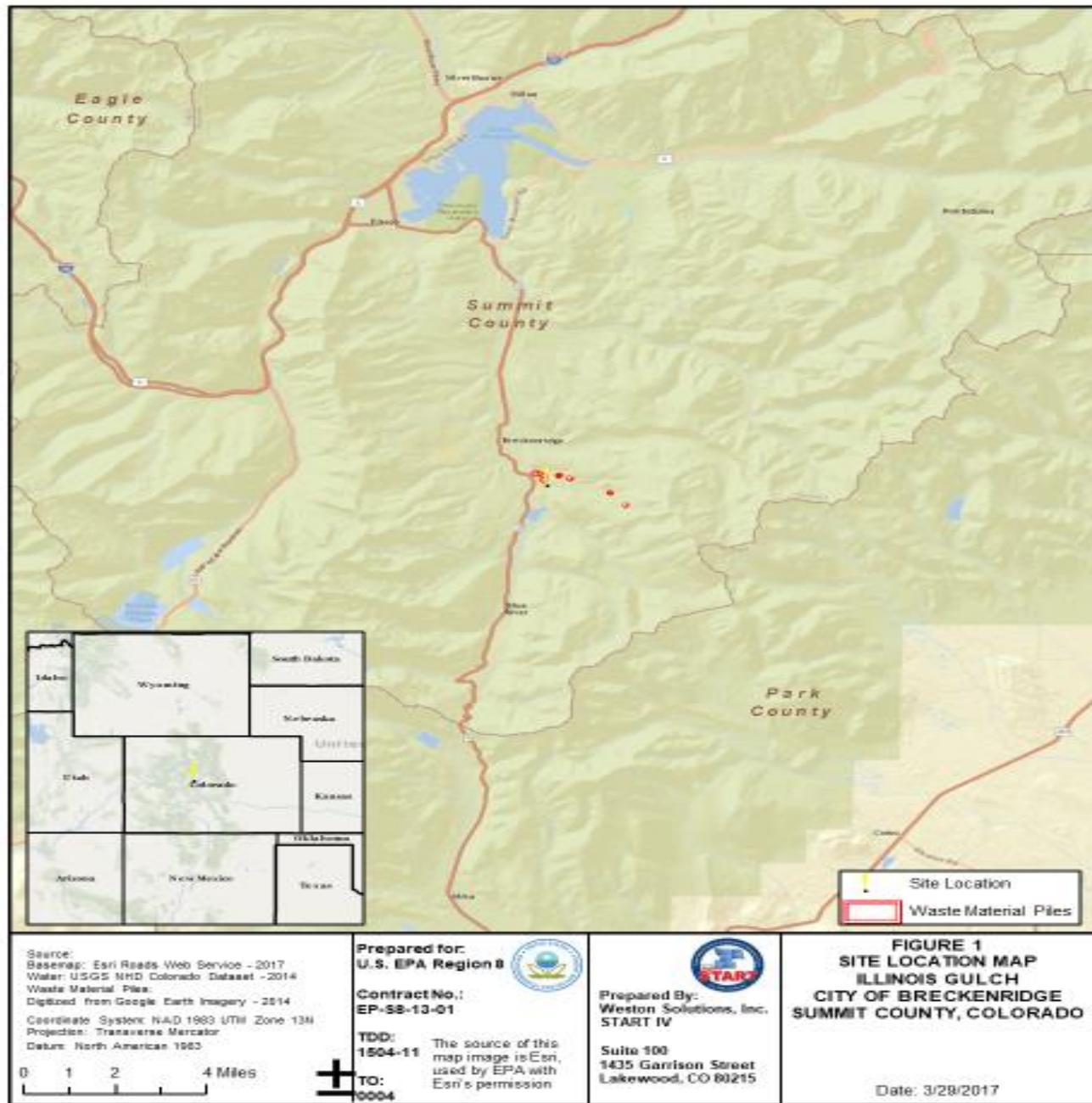


A landscape photograph showing a wide, shallow gulch. The background is a dense forest of tall, thin evergreen trees under a cloudy sky. The middle ground features a large, light-colored, possibly gravelly or sandy area that appears to be a natural or man-made feature within the gulch. The foreground is dominated by a lush, green field of tall grasses or reeds. The overall scene is a natural, somewhat rugged environment.

# Illinois Gulch

Site Assessment Summary – August 2019



Source:  
 BaseMap: Esri Roads Web Service - 2017  
 Water: USGS NHD Colorado Dataset - 2014  
 Waste Material Piles:  
 Digitized from Google Earth Imagery - 2014  
 Coordinate System: NAD 1983 UTM Zone 13N  
 Projection: Transverse Mercator  
 Datum: North American 1983

0 1 2 4 Miles



Prepared for:  
**U.S. EPA Region 8**



Contract No.:  
**EP-S8-13-01**

TDD:  
**1504-11**  
 TO:  
**0004**

The source of this  
 map image is Esri,  
 used by EPA with  
 Esri's permission

Prepared By:  
**Weston Solutions, Inc.**  
**START IV**



Suite 100  
 1435 Garrison Street  
 Lakewood, CO 80215

**FIGURE 1**  
**SITE LOCATION MAP**  
**ILLINOIS GULCH**  
**CITY OF BRECKENRIDGE**  
**SUMMIT COUNTY, COLORADO**

Date: 3/28/2017





# Data Collection Activities

2013 Surface Water - CDPHE

2014 Waste Piles/Surface Water – MO

2015 Phase 1 - Residential Soil Sampling – EPA

2016 Synoptic Surface Water/Loading – USGS/EPA

2017 Synoptic Surface Water/Loading – USGS/EPA

2017 Phase 2 - Residential Soil Sampling - EPA



# Willard Pile Source Definition

Willard Waste  
Pile/Soil

Willard Adit 1

Willard  
Adit/Seep 2



# Willard Waste Pile/Soil

## Key Findings

### Mine Pile Soil Concentrations

- Arsenic concentrations range up to 3,357 mg/kg
- Lead concentrations over 90,000 mg/kg

### Run-off Observed

- Fine/silty, iron-stained, metals-laden sediment
- Deposited/intermingle within on-site wetland
- Observed in Iron Springs; Illinois Gulch; Blue River

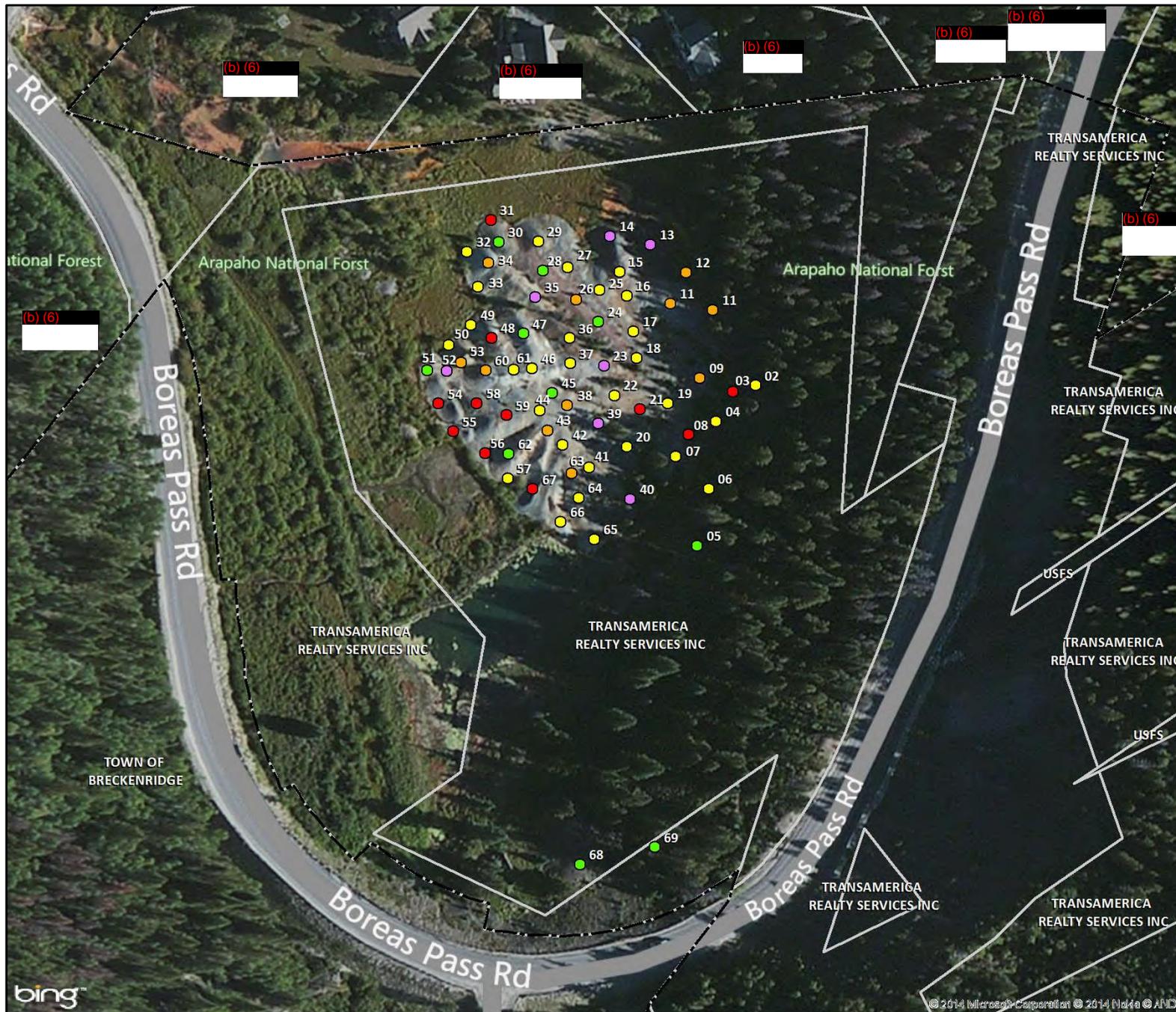
### Residential Properties

- Elevated heavy metals concentrations including arsenic and lead above EPA Residential Soil Levels on adjacent/downstream properties









**Figure 5.**  
**Illinois Gulch - Willard Pile XRF**  
**Arsenic Results**

Arsenic (As) Units in ppm

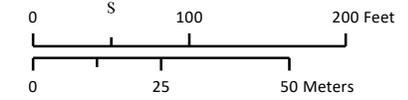
- 0 - 67
- >67 - 100
- >100 - 300
- >300 - 500
- >500 - 3,357
- City Boundary
- Parcel Boundary

Date: August 25, 2014

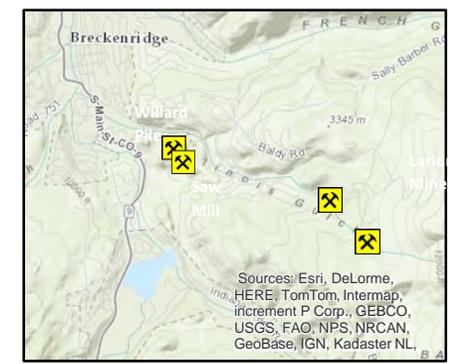
Map Projection: UTM, Meters, Zone 13N, NAD 83

**Data Sources:**

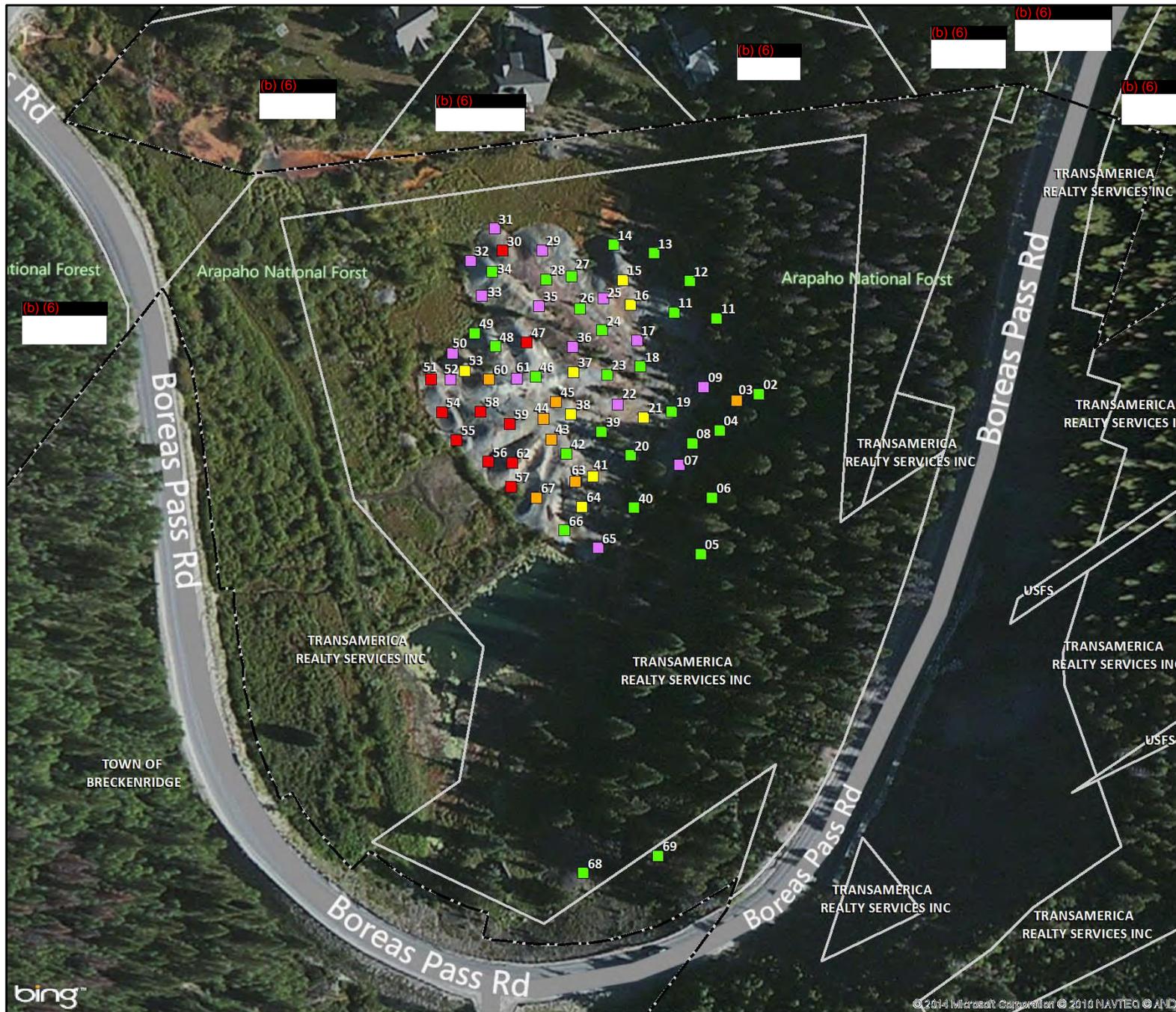
- Imagery - Microsoft Bing web service (2014);
- Sample Locations - U.S. EPA Region 8 (2014);
- Parcel Boundaries - Summit County, Colorado (2014);
- City Boundaries - Summit County, Colorado (2014).



Area Enlarged



Sources: Esri, DeLorme, HERE, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL,



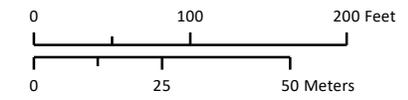
**Figure 6.**  
**Illinois Gulch - Willard Pile XRF**  
**Lead Results**

- Lead (Pb) Units in ppm**
- >500 - 1,500
  - >1,500 - 3,000
  - >3,000 - 5,000
  - >5,000 - 10,000
  - >10,000 - 99,311
  - City Boundary
  - Parcel Boundary

Date: August 25, 2014

Map Projection: UTM, Meters, Zone 13N, NAD 83

**Data Sources:**  
 Imagery - Microsoft Bing web service (2014);  
 Sample Locations - U.S. EPA Region 8 (2014);  
 Parcel Boundaries - Summit County, Colorado (2014);  
 City Boundaries - Summit County, Colorado (2014).



Area Enlarged

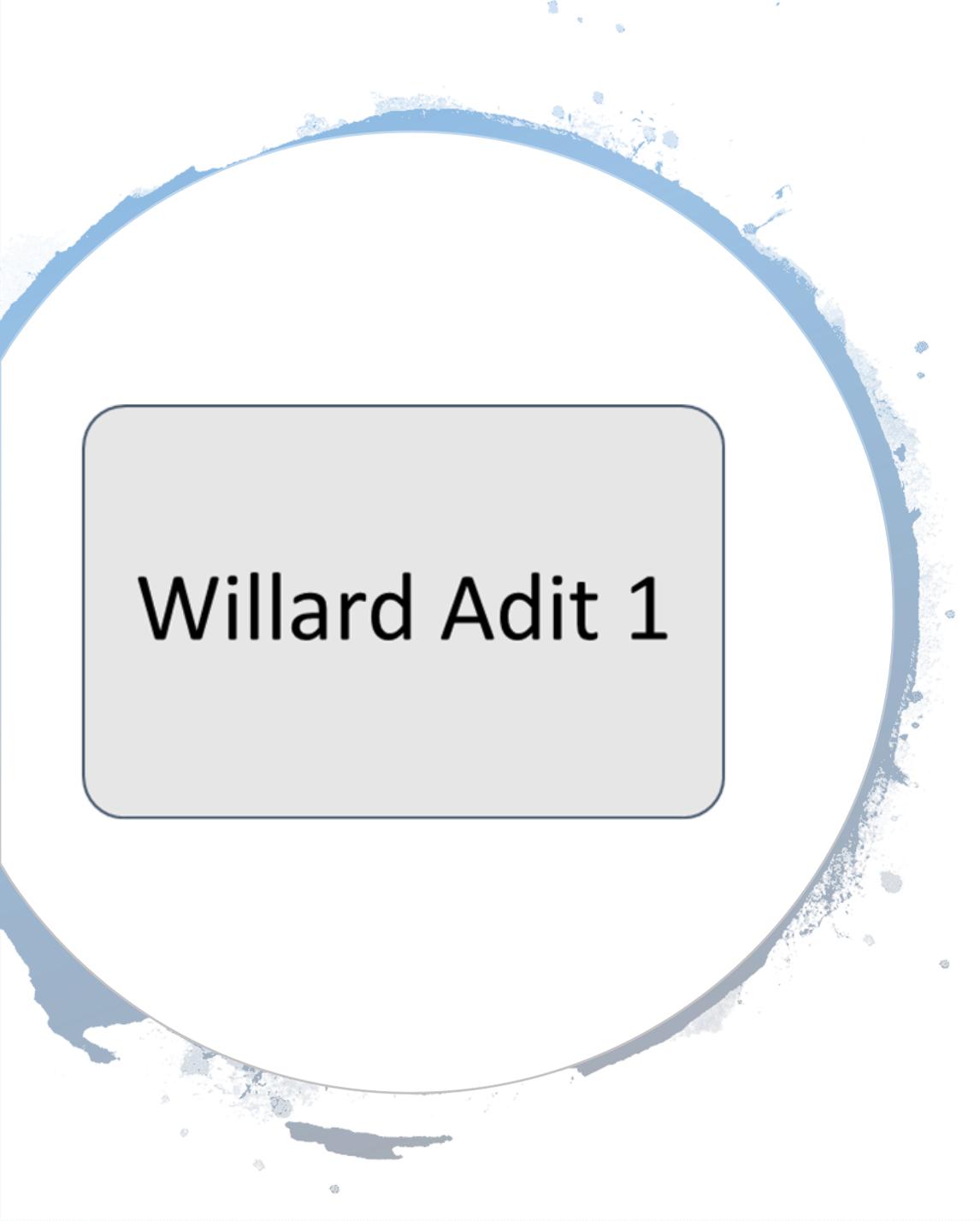


# Residential Soil Sampling

- Lead and Arsenic concentrations exceed background and residential/industrial use RSLs
  - Arsenic ranges up to 54 mg/kg
  - Lead ranges up to 1,170 mg/kg
- Residential RSLs: As=0.68 mg/kg; Pb=400 mg/kg
- Industrial RSLs: As=3.0 mg/kg; Pb=800 mg/kg
- Average background: As=14 mg/kg; Pb=140 mg/kg



# Key Findings



## Willard Adit 1

- Continuous discharge from Willard Adit #1 found to contain elevated heavy metals concentrations and low pH.
- Discharge from the mine adits within the Willard Waste Area is a primary source of metals migration, deposition, and iron staining within the adjacent wetland, Iron Springs Gulch, Illinois Gulch, and adjacent/downstream properties.
- Episodic surges and discharges from the Puzzle mine/Willard Adit #1 have occurred in the past, including a documented blowout in April 2006 resulting in a downstream fish kill



# Iron Springs – Boreas Pass Road



# Water Quality Status

- Blue River Segment 12, Illinois Gulch, has been on the State's 303(d) list of water quality impaired waterbodies for nonattainment of water quality standards for dissolved zinc since 2004, when it was given a high priority.
- This same segment, Illinois Gulch, was also included on the State's 303(d) list for dissolved cadmium in 2009.
- Excess dissolved zinc and cadmium impairs the Aquatic Life Cold 1 classification for Segment 12.
- TMDL indicates that high concentrations of dissolved zinc and cadmium are primarily the result of mining activity in the watershed since the 1880's (CDPHE, 2010 and 2011).
- Water quality in Illinois Gulch above the Iron Springs Gulch (and influence of the Puzzle Mine) is periodically above assigned standards, but water quality below the mine has significantly elevated acute levels of cadmium and zinc.



Site ID	Latitude (WGS 84)	Longitude (WGS 84)
IG-01	39.4724150	-106.0390350
IG-02	39.4715410	-106.0346070
IG-03	39.4715950	-106.0340200
IG-3-1	39.4712500	-106.0286150
IG-04	39.4706610	-106.0326340
IG-05	39.4705830	-106.0325210
IG-06	39.4703330	-106.0324400
IG-07	39.4699710	-106.0319190
IG-08	39.4699460	-106.0318650
IG-09	39.4699230	-106.0313690
IG-10	39.4694070	-106.0300320
IG-11	39.4692990	-106.0299290
IG-12	39.4687560	-106.0300910
IG-13	39.4687160	-106.0287820
IG-14	39.4667600	-106.0228683
IG-15	39.4624266	-106.0035150
IG-16	39.4694700	-106.0289680
IG-17	39.4684000	-106.0298200
IG-18	39.4679450	-106.0298633
IG-19	39.4703350	-106.0304633

**Legend**

- Adit/Mine Feature
- River or Stream
- Subwatershed Boundary
- River/Stream Sample
- Approximate Location of River or Stream
- County Boundary
- Lake or Pond

Source of Aerial base map:

Scale in Feet

0 50 100 200

IG-15 is located approximately 6000 feet upstream from IG-14.

NAD83 StatePlane Colorado Central, Feet

0 150 300 600

**Figure 1**  
 Illinois Gulch Sample Location and Mining Features Map

**ITRS**

# Water Quality Results

## SECTION FOUR

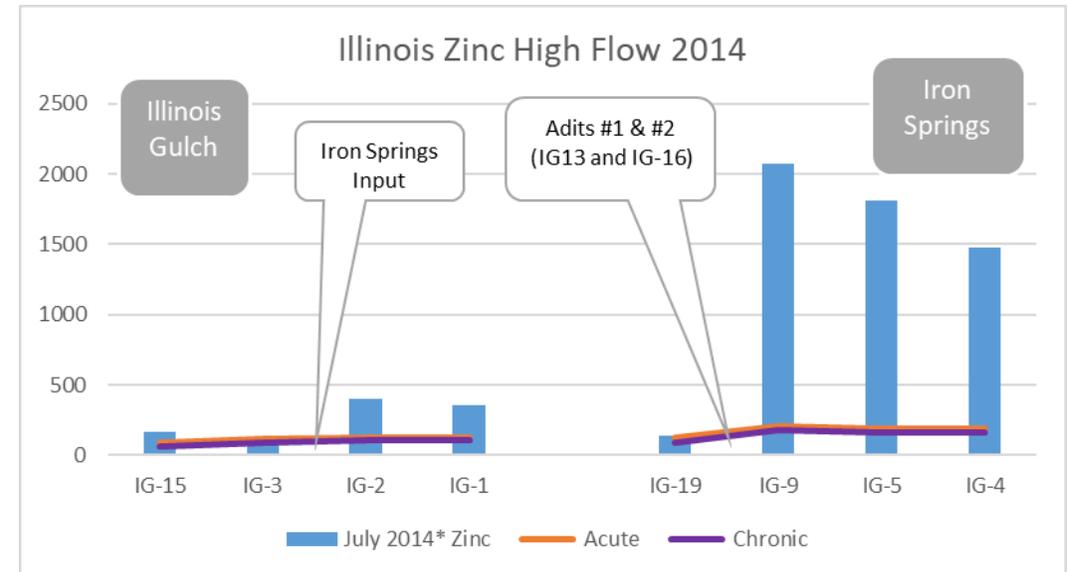
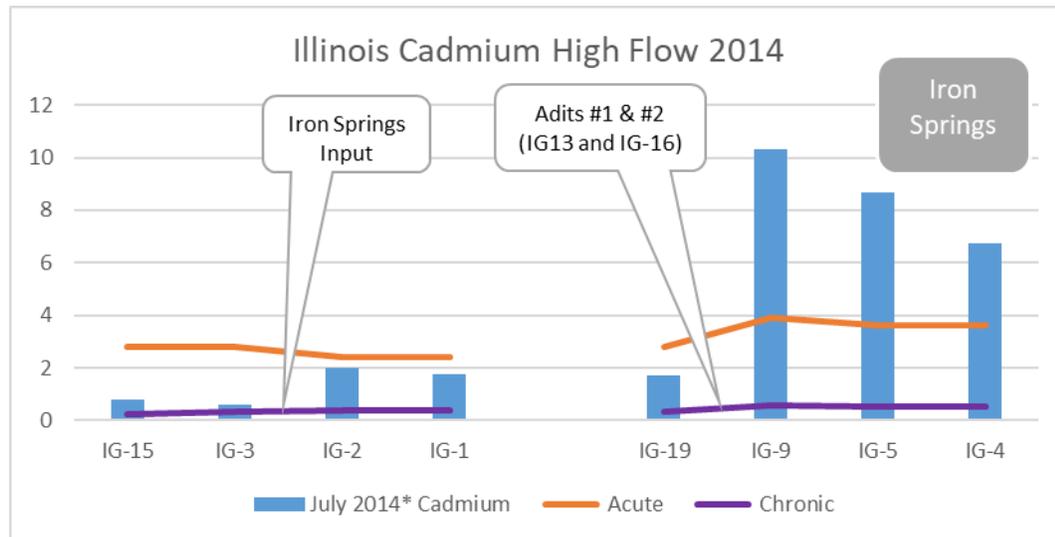
## Surface Water Sample Results

**Table 4-4a**  
**Iron Springs Gulch Mine Features Hardness, pH, Flow Rate, and Dissolved Metal Results**

Sample Location	Sample ID	Sample Date	Hardness (mg/L)	pH	Flow Rate (CFS)	As (µg/L)	Cd (µg/L)	Cu (µg/L)	Fe (T) (µg/L)	Pb (µg/L)	Mn (µg/L)	Ni (µg/L)	U (µg/L)	Zn (µg/L)
Willard Adit 1 Discharge, Puzzle Adit	IG-13	05/31/12	180	5.16	0.05	6.2	38	390	23000	220	2600	29	2.8	7800
		06/05/13	230	5.1	0.11	200	67	1400	64000	460	3600	43	5.5	13000
		08/28/13	200	4.48	0.04	6.1	26	180	16000	190	2400	21	1.9	5900
		07/02/14	222	3.30	0.076	29.7	52.1	423	35000	316	3580	27.3		10200
		09/18/14	207	3.57	0.0601	8.99	32.4	158	22200	257	3170	17.5		8150
Iron Springs Mine Dump (Willard Pile) Seep [a]	IG-12	05/31/12	250	7.06	NA	11	2.5	<5	6900	0.42	570	<2	0.49	540
		08/22/12	380		NA	4.5	<0.07	<5	962000	<0.15	170	<2	0.41	51
		06/05/13	290	7.53	NA	10	0.63	<4	9600	0.92	340	<1	2.8	190
		08/28/13	230	7.3	NA	2.5	<0.07	<4	810	0.46	98	<1	2.7	<10
		07/02/14	279	7.78	NC	0.972	<0.1	1.53	885	0.136	69.9	<0.5		24.3
09/18/14	299	6.43	N/C	1.52	<0.1	0.531	773	<0.1	274	<0.5		18.4		
Willard Adit 2 located 100 yards to the north of Puzzle Adit	IG-16	05/31/12	200		0.02	3	4	7	19000	3.9	1300	16	0.34	2300
		08/22/12	190	5.65	0.01	2.4	6.9	43	14900	5.1	1700	20	0.38	3300
		06/05/13	190	4.15	0.02	2.3	9.4	120	31000	31	1500	28	1.2	4200
		08/28/13	190	2.07	0.01	2.4	4.9	14	16000	17	1400	18	0.38	2700
		07/02/14	179	4.55	0.013	1.94	8.72	70.2	23400	50.9	1360	18.7		3320
09/18/14	183	5.25	0.02	2.58	5.53	14.5	16600	50.2	1400	13		2730		
Outlet of pond above Willard Pile	IG-17	07/16/13	230	6.51	0.039	0.43	<0.07	<4	740	0.33	190	<1	3.2	50
		08/28/13	260	7.87	0.13	0.41	<0.07	<4	510	0.21	230	<1	2.4	<10
		07/02/14	280	8.00	0.088	0.726	<0.1	1.51	510	<0.1	59.1	<0.5		20.2
		09/18/14	298	6.37	0.0221	<0.5	<0.1	0.573	773	<0.1	277	<0.5		17.6

# Water Quality Results – Illinois Gulch

## Dissolved Cadmium





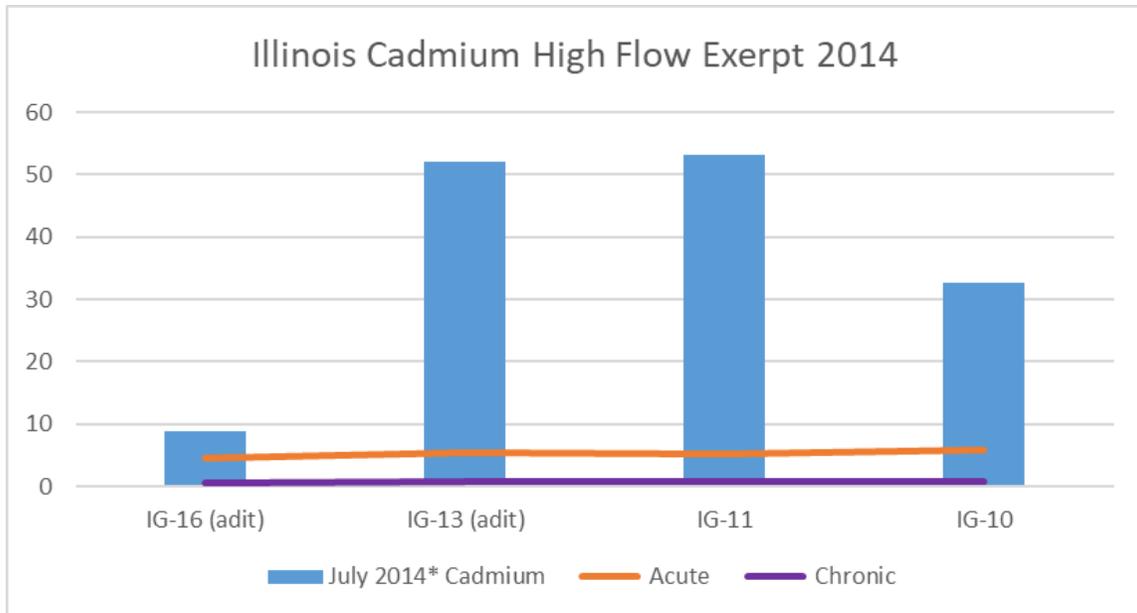
## Willard Adit/Seep 2

# Key Findings

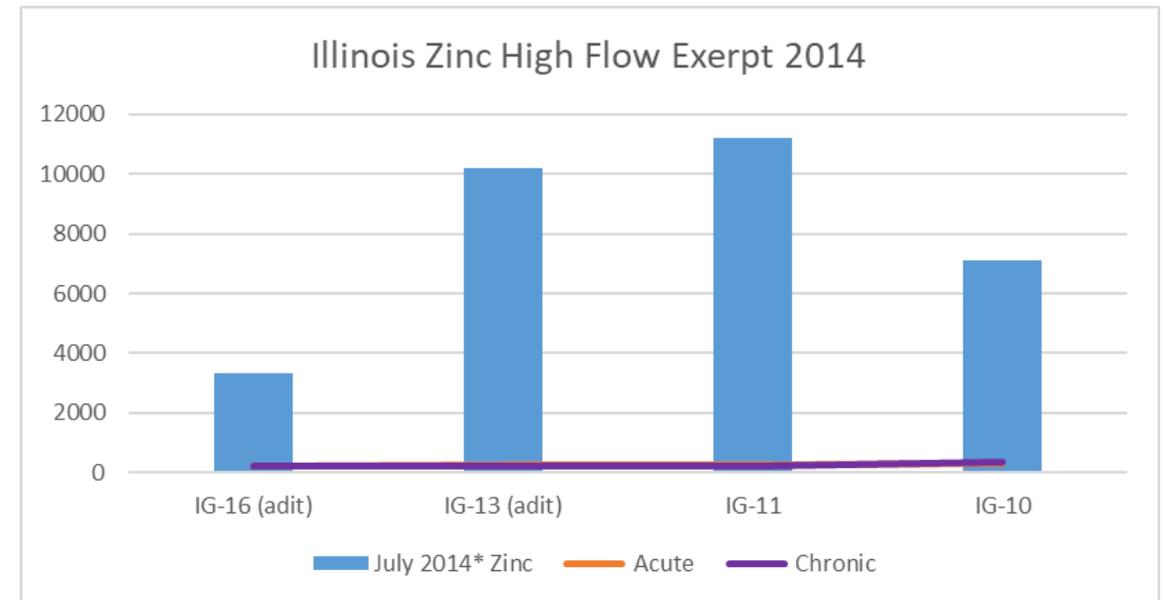
- Not connected to Willard Adit #1 or the Puzzle Willard Extension Shaft
- Continuous discharge from Willard Adit #2 found to contain similar constituents (cadmium and zinc) and other heavy metals as Adit #1, well as low pH.
- Discharge combines with flow from Willard Adit 1 and flow through wetland prior to entering Iron Springs.

# Discharge from Willard Adits

Illinois Cadmium High Flow Excerpt 2014



Illinois Zinc High Flow Excerpt 2014



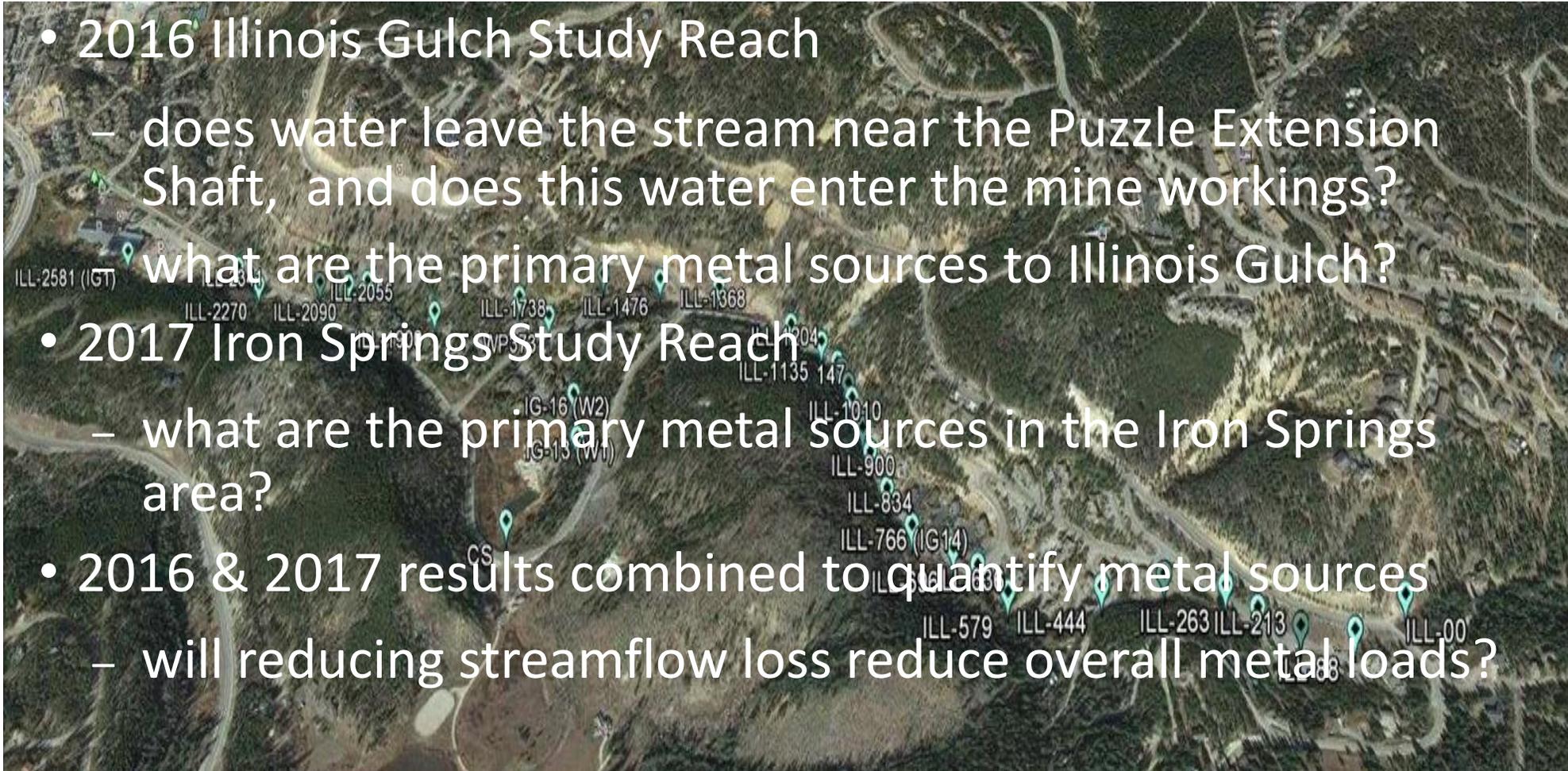
# Key Findings

## **Willard Mine Waste Area – Water Quality**

Elevated heavy metals concentrations within Iron Springs Gulch discharge to Illinois Gulch within a relatively short distance.

Significant increases of metals loading from Iron Springs Gulch cause exceedances above the Colorado Water Quality Standards for cadmium and zinc in downstream Illinois Gulch indicating a likely impact to aquatic life.

# USGS – FLOW TRACER STUDY

- 
- 2016 Illinois Gulch Study Reach
    - does water leave the stream near the Puzzle Extension Shaft, and does this water enter the mine workings?
    - what are the primary metal sources to Illinois Gulch?
  - 2017 Iron Springs Study Reach
    - what are the primary metal sources in the Iron Springs area?
  - 2016 & 2017 results combined to quantify metal sources
    - will reducing streamflow loss reduce overall metal loads?

# Illinois Gulch Results (2016)

## Largest source: Iron Springs

- #1 Source: Al, Cd, Cu, Fe, Mn, Ni, Pb, U, Zn



ILL-2126, Iron Springs at Mouth

Rank	Constituent	Contribution
1	Al	42%
1	Cd	65%
1	Cu	51%
1	Fe	67%
1	Mn	89%
1	Ni	78%
1	Pb	31%
1	U	36%
1	Zn	76%
2	As	29%
2	Cr	13%

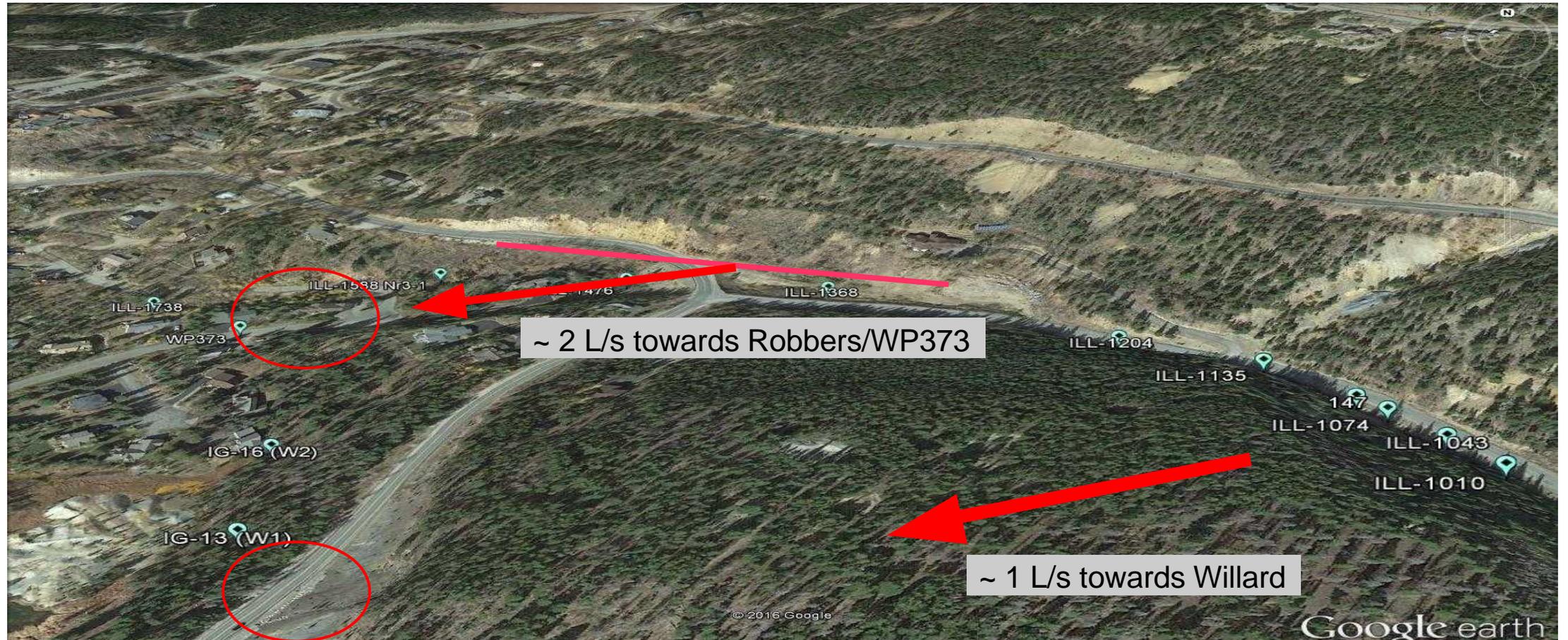
# FLOW LOSS AND WILLARD ADIT #1

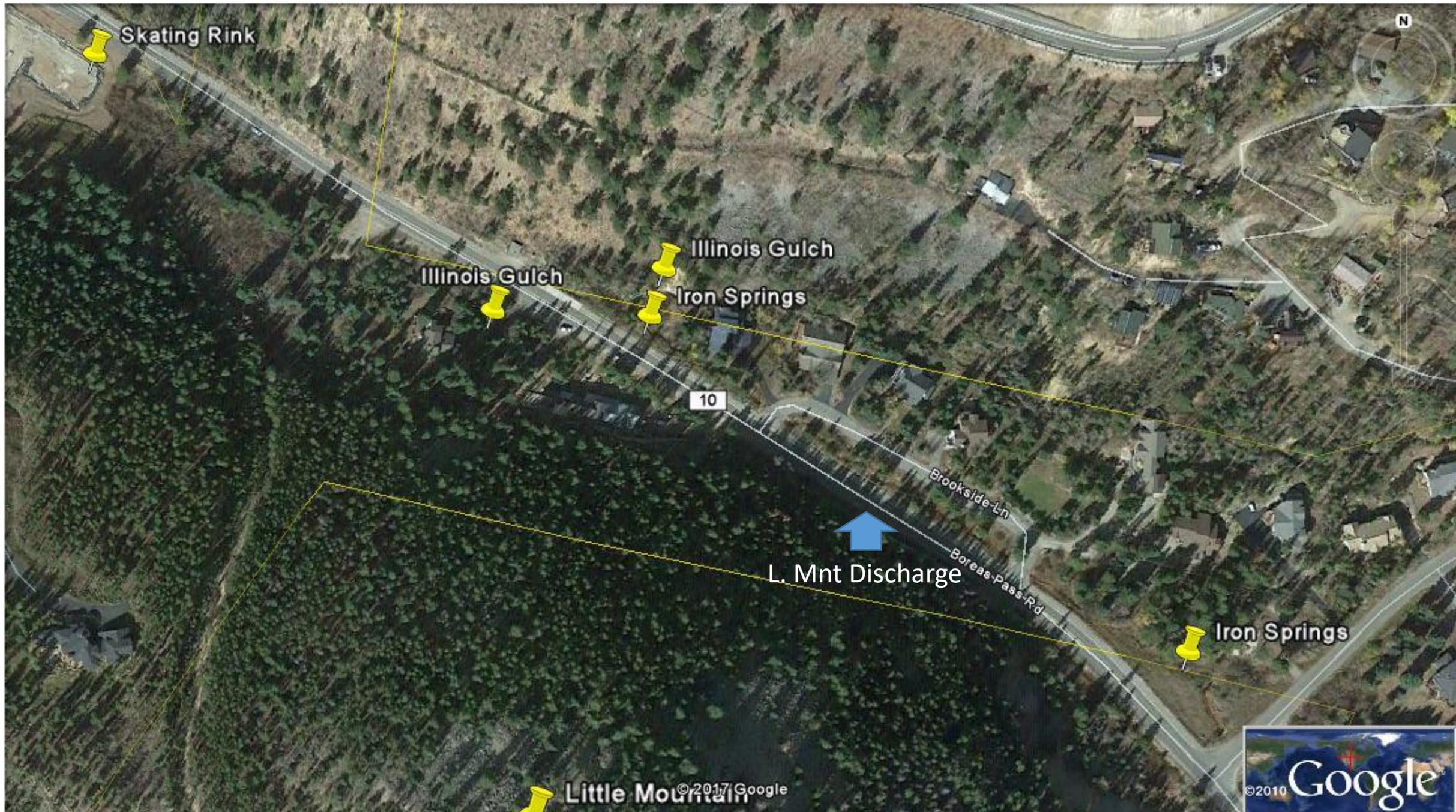
100% of the flow loss near the Puzzle Extension Shaft enters Willard Adit 1

0% of the flow loss downstream of Puzzle Extension Shaft enters Willard Adit 1

Willard Adit 1 discharge is 22 gal/min as measured by flume

# Flow Profile: Areas of Flow Loss (2016)





Skating Rink

Illinois Gulch

Illinois Gulch

Iron Springs

10

Brookside Ln

Boreas Pass Rd

L. Mnt Discharge

Iron Springs

Little Mountain



LITTLE MOUNTAIN/GERMANIA INPUT

06/18/2016 10:50

# Conclusions

- Primary contribution of metals loading is from Iron Springs
- Cadmium exceeds chronic standard for entire Illinois Gulch study reach
- Cadmium exceeds acute standards downstream of Iron Springs
- Zinc exceeds acute and chronic standards downstream of Iron Springs
- Small contribution from Willard Adit #2 & the Little Mountain area
- Loss of flow near the Puzzle Extension Shaft, and other areas  
flow loss enters workings and supplies water to Willard 1

## Survey – Blue River



# Toxicological Impacts

- Cadmium has no known beneficial function in the human body and causes cancer, bioaccumulates in tissue, and can affect kidney, liver and bones, and can cause genetic mutations.
- Cadmium bioaccumulates in mammals and fish tissue and transfers through the food chain via ingestion.
- Aquatic exposure to relatively low concentrations of cadmium result in mortality of fish, and other chronic effects such as reduced growth and reproduction which occur at relatively low concentrations.
- Zinc is especially toxic to fish causing mortality due to affecting the morphology of the gill epithelium/membrane resulting in acute respiratory stress.



# Key Findings

## **Illinois Gulch Water Quality**

Cadmium concentrations above chronic WQS are observed in Illinois Gulch above the confluence with Iron Springs Gulch.

A significant contribution and increase of cadmium and zinc concentrations are observed in Illinois Gulch below Iron Springs and result in acute and chronic exceedances to aquatic life



Questions?