A Permeable Cap for a Mercury Waste Repository in Serpentine Soil

Optimized and Sustainable Remediation of Abandoned Mercury Mines in California

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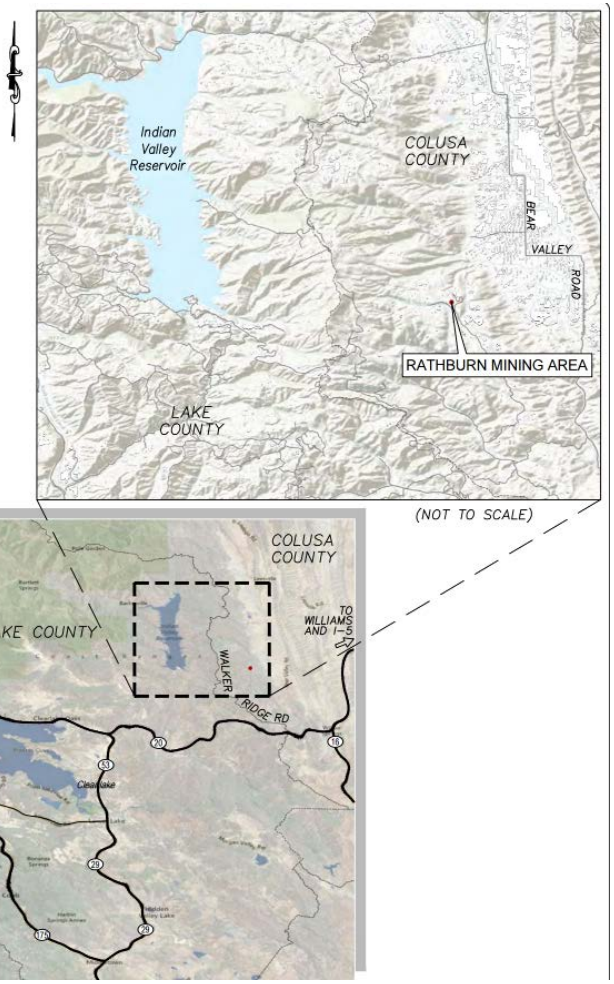
ECM Consultants

Introduction

- There are believed to be more than 2,000 uninvestigated mercury mines in California- practical, reliable solutions are paramount
- This work involved stabilization and capping of 33,000 CCY of mercury contaminated soil from two mines on BLM land
- Novel permeable cap that saved BLM over $1M relative to anticipated costs
- Located in Colusa County in the Sulphur Creek Mining District



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The Challenge

Mercury over 800 mg/kg in soil at two former open-pit mercury mines (Rathburn North & Rathburn South)

- Largest producers of mercury in the Sulphur Creek Mining District
- 100 flasks (7,600 lbs) of mercury produced
- Large waste rock dumps generated

Removal Action Objectives under CERCLA are to prevent or reduce:

- Human & ecological exposure
- Migration of mercury due to surface runoff, erosion, and leaching

EE/CA Selected Alternative

Onsite Consolidation, In-Place Stabilization and Capping

Innovative Alternative

Impermeable cap limitations: cost, maintenance, sustainability

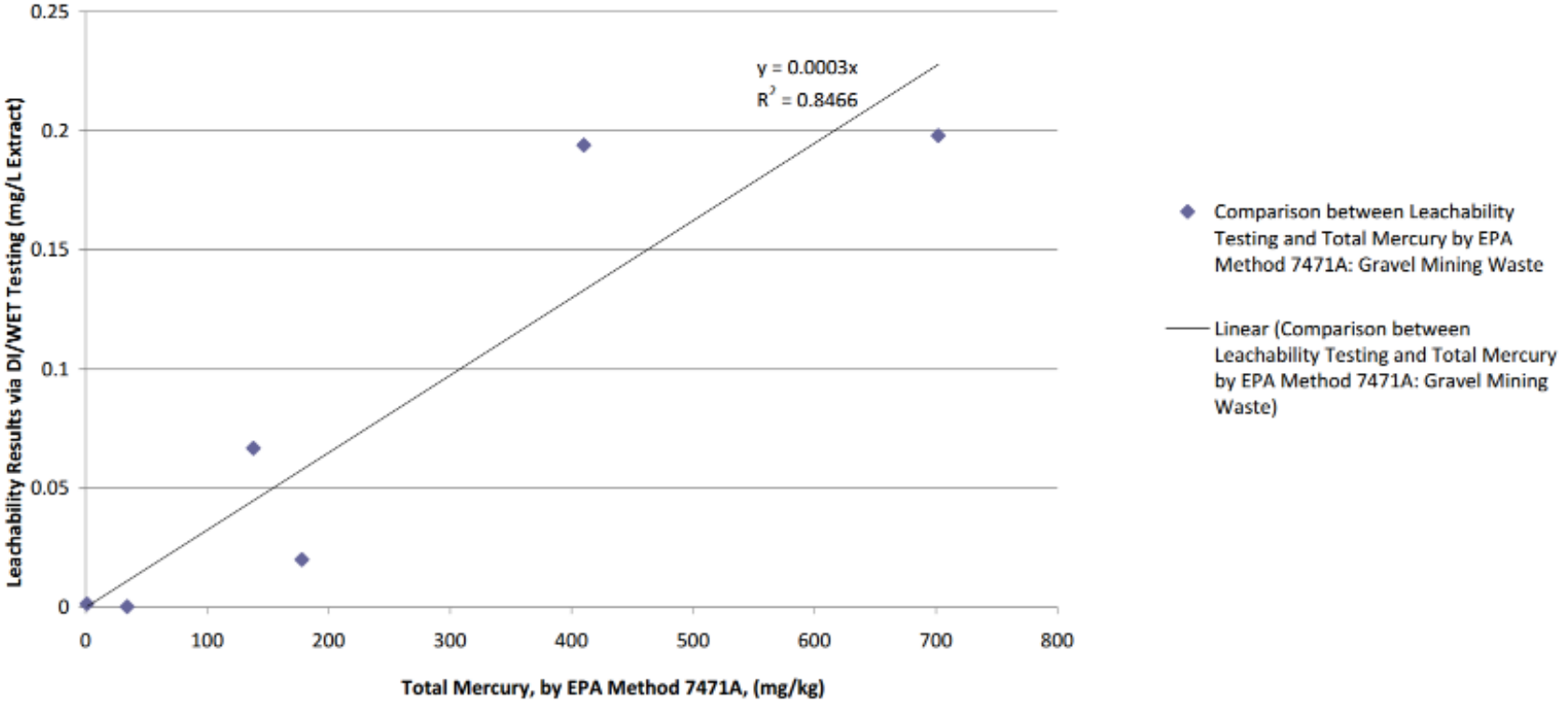
Permeable cap with leachate collection limitations: cost, operation and maintenance, leachate disposal and sustainability

Is there a technical basis for a permeable cap without leachate collection?

Mercury Leaching an Issue?

- Acid-Base Accounting indicated neutralization potential is well over 3X the acid generating potential
- Highest deionized Waste Extraction Test (similar to SPLP outside Calif) yielded 0.198 mg/L
- STLC for mercury is 0.2 mg/L, so worst case is below that
- Worst case, DAF = 100 is enough to attenuate leaching mercury to MCLs

Comparison between Leachability Testing and Total Mercury
EPA Method 7471A: Gravel Mining Waste



Does Groundwater Confirm?

Installed and sampled six groundwater wells:

- One upgradient of both mines
- One downgradient of each mine
- Shallowest groundwater encountered at 33 ft bgs
- All wells contained mercury below the California MCL of 2 µg/L

Ground Water Test Results				
Sample Location	**Date**	**Total Hg (µg/L)**	**Filtered (F) Hg (µg/L)**	**Turbidity (NTU)**
RB	**6/11/2010**	1.7	<0.20	70
RS-ALT	**6/11/2010**	<0.20	<0.20	13
RN-ALT	**6/17/2010**	<0.20	<0.20	>200
PS	**6/17/2010**	<0.20	<0.20	1.6
PS DUP	**6/17/2010**	<0.20	<0.20	1.6
EB061610	**6/17/2010**	<0.20		
PB	**6/17/2010**	<0.20	<0.20	6.6
PN	**6/17/2010**	0.46	<0.20	>200
California MCL		**2**	**2**	**NE**

Making the Case

- California Water Board agreed this is Group C mining waste with no bottom liner needed
- This helped optimize the design, since we could eliminate any remedial technologies required to mitigate mercury leaching
- It is also more sustainable since we did not need to acquire geosynthetic materials, transport them, and burn more fuel preparing the site to receive them
- Total cost savings believed to exceed $1 million

Evaluating Borrow Source for CAP

BLM identified two sources meeting gradation requirements:

- Sourced 2 miles and 8 miles away; a long, expensive haul
- These sources were sandstone-based soils
- Double the soil volume would be needed to facilitate revegetation. Even more expensive!

Sandstone and serpentenite layers have differing levels of Ca and Mg making an inconsistent root zone for vegetation:

- Invasive plants can grow in the sandstone soil more easily where Ca levels are higher
- Deeper rooting plants can get started in the high-Ca sandstone, but when their roots encounter the serpentenite soil with high Mg, growth stops
- The plants become weak and can't grow to their full potential
- The invasive species then take over; but the invasive species can't grow in the high Mg serpentenite soil

Serpentenite Challenges

Adjacent serpentenite soil was a shorter haul but it too had disadvantages:

- Frequent rocks exceeding 2 inches (interference with compaction)
- Vulnerable to erosion since its natural vegetation would be sparse and re-establish slowly

The best erosion control is to allow water to infiltrate while vegetation grows back:

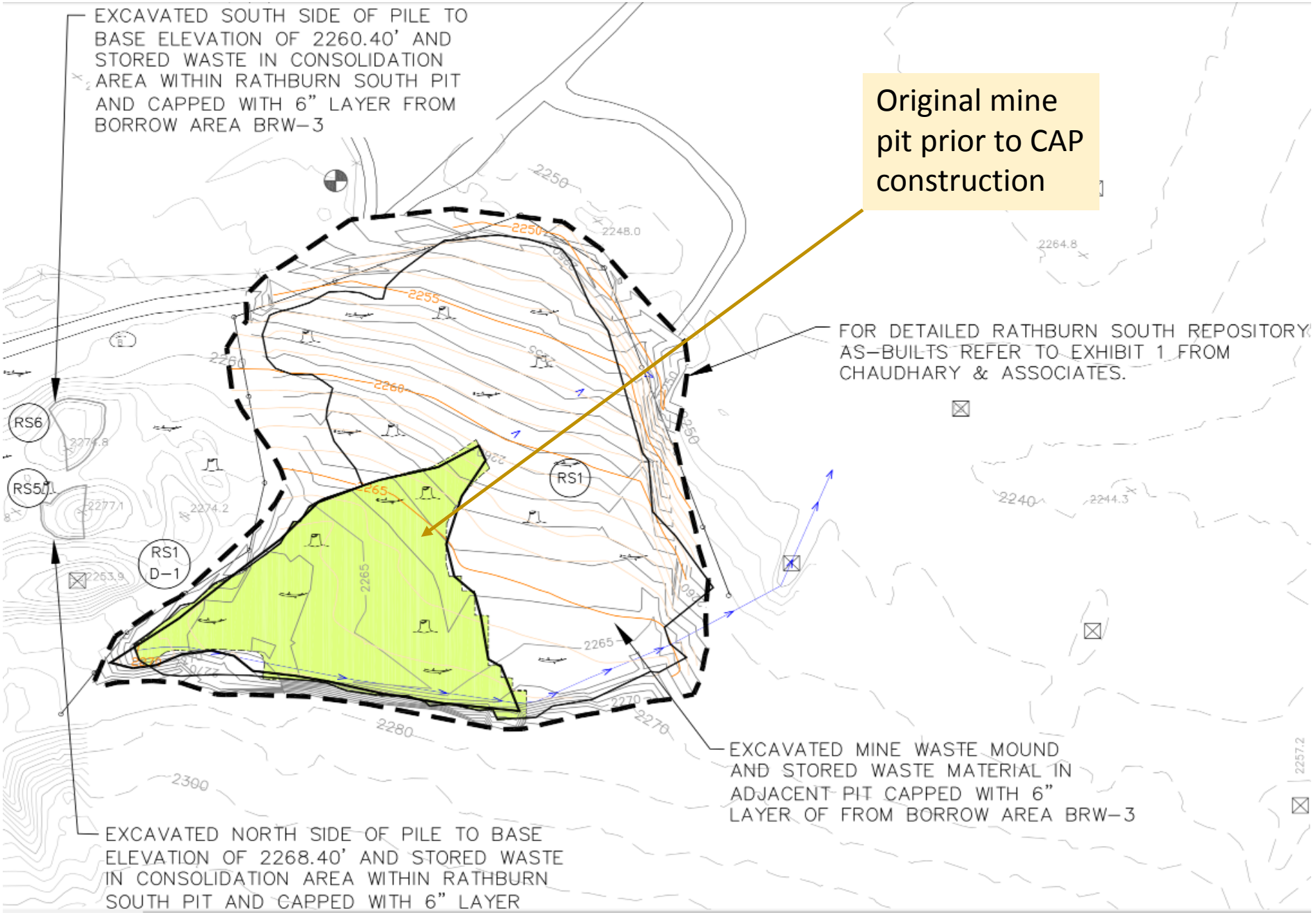
- Not an ordinary landfill cap, infiltration acceptable
- Determined water infiltration will not cause mercury leaching

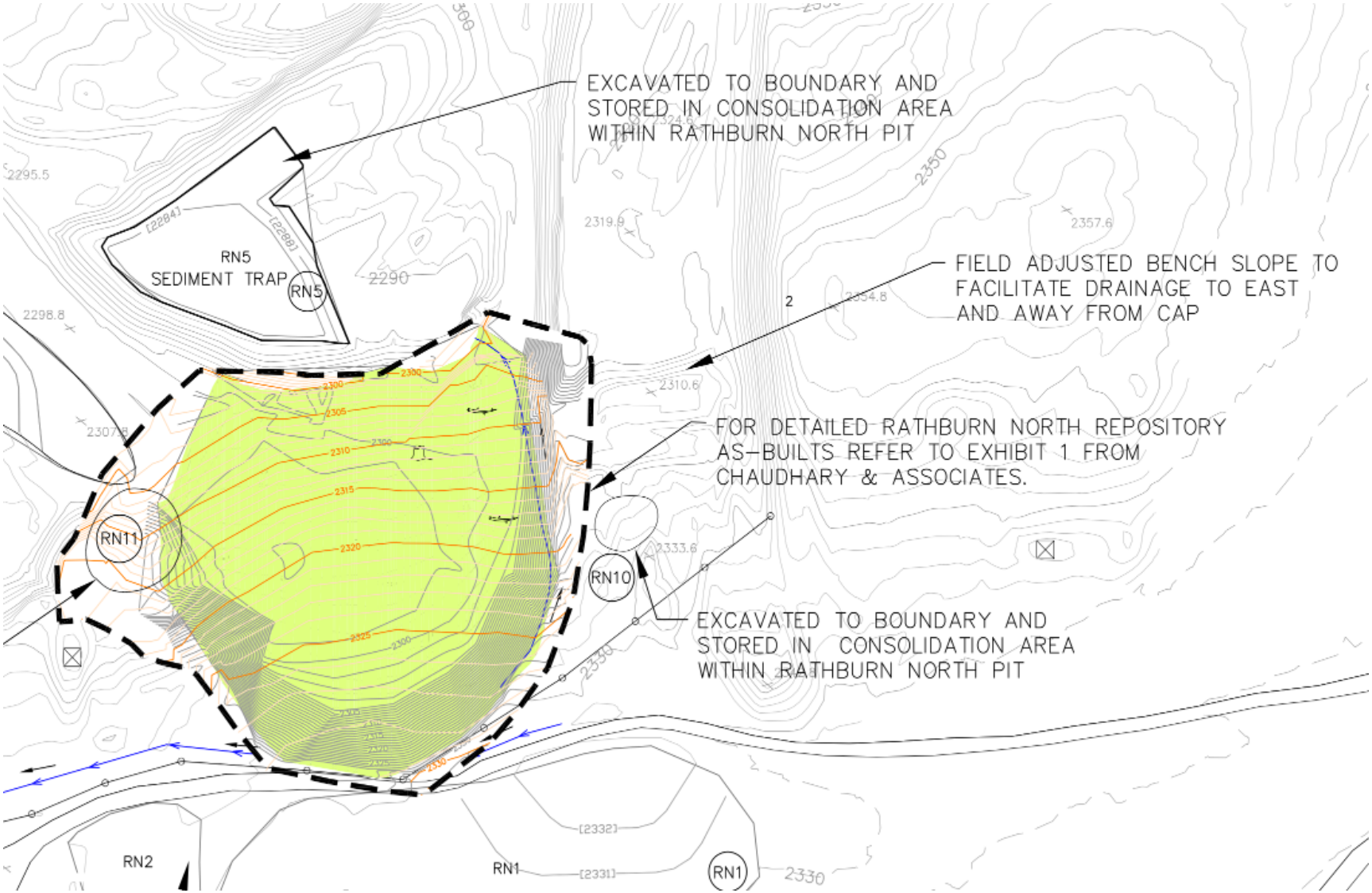
Borrow Source Selection

BLM agreed to use the native serpentenite top soil:

- The rocks aren't a problem because you do not want to compact the top soil anyway
- Native plants can grow in it
- Keep slopes gentle to promote infiltration
- Cover the placed top soil with vegetation slash to promote plant growth
- Cap still achieves all removal action objectives
- Cost savings of $109,000

Excavation & Consolidation


EXCAVATED SOUTH SIDE OF PILE TO BASE ELEVATION OF 2260.40' AND STORED WASTE IN CONSOLIDATION AREA WITHIN RATHBURN SOUTH PIT AND CAPPED WITH 6" LAYER FROM BORROW AREA BRW-3
Original mine pit prior to CAP construction
FOR DETAILED RATHBURN SOUTH REPOSITORY AS-BUILTS REFER TO EXHIBIT 1 FROM CHAUDHARY & ASSOCIATES.
RS6
RS5
RS1
RS1 D-1
EXCAVATED MINE WASTE MOUND AND STORED WASTE MATERIAL IN ADJACENT PIT CAPPED WITH 6" LAYER OF FROM BORROW AREA BRW-3
EXCAVATED NORTH SIDE OF PILE TO BASE ELEVATION OF 2268.40' AND STORED WASTE IN CONSOLIDATION AREA WITHIN RATHBURN SOUTH PIT AND CAPPED WITH 6" LAYER


EXCAVATED TO BOUNDARY AND STORED IN CONSOLIDATION AREA WITHIN RATHBURN NORTH PIT
FIELD ADJUSTED BENCH SLOPE TO FACILITATE DRAINAGE TO EAST AND AWAY FROM CAP
FOR DETAILED RATHBURN NORTH REPOSITORY AS-BUILTS REFER TO EXHIBIT 1 FROM CHAUDHARY & ASSOCIATES.
EXCAVATED TO BOUNDARY AND STORED IN CONSOLIDATION AREA WITHIN RATHBURN NORTH PIT
RN5
SEDIMENT TRAP
RN5
RN11
RN10
RN2
RN1
RN1
2290
2350
2330
2295.5
2298.8
2307.8
2310.6
2319.9
2333.6
2357.6
[2284]
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[2331]

Native Species Application

- Mixture of native seed was selected with consultation with plant fertility specialist Dr. Vic Claassen with UC Davis
- Hand-broadcast at 54 lbs. per acre
- Covered with native slash and wood chips
- Straw wattles placed to control potential runoff
- Seedlings from BLM also planted
  - 132 ceanothus plants
  - 46 McNab cypresses

Chipping

Erosion Control

Seeding

Topsoil Placement

Project Completion

Reclaiming the West

← BEFORE

AFTER →

QUESTIONS?

Cinnabar vein found onsite