BLM/DOJ/EPA INFORMATIONAL EXCHANGE AND COORDINATION MEETING
SEPTEMBER 29, 1988
Main Justice Building, Rm. 2603
9:00 AM

PARTICIPANTS

Name	Agency	Telephone
GREGORY BAKER	EPA REGION 9	(415) 974 8533 FTS 454 8537
TIM ELLIOTT Kris Clark Steve Brown	Interior - SOL 1849 C St. NW. W. DC. 20240	343-4722 343-2293 343-4146
Dave Howell Bernie Hyde	BLM 18th & C St. Main Interior	343-4846 343-5517
AL JAHNS	DOI/SOL/SACTO	460-4831
Eydie Piner	EPA/HQ	475-9759
Jennifer Decker	EPA/Region IX	(415) 974-8161
Ivy Main	EPA - OGC	382-7703
Chip Landman	EPA - FED FAC	382-2035
CHRIS GRUNDLER	EPA - FED FAC COMPLIANCE OFFICE	475-9801
J. STEVEN ROGERS	DOJ - EAS	633-4548
John D. Rothman	EPA R9 ORC	454-7453 (FTS)
Peggy Strand	DOJ - EDS	633-2219
Linda Southerland	EPA - Fed Fac	475-9808
Walker Smith	DOJ - EES	633-2639
GARY Fisher	DOJ - EES	633-4485

U.S. DEPARTMENT OF JUSTICE
LAND AND NATURAL RESOURCE DIVISION
ENVIRONMENTAL DEFENSE SECTION
WASHINGTON, D.C. 20530
FAX # (202/FTS) 633-2584 AUTOMATIC
VOICE CONFIRMATION # (202) 633-2872

FACSIMILE COVER SHEET

TO: KRIS CLARK, SOLICITOR'S OFFICE
Phone 343 5372

FROM: J. STEVEN ROGERS

DATE: 9/28/88

NUMBER OF PAGES: 3 (Including cover sheet)

DESTINATION'S FAX #: ______

DESTINATION'S VOICE COORDINATION #: ______

KRIS - Please distribute copies to your people. Thanks -
JSR

Memorandum

Subject	Date
Atlas Asbestos: BLM/DOJ/EPA Meeting: September 29, 1988 9:00 AM, Rm. 2603 Main Justice	September 28, 1988

To	From
All Participants	J. Steven Rogers Environmental Defense Section

Attached is the agenda for the meeting, which incorporates all comments received.

BLM/DOJ/EPA INFORMATIONAL EXCHANGE AND COORDINATION MEETING
SEPTEMBER 29, 1988
Main Justice Building, Rm. 2603
9:00 AM

AGENDA

I. Introductions

II. Atlas Asbestos Site: BLM Perspective:
DH Historical Overview and geographical description; slides maps. Scope of the Site and the problems; Relationship of Atlas site to the Resource Management Area and regional contamination problems; DH BLM actions to date and BH proposals for future action/coordination;

III. Atlas Asbestos Site: EPA Perspective:
Historical Overview; Basis for NPL listing; Scope of the site and the problems; Relationship of Atlas site to the Resource Management Area and regional contamination problems; Review/Status of the RI and the FS; Scope and nature of proposed remedies; EPA response actions to date and proposals for future action/coordination;

Am I correct
Can you describe
can you clarify.

IV. Atlas Asbestos Site: Discussion of future actions and coordination;

V. Discussion of appropriate mechanism to ensure early notification/involvement of federal agencies in EPA response actions where there is potential federal generator liability or natural resources issues.

VI. BLM Federal Facilities update

what is percent of reduction from from mines in Los Gatos basin? but is reduction
Reductions have to be major/massive ~~reduction~~ to reduce rate.

Actions to Date:
~~Ba~~ Provided full comments since 1984
RAWP for safety.

Proposals for future act (BLM) - difficult to Plan lacking RI, Risk Assessment, Prelim Alts., FS.
Restrict site access / signing (i.e.) 27 vehicle routes
Road work - fence berm - other if necessary
Stabilization if necessary
diversion if necessary.
Patrols.
Studies of other needs · rveg/rehab

Action at Joe Mine

Other proposal
Strikes me as ~~a~~ nonpoint source problem in 4 basins rather than a CERCLA problem though difficult to tell w/o any info from EPA.

If basin is to be addressed ~~the~~ point source system to collect & remove major flow and source control where cost effective, is the approach that seems most appropriate. If four basins it will be more difficult and expensive. We certainly want to do our share to control the problems at Atlas - our share of the real problem. ~~Perhaps some sharing of cost at a common removal facility would be approp - on Los Gatos Creek~~

On site of mine we need to review proposals appropriate to mines contrib to problem and find a cost effective approach - Need to find out who will handle private land - (protection from mine party suits)

our needs: RI - FS Alternatives - FS - Assurance of full PRP search - Partnership on future efforts

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

SEP 26 1988

OFFICE OF
SOLID WASTE AND EMERGENCY RESPONSE

MEMORANDUM

SUBJECT: Atlas Mine Site Meeting Scheduled For September 29, 1988

FROM: Christopher Grundler, Director
Federal Facilities Hazardous Waste Compliance Office

TO: Addressees

In preparation for our meeting on September 29, 1988, I would like to review the bidding and the topics to be addressed, as well as propose an agenda for the meeting. In order to have a productive meeting, I want to make sure that we begin the meeting with a common understanding of the issues to be addressed and the objectives for the meeting.

EPA is currently performing a fund lead RI/FS at the Atlas Asbestos Mine site located near Coalinga, California. The site is located on land owned partly by mining claimants and partly by the Bureau of Land Management (BLM). The Atlas site is located in a large resource management area, owned largely by BLM, which contains large quantities of asbestos. Some of the asbestos problem in the resource management area results from the naturally occurring raw asbestos; some of the problem is the result of asbestos mining and milling operations which have disturbed the natural asbestos. (proportions?)

On August 26, 1988, EPA Headquarters personnel met with BLM attorneys and attorneys from both the Enforcement and Defense Sections of the Department of Justice's Lands and Natural Resources Division. All present agreed that there is a problem in the resource management area resulting from asbestos. All present agreed that BLM has the primary responsibility for taking any necessary remedial action on its lands pursuant to Section 120 of CERCLA.

At the August 26th meeting BLM indicated that they would like to explore with EPA the possibility of participating in a response to the larger asbestos situation within the resource management area in which the Atlas site is located. BLM and EPA agreed that we should be working together to develop a coordinated strategy to address the problems at Atlas and the resource management area.

We agreed to meet on September 29th to discuss the work to be done, both at the Atlas site and the larger resource management area. The Department of Justice attorneys offered to host such a meeting. Accordingly, a meeting has been scheduled for September 29, 1988, for the purpose of establishing a strategy and an agenda for action at Atlas and the larger resource management area.

EPA's objectives for this meeting are to: 1) establish BLM's commitment to work with EPA to address the asbestos problem in the resource management area, including the Atlas site; 2) develop a strategy and schedule for addressing the resource management area, including the Atlas site; 3) coordinate EPA and BLM activities to minimize duplication of efforts; 4) expedite cleanup of the resource management area, including the Atlas site; 5) develop a strategy whereby EPA can support BLM in any necessary request by BLM for funding to address the resource management area, including the Atlas site.

PROPOSED MEETING AGENDA

Following introductions, EPA's Region IX will provide a brief historical overview, covering the discovery of contamination at the site, and the events leading to NPL listing. Region IX will then discuss the environmental problems at the NPL site, review the RI and FS for Atlas as well as EPA's plans with respect to the asbestos problem within the resource management area.

Following Region IX's presentation, a representative of BLM could then describe the regional situation, the history of asbestos mining in the area, and discuss any actions BLM has taken to address the contamination.

These briefings should provide the basis for discussion of the action to be taken at the Atlas site and within the larger resource management area.

Please let me know if you have any questions or any comments or suggestions on the proposed agenda. I can be reached by telephone at 475-9801.

Addressees:

BLM: Bernard Hyde
Kristina Clarke
Steve Brown

DOJ: Nancy Firestone
Walker Smith
Gary Fisher
J. Steven Rogers

EPA: Jon Wactor
Jenny Decker
Ivy Main
Eydie Pines

ATLAS SITE CLOSURE

WHITE CREEK ROAD FENCE/BERM
CONSTRUCTION (4,820 FEET)

* 4' HIGH FENCE
* 8' BERM
* 3 GATES

WHITE CREEK ROAD SIGNS

* 4 SIGNS

PERIMETER BARRIERS

* 4 PIPE BARRIERS
* 23 FENCE BARRIERS

PERIMETER SIGNS

*120 SIGNS

PATROLS

* WEEKLY SINCE NOVEMBER 87

PLANNED ACTIONS FY -89

PATROL

SIGN - FENCE MAINTENANCE

CATCHMENT SITE EVALUATION

STREAM DIVERSION CONTRACT PREPARATION

SLOPE STABILIZATION CONTRACT PREPARATION

REVEGETATION STUDY

HAZARD REDUCTION - UNSTABLE SLOPE ABOVE
SETTLING POND

WHITE CREEK ROAD RENOVATION

KING CITY ASBESTOS COMPANY

JOE PIT MINE

PLAN OF OPERATION REVISION

* SITE CLOSURE
* LONG-TERM STABILIZATION/ REVEGETATION
* AIR/WATER QUALITY MONITORING
* REVEGETATION STUDY
* DUE - 07/05/88

BOND

* $1,000,000.00 INTERIM BOND
* DUE - 06/09/88
* FINAL BOND - $ BASED ON RECLAMATION COST

FAILURE TO OBTAIN BOND/COMPLETE PLAN

* NOTICE OF NONCOMPLIANCE
* ORDER TO CEASE OPERATIONS

ATLAS AND COALINGA
PRP MAILING LIST

PRPs	LOCATION
o Asbury Transportation Co. 1635 East Denni Street Wilmington, California 90744 (213)775-2904 Mr. Al Eyrand, President	Atlas & Coalinga Warehouses
o Atlas Minerals 353 Nassau Road Princeton, New Jersey 08540 (609)921-2000 Mr. Weavers, President Send inquiries/notices to: 743 Horizon Court, Suite 202 Grand Junction, CO 81506 (303)243-5800 Mr. Richard Blubaugh Regulatory Affairs Manager	Atlas Mines and Mills
o Bureau of Land Management California State Office 2800 Cottage Way Sacramento, California 95825 (916)978-4720 Mr. Richard Johnson Deputy State Director of Resources	Atlas Mines and Mills

PRPs (Continued)	LOCATION (Continued)
o California Minerals Corporation c/o Bridges and Bridges Law Offices 2975 Wilshire Boulevard Los Angeles, California 90010 (213)382-2291 Mr. Claude Bridges, Attorney	Atlas Mines, Mill and Warehouse
o Mr. Robert Hampton 1175 West Elm Avenue Coalinga, California 93210 (209)935-1316 Send inquiries/notices to: P.O. Box 104 Taft, California 93268	Atlas and Coalinga Warehouses
o Interstate Towing Services 1175 West Elm Avenue Coalinga, California 93210 (209)935-2126 Send inquiries/notices to: Mr. Lee Quick, Owner P.O. Box 708 Coalinga, CA 93210	Atlas and Coalinga Warehouses
o Mr. John Johns 210 West Glenn Avenue Coalinga, California 93210 (209)935-1838 Mr. John Johns, Property Owner	Atlas Warehouse

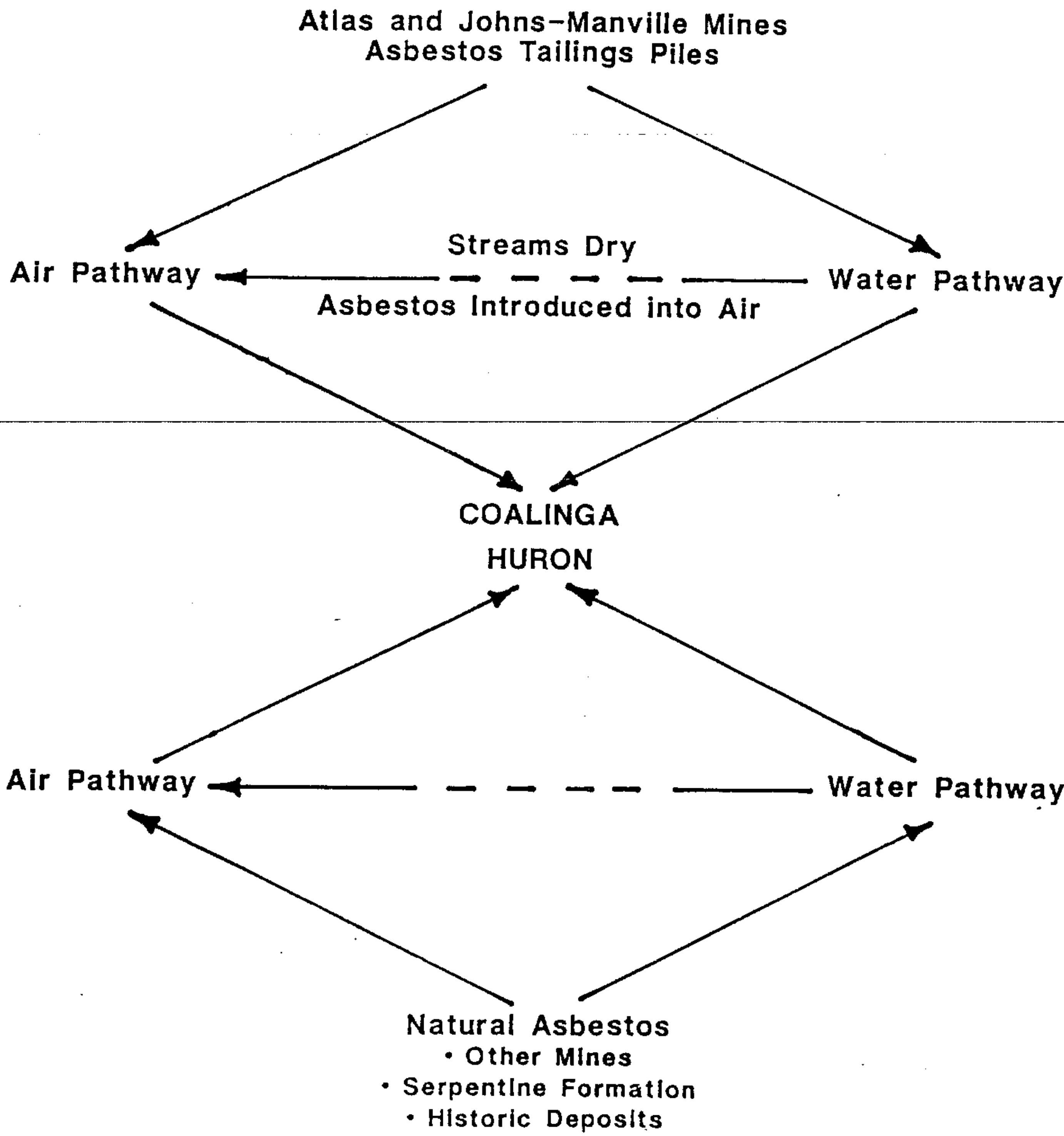
PRPs (Continued)	LOCATION (Continued)
o Manville Sales Corporation 12999 Deer Creek Canyon Road Littleton, CO 80127-5146 (303)978-2000 Mr. Richard B. Von Wald Senior Vice President and Legal Counsel Send inquiries/notices to: P.O. Box 5108 Denver, CO 80217-5108 (303)978-3125 Mr. David Noyes Manager, Environmental Regulations	Coalinga Mine, Mill and Warehouse
o Kern County Land Co. c/o Tenneco West 10000 Ming Avenue Bakersfield, California 93311 (805)835-6060 Mr. Wayne Broome Send inquiries/notices to: Tenneco West P.O. Box 9380 Bakersfield, California 93389 (805)835-6016 David Stanton Sr. Vice President and General Counsel	Coalinga Mine, Mill and Warehouse
o Marmac Resources Company 5143 Sunset Boulevard Los Angeles, California 90027 (213)666-1916 Mr. Earl Chambers, President	Coalinga Mine, Mill and Warehouse

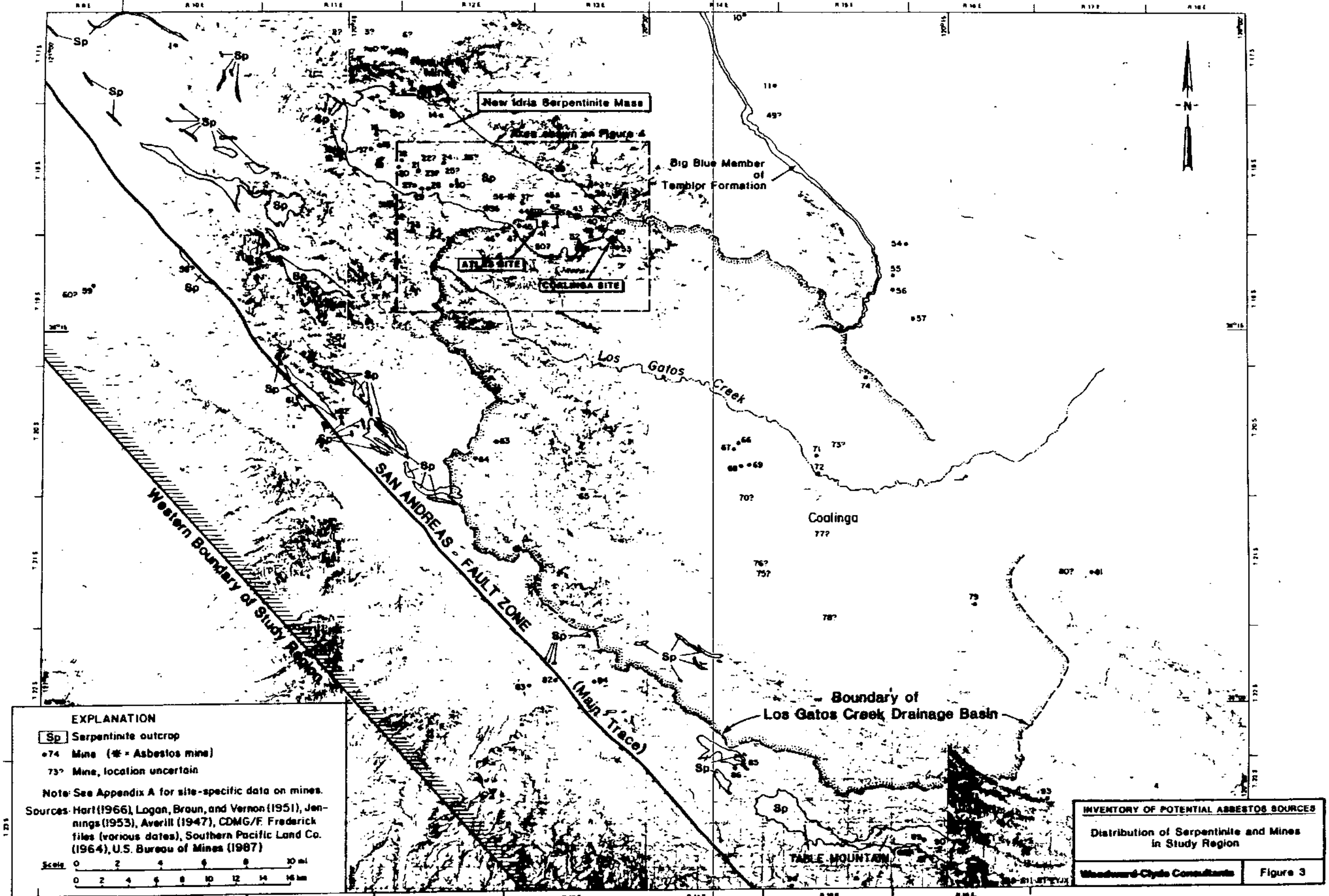
PRPs (Continued)	LOCATION (Continued)
o Mr. Philip Martin Cantua Ranch P.O. Box 88 Three Rocks, California 93608 (209)829-6269	Coalinga Mine
o Santa Fe Energy Company 12070 Telegraph Rd. Santa Fe Springs, CA 90670 (213)944-0311 Joseph Cerullo, Attorney	
o Santa Fe Pacific Realty Corporation 250 S. Rock Blvd., Suite 100 Reno, Nevada 89502 (702)329-9144 Mr. Ted Fitzpatrick Send inquiries/notices to: c/o McCutchen, Doyle, Brown & Enersen 3 Embarcadero Center San Francisco, CA 94111 (415)393-2000 Mr. Edward Strohbehn, Jr.	Coalinga Mill
o Southern Pacific Land Co. 3 Embarcadero Center San Francisco, California 94111 (415)393-2000 Mr. Edward Strohbehn, Esquire	Coalinga Mill

PRPs (Continued)	LOCATION (Continued)
o Southern Pacific Transportation Company Southern Pacific Building One Market Plaza San Francisco, California 94105 (415)541-1769 Mr. David W. Long, Attorney	Atlas and Coalinga Warehouses
o Mr. Charles Squire 2031 North Brighton Burbank, California 91504 (818)845-9685	Atlas and Coalinga Warehouses
o Union Carbide Corporation 39 Old Ridgebury Road Danbury, CT 06817 (203)794-6584 Mr. Richard Tisch Environmental Counsel	Atlas and Coalinga Mines
o Vinnell Mining and Minerals Corporation 10530 Rosenhaven Fairfax, Virginia 22030 (703)385-4544 Mr. Edward Heine, President <u>Send inquiries/notices to:</u> c/o Schell & Delamer Law Offices Wilshire Square II, Suite 500 3333 Wilshire Blvd. P.O. Box 76954 Los Angeles, California 90010 (213)385-8182 Mr. Kenneth Prindle, Attorney	Atlas Mines, Mill and Warehouse

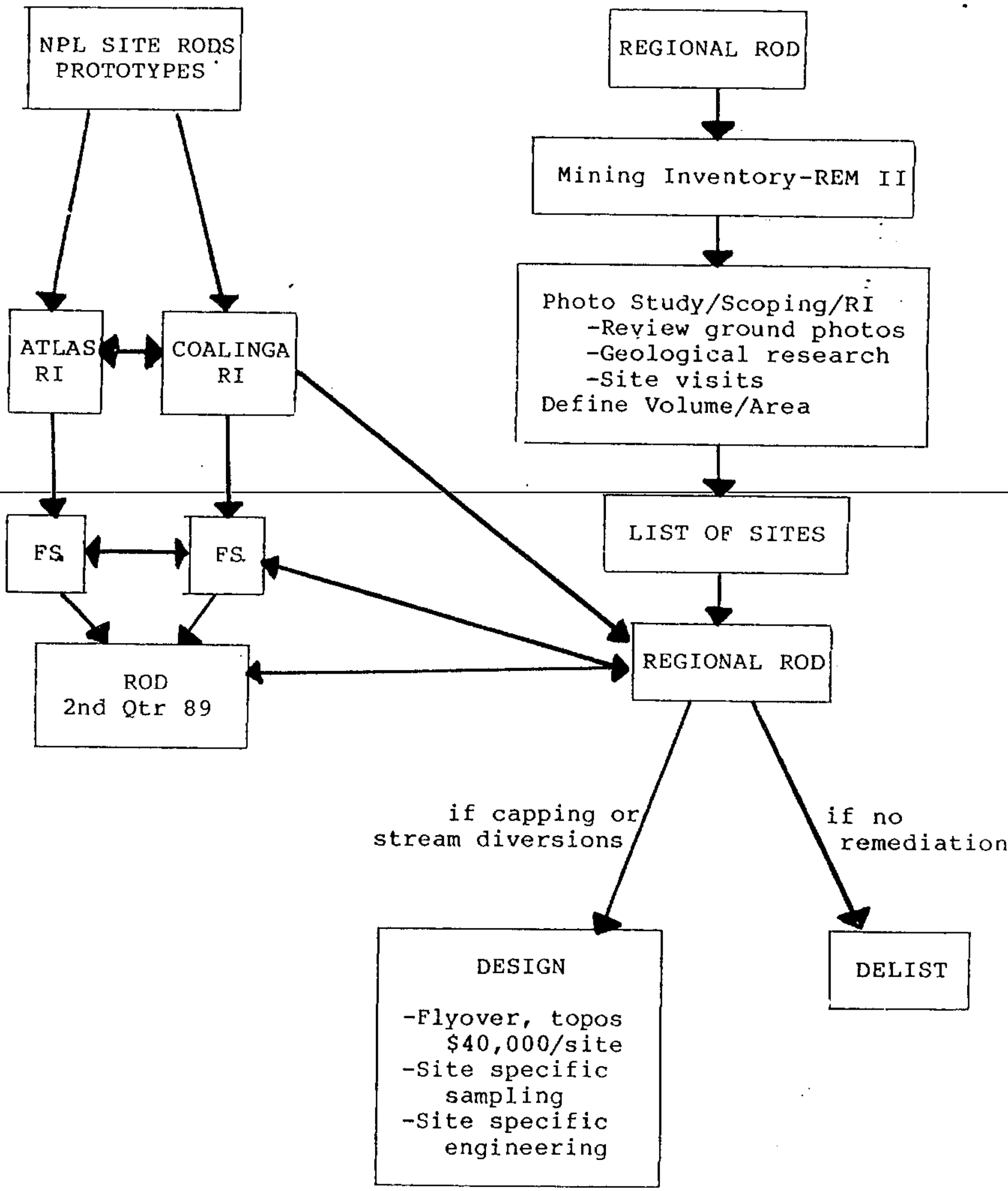
PRPs (Continued)	LOCATION (Continued)
o Westside Trucking Company 1508 Coalinga Avenue Coalinga, California 93210 (209)935-1339 Mr. Lowell Baker, Owner	Atlas Mill and Warehouse
o Wheeler Properties, Inc. 2300 Dickerson Rd. Reno, Nevada 89503-4867 (702)323-6800 Send inquiries/notices to: Ms. Dorothy Bunce, Attorney 311 E.Liberty Reno, Nevada 89501	Atlas Mine, Mill and Warehouse

ASBESTOS SOURCES




New Idria Serpentinite Mass
Area shown on Figure 4
Big Blue Member of Temblor Formation
ATLAS SITE
COALINGA SITE
Los Gatos Creek
Coalinga
SAN ANDREAS - FAULT ZONE (Main Trace)
Western Boundary of Study Region
Boundary of Los Gatos Creek Drainage Basin
TABLE MOUNTAIN
N
EXPLANATION
Sp Serpentinite outcrop
•74 Mine (✱ = Asbestos mine)
73? Mine, location uncertain
Note: See Appendix A for site-specific data on mines.
Sources: Hart (1966), Logan, Braun, and Vernon (1951), Jennings (1953), Averill (1947), CDMG/F. Frederick files (various dates), Southern Pacific Land Co. (1964), U.S. Bureau of Mines (1987)
Scale 0 2 4 6 8 10 mi
0 2 4 6 8 10 12 14 16 km
INVENTORY OF POTENTIAL ASBESTOS SOURCES
Distribution of Serpentinite and Mines in Study Region
Woodward-Clyde Consultants
Figure 3

o RECOMMENDATIONS



INVENTORY OF POTENTIAL ASBESTOS SOURCES IN
THE NEW IDRIA-COALINGA STUDY REGION

FOR

THE ATLAS AND COALINGA SITES
FRESNO COUNTY, CALIFORNIA

U.S. EPA CONTRACT NO.: 68-01-6939
WORK ASSIGNMENT NO.: 135-9L34.0
DOCUMENT CONTROL NO.: 239-RI1-RT-EYJX

September 15, 1987

Prepared for:

U.S. Environmental Protection Agency

Prepared by:

Woodward-Clyde Consultants

APPENDIX A

TABULATION OF PRODUCING MINES IN THE NEW IDRIA - COALINGA STUDY REGION

Compiled From: Hart (1966), Logan, Braun and Vernon (1951), Jennings (1953), Averill (1947), CDMG/F. Frederick files (various dates), Southern Pacific Land Co. (1964), U.S. Bureau of Mines (1987)

239-RI1-RT-EYJX

NEW IDRIA FORMATION MINES SITES ON BLM PROPERTY

A) **Mines on BLM Property**: Generally the volume of tailings, acreage, possible threat to nearby populations and/or the environment are unknown. Mine site numbers refer to the attached list and map showing all mine sites currently identified in the New Idria area.

Formation

Mine #	Mine Name(s)	Commodity	Est. Amount of Production/Dates	Est. Surface Area/ Above Workings
8	Wonder	Mercury	Discovered-1906 Some-1942	Total 400′ of workings 50′ x 250′ (1947)
9	Spanish	---	---	---
17	Red Rock	Mercury	---	---
22	Hines	Chromium	---	---
26	Tirado Chrome	Chromium	---	---
27	Picacho	Mercury	Discovered pre-1871	---
28	Bobcar and Anchor	Chromium Iron	Discovered 1954	---
29	Trinity	Chromium	---	---
34	Florence Mack	Mercury	Discovered in 1904	200′ x 100′
36	Union Carbide (Joe 5-7)	Asbestos	Production 1963 to Present (intermittent); 1963-83 by Union Carbide; 1984, 85 by Calldria Corp.*; 1986, 87 by King City Asbestos Corp.	2000′ x 2000′ as shown on Totpgraphic map
38	Anita (Rita, Chiquita, Santa Reta)	Mercury	Discovered in 1910, last production in 1942	---
41	Atlas Asbestos Co.	Asbestos	Production 1963-80	Tailings: 1500′ x 4300′

Mine #	Mine Name(s)	Commodity	Est. Amount of Production/Dates	Est. Surface Area/ Above workings
42	Basic Resources Corp.	Asbestos	Pilot Mining Operation in 1959	---
43	"Section 28 Mine"	Asbestos	Operations probably by Union Carbide (as major claim holder in area)	---
44	Todd Industries	Asbestos	---	---
46	Rhodes/By les/Gribble	Chromium	---	---
50	White Creek Magnesite Mine	Magnesium	---	---

B) <u>Mines Partially on BLM Property</u>: The exact location or acreage of tailings material is unclear at this time. Additional information on volume and acreage will be available to supplement this table by December 1988 upon completion of EPA's New Idria Regional Study.

<u>Possible BLM Ownership</u>

Mine #	Mine Name(s)	Commodity	Est. Amount of Production/Dates	Est. Surface Area/ Above Workings
Part of 7	New Idria Group	Mercury	1853 to 1966-568,092 flasks ($55 million)	0.8 sq. mile at surface (more than 20 linear miles of workings in subsurface)
12	A&C Group	Asbestos	Small; 1917-20	---
Part of 15	Clear Creek	Mercury	---	---
Part of 21	Fourth of July	Mercury	---	---
Part of 37	Gem Mine (Dallas Mining Co.)	Gemstones (benitoite)	Shutdown in 1912	---
Part of 39	Del Mexico (Mexican)	Mercury	Discovered in 1860, intermittently active to 1958	---
48	Butler Estate (Mistake; koski; Dames/Thickston)	Chromium	Active ca 1900 to 1958. 202 carloads ore ($350,000) shipped Sept 1956-May 1958. Largest producer of chromite in Fresno Co. 1953-58 production 23,000 long tons. Still active in 1976.	850' x 550' 250' deep
Part of 52	Dames-Corbett (Dames-Corbett-Byles; Corbett-Byles)	Chromium Iron	Discovered 1910. In 1945-55, shipped 11 tons lump ore, and 530 tons concentrates	---

Appendix A

TABULATION OF PRODUCING MINES IN THE NEW IDRIA-COALINGA REGION
(Page 1 of 8)

Map No. (on Fig. 3)	Mine Name(s)	Location Sec.Twp.Rge/County	Commodity	Est. Amount of Production/Dates	Type of Workings Tailings/Buildings	Est. Surface Area Above Workings	Remarks/ References
1	Firefly (Monterey, Fireflex, Mascovich)	20,21 - 17S-10E San Benito	Coal; listed also as a uranium deposit-1978	? Operating in 1945 (coal)	Adit, drifts, raise-total 1187'	400' x 460"	Opened in 1870. Coal bed 6' thick. Averill (1947); USBM (1987)
2	Vallecitos Clay Mine	W 1/2 15-17S-11E San Benito	Clay-bentonite	---	---	---	USBM (1987)
3	San Benito Coal Mine	14(?)-17S-11E San Benito	Coal (sub-bituminous)	Small-ca 1906	---	---	Averill (1947)
4	Sampson (Maltby No. 3)	26,27 -17S-11E 34,35 San Benito	Magnesium	Large - 1917-26	---	288 acres	Averill (1978); USBM (1987)
5	North Star	36-17S-11E San Benito	Mercury	---	---	---	USBM (1987)
6	Ashurst Ranch Pit	SW 1/4 18-17S-12E San Benito	Clay	---	---	---	USBM (1987)
7	New Idria Group	29,32,-17S-12E 33 San Benito	Mercury	1853 to 1966-568,092 flasks ($55 million)	Town of New Idria, dumps, roads, buildings, shafts, etc.	0.8 sq. mile at surface (more than 20 linear miles of workings in subsurface)	Produced 1853 to 1972. Eckel and Meyers (1946); Averill (1947); CDMG Mine files (1987); USBM (1987)

New Idria Group includes the New Idria, Ranchito, Molina, and San Carlos mines.

NOTE: A 1982 plan to rework New Idria tailings for gold was stopped by court order in September 1982.

Map No. (on Fig. 3)	Mine Name(s)	Location Sec.Twp.Rge/County	Commodity	Est. Amount of Production/Dates	Type of Workings Tailings/Buildings	Est. Surface Area Above Workings	Remarks/ References
8	Wonder	NW 1/4 31-17S-12E San Benito	Mercury	Divcovered-1906 Some-1942	Total 400' of workings	50' x 250' (1947)	Eckel and Meyers (1946); Averill
9	Spanish	NE 1/4 31-17S-12E San Benito	---	---	---	---	USBM (1987)
10	Unnamed gravel pit	SW 1/4 11-17S-14E Fresno	Sand and gravel	---	---	---	USBM (1987)
11	Unnamed gravel pit	SE 1/4 25-17S-14E Fresno	Sand and gravel	---	---	---	USBM (1987)
12	A&C Group	10-18S-11E San Benito	Asbestos	Small-1917-20	Ore hand-sorted from shallow workings	---	CDMG files-Consulting reports of F. Frederick (1959)

Appendix A

TABULATION OF PRODUCING MINES IN THE NEW IDRIA-COALINGA REGION
(Page 2 of 8)

Map No. (on Fig. 3)	Mine Name(s)	Location Sec.Twp.Rge/County	Commodity	Est. Amount of Production/Dates	Type of Workings Tailings/Buildings	Est. Surface Area Above Workings	Remarks/ References
13	San Benito Asbestos Co.	15-18S-11E San Benito	Asbestos	?-prior to 1926	---	---	USBM (1987)
14	Aurora (Morning Star)	NE 1/4 5-18S-12E San Benito Co.	Chromium Mercury	Discovered 1853 Some-1943, 44 Most-1933 to 40 Last production 1945	Surface benches, 5 adits, 4 shafts, 1600' total subsurface workings	300' x 350'	Averill (1947); Eckel and Meyer (1946); USBM (1987); CDMG Mine files (1987)
15	Clear Creek	2,11,12-18S,11E San Benito Co.	Mercury	---	---	---	Eckel and Meyers (1946); USBM (1987)
16	Tirado and Shear	12-18S-11E San Benito Co.	Mercury	Discovered 1925	Open cuts	---	Eckel and Meyers (1946); USBM (1987)
17	Red Rock	11-18S-11E San Benito Co.	Mercury	---	---	---	Eckel and Meyers (1946); USBM (1987)
18	Andy Johnson	18-18S-12E San Benito Co.	Mercury	Discovered pre-1880	Open cuts plus 1500' subsurface workings	---	Eckel and Meyers (1946); USBM (1987)
19	Alpine	13-18S-11E San Benito Co.	Mercury Asbestos, Chromite(?)	Discovered 1941	Shallow open cuts, and 100' subsurface workings	---	Eckel and Meyers (1946); USBM (1987)
20	Tirado	18-18S,12E San Benito Co.	Mercury	Discovered 1914	Open cuts	---	Eckel and Meyers (1946); USBM (1987)
21	Fourth of July	SE 1/4 18-18S-12E San Benito Co.	Mercury	---	---	---	Eckel and Meyers (1946); USBM (1987)
22	Hines	17-18S-12E San Benito Co.	Chromium	---	---	---	USBM (1987) Walker and Griggs (1953)
23	Harrison	17-18S-12E San Benito Co.	Chromium	---	---	---	USBM (1987) Walker and Griggs (1953)
24	Elma Queen	16-18S-12E San Benito Co.	Chromium	---	---	---	USBM (1987) Walker and Griggs (1953)
25	Valdez Bros.	16-18S-12E San Benito Co.	Chromium	---	---	---	USBM (1987) Walker and Griggs (1953)
26	Tirado Chrome	15-18S-12E San Benito Co.	Chromium	---	---	---	USBM (1987) Walker and Griggs (1953)

Appendix A

TABULATION OF PRODUCING MINES IN THE NEW IDRIA-COALINGA REGION
(Page 3 of 8)

Map No. (on Fig. 3)	Mine Name(s)	Location Sec.Twp.Rge/County	Commodity	Est. Amount of Production/Dates	Type of Workings Tailings/Buildings	Est. Surface Area Above Workings	Remarks/ References
27	Picacho	19,20-18S,12E San Benito Co.	Mercury	Discovered pre-1871	Open cuts, plus 1000' subsurface workings	---	Eckel and Meyers (1946); USBM (1987)
28	Bobcat and Anchor	20-18S-12E San Benito Co.	Chromium Iron	Discovered 1954	Surface trench; ore body 3.8 m long x 1.2 m wide	---	USBM (1987)
29	Trinity	20-18S-12E San Benito Co.	Chromium	---	---	---	USBM (1987) Walker and Griggs (1953)
30	Sawmill Creek	21-18S-12E San Benito Co.	Chromium	3100 + tons (1954-57)	---	---	CDMG Mine Files (1987)
31	Simms Asbestos (St. Thomas)	NE 1/4 25-18S-12E San Benito Co.	Asbestos	Operating in 1945	---	---	Averill (1947); USBM (1987)
32	Breen	NE 1/4 36-18S-11E NW 1/4 31-18S-12E San Benito Co.	Mercury	---	300' of subsurface workings	---	Eckel and Meyers (1946) USBM (1987)
33	New Tirado (Santa Margarita)	SE 1/4 31-18S-12E San Benito Co.	Mercury	Discovered 1938(?)	100' of subsurface workings	---	Eckel and Meyers (1946) USBM (1987)
34	Florence Mack	SE 1/4 32-18S-12E San Benito Co.	Mercury	Discovered in 1904	900' of subsurface workings	220' x 100'	Eckel and Meyers (1946) USBM (1987)
35	Asbestos Ridge	SW 1/4 26-18S-12E San Benito Co.	Asbestos Chromium	---	---	---	Property owned by King City Asbestos Corp. Inc. USBM (1987)
36	Union Carbide (Joe 5-7)	NW 1/4 25-18S-12E San Benito Co.	Asbestos	Production 1963 to Present (intermittent); 1963-83 by Union Carbide; 1984, 85 by Calidria Corp.*; 1986, 87 by King City Asbestos Corp.	Open pit mining-quarry face 1350' long at base (1983); benches 40' wide, 20' high. Ore tracked to mill at King City	2000' x 2000' as shown on topographic map	Exploration began 1958, claim "rush" in 1959. CDMG Mine Fil (1987); San Benito Co. Assessc files (1987); USBM (1987)
37	Gem Mine (Dallas Mining Co.)	NE 1/4 25-18S,12E San Benito Co.	Gemstones (benitoite)	Shutdown in 1912	Open cut, 40' adit, 25' shaft, 60' crosscut	---	Averill (1947); USBM (1987)
38	Anita (Rita, Chiquita, Santa Reta)	SW 1/4 17-18S-13E Fresno Co.	Mercury	Discovered in 1910, last production in 1942	1500' of subsurface workings	---	Eckel and Meyers (1946); USBM (1987); Logan, Brown, and Verr (1951)

* Calidria Corp. was a wholly-owned subsidiary of Union Carbide.

Appendix A

TABULATION OF PRODUCING MINES IN THE NEW IDRIA-COALINGA REGION
(Page 4 of 8)

Map No. (on Fig. 3)	Mine Name(s)	Location Sec.Twp.Rge/County	Commodity	Est. Amount of Production/Dates	Type of Workings Tailings/Buildings	Est. Surface Area Above Workings	Remarks/ References
39	Del Mexico (Mexican)	SW 1/4 22-18S,13E Fresno Co.	Mercury	Discovered in 1860, intermittently active to 1958	Open cuts and 1800' of of subsurface workings	---	Eckel and Meyers (1946); USBM (1987); Southern Pacific Land Co. (1964)
40	Coalinga Asbestos Co.	27,34-18S-13E 1-19S-13E Fresno Co.	Asbestos	Production 1964-74, Amount of production unavailable. Johns-Manville bankrupt in 1974	Open pits: Two pits: Jensen Pit in SE 1/2 Sec 34, and newer Christie Pit in S 1/2 Sec 27. Mill facilities and tailings site: In Sec 1-T 19S, R13E leased from Southern Pacific Co.	Jensen Pit: 1000' x 1000'; Christie Pit: 2000' x 2100'; Mill/Tailings: 500' x 1200'	During "asbestos rush" of 1959 two major participants (Kern County Land Co. and Johns-Manville Sales Corp.) together formed Coalinga Asbestos Co. CDMG Mine Files (1987)
41	Atlas Asbestos Co.	32,31,30-18S,13E 25-18S,12E Fresno Co.	Asbestos	Production 1963-80 Amount of production unavailable. Atlas Asbestos Co. bankrupt in 1980	Open pits: Two pits: Rover pit in NE 1/4 Sec 31, and Santa Cruz pit in NE 1/4 Sec 31 and NW 1/4 Sec 32 Tailings and mill: located east, south, and northwest of Santa Cruz pit. Mill in Sec 32. Processed asbestos trucked to warehouse in Coalinga or beyond	Tailings: 1500' x 4300' Rover pit: 800' x 1000'; Santa Cruz pit: 1000' x 1600. Separate tailings area in Sec 30, T18S-13S and Sec 25, T18S-12E	Started by Atlas Metals Div. o Atlas Corp.-Sold in 1968 (loss of $1 million +) to Atlas Asbestos Co. CDMG Mines Files (1987)
42	Basic Resources Corp.	S 1/2 30-18S-13E Fresno Co.	Asbestos	Pilot mining operation in 1959	Surface ripping (bulldozer); processing (screening) of ore at mining site; truck to pilot millsite in Coalinga	---	CDMG files - Consulting report of F. Frederick (1959)
43	"Section 28 Mine"	S 1/2 28-18S-13E Fresno Co.	Asbestos	Operations probably by Union Carbide (as major claim holder in area)	---	---	Fresno County Recorders office documents (see Appendix A)
43A	"Section 29 Mine"	NW 1/4 29-18S-13E Fresno Co.	Asbestos	As above	---	---	As above
44	Todd Industries	SE 1/4 25-18S-13E Fresno Co.	Asbestos	---	---	---	USBM (1987)
45	Big Ridge (Jeanne/Condon [illegible]	N 1/2 36-18S-12E Fresno Co.	Chromium	90 tons in 1917, 1268 tons in 1956-57	Line of pits along crest of a ridge	---	USBM (1987); Walker and Griggs (1953); CDMG Mine Files (1987)

Appendix A

TABULATION OF PRODUCING MINES IN THE NEW IDRIA-COALINGA REGION
(Page 5 of 8)

Map No. (on Fig. 3)	Mine Name(s)	Location Sec.Twp.Rge/County	Commodity	Est. Amount of Production/Dates	Type of Workings Tailings/Buildings	Est. Surface Area Above Workings	Remarks/ References
46	Rhodes/Byles/Gribble	S 1/2 35-18S-12E Fresno Co.	Chromium	---	---	---	USBM (1987); Walker and Griggs (1953)
47	Tromby No. 1 and 2	C36-18S-12E Fresno Co.	Chromium	---	---	---	USBM (1987); Wakler and Griggs (1953).
48	Butler Estate (Mistake; Koski; James/Thickston)	SW 1/4 34-18S-13E Fresno Co.	Chromium	Active ca 1900 to 1958. 202 carloads ore ($350,000) shipped Sept 1956-May 1958. Largest producer of chromite in Fresno Co. 1953-58 production 23,000 long tons. Still active in 1976	Deep open pit. Three mills that processed ore are on White Creek (Holman and Chambers/ Russell) and San Benito River (James). After 1952, all ore was trucked to Coalinga. In 1976, a mill for concentrating chromite was being built inside former asbestos mill (Coalinga Asbestos Co.) in Sec 1-19S-13E	850' x 550', 250' deep	Associated mercury (0.9%) Matthews (1961); Southern Pacific Land Co. 1964). CDMG Mine Files (1987)
49	Unnamed gravel pit	E 1/2 1-18S-14E Fresno Co.	Sand and gravel	---	---	---	USBM 1987)
50	White Creek Magnesite Mine	E 1/2 5-19S-13E Fresno Co.	Magnesium	---	---	---	USBM (1987)
51	Archer	NE 1/4 3-19S-13E Fresno Co.	Mercury	Discovered 1904; worked until 1942, again in late 1940's	Several open cuts, two adits, several drifts	---	Logan, Braun, Vernon (1951) USBM (1987)
52	James-Corbett (James-Corbett-Byles; Corbett-Byles)	NE 1/4 3-19S,13E Fresno Co.	Chromium Iron	Discovered 1910. In 1945-55, shipped 11 tons lump ore, and 530 tons concentrates	Large benched cut 75 m long, 25 m deep - probable ore body is 10 m x 10 m x 5 m	---	CDMG Mine Files (1987); USBM (1987)
53	Railroad	NW 1/4 1-19S-13E Fresno Co.	Chromium	60 tons shipped, 1955-56	Two open cuts: 105' x 50' and 120' x 70'	---	Southern Pacific Land Co. (1964); USBM (1987); Symons and Davis (1958)
54	Unnamed gravel pit	NE 1/4 1-19S-15E Fresno Co.	Sand and gravel	---	---	---	USBM (1987)
55	Unnamed gravel pit	SW 1/4 12-19S-15E Fresno Co.	Sand and gravel	---	---	---	USBM (1987)
56	Unnamed gravel pit	NE 1/4 13-19S-15E Fresno Co.	Sand and gravel	---	---	---	USBM (1987)

Appendix A

TABULATION OF PRODUCING MINES IN THE NEW IDRIA-COALINGA REGION
(Page 6 of 8)

Map No. (on Fig. 3)	Mine Name(s)	Location Sec.Twp.Rge/County	Commodity	Est. Amount of Production/Dates	Type of Workings Tailings/Buildings	Est. Surface Area Above Workings	Remarks/ References
57	Unnamed gravel pit	SW 1/4 19-19S-16E Fresno Co.	Sand and gravel	---	---	---	USBM (1987)
58	Unnamed mine	10-19S-10E San Benito Co.	Copper	---	---	---	USBM (1987)
59	Eade	N 1/2 14-19S-9E Monterey Co.	Sand and gravel	Operated intermittently in early/mid 1960's	Used by State for road base and aggregate	---	Hart (1966)
60	Mylar (San Lorenzo Creek)	SE 1/4 15-19S-9E Monterey Co.	Bituminous sandstone	Two quarries, some production 1890-1895	Used as natural asphalt concrete for road paving	---	Hart (1966)
61	Mee Ranch Chromite	SW 1/4 9-20S-11E Monterey Co.	Chromium	Small production; massive chromite boulders	Placer deposit	---	Hart (1966)
62	Mee Ranch Stone	S 1/2 9,14, 16-20S-11E Monterey Co.	Crushed and broken stone	Intermittently active for many years	Three small pits. Used as source of road base	---	Hart (1966)
63	Mother Green's Ball Mtn. Mineral Spring	24-20S-12E Fresno Co.	Mineral water	Planned to bottle water in 1948	---	---	Logan, Braun, Vernon (1951)
64	Del Monte (Drabble)	26-20S-12E Fresno Co.	Coal	Worked in 1896	Several adits	---	Logan, Braun, Vernon (1951)
65	Coalinga Mineral Springs (Fresno Hot Springs)	SE 1/4 34-20S-13E Fresno Co.	Mineral water	Water used since late 1800's. Best known resort/spa in Fresno Co.	15 springs above hotel	---	Logan, Braun, Vernon (1951)
66	Unnamed mine	NE 1/4 22-20S-14E Fresno Co.	Gypsum	Worked about 1900	---	---	Southern Pacific Land Co. (1964); USBM (1987)
67	California Coal Mine	NE 1/4 22-20S-14E 3 miles NW of Coalinga Fresno Co.	Coal	Active in 1880-96 and 1940; 1892 monthly production of 300 tons	One 400' incline, two adits (one 1370' long)	---	Lignite seams to 2' thick; Logan, Braun, Vernon (1951) Southern Pacific Land Co. (1964)
68	San Joaquin Valley Coal Mine	NW 1/4 26-20S-14E Fresno Co.	Coal	Active 1880-96, 1890 daily production was 15 tons. Most extensive of Fresno Co. coal mines	Three adits (300', 400' 1700'); one 300' incline to 200' depth	---	Main bed 4' thick (average) Logan, Braun, Vernon (1951) Southern Pacific Land Co. (1964)
69	Eureka	NW 1/4 26-20S-14E [illegible]	Gypsum	Operated 1896	---	---	Southern Pacific Land Co. (1964); USBM (1987)

Appendix A

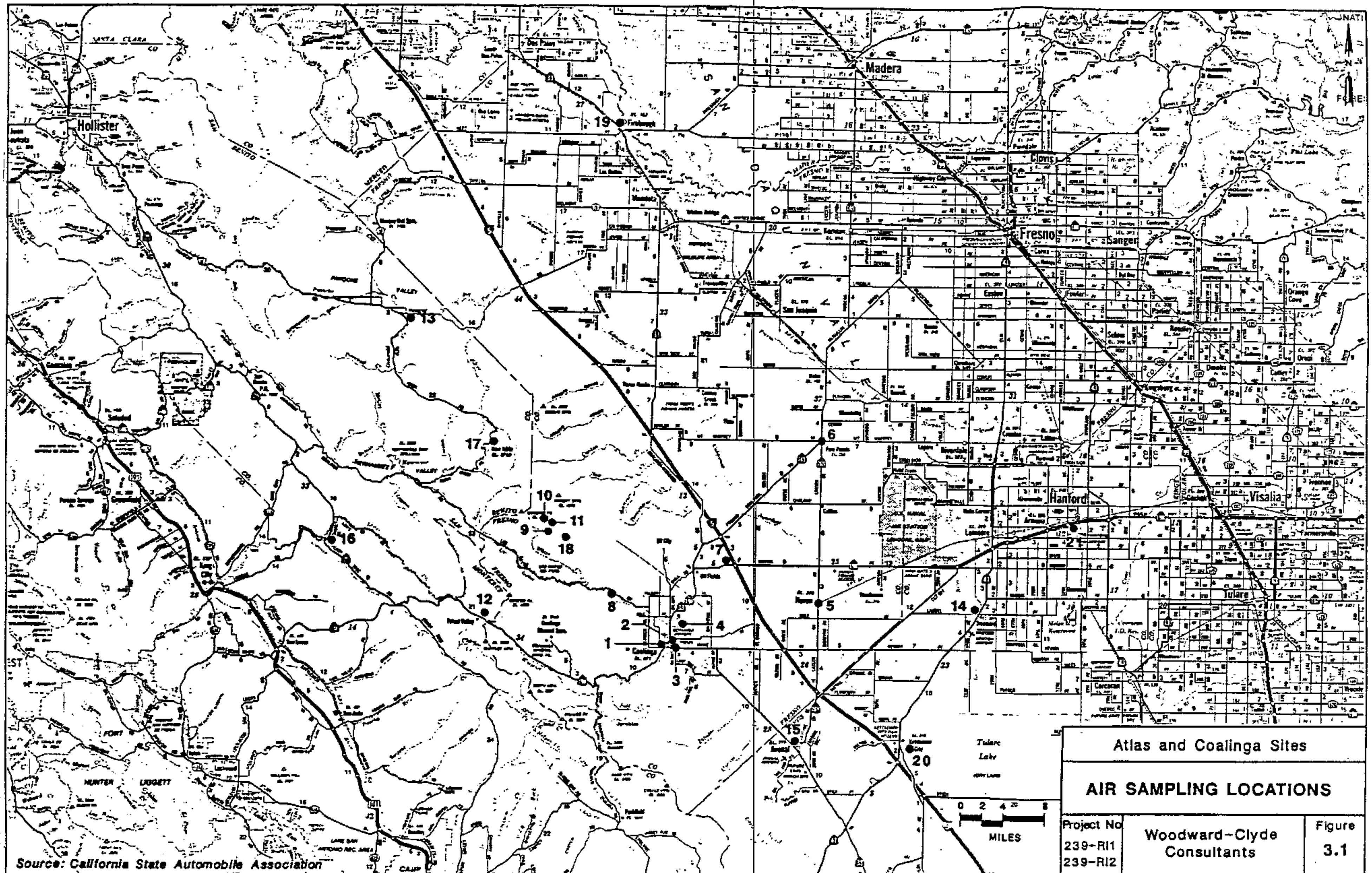
TABULATION OF PRODUCING MINES IN THE NEW IDRIA-COALINGA REGION
(Page 7 of 8)

Map No. (on Fig. 3)	Mine Name(s)	Location Sec.Twp.Rge/County	Commodity	Est. Amount of Production/Dates	Type of Workings Tailings/Buildings	Est. Surface Area Above Workings	Remarks/ References
70	Coalinga	SW 1/4 35-20S-14E NE 1/4 2-21S-14E Fresno Co.	Gypsum	Production 1957-58, supplied 50 ton/hr mill	Surface stripping (6" - 24" overburden) to 6" - 24" local lenses of gypsite	---	Southern Pacific Land Co. (1964); USBM (1987)
71	Owl Folsom Pit and Mill	20-20S-15E Fresno Co.	Sand and gravel	---	---	---	USBM (1987)
72	Coalinga Pit (operated by Granite Const. Co.)	SE 1/4 29-20S-15E Fresno Co.	Sand and gravel	---	---	---	USBM (1987)
73	Coalinga Mine	C21-20S-15E Fresno Co.	Gypsum	Operated 1892-97	---	---	VerPlanck (1952); USBM (1987)
74	Unnamed gravel pit	NE 1/4 2-20S-15E Fresno Co.	Sand and gravel	---	---	---	USBM (1987)
75	Sunrise and Sunset	C24-21S-14E Fresno, Co.	Manganese	Produced 33 tons in 1917	---	---	Trask (1950); USBM (1987)
76	Montford Marl	24-21S-14E Fresno Co.	Limestone	Lime produced in the 1880's	Limestone bed 12' wide, extends across 40 acres	---	Logan, Braun, Vernon (1951); USBM (1987)
77	Unnamed gravel pit	SW 1/4 9-21S-15E Fresno Co.	Sand and gravel	---	---	---	USBM (1987)
78	Jacalitos	33-21S-15E Fresno Co.	Sand and gravel	---	---	---	USBM (1987)
79	Zapato Creek	SW 1/4 27-21S-16E Fresno Co.	Sand and gravel Aggregate from terrace deposits	--- ---	Thompson & Thompson Construction Co.	---	USBM (1987)
80	Webb and Mingus	C 20-21S-17E Fresno Co.	Clay-Fullers Earth	Production? pre-1930	---	---	USBM (1987)
81	Unnamed gravel pit	E 1/2 21-21S-17E Fresno Co.	Sand and gravel	---	---	---	USBM (1987)
82	Stone Canyon Jasper	16?-22S-13E Monterey Co.	Jasper	Collecting locality for lapidary material	---	---	Hart (1966)
83	Big Sandy	SW 1/4 17-22S-13E Monterey Co.	Sand and gravel	---	Small pits developed for local use	---	Sandstone of Santa Margarita Formation (Hart, 1966)

Appendix A

TABULATION OF PRODUCING MINES IN THE NEW IDRIA-COALINGA REGION

Map No. (on Fig. 3)	Mine Name(s)	Location Sec.Twp.Rge/County	Commodity	Est. Amount of Production/Dates	Type of Workings Tailings/Buildings	Est. Surface Area Above Workings	Remarks/ References
84	Stone Canyon Coal	14-22S-13E Monterey Co.	Coal	Discovered 1870. Substantial but intermittent production to 1935	---	---	Hart (1966)
85	Patriquin (Pitts; Cholame-Parkfield; Parkfield; Franciscan)	NE 1/4 2-23S-14E W 1/2 1-23S-14E Monterey Co.	Mercury	Discovered 1873. Largest mercury mine in Monterey Co. Produced 1798 flasks mercury	Glory hole and 1000' ± subsurface workings. SE extension in Sec 1 called Gillette Mine	310' x 360'	Bailey (1942); Hart (1966); USBM (1987)
86	Poppy/GWD	E 1/2 2-23S-14E Monterey Co.	Mercury	Poppy: 3 flasks-1932 GWD: 7 flasks-1937-40	Small open cuts and pits, several adits	---	Bailey (1942); Hart (1966); USBM (1987)
87	White (Table Mtn)	NE 1/4 30-23S-16E Monterey Co.	Mercury	Developed 1916, produced 3 flasks. Reopened in 1940's	Three short adits, several drifts	100' x 100'	Bailey (1942); Hart (1966); USBM (1987)
88	Table Mtn. Asbestos	30-23S-16E Monterey Co./ Kings Co.	Asbestos	No production to March 1963	Asbestos associated with Table Mtn. serpentinite, as in New Idria serpentinite mass	S.P. Land Co. Mineral Survey reports promising potential in Sec. 25-23S-15E, and Sec. 19, 29,33-23S-16E	Hart (1966); Southern Pacific Land Co. (1964)
89	Kings (Table Mtn.; Fredanna)	SW 1/4 20-23S-16E Kings Co.	Mercury	First production 1902. Produced 1041 flasks 1905-1945	Shaft, two adits, numerous pits. NE extension into Sec. 19-23S-16E	---	Bailey (1942); Jennings (1953); USBM (1987)
90	Little Kings	NE 1/4 29-23S-16E Kings Co.	Mercury	Produced 800 flasks in 1958-62	Adit and incline, drifts	---	Southern Pacific Land Co. (1964); USBM (1987)
91	Dawson	NW 1/4 28-23S-16E Kings Co.	Mercury	First production 1918. Produced 1076 flasks 1918-42	Glory hole (50' x 150' x 50' deep) and several 100' subsurface workings	---	Southern Pacific Land Co. (1964); Bailey (1942); USBM (1987)
92	Avenal Canyon (Canyon)	NE 1/4 22-23S-16E Kings Co.	Mercury	Small production 1937-39	---	---	Jennings (1953); USBM (1987)
93	Unnamed gravel pit	SE 1/4 7-23S-16E Kings Co.	Sand and gravel	---	---	---	USBM (1987)
94	Turkey Flat	S 1/2 32-23S-15E Monterey Co.	Sand and gravel	Production probably before 1960	Pit-50' x 100' x 12-14' deep. Apparently used as fill or sub-	---	Hart (1966)



Atlas and Coalinga Sites

AIR SAMPLING LOCATIONS

Project No 239-RI1 239-RI2 | Woodward-Clyde Consultants | Figure 3.1

239-RI1-OP-EZRK-1

Environmental Asbestos: Problems Associated with PLM Soil Analysis

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ABSTRACT

Experience with laboratories and a review of data generated through the Superfund process confirm a lack of standardized sample preparation techniques and counting rules using Polarized Light Microscopy for asbestos-laden soil samples. Variation in analytical procedures reduces comparability of data generated by different laboratories. The absence of a standardized analytical technique makes decision-making difficult and may be affecting remedial consistency from site to site. As such, PLM soil results should be limited in use to characterization of spatial boundaries of contamination and for preparation of qualitative risk assessments. Extrapolation from soils data to quantitative risk assessments is not recommended until an adequate standardized methodology for the analysis of asbestos in soils has been adopted. National research needs are highlighted.

INTRODUCTION

The U.S. EPA "Interim Method for the Determination of Asbestos in Bulk Insulation Samples" is specifically designed to estimate the concentrations of total asbestos content in building materials. Due to the lack of any other published methodology, this "Interim Bulk Method"[1,2] has become the industry standard for quantifying asbestos concentrations in soils. However, this technique has not been evaluated for accuracy or precision for soil analysis.

This study compares Polarized Light Microscopy (PLM) analyses from three laboratories used for the RI at the Atlas and Coalinga Asbestos sites. These data are compared with results from six other asbestos sites and the Research Triangle Institute (RTI) bulk asbestos round robin program. The review highlights the need for a standardized risk-based analytical methodology specifically designed for asbestos in soils. Until a method is developed, PLM soil sample results should not be relied upon to quantify asbestos concentrations for contaminant transport or risk assessment models.

The Atlas Asbestos Mine site is located within the New Idria serpentinite mass, a 50-mi.^{2} serpentinite formation rich in chrysotile asbestos in California. The Coalinga Asbestos site is located just southeast of the New Idria formation and the Atlas site. Both sites contain abandoned asbestos mill facilities, tailings piles and associated open pit mines. These sites were listed on the NPL in 1984. The principal health concern is inhalation of air-borne asbestos-laden dust by local residents and site visitors.

SOIL ANALYSES BY POLARIZED LIGHT MICROSCOPY

(PLM) Soil samples for the Atlas and Coalinga Superfund sites were sent to three laboratories—EMS Laboratory, McCrone Environmental Services and Med-Tox Associates—for PLM analysis as specified by the EPA Interim Bulk Method. Each laboratory used the PLM "field of view" estimation technique to determine the asbestos content of soil samples.

Laboratory Consistencies

Data sheets and personal communications with the laboratories confirm that the microscopists generally agree on the overall identification of serpentine structures and mineral content in the Atlas and Coalinga soil samples.[3-8] The microscopists confirm the samples are more complex than typical chrysotile product samples. The soils contain high concentrations of chrysotile, antigorite, and lizardite, minerals having the same basic chemical formula ($Mg_3SiO_2O_5(OH)_4$) but different crystal structures. These minerals exist as polymorphs of each other and as both asbestiform and non-asbestiform aggregates.[4,9-15] The combination of minerals causes somewhat unusual optical properties such as higher refractive indices when compared to chrysotile from other ore bodies. Central stop dispersion staining colors observed by McCrone are noted to be more typically associated with antigorite, a non-fibrous form of serpentine.[5] EMS and McCrone both report gold to magenta dispersion staining colors.[16] To more accurately characterize the PLM-DS results, TEM was performed on a subset of samples. The analyses confirm that the serpentine minerals in the samples are principally chrysotile asbestos structures.[3-8,16]

ANALYTICAL DIFFERENCES BETWEEN LABORATORIES

There are four major variables in PLM analyses among the laboratories which are:

- Sample preparation prior to analysis
- Differences in analytical techniques
- Lack of standardized terminology and chrysotile/serpentine classification schemes
- Fundamental differences in counting rules

Sample Preparation

Sample preparation techniques differ among the laboratories, principally on sieving and the use of grinding by mortar and pestle.[3-6,8,14,16-19] The EMS samples are sieved and separated into fine (<2mm) and coarse fractions (>2mm); without grinding the fine fraction, the samples are prepared for PLM analysis. Based on the presence or absence of asbestos in the fine fraction, coarse fractions are lightly ground as necessary for analysis. McCrone sample preparation is similar to EMS and includes sieving samples into size fractions of gravel (<2mm), sand (50μm-2mm) and silt and clay (>50μm) without grinding. Sample preparation by Med-Tox includes lightly grinding soil samples for a few seconds to one minute each with a mortar and pestle (Table 1).

Table 1
Use of Grinding and Sieving Techniques for PLM Soil Sample Preparations

Site Name Laboratory Name	Grinding with Mortar/Pestle	Sieves
Atlas/Coalinga EMS	No	>2mm coarse <2mm fine
Atlas/Coalinga McCrone	No	Sieved 41/60 samples into >2mm gravel 50um-2mm sand <50um silt/clay
Atlas/Coalinga Med-Tox	Yes, mortar/pestle; few seconds to one minute/sample	No
City of Coalinga IT Lab	Yes, homogenized in 250 ml jars; no mortar/pestle	No
Asbestos in Roads Study Med-Tox	Yes, few seconds to one minute/sample	Yes, used a 200-mesh screen to separate silt & coarse fractions
Globe, Arizona TMA/EAL	Microscopist no longer at lab so follow-up no possible.	
Copper Cove Roads/ Copperopolis EAL Lab	Yes, sufficient time to reduce veins, etc. to free fibers/total asbestos measured	No
South Bay Asbestos Versar	No	Yes, used sieve to separate .710, .355 and .250 mm fraction
Quarry Samples Clayton	Yes, lightly	No

Since the EPA Interim Bulk Method states that sample preparation is "dependent upon the samples encountered and personal preferences" of the microscopist, each of these techniques is within the margin of acceptability for PLM sample preparation. Grinding, for example, is only one of the six acceptable means for obtaining a homogenous, representative subsample.[1,2] Further review of sample preparation techniques from other asbestos Superfund removal and remedial sites[20-26] indicates similarly widespread inter-laboratory variations in the use of sieving and grinding (Table 1).

Some bias due to grinding and sieving soils is expected, although the magnitude of the bias caused by the preparation differences is unknown without a standard for comparison.[16] It is well documented in asbestos studies that natural serpentine minerals and manufactured asbestos-laden products including chrysotile structures are easily broken into elongated cleavage fragments and free fibers by natural weathering processes, and by chemical or mechanical disturbances in vitro, in vivo and in the general environment.[9,10,27-36] McCrone's sample report, for example, notes that the matted fibers "displaced more pronounced fibrosity upon crushing."[5] This easily fragmented characteristic of chrysotile is an important factor in soil concentrations, and sample preparation should be standardized to eliminate this variable in the PLM analytical procedure.

Analytical Methods

In addition to sample preparation techniques, the wide range of asbestos content in these soils is due in part to the different analytical techniques employed by the laboratories (Table 2). All three laboratories use the "field of view" estimation technique with dispersion staining (PLM/DS). EMS and Med-Tox results are reported as per cent area.[3,4,6] McCrone analyzes by PLM/DS and stereomicroscopy, reporting results as per cent volume.[4,5] Of the other laboratories listed on Table 2, one uses the point count technique.[20] As the EPA Interim Bulk Method specifies use of point counting or "an equivalent estimation method," no standardization of methodology or units is assured.

Table 2
Analytical Techniques for PLM Soil Analyses

Site Name Laboratory Name	Analytical Techniques
Atlas/Coalinga EMS Laboratory	PLM/DS Visual Estimates TEM
Atlas/Coalinga McCrone	PLM/DS Stereomicroscopy
Atlas/Coalinga Med-Tox	PLM/DS Visual Estimates TEM
City of Coalinga IT Lab	Point Count PLM/DS TEM
Asbestos in Roads Study Med-Tox	PLM/DS Visual Estimates TEM
Globe, Arizona TMA/EAL	Visual Estimates
Copper Cove Roads Copperopolis EAL Lab	PLM/DS TEM
South Bay Asbestos Versar	PLM/DS Stereomicroscopy
Quarry Samples	Visual Estimates

* Analytical methods include: Point Count, Visual/field of view estimation, PLM/Dispersion Staining, Stereomicroscopy and Transmission Electron Microscopy (TEM).

Table 3
Terminology Used in PLM Soil Analyses Reports

Site Name Laboratory Name	Terminology Used for Structures of Concern
Atlas/Coalinga EMS Laboratory	Chrysotile
Atlas/Coalinga McCrone	Serpentine Asbestos
Atlas/Coalinga Med-Tox	Elongate Serpentine or Chrysotile
City of Coalinga IT Lab	Chrysotile
Asbestos in Roads Study Med-Tox	Chrysotile/Antigorite
Globe, Arizona TMA/EAL	Chrysotile
Copper Cove Roads Copperopolis EAL Lab	Chrysotile
South Bay Asbestos Versar	Chrysotile or Serpentine
Quarry Samples	Chrysotile

Terminology

Another variable identified in this study is a result of non-standardized classification schemes and terminology used by each laboratory for the observed serpentine or chrysotile structures. For spatially similar samples from the Atlas and Coalinga sites, the microscopists' morphological descriptions include: white matted plates; pale green elongated serpentine; lathe-shaped bundles; acicular fibers; rounded, somewhat flattened fragments; silky, wavy bundles; harder green, elongated chips; cleavage fragments and serpentine minerals.[3,4,5,6,16] The reported structures of concern include chrysotile, serpentine asbestos, and elongate serpentine, among others (Table 3). For the end-user of the soils data, this variability in terminology makes interpretation of results very difficult.

Counting Rules

Since inter-laboratory terminology is not standardized, differences in counting rules are difficult to assess. All three laboratories count structures with aspect ratios greater than or equal to 3:1. However, discussions with the microscopists show that counting rules beyond aspect ratio definition vary based on their understanding of the end-use of the data by the clients.

EMS counted only free chrysotile fibers that could easily become air-borne without mechanical disturbances of the soil matrices; the microscopist understood that the soil results were to be used as input to an air transport model, and therefore counted only free fibers.[3,16] McCrone reported chrysotile and all fibrous chrysotile-like minerals as "serpentine asbestos"; this category included particles such as fibrous grains, matted clumps of fibers and green elongated chips;[4,5,16] McCrone attempted to estimate the total friable asbestos content of the soils. Due to the non-standard mineralogical content of these samples, Med-Tox reported both "elongate serpentine" and "chrysotile asbestos" concentrations. Elongate serpentine was defined by Med-Tox as including all serpentine fragments including chrysotile, lizardite and antigorite; this category represented the Med-Tox estimate of the maximum asbestos content of the soils. "Chrysotile asbestos" was defined by Med-Tox as having classical chrysotile properties and included bundles of fibers.[4,6,16]

"Asbestos fibers" are defined in the EPA Interim Bulk Method as having an aspect ratio of 3:1 and being positively identified as an asbestos mineral based on six optical properties.[1] These three laboratory counting procedures, therefore, are within this margin of acceptability for the Interim PLM Bulk Method. Qualitatively, the EMS results appear to represent the immediately releasable asbestos content while the Med-Tox data probably estimate the maximum quantity of potentially releasable asbestos.

However, as there is no standardized terminology or inter-laboratory quality assurance program for asbestos in soils, the accuracy of the sample results is impossible to determine.

Sample Results

A partial yet representative subset of the Atlas and Coalinga soil data is presented in Tables 4 and 5. Med-Tox and McCrone split samples show high correlation and precision (Table 4). This agreement of analytical results can most likely be attributed to extensive communication with the client before analysis of the samples, thereby ensuring both laboratories were attempting to fulfill similar objectives.

The range of asbestos concentrations reported by EMS and Med-Tox highlights the need for standardization of the PLM method (Table 5). Since the EMS and Med-Tox samples are not splits, an exact comparison of data cannot be made. Nonetheless, precision of data for similar types of soils from spatially comparable locations would be expected to be better than the >1% to 85% range of asbestos measured.[3-8,16]

Table 4
Inter-laboratory Comparison of Atlas and Coalinga Split Soil Samples*

Lab	Med-Tox		McCrone
Soil Type	Elongate Serpentine % Area	Chrysotile Asbestos %Area	Serpentine Asbestos % Volume
Mine/Mill Tailings	80% 65%	60% 25%	85% 80%
Serpentine Formation	85%	50%	65%
Streambeds	15%	5%	32.5%
Alluvial Fan	1%	1%	1%

* The Med-Tox and McCrone data are from split samples. These five samples from five soil types (i.e. mill tailings, streambeds, etc.) are representative of the 60 samples reviewed for this study.

Table 5
Results of Non-split, Spatially Comparable Samples from the Atlas and Coalinga Sites*

Lab	EMS	Med-Tox	
Soil Type	Chrysotile Asbestos % Area	Elongate Serpentine % Area	Chrysotile Asbestos %Area
Mine/Mill Tailings	<1% 1%	80% 65%	60% 25%
Serpentine Formation	1%	85%	50%
Streambeds	<1%	15%	5%
Alluvial Fan	<1%	1%	1%

* These five EMS and Med-Tox samples are not splits of the identical soil samples. However, the EMS and Med-Tox sample locations are spatially comparable as listed under "soil type" and should have a lower range of asbestos content. This range is representative of the 64 EMS and 60 Med-Tox sample results reviewed for this study.

EPA INTERIM METHOD FOR INSULATION VERSUS SOIL SAMPLES

The Research Triangle Institute (RTI) December 1987 Bulk Analysis Round acceptance criteria for asbestos content of building material split samples ranges from <1% to 80% area.[17] Similar ranges of acceptability can be seen in all other rounds as well. RTI describes the laboratory performances as assessed on the basis of correct identification of "positive" (containing < or = 1% asbestos) and "negative" (> or = 1% asbestos) or false negatives using the Interim Bulk Method. "Although the criteria are lenient," the RTI report states, "they recognize the basic concern of the public—the presence or absence of asbestos fibers in a submitted sample." The Interim Bulk Method was designed for use as a screening tool, recognizing the typical asbestos content and size range of insulation and building materials (generally 5-20% asbestos and longer fibers). Identification of the presence or absence of asbestos is the current goal, not precise quantification of asbestos content. However, in order to use soil data for hazardous waste site characterization and as input to risk assessments, accurate quantification of the asbestos content becomes the goal.

The ASTM is in the process of peer reviewing a more quantitative PLM bulk analytical methodology for insulation materials. This effort and the RTI round robin program may improve quantitation.[16,38]

However, a more quantitative methodology for bulk insulation is not sufficient for analysis of asbestos content in soils. The RTI round robin and building samples are more homogenous than is commonplace with environmental asbestos samples. Soils containing high concentrations of non-asbestiform serpentine material, cellulose, particulates and other interferences can cause difficulties in conclusive identification of chrysotile fibers by skilled microscopists.[33,35,36] The limits of optical resolution of light microscopy do not allow short or narrow fibers to be easily quantified.[16,38] Moreover, TEM soil samples and air monitoring data from the Atlas and Coalinga sites confirm that short fibers are typical of the asbestos deposits in the New Idria

Formation. In light of these and other differences between insulation materials and soil samples, the use of the Interim Bulk Method may be inappropriate for quantitation of asbestos in soils.

Table 6
Summary of Inter-laboratory Comparisons of PLM Sample Preparation and Analytical Techniques

Site Name / Lab Name	No. Samples (1)	Analy. Method (2)	Sample Prep Grinding (3)	Sieves (4)
Atlas/Coalinga EMS	64	% Area Visual PLM/DS TEM	No	>2mm coarse <2mm fine
	Description of Structures: <u>Chrysotile</u>; free fibers of 3:1 aspect ratio; large, non-fibrous, nonrespirable particles not counted even if could see veins Comments by Lab: Strong evidence of fibrous material in serpentine; attempted to estimate asbestos available for immediate release, not total serpentine-bound chrysotile. Understood data to be used as input to air transport model. (1-2 hrs/sample)			
McCrone	60	% Vol PLM/DS Stereo	No	Sieved 41/60 >2mm gravel 50um-2mm sand <50um silt/cl
	Description of Structures: <u>Serpentine Asbestos</u>; plates of matted serpentine represented the dominant morphology of asbestos; less abundant, harder green elongated chips became more fibrous when crushed at 40X. (1-2 hrs/sample)			
(A/C cont.) Med-Tox	60	% Area Visual PLM/DS TEM	Yes. Mortar & pestle; seconds to 1 min/sample	No
	Description of Structures/Comments by Lab: <u>Elongate Serpentine</u>; only particles with 3:1 aspect ratio, including antigorite, lizardite and chrysotile. Includes non-asbestiform structures and is probably maximum releasable asbestos in samples. <u>Chrysotile</u>; definite chrysotile only with 3:1 aspect ratio; includes bundles with fibrous split ends. (1-3 hrs/sample)			
City of Coalinga IT Lab	454	% Area Point Count Few TEM & DS	Partial; were homogenized in 250 ml jar before prep. No mortar/pes	No
	Description of Structures: <u>Chrysotile</u>; aspect ratios 3:1; if no appearance of fibers, were not counted; non-asbestiform lizardite, antigorite were not counted. Verbal Comments by Lab: Lab performed analysis looking for fibrous materials. Lab uses point count as no standard written methodology exists for field estimation, noting that dups analyzed by other labs for other sites routinely give higher results than IT. (20 min./sample)			
Asbestos in Roads Study Med-Tox	18	% Area PLM-DS and TEM	Yes. Few seconds to 1 min/sample	Yes. Used a 200-mesh screen; interested in silt & coarse
	Description of Structures: <u>Chrysotile/antigorite</u>; contained fibrous chrysotile and other non-fibrous antigorite, picrolite; non-disaggregated, tightly-bound fibers of 3:1 aspect ratio. Sample analysis rushed which may have affected results.			
Globe, AZ TMA/EAL	Visual estimation used on all PLM samples; as microscopist no longer at lab for discussions, no follow-up possible.			
Copper Cove Roads Copperopolis EAL Lab	29	% Vol PLM-DS & few TEM	Yes. Sufficient time to reduce veins to free fibers for est. of total asbestos	No
	Structure of Concern/Lab Reports: <u>Chrysotile</u>; sample observed to have high concentrations of antigorite, lizardite, quartz, feldspar and misc. particles in samples of 30-70% chrysotile; grinding time key as concern was to quantify total asbestos content potentially available for release with high vehicular activity on roads.			
South Bay Asbestos Versar	11	% Area Stereo and few PLM-DS	No.	Yes. Used a sieve to separate .710, .355 and .250 mm fractions
	Description of Structures: <u>Chrysotile</u>; fibers with 3:1 aspect ratio; included free fibers and chrysotile associated with particulates; tightly-bound matts counted. <u>Serpentine</u>; contained chrysotile and other fibers; included non-asbestiform serpentine rock and serpentine-bound chrysotile.			
Quarry Samples Clayton Labs	50	% area Visual Est.	Yes, lightly	No
	Description of Structures: <u>Chrysotile</u>; counted aspect ratio 3:1, >5um length; looked for asbestiform characteristics.			

1) Sample number is the total number of soil samples reviewed for the purposes of this paper only and is a subset of the total samples taken at each site.

2) Analytical methods include: Point Count, Visual/field Estimation, PLM/Dispersion Staining, Stereomicroscopy and Transmission Electron Microscopy (TEM).

3 and 4) Grinding and sieving procedures are based on the written lab reports, if available, or on discussions with the microscopists.

SOIL RESULTS FOR ASSESSMENT OF ASBESTOS EXPOSURES AND RISK

Asbestos literature clearly indicates a correlation between the respirability and carcinogenicity of air-borne asbestos structures. Overall carcinogenicity of asbestos is determined by physical characteristics such as length, aspect ratio, aerodynamic diameter, and durability of the fibers. More specifically, penetration of fibers into the alveolar spaces of the lungs and correlation with increased incidences of asbestos-related disease appear to relate to the concentrations of fibers having both diameters of 0.025μm or less and lengths of more than 5 to 8μm.[9,10,13,28-32,39-44] Although shorter fibers (>5 μm) have been shown to be less carcinogenic than long, thin structures, short fibers appear to be biologically active with no known concentration below which there is no risk.[28,39-42,44-47] As stated by W. Nicholson in *Airborne Levels of Mineral Fibres in the Non-occupational Environment*, "Because of their much greater number, fibres >5 μm may be the dominant contributors to the cancer risk of a particular aerosol."[46] The issue of short fiber risk is particularly important for asbestos waste sites due to long-term exposures to low concentrations of predominantly shorter fibers. Other particulates and debris associated with the asbestos may also influence the biological activity of the fibers.[12] Unfortunately, definitive resolution of the issue of the carcinogenicity of short chrysotile fibers is very likely years away.[9,10,28-32,41]

Ideally, the end-use of the soil sampling data should determine both the sample preparation techniques and counting rules. As inhalation is the route of exposure posing the greatest risk, any friable portion of asbestos-laden soil is of potential concern. Fiber dimensions should be conserved in soil samples in order to extrapolate from occupational data to ambient air risks. Alteration of fiber size distribution by sample preparation should not be done unless total mass of asbestos is to be used as a measure of potential exposure. Changes in the fiber size distribution also reduce the usefulness of the soil data for comparison with air monitoring data. Additionally, soil results are often the basis for soil emission factors for lifetime risk models.[7,11,23,39,47-49] Wide ranges of soil results such as those presented in this paper lead to model outputs and risk calculations that can vary by many orders of magnitude. As the importance of quantification of risk and risk-based cleanup criteria increases in Superfund and the hazardous waste industry, precise quantification of asbestos soil concentrations and the determination of the relationships between those concentrations, emission models and risk become more critical goals. Risk-derived counting rules and analytical techniques should be established so that health experts make decisions about fibers of concern.

THE NEED FOR A STANDARDIZED, RISK-BASED ANALYTICAL METHOD

Asbestos experts and agencies nationwide see the need for additional research to determine a regulatory standard for ambient asbestos exposures and to solve some of the analytical problems discussed in this paper.[9,10,16,28,38] Although microscopist training and experience with PLM sample analysis greatly improve reproducibility and precision,[16] the laboratories interviewed for the purposes of this study recognize the need for more a specific protocol and a quality assurance program for PLM soil analysis.[16-38] Possibilities for a soil methodology include using a combination of techniques such as PLM-DS, X-ray diffraction and scanning electron microscopy.

TEM analysis of soils has been proposed by some as a conservative approach for measuring the total amount of asbestos that could potentially act as an emission source when the soil matrix is disturbed.[16,38,51] However, TEM analysis of soils may not be an affordable alternative to PLM for large investigations. Based on currently available technology, TEM may not be a useful measure of asbestos content if the results are to be used for quantification of risk or for inter-laboratory and site-to-site data comparisons. Some of the concerns about the use of TEM include the extrapolation from minute samples to total site characterization; the high costs associated with obtaining a statistically significant number of samples; the absence of a standardized written soil methodology; total asbestos mass being dominated by a few veins or large particles; and size fraction loss due to grinding for TEM sample preparation.[16,38,50-52] A comparison of the Atlas and Coalinga PLM and TEM data will be presented in a future paper, but initial data reviews indicate that TEM and PLM results have no apparent correlation.

In addition to analytical techniques, standardized sample preparation procedures, terminology and counting rules need to be specified. Immediately releasable asbestos fibers and maximum friable asbestos content might be used for calculating current and future potential risk, respectively. Reporting formats should be standardized to include, among others: descriptions of sample preparation, equipment used, optical properties, detailed descriptions of counting parameters, observed interferences, and comments. Quality assurance might include intra-laboratory checks and an inter-laboratory round robin program.

POLICY ISSUES

Considerable effort has been made by EPA, other regulatory agencies at the county and state levels, and private industry in search of appropriate analytical methodologies for soil sampling.[20,25,39,48,51,60] Moreover, non-standardized methodologies raise concerns associated with the lack of consistency for cleanup criteria, the defense of capital and maintenance costs for remediation, and the unclear risks to the public.

The 1988 EPA Report to Congress on asbestos-containing materials in buildings[61] suggests that EPA serve as a clearinghouse for evolving asbestos technical information related to public buildings. The report discusses the option of the Federal government supporting much of the research needed to fill the data gaps for regulating asbestos in buildings. The EPA Administrator's cover letter to the report states, "The nation's study and research program should be proportional to the magnitude of the public investment in controlling the problem which is contemplated." Asbestos regulation and remedial costs for NPL and non-NPL sites have similar financial impacts on all levels of government and private industry based on the number of abandoned asbestos sites identified to date (i.e. [39,57,59]). The costs of investigations and remediation at the existing NPL and removal sites alone will ultimately amount to millions of dollars. The magnitude of the potential expenditures at asbestos waste sites warrants a national investment in the development of sampling protocols to justify those costs and make technically sound decisions.

CONCLUSIONS

Many experts have called for improvements in methodologies for asbestos sampling and analytical techniques. Based on this study of the Atlas and Coalinga data and inter-laboratory variations at six other sites, a risk-based analytical methodology specifically designed for asbestos in soils is needed. Standardized sample preparation and analytical techniques, terminology, counting methodologies and data reporting formats are essential for reduction of variables for quantification of asbestos in soils. A nationwide inter-laboratory quality assurance program is recommended.

Until a standardized soil analytical methodology is developed, the currently available data base supports taking only limited soil samples for identification of spatial limits of asbestos contamination and for enforcement purposes. Sampling with the objective of quantifying asbestos concentrations, in particular as data input to air emission or risk modeling efforts, should be discouraged.

DISCLAIMER:

This paper does not in any way reflect the opinion of the U.S. EPA and should not be construed to represent official Agency policy.

ACKNOWLEDGEMENT

Special appreciation goes to Dan Cox of the FPE Group, and Laurie Mann and Melanie Field of the U.S. EPA for their help. Southern Pacific Land Company, Southern Pacific Transportation Company, and the U.S. Environmental Protection Agency financed the Superfund soil studies referenced in this document.

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Environmental Asbestos: Problems Associated with PLM Soil Analysis

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ABSTRACT

Experience with laboratories and a review of data generated through the Superfund process confirm a lack of standardized sample preparation techniques and counting rules using Polarized Light Microscopy for asbestos-laden soil samples. Variation in analytical procedures reduces comparability of data generated by different laboratories. The absence of a standardized analytical technique makes decision-making difficult and may be affecting remedial consistency from site to site. As such, PLM soil results should be limited in use to characterization of spatial boundaries of contamination and for preparation of qualitative risk assessments. Extrapolation from soils data to quantitative risk assessments is not recommended until an adequate standardized methodology for the analysis of asbestos in soils has been adopted. National research needs are highlighted.

INTRODUCTION

The U.S. EPA "Interim Method for the Determination of Asbestos in Bulk Insulation Samples" is specifically designed to estimate the concentrations of total asbestos content in building materials. Due to the lack of any other published methodology, this "Interim Bulk Method"[1,2] has become the industry standard for quantifying asbestos concentrations in soils. However, this technique has not been evaluated for accuracy or precision for soil analysis.

This study compares Polarized Light Microscopy (PLM) analyses from three laboratories used for the RI at the Atlas and Coalinga Asbestos sites. These data are compared with results from six other asbestos sites and the Research Triangle Institute (RTI) bulk asbestos round robin program. The review highlights the need for a standardized risk-based analytical methodology specifically designed for asbestos in soils. Until a method is developed, PLM soil sample results should not be relied upon to quantify asbestos concentrations for contaminant transport or risk assessment models.

The Atlas Asbestos Mine site is located within the New Idria serpentinite mass, a 50-mi.[2] serpentinite formation rich in chrysotile asbestos in California. The Coalinga Asbestos site is located just southeast of the New Idria formation and the Atlas site. Both sites contain abandoned asbestos mill facilities, tailings piles and associated open pit mines. These sites were listed on the NPL in 1984. The principal health concern is inhalation of air-borne asbestos-laden dust by local residents and site visitors.

SOIL ANALYSES BY POLARIZED LIGHT MICROSCOPY

(PLM) Soil samples for the Atlas and Coalinga Superfund sites were sent to three laboratories—EMS Laboratory, McCrone Environmental Services and Med-Tox Associates—for PLM analysis as specified by the EPA Interim Bulk Method. Each laboratory used the PLM "field of view" estimation technique to determine the asbestos content of soil samples.

Laboratory Consistencies

Data sheets and personal communications with the laboratories confirm that the microscopists generally agree on the overall identification of serpentine structures and mineral content in the Atlas and Coalinga soil samples.[3-8] The microscopists confirm the samples are more complex than typical chrysotile product samples. The soils contain high concentrations of chrysotile, antigorite, and lizardite, minerals having the same basic chemical formula ($Mg_3SiO_2O_5(OH)_4$) but different crystal structures. These minerals exist as polymorphs of each other and as both asbestiform and non-asbestiform aggregates.[4,9-15] The combination of minerals causes somewhat unusual optical properties such as higher refractive indices when compared to chrysotile from other ore bodies. Central stop dispersion staining colors observed by McCrone are noted to be more typically associated with antigorite, a non-fibrous form of serpentine.[5] EMS and McCrone both report gold to magenta dispersion staining colors.[16] To more accurately characterize the PLM-DS results, TEM was performed on a subset of samples. The analyses confirm that the serpentine minerals in the samples are principally chrysotile asbestos structures.[3-8,16]

ANALYTICAL DIFFERENCES BETWEEN LABORATORIES

There are four major variables in PLM analyses among the laboratories which are:

- Sample preparation prior to analysis
- Differences in analytical techniques
- Lack of standardized terminology and chrysotile/serpentine classification schemes
- Fundamental differences in counting rules

Sample Preparation

Sample preparation techniques differ among the laboratories, principally on sieving and the use of grinding by mortar and pestle.[3-6,8,14,16-19] The EMS samples are sieved and separated into fine (<2mm) and coarse fractions (>2mm); without grinding the fine fraction, the samples are prepared for PLM analysis. Based on the presence or absence of asbestos in the fine fraction, coarse fractions are lightly ground as necessary for analysis. McCrone sample preparation is similar to EMS and includes sieving samples into size fractions of gravel (<2mm), sand (50μm-2mm) and silt and clay (>50μm) without grinding. Sample preparation by Med-Tox includes lightly grinding soil samples for a few seconds to one minute each with a mortar and pestle (Table 1).

Table 1
Use of Grinding and Sieving Techniques for PLM Soil Sample Preparations

Site Name Laboratory Name	Grinding with Mortar/Pestle	Sieves
Atlas/Coalinga EMS	No	>2mm coarse <2mm fine
Atlas/Coalinga McCrone	No	Sieved 41/60 samples into >2mm gravel 50um-2mm sand <50um silt/clay
Atlas/Coalinga Med-Tox	Yes, mortar/pestle; few seconds to one minute/sample	No
City of Coalinga IT Lab	Yes, homogenized in 250 ml jars; no mortar/pestle	No
Asbestos in Roads Study Med-Tox	Yes, few seconds to one minute/sample	Yes, used a 200-mesh screen to separate silt & coarse fractions
Globe, Arizona TMA/EAL	Microscopist no longer at lab so follow-up no possible.	
Copper Cove Roads/ Copperopolis EAL Lab	Yes, sufficient time to reduce veins, etc. to free fibers/total asbestos measured	No
South Bay Asbestos Versar	No	Yes, used sieve to separate .710, .355 and .250 mm fraction
Quarry Samples Clayton	Yes, lightly	No

Table 2
Analytical Techniques for PLM Soil Analyses

Site Name Laboratory Name	Analytical Techniques
Atlas/Coalinga EMS Laboratory	PLM/DS Visual Estimates TEM
Atlas/Coalinga McCrone	PLM/DS Stereomicroscopy
Atlas/Coalinga Med-Tox	PLM/DS Visual Estimates TEM
City of Coalinga IT Lab	Point Count PLM/DS TEM
Asbestos in Roads Study Med-Tox	PLM/DS Visual Estimates TEM
Globe, Arizona TMA/EAL	Visual Estimates
Copper Cove Roads Copperopolis EAL Lab	PLM/DS TEM
South Bay Asbestos Versar	PLM/DS Stereomicroscopy
Quarry Samples	Visual Estimates

* Analytical methods include: Point Count, Visual/field of view estimation, PLM/Dispersion Staining, Stereomicroscopy and Transmission Electron Microscopy (TEM).

Since the EPA Interim Bulk Method states that sample preparation is "dependent upon the samples encountered and personal preferences" of the microscopist, each of these techniques is within the margin of acceptability for PLM sample preparation. Grinding, for example, is only one of the six acceptable means for obtaining a homogenous, representative subsample.[1,2] Further review of sample preparation techniques from other asbestos Superfund removal and remedial sites[20-26] indicates similarly widespread inter-laboratory variations in the use of sieving and grinding (Table 1).

Some bias due to grinding and sieving soils is expected, although the magnitude of the bias caused by the preparation differences is unknown without a standard for comparison.[16] It is well documented in asbestos studies that natural serpentine minerals and manufactured asbestos-laden products including chrysotile structures are easily broken into elongated cleavage fragments and free fibers by natural weathering processes, and by chemical or mechanical disturbances in vitro, in vivo and in the general environment.[9,10,27-36] McCrone's sample report, for example, notes that the matted fibers "displaced more pronounced fibrosity upon crushing."[5] This easily fragmented characteristic of chrysotile is an important factor in soil concentrations, and sample preparation should be standardized to eliminate this variable in the PLM analytical procedure.

Analytical Methods

In addition to sample preparation techniques, the wide range of asbestos content in these soils is due in part to the different analytical techniques employed by the laboratories (Table 2). All three laboratories use the "field of view" estimation technique with dispersion staining (PLM/DS). EMS and Med-Tox results are reported as per cent area.[3,4,6] McCrone analyzes by PLM/DS and stereomicroscopy, reporting results as per cent volume.[4,5] Of the other laboratories listed on Table 2, one uses the point count technique.[20] As the EPA Interim Bulk Method specifies use of point counting or "an equivalent estimation method," no standardization of methodology or units is assured.

Table 3
Terminology Used in PLM Soil Analyses Reports

Site Name Laboratory Name	Terminology Used for Structures of Concern
Atlas/Coalinga EMS Laboratory	Chrysotile
Atlas/Coalinga McCrone	Serpentine Asbestos
Atlas/Coalinga Med-Tox	Elongate Serpentine or Chrysotile
City of Coalinga IT Lab	Chrysotile
Asbestos in Roads Study Med-Tox	Chrysotile/Antigorite
Globe, Arizona TMA/EAL	Chrysotile
Copper Cove Roads Copperopolis EAL Lab	Chrysotile
South Bay Asbestos Versar	Chrysotile or Serpentine
Quarry Samples	Chrysotile

Terminology

Another variable identified in this study is a result of non-standardized classification schemes and terminology used by each laboratory for the observed serpentine or chrysotile structures. For spatially similar samples from the Atlas and Coalinga sites, the microscopists' morphological descriptions include: white matted plates; pale green elongated serpentine; lathe-shaped bundles; acicular fibers; rounded, somewhat flattened fragments; silky, wavy bundles; harder green, elongated chips; cleavage fragments and serpentine minerals.[3,4,5,6,16] The reported structures of concern include chrysotile, serpentine asbestos, and elongate serpentine, among others (Table 3). For the end-user of the soils data, this variability in terminology makes interpretation of results very difficult.

Counting Rules

Since inter-laboratory terminology is not standardized, differences in counting rules are difficult to assess. All three laboratories count structures with aspect ratios greater than or equal to 3:1. However, discussions with the microscopists show that counting rules beyond aspect ratio definition vary based on their understanding of the end-use of the data by the clients.

EMS counted only free chrysotile fibers that could easily become air-borne without mechanical disturbances of the soil matrices; the microscopist understood that the soil results were to be used as input to an air transport model, and therefore counted only free fibers.[3,16] McCrone reported chrysotile and all fibrous chrysotile-like minerals as "serpentine asbestos"; this category included particles such as fibrous grains, matted clumps of fibers and green elongated chips;[4,5,16] McCrone attempted to estimate the total friable asbestos content of the soils. Due to the non-standard mineralogical content of these samples, Med-Tox reported both "elongate serpentine" and "chrysotile asbestos" concentrations. Elongate serpentine was defined by Med-Tox as including all serpentine fragments including chrysotile, lizardite and antigorite; this category represented the Med-Tox estimate of the maximum asbestos content of the soils. "Chrysotile asbestos" was defined by Med-Tox as having classical chrysotile properties and included bundles of fibers.[4,6,16]

"Asbestos fibers" are defined in the EPA Interim Bulk Method as having an aspect ratio of 3:1 and being positively identified as an asbestos mineral based on six optical properties.[1] These three laboratory counting procedures, therefore, are within this margin of acceptability for the Interim PLM Bulk Method. Qualitatively, the EMS results appear to represent the immediately releasable asbestos content while the Med-Tox data probably estimate the maximum quantity of potentially releasable asbestos.

However, as there is no standardized terminology or inter-laboratory quality assurance program for asbestos in soils, the accuracy of the sample results is impossible to determine.

Sample Results

A partial yet representative subset of the Atlas and Coalinga soil data is presented in Tables 4 and 5. Med-Tox and McCrone split samples show high correlation and precision (Table 4). This agreement of analytical results can most likely be attributed to extensive communication with the client before analysis of the samples, thereby ensuring both laboratories were attempting to fulfill similar objectives.

The range of asbestos concentrations reported by EMS and Med-Tox highlights the need for standardization of the PLM method (Table 5). Since the EMS and Med-Tox samples are not splits, an exact comparison of data cannot be made. Nonetheless, precision of data for similar types of soils from spatially comparable locations would be expected to be better than the >1% to 85% range of asbestos measured.[3-8,16]

Table 4
Inter-laboratory Comparison of Atlas and Coalinga Split Soil Samples*

Lab	Med-Tox		McCrone
Soil Type	Elongate Serpentine % Area	Chrysotile Asbestos %Area	Serpentine Asbestos % Volume
Mine/Mill Tailings	80% 65%	60% 25%	85% 80%
Serpentine Formation	85%	50%	65%
Streambeds	15%	5%	32.5%
Alluvial Fan	1%	1%	1%

* The Med-Tox and McCrone data are from split samples. These five samples from five soil types (i.e. mill tailings, streambeds, etc.) are representative of the 60 samples reviewed for this study.

Table 5
Results of Non-split, Spatially Comparable Samples from the Atlas and Coalinga Sites*

Lab	EMS	Med-Tox	
Soil Type	Chrysotile Asbestos % Area	Elongate Serpentine % Area	Chrysotile Asbestos %Area
Mine/Mill Tailings	<1% 1%	80% 65%	60% 25%
Serpentine Formation	1%	85%	50%
Streambeds	<1%	15%	5%
Alluvial Fan	<1%	1%	1%

* These five EMS and Med-Tox samples are not splits of the identical soil samples. However, the EMS and Med-Tox sample locations are spatially comparable as listed under "soil type" and should have a lower range of asbestos content. This range is representative of the 64 EMS and 60 Med-Tox sample results reviewed for this study.

EPA INTERIM METHOD FOR INSULATION VERSUS SOIL SAMPLES

The Research Triangle Institute (RTI) December 1987 Bulk Analysis Round acceptance criteria for asbestos content of building material split samples ranges from <1% to 80% area.[17] Similar ranges of acceptability can be seen in all other rounds as well. RTI describes the laboratory performances as assessed on the basis of correct identification of "positive" (containing < or = 1% asbestos) and "negative" (> or = 1% asbestos) or false negatives using the Interim Bulk Method. "Although the criteria are lenient," the RTI report states, "they recognize the basic concern of the public—the presence or absence of asbestos fibers in a submitted sample." The Interim Bulk Method was designed for use as a screening tool, recognizing the typical asbestos content and size range of insulation and building materials (generally 5-20% asbestos and longer fibers). Identification of the presence or absence of asbestos is the current goal, not precise quantification of asbestos content. However, in order to use soil data for hazardous waste site characterization and as input to risk assessments, accurate quantification of the asbestos content becomes the goal.

The ASTM is in the process of peer reviewing a more quantitative PLM bulk analytical methodology for insulation materials. This effort and the RTI round robin program may improve quantitation.[16,38]

However, a more quantitative methodology for bulk insulation is not sufficient for analysis of asbestos content in soils. The RTI round robin and building samples are more homogenous than is commonplace with environmental asbestos samples. Soils containing high concentrations of non-asbestiform serpentine material, cellulose, particulates and other interferences can cause difficulties in conclusive identification of chrysotile fibers by skilled microscopists.[33,35,36] The limits of optical resolution of light microscopy do not allow short or narrow fibers to be easily quantified.[16,38] Moreover, TEM soil samples and air monitoring data from the Atlas and Coalinga sites confirm that short fibers are typical of the asbestos deposits in the New Idria

Formation. In light of these and other differences between insulation materials and soil samples, the use of the Interim Bulk Method may be inappropriate for quantitation of asbestos in soils.

Table 6
Summary of Inter-laboratory Comparisons of PLM Sample Preparation and Analytical Techniques

Site Name / Lab Name	No. Samples (1)	Analy. Method (2)	Sample Prep Grinding (3)	Sieves (4)
Atlas/Coalinga EMS	64	% Area Visual PLM/DS TEM	No	>2mm coarse <2mm fine
	Description of Structures: <u>Chrysotile</u>; free fibers of 3:1 aspect ratio; large, non-fibrous, nonrespirable particles not counted even if could see veins Comments by Lab: Strong evidence of fibrous material in serpentine; attempted to estimate abestos available for immediate release, not total serpentine-bound chrysotile. Understood data to be used as input to air transport model. (1-2 hrs/sample)			
McCrone	60	% Vol PLM/DS Stereo	No	Sieved 41/60 >2mm gravel 50um-2mm sand <50um silt/cl
	Description of Structures: <u>Serpentine Asbestos</u>; plates of matted serpentine represented the dominant morphology of asbestos; less abundant, harder green elongated chips became more fibrous when crushed at 40X. (1-2 hrs/sample)			
(A/C cont.) Med-Tox	60	% Area Visual PLM/DS TEM	Yes. Mortar & pestle; seconds to 1 min/sample	No
	Description of Structures/Comments by Lab: <u>Elongate Serpentine</u>; only particles with 3:1 aspect ratio, including antigorite, lizardite and chrysotile. Includes non-asbestiform structures and is probably maximum releasable asbestos in samples. <u>Chrysotile</u>; definite chrysotile only with 3:1 aspect ratio; includes bundles with fibrous split ends. (1-3 hrs/sample)			
City of Coalinga IT Lab	454	% Area Point Count Few TEM & DS	Partial; were homogenized in 250 ml jar before prep. No mortar/pes	No
	Description of Structures: <u>Chrysotile</u>; aspect ratios 3:1; if no appearance of fibers, were not counted; non-asbestiform lizardite, antigorite were not counted. Verbal Comments by Lab: Lab performed analysis looking for fibrous materials. Lab uses point count as no standard written methodology exists for field estimation, noting that dups analyzed by other labs for other sites routinely give higher results than IT. (20 min./sample)			
Asbestos in Roads Study Med-Tox	18	% Area PLM-DS and TEM	Yes. Few seconds to 1 min/sample	Yes. Used a 200-mesh screen; interested in silt & coarse
	Description of Structures: <u>Chrysotile/antigorite</u>; contained fibrous chrysotile and other non-fibrous antigorite, picrolite; non-disaggregated, tightly-bound fibers of 3:1 aspect ratio. Sample analysis rushed which may have affected results.			
Globe, AZ TMA/EAL	Visual estimation used on all PLM samples; as microscopist no longer at lab for discussions, no follow-up possible.			

(Table 6 Continued)

Site Name / Lab Name	No. Samples (1)	Analy. Method (2)	Sample Prep Grinding (3)	Sieves (4)
Copper Cove Roads Copperopolis EAL Lab	29	% Vol PLM-DS & few TEM	Yes. Sufficient time to reduce veins to free fibers for est. of total asbestos	No
	Structure of Concern/Lab Reports: <u>Chrysotile</u>; sample observed to have high concentrations of antigorite, lizardite, quartz, feldspar and misc. particles in samples of 30-70% chrysotile; grinding time key as concern was to quantify total asbestos content potentially available for release with high vehicular activity on roads.			
South Bay Asbestos Versar	11	% Area Stereo and few PLM-DS	No.	Yes. Used a sieve to separate .710, .355 and .250 mm fractions
	Description of Structures: <u>Chrysotile</u>; fibers with 3:1 aspect ratio; included free fibers and chrysotile associated with particulates; tightly-bound matts counted. <u>Serpentine</u>; contained chrysotile and other fibers; included non-asbestiform serpentine rock and serpentine-bound chrysotile.			
Quarry Samples Clayton Labs	50	% area Visual Est.	Yes, lightly	No
	Description of Structures: <u>Chrysotile</u>; counted aspect ratio 3:1, >5um length; looked for asbestiform characteristics.			

1) Sample number is the total number of soil samples reviewed for the purposes of this paper only and is a subset of the total samples taken at each site.

2) Analytical methods include: Point Count, Visual/field Estimation, PLM/Dispersion Staining, Stereomicroscopy and Transmission Electron Microscopy (TEM).

3 and 4) Grinding and sieving procedures are based on the written lab reports, if available, or on discussions with the microscopists.

SOIL RESULTS FOR ASSESSMENT OF ASBESTOS EXPOSURES AND RISK

Asbestos literature clearly indicates a correlation between the respirability and carcinogenicity of air-borne asbestos structures. Overall carcinogenicity of asbestos is determined by physical characteristics such as length, aspect ratio, aerodynamic diameter, and durability of the fibers. More specifically, penetration of fibers into the alveolar spaces of the lungs and correlation with increased incidences of asbestos-related disease appear to relate to the concentrations of fibers having both diameters of 0.025µm or less and lengths of more than 5 to 8µm [9,10,13,28-32,39-44] Although shorter fibers (>5 µm) have been shown to be less carcinogenic than long, thin structures, short fibers appear to be biologically active with no known concentration below which there is no risk.[28,39-42,44-47] As stated by W. Nicholson in *Airborne Levels of Mineral Fibres in the Non-occupational Environment*, "Because of their much greater number, fibres >5 µm may be the dominant contributors to the cancer risk of a particular aerosol."[46] The issue of short fiber risk is particularly important for asbestos waste sites due to long-term exposures to low concentrations of predominantly shorter fibers. Other particulates and debris associated with the asbestos may also influence the biological activity of the fibers.[12] Unfortunately, definitive resolution of the issue of the carcinogenicity of short chrysotile fibers is very likely years away.[9,10,28-32,41]

Ideally, the end-use of the soil sampling data should determine both the sample preparation techniques and counting rules. As inhalation is the route of exposure posing the greatest risk, any friable portion of asbestos-laden soil is of potential concern. Fiber dimensions should be conserved in soil samples in order to extrapolate from occupational data to ambient air risks. Alteration of fiber size distribution by sample preparation should not be done unless total mass of asbestos is to be used as a measure of potential exposure. Changes in the fiber size distribution also reduce the usefulness of the soil data for comparison with air monitoring data. Additionally, soil results are often the basis for soil emission factors for lifetime risk models.[7,11,23,39,47-49] Wide ranges of soil results such as those presented in this paper lead to model outputs and risk calculations that can vary by many orders of magnitude. As the importance of quantification of risk and risk-based cleanup criteria increases in Superfund and the hazardous waste industry, precise quantification of asbestos soil concentrations and the determination of the relationships between those concentrations, emission models and risk become more critical goals. Risk-derived counting rules and analytical techniques should be established so that health experts make decisions about fibers of concern.

THE NEED FOR A STANDARDIZED, RISK-BASED ANALYTICAL METHOD

Asbestos experts and agencies nationwide see the need for additional research to determine a regulatory standard for ambient asbestos exposures and to solve some of the analytical problems discussed in this paper. [9,10,16,28,38] Although microscopist training and experience with PLM sample analysis greatly improve reproducibility and precision,[16] the laboratories interviewed for the purposes of this study recognize the need for more a specific protocol and a quality assurance program for PLM soil analysis.[16-38] Possibilities for a soil methodology include using a combination of techniques such as PLM-DS, X-ray diffraction and scanning electron microscopy.

TEM analysis of soils has been proposed by some as a conservative approach for measuring the total amount of asbestos that could potentially act as an emission source when the soil matrix is disturbed.[16,38,51] However, TEM analysis of soils may not be an affordable alternative to PLM for large investigations. Based on currently available technology, TEM may not be a useful measure of asbestos content if the results are to be used for quantification of risk or for inter-laboratory and site-to-site data comparisons. Some of the concerns about the use of TEM include the extrapolation from minute samples to total site characterization; the high costs associated with obtaining a statistically significant number of samples; the absence of a standardized written soil methodology; total asbestos mass being dominated by a few veins or large particles; and size fraction loss due to grinding for TEM sample preparation.[16,38,50-52] A comparison of the Atlas and Coalinga PLM and TEM data will be presented in a future paper, but initial data reviews indicate that TEM and PLM results have no apparent correlation.

In addition to analytical techniques, standardized sample preparation procedures, terminology and counting rules need to be specified. Immediately releasable asbestos fibers and maximum friable asbestos content might be used for calculating current and future potential risk, respectively. Reporting formats should be standardized to include, among others: descriptions of sample preparation, equipment used, optical properties, detailed descriptions of counting parameters, observed interferences, and comments. Quality assurance might include intra-laboratory checks and an inter-laboratory round robin program.

POLICY ISSUES

Considerable effort has been made by EPA, other regulatory agencies at the county and state levels, and private industry in search of appropriate analytical methodologies for soil sampling.[20,25,39,48,51,60] Moreover, non-standardized methodologies raise concerns associated with the lack of consistency for cleanup criteria, the defense of capital and maintenance costs for remediation, and the unclear risks to the public.

The 1988 EPA Report to Congress on asbestos-containing materials in buildings[61] suggests that EPA serve as a clearinghouse for evolving asbestos technical information related to public buildings. The report discusses the option of the Federal government supporting much of the research needed to fill the data gaps for regulating asbestos in buildings. The EPA Administrator's cover letter to the report states, "The nation's study and research program should be proportional to the magnitude of the public investment in controlling the problem which is contemplated." Asbestos regulation and remedial costs for NPL and non-NPL sites have similar financial impacts on all levels of government and private industry based on the number of abandoned asbestos sites identified to date (i.e. [39,57,59]). The costs of investigations and remediation at the existing NPL and removal sites alone will ultimately amount to millions of dollars. The magnitude of the potential expenditures at asbestos waste sites warrants a national investment in the development of sampling protocols to justify those costs and make technically sound decisions.

CONCLUSIONS

Many experts have called for improvements in methodologies for asbestos sampling and analytical techniques. Based on this study of the Atlas and Coalinga data and inter-laboratory variations at six other sites, a risk-based analytical methodology specifically designed for asbestos in soils is needed. Standardized sample preparation and analytical techniques, terminology, counting methodologies and data reporting formats are essential for reduction of variables for quantification of asbestos in soils. A nationwide inter-laboratory quality assurance program is recommended.

Until a standardized soil analytical methodology is developed, the currently available data base supports taking only limited soil samples for identification of spatial limits of asbestos contamination and for enforcement purposes. Sampling with the objective of quantifying asbestos concentrations, in particular as data input to air emission or risk modeling efforts, should be discouraged.

DISCLAIMER:

This paper does not in any way reflect the opinion of the U.S. EPA and should not be construed to represent official Agency policy.

ACKNOWLEDGEMENT

Special appreciation goes to Dan Cox of the FPE Group, and Laurie Mann and Melanie Field of the U.S. EPA for their help. Southern Pacific Land Company, Southern Pacific Transportation Company, and the U.S. Environmental Protection Agency financed the Superfund soil studies referenced in this document.

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SUMMARY OF RESULTS FROM THE ATLAS/COALINGA RI:

- o Quantification: Quantification of asbestos levels in soil, water and air have wide ranges due to problems with the analytical techniques for asbestos; all ranges will be presented in the final RI. No "black and white" decisions can be made based on data or risk models.

- o Air Results: Almost no asbestos blows directly off the sites without mechanical disturbances (ORV, hunters, cattle). Activities on the mine tailings poses a high inhalation risk for bikers, hunters, etc. (10-100 visitors to area each day); forty hunters buy permits to be in the area and have keys to areas.

- o Soil Results: Soil results from similar samples range from ND to 98% due to quantification problems with asbestos analytical techniques.

- o Water Results: Concentrations very high but almost all short fibers. Concentrations above the mine site is greater than what is running off the Coalinga mine .

  ~~MCLG: Exceeding the MCLG by discharging flood waters into~~ the California Aqueduct from Los Gatos Creek is not likely. To be conservative and to respond to the public EPA will order that asbestos-laden flood waters cannot be discharged into the aqueduct.

- o Asbestos from NPL Sites via Water Pathway: Model efforts show 5-37% of the asbestos entering the creeks comes directly from the sites, depending on model effort.

  Contributions

Atlas only:	30% of asbestos carried to Huron via surface water pathway; PRP estimates 4% from Atlas.
Coalinga only:	5% of waterborn asbestos carried to Huron; Coalinga contribution lower than Atlas primarily due to a small non-permanent retention dam below the site and temporary stream diversion; PRP estimates .5% from Coalinga.
Other mines:	48-58% maximum according to EPA contractor model.
Natural:	6-10% of asbestos carried to Huron via surface water transport.

- o Natural Runoff: Differentiation between natural and mined asbestos is not possible. Both SPLC's consultants and labs and EPA staff and contractors have concluded this.

The Con se pot. opts.

Feasibility Study Analysis of Remedial Alternatives

Alternative #1:

- o No Remedial Action
- o Continued Monitoring Program for the Atlas site including streamwater and airborne asbestos sampling, and aerial photographic reviews

Present worth costs over 30 years: $833,200

Alternative #2:

- o Restrict access to Atlas site by fencing mines and stockpile areas

Construction capital costs:	$473,600	
O&M costs:	87,600	(n=30 years)
~~Present worth costs:~~	~~561,200~~	

Alternative #3:

- o Interception and diversion of run-on surface waters upstream of mines and stockpiles
- o Minimally-intrusive improvements to surface drainage of mines and stockpile areas
- o Run-off and sediment retention dams at mines and stockpile areas
- o Fence mines and stockpile areas

Total capital costs:	$3,943,000	
O&M present worth:	285,900	(n=30 years)
Total present worth:	4,228,900	

Alternative #4: (Extension of Alternative #3)

- o Complete regrading and engineered improvements to surface drainage of mines and stockpile areas
- o Interception and diversion of run-on surface waters upstream of mines and stockpiles
- o Run-off and sediment retention dams at mines and stockpile areas
- o Fence mines and stockpile areas

Construction capital costs:	$9,115,900	
O&M present worth:	285,900	
Total present worth:	9,401,800	

Alternative #5:

- o Construct vegetated soil cap on mine surfaces and stockpiles
- o Intercept and divert run-on surface waters upstream of mines and stockpiles
- o Fence mines and stockpiles

Construction capital total:	$14,334,600	
O&M present worth:	285,900	(n=30 years)
Total present worth:	$14,620,500	

Alternative #6:

- o Completely excavate, chemically fixate and replace on-site waste material

Construction capital costs:	$103,335,800	(n=4 years)
O&M present worth:	137,400	(n=30 years)
Total present worth:	103,473,200	

Alternative #7:

- Removal of waste material to Class I landfill facility

  Present worth costs: $243,326,000 (n=10 years)

Alternatvie #8:

- Construction of dam at White Creek
- Costs based on reports by DWR; not enough information is available at this time to predict accuracy of capital costs versus yearly O&M estimates, but this analysis is useful for comparitive purposes.

  Present worth costs including 100-year O&M $16,500,000

Alternative #9:

- Enlarge existing ponding basin in Huron
- Would be suggested as a recommendation to BOR/DWR

Land aquisition:	$28,490,000	
Construction:	26,290,000	
Total Capital:	54,780,000	
O&M Present worth:	25,365,000	(n=30 yrs)
Total Present worth:	$80,145,000	

Notes:

- high costs are associated with importation of water supplies for dust suppression costs/wetting soil to satisfy NESHAP; hauling rates for borrow sources due to elevation gain with sources assumed near Los Gatos Creek; remote location of sites includes a margin for cost error in contingencies, etc.
- assuming no RCRA soil cap; only 6" vegetated cover
- assuming very little level C/respirator use due to wetting soils
- assuming heavy equipment with positive pressure ventilation