



Digging Deeper Bonita Peak Mining District

Terrestrial Ecological Risk Assessment

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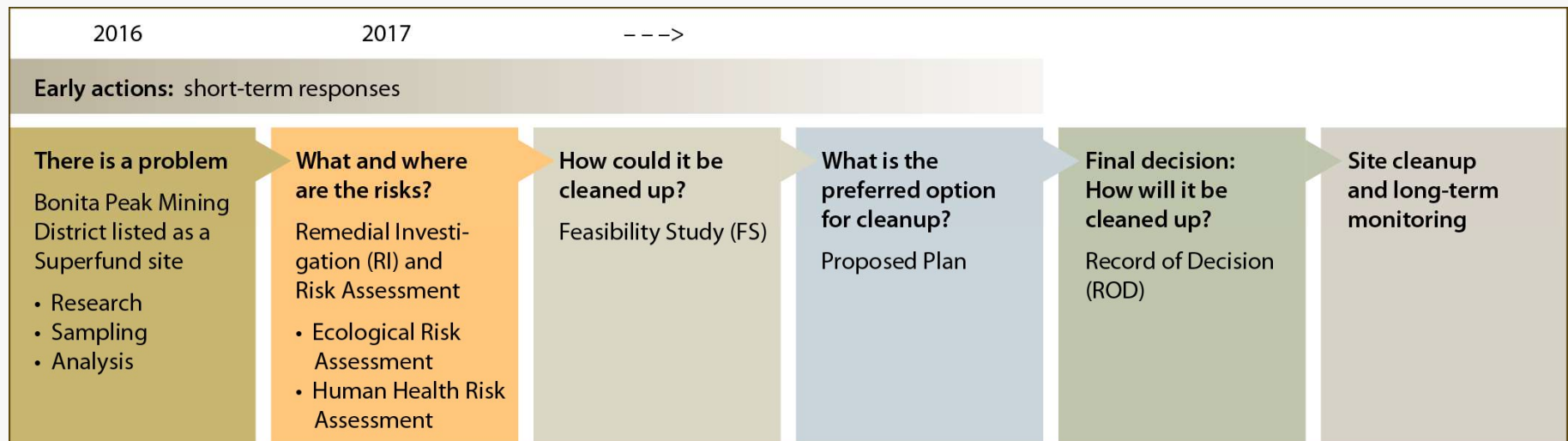


Overview

- Screening Level Ecological Risk Assessment
 - Contaminants of Potential Ecological Concern (COPECs)
 - Site Ranking
- Baseline Ecological Risk Assessment
 - Work Plan
 - Problem Formulation
 - Conceptual Site Model
 - Exposure Models
 - Receptors



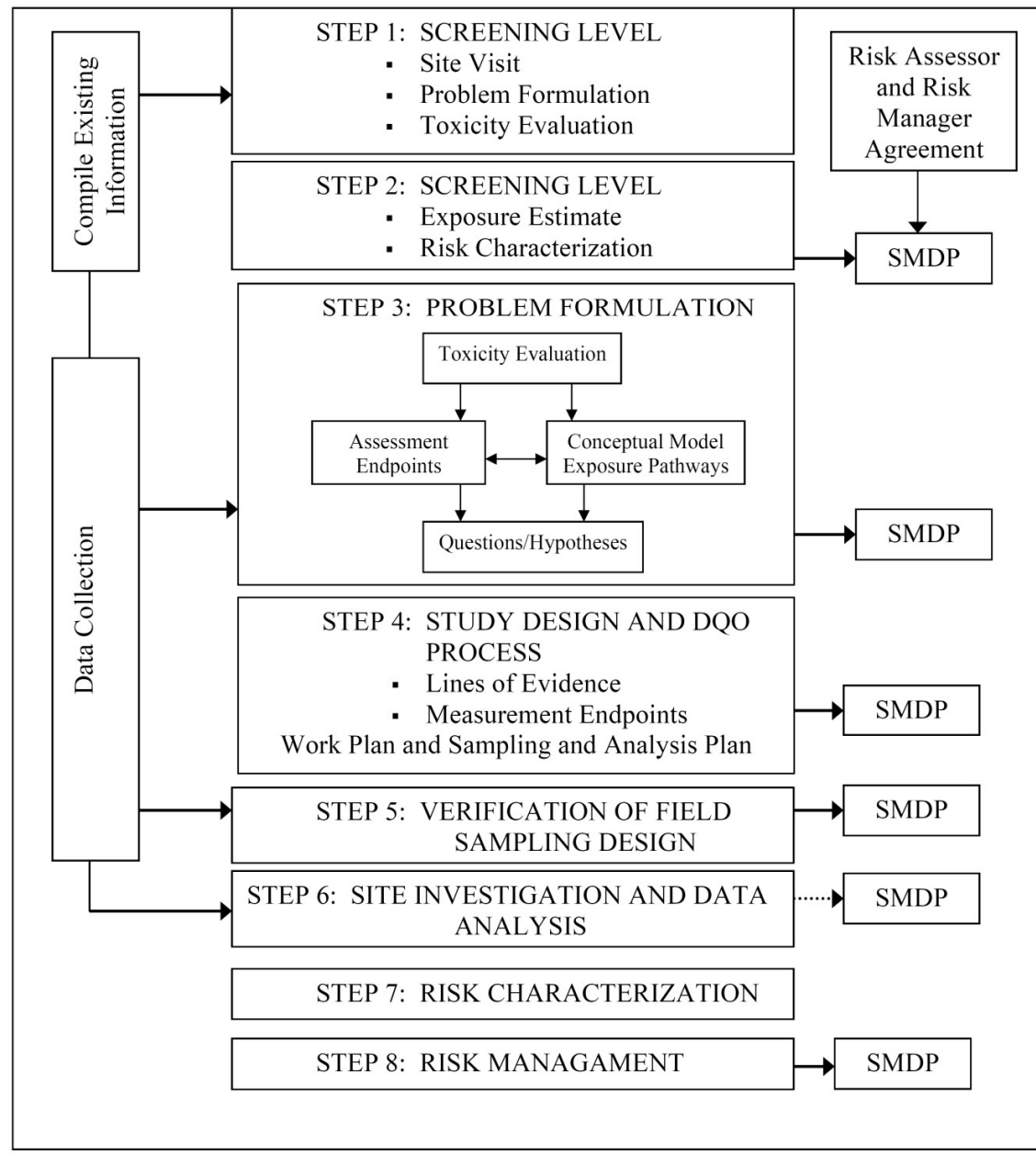
Ecological Risk Assessment



Remedial Investigation/Feasibility Study

- NCP § 300.430

Figure 1-1
Eight Step Process Recommended in Ecological Risk Assessment
Guidance for Superfund (ERAGs) (USEPA, 1997)





Screening Level Ecological Risk Assessment

Outcomes

- Ecological threats are negligible
- Not enough information to determine risk; assessment should continue
- Adequate information to determine that potential for adverse effects exists; more site-specific investigation required



Goals of the BPMD SLERA

1. Identify Contaminants of Potential Ecological Concern (COPECs)
2. Assess risk of COPECs to receptor groups
3. Rank mine-impacted exposure areas



BPMD SLERA

Receptor Groups

1. Plants
2. Soil invertebrates
3. Birds
4. Mammals





BPMD SLERA

Exposure Area Groups

1. Mine Sites (35)
2. Overbank Soil (25)
3. Campsites (12)





Target Analytes

Aluminum	Lead
Antimony	Manganese
Arsenic	Mercury
Barium	Molybdenum
Beryllium	Nickel
Cadmium	Selenium
Chromium	Silver
Cobalt	Thallium
Copper	Vanadium
Iron	Zinc



COPEC Selection

Process

1. Identify Ecological Screening Values (ESVs)
2. Calculate Hazard Quotients





Ecological Screening Values

Analyte	Soil No-Effect Ecological Screening Value (mg/kg)			
	Plants	Invertebrates	Birds	Mammals
Aluminum	--	--	--	--
Antimony	11	78	--	0.27
Arsenic	18	6.8	43	46
Barium	110	330	820	2000
Beryllium	2.5	40	--	21
Cadmium	32	140	0.77	0.36
Chromium	--	0.4	26	34
Cobalt	13	--	120	230
Copper	70	80	28	49
Iron	--	--	--	--
Lead	120	1700	11	56
Manganese	220	450	4300	4000
Mercury	34	0.05	0.013	1.7
Molybdenum	2	--	17	4.8
Nickel	38	280	210	130
Selenium	0.52	4.1	1.2	0.63
Silver	560	--	4.2	14
Thallium	0.05	--	6.3	0.22
Vanadium	60	--	7.8	280
Zinc	160	120	46	79



Hazard Quotient (HQ)

$$\text{HQ} = \text{Exposure} / \text{Benchmark}$$

$\text{HQ} < 1$ = Acceptable risk

$\text{HQ} > 1$ = Further evaluation warranted *or*
unacceptable risk



COPEC Selection

Analyte	Mine Sites		Overbank Soils		Campsites	
	Soil COPEC	Reason	Soil COPEC	Reason	Soil COPEC	Reason
Aluminum	Y	No ESV	Y	No ESV	Y	No ESV
Antimony	Y	HQ > 1	Y	HQ > 1	Y	HQ > 1
Arsenic	Y	HQ > 1	Y	HQ > 1	Y	HQ > 1
Barium	Y	HQ > 1	Y	HQ > 1	Y	HQ > 1
Beryllium	Y	HQ > 1	Y	HQ > 1	N	HQ < 1
Cadmium	Y	HQ > 1	Y	HQ > 1	Y	HQ > 1
Chromium	Y	HQ > 1	Y	HQ > 1	Y	HQ > 1
Cobalt	Y	HQ > 1	Y	HQ > 1	Y	HQ > 1
Copper	Y	HQ > 1	Y	HQ > 1	Y	HQ > 1
Iron	Y	No ESV	Y	No ESV	Y	No ESV
Lead	Y	HQ > 1	Y	HQ > 1	Y	HQ > 1
Manganese	Y	HQ > 1	Y	HQ > 1	Y	HQ > 1
Mercury	Y	HQ > 1	Y	HQ > 1	Y	HQ > 1
Molybdenum	Y	HQ > 1	Y	HQ > 1	Y	HQ > 1
Nickel	N	HQ < 1	Y	HQ > 1	N	HQ < 1
Selenium	Y	HQ > 1	Y	HQ > 1	Y	HQ > 1
Silver	Y	HQ > 1	Y	HQ > 1	Y	HQ > 1
Thallium	Y	HQ > 1	Y	HQ > 1	Y	HQ > 1
Vanadium	Y	HQ > 1	Y	HQ > 1	Y	HQ > 1
Zinc	Y	HQ > 1	Y	HQ > 1	Y	HQ > 1



Goals of the BPMD SLERA

1. Identify Contaminants of Potential Ecological Concern (COPECs)
2. Assess risk of COPECs to receptor groups
3. Rank Mine-impacted exposure areas



Risk Ranking

1. Calculate COPEC-specific HQs for receptor groups
Plants, soil invertebrates, mammals, and birds
2. Sum COPEC-specific HQs for each exposure area
3. Sum all COPEC HQs for each exposure area
Total Risk
4. Rank Total Risk for each area type
Mine site, overbank soil, campsite
5. Categorize areas based on total risk



Site X

$$\text{Pb: } HQ_{\text{Plants}} + HQ_{\text{Inverts}} + HQ_{\text{Mammals}} + HQ_{\text{Birds}} = HQ_{\text{Pb, Site X}}$$

$$\text{Zn: } HQ_{\text{Plants}} + HQ_{\text{Inverts}} + HQ_{\text{Mammals}} + HQ_{\text{Birds}} = HQ_{\text{Zn, Site X}}$$

$$\text{Sb: } HQ_{\text{Plants}} + HQ_{\text{Inverts}} + HQ_{\text{Mammals}} + HQ_{\text{Birds}} = HQ_{\text{Sb, Site X}}$$

$$\text{Se: } HQ_{\text{Plants}} + HQ_{\text{Inverts}} + HQ_{\text{Mammals}} + HQ_{\text{Birds}} = HQ_{\text{Se, Site X}}$$

$$HQ_{\text{Total, Site X}}$$



Site Ranking

1. HQ_{Total}, Site S
2. HQ_{Total}, Site T
3. HQ_{Total}, Site U
4. HQ_{Total}, Site V
5. HQ_{Total}, Site W
6. HQ_{Total}, Site X
7. HQ_{Total}, Site Y
8. HQ_{Total}, Site Z

Site Categorization

Higher Risk

1. HQ_{Total}, Mine S
2. HQ_{Total}, Mine T
3. HQ_{Total}, Mine U

Moderate Risk

4. HQ_{Total}, Mine V
5. HQ_{Total}, Mine W

Lower Risk

6. HQ_{Total}, Mine X
7. HQ_{Total}, Mine Y
8. HQ_{Total}, Mine Z



Site Categorization

Higher Risk

$HQ_{Total} > 500$

Moderate Risk

$200 < HQ_{Total} < 500$

Lower Risk

$HQ_{Total} < 200$

Risk Ranking	NPL Mine Site Name	Total Risk	Top 3 Risk Drivers			Fraction of Total Risk (%)
			Driver 1	Driver 2	Driver 3	
1	Bandora Mine	8491	Zn	Pb	Sb	80
2	Mountain Queen Mine	6884	Pb	Sb	Zn	88
3	Clipper Mine	4802	Pb	Zn	Sb	93
4	Ben Butler Mine	4723	Pb	Zn	Sb	91
5	Koehler Tunnel	4445	As	Pb	Hg	93
6	Red Cloud Mine	4188	Pb	Sb	Zn	85
7	Sunnyside Mine	3984	Pb	Zn	Cd	86
8	Grand Mogul Mine	3969	Pb	Zn	Sb	87
9	Mogul Mine	3626	Pb	Zn	Sb	86
10	Pride of the West Mine	3190	Pb	Zn	Cd	85
11	Junction Mine	2756	Pb	Hg	As	86
12	Silver Wing Mine	2590	Sb	Pb	Cu	84
13	Forest Queen Mine	2558	Pb	Mn	Zn	84
14	Paradise Mine	2186	Pb	Se	Sb	94
15	London Mine	2125	Pb	Sb	Zn	81
16	Vermillion Mine	2026	Pb	Zn	Hg	85
17	Longfellow Mine	1650	As	Pb	Sb	85
18	Anglo Saxon Mine	1575	Pb	Sb	Zn	85
19	Boston Mine	1540	Pb	Sb	Zn	70
20	Tom Moore Mine	1503	Pb	Zn	Mb	82
21	Howardsville CO Goldfields Tailings	1501	Pb	Zn	As	73
22	Frisco/Bagley Tunnel	1367	Pb	Zn	Hg	81
23	Henrietta Mine	1199	Pb	Zn	Sb	88
24	Ben Franklin Mine	1158	Pb	Zn	Sb	85
25	Columbus Mine	1035	Pb	Zn	Hg	84
26	Sunbank Group Mine	981	Sb	Pb	Tl	77
27	Dewitt Mine	978	Pb	Sb	As	84
28	Kittimack Tailings	959	Pb	Zn	Cu	81
29	Yukon Tunnel (Gold Hub)	859	Pb	Cu	Se	75
30	Brooklyn Mine	580	Pb	Sb	Zn	76

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32	Joe and Johns Mine	459	Pb	As	Zn	58
33	Red and Bonita Mine	324	Pb	Hg	Zn	84
34	Natalie/Occidental Mine	248	Pb	Se	Hg	57
35	Lark Mine	208	Pb	Sb	As	55



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Risk Ranking	Exposure Unit	Total Risk	Top 3 Risk Drivers			Fraction of Total Risk (%)
			Driver 1	Driver 2	Driver 3	
HIGHER-RISK EXPOSURE UNITS						
1	EU-15 (Animas)	4175	Zn	Cd	Pb	74
2	EU-10 (Animas)	2024	Pb	Mn	Zn	83
3	EU-24 (Cement)	1259	Zn	Mn	Pb	62
4	EU-13 (Animas)	1222	Pb	Hg	Zn	73
5	EU-16 (Animas)	898	Pb	Mn	Hg	70
6	EU-12 (Animas)	757	Pb	Zn	Mn	66
7	EU-04 (Mineral)	755	Pb	As	Zn	70
8	EU-3.5 (Mineral)	670	Pb	Hg	Cr	81
9	EU-22 (Cement)	664	Zn	Pb	Sb	80
10	EU-19 (Animas)	650	Pb	Mn	Tl	56
11	EU-09 (Animas)	561	Pb	Zn	Mn	78
12	EU-14 (Animas)	557	Pb	Zn	Mn	59
MODERATE-RISK EXPOSURE UNITS						
13	EU-05 (Mineral)	486	Zn	Cd	Mn	68
14	EU-20 (Cement)	379	Pb	Zn	Hg	65
15	EU-08 (Animas)	330	Pb	Zn	Mn	77
16	EU-01 (Mineral)	320	Pb	Zn	Sb	49
17	EU-03 (Mineral)	314	Pb	Mn	Cr	68
18	EU-21 (Cement)	257	Pb	Zn	Sb	59
LOWER-RISK EXPOSURE UNITS						
19	EU-06 (Mineral)	185	Mn	Se	Zn	51
20	EU-17 (Animas)	182	Mn	Zn	Pb	60
21	EU-07 (Animas)	174	Pb	Zn	Cr	63
22	EU-18 (Animas)	147	Pb	Cr	Zn	57
23	EU-23 (Cement)	139	Pb	Cr	Sb	63
24	EU-02 (Mineral)	109	Pb	Zn	Se	56
25	EU-11 (Animas)	100	Cr	Pb	Zn	52



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Risk Ranking	Campsite	Total Risk	Top 3 Risk Drivers			Fraction of Total Risk (%)
			Driver 1	Driver 2	Driver 3	
HIGHER-RISK SITES						
1	CMP4 (Animas)	7607	Pb	Zn	Hg	87
2	CMP7 (Animas)	2007	Pb	Zn	Sb	90
3	CMP2 (Animas)	557	Pb	Cu	Zn	78
MODERATE-RISK SITES						
4	CMP15a (Mineral)	472	Pb	Cu	Cd	54
5	CMP9 (Cement)	335	Pb	Sb	Zn	66
LOWER-RISK SITES						
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SLERA Summary

Higher-risk exposure areas

- a) 86% mine sites
- b) 48% overbank soil areas
- c) 24% campsites

Lower-risk exposure areas

- a) 0% mine sites
- b) 28% overbank soil areas
- c) 58% campsites



SLERA Summary

Mine sites

- Lead and Zinc drive risk

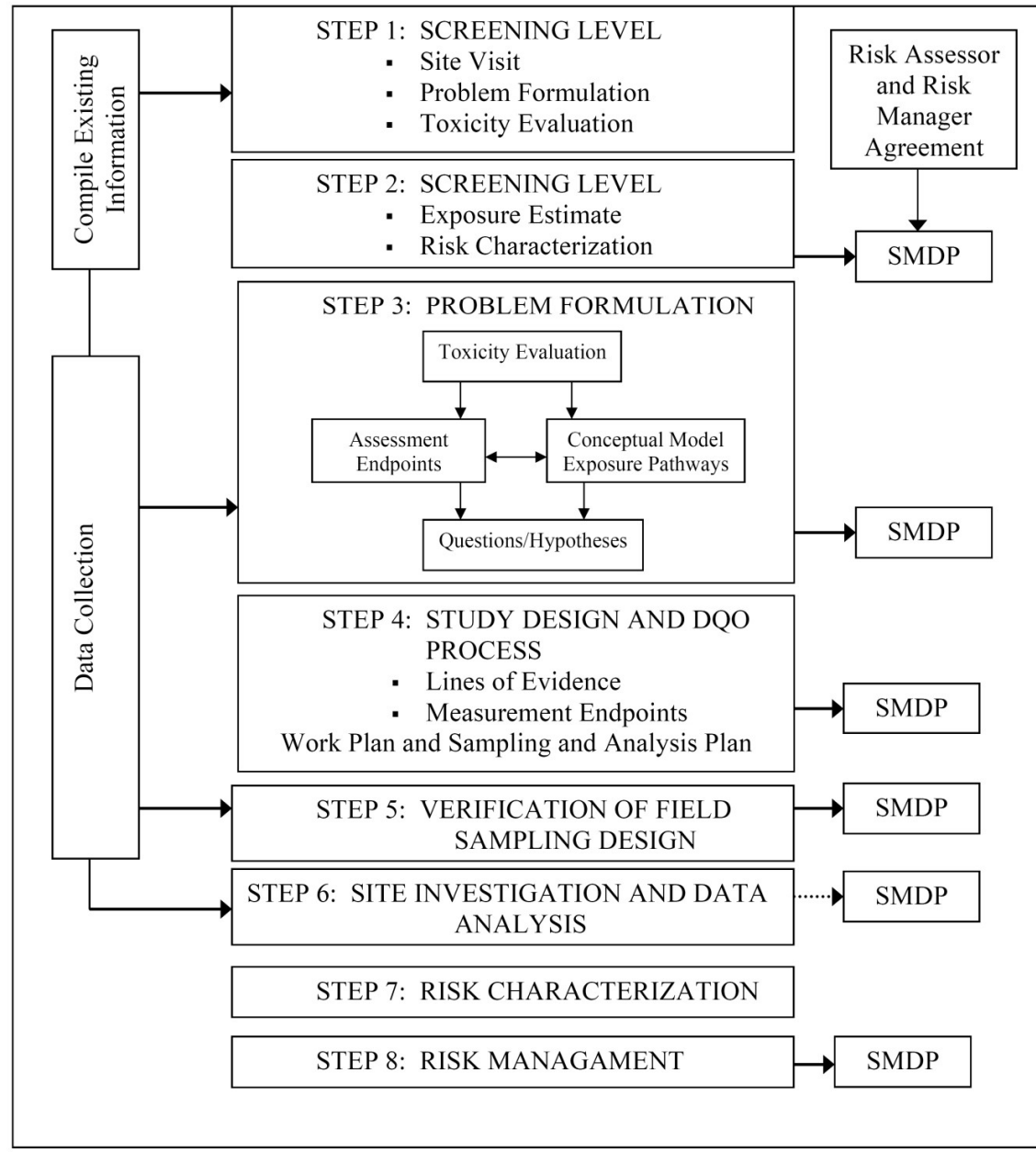
Overbank soil sites

- Lead and Zinc drive risk

Campsites

- Lead and Zinc drive risk

Figure 1-1
Eight Step Process Recommended in Ecological Risk Assessment
Guidance for Superfund (ERAGs) (USEPA, 1997)





Baseline Ecological Risk Assessment

Work Plan Goals

1. Refine the terrestrial SLERA
 - Terrestrial habitats and wildlife
 - Conceptual Site Model
2. Select risk assessment endpoints
 - Ecological resources to be protected
3. Determine measurement endpoints
4. Exposure and effects assessment
5. Identify data collection needs

DRAFT

Terrestrial Baseline Ecological Risk Assessment WORK PLAN

Bonita Peak Mining District and Durango Reach
San Juan County, CO
La Plata County, CO

March 2017

Prepared by:
TechLaw, Inc.
ESAT Region 8
16194 W. 45th Drive
Golden, CO 80403



Prepared for:
US Environmental Protection Agency
Region 8
1595 Wynkoop Street
Denver, CO 80202

DCN: EP8-4-1229



Problem Formulation

- Sources of contamination
- Release and transport mechanisms
- Contact points
- Routes of entry
- Exposure pathways
- Key ecological receptors

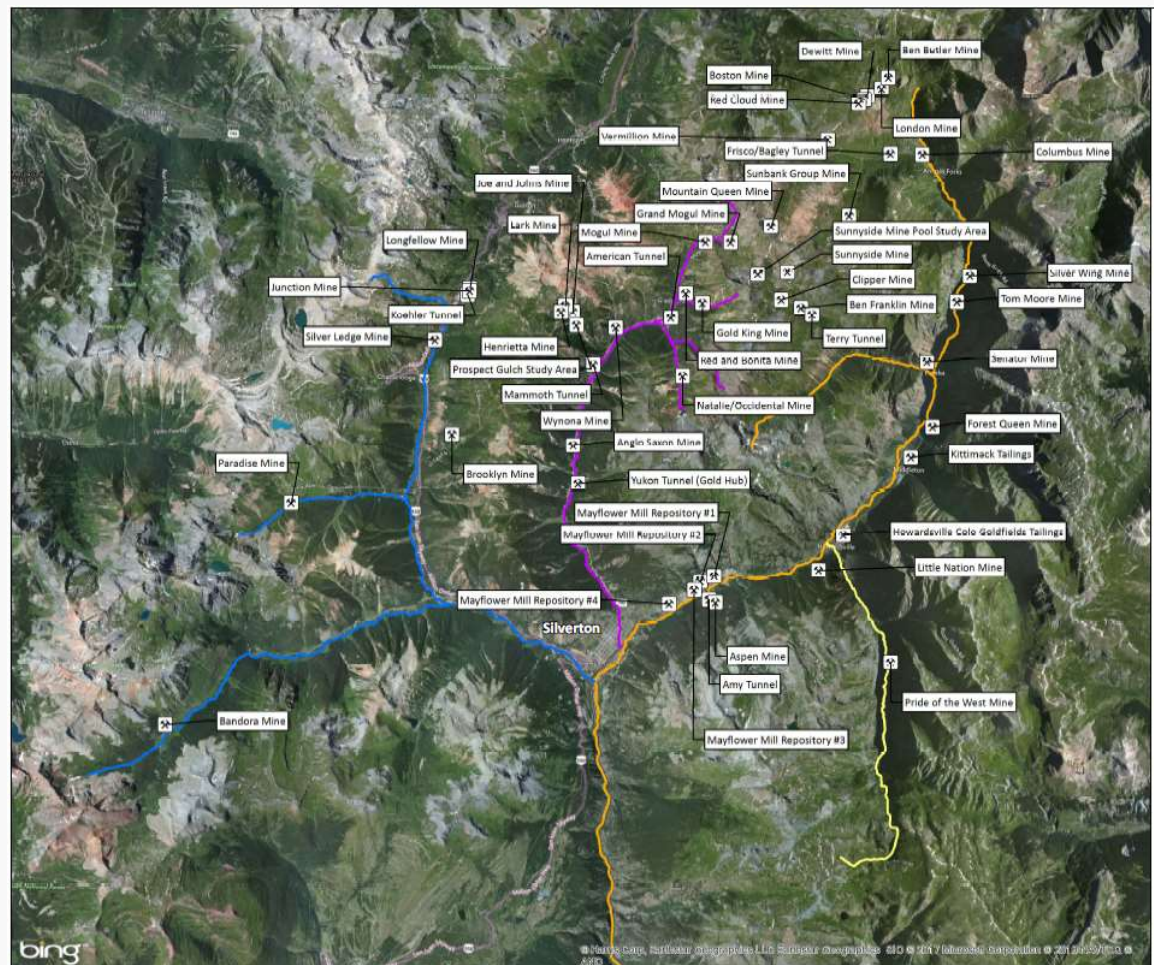




Contamination Sources

Total 48 NPL sites

- 42 mine and tunnel sites
- Floodplain tailings deposits
- Prospect Gulch Study Area
- Sunnyside Mine Pool Study Area
- Mayflower Mill Repositories





Fate and Transport

- Mechanical (wind)
- Infiltration/seepage
- Erosion
 - 'Halo' soils
 - Floodplains
 - Surface water
 - Sediments
- Receptor exposure





Halo Areas

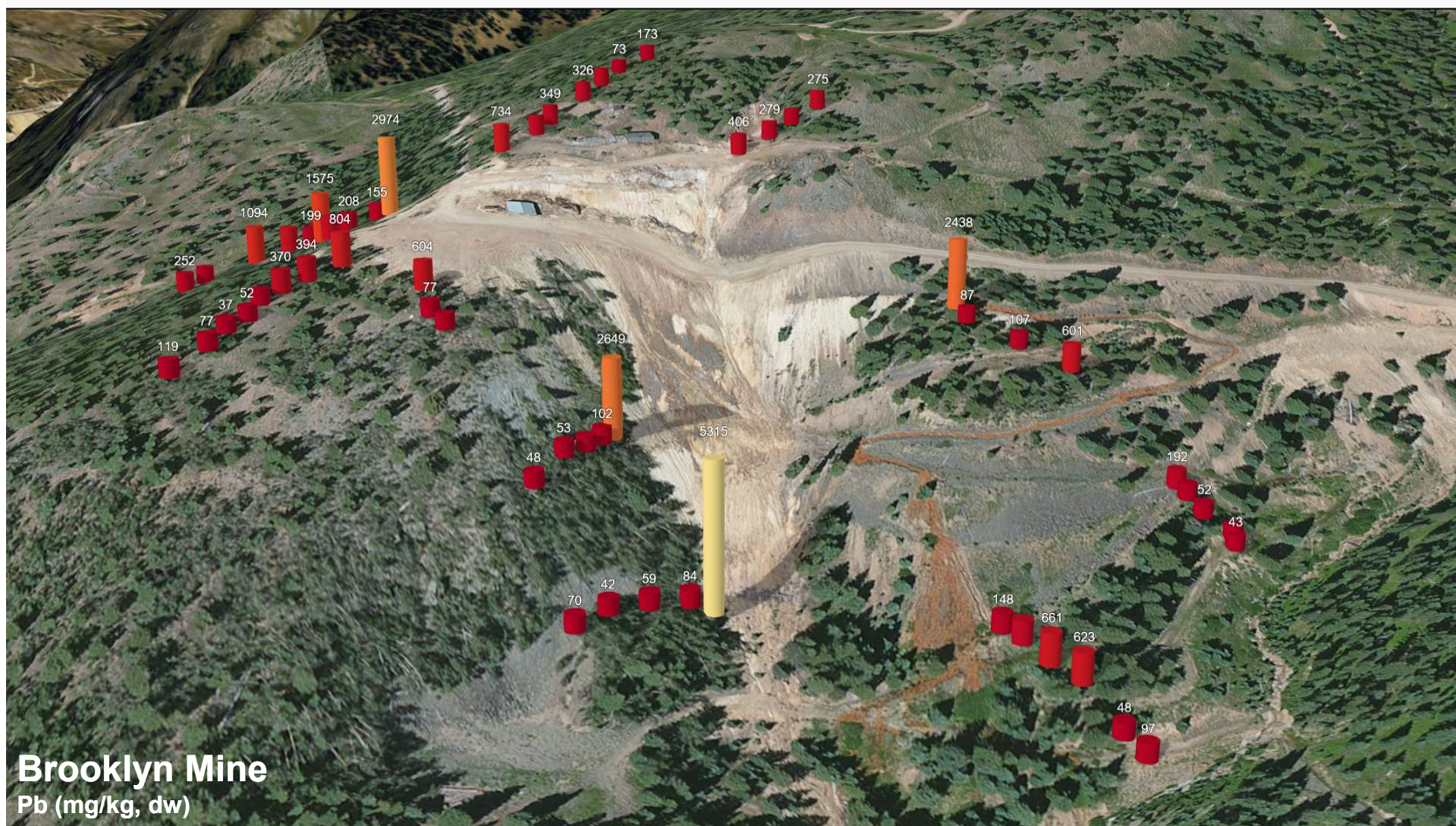


Area of Influence





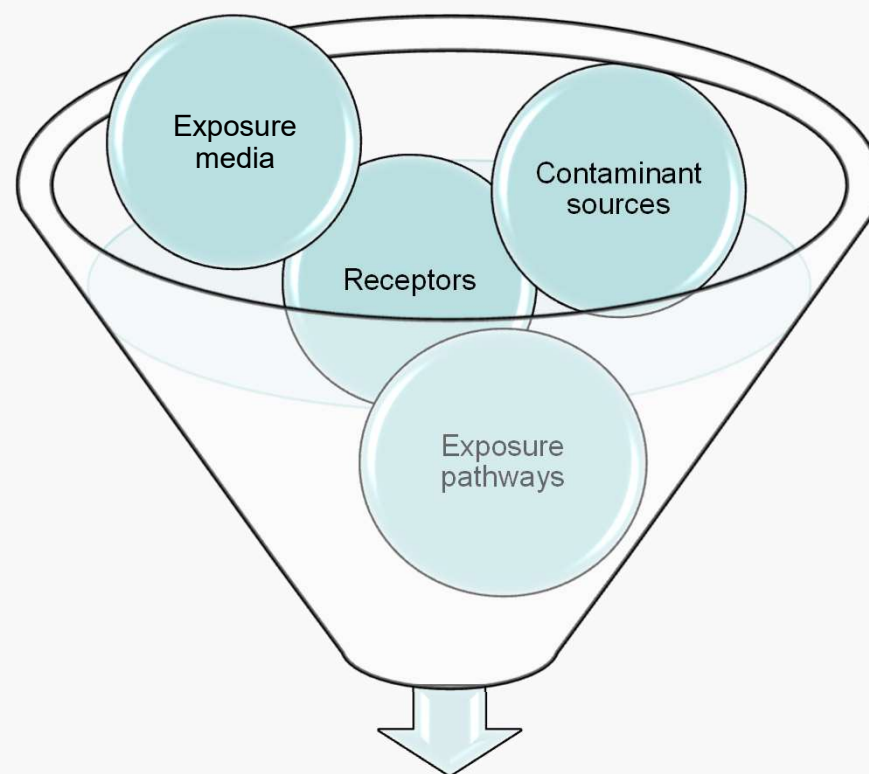
Halo Areas





Conceptual Site Model

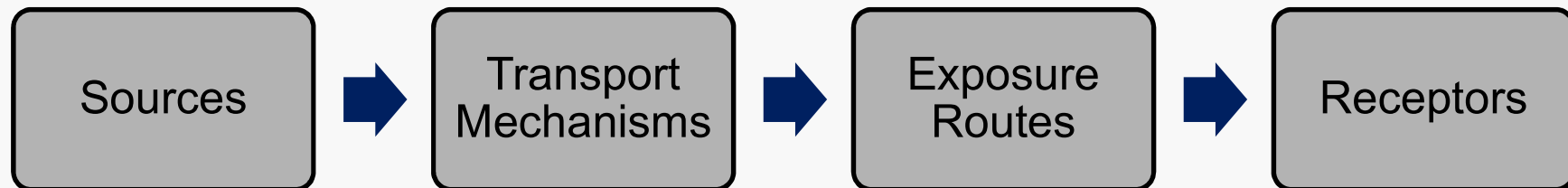
- Result of Problem Formulation phase (Step 3)
- Roadmap used to select risk assessment and measurement endpoints



Conceptual Site Model

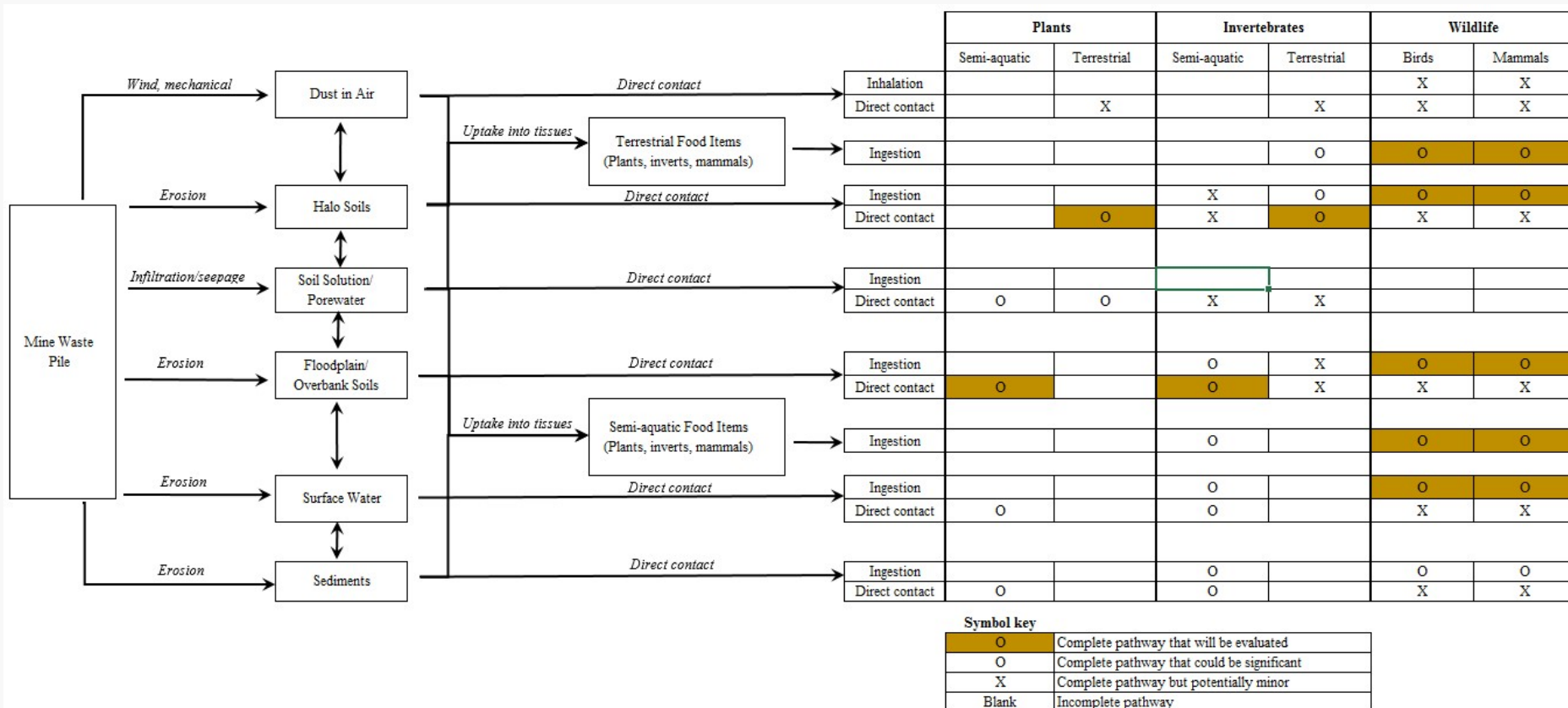


Conceptual Site Model





Conceptual Site Model





Assessment and Measurement Endpoints

- Maintain stable and healthy plant and invertebrate communities
 - Compare soil metals concentrations to ecological screening values (ESVs)
- Maintain stable and healthy bird and mammal populations
 - Food chain modeling
 - Estimate exposure
 - Compare to toxicity reference values (TRVs)

Hazard quotient (HQ) = Exposure estimate / ESV or TRV



Target Receptors

Feeding guild	Birds	Mammals
Herbivores	White-tailed ptarmigan	American pika Yellow-bellied marmot Northern pocket gopher American beaver Moose
Terrestrial insectivores	Mountain bluebird	Montane shrew
Aerial insectivores	Cliff swallow	Fringed myotis bat
Omnivores	American robin	Deer mouse
Carnivores	Golden eagle Northern goshawk	Canada lynx



Exposure Units

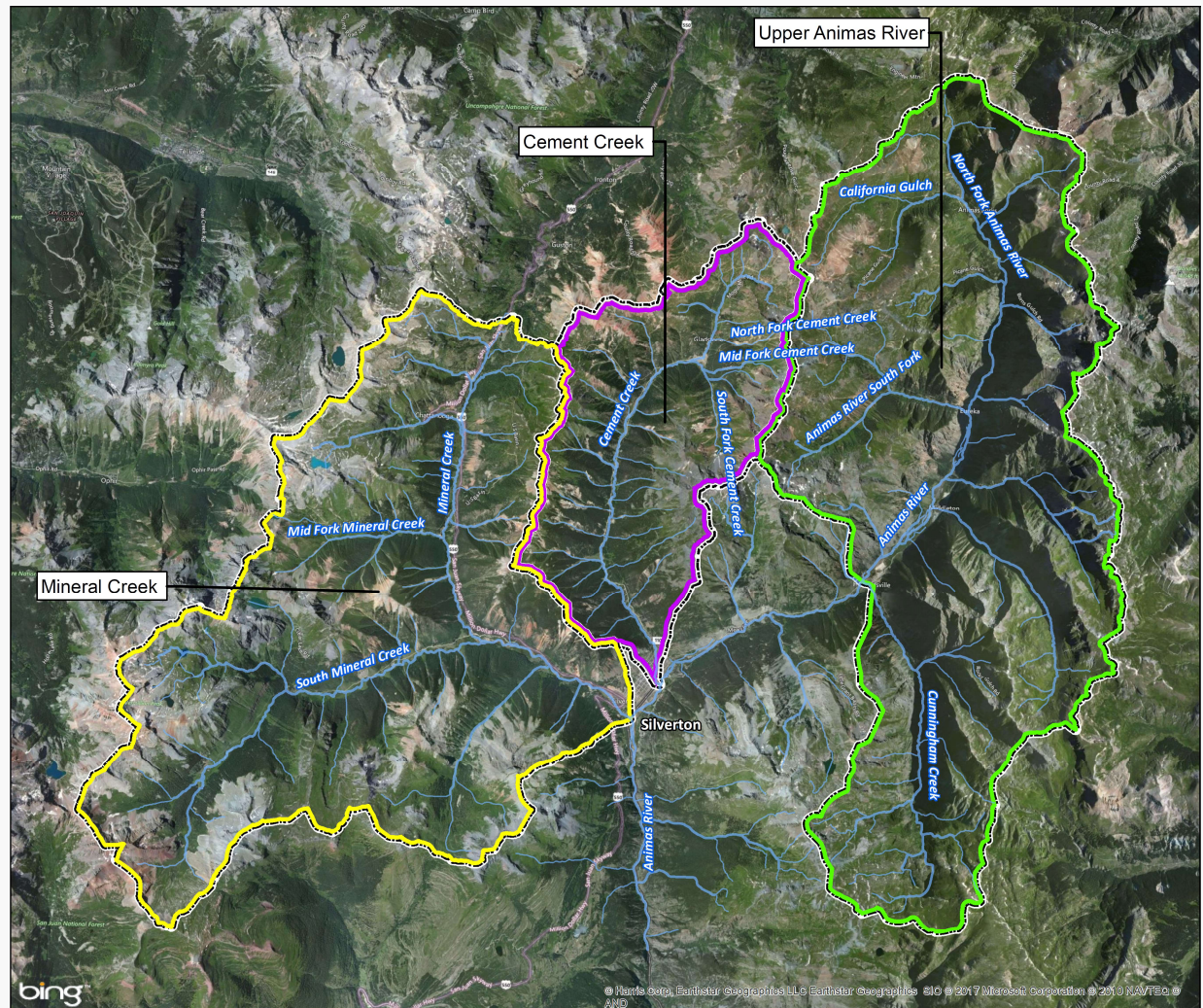
Target receptor species	Home-range category	EU descriptions (number of EUs)
Canada lynx Coyote Golden eagle	Very large	Entire BPMD, including upland and floodplain habitats (n=1)
Moose Northern goshawk	Large	Major sub watersheds located in the BPMD; Mineral Cr., Cement Cr., and Animas R. above Silverton (n=3)
American robin Cliff swallow Fringed myotis bat American beaver	Medium	Each floodplain EU located along Mineral Cr., Cement Cr., and Animas R. above Silverton; Including reference reaches (n=30)
Mountain bluebird White-tailed ptarmigan American pika Yellow-bellied marmot Northern pocket gopher	Medium	Mine site halo sampling DRCs; High-level, medium-level, low-level, and upland vegetated (n=4)
Montane shrew Deer mouse	Small	Floodplain sampling DRCs; High-level, medium-levels, low-level, and floodplain reference (n=4)



Watershed and Sub-Watershed EUs

Three sub-watersheds

- Mineral Creek
- Cement Creek
- Upper Animas Creek
- Large home-range receptors



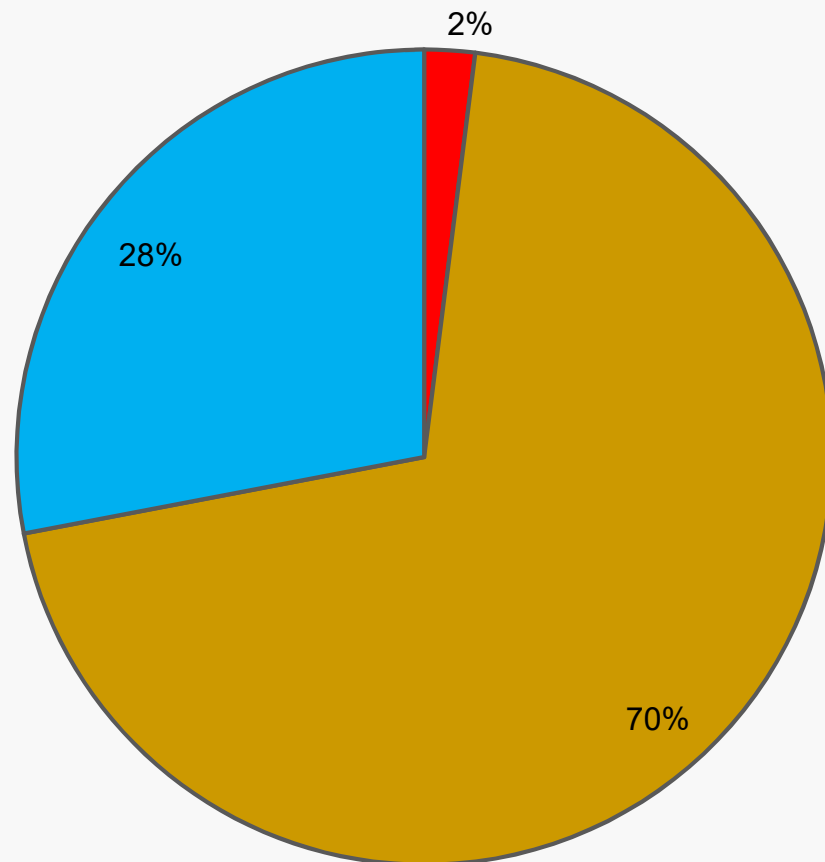


Area Use Factors

- Only needed for large home-range receptors
 - Method to normalize exposure over large areas and habitat types
- AUF development requires:
 - Estimating acreages of all habitats in the assessment area
 - Conduct AUF halo area studies to estimate halo size



Area Use Factors



■ Halo Areas ■ Upland Vegetated ■ Floodplains

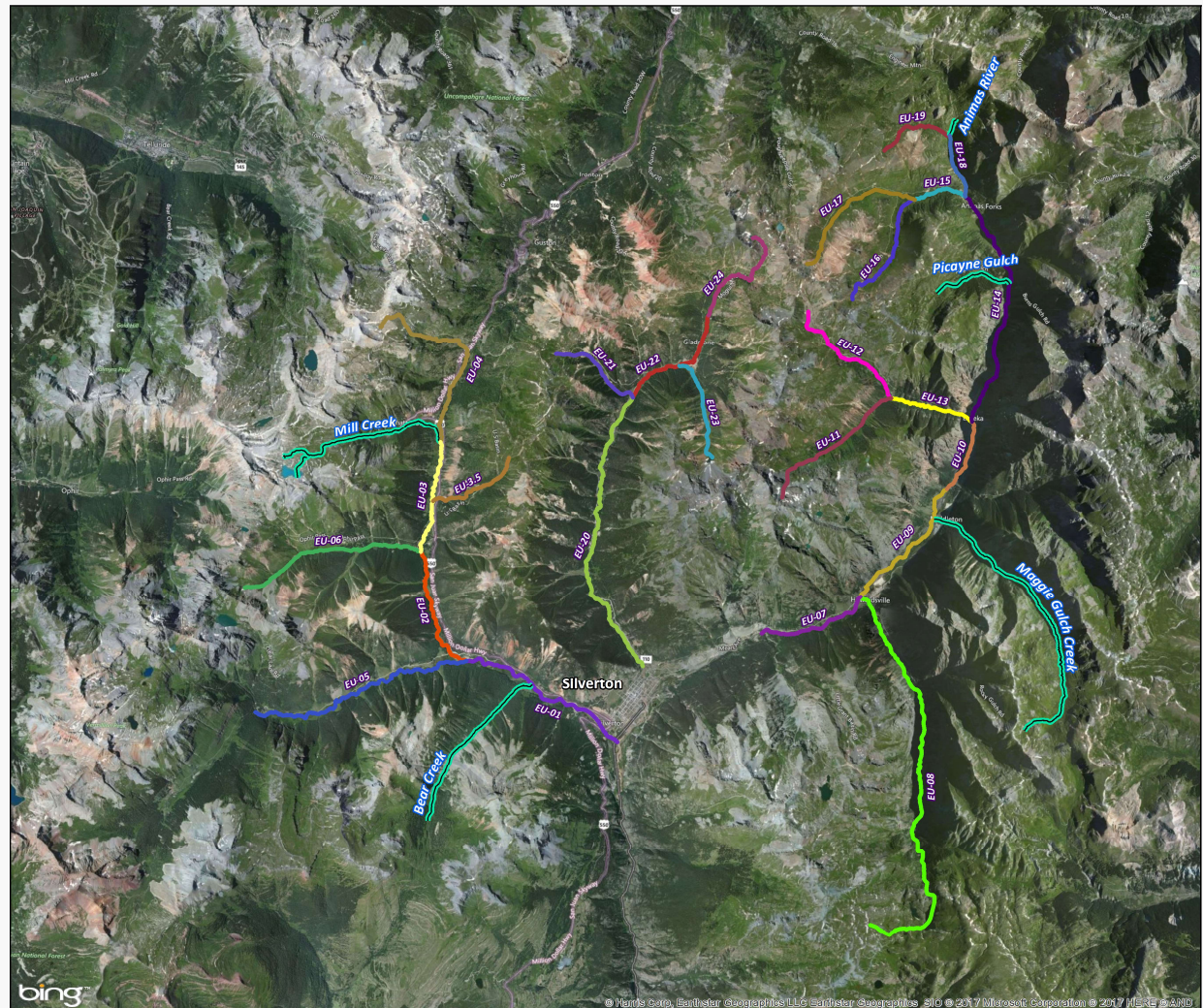




Floodplain EUs

Thirty exposure units

- Mineral Creek (7)
- Cement Creek (5)
- Upper Animas Creek (13)
- Reference (5)
- Medium home-range, floodplain receptors





Dose Response Categories

High-level DRC

- High-level soils
- High-level water
- High-level food items

Mid-level DRC

- Mid-level soils
- Mid-level water
- Mid-level food items

Low-level DRC

- Low-level soils
- Low-level water
- Low-level food items

Reference/Upland

- Reference/Upland soils
- Reference water
- Reference/Upland food items



Exposure Modeling

- Estimated daily dose equation:

$$EDD_{\text{total}} = EDD_{\text{soil}} + EDD_{\text{water}} + EDD_{\text{diet}}$$

- $EDD_x = \text{Ingestion rate} \cdot \text{COPEC concentration in each media type}$
- Units
 - mg of COPEC/kg body weight/day
- Hazard quotient = $EDD_{\text{total}} / \text{Toxicity Reference Value}$



Large home-range receptors

Exposure Modeling – Golden eagle

Exposure unit	Entire site
AUFs	Halos, floodplains, upland
Diet	Small mammal tissue
Body Weight	4.8 kg
Soil Ingestion Rate	0.00078 kg(dw)/kg(bw)/day
Water Ingestion Rate	0.035 L/kg(bw)/day
Food Ingestion Rate	0.178 kg(ww)/kg(bw)/day





Medium home-range receptors

Exposure Modeling – American beaver

Exposure units	Each Floodplain EU (n=30)
Diet	Plants (100%)
Body Weight	20.3 kg
Soil Ingestion Rate	0.00085 kg(dw)/kg(bw)/day
Water Ingestion Rate	0.073 L/kg(bw)/day
Food Ingestion Rate	0.153 kg(ww)/kg(bw)/day





Medium home-range receptors

Exposure Modeling – Yellow-bellied marmot

Exposure units	Dose Response Categories (Uplands)
Diet	Plants (95%); Invertebrates (5%)
Body Weight	3.5 kg
Soil Ingestion Rate	0.00388 kg(dw)/kg(bw)/day
Water Ingestion Rate	0.087 L/kg(bw)/day
Food Ingestion Rate	0.194 kg(ww)/kg(bw)/day





Small home-range receptors

Exposure Modeling – Montane shrew

Exposure units	Dose Response Categories (Floodplains)
Diet	Invertebrates (90%); Plants (10%)
Body Weight	0.015 kg
Soil Ingestion Rate	0.0406 kg(dw)/kg(bw)/day
Water Ingestion Rate	0.223 L/kg(bw)/day
Food Ingestion Rate	0.406 kg(ww)/kg(bw)/day





Risk Characterization

- HQs for each combination of target receptor, COPEC, and EU or DRC
- Range of HQs calculated using:
 - Maximum and average exposure estimates
 - No-and low-effect toxicity values
- Uncertainty analysis and reporting
 - Identify and discuss assumptions and uncertainties
 - Discuss inherent biases as they relate to risk estimates



What is next?

- Halo & floodplain vegetation, invertebrate, soil collection and analysis
 - Summer 2018
- Refine halo area estimates
- Refine habitat area estimates
- Draft Baseline Ecological Risk Assessment





Questions?

