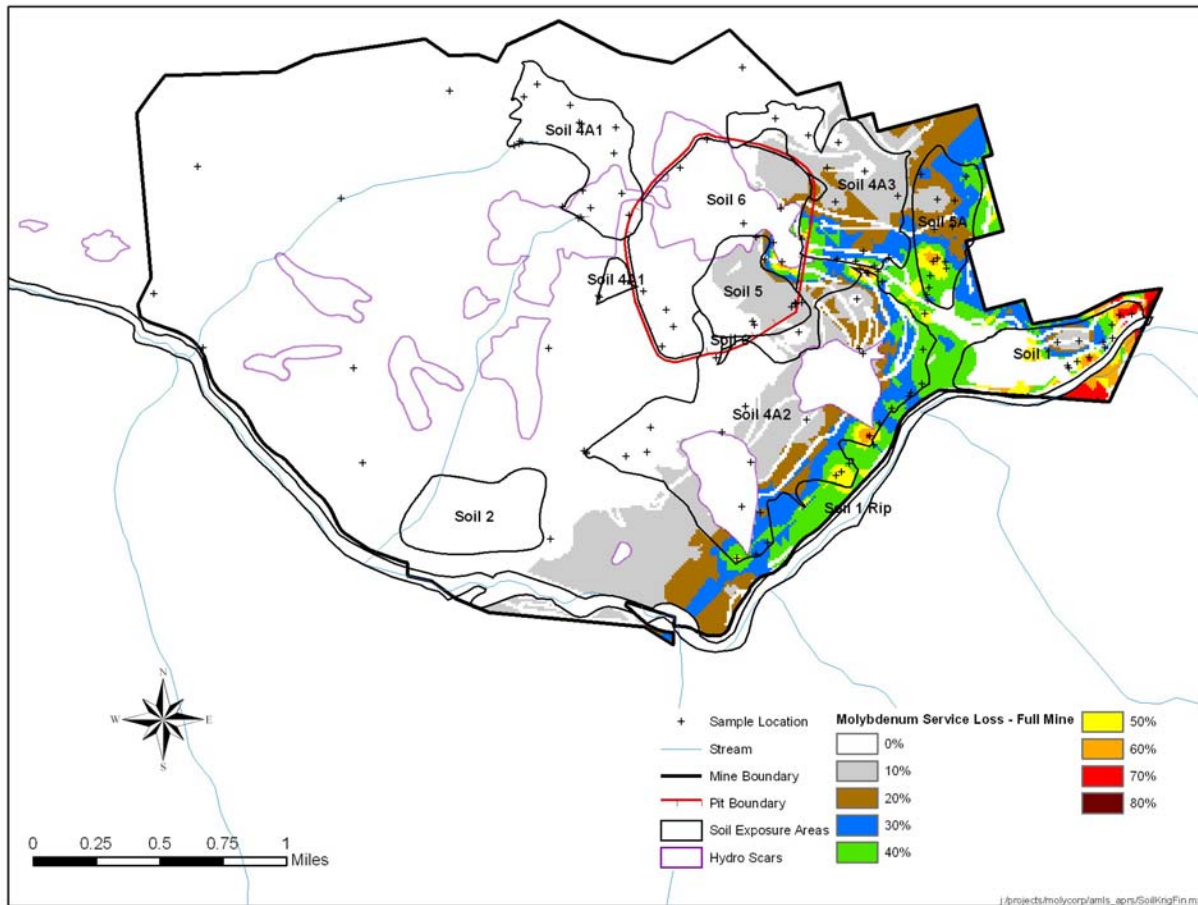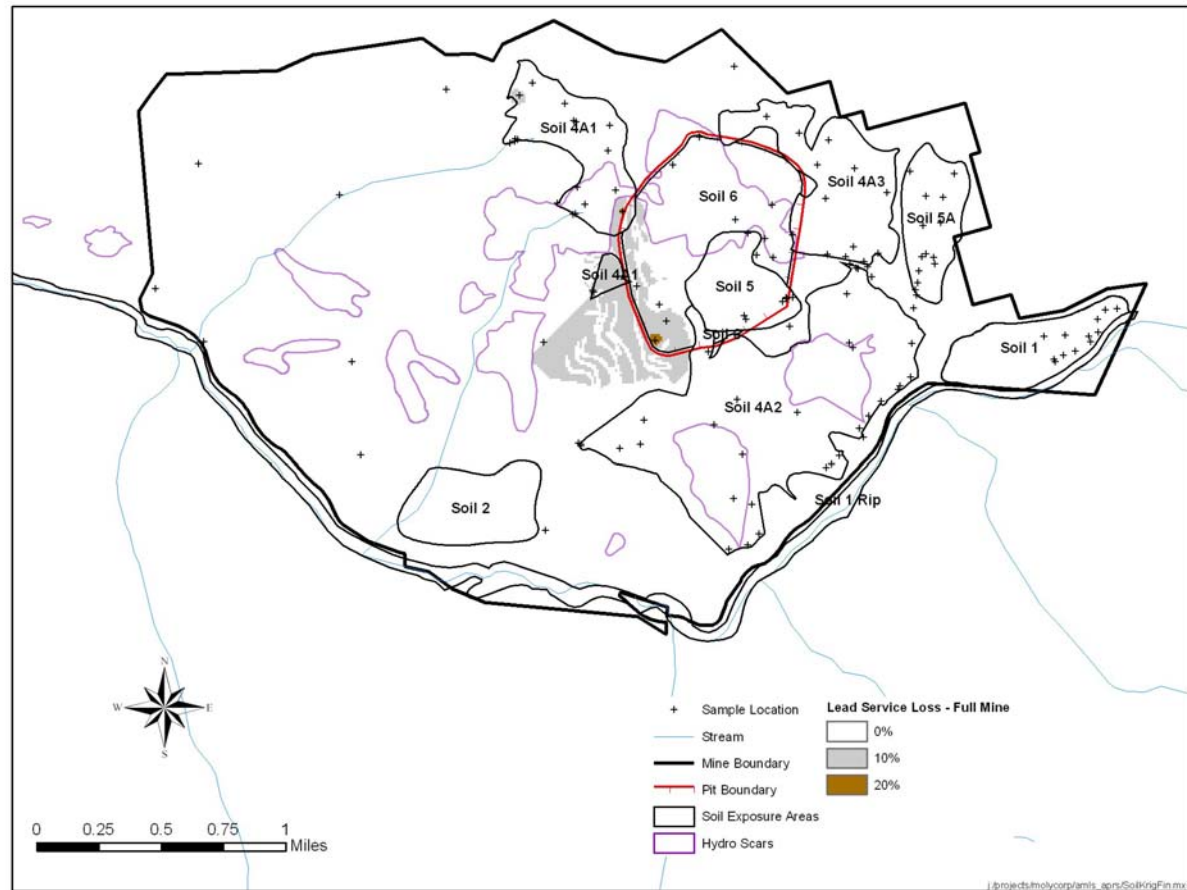
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Mine SL: Mo, soil polygons only
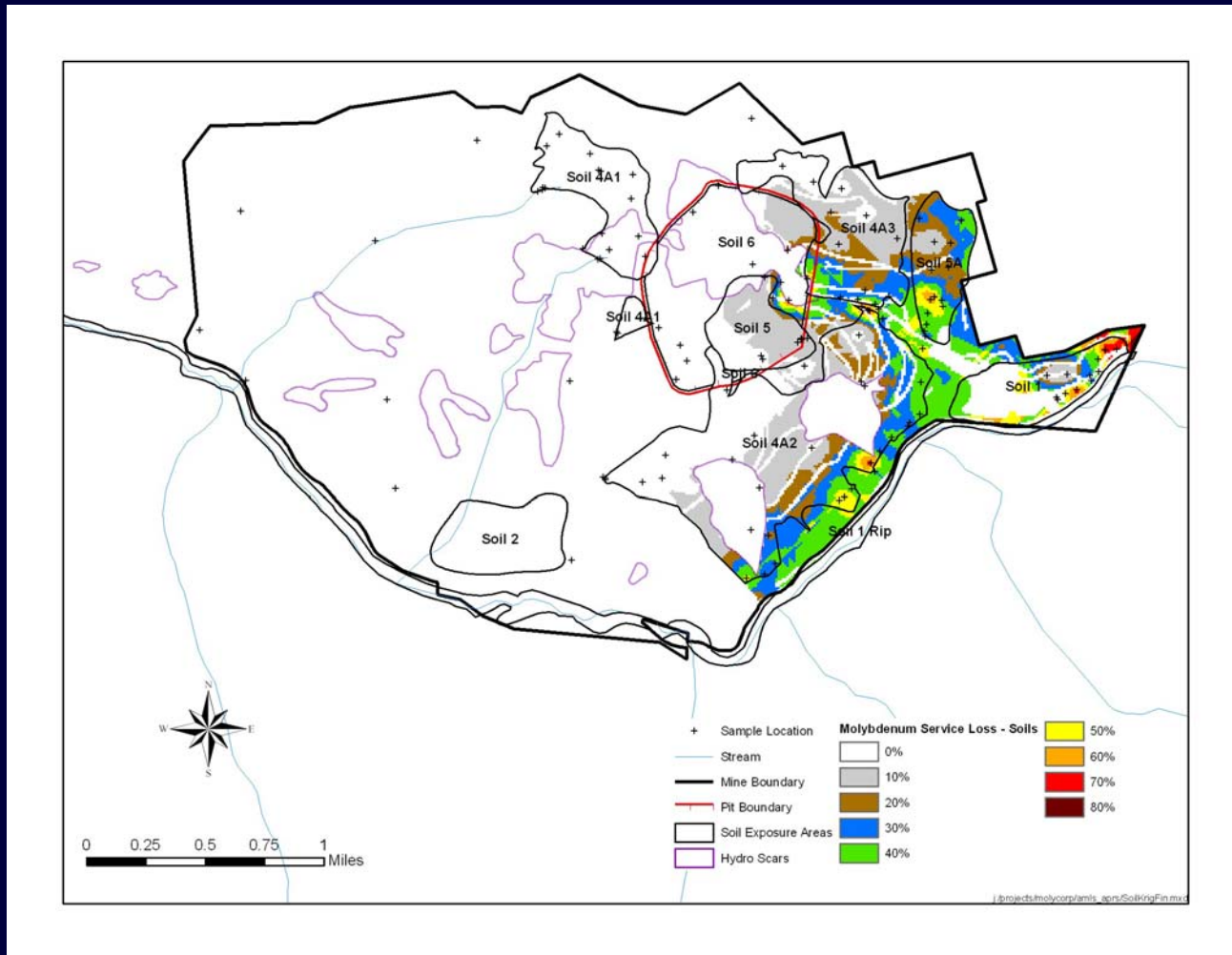
Mine SL: Pb, soil polygons only

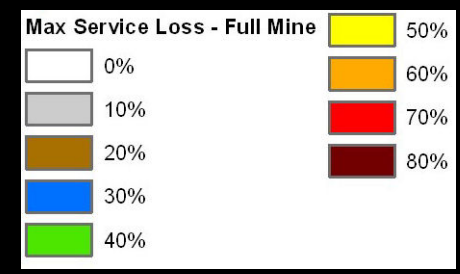# Mine SL: Mo, entire site

# Mine SL: Pb, entire site

Max service loss

Molybdenum

Lead

Max Service Loss - Full Mine

☐	0%	☐	50%
☐	10%	☐	60%
☐	20%	☐	70%
☐	30%	☐	80%
☐	40%		

Total Service Loss: Mine Area

MINE AREA - KRIG (Max Samples)

Mask	Service Loss	Count	Acres	ServLossAc
Soil	0	4995	286.66	0.0
Soil	10	4587	263.25	26.3
Soil	20	1694	97.22	19.4
Soil	30	2288	131.31	39.4
Soil	40	2501	143.53	57.4
Soil	50	582	33.4	16.7
Soil	60	183	10.5	6.3
Soil	70	91	5.22	3.7
Soil	80	20	1.15	0.9
		10% bins	**Total**	**170.1**

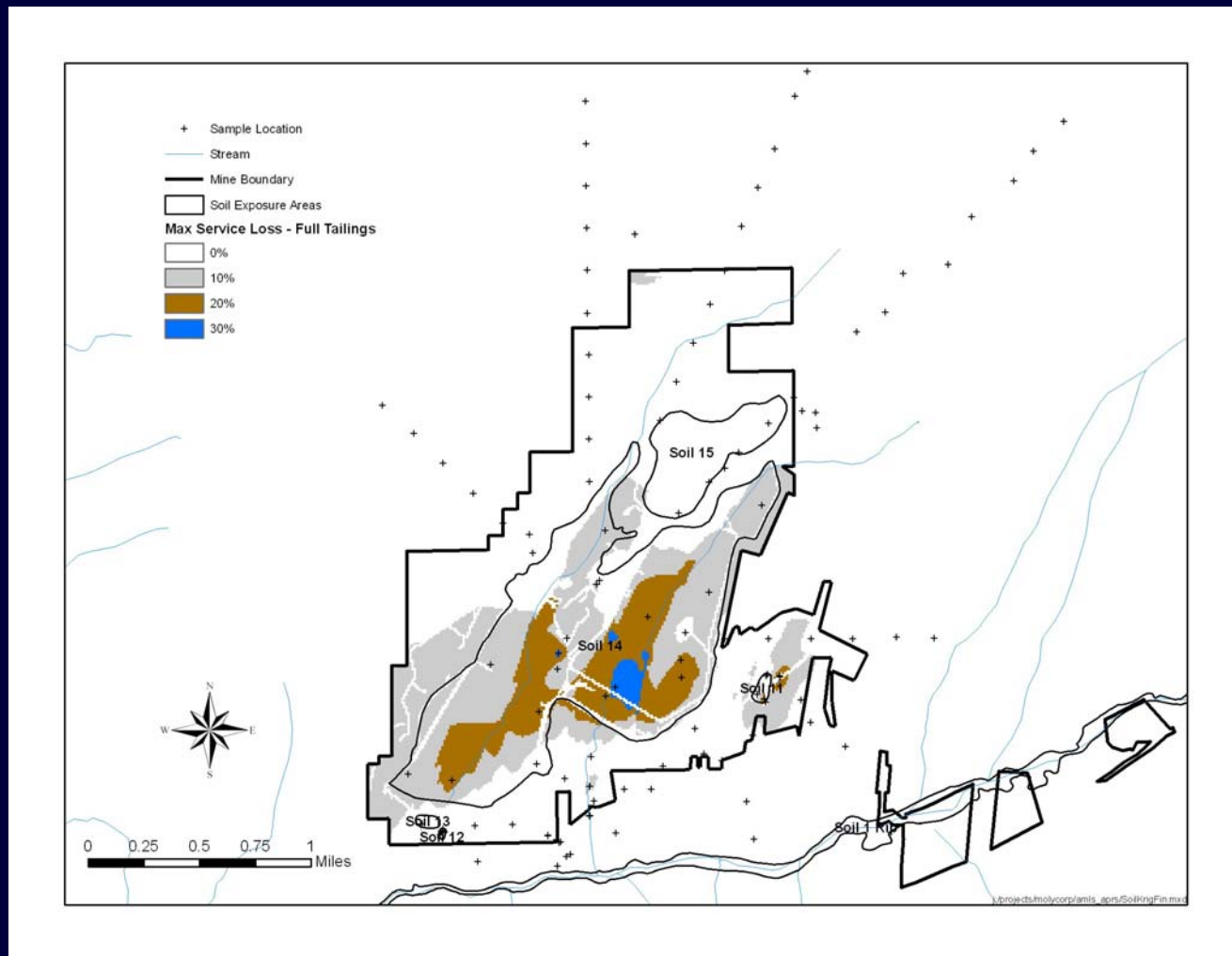| Mask	Service Loss	Count	Acres	ServLossAc
Mine	0	32861	1885.89	0.0
Mine	10	8243	473.07	47.3
Mine	20	2604	149.44	29.9
Mine	30	2717	155.93	46.8
Mine	40	2671	153.29	61.3
Mine	50	635	36.44	18.2
Mine	60	305	17.5	10.5
Mine	70	206	11.82	8.3
Mine	80	23	1.32	1.1
		10% bins	**Total**	**223.4**

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Areal Coverage of Mo: Tailings

▸ Inverse distance weighting (IDW) used to estimate areal distribution of Mo concentrations in the tailings area

- IDW employed because krig was unstable and appeared to over predict extent of contamination

- Low estimate = includes only SS14

  - uses all soil samples in the IDW analysis

- High estimate = includes all areas within mine-owned lands around the tailings

  - uses $[Mo]_{max}$ where there are multiple samples in one location

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Tailings SL: Mo, SS14 Only
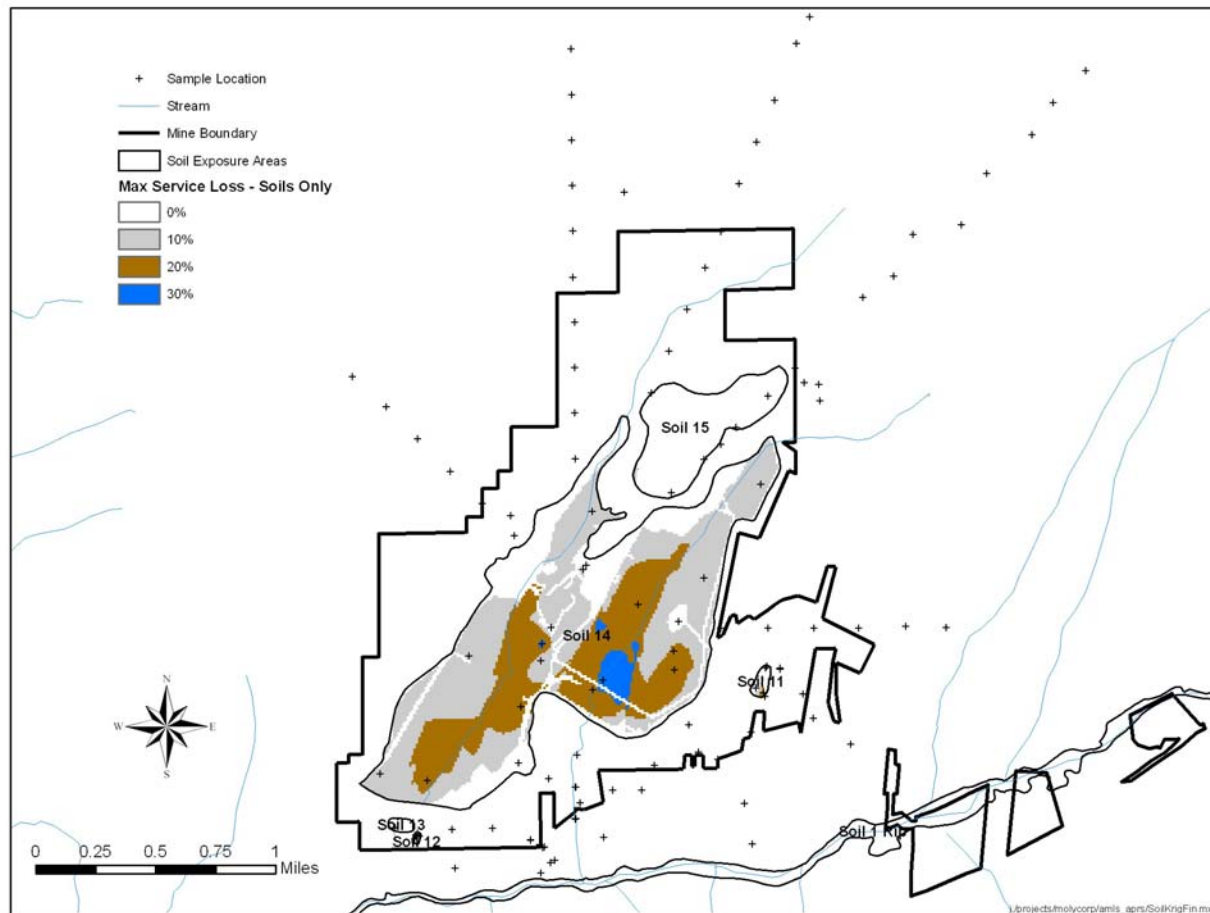
Tailings SL: Mo, Entire Tailings Area

Total Service Loss: Tailings

TAILINGS AREA - IDW - ALL SAMPLES

Mask	Service Loss	Count	Acres	ServLossAc
Soil	0	5953	341.64	0.0
Soil	10	6159	353.47	35.4
Soil	20	1503	86.26	17.3
Soil	30	1	0.06	0.0
		10% bins	**Total**	**52.6**

TAILINGS AREA - IDW - MAX SAMPLES

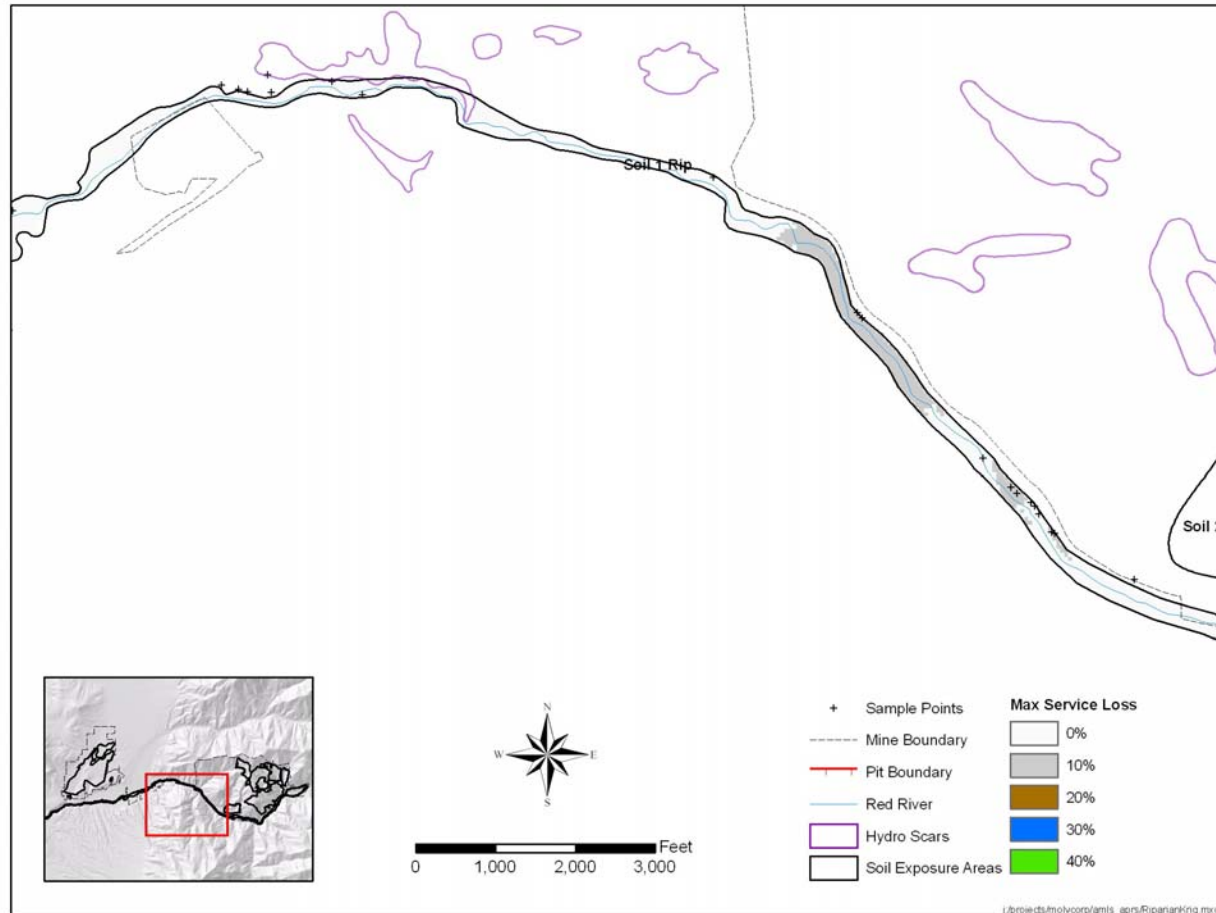| Mask	Service Loss	Count	Acres	ServLossAc
Tail	0	24914	1429.81	0.0
Tail	10	9678	555.42	55.5
Tail	20	3621	207.81	41.6
Tail	30	303	17.39	5.2
		10% bins	**Total**	**102.3**

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Areal Coverage of Mo: Riparian

▸ IDW used to estimate areal extent of Mo concentrations in the riparian area

  ▫ Included all soils data from within the riparian (not based on exposure area)

  ▫ Included only areal coverage in riparian soils polygon (URS' GIS) for injury quantification

  ▫ Low estimate = uses all soil samples in the IDW analysis

  ▫ High estimate = uses $[Mo]_{max}$ where there are multiple samples in one location
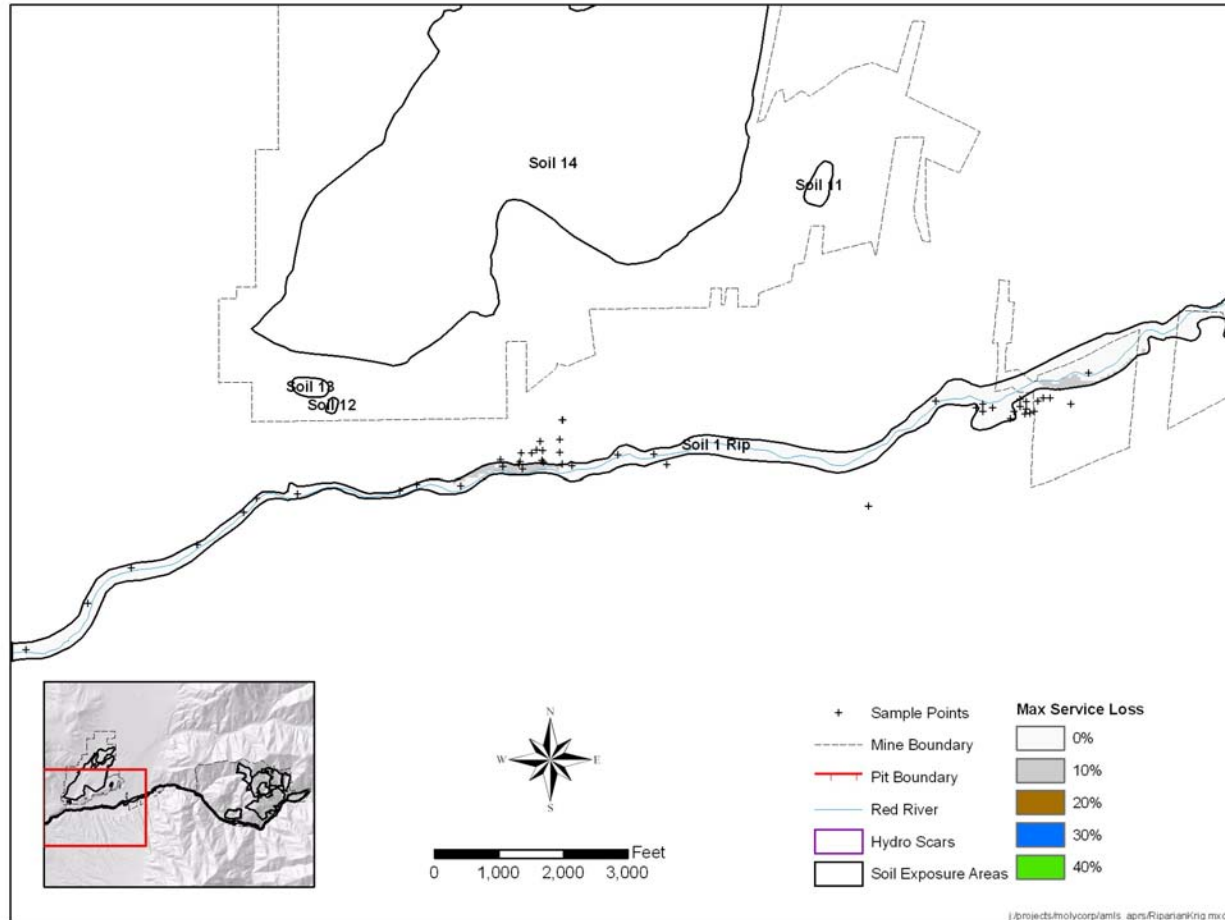
Riparian SL: Mo, Upper Reach
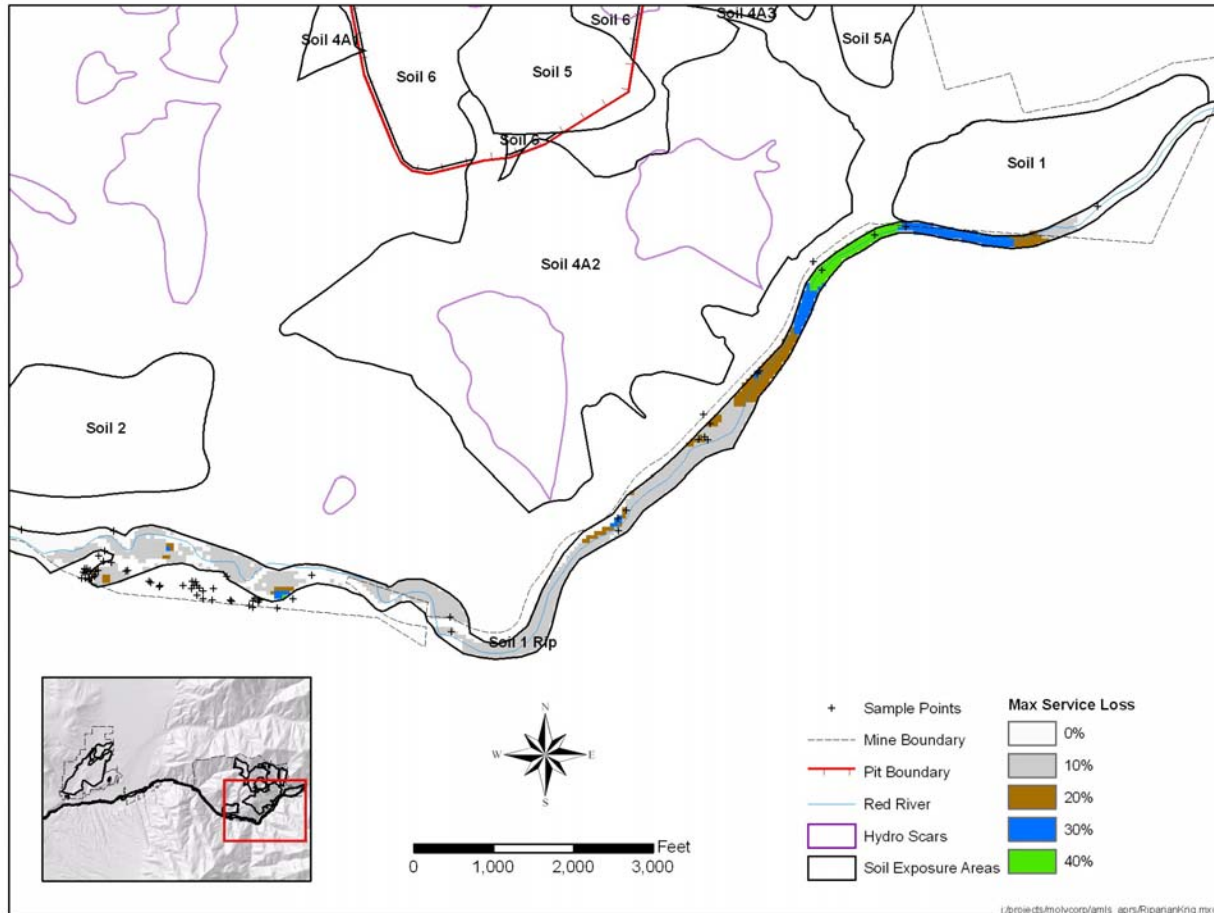
Riparian SL: Mo, Middle Reach

Riparian SL: Mo, Lower Reach

Total Service Loss: Riparian

Service Loss using IDW - All Points:

Service Loss	Count	Acres	ServLossAc
0	3534	202.82	0.0
10	1417	81.32	8.1
20	132	7.58	1.5
30	184	10.56	3.2
		Total	**12.8**

Service Loss using IDW - Max Points:

Service Loss	Count	Acres	ServLossAc
0	3466	198.91	0.0
10	1419	81.44	8.1
20	163	9.35	1.9
30	132	7.58	2.3
40	87	4.99	2.0
		Total	**14.3**

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Sensitivity Analysis

- Conducted several alternative analyses using different bounding assumptions
  - 1% SL bins instead of 10%
  - % pixels per bin * total area
  - Simplified estimation using percent of samples in each injury bin.
- Inspected various outputs to estimate approximate upper and lower bound estimates of service loss for the different areas
  - Mine site: 170 – 220 service loss acres (SLAs)
  - Tailings: 50 – 100 SLAs
  - Riparian: 10 – 20 SLAs

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HEA Debit Parameters

- Units = discounted riparian service acre-years
  - Tailings and mine habitats converted to "riparian equivalents"
    - 1 Tailings acre = 0.2 Riparian acres
    - 1 Mine Site acre = 0.02 Riparian acres
- Discount rate = 3%
- Levels of service loss remain constant through 2100

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HEA Debit Parameters (con't)

▶ Assumes riparian Mo concentrations have been constant since 1980

  ◽ i.e., 100% of pipeline spills had already occurred and most of the tailings were scoured out by 1980, leaving only the existing residues.

▶ Assumes tailings areal coverage has not changed since 1980

  ◽ 1982 and 2001 tailings pond maps appear to be identical

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HEA Debit (DRSAYs)

	Service Loss Acres		Riparian Scale Factor	Riparian Service Loss Acres	
	Low	High	Riparian Equiv wgt	Adj Low	Adj High
Tailings	50	100	0.2	10	20
Mine	170	220	0.02	3.4	4.4
Riparian	10	20	1	10	20
			Total:	**23.4**	**44.4**

Discounted Riparian Service Acre Years (1981 - 2100)

			Total:	**1,586**	**3,010**

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