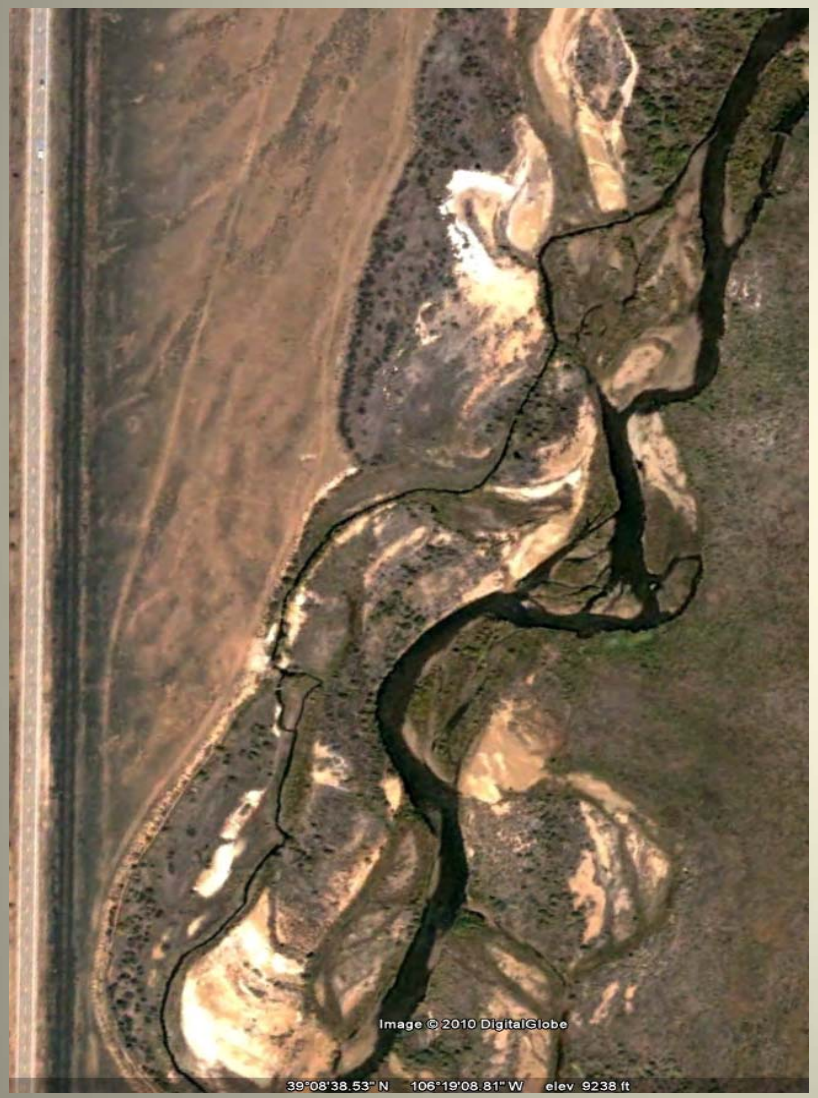
Soil Treatment at the California Gulch NPL Site for Vegetation Reestablishment and Mitigation of Metal Mobility

Stuart Jennings, RRG, Jan Christner, URS
Mike Holmes, EPA and John DeAngelis, PWT

Operable Unit 11 of the California Gulch Superfund Site near Leadville, CO

Pre-Treatment (~2008)

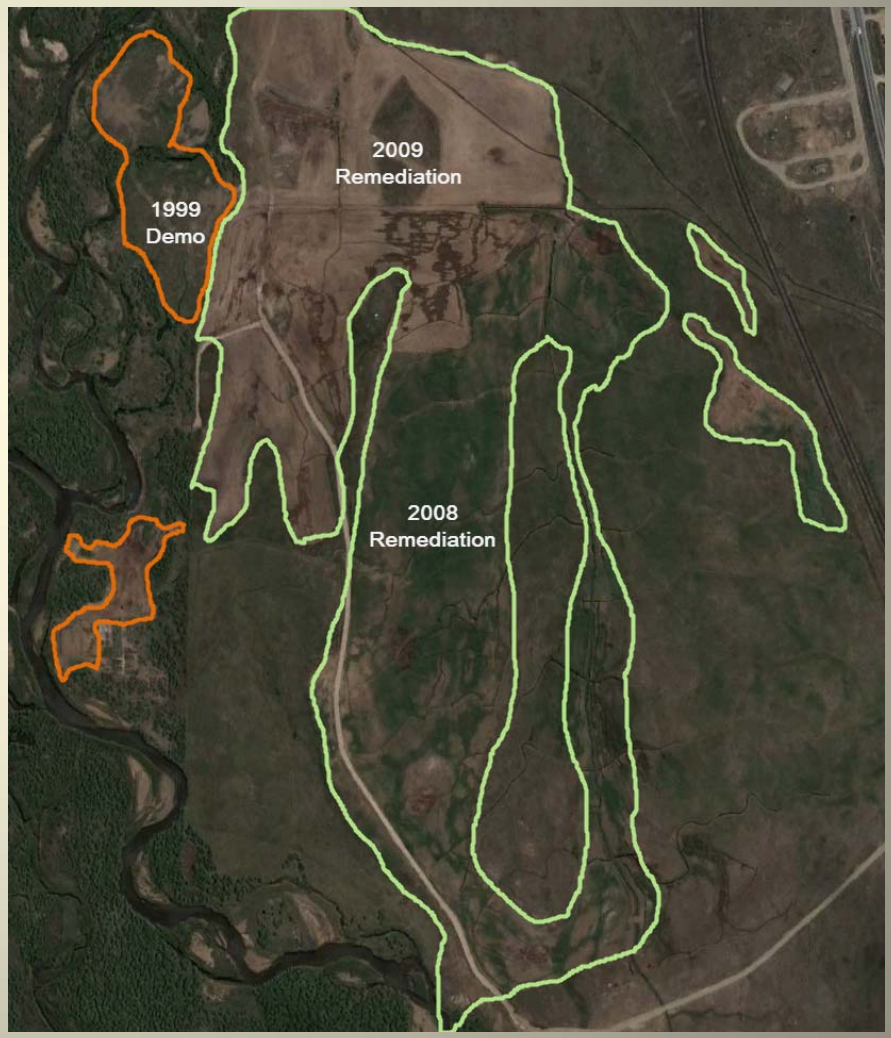


Post Treatment (~2010)

Irrigated Meadows

Before remediation

After remediation



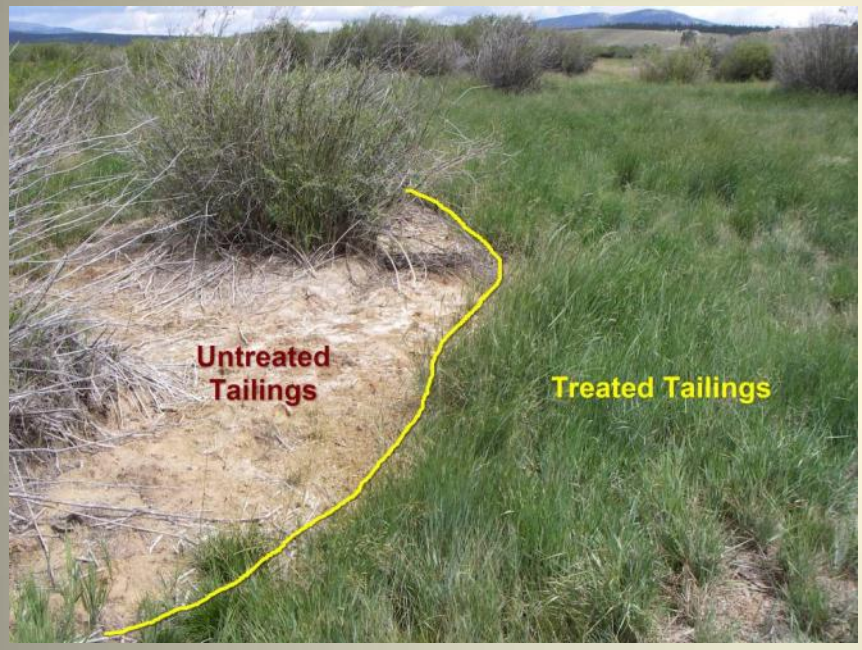
Arkansas River Fluvial Tailing Areas

Fluvial Tailing Deposits

Unstable Streambanks

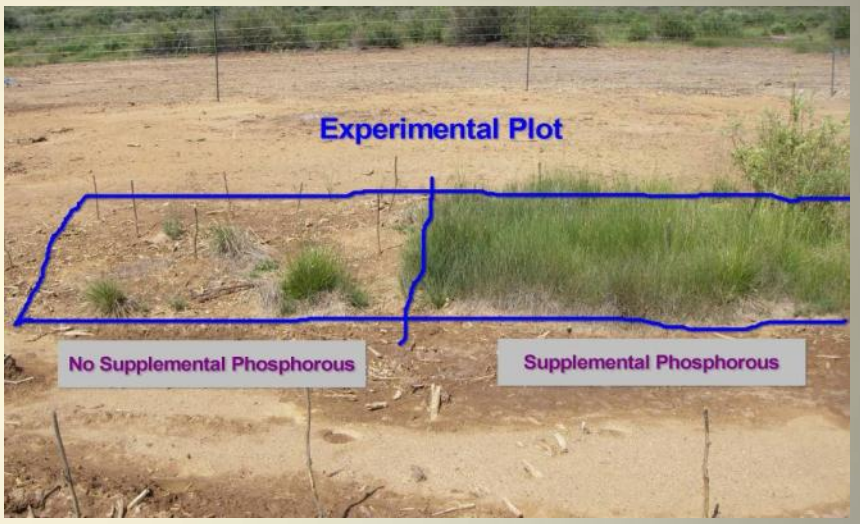
Prior Research and Demonstration Work

1999 EPA Demonstration



Harry Compton (EPA), Mark Sprenger, (EPA), Sally Brown (USDA/UW), Mike Zimmerman (EPA), Jan Christner (URS)

University Research



CSU Revegetation Research
Kevin Fisher, MS 1999
Joe Brummer, principal investigator

Two Treatment Strategies

Irrigated Meadow Contamination

- 153 acres treated to either 6 or 12 inch depth using a tractor-pulled plow
- Thin deposits of relatively uniform depth

Fluvial Tailing Deposits

- 18 acres treated with an excavator-mounted soil mixer
- Thick deposits of varying depths within the floodplain

Remedial Action Objectives

- **Minimize future human exposures**
- **Minimize erosion**
- **Control leaching and migration of metals**
- **Reduce toxins in plants**
- **Reduce metal exposures of wildlife and livestock**

Remedial Timeline

1990's-2006—Data Collection, Research, Demonstration

2007—Work plan

2008-2009—Construction

2010-present—Monitoring and maintenance

Soil Treatment

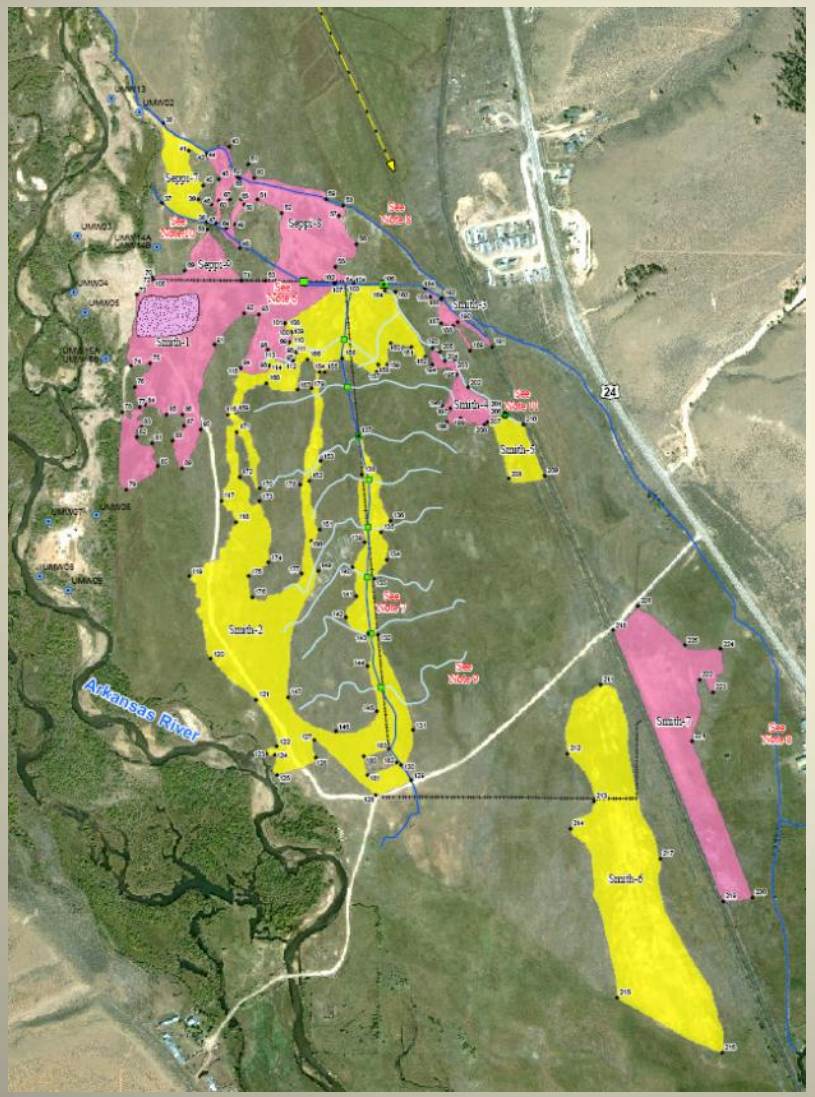
Approach

- Add lime to control current and future acidity
- Add organic amendment to serve as basis for long-term soil fertility/nutrient cycling
- Add supplemental phosphorous
- Treat entire contamination thickness
- Seed
- Monitor and maintain

Expected Outcome

- Soil pH will remain between 7-8 and control soluble metals
- Nutrient cycling will be perpetuated by soil organisms
- Vegetation will not translocate harmful concentrations of contaminants into shoots
- Water balance will be improved
  - Reduced metal flux to groundwater
  - Reduced runoff/reduced erosion
  - Increased evapotranspiration
- Conventional land uses will be restored (grazing and recreation)
- Meet RAO's and Performance Standards

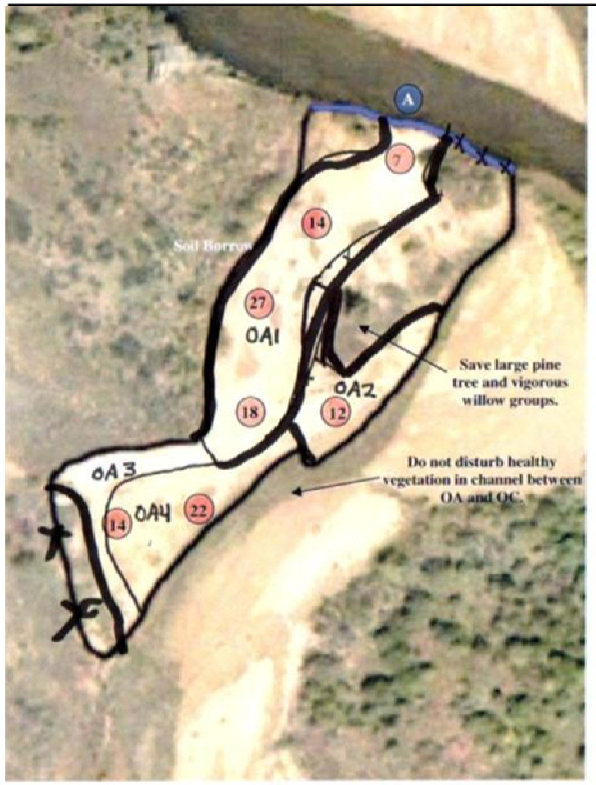
Soil Treatment Polygons— Irrigated Meadows North



12-inch tillage --Pink coded polygons

6-inch tillage – Yellow coded polygons

FLUVIAL DEPOSIT OA



Bank Stabilization

Bank A: 80' Type 2 stabilization of 1'-2' high bank. Save all willows along the bank. ~~Where willows are located along the bank, place the biolog behind the willows.~~ The completed bank should include a transition zone with a second tier of willows on 10' spacing.

OA1 Treat to 30". 5% Rock
OA2 Treat to 12". 40% Rock
OA3 Level. Treat to 12". 5% Rock
OA4 Treat to 6". 50% Rock

Fluvial Deposit Outline
Bank Stabilization Location
15 Depth of mine waste (inches)

Note: Figure not to scale.
Locations and streambank lengths estimated.
All treatment locations will be confirmed and marked prior to initiation of construction.

Physical Characteristics

Area: 1 acres
Average Depth: 15"
Depth Range: 9" to 27"
Fine grained to sandy mine waste over sand and cobble alluvium.
Timbers located on site may be used for bank stabilization.
A large pine tree is located within the deposit.

2006 Data

Arsenic	67.3 mg/kg
Cadmium	21.8 mg/kg
Copper	145 mg/kg
Lead	1270 mg/kg
Manganese	1170 mg/kg
Mercury	0.92 mg/kg
Zinc	2940 mg/kg
pH	3.0
ABA	-141.7 t/1000t

Proposed Treatment

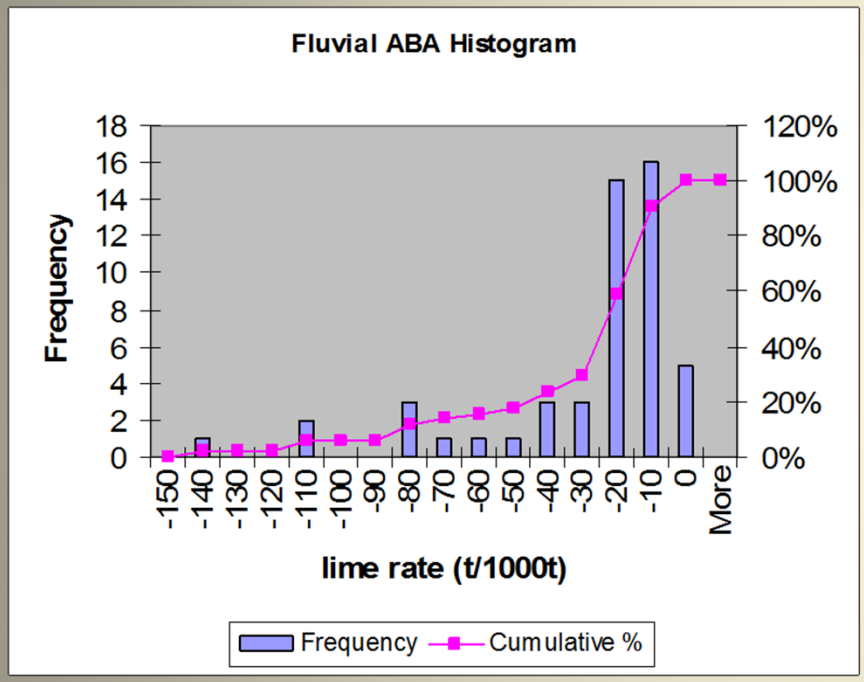
Lime amendment rate: 150 tons/dry ton soil
Organic amendment rate: Default
Fertilizer rate: Default
Till Depth: 9" to 27"
Till Equipment: Deep till rotary mixer.
Seed Mix: Fluvial Deposit Seed Mix
Notes: Save healthy willows throughout site and grassy vegetation adjacent to tributary. Do not disturb vigorous willows located near the river bank or the large tree. Do not disturb well vegetated area between deposits OA and OC.

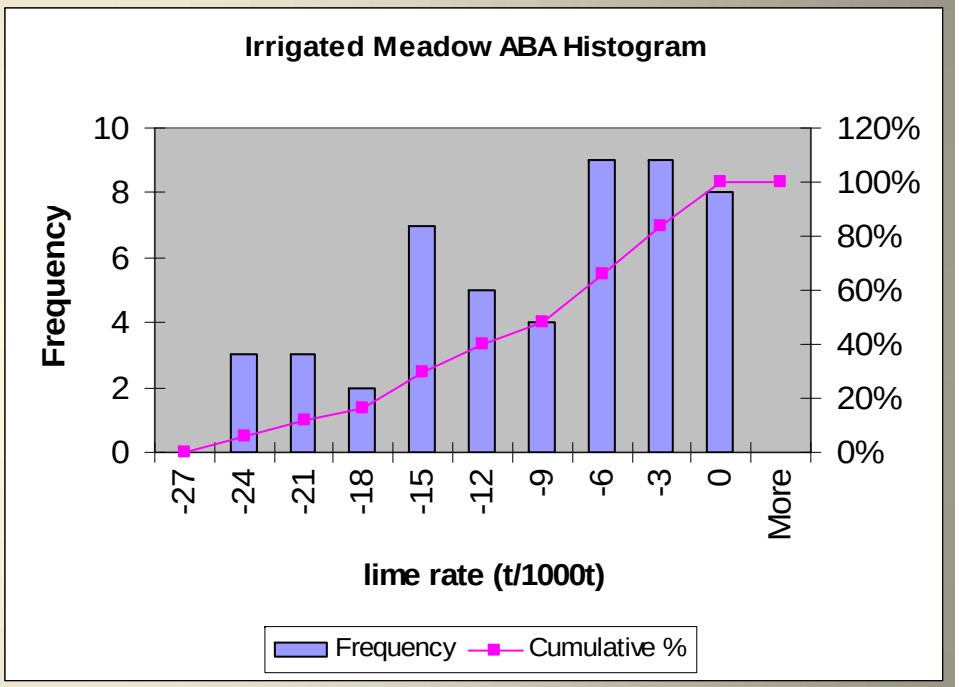
Bank Stabilization

Good grassy and woody vegetation is present between deposits OA and OC, so no stabilization is required.
Limited grassy and woody vegetation is present along an erosive one foot high streambank along the Arkansas River. Type 2 bank stabilization is required.

Lime Amendment Mixing into Fluvial Tailing Deposits

Lime Requirement for Soil Treatment





national ground water association

Remediation of Abandoned Mine Lands

Friday, October 3, 2008 : 2:40 p.m.

Lime Amendment of Contaminated Soil and Acid-Producing Fluvial Tailing Deposits along the Upper Arkansas River, Colorado

Stuart R. Jennings, Reclamation Resaerch Group LLC

Sugar Beet Lime

13,000 tons used for project


730

Compost Amendment

28,000 tons used for project (45,000 cy)

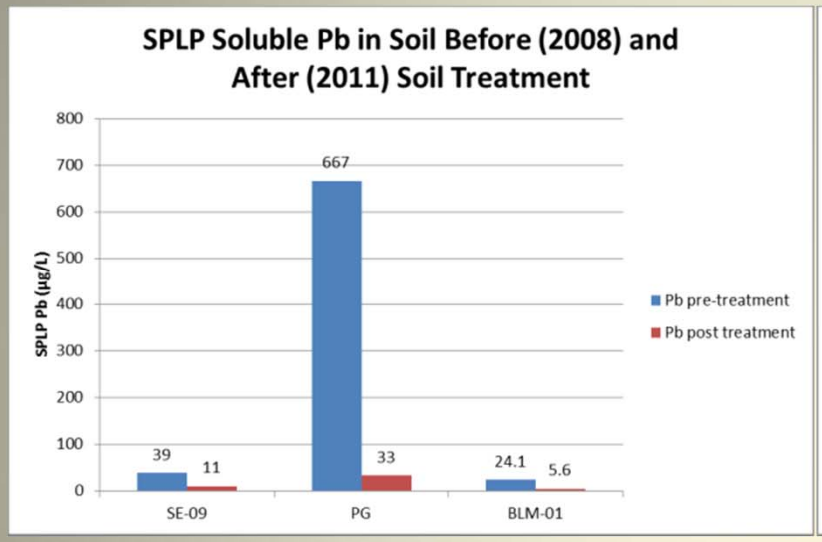
RESULTS

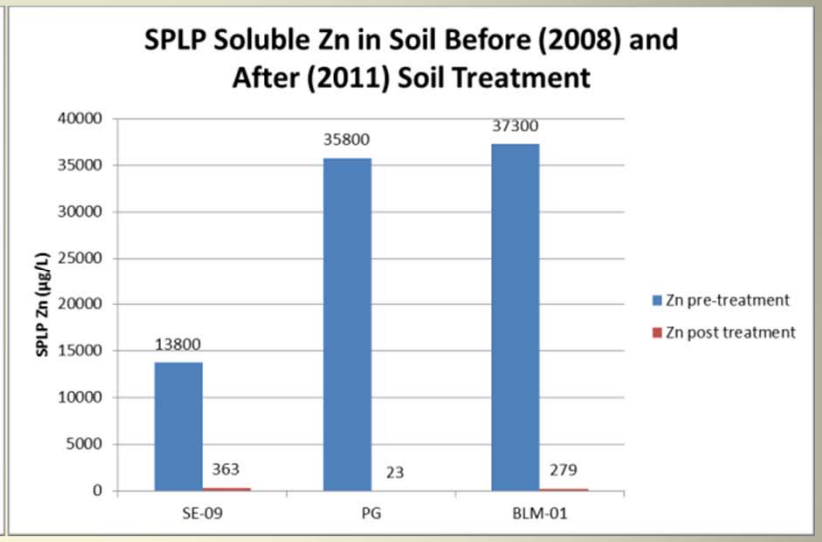
Soil Total Metal Levels (2011) Post-Treatment

	Ca	Mg	Al	Fe	Mn	Cu	Cd	Pb	Zn
	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Irrigated Meadows-North 1	**22,200**	**3,300**	**10,700**	**21,000**	**1,250**	**105**	**21**	**2,000**	**2,350**
Irrigated Meadows-North 2	**25,500**	**4,060**	**7,230**	**34,500**	**2,390**	**210**	**27**	**8,460**	**6,470**
Irrigated Meadows-South	**11,200**	**3,440**	**8,400**	**16,400**	**996**	**58**	**14**	**1,090**	**1,675**
Fluvial Deposits	**36,800**	**4,780**	**6040**	**30,200**	**825**	**158**	**18**	**2,300**	**2,490**

Elevate metal levels and essentially unchanged from pre-treatment

Changes in SPLP Soluble Metal Levels Before and After Treatment





Post-Treatment Comparisons between Totals and Water Soluble levels	Pb	Zn
Water soluble as a percent of total	0.022%	0.065%
Total as a factor of soluble	4588X	1543X

Soil Conditions

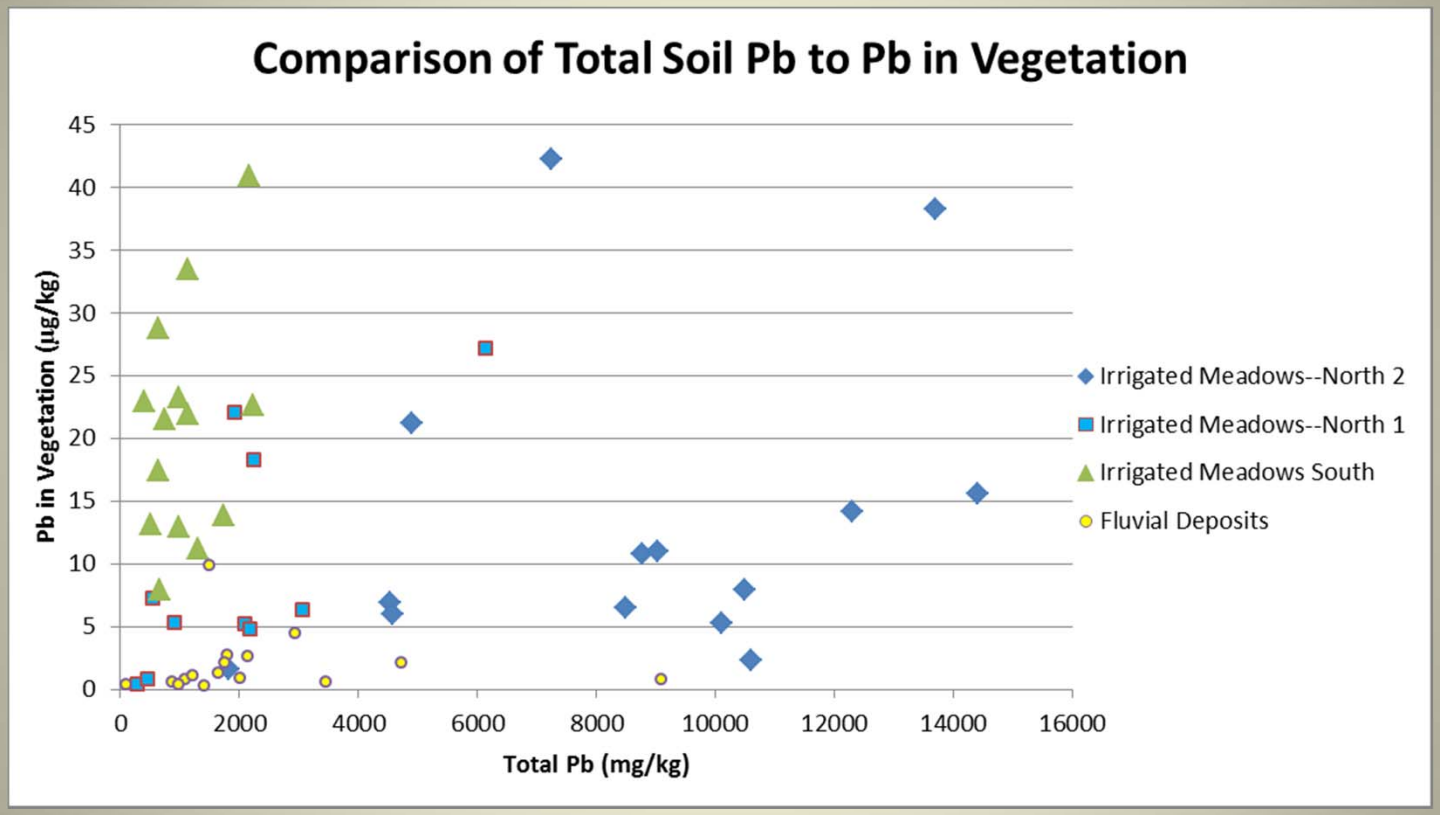
Soil pH and Electrical Conductivity

- Acidic prior to treatment
- Neutral to slightly alkaline following lime addition (7-8)
- Soil solution dominated by metals prior to treatment
- Soil solution dominated by alkaline cations and nutrients following treatment

Soil Organic Matter and Fertility

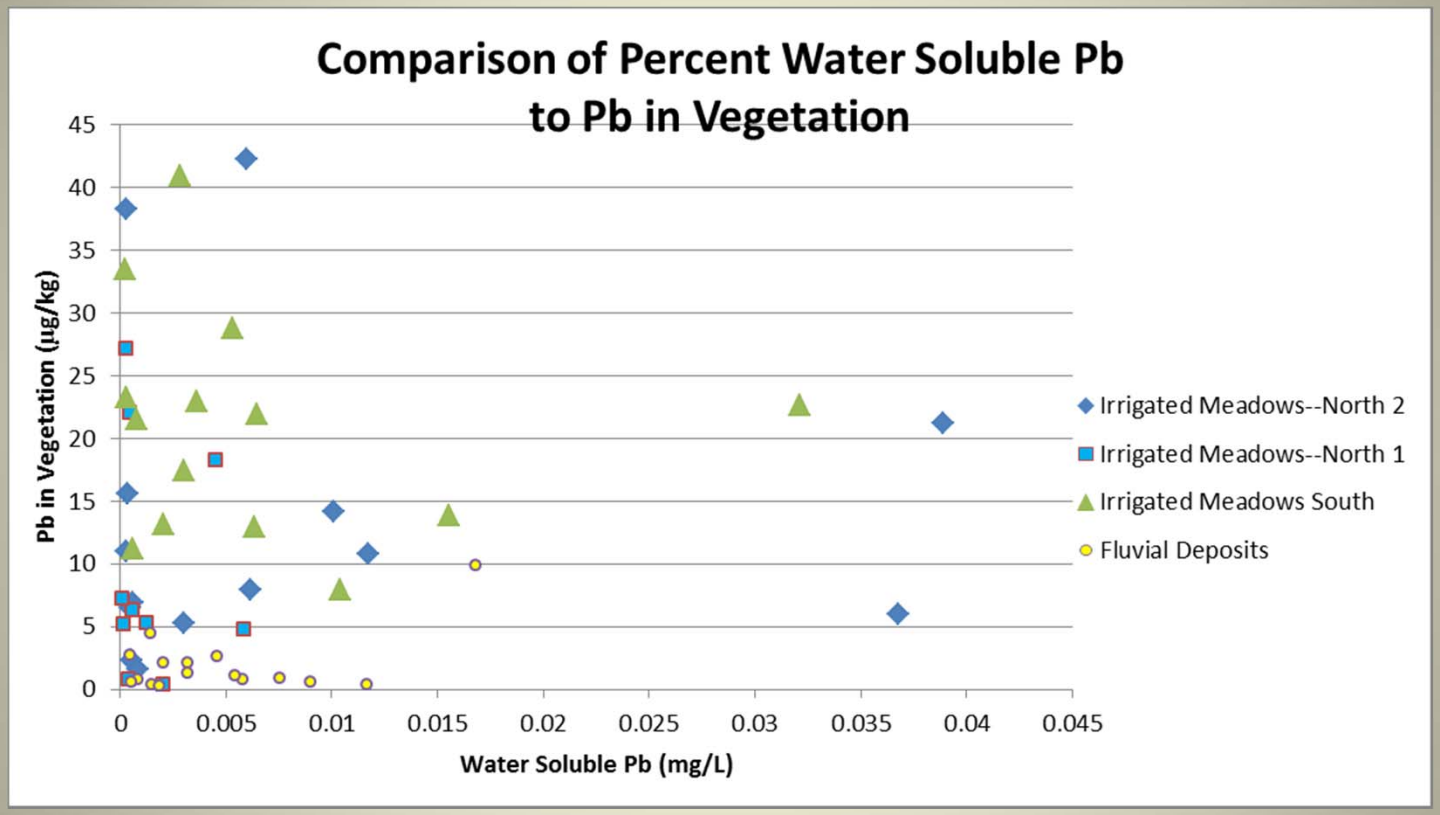
- Prior to treatment organic matter varied widely from near zero (bare areas) to adequate (sparse areas)
- Prior to treatment plant macronutrients N/P/K were deficient in nearly all barren/sparsely vegetated areas
- Following treatment adequate to abundant fertility levels were observed

Lead levels in Vegetation



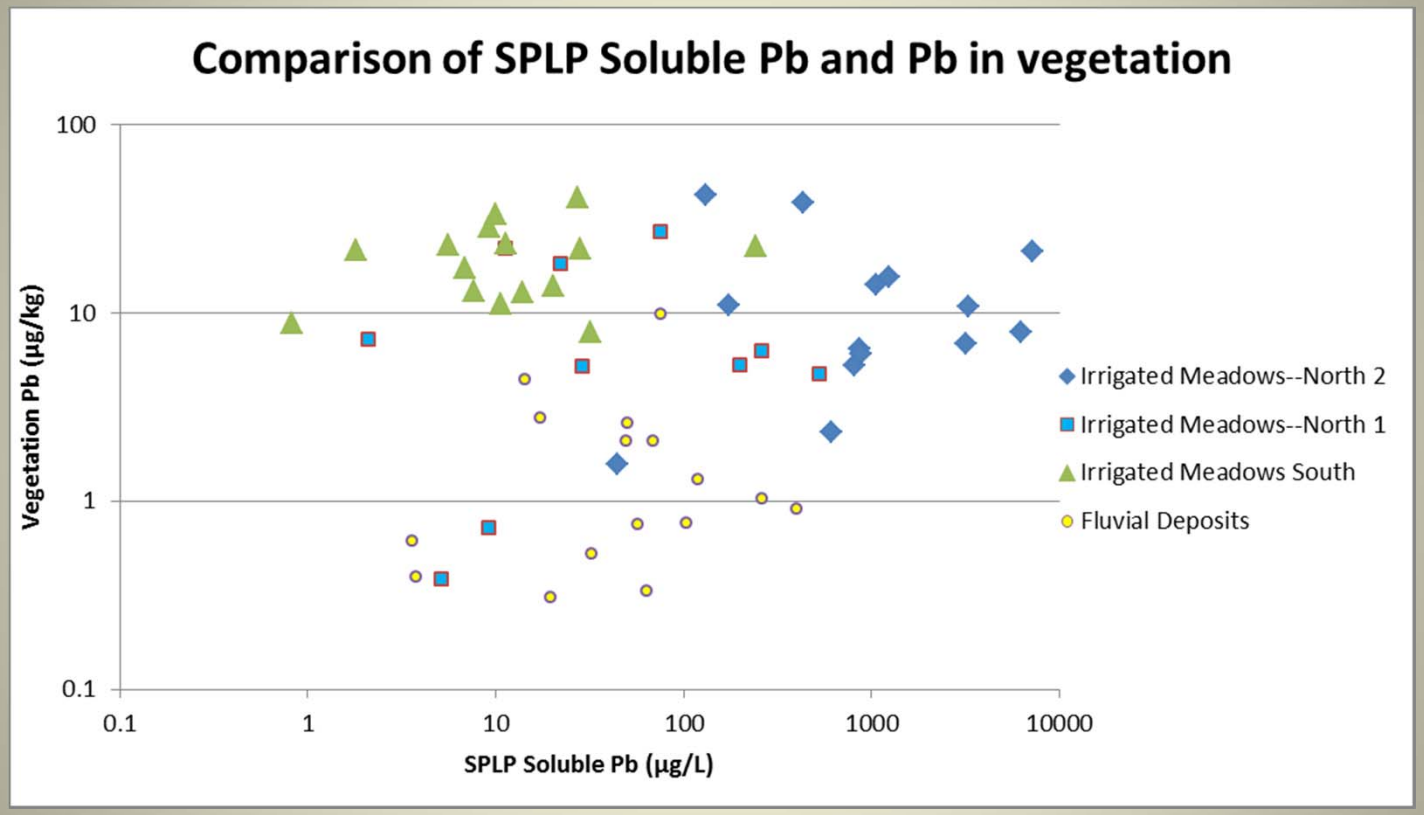
The amount of Pb in vegetation appears unrelated to total Pb in soil. Differences are apparent by site.

Lead levels in Vegetation



Water soluble Pb also appears to be a poor predictor of Pb in vegetation.

Lead levels in Vegetation



SPLP soluble Pb appears to provide good discrimination of Pb in vegetation by site location

2011 Vegetation Monitoring

Fluvial Deposit QF

Irrigated Meadow SM-06

Total Metal Levels (mg/kg)		
	Pb	Zn
QF	988	1310
SM-06	4900	5060

June 2009

July 2009

Fluvial Deposit QF

November 2009

July 2010

October 2010

PWT
PACIFIC WESTERN TECHNOLOGIES, LTD.

On-going Maintenance

Streambank Repairs due to High Flow in 2011

Reseeding Bare Spots caused by Excess Salinity

On-going Management

Grazing Intensity

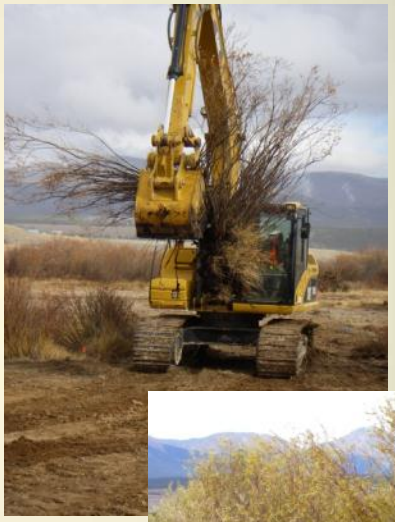
Weed Control

Remediation and Stabilization Using Natural Materials

Remediation and Stabilization Using Natural Materials

Carex

Willows



Soil Treatment and Vegetation Trends—Arkansas River OU 11

Soil Characteristic	Pre-Treatment	Post-Treatment
Total Metals	Elevated	Elevated
Soluble Metals	Elevated	Reduced
Soil pH	Acidic	Neutral/alkaline
Soil Fertility	Low	High
Soil Organic Matter	Low	High
Biological Function	Low	High
Erosion	High	Low

Vegetation Characteristics	Pre-treatment	Post-treatment*
Vegetation Cover	Bare-Sparse	Moderate-Heavy
Plant Production	Very Low	Low-Heavy
Metals in Vegetation	Elevated	Low-Moderate
Typical Species	Weedy/Low-value forage	Non-weedy/High-value forage
Utility for Grazing	Low	High

10 year old treated tailings

Livestock grazing remediated land

Questions/Discussion

EPA United States Environmental Protection Agency

URS

Colorado Department of Public Health and Environment

PWT PACIFIC WESTERN TECHNOLOGIES, LTD.

E2 Consulting Engineers, Inc.

Frontier Environmental Services, Inc.

RECLAMATION RESEARCH GROUP

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