Libby Asbestos Superfund Site
Residential and Commercial Properties
Operable Unit 4
Libby, Montana

Remedial Investigation Report

Contract No. W9128F-11-D-0023
Task Order No.: 0003 and 0007

June 2014

Prepared for:

U.S. Environmental Protection Agency
Region 8
1595 Wynkoop Street
Denver, Colorado 80202

Prepared by:

CDM Federal Programs Corporation
555 17th Street, Suite 1200
Denver, Colorado 80202

Under a contract with:

U.S. Army Corps of Engineers
Omaha District
Offutt AFB, Nebraska 68113

This page left blank intentionally

Libby Asbestos Superfund Site,
Libby, Montana
Remedial Investigation Report
Residential and Commercial Properties
Operable Unit 4

Approved by: _____ Date: 6/25/14

Elizabeth Fagen, P.E.
U.S. EPA, Region VIII, Libby OU4 Remedial Project Manager

Approved by: _____ Date: 6/19/14

Rebecca Thomas
U.S. EPA, Region 8, Libby Project Team Leader

DARLING.MARY.N.1231359717 Digitally signed by DARLING.MARY.N.1231359717
DN: c=US, o=U.S. Government, ou=DoD, ou=PKI, ou=USA, cn=DARLING.MARY.N.1231359717
Date: 2014.06.19 16:21:51 -05'00'

Approved by: _____ Date: _____

Mary Darling, RA, PMP
U.S. Army Corps of Engineers, Project Manager

This page left blank intentionally

Table of Contents

Section 1 Introduction 1-1

1.1 Report Organization 1-1
1.2 Site Background 1-2
1.3 Regulatory History 1-3
1.4 Operable Unit 4 Study Boundary 1-6
1.5 LA Characteristics 1-7
1.6 Health Effects 1-7

Section 2 Data Collection and Management 2-1

2.1 Sampling Overview 2-1
2.2 Site Databases 2-1
2.2.1 Libby2 Database 2-1
2.2.2 Scribe Database 2-2
2.2.3 Response Manager 2-2
2.3 Data Attributes 2-2
2.4 Excluded Datasets 2-3
2.4.1 Health and Safety Samples 2-3
2.4.2 Outdoor Air Removal Samples 2-3
2.4.3 Quality Control Samples and Analyses 2-3
2.4.4 Invalid/Rejected Database Results 2-4
2.5 Analytical Methods 2-4
2.5.1 PLM 2-5
2.5.1.1 PLM-9002 2-5
2.5.1.2 Libby-Specific PLM 2-5
2.5.2 PCM 2-7
2.5.3 TEM 2-7
2.5.3.1 TEM AHERA 2-8
2.5.3.2 ASTM D5755 2-8
2.5.3.3 TEM ISO 2-9
2.5.4 EPA Methods 2-10
2.5.4.1 EPA 100.2 2-10
2.5.4.2 EPA 600 2-10
2.6 Quality Assurance/Quality Control 2-11

Section 3 Site Study Area Investigation and Removal Actions 3-1

3.1 Phase 1 Investigation 3-1
3.1.1 Initial Phase 1 Investigation 3-1
3.1.2 Subsequent Phase 1 Investigation 3-3
3.2 Phase 2 Investigation 3-4
3.2.1 Objectives and Conclusions 3-4
3.2.2 Study Design 3-6
3.2.3 Air Results 3-7
3.2.3.1 Stationary/Personal Air Samples 3-7
3.2.3.2 Real-Time Aerosol Monitors 3-8
3.2.4 Source Media Results 3-8

3.3 Contaminant Screening Study 3-9
3.3.1 2002 Study Design 3-9
3.3.2 2003 Study Design 3-9
3.3.3 Results 3-10
3.4 Contamination Assessments at Specialty Properties 3-11
3.4.1 Kootenai Bluffs Subdivision 3-11
3.4.2 Kootenai Valley Head Start 3-12
3.4.3 Libby Elementary School 3-12
3.4.4 Libby Middle School 3-13
3.4.5 Libby High School 3-14
3.4.6 Libby School District Administration Building 3-15
3.4.7 McGrade Center 3-15
3.4.8 Cemetery Park Ball Fields 3-16
3.4.9 St. John's Rehabilitation Center and Helipad Field 3-17
3.4.10 Libby Drive-In Theater 3-17
3.4.11 Cabinet View Country Club 3-18
3.4.12 J. Neils Park 3-18
3.4.13 City of Libby Alleys 3-19
3.4.14 Creeks 3-20
3.4.14.1 Flower Creek 3-20
3.4.14.2 Granite Creek 3-21
3.4.14.3 Pipe Creek (Lower Section) 3-21
3.4.14.4 Libby Creek 3-21
3.4.14.5 Other OU4 Creeks 3-22
3.4.15 Highway 37 Embankment 3-22
3.4.16 Johnston Acres Subdivision 3-22
3.4.17 Former Concrete Plant 3-23
3.4.18 Former Landfill 3-24
3.4.19 Lincoln County Landfill 3-24
3.4.19.1 Air 3-25
3.4.19.2 Soil 3-25
3.4.19.3 Asbestos Cell Capacity 3-26
3.4.20 Borrow Sources 3-27
3.4.20.1 Fill Material Parameters 3-27
3.4.20.2 Fill Material Sampling 3-28
3.4.20.3 Borrow Source and Fill Material Locations 3-29
3.4.21 Periodic Monitoring at Project-Related Facilities 3-29
3.5 Natural Resource Conservation Service 3-30
3.6 Sediment Core Pilot Study 3-30
3.7 Post Cleanup Evaluation Study 3-30
3.8 Supplemental Remedial Investigation 3-31
3.8.1 Overview 3-31
3.8.2 Results 3-32
3.8.3 Conclusions 3-33
3.9 Cumulative Exposure Assessment 3-35
3.10 Ambient Air Program 3-35
3.10.1 2000 to 2003 Summary 3-35
3.10.1.1 Results 3-36

3.10.1.2 Conclusions 3-36
3.10.2 2006 to 2008 Summary....3-37
3.10.2.1 Results 3-38
3.10.2.2 Conclusions 3-38
3.10.3 2010 to 2013 Summary....3-38
3.10.3.1 Results 3-40
3.10.3.2 Conclusions 3-40
3.11 Demolition Study 3-40
3.11.1 Monitoring Activities....3-40
3.11.2 2005 Building Demolitions Results....3-41
3.11.3 2006 Building Demolitions Results....3-42
3.11.4 Conclusions....3-42
3.12 Dust Pilot Study 3-43
3.13 Creek Activity-Based Sampling....3-45
3.14 Residential Activity-Based Sampling 3-46
3.14.1 2007-2008 Residential Activity-Based Sampling....3-46
3.14.1.1 Indoor Activity-Based Sampling....3-47
3.14.1.2 Property Selection....3-47
3.14.1.3 Soil Collection....3-48
3.14.1.4 Scripted Activities....3-48
3.14.1.5 Air Sampling....3-49
3.14.1.6 Dust Sampling 3-49
3.14.1.7 Outdoor Activity-Based Sampling 3-49
3.14.1.8 Property Selection....3-49
3.14.1.9 Scripted Activities....3-50
3.14.1.10 Air Sampling....3-51
3.14.1.11 Soil Sampling....3-51
3.14.1.12 Soil Condition Data....3-51
3.14.1.13 Results 3-51
3.14.1.14 Conclusions....3-52
3.14.2 Experimental ABS Air Samples 3-53
3.14.3 2010 Residential Activity-Based Sampling....3-53
3.14.3.1 Study Design 3-53
3.14.3.2 Supplemental Analysis 3-56
3.14.3.3 Results 3-56
3.14.3.4 Conclusions 3-57
3.14.4 2011 Residential Activity-Based Sampling....3-58
3.14.4.1 Study Design 3-58
3.14.4.2 Results 3-60
3.14.4.3 Conclusions 3-60
3.14.5 2013 Residential Activity-Based Sampling....3-61
3.14.5.1 Study Design 3-61
3.14.5.2 Results 3-62
3.14.5.3 Conclusions 3-62
3.15 USGS Background Soil Study....3-63
3.16 School Investigation 3-64
3.16.1 Kootenai Valley Head Start 3-65
3.16.2 Libby Elementary School....3-65

3.16.3 Libby Middle School 3-65
3.16.4 Libby High School 3-66
3.16.5 Libby School District Administration Building 3-66
3.17 School Activity-Based Sampling 3-66
3.17.1 Kootenai Valley Head Start 3-67
3.17.2 Libby Elementary School 3-67
3.17.3 Libby Middle School 3-68
3.17.4 Libby High School 3-68
3.17.5 Libby School District Administration Building 3-68
3.18 Limited-Use Area Activity-Based Sampling 3-69
3.19 Woodchip Activity-Based Sampling 3-70
3.20 Background and Borrow Source Activity-Based Sampling 3-71
3.20.1 Background Soil ABS Investigation 3-71
3.20.2 Borrow Soil ABS Investigation 3-71
3.20.3 Results 3-71
3.21 Nature and Extent of LA in Tree Bark and Duff from the Forest 3-72
3.22 Nature and Extent of LA in Surface Water and Sediment 3-73
3.23 Tradesperson Activity-Based Sampling 3-74
3.24 Woodstove Ash Activity-Based Sampling 3-75
3.25 Flowerbed Sampling 3-77
3.26 Water Source Study 3-78
3.26.1 Phase I (Low Flow) Study 3-79
3.26.2 Phase II (High Flow) Study 3-80
3.26.3 Results 3-80
3.27 Comparative Exposure Activity-Based Sampling 3-81
3.28 Tissue Assessment 3-81
3.29 Porewater in the Tributaries 3-83
3.30 Removal Status 3-84
3.30.1 Removal Action Decision Criteria 3-84
3.30.2 Property Organization and Classification 3-84
3.30.3 Numbers of Properties 3-85
3.31 Property Inspections 3-85
3.31.1 Soil 3-86
3.31.2 Dust 3-88
3.31.3 Bulk Materials 3-88
3.32 Pre-Design Inspections/General Property Inspections at Specialty Properties 3-88
3.32.1 Kootenai Valley Head Start 3-89
3.32.2 Libby Elementary School 3-89
3.32.3 Libby Middle School 3-90
3.32.4 Libby High School 3-90
3.32.5 Libby School District Administration Building 3-90
3.32.6 St. John's Rehabilitation Center and Helipad Field 3-91
3.32.7 Cabinet View Country Club 3-91
3.32.8 Alleys 3-92
3.32.9 Creeks 3-92
3.32.9.1 Flower Creek 3-92
3.32.9.2 Granite Creek 3-92
3.32.9.3 Pipe Creek 3-92

3.32.9.4 Libby Creek 3-93
3.32.10 Former Concrete Plant 3-93
3.33 Removal Actions 3-93
3.33.1 Clearance Criteria 3-93
3.33.2 Indoor Removal Actions 3-94
3.33.2.1 Areas of Exposed Vermiculite Insulation 3-94
3.33.2.2 Building Material Demolition 3-95
3.33.2.3 Interior Cleaning 3-95
3.33.2.4 Indoor Soils 3-96
3.33.3 Outdoor Removal Actions 3-96
3.33.4 Structure Demolition 3-97
3.33.5 Disposal of Contaminated Materials 3-97
3.33.6 Completed Properties 3-97
3.34 Removal Actions at Specialty Properties 3-98
3.34.1 Libby High School 3-98
3.34.2 Kootenai Valley Head Start 3-99
3.34.3 Libby Middle School 3-100
3.34.4 Libby Elementary School 3-101
3.34.5 Kootenai Bluffs Subdivision 3-101
3.34.6 Cemetery Park Ball Fields 3-101
3.34.7 Libby School District Administration Building 3-101
3.34.8 Johnston Acres Subdivision 3-101
3.34.9 St. John's Rehabilitation Center and Helipad Field 3-102
3.34.10 J. Neils Park 3-102
3.34.11 City of Libby Alleys 3-102
3.34.12 Creeks 3-103
3.34.13 Former Concrete Plant 3-104
3.34.14 Cabinet View Country Club 3-104

Section 4 Physical Characteristics of the Study Area 4-1

4.1 Physical Setting 4-1
4.2 Climate 4-1
4.3 Surface Water Hydrology 4-2
4.4 Geology and Soils 4-2
4.5 Hydrogeology 4-4
4.6 Demography and Land Use 4-5
4.7 Ecology 4-6
4.7.1 Terrestrial Animals 4-6
4.7.2 Terrestrial Plants 4-6
4.7.3 Presence of Threatened, Endangered, and Protected Species 4-6

Section 5 Nature and Extent of Contamination 5-1

5.1 Indoor Air 5-1
5.2 Outdoor Air 5-1
5.2.1 Ambient Air 5-1
5.2.2 Outdoor ABS Air 5-1
5.3 Vermiculite Insulation 5-1
5.4 Bulk Materials 5-2
5.5 Indoor Dust 5-2

5.6 Surface Soil 5-3
5.7 Subsurface Soil 5-3
5.8 Sediment 5-3
5.9 Surface Water 5-4
5.10 Groundwater 5-4
5.11 Porewater 5-4
5.12 Tree Bark and Duff in the Forest 5-4
5.13 Tissue 5-4

Section 6 Contaminant Fate and Transport 6-1

6.1 Releases to the Environment 6-1
6.2 Transport and Deposition 6-1
6.3 Transformation and Degradation in the Environment 6-2

Section 7 Risk Assessment 7-1

Section 8 Summary and Conclusions 8-1

8.1 Summary 8-1
8.1.1 Background 8-1
8.1.2 Investigations 8-1
8.1.3 Property Category Status 8-2
8.1.4 Removal Status 8-2
8.1.5 Potential Data Gaps 8-3
8.1.5.1 Uncharacterized Properties 8-3
8.1.5.2 Partially-Characterized Properties 8-3
8.1.5.3 Properties Outside Current OU4 NPL Boundary 8-3
8.1.5.4 Visible Vermiculite in Soils 8-3
8.1.5.5 Potential Exposure Pathways 8-4
8.2 Conclusions 8-4

Section 9 References 9-1

List of Tables

2-1 Libby OU4 Sampling Event Descriptions
2-2 PLM-VE Bin Classification
3-1 Initial Phase I Investigation
3-2 Subsequent Phase I Investigation
3-3 Phase II Investigation Air
3-4 Phase II Investigation Source Materials
3-5 Contaminant Screening Study
3-6 Kootenai Bluffs Subdivision Investigation
3-7 Kootenai Valley Head Start/Plummer Elementary Investigation
3-8 Libby Elementary Investigation
3-9 Libby Middle School Investigation
3-10 Libby High School Investigation
3-11 Libby School District Administration Building Investigation
3-12 McGrade Center Investigation

3-13 Cemetery Park Ball Fields Investigation
3-14 St. John's Rehabilitation Center and Helipad Field Investigation Results
3-15 Libby Drive-In Theater Investigation
3-16 Contamination at Specialty Properties – Cabinet View Country Club
3-17 Contamination at Specialty Properties – J. Neils Park
3-18 Contamination at Specialty Properties – City of Libby Alleys
3-19 Contamination at Specialty Properties – Creeks
3-20 Contamination at Specialty Properties - Highway 37 Embankment
3-21 Contamination at Specialty Properties – Johnston Acres Subdivision
3-22 Contamination at Specialty Properties – Former Concrete Plant
3-23 Contamination at Specialty Properties – Former Landfill
3-24 Contamination at Specialty Properties – Lincoln County Landfill
3-25 Contamination at Specialty Properties – Borrow Sources
3-26 Contamination at Specialty Properties – Periodic Monitoring at Project-Related Facilities
3-27 Post Cleanup Evaluation Study
3-28 Supplemental RI (SQAPP)
3-29 Ambient Air
3-30 Demolition Study
3-31 2007-2008 Residential Activity-Based Sampling
3-32 2010 Residential Activity-Based Sampling
3-33 2011 Residential Activity-Based Sampling
3-34 2013 Residential Activity-Based Sampling
3-35 Schools Investigation
3-36 Public Schools ABS Investigation
3-37 Limited Use Area Activity-Based Sampling
3-38 Woodchip Activity-Based Sampling
3-39 Background and Borrow Source ABS Investigation
3-40 Nature and Extent of LA Contamination in the Forest Investigation
3-41 Nature and Extent of LA Contamination in Surface Water and Sediment Investigation
3-42 Tradesperson Indoor Air Re-Analysis Investigation
3-43 Woodstove ABS Investigation
3-44 Flowerbed Investigation
3-45 Water Source Investigation
3-46 Fish and Game Tissue Assessment Investigation
3-47 Porewater in the Tributaries
3-48 Overview of Removal Action Levels
3-49 PDI and GPI Results
5-1 Nature of Soil Materials Left in Place

List of Figures

1-1 Site Location Map Libby Montana
1-2 Operable Unit Boundaries, Libby Asbestos Site
1-3 Operable Unit 4 Topographic Contour Map
3-1 Properties of Special Interest
3-2 City of Libby Alleys
3-3 OU4 Creek Investigations and Removal Action

3-4 Borrow Source and Material Fill Locations
3-5 SQAPP
3-6 Outdoor Ambient Air Sampling Locations
3-7 Outdoor Activity-Based Sampling Properties
3-8 Indoor Activity-Based Sampling Properties
3-9 Scenario 4 Driving Boundaries
3-10 Scenario 5 Bicycle Routes
3-11 Background and Borrow Source
3-12 Nature & Extent Tree Bark and Duff Sample Locations
3-13 Nature & Extent Surface Water and Sediment Sample Locations
3-14 Woodstove Tree Collection Locations
3-15 Water Source Study Sample Locations
3-16 Tissue Assessment Study Location of Deer Collection
3-17 Porewater in the Tributaries Sample Locations
3-18 Libby GRZ Areas and Removal Zones
3-19 GRZ(s) 1 and 2
3-20 GRZ(s) 3
3-21 GRZ(s) 4
3-22 GRZ(s) 5
3-23 GRZ(s) 6 and 13
3-24 GRZ(s) 7, 8 and 9
3-25 GRZ(s) 10
3-26 GRZ(s) 11, 12, 15 and 17A
3-27 GRZ(s) 14
3-28 GRZ(s) 15 and 17B
3-29 GRZ(s) 18 and 19
3-30 GRZ(s) 20 and 21
3-31 GRZ(s) 22 and 23
3-32 GRZ(s) 24
4-1 Wind Rose for LBBM8 (2007-2013)

List of Appendices

Appendix A Sample Collection Details and Analytical Results for Investigation, Design, and Removal Clearance Samples (provided electronically)
Appendix B Sample Collection Details and Analytical Results for Health and Safety Monitoring Samples (provided electronically)
Appendix C Landfill Volume Calculations
Appendix D Dust Pilot Study Data (provided electronically)

Acronyms

%	percent
<	less than
>	greater than
≥	greater than or equal to
°F	degrees Fahrenheit
µm	micrometer
ABS	activity-based sampling
ACM	asbestos-containing material
AHERA	Asbestos Hazard and Emergency Response Act
AMSL	above mean sea level
ARAR	applicable or relevant and appropriate requirements
ARP	Asbestos Resource Program
ASTM	American Society of Testing and Materials
ATSDR	Agency for Toxic Substances and Disease Registry
ATV	all-terrain vehicle
BCY	bank cubic yard
bgs	below ground surface
BNSF	Burlington Northern and Santa Fe Railroad
CARB	California Air Resource Board
CB&I	CB&I Federal Services, LLC
cc^{-1}	per cubic centimeter
CDM Smith	CDM Federal Programs Corporation
CE	Cleanup Evaluation
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
cfs	cubic feet per second
cm^{-2}	per square centimeter
cm^2	square centimeters
CSS	Contaminant Screening Study
CUA	common-use area
CVCC	Cabinet View Country Club
DI	detailed investigation
DQO	data quality objective
EDS	energy dispersive spectrometry
EIC	Exterior Inspection Checklist
EPA	United States Environmental Protection Agency
EPIF	Exterior Property Inspection
ERS	Environmental Resource Specialist
ERSS	Emergency and Rapid Response Services
ERT	Environmental Response Team
ESAT	Environmental Services Assistance Team
ESATR8	Environmental Services Assistance Team Region 8
FBAS	fluidized bed asbestos segregator
FS	feasibility study
FSDS	field sample data sheet

ft^2	square feet
g	gram
g/cm^2	grams per square centimeter
GPI	general property investigation
GPS	global positioning system
Grace	W.R. Grace and Company
GRZ	geographic removal zones
HEPA	High Efficiency Particulate Air
HHRA	human health risk assessment
H&S	health and safety
ID	identification
IDW	investigation-derived waste
IFF	Information Field Form
IPIF	Interior Property Inspection Forms
ISO	International Organization for Standardization
IUR	inhalation unit risk
KDC	Kootenai Development Corporation
L	liter
L/min	liters per minute
LA	Libby amphibole asbestos
LCEH	Lincoln County Environmental Health Department
Libby Site	Libby Asbestos Superfund Site
LUA	limited use area
MCE	mixed cellulose ester
MCL	maximum contaminant level
MDEQ	Montana Department of Environmental Quality
MFL	million fibers per liter
mi^2	square mile
mm	millimeter
Ms/cm^2	million structures per square centimeter
Ms/g	million structures per gram
NaK	sodium and potassium
ND	non-detect
NIOSH	National Institute of Occupational Safety and Health
NPL	National Priority List
NSUA	non-specific use area
NTP	National Toxicology Program
OIF	Occupant Information Forms
ORD	Office of Research and Development
OSHA	Occupational Safety and Health Administration
OU	operable unit
PCC	Property Closeout Checklist
PCM	phase contrast microscopy
PCME	phase contrast microscopy-equivalent
PDI	pre-design inspection
PE	performance evaluation
PLM	polarized light microscopy
PLM-VE	polarized light microscopy-visual estimation

PLM-Grav	polarized light microscopy-gravimetric
PPE	personal protective equipment
QA	quality assurance
QAPP	quality assurance project plan
QC	quality control
RAFS	releasable asbestos field sampler
RAM	real-time aerosol monitor
RAWP	Response Action Work Plan
RfC	reference concentration
RI	remedial investigation
ROD	Record of Decision
s/cm^2	structures per square centimeter
s/cc	structures per cubic centimeter
s/g	structures per gram
SAED	selected area electron diffraction
SAP	sampling and analysis plan
SEIC	Supplemental Exterior Inspection Checklist
SEM	scanning electron microscopy
SI	screening investigation
SIIC	Supplemental Interior Inspection Checklist
SOP	standard operating procedure
SQAPP	Supplemental Remedial Investigation Quality Assurance Project Plan
SQL	standard query language
SRC	SRC, Inc.
SSVR	small scale vermiculite removal
SUA	specific use area
TEM	transmission electron microscopy
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USFS	United States Forest Service
USGS	United States Geological Survey
UV	ultraviolet light
VCBM	vermiculite-containing building materials
VCS	vermiculite-containing soil
VVEF	Visual Vermiculite Estimation Form
ww	wet weight
XRD	x-ray diffraction
yd^3	cubic yard

This page left blank intentionally

Section 1

Introduction

The purpose of this remedial investigation (RI) report is to present sufficient information to support a feasibility study (FS) and remedial action decisions for the residential, commercial, industrial, and public properties in Operable Unit 4 (OU4) of the Libby Asbestos Superfund Site (Libby Site) in Libby, Montana. Libby is a community in northwestern Montana located seven miles southwest of a vermiculite mine that operated from the 1920s until 1990. Figure 1-1 presents the location of Libby, within the state of Montana. The mine began limited operations in the 1920s and was operated on a larger scale by the W.R. Grace and Company (Grace) from approximately 1963 to 1990. Studies revealed that the vermiculite from the mine contains amphibole-type asbestos, referred to as Libby amphibole asbestos (LA).

Epidemiological studies revealed that workers at the mine had an increased risk of developing asbestos-related lung disease (McDonald *et al.* 1986, 2004; Amandus and Wheeler 1987; Amandus *et al.* 1987; Whitehouse 2004; Sullivan 2007). Additionally, radiographic abnormalities were observed in 17.8 percent (%) of the general population of Libby, including former workers, family members of workers, and individuals with no specific pathway of exposure (Peipins *et al.* 2003; Whitehouse *et al.* 2008; Antao *et al.* 2012; Larson *et al.* 2010, 2012a, 2012b). Although the mine has ceased operations, historic or continuing releases of LA from mine-related materials could be serving as a source of ongoing exposure and risk to current and future residents and workers in the area. The Libby Site was listed on the United States Environmental Protection Agency (EPA) National Priorities List (NPL) in October 2002.

This RI report includes a comprehensive description of the nature and extent of LA contamination and describes past investigative and removal actions within OU4[1] between 1999 and 2013. The subsequent FS report will use the information from the RI report to perform a systematic analysis to determine the need for, and scope of, any required remedial action.

During the numerous investigations that have been performed at OU4, LA has been observed in all media sampled: air (indoor and outdoor ambient), vermiculite insulation and bulk materials, indoor dust, soil (surface and subsurface), water, duff[2], tree bark, ash, and tissue (fish and deer). Removal actions have been completed and are continuing at some properties within OU4 thereby lessening exposure to LA source materials by removal of the most highly contaminated surface soils, removal of insulation from attic spaces and exposed walls, removal of contaminated dust, and removal or encapsulation of friable building materials. The details regarding how these conclusions were reached are provided in this RI report.

1.1 Report Organization

This RI report is organized according to the format suggested in the *Guidance for Conducting Remedial Investigations and Feasibility Studies under the Comprehensive Environmental Response Compensation and Liability Act* (CERCLA) (EPA 1988), and includes the following sections:

---

[1] Data collected from OU99 (i.e., collected from areas outside the NPL) that can be used to provide a frame of reference for contamination at the Libby Site have also been included.

[2] Organic litter and debris on the forest floor.

- **Section 1 – Introduction**. Provides the purpose and organization of the RI report, a brief description of the site location and layout, and a summary of mining and regulatory activities conducted to date at the Libby Site.
- **Section 2 – Data Collection and Management**. Provides an overview of sampling, site databases, data presentation, excluded datasets, analytical methods, sample preparation methods, and quality assurance/quality control.
- **Section 3 - Study Area Investigations and Removal Actions**. Provides an overview of site investigations and removal actions completed at OU4.
- **Section 4 – Physical Characteristics of the Study Area**. Provides a description of the physical characteristics of the Libby Site, including a discussion of climate, surface water, geology, groundwater, land use, and demographics.
- **Section 5 – Nature and Extent of Contamination**. Describes the nature and extent of LA contamination within OU4.
- **Section 6 – Contaminant Fate and Transport.** Provides a discussion of the important factors involved in fate and transport of LA in OU4.
- **Section 7 – Risk Assessment.** Provides a brief statement regarding the site-wide human health and ecological risk assessments.
- **Section 8 – Summary and Conclusions**. Summarizes the material in the previous sections and provides conclusions drawn from that work.
- **Section 9 – References**. Lists all the references used in the preparation of this RI report.

1.2 Site Background

Numerous hard rock mines have operated in the Libby area since the 1880s, but the dominant impact to human health and the environment in Libby has been from vermiculite mining and processing. Prospectors first located vermiculite deposits in the early 1900s on Rainy Creek, northeast of Libby. Edward Alley, a local rancher, was a prospector that explored the old gold mining tunnels and digs in the area. Reportedly, while exploring tunnels in the area, he stuck his miner's candle into the wall to chip away some ore samples. When he retrieved his candle, he noticed that the vermiculite around the candle had expanded, or “popped,” and turned golden in color.

In 1919, Alley bought the Rainy Creek claims and started the vermiculite mining operation called the “Zonolite Company.” While others thought the material was useless, he experimented with it and discovered it had good insulating qualities. Over time, vermiculite became a product used in insulation, feed additives, fertilizer/soil amendments, construction materials, absorbents, and packing materials. Many people used vermiculite products for insulation in their houses and soil additives in their gardens. In 1963, Grace bought the mine and associated processing facilities and operated them until 1990.

Operations at the mine included blast and drag-line mining and milling of the ore. Dry milling was conducted through 1985, and wet milling was conducted from 1985 until closure in 1990. After milling, concentrated ore was transported down Rainy Creek Road by truck to a screening facility (known today as the former Screening Plant) adjacent to Montana Highway 37 (hereafter referred to

as Highway 37), at the confluence of Rainy Creek and the Kootenai River. Here the ore was size-sorted and transported by rail or truck to processing facilities in Libby and nationwide. At the processing plants, the ore was expanded or "exfoliated" by rapid heating, then exported to market via truck or rail. Historic maps show the location of the "Zonolite Company" processing operation at the edge of the Stimson Lumber Mill, near present day Libby City Hall. This older processing plant was taken off line and demolished sometime in the early 1950s. The other processing plant (known today as the former Export Plant), was located near downtown Libby near the intersection of the Kootenai River and Highway 37. Expansion operations at the Export Plant ceased sometime prior to 1981, although existing site buildings were still used to bag and export milled ore until 1990.

Grace applied for and received an operating permit in 1972 under the Metal Mine Reclamation Act. Areas were reclaimed as they were mined out. After operations ceased in 1990, major reclamation began and included demolition of existing facilities, standard land recontouring, and revegetation. The remaining 125 bonded acres within the permit boundary include 65 acres of over-steepened coarse tailings, 45 acres encompassing a minor landslide that exposed an old landfill of solid mine waste and 15 acres encompassing the Gloryhole and some riprap borrow areas.

Over the course of Grace's operation in Libby, invoices indicate shipment of nearly 10 billion pounds of vermiculite from Libby to processing centers and other locations. Most of this was shipped and used within the United States. Nearly all of this material ended up in a variety of commercial products that were marketed and sold to millions of consumers. Before the mine closed in 1990, Libby produced approximately 80% of the world's supply of vermiculite.

While the mine was in operation, the milling process released high amounts of airborne particulates into the atmosphere. In addition, waste products and off-specification materials were made available to the general public on a large scale. Vermiculite products and wastes were used in thousands of private residences, businesses, and public buildings across the Libby Site. Vermiculite insulation, both commercially purchased and/or obtained otherwise, was used frequently in Libby buildings. In the course of various Site investigations, the EPA has encountered vermiculite used as an additive in mortar, plaster, and concrete; as insulation in attic and walls; in soils at depth around septic tanks, tree roots, underground pipe trenches, building foundations; and in surface soils in gardens, yards, driveways, and play areas.

Vermiculite from the mine contains varying concentrations of LA. Historical mining, milling, and processing operations, as well as bulk transfer of mining-related materials, tailings, and waste to locations throughout Kootenai Valley, are known to have resulted in releases of LA to the environment.

1.3 Regulatory History

Asbestos is a hazardous substance as defined by 40 Code of Federal Regulations (CFR) Section 302.4 of the National Oil and Hazardous Substances Pollution Contingency Plan. In November 1999, the EPA responded to requests from the State of Montana, Lincoln County Health Board to investigate the potential exposure to asbestos related to the former mine operations and vermiculite processing. The EPA Response Team briefly inspected the former mine and processing facilities, interviewed local officials and members of impacted families, interviewed a pulmonologist in Spokane, Washington, and collected a small set of initial samples. A more detailed summary of initial Libby Site evaluation is found in the EPA Action Memorandum dated May 23, 2000, *Request for a Time Critical Removal Action Approval and Exemption from the 12-month, $2-million Statutory Limit at the Libby Asbestos Site-*

Export Plant and Screening Plant former Processing Areas, Libby, Lincoln County, Montana (EPA 2000a). The initial investigation revealed two significant findings:

- There are a large number of current and historic cases of asbestos-related diseases centered on Libby, Montana.
- There is a likelihood that significant amounts of asbestos-contaminated vermiculite still remained in and around Libby.

These findings led the EPA to initiate a larger scale rapid investigation in December 1999 (Phase 1 investigation discussed in Section 3.1) to meet the following goals:

- Obtain information on airborne asbestos levels in Libby in order to judge whether time-critical intervention was needed to protect public health.
- Obtain data on asbestos levels in potential source materials (at the former Export Plant and Screening Plant), and identify the most appropriate analytical methods to screen and quantify asbestos in source materials.

Under CERCLA Section 104, the EPA has the authority to complete both removal and remedial actions. To date, all removals have been conducted using removal action authority to facilitate the timely removal of the most contaminated areas. The initial removal authority for time-critical actions began at the processing areas in May 2000 (EPA 2000a). As additional areas requiring removal were identified, amendments to the initial action memo were approved and are briefly summarized below:

- **July 20, 2001 –** Amendment increasing the funding ceiling for continued removal actions at the former Export Plant and Screening Plant, and expanding the scope of removal actions to include Rainy Creek Road, Libby High School, Libby Middle School, Plummer Elementary (hereafter referred to as Kootenai Valley Head Start), and two private properties (EPA 2001a).
- **May 2, 2002 –** Amendment increasing the funding ceiling and expanding the scope of removal actions to address residential/commercial properties in OU4 (EPA 2002a).
- **May 15, 2006 –** Amendment increasing the funding ceiling for removal actions at additional properties in OU4 (EPA 2006a).
- **June 27, 2006 –** Amendment increasing the funding ceiling and expanding the scope of removal actions to include Troy, Montana (EPA 2006b).
- **September 24, 2008 –** Amendment increasing the funding ceiling and expanding the scope of removal actions to include specific creeks in Libby and Troy, Montana (EPA 2008a).
- **June 17, 2009 –** Amendment increasing the funding ceiling for additional residential/commercial removal actions in Libby and Troy, Montana (EPA 2009a).
- **August 13, 2009 –** Amendment expanding the scope of removal actions to include the Cabinet View Country Club Golf Course (EPA 2009b).
- **March 14, 2012 –** Amendment to request and document approval for changes to removal action and removal protocols described in the original Action Memorandum and previous Amendments, and to outline a new neighborhood clean-up approach (EPA 2012a).

- **August 28, 2012 –** Amendment to address the removal of LA-containing vermiculite waste in the Rainy Creek floodplain near the mine (EPA 2012b).

In October 2002, the Libby Site was listed on the EPA's Superfund NPL, making it eligible to receive additional federal funds for investigation and removal, and transition the project from the EPA's Removal Program to the Remedial Action Program. In 2009, for the first time in the history of the agency, the EPA declared a Public Health Emergency in Libby to provide federal health care assistance for victims of asbestos related disease.

To facilitate a multi-phase approach to remediation of the Libby Site, eight separate OUs have been established. Official OU boundaries will not be determined until the Record of Decision (ROD) is published for each OU. OU1 and OU2 boundaries have been established. All remaining OUs have "study boundaries" which will be finalized once their ROD is published. All OUs are shown on Figure 1-2 and include:

- **OU1**. OU1 is defined geographically by the parcel of land that included the former Export Plant and the Highway 37 embankments, and is situated on the south side of the Kootenai River, just north of the downtown area of the City of Libby. The property is bound by the Kootenai River on the north, the Burlington Northern and Santa Fe (BNSF) railroad thoroughfare on the south, and residential properties on the east and west.

- **OU2**. OU2 includes areas impacted by contamination released from the former Screening Plant. These areas include the former Screening Plant, the Flyway property, the Highway 37 right-of-way adjacent to the former Screening Plant and/or Rainy Creek Road, and privately owned properties.

- **OU3**. The mine OU includes the property in and around the Zonolite Mine owned by Grace or Grace-owned subsidiaries (excluding OU2) and any area (including any structure, soil, air, water, sediment or receptor) impacted by the release and subsequent migration of hazardous substances and/or pollutants or contaminants from such property. including, but not limited to, the mine property, the Kootenai River and sediments therein, Rainy Creek, Rainy Creek Road and areas in which tree bark is contaminated with such hazardous substances and/or pollutants and contaminants.

- **OU4**. OU4 is defined as residential, commercial, industrial (not associated with former Grace operations), and public properties, including schools and parks in and around the City of Libby, or those that have received material from the mine not associated with Grace operations (e.g., properties that have utilized vermiculite from the mine in a garden or flowerbed).

- **OU5**. OU5 is defined geographically by the parcel of land that included the former Stimson Lumber Company. OU5 is bound by the high bank of Libby Creek to the east, the BNSF railroad to the north, and residential/commercial/industrial property within OU4 to the south and west. This OU is approximately 400 acres in size and is currently occupied by various vacant buildings as well as multiple operating businesses (lumber processing, log storage, excavation contractor, etc.). Within the boundary of OU5 exists the Libby Groundwater Superfund Site, which is not associated with the Libby Site.

- **OU6**. Owned and operated by the BNSF railroad, OU6 is defined geographically by the BNSF property boundaries from the eastern boundary of OU4 to the western boundary of OU7 and extent of contamination associated with the Libby and Troy rail yards.

- **OU7**. The Troy OU includes all residential, commercial, and public properties in and around the town of Troy, Montana, approximately 20 miles west of downtown Libby.
- **OU8**. United States and Montana State Highway rights-of-way and secondary state route rights-of-way within the boundaries of OU4 and OU7.

1.4 Operable Unit 4 Study Boundary

Establishing the NPL OU4 boundary at the Libby Site is not straightforward for two primary reasons. First, the dominant mechanism for the spread of LA contamination in OU4 was not transport by air or water. At Libby, people spread contamination randomly over a large area by utilizing vermiculite products on their properties (e.g., use of vermiculite-containing insulation in attics, application of vermiculite in flowerbeds and gardens), or unknowingly transporting contamination on their clothes or equipment. Thus, there is no obvious, large-scale plume or continuous area of contamination that can be used to establish the OU4 NPL boundary. Instead, OU4 consists of a large, undefined area with pockets of contamination throughout. Second, while the contamination was most concentrated in Libby, the human actions that spread the contamination were not confined only to the immediate area. As noted previously, the OU4 NPL boundary will not be finalized until the OU4 ROD is published. The current OU4 NPL boundary established is considered a "study boundary" which will be finalized once the ROD is published.

In the interim, the EPA established an initial OU4 NPL boundary, as shown on Figure 1-2, to guide sampling activities and provide a general area of concern. The EPA developed an initial boundary for OU4 that:

- Included the majority of populated, developed areas in and around Libby where vermiculite products and wastes may have been frequently used.
- Included most locations where vermiculite workers resided (with the exception of Troy) and may have transported contaminated dust on clothes or equipment.
- Excluded outlying areas that were expected to be relatively free of asbestos contamination related directly to the vermiculite mine or vermiculite processing. Any impacts in these areas would likely be isolated in nature and of a scale similar to the other parts of the country where vermiculite products may have been used.
- Was based loosely on the geographic boundaries of the Kootenai Valley.
- Was based upon the conceptual site model, which addresses various exposure pathways.
- Would capture the majority, if not all, of any undiscovered, or immeasurable, plume(s) of asbestos contamination that may have been aerially dispersed in the Libby community from the vermiculite mine and/or vermiculite processing operations.

There are some properties outside the OU4 NPL boundary that have been investigated and/or have had removal actions performed. But this was only when specific information was presented that indicated the property might be contaminated and the asbestos contamination was suspected to be directly related to vermiculite mining or processing wastes.

1.5 LA Characteristics

The main contaminant of concern at the Libby Site is asbestos. The vermiculite deposit near Libby contains naturally-occurring amphibole asbestos that is comprised of a range of mineral types and morphologies. Historically, the form of asbestos that is present in the vermiculite deposit was classified as tremolite/actinolite (e.g., McDonald *et al.* 1986, Amandus and Wheeler 1987). More recently, the United States Geological Survey (USGS) performed electron probe micro-analysis and x-ray diffraction (XRD) analysis of 30 samples obtained from asbestos veins at the mine (Meeker *et al.* 2003). Using mineralogical naming rules recommended by Leake *et al.* (1997), the results indicate that the asbestos at Libby includes a number of related amphibole types. The most common forms are winchite and richterite, with lower levels of tremolite, magnesio-riebeckite, edenite, and magnesio-arfvedsonite. Although Meeker *et al.* (2003) did not report the presence of actinolite, the authors did note that, depending on the valence state of iron and data reduction methods utilized by other analytical laboratories, some minerals may also be classified as actinolite. Because the mineralogical name changes that have occurred over the years do not alter the asbestos material that is present in Libby, and because there are no toxicological data to distinguish differences in toxicity among these different forms, the EPA does not believe that it is important to attempt to distinguish among these various amphibole types. Therefore, the mixture of asbestos present at the Libby Site is referred to as LA. LA is a hazardous substance under CERCLA.

1.6 Health Effects

Inhalation of asbestos fibers is known to cause several respiratory diseases, including pleural thickening, asbestosis, lung cancer, and mesothelioma. Studies by National Institute of Occupational Safety and Health (NIOSH) researchers of the vermiculite mine (Amandus *et al.* 1987) and Grace sponsored investigations (McDonald *et al.* 1986) show that workers at the mine had an increased risk of developing asbestos-related lung disease (Amandus and Wheeler 1987, Sullivan 2007, Whitehouse 2004, Whitehouse *et al.* 2008). Additionally, residents may have been exposed to asbestos through handling LA source materials on their property or from inhaling the ambient air while the mine was operational. The significant vertical relief surrounding the Kootenai Valley causes severe and persistent inversion patterns throughout the year. During the mine's operation, the inversion patterns in the valley caused airborne particulates to be suspended for longer periods of time (EPA 2000a). Figure 1-4 illustrates the topography of the Kootenai Valley.

In 2000, the Agency for Toxic Substances and Disease Registry (ATSDR) sponsored asbestos medical screening for former Grace workers from Libby and persons who lived, worked or recreated in Libby for at least six months before December 31, 1990. The study continued into 2001 and included interviews, chest x-rays of participants at least 18 years old, and lung function tests. A total of 7,307 participants were screened over the two-year period. The study found that 18% of x-rayed participants had abnormalities in the lining of their lungs (referred to as pleural abnormalities) (Peipins *et al.* 2003). The national rate of pleural abnormalities of participants with no known asbestos exposures ranges from 0.2% to 2.3%. The study concluded that the prevalence of pleural abnormalities was highest among former Grace workers (51%) and the majority of participants reported having multiple routes of exposures (i.e., occupational, recreational, household exposure, other) (ATDSR 2002a).

In December 2000, the ATSDR published an initial mortality review of the Libby Site ranging from 1979 to 1998. This comparison of death certificate data to state and national mortality rates showed that there was a 20% to 40% increase in malignant and nonmalignant respiratory deaths in Libby

over this period. Specifically, asbestosis mortality in Libby was 40% to 80% higher than expected and lung cancer mortality was 1.2 to 1.3 times higher. Data on mesothelioma mortality was elevated but difficult to correlate given the infrequent nationwide data on such a rare cancer. Most of the increase in respiratory mortality was associated with occupational exposures (ATSDR 2002b).

In response to the proposal for the Libby Site's inclusion on the NPL in 2002, the ATSDR conducted a public health assessment (ATSDR 2003). The public health assessment evaluated the health implications of the Libby Site using available environmental data, potential exposure scenarios, community health concerns, and health outcome data. The following conclusions are excerpted from this assessment:

- People in the Libby area were exposed to hazardous levels of asbestos in the past.
- People in the Libby area have elevated levels of disease, and death, associated with exposure to asbestos.
- People could still be exposed to hazardous levels of asbestos near current source areas. These levels could be especially hazardous to sensitive populations, including people who have been exposed for many years already, smokers, and young children.
- The exact level of risk associated with low-level exposure to asbestos cannot be determined due to uncertainties in the analysis and toxicology of LA. Nevertheless, continuing exposures to LA pose an unacceptable risk to residents and workers who have already been exposed for many years.
- The removal actions undertaken by the EPA are protective of public health.

Since 1999, the EPA has been performing removal actions at OU4 to address the most contaminated areas and decrease the exposure pathways at residential properties and public areas. In June 2009, the EPA declared a public health emergency in Libby highlighting the need for continued removal efforts as well as medical screening and treatment resources for affected residents.

At the time of this report, medical researchers from Mount Sinai, the University of Montana, Idaho State University, and Libby's Center for Asbestos Related Disease have begun a five-year study to investigate long-term health effects of human exposure to LA contaminated vermiculite ore. The study will examine asbestos risks during childhood, lung scarring among Libby residents not directly involved in vermiculite mining, and the relationship between lung scarring and autoimmune disorders. Additional research in small mammal exposure and pathologic assessment of lung tissue from exposed individuals is planned to quantify the health risks to Libby residents from exposure to LA through internal dosimetry and LA toxicity.

Section 2

Data Collection and Management

2.1 Sampling Overview

Multiple investigations [property investigations, activity-based sampling (ABS), etc.] and removal events have occurred at OU4. This report discusses each of the events and presents analytical data and observations relevant to the risk assessment and FS. Discussions in this report are grouped by phase (investigation, design, removal) then arranged chronologically thereafter. Several atypical properties have warranted specialized contamination assessments and those properties are summarized in addition to the overall summaries. Each of the events listed in Table 2-1 is summarized in Section 3.

Over the 14-year period of remedial investigations and removal actions at OU4, more than 143,000 samples have been collected of air (indoor, outdoor ambient, and outdoor near disturbed source materials), vermiculite insulation and bulk materials, indoor dust, soil (surface and subsurface), sediment, water (surface water and porewater), tissue, tree bark, and duff. Only those samples with analytical results are discussed in this RI report[3].

Although many of the investigations described in this section include properties outside OU4, only the samples that were collected from properties within OU4 (with the exception of data regarding nature and extent of contamination in the forest, surface water, and sediment) are included in the dataset for this RI report and summarized in the discussion below. In addition, due to the volume of samples collected, analytical results are summarized by investigation throughout the text and only results for LA are presented (i.e., results for chrysotile or other amphibole types are not discussed).

2.2 Site Databases

This section provides an overview of the data management applications utilized at the Libby Site. Additional information on these applications can be found in the *EPA Data Management Plan* for the Libby Asbestos Superfund Site (EPA 2013a). Data for the Libby Site are constantly changing as new samples are collected, analytical results are received, corrections are made, and property information is updated. All sample and analytical data presented in this report are based on the Libby2 database as of December 31, 2009, and a Scribe database snapshot dated April 15, 2014. The complete, final OU4 dataset, included in Appendix A, details the LA analytical results at OU4 by media and is a compilation of these database sources. Additional information regarding the samples that have been included in the data summary tables for this report, excluded sample results, and visible vermiculite data have been summarized in this appendix. Copies of the databases may be obtained upon request by the EPA.

2.2.1 Libby2 Database

Historically, there was a single standard query language (SQL) server database for the entire Libby project, referred to as the "Libby2 Database", which was used to manage and maintain most[4] sample information, analysis details, and analytical results for all samples collected at the Libby Site. The Libby2 Database was also used to track property status information. As of December 31, 2009, the

---

[3] Some samples that have been collected have been archived for future potential analysis.

[4] Investigation samples from OU3 and OU7 were not maintained in the Libby2 Database.

Libby2 Database is no longer utilized to manage data or property status, but analytical data have been compiled from the Libby2 Database for use in this report.

2.2.2 Scribe Database

All sample data from 1999 to present, and analytical data collected since January 2010, are maintained exclusively in Scribe. Scribe is a software tool developed by the EPA Environmental Response Team (ERT) to assist in the process of managing environmental data. A Scribe project is a Microsoft Access database.

2.2.3 Response Manager

All property information gathered at the Libby Site is managed in Response Manager. Response Manager is a SQL server database tool developed for managing property information for Libby, Montana. This application is used to track property information, including records of property access and removal status information, owner names and contact information, property-specific communications made at the relevant Information Center (e.g., Environmental Resource Specialist (ERS), U-Dig), and the status of all actions taken in response to these interactions.

2.3 Data Attributes

Results for samples analyzed by transmission electron microscopy (TEM) are presented in terms of total LA concentration (all LA structures that were deemed countable by the analytical method), when available, in order to speak to nature and extent of LA contamination. In addition, if the raw structure information is available, phase contrast microscopy equivalent[5] (PCME) concentrations have been presented for air samples. In some cases, only results for PCME are available and have been presented. Sample-related information and associated analytical results, including results for other amphibole and chrysotile asbestos, can be found electronically for each sample in Appendix A. All concentration data are shown to two significant digits.

Soil samples were designated as either surface or subsurface samples based on the top depth provided in the project database. The top depth of a surface soil sample is equal to zero inches below ground surface (bgs) (e.g., zero to six inches); the top depth of a subsurface soil sample is greater than zero inches bgs (e.g., four to eight inches). The bottom depth of soil sample collection was not a determining factor in establishing surface/subsurface designation. Soil samples may have been analyzed by multiple analytical methods or by the same method more than once. All available analytical results are presented for each sample. In order to distinguish these cases, both the count of samples and the count of analyses are presented when data are summarized.

Visible vermiculite information has been collected in various formats throughout the course of the project. Early visible vermiculite observations made prior to the inception of the visible vermiculite standard operating procedure (SOP) (CDM-LIBBY-06) (i.e., prior to October 2006) are qualitative statements provided in the sample comments field on the field sample data sheet (FSDS) or in the lognotes. Visible vermiculite data collected using CDM-LIBBY-06 provides a qualitative rank of visible vermiculite quantity observed at each sub-sampling point of the soil composite sample. Typically, the number of sub-sampling points is 30, but it can be greater depending on the specific sampling protocol. The ranking system requires the sampler to categorize the level of visible vermiculite at each point inspected as none, low, medium, or high. Historically, these data were only captured in the

[5] PCME definition: structure length greater than (>) 5 micrometers (µm), width greater than or equal to (≥) 0.25 µm, and an aspect ratio (length:width) ≥ 3:1 (NIOSH 1994).

sample comments field, but since data management switched to Scribe in 2010, the information is available in separate fields in a separate table dedicated to summarizing visible vermiculite data. Historical visible vermiculite data have been back-populated in Scribe when available in the sample comments field.

Lastly, it is important to note that soil composite sampling has evolved throughout the course of the investigations described in this report, as described in the 30-point composite sampling of surface soil SOP (CDM-LIBBY-05). Early investigations utilized a 5-point composite sampling methodology that was later revised on May 10, 2007, to be a 30-point composite sampling methodology. It was also at this time that changes in sample depth increments for use areas were invoked.

2.4 Excluded Datasets

2.4.1 Health and Safety Samples

Samples that have been collected in adherence with health and safety (H&S) requirements, as outlined in the *Comprehensive Site Health and Safety Program* (CDM Smith 2006a) and the *Comprehensive Accident Prevention Plan* (CDM Smith 2011a), are not discussed in this report. The majority of these samples are worker personal air samples that were collected to demonstrate the protectiveness of the respiratory protection used by field personnel during investigation and removal activities. These samples have been identified as personal air samples that have both TEM and PCM results, or samples that only have PCM results. Additionally, samples that do not characterize the contamination inherent to a property but have been collected to ensure contamination has not migrated as a result of project operations (i.e., air monitoring at the landfill, air monitoring in decontamination trailers, bulk material samples of decontaminated personal protective equipment [PPE], bulk material samples of landfill vehicle air filters) are also not discussed in this report. Landfill operations are governed by the *Lincoln County Class IV Asbestos Landfill Operations Plan, Revision 2* (CDM Smith 2008a) and are not summarized in detail in this report. Sample-related information and analytical results of samples associated with H&S or project operations can be found electronically in Appendix B.

2.4.2 Outdoor Air Removal Samples

Outdoor stationary air samples collected during a removal action (to ensure adequate dust suppression was implemented), and any confirmatory bulk, indoor air, and water samples are not discussed in this report. Rather, it is assumed that all clearance or confirmation samples collected as part of the removal program satisfied the clearance sample criteria, as described in Section 3.33.1, before the removal was considered complete. Sample-related information and analytical results of samples associated with the removal program can be found electronically in Appendix A.

2.4.3 Quality Control Samples and Analyses

Field quality control (QC) samples that are intended to assess sample handling and decontamination procedures (e.g., field blanks, lot blanks, dry blanks, and equipment blanks) are not included in the OU4 dataset and are discussed separately in various quality assurance (QA)/QC Summary Reports (EPA 2012c, EPA 2014a). Soil field duplicates and soil field splits were collected to evaluate the heterogeneity of the sampled areas and have been used in identifying contaminated soil for removal actions. Therefore, field duplicates and field splits are included in the OU4 dataset and are discussed within the respective investigation-specific sections of this report.

All analytical and preparation laboratory QC analyses that have been performed by TEM have also been excluded because they are intended to detect potential laboratory contamination and evaluate potential differences between analysts and laboratories. In addition the method by which laboratory QC analyses that have been performed by TEM are performed does not provide a useful evaluation of the overall sample concentration. These results are included and discussed separately in various QA/QC summary reports (EPA 2012c, EPA 2014a).

Analytical and preparation laboratory QC analyses (e.g., preparation blanks) that have been performed by polarized light microscopy (PLM) that are intended to detect potential laboratory contamination have not been included in this report. Again, these results are included and discussed separately in various QA/QC summary reports (EPA 2012c, EPA 2014a). Analytical and preparation laboratory QC analyses (e.g., laboratory duplicates) that have been performed by PLM, which provide additional evaluation of samples that have been collected, have been included in this report because they provide useful information in evaluating nature and extent of contamination.

2.4.4 Invalid/Rejected Database Results

In some cases, results in the database have been deemed rejected as a result of validation performed by CB&I using Site-specific validation SOPs for asbestos data validation. These samples have been excluded from all data summaries in this report. Additionally, there are some results in the database that are invalid because all components of the results are not present (e.g., the analytical sensitivity). A detailed list of the invalid/rejected samples is included in Appendix A.

2.5 Analytical Methods

The EPA has employed commercial asbestos test methods for various sample media collected at OU4, as discussed in this section. When necessary, the analytical methods were incorporated into project-specific SOPs or modified to meet the data reporting requirements to support project decision making. In some instances, the EPA conducted pilot studies or performance evaluation (PE) studies to ensure the successful implementation of a sample collection, processing, or analytical technique. The following analytical methods used to analyze OU4 samples are discussed herein:

Air:

- Phase contrast microscopy (PCM) in accordance with NIOSH 7400
- TEM in accordance with the Asbestos Hazard and Emergency Response Act (AHERA); hereafter referred to as TEM AHERA
- TEM in accordance with International Organization for Standardization (ISO) 10312:1995(E); hereafter referred to as TEM ISO

Dust:

- American Society of Testing and Materials (ASTM) D5755, following TEM AHERA counting rules

Soil:

- PLM in accordance with NIOSH 9002 (hereafter referred to as PLM-9002)
- PLM using visual area estimation (hereafter referred to as PLM-VE)
- PLM-Gravimetric (hereafter referred to as PLM-Grav)
- EPA 600/R-93/116 (hereafter referred to as EPA 600)

- TEM ISO, following preparation using the fluidized bed asbestos segregator (FBAS)

Tree Bark, Duff, and Tissues:

- TEM ISO

Vermiculite Insulation and Bulk Materials:

- PLM-9002

Water:

- EPA 100.2
- TEM ISO (with preparation in accordance with EPA 100.2)

2.5.1 PLM

The PLM method capitalizes on the fact that light passing through a translucent mineral will interact with the internal crystal structure of the mineral grains, and the transmitted light (that which passes through the particle) tends to be polarized, having a higher intensity in some orientations than in others. Because this effect depends on the composition and/or structure of the particle, each mineral has a unique effect on light passing through it. Thus, based on the optical properties (e.g., refractive index, birefringence, color) of the particle, it is possible to distinguish asbestos from non-asbestos, and to classify different types of asbestos.

PLM is not applicable to samples that may contain many fine fibers below the resolution of the light microscope (e.g., air samples). For this reason, PLM is only applied to bulk samples of soil or construction materials, where many of the asbestos structures present can be expected to be fairly large.

At the Libby Site, there are two different PLM methods that are utilized to analyze soil and other bulk materials – PLM 9002 and the Libby-specific PLM methods as described in Section 2.5.1.2.

2.5.1.1 PLM-9002

NIOSH Method 9002 (Issue 2), *Asbestos (Bulk) by PLM,* was issued in 1994 (NIOSH 1994b). In this method, the PLM analyst utilizes visual estimation techniques (e.g., standard area projections, photographs, drawings, or trained experience) to determine the asbestos content of bulk materials (e.g., soil, insulation). Results are reported qualitatively for levels below 1%, either as non-detect (ND) when no asbestos is observed, or as "less than (<) 1%" when asbestos (tremolite/actinolite) is present but at levels lower than 1%. Results above 1% are reported quantitatively (usually to the nearest whole percent based on area estimation).

At the Libby Site, PLM-9002 is principally used as a screening tool for rapid turn-around PLM analysis of unprocessed soil samples collected during response actions and restoration activities.

2.5.1.2 Libby-Specific PLM

In early 2002 at the onset of the RI contaminant screening study (CSS), the EPA recognized that existing soil analytical methods, such as PLM-9002, were inadequate for measuring low concentrations of LA below 1%. Thus, the EPA began researching a more accurate soil analytical method. Additionally, the cost and turnaround time of any new methods was of concern, given the need to screen the thousands of soil samples planned to be collected under the CSS.

To address these issues, the EPA, with assistance from the USGS and SRC, Inc. (SRC), designed and implemented a soil PE study. The objectives of the PE study were to:

- Develop PE test materials of known, verified LA concentrations in soil that could be used to test the efficacy of soil analytical methods.
- Use the PE test materials to evaluate multiple commercially available analytical methods and technologies to determine their suitability for detecting and measuring LA in soil at various concentrations and under conditions similar to those found at the Libby Site.
- Based upon these results, develop and refine project-specific test methods to detect low concentrations of LA in soil.
- Based upon the results, develop a set of acceptance criteria for the PE test materials.
- Use PE test materials as a QC tool for testing the performance of analytical laboratories.

The PE study was conducted in several test phases, with the majority of the work conducted in 2002. The details of the phased approach are described in the *Quality Assurance Project Plan, Performance Evaluation Study for Analytical Methods in Soil, Part B, Revision 1* (EPA 2003a). While the PE study was underway, soil samples collected as part of the CSS were held without analysis. During 2003, following the interim results of the PE study, the EPA released the CSS soil samples for analysis using the Libby-specific PLM methods. Soil samples for analysis by the Libby-specific PLM methods are first processed in accordance with SOP ISSI-LIBBY-01. In brief, each soil sample is dried and sieved through a ¼-inch screen. Particles retained on the screen (if any) are referred to as the "coarse" fraction. Particles passing through the screen are referred to as the "fine" fraction, and this fraction is ground by passing it through a plate grinder. The resulting material is referred to as the "fine ground" fraction. The fine ground fraction is split into four equal aliquots; one aliquot is submitted for analysis and the remaining three aliquots are archived.

The coarse fractions are examined in accordance with SOP SRC-LIBBY-01, referred to as "PLM-Grav". SRC-LIBBY-01, *Qualitative Estimation of Asbestos in Coarse Soil by Visual Examination Using Stereomicroscopy and Polarized Light Microscopy (PLM)*, was developed in 2002 and contains elements from NIOSH Method 9002 and EPA 600/R-93/116. PLM-Grav provides a screening method to examine the coarse soil fraction for evidence of asbestos mineral content using stereomicroscopy with confirmation of asbestos by PLM. The method is suitable for use on soil and other soil-like media (e.g., sediment) to quantify all types of asbestos fibers, including chrysotile and amphiboles (like those characteristic of the Libby Site). The method sensitivity can be affected by the homogeneity of the sample, the accuracy of the weight measurements obtained at the laboratory, and the effectiveness of the sample reduction and filtering procedures.

The fine ground aliquots are examined using visual area estimation in accordance with SOP SRC-LIBBY-03, referred to as "PLM-VE". SRC-LIBBY-03 *Analysis of Asbestos Fibers in Soil by PLM,* was developed in 2003 and is based on NIOSH Method 9002, EPA 600/R-93/116, and California Air Resources Board (CARB) Method 435. PLM-VE is a semi-quantitative method that utilizes LA-specific reference materials to allow assignment of fine ground samples into one of four reporting "bins", as follows:

- Bin A (ND): non-detect
- Bin B1 (Trace): detected at levels lower than the 0.2% (by mass) LA reference material

- Bin B2 (<1%): detected at levels lower than the 1% (by mass) LA reference material but greater than or equal to the 0.2% LA reference material
- Bin C: LA detected at levels greater than or equal to the 1% LA reference material; results are reported to the nearest whole percent

PLM-VE has been used since 2003 for OU4 investigation soil samples because of its reliability to detect low concentrations of LA in soil to 0.2% in a cost-effective, rapid manner. The details of the PE study are summarized in a separate PE study report prepared by SRC and CDM Smith (CDM Federal Programs Corporation) and are in review at the EPA (EPA 2008b).

2.5.2 PCM

The NIOSH Method 7400 (Issue 2), *Asbestos and Other Fibers by PCM* (1994a), is the historical technique used for the measurement of asbestos fibers in air and is the method upon which many occupational exposure regulations are based. A key limitation of PCM is that structure discrimination is based only on size and shape. Because of this, it is not possible to distinguish between asbestos and non-asbestos structures. All structures that have a length greater than five micrometers (µm) and have an aspect ratio (length: width) of 3:1 or more are counted as PCM "fibers". The limit of resolution of PCM is about 0.25 µm, so structures thinner than this are generally not observable; there is no upper width restriction imposed.

PCM is typically used as the primary analysis method for worker air samples collected as part of H&S monitoring. This is because results for these samples are compared to Occupational Safety and Health Administration (OSHA) exposure limits that are based on PCM.

2.5.3 TEM

TEM methods are more complex than PCM and PLM and require the use of a more sophisticated analytical instrument that operates at higher magnification (e.g., 20,000x) and hence is able to detect structures much smaller than can be been seen by other methods. TEM methods can be used for air, dust, water, and solid media (e.g., soil, duff, tree bark, tissue).

When a sample is analyzed by TEM, the analyst records the size (length, width) and structure type (e.g., fiber, bundle) of each individual asbestos structure that is observed. This structure attribute information can be used to determine the number of PCME structures observed in the TEM analysis. PCME is important for the purposes of human health risk assessment because available toxicity values are based on studies utilizing PCM data. As noted above, in the PCM method (NIOSH 1994a), a structure is counted as a PCM fiber if it has a length of five µm or longer and an aspect ratio of at least 3:1. Although there is no thickness rule specified in the PCM method, particles thinner than about 0.25 µm are not usually detectable by PCM. Hence, the TEM counting rules for PCME structures are: length greater than (>) 5 µm, width greater than or equal to (≥) 0.25 µm, aspect ratio ≥ 3:1. Note that the PCME counting rule for width does not include an upper width cut-off of three µm, per EPA (2008b), because particles wider than three µm are counted by the PCM method (NIOSH 1994a). Thus, to ensure comparability between the exposure concentrations and the toxicity values, no upper width restriction is applied.

The TEM analyst also records the mineral type of each individual asbestos structure that is observed. Mineral type is determined by energy dispersive spectrometry (EDS) and selected area electron diffraction (SAED):

- EDS is a method that takes advantage of the fact that an atom that is excited by absorbing a high energy electron will tend to re-emit the absorbed energy at a wavelength that is characteristic of the absorbing atom. Thus, when a particle is examined under a TEM instrument equipped with EDS, it is possible to obtain data on the atomic composition of each particle being examined. This makes it easy to distinguish organic fibers from mineral fibers, and also allows for distinguishing between different types of mineral fibers.

- SAED is a method based on the fact that crystalline structures diffract electrons to form a diffraction pattern that is characteristic of the underlying crystal structure. Thus, when a particle is examined under a TEM instrument equipped with SAED, it is possible to obtain a diffraction pattern that is helpful in distinguishing organic from mineral fibers, and in classifying the nature of the mineral fiber (amphibole versus chrysotile).

There are many different standard methods that have been developed for TEM. These methods differ mainly in the recording rules that are utilized by the TEM analyst in reporting observed asbestos structures. At the Libby Site, the most commonly used recording rules are those specified by AHERA (see Section 2.5.3.1), ASTM 5755 (see Section 2.5.3.2), ISO 10312:1995(E) (see Section 2.5.3.3), and EPA 100.2 (see Section 2.5.2.4). Some samples have been analyzed multiple times by TEM. In these cases, the TEM results have been pooled in accordance with Technical Memo 11 (EPA 2007a).

2.5.3.1 TEM AHERA

This TEM method is based on regulations established for evaluating asbestos risks in schools under AHERA, *Appendix A to Subpart E of 40 CFR Part 763, EPA's Interim Transmission Electron Microscopy Analytical Methods C Mandatory and Nonmandatory C and Mandatory Section to Determine Completion of Response Actions* (EPA 1987). Structure recording rules for TEM AHERA differ from other recording rules (i.e., TEM ISO, EPA 100.2) in that no attempt is made to record individual fibers that are part of a larger matrix or cluster aggregate. As a consequence, a sample analyzed using TEM AHERA recording rules may report a lower structure count than if it were analyzed using TEM ISO recording rules.

Under TEM AHERA recording rules, a fiber is defined as any structure ≥ 0.5 µm that has substantially parallel sides and an aspect ratio ≥ 5:1. At the Libby Site, this aspect ratio rule has varied over time (refer to the current version of Libby laboratory modification #LB-000031), with more recent samples analyzed using an aspect ratio rule of ≥ 3:1, which allows for the estimation of PCME structures.

2.5.3.2 ASTM D5755

The ASTM originally released their dust method D-5755, *Standard Test Method for Microvacuum Sampling and Indirect Analysis for Dust by TEM for Asbestos Structure Number Concentrations*, in August 1995. Since that time, ASTM has reissued this method three times (in 2002, 2003, and 2009). The current method version is ASTM D 5755-09 (ASTM 2009).

In brief, the ASTM D5755 method provides a standardized procedure to identify asbestos in dust and estimate the surface loading of asbestos in the sampled dust, reported as the number of asbestos structures per unit area of the sampled surface (e.g., structures per square centimeter [s/cm^2]). The procedure specifies an indirect filter preparation technique, which is intended to disperse aggregated asbestos into fundamental fibrils, fiber bundles, clusters, or matrices that can be more accurately quantified by TEM. Due to the use of an indirect sample preparation technique, the asbestos observed for quantification may not represent the physical form of the asbestos as sampled. Dust samples analyzed in accordance with ASTM D5755 utilize AHERA structure recording rules (see Section 2.5.3.1). Because of this, results for samples analyzed by ASTM have been included with other TEM results when both are available.

2.5.3.3 TEM ISO

The ISO 10312:1995(E) method, *Ambient air – Determination of Asbestos fibers – Direct-transfer Transmission Electron Microscopy Method*, was issued in 1995 (ISO 1995). This TEM method is suitable for use in determining the concentration of asbestos structures in both indoor and outdoor environments. TEM ISO structure recording rules differ from other TEM analysis methods (i.e., TEM AHERA) in that there is a fairly complex set of rules for counting fibers that occur in higher order structures (e.g., matrices, clusters), tending to enumerate individual fibers when they can be clearly distinguished, and counting the higher order particles as a unit when the individual fibers cannot be clearly resolved.

Under TEM ISO recording rules, a fiber is defined as any structure ≥ 0.5 µm that has substantially parallel sides and an aspect ratio ≥ 5:1. At the Libby Site, this aspect ratio rule has varied over time (see Libby laboratory modification #LB-000016), with more recent samples analyzed using an aspect ratio rule of ≥ 3:1, which allows for the estimation of PCME structures.

At the Libby Site, TEM ISO is typically used as the principle recording method for investigative samples (e.g., ABS, ambient air monitoring). Although ISO 10312:1995(E) is written as an analytical method for air filters that are directly prepared, at the Libby Site, this method has also been utilized to specify the desired recording rules for air samples that have been prepared indirectly (per SOP EPA-LIBBY-08) and for the TEM analysis of other non-air media, such as dust, tree bark, duff, soil, water, and tissue.

When TEM ISO is applied to non-air media, the filter is usually prepared in the TEM laboratory from the sampled media (e.g., duff, tree bark, tissue). Once the sampled medium is placed onto a filter, there is effectively no difference between various media in structure recording requirements (i.e., the TEM ISO recording rules are similar regardless of the medium).

Soil samples can also be analyzed by TEM if prepared by the FBAS method. One limitation of the PLM-VE method (see Section 2.5.1.2) is that the analysis results only provide semi-quantitative information on soil concentrations less than 1%. Studies have shown asbestos concentrations of potential health concern may be released to air from soils with low-levels (less than 1%) of asbestos contamination. For this reason, the EPA has been engaged in an on-going effort to develop and evaluate methods for the characterization of relatively low levels of asbestos in soil.

One such method utilizes FBAS in accordance with SOP ESAT-LIBBY-01, *Fluidized Bed Asbestos Segregator Method for Determination of Releasable Asbestos Fibers in Soil*. In brief, soil samples are size-segregated by sieving and then homogenized and fluidized in the segregator. Small particles (i.e., approximately 10 µm aerodynamic diameter and smaller) are elutriated from the soil material and collected on an air filter. This filter is then analyzed by TEM for asbestos in basic accordance with TEM ISO, as modified by Libby-specific laboratory modification requirements.

To alleviate the potential issue of overloaded filters for FBAS samples, the Environmental Services Assistance Team Region 8 (ESATR8) laboratory developed the "rock flour" preparation method (TechLaw, Inc. 2011). This preparation method was developed based on techniques published by Webber *et al.* (2008) for enriching amphibole fiber recovery from solid media. In brief, filters are generated using the FBAS while maximizing the soil mass (5 grams) such that the resulting filter is intentionally overloaded. At the TEM laboratory, the FBAS filter is ashed using the same procedures described in Libby-specific SOP EPA-LIBBY-08. The resulting ash residue is suspended in water, sonicated, and the suspension allowed to settle in a graduated cylinder for three hours. This process allows the heavier soil particles to settle out, but the asbestos fibers, which have a larger surface area

to weight ratio, remain in suspension (Webber *et al.* 2008). After the settling time has elapsed, an aliquot of the top portion of the suspension is placed onto a new filter, which is used to prepare grids for analysis by TEM.

PE studies of the FBAS method (Januch *et al.* 2013) show that there is an approximately linear relationship between the concentration of LA in PE standards (as mass percent) and the reported FBAS LA soil concentration (as structures per gram [s/g]). Method detection limits achieved in these studies ranged from 0.002% to 0.005% (by mass), which is approximately 100-times lower than the detection limits that are reliably achieved using other analytical methods for asbestos in soil (e.g., PLM-VE).

2.5.4 EPA Methods

2.5.4.1 EPA 100.2

EPA 100.2, *Determination of Asbestos Structures over 10 µm in Length in Drinking Water,* (EPA 1994) is a method for the preparation and analysis of water samples by TEM. This method is derived from EPA 100.1, *Analytical Method for Determination of Asbestos in Water*. The principle difference between the recording rules specified in these methods is that EPA 100.1 records all[6] asbestos structures, whereas EPA 100.2 records only those asbestos structures that are longer than 10 µm, since this is the basis of the maximum contaminant level for asbestos in drinking water. In general, the structure recording rules for both methods are similar to those utilized by TEM ISO in that higher order structures (e.g., matrices, clusters) are disaggregated to enumerate individual fibers when they can be clearly distinguished.

In accordance with the method, if the collected water is not filtered within 48 hours, samples must undergo special preparation methods[7] to address bacterial and algal growth that can influence the reporting of structures in the TEM analysis. In brief, sample preparation includes an ozonation/ ultraviolet light (UV) treatment and sonication step, which is designed to oxidize organic matter present in the water or on the walls of the bottle, thus destroying any material that might cause clumping and binding of asbestos structures. Beginning in July of 2010 (per Libby laboratory modification #LB-000020a), all water samples were prepared using the ozonation/UV treatment regardless of the elapsed time between sample collection and filtration.

2.5.4.2 EPA 600

EPA 600/R-93/116 was issued in 1993 (EPA 1993). In this method, the analyst utilizes qualitative and quantitative analysis of bulk materials for estimating asbestos content. The method employs PLM, XRD and TEM for qualitative identification of materials. Quantitative analysis is accomplished by comparison of gravimetrically prepared standards of known composition with unknown samples using a combination of visual comparison, point counting, gravimetry, and quantitative x-ray diffraction.

At the Libby Site, PLM by EPA 600 was used on a small sub-set of samples analyzed from December 2002 to January 2003 as part of the PE study. Historically, this is not a method that was commonly used at the Libby Site. More recently (beginning in 2013), PLM by EPA 600 has been used as a secondary analysis method for bulk materials. If LA concentrations are reported as <1% by PLM 9002, the sample is re-analyzed by EPA 600, using PLM point counting (400 points) to provide a more quantitative estimate of the amount of LA that is present.

---

[6] All structures longer than 0.5 µm with an aspect ratio of 3:1 or greater.

[7] See Section 6.2 of EPA Method 100.1 or Attachment 1 of EPA Method 100.2.

2.6 Quality Assurance/Quality Control

The quality of work conducted by the EPA at the Libby Site is ensured through the implementation of a rigorous QA program for field activities, soil sample preparation activities, and analytical laboratory activities. The QA program specifies use of certain QA/QC procedures and measures, which are specified in governing documents and summarized in *Quality Assurance and Quality Control Summary Report (1999-2009) for the Libby Asbestos Superfund Site* (EPA 2012c), *Quality Assurance and Quality Control Summary Report (2010-2013) for the Libby Asbestos Superfund Site* (EPA 2014a), and *Annual QA/QC Summary Report (2010-2012) for Task Order 2019* (CB&I 2014). The key elements of the QA/QC program include the following:

- The development of detailed sampling and analysis plans (SAP) and quality assurance project plans (QAPP) to guide all sample collection and analysis efforts.
- The development of detailed site-specific SOPs for sample collection, preparation, and analysis.
- Extensive training of all field and laboratory staff.
- Extensive review and checking by senior staff of the work performed by field and laboratory staff.
- Periodic internal and external audits of field and laboratory operations.
- Iterative modifications to improve methods and document procedures used to address any issues or problems identified by field staff, laboratory staff, or data users.
- The development of electronic data management tools for recording and transferring data that include a variety of error checks and error traps.
- The collection and analysis of a variety of different types of field and laboratory QC samples.
- A review and verification of electronic data in the Libby Site databases.
- Validation of analytical laboratory data packages.

Based on the QC data that have been collected at the Libby Site and reviewed as part of EPA (2012c; 2014a) it was concluded that:

- Blank samples (e.g., lot blanks, field blanks, preparation blanks, laboratory blanks) show that inadvertent contamination of field samples with LA or other forms of asbestos is not of significant concern, in the field, at the soil preparation laboratory, or at the analytical laboratory.
- Field duplicate and split samples in multiple media types show that variability due to small-scale heterogeneity is likely to be small and results tend to be reproducible.
- Soil preparation duplicates show that results are not greatly influenced by differences in soil preparation laboratory techniques.

For both TEM and PLM, there is generally high agreement (good concordance) for intra-laboratory analyses. Inter-laboratory analyses suggest that, while results are generally acceptable, there are differences in methods or procedures between analytical laboratories and corrective action may be useful in achieving better agreement and reducing uncertainties due to analytical measurement errors.

This page left blank intentionally

Section 3

Site Study Area Investigation and Removal Actions

Section 3 presents an overview of site investigations and removal actions completed at OU4. Results in the sections below will not be interpreted in terms of human health or ecological risk, rather only the objectives of the studies along with the analytical results will be presented.

3.1 Phase 1 Investigation

Phase 1 investigation field sampling was completed in accordance with the *Phase 1 Sampling and Quality Assurance Project Plan* (EPA 1999) and *Phase 1 Sampling and Quality Assurance Project Plan, Revision 1* (EPA 2000b). These documents are interchangeably referred to as the *Phase 1 QAPP*. While the initial Phase 1 investigation was primarily conducted from 1999 to 2002, the procedures contained in the *Phase 1 QAPP* have been used to collect various characterization data since 2002, and are still in use for non-routine sampling requests and routine H&S monitoring at the Libby Site. This section summarizes the initial Phase 1 data on which development of the CSS was based, and the subsequent Phase 1 data collected at OU4 to date.

3.1.1 Initial Phase 1 Investigation

The initial Phase 1 investigation for OU4, implemented between December 1999 and March 2002, was designed as a rapid pilot-scale investigation with two main objectives:

- Determine airborne asbestos levels in Libby in order to judge whether a time-critical intervention was needed to protect public health.
- Obtain data on asbestos levels in source materials to determine the most appropriate analytical methods.

Sampling focused on indoor and outdoor stationary air, vermiculite insulation and building materials, indoor dust, and outdoor surface and subsurface soils in order to meet these objectives. Investigation surface water samples were also collected on a very limited basis. Sample results for each media type are presented in Table 3-1 for air, vermiculite insulation, bulk materials, dust, and soil respectively. Refer to Appendix A for additional information on individual sample details and analytical results. Results are summarized below in brief:

- A total of 256 stationary indoor air samples were collected during initial OU4 Phase 1 investigation activities. Total LA was detected at a frequency of 33% ranging in concentrations from 0.00020 structures per cubic centimeter (s/cc) to 0.54 s/cc by TEM analysis.
- A total of 102 stationary outdoor air samples were collected during initial OU4 Phase 1 investigation activities. Total LA was detected at a frequency of 13% ranging in concentrations from 0.000096 s/cc to 0.0017 s/cc by TEM analysis.
- A total of 112 vermiculite insulation samples were collected during initial OU4 Phase 1 investigation activities. Tremolite/actinolite was detected at a frequency of 67% ranging from <1% to 5% by PLM-9002.

- A total of 33 samples of bulk building materials were collected during initial OU4 Phase 1 investigation activities. Tremolite/actinolite was detected at a frequency of 12% ranging from <1% to 1.5% by PLM-9002.
- A total of 2,127 indoor dust samples were collected during the initial OU4 Phase 1 investigation activities. Total LA was detected at a frequency of 15% ranging in concentrations from 30 s/cm^2 to 570,000 s/cm^2 by TEM and ASTM analysis.
- A total of 2,243 surface soil samples were collected during the initial OU4 Phase 1 investigation activities. LA was detected at a frequency of 12% for 1,175 samples (1,178 analyses) ranging in concentrations from trace to 3% by PLM-VE. LA was detected at a frequency of 2% for 692 samples (696 analyses) ranging in concentrations from trace to 100% by PLM-Grav. Tremolite/ actinolite was detected at a frequency of 28% for 2,236 samples (2,329 analyses) ranging in concentration from <1% to 15% by PLM-9002. Vermiculite was observed in 448 samples based on a qualitative assessment. Vermiculite was not observed in 908 samples based on a qualitative assessment. Information on vermiculite was not available for 887 samples.
- A total of 133 subsurface soil samples were collected during the initial OU4 Phase 1 investigation activities. LA was detected at a frequency of 16% for 49 samples with concentrations ranging from trace to <1% by PLM-VE. LA was not detected in 39 samples by PLM-Grav. Tremolite/ actinolite was detected at a frequency of 43% for 133 samples (135 analyses) ranging in concentration from <1% to 10% by PLM-9002. Vermiculite was observed in 14 samples based on a qualitative assessment. Vermiculite was not observed in 30 samples based on a qualitative assessment. Information on vermiculite was not available for 89 samples.
- A total of three investigatory surface water samples were collected during the initial OU4 Phase 1 investigation activities to determine the presence of LA. Results by TEM indicate one LA structure was present in one of the samples, while the others were non-detect for LA (Appendix A). Concentration data are not available for these samples because all of the analytical inputs necessary to compute the concentration were not available.

Results of initial Phase 1 sampling prompted the removal of major LA sources at various properties in and around Libby, including the former Screening Plant (OU2), former Export Plant (OU1), Kootenai Development Corporation (KDC) Bluffs (Section 2.5.1), KDC Flyway (OU2), Kootenai Valley Head Start (Section 2.5.2), Libby High School (Section 2.5.5), Libby Middle School (Section 2.5.4), and several residential and commercial properties.

Preliminary work of the Phase 1 investigation did not provide enough information to determine appropriate soil analytical methods; therefore, additional work related to analytical method development was conducted under subsequent investigation efforts. The soil PE study is discussed in Section 2.5.3.2.

Additionally, a review of the Phase 1 data showed that LA-contaminated materials were used randomly at unknown properties in the past, and the EPA determined that each property in the Kootenai Valley required screening for potential sources of LA. However, as a result of the size of the Libby Site and the number of properties that needed to be evaluated, emphasis needed to be placed on an investigative approach that minimized sampling and analysis to identify areas requiring removal/remediation. The sampling program developed to address these objectives is referred to as the CSS and is discussed in Section 2.4.

The initial Phase 1 work yielded information critical to developing the procedures used in the CSS, as documented in the following technical memoranda produced by SRC. These memoranda can be found in Appendix A of the *Final Sampling and Analysis Plan (SAP), Remedial Investigation Contaminant Screening Study* (hereafter referred to as the *CSS SAP* [CDM Smith 2002a]).

- Technical Memorandum 1 concluded that the presence of visible vermiculite in soil at the Libby Site is a reliable and useful indicator of the presence of elevated levels of asbestos by PLM; therefore no soil samples were required to be collected in areas where visible vermiculite was observed during the 2002 CSS.
- Technical Memorandum 2 concluded that sampling bulk vermiculite insulation was not necessary due to the elevated frequency of LA in insulation; therefore, no vermiculite insulation samples were collected during the 2002 CSS.
- Technical Memorandum 3 concluded that it is reasonable to perform indoor dust removal at buildings containing vermiculite insulation, without basing indoor dust removal decisions on the results of dust samples. Therefore, beginning with the 2002 CSS, dust samples were typically not collected from buildings in which vermiculite insulation was observed.

3.1.2 Subsequent Phase 1 Investigation

Since the completion of initial Phase 1 data collection activities in March 2002, additional general investigation sampling has been conducted throughout OU4 with the primary purpose of identifying or quantifying LA. The data were used to guide removal decisions. The *Phase 1 QAPP* (EPA 2000b) governs the collection of these samples, as well as the collection of samples not specified under other field sampling plans (i.e., non-routine requests).

Phase 1 samples collected in OU4 subsequent to March 2002 include the following: indoor ambient air, bulk building materials, indoor dust, outdoor surface and subsurface soil, and well water. It should be noted that, as mentioned previously, Technical Memorandum 2 provided rationale for discontinuing the collection of bulk vermiculite insulation samples. However, sampling of building materials continued at OU4 on a somewhat limited basis after March 2002, and is still conducted as part of general property investigation (GPI) activities to guide removal decisions (Section 3.32). If the building material is friable or deteriorated, or there are plans to demolish or re-model buildings or areas of buildings with vermiculite-containing building materials (VCBM) present, sampling of the material will be conducted in general accordance with Administrative Rules of Montana (ARM) 17.74.354(3)(c), Inspection Requirements for Demolition and Renovation Activities. Each of the media types collected since March 2002 is presented in Table 3-2. Refer to Appendix A for additional information on individual sample details and analytical results. Results are summarized below in brief.

- A total of 820 stationary indoor air samples were collected during the supplemental OU4 Phase 1 investigation activities. Total LA was detected at a frequency of 3% ranging in concentrations from 0.00058 s/cc to 0.032 s/cc by TEM analysis.
- A total of five vermiculite insulation samples were collected during the supplemental OU4 Phase 1 investigation activities. Tremolite/actinolite was detected in all samples ranging from 2% to 3% by PLM-9002.
- A total of 84 samples (110 analyses) of bulk building materials were collected during the supplemental OU4 Phase 1 investigation activities. Tremolite/actinolite was detected at a frequency of 9% ranging from <1% to 2% by PLM-9002.

- A total of 383 indoor dust samples were collected during the supplemental OU4 Phase 1 investigation activities. Total LA was detected at a frequency of 10% ranging in concentrations from 36 s/cm^2 to 47,000 s/cm^2 by TEM analysis.
- A total of 162 surface soil samples were collected during the supplemental OU4 Phase 1 investigation activities. LA was detected at a frequency of 16% for 38 samples ranging in concentrations from trace to <1% by PLM-VE. LA was not detected in 27 samples by PLM-Grav. Tremolite/actinolite was detected at a frequency of 11% for 159 samples ranging in concentration from <1% to 70% by PLM-9002. Vermiculite was observed in 45 samples based on a qualitative assessment. Vermiculite was not observed in 76 samples based on a qualitative assessment. Information on vermiculite was not available for 41 samples.
- A total of 25 subsurface soil samples were collected during the supplemental OU4 Phase 1 investigation activities. LA was detected at a frequency of 67% for three samples with concentrations ranging from trace to 1% by PLM-VE. LA was not detected in one sample by PLM-Grav. Tremolite/actinolite was detected at a frequency of 20% ranging in concentration from <1% to 10% by PLM-9002. Vermiculite was observed in 15 samples based on a qualitative assessment. Vermiculite was not observed in 10 samples based on a qualitative assessment.
- Two investigatory water samples were collected at an OU4 property. Total LA was not detected in either sample by TEM analysis.

3.2 Phase 2 Investigation

Phase 2 investigation field sampling was conducted in the Fall of 2001 and completed in accordance with the *Phase 2 Sampling and Quality Assurance Project Plan* (EPA 2001b). Specifics on sample collection procedures and conclusions of the Phase 2 investigation work were detailed in the *Phase 2 Data Summary Report* (EPA 2006c) and are summarized below.

3.2.1 Objectives and Conclusions

The objectives and major conclusions of the Phase 2 field investigation were:

Objective 1: Determine what method is best for collection of air samples through the collection of samples that measure asbestos levels in the breathing zone of individuals engaged in routine activities, excluding active cleaning and special activities (active cleaning, active disturbance of vermiculite, and active disturbance of soil) in and about Libby, and to compare those measurements to data collected from co-located stationary air monitors in order to help guide future air sampling activities at the Libby Site that are needed to evaluate risks to individuals engaged in both routine and special activities in the house.

> **Conclusion 1:** Stationary air monitors may tend to underestimate exposure and risk of individuals who engage in activities that disturb asbestos-containing source material. The magnitude of the underestimation depends upon the scenario; scenarios that are associated with routine activities and minimal disturbances are associated with only small differences (ratios close to 1), while scenarios that are associated with active disturbances are associated with the greatest differences (ratios above 1). The absolute magnitude of the difference between a pair of stationary and personal samples is expected to be highly variable between different settings, depending on the intensity and duration of disturbance activities, the nature of the source material, the speed and direction of wind or air flow in the vicinity, and the distance between the activity and the stationary monitor.

Objective 2: Determine what method of analysis is best for air samples through a series of different air samples analyzed by both the TEM and PCM methods in order to help judge which type of measurement is most appropriate, and to derive a site-specific relationship between the two (if possible). In particular, the goal was to address two questions related to differences between PCM and TEM: 1) Does PCM overestimate asbestos concentrations relative to TEM, because PCM does not distinguish between asbestos and non-asbestos fibers in a sample? and 2) Does PCM underestimate asbestos concentrations relative to TEM, because PCM cannot visualize structures thinner than about 0.25 µm in thickness and does not include structures shorter than five µm?

> **Conclusion 2:** The use of PCM will usually tend to overestimate exposure of individuals who engage in activities that disturb asbestos-containing source material, especially in residential environments, since a number of non-asbestos fibers will be included. Conversely, use of PCM will tend to underestimate exposure to total LA, since about 55% of all LA structures are either too thin or too short to count by PCM. Because the relationship between PCM and TEM varies with the setting of the activity, the type of source material, and the location of the air monitor, it is not possible to establish a default site-specific relationship between the two methods.

Objective 3: Determine if the levels of asbestos observed in Libby are of potential human health concern through the analysis of the data collected to derive preliminary assessments of the potential health risk to people who engage in the types of routine and special activities investigated. It is important to note that, because the Phase 2 investigation was not intended to be systematic or comprehensive and hence did not span all possible exposure conditions and all exposure locations, the project plan emphasized that the data should be interpreted as providing only an initial estimate of the range of different exposure levels (and hence health risks) that residents of Libby may experience from both routine and special activities.

> **Conclusion 3:** In general, the levels of LA in air tend to be highly variable over time and space. This emphasizes the need to collect additional data on the levels of LA that occur in association with a wide range of activities and at a wide range of locations in order to better understand the exposures and risks which may be occurring at the Libby Site.

Additional conclusions for the Phase 2 investigation were derived during the data analysis. These conclusions were not based on primary investigation objectives, but have provided additional guidance on the design of all investigations conducted at the Libby Site since the Phase 2 investigation was completed. These additional conclusions include the following:

> **Conclusion 4:** Concentration values in most samples of air and dust are in a range where TEM analysis based on only 10-20 grid openings is likely to identify only a relatively small number of LA particles. Because there is high analytical uncertainty associated with a small number of detected particles, future sampling efforts should seek to increase the number of grid openings evaluated to the extent allowed by time and cost constraints. This will result in a lower sensitivity and decrease uncertainty in concentration, exposure, and risk estimates.

> **Conclusion 5:** The data collected during Phase 2 were not adequate to derive any meaningful estimates of transfer factors for LA from soil to outdoor air, soil to indoor dust, or indoor dust to indoor air. This is mainly because of the high variability in soil, dust, and air values, coupled with a relatively high analytical sensitivity and a resultant high frequency of non-detects for most Phase 2 samples.

3.2.2 Study Design

The general investigation design was to investigate the concentrations of asbestos fibers in air that may occur in the breathing zone of individuals engaged in a variety of activities that might lead to the disturbance of asbestos-contaminated source materials such as dust, vermiculite insulation, and soil. To this end, Phase 2 was divided into four general activity-based "scenarios," as follows:

Scenario 1 – Routine Household Activities: Scenario 1 focused on the airborne exposures of residents engaged in routine household activities excluding active cleaning. A total of 16 residences participated in Scenario 1. This included residences with and without vermiculite insulation, and residences with and without measured levels of asbestos in indoor air and dust. The types of activities performed during the sample collection period were recorded by the resident in an activity log. Any special activities that were a potential source of increased exposure to airborne asbestos fibers were also recorded in the activity log.

Scenario 2 – Active Household Cleaning Activities: Scenario 2 focused on active cleaning-related activities (vacuuming, sweeping, dusting) that are likely to cause increased levels of dust (and hence asbestos) in indoor air. A total of 22 residences participated in Scenario 2 (these residences included 13 of the 16 locations participating in Scenario 1). In addition to the cleaning activities of vacuuming, sweeping, and dusting, an additional cleaning scenario was evaluated at one residence to assess exposures specifically related to beating sofa cushions. Vacuuming/sweeping/dusting cleaning activities are referred to as Scenario 2A and beating sofa cushions is referred to as Scenario 2B.

Scenario 3 – Active Disturbance of Vermiculite: Scenario 3 focused on exposures that occur when vermiculite sources are actively disturbed, such as when a contractor performs remodeling or repair work in a house with vermiculite insulation, or when a resident enters a space (e.g., an attic area) with accessible vermiculite insulation. Seven residences participated in Scenario 3. Six of these seven residences had vermiculite insulation in the attic, and samples of insulation from all six of these attics contained detectable levels of LA when examined by PLM. Scenario 3 exposure activities were separated into the following categories:

- 3A) Sweeping or moving debris/insulation in attic
- 3B) Cutting holes into ceilings or walls (e.g., replacing a ceiling fan)
- 3C) Replacing or removing carpeting
- 3D) Removing vermiculite insulation via hand-bagging
- 3E) Removing vermiculite insulation via vacuum truck

Scenario 4 – Active Disturbance of Soil (Rototilling Activities): Scenario 4 focused on exposures that occur when garden soil is actively disturbed during rototilling activities. This scenario was chosen both because vermiculite is known to have been added to a number of gardens in Libby and rototilling is a realistic and aggressive soil disturbance scenario. While the Phase 2 QAPP specified that rototilling was to be performed for three gardens (one garden without visible vermiculite and two gardens with visible vermiculite), the activity was only completed in one garden with visible vermiculite.

3.2.3 Air Results

There were several types of personal and stationary air monitoring samples collected during the Phase 2 investigation. The sections below summarize the different types of air samples collected.

3.2.3.1 Stationary/Personal Air Samples

Phase 2 stationary air samples were collected during a series of both indoor and outdoor scenario activities as described above. Stationary air monitors were placed in the main area(s) of the residences where scenario-related activities were occurring and placed on stands (approximately four to six feet above the ground surface). During Scenarios 2 and 3, several outdoor stationary air samples were also collected to monitor for potential releases of contaminated materials during scenario-related activities. For Scenario 4, the stationary air monitors were placed in four locations surrounding the perimeter of the rototilling activity.

In addition, Phase 2 stationary clearance samples were collected to establish when the houses were suitable for re-occupation by the resident after scenario activities were complete. Three sequential clearance samples were collected after the scenario activities were completed.

Personal air monitors were worn at the breathing zone by EPA contractors. Two types of personal air samples were collected during the disturbance activity. A "full period" personal air sample was collected from the beginning of the disturbance activity until the end of the disturbance activity. The full period sample represents the average exposure during the disturbance activity. Several "excursion" personal air samples were collected at shorter intervals within the disturbance activity when it was suspected that the highest air concentrations might be present.

Table 3-3 presents a summary of all personal and stationary air samples analyzed by TEM for scenarios 1-4. Refer to Appendix A for additional information on individual sample details and analytical results. Results are summarized below in brief:

- A total of 44 personal and stationary indoor air samples were collected during Scenario 1 of the Phase 2 investigation routine activities. Total LA was detected at a frequency of 63% and 61% for personal and stationary air samples, respectively. Total LA concentrations ranged from 0.000064 s/cc to 0.0016 s/cc by TEM analysis.
- A total of 320 personal and stationary, indoor and outdoor air samples were collected during Scenario 2 of the Phase 2 investigation active cleaning activities. Total LA was detected at a frequency of 8-100% ranging in concentrations from 0.00074 s/cc to 0.25 s/cc by TEM analysis.
- A total of 176 personal and stationary, indoor and outdoor air samples were collected during Scenario 3 of the Phase 2 investigation vermiculite disturbance activities. Total LA was detected at a frequency of 8-76% ranging in concentrations from 0.00039 s/cc to 9.2 s/cc by TEM analysis.
- A total of 17 personal and stationary, outdoor air samples were collected during Scenario 4 of the Phase 2 investigation rototilling activities. Total LA was detected at a frequency of 50-100% ranging in concentrations from 0.0027 s/cc to 0.17 s/cc by TEM analysis.

3.2.3.2 Real-Time Aerosol Monitors

Airborne dust levels were measured using a real-time aerosol monitor (RAM) in accordance with EPA-LIBBY-03, *Site-specific SOP for Real-time Aerosol Monitoring*. Two types of measurements were obtained from the RAMs. First, continuous measurements of airborne dust levels (milligram/cubic meter) were acquired at 1-second intervals prior to the activity, during the activity, and at one or more times following the activity. These measures of airborne dust are referred to as RAM dust levels in this report. Second, filters placed within the RAM were analyzed for asbestos in the same manner as personal and stationary filters. The concentrations of asbestos in air derived from RAM filters will be referred to as "HazDust" asbestos concentrations in this report. Due to the variability in air flow rates through HazDust filters, confidence in estimates of asbestos concentrations in air is low for HazDust samples compared to the asbestos concentrations from stationary and personal air monitors. Because of this, the Phase 2 data summary used HazDust asbestos concentrations only in an evaluation of the correlation between dust and LA levels in air, and was not used to estimate human exposure or risk. Refer to the *Phase 2 Data Summary Report* (EPA 2006c) for additional information on individual sample details and analytical results.

3.2.4 Source Media Results

Samples of source media (soil dust, bulk building materials, and vermiculite insulation) were collected in an attempt to generate a correlation with measured air concentrations. Table 3-4 presents a summary of the results for the source media samples collected as part of the Phase 2 investigation. Results for TEM analyses will only be presented for total LA because structure information needed to compute PCME concentrations is not available for all samples. Refer to Appendix A for additional information on individual sample details and analytical results. Results are summarized below in brief:

- As part of the Phase 1 investigation, two surface soil samples had been collected from the garden selected for rototilling. Therefore, no additional soil samples were collected as part of the Phase 2 investigation. The soil results from the Phase 1 samples were non-detect and <1% by PLM-9002.

- If vermiculite insulation samples were not previously collected as part of the Phase 1 investigation, samples were collected as part of the Phase 2 investigation. In most instances, the insulation was collected from several locations at different depths in order to obtain representative samples of the insulation. A total of 10 vermiculite insulation samples (12 analyses) were collected during the Phase 2 investigation activities. Tremolite/actinolite was detected in 75% of the samples with reported values of <1% by PLM-9002.

- Dust samples were collected before and after Scenarios 2 and 3 were performed. Composite surficial dust samples were collected from two to four different indoor locations (each location area consisting of 100 square centimeters [cm^2]). Dust sampling locations included both surfaces where dust may settle out (e.g., window sills, shelves), as well as floors (e.g., entryways, living areas). If cleaning activities resulted in the generation of a visible pile of dust or dirt, a sample of this material was also collected using the microvacuum technique. These samples were referred to as "dust pile" samples. A total of 47 dust samples were analyzed for the Phase 2 investigation. Total LA was detected at an overall frequency of 49% ranging in concentrations from 19 s/cm^2 to 320,000 s/cm^2 by TEM analysis.

3.3 Contaminant Screening Study

As mentioned above, the Phase 1 investigation demonstrated the random distribution of LA-contaminated materials throughout the Kootenai Valley, and the CSS was designed to systematically screen approximately 3,500 properties. The CSS combined visual inspections, verbal interviews, and outdoor soil sampling to screen for the presence of potential LA source materials in accessible areas where exposure was most likely to occur and access was granted by the property owner.

CSS investigations have been conducted at properties at OU4 since 2002. The 2002 CSS was initially designed in 2002 and slightly modified in 2003.

3.3.1 2002 Study Design

The 2002 CSS field activities were performed in accordance with the *CSS SAP* (CDM Smith 2002a). Specifics on sample collection procedures and SOPs are provided in this section. The objective of the CSS investigation was to determine if contamination is present in high traffic areas on individual residential, commercial, and industrial properties. Property-specific contamination history and locations of visible vermiculite were recorded on *Information Field Forms* (IFFs). The data collected was used to determine the magnitude of the problem by identifying how many properties require removal, may require removal (i.e., pending), or do not require removal.

Soil samples were collected in accordance with CDM-LIBBY-05, *Site-specific SOP for Soil Sample Collection, Revision 1*. In general, two to five 5-point (fewer if conditions limited collection) composite soil samples were collected from each property. Each composite sample characterized areas up to 5,500 square feet (ft^2); samples were collected from zero to one inch bgs in yards and zero to six inches bgs for driveways, landscaped areas, gardens, fill areas, etc. Because the EPA initially theorized that identification of vermiculite in soil was an indicator of presence of LA at levels of concern, samples were intentionally collected from areas where vermiculite was not observed. During the CSS investigation, there was no formalized approach to inspect or quantify vermiculite in soil.

3.3.2 2003 Study Design

The 2003 CSS and RI were slightly modified from the 2002 CSS field effort. The significant difference between the investigations is that, based on preliminary findings from the 2002 CSS, the 2003 field activities were enhanced to include intrusive techniques for attic inspections, inspection of building materials for vermiculite, indoor dust sampling, and soil sampling in large use areas that were purposely excluded from the 2002 CSS program. Additional details of the 2003 CSS program are included in the *Contaminant Screening Study, Final Technical Memorandum* (CDM Smith 2006b).

The 2003 field activities were performed in accordance with the *Final Sampling and Analysis Plan, Remedial Investigation Contaminant Screening Study, Revision 1* (hereafter referred to as the *CSS SAP, Revision 1*[CDM Smith 2003a]) and *Final Sampling and Analysis Plan, Remedial Investigation* (CDM Smith 2003b). Specifics on sample collection procedures and SOPs are listed below.

Similar to the 2002 CSS field activities, 2003 CSS soil samples were collected in accordance with CDM-LIBBY-05, *Site-specific SOP for Soil Sample Collection, Revision 1*. The primary difference between the 2002 and 2003 CSS soil sample collection procedure was that for the 2003 CSS effort, only specific-use areas (SUAs) (e.g., flowerbeds, gardens, driveways, etc.) were not sampled if vermiculite was observed. Yards and driveways were sampled regardless of the presence of vermiculite. Similar to the 2002 CSS investigation, there was no formalized approach to inspect or quantify vermiculite in soil.

During the 2003 CSS field effort, field teams began collecting dust samples from properties if LA sources were present and/or if secondary indicators (e.g., former mine worker) were present. The 2003 CSS dust samples were collected in accordance with ASTM D5755 with modifications as described in the *Sampling and Analysis Plan for Indoor Dust* (EPA 2003b). This SAP specifies that two dust samples would be collected from the high traffic and horizontal surfaces of each floor, and three 100 cm^2 sample areas would be included on each cassette.

As specified in the *Sampling and Analysis Plan for Indoor Dust* (EPA 2003b), microvacuum dust samples associated with the 2003 RI were analyzed in accordance with TEM AHERA or TEM ISO. A target analytical sensitivity of 500 per square centimeter (cm^{-2}) was established for these samples. Samples with analytical sensitivities greater than 1,000 cm^{-2} were used for removal decisions only on a case-by-case basis.

3.3.3 Results

Results for dust and soil samples collected as part of the CSS investigation are summarized in Table 3-5. Refer to Appendix A for additional information on individual sample details and analytical results. Results are summarized below in brief:

- A total of 2,056 indoor dust samples were collected and analyzed during the CSS. Total LA was detected at a frequency of 9% ranging in concentrations from 44 s/cm^2 to 260,000 s/cm^2 by TEM analysis. There are additional samples that were collected and not analyzed. The remaining samples were archived indefinitely after the analytical soil results for each property were reviewed. It was assumed properties without soil contamination would be less likely to have contaminated dust samples.

- A total of 13,415 surface soil samples were collected during the CSS. LA was detected at a frequency of 8% for 13,077 samples (13,169 analyses) ranging in concentrations from trace to 6% by PLM-VE. LA was detected at a frequency of 1% for 8,260 samples (8,608 analyses) ranging in concentrations from trace to 68% by PLM-Grav. Tremolite/actinolite was detected at a frequency of 10% for 395 samples (398 analyses) at <1% by PLM-9002. Tremolite/actinolite was detected at a frequency of 4% for 79 samples (84 analyses) at trace by PLM-600. Vermiculite was observed in 1,235 samples based on a qualitative assessment and in two samples based on a quantitative assessment. Vermiculite was not observed in 2,802 samples based on a qualitative assessment. Information on vermiculite was not available for 9,376 samples.

- A total of 76 subsurface soil samples were collected during the CSS. LA was detected at a frequency of 11% for 74 samples (80 analyses) with trace concentrations of LA by PLM-VE. LA was not detected in 51 samples by PLM-Grav. Tremolite/actinolite was detected at a frequency of 14% for seven samples with one sample reporting <1% by PLM-9002. Vermiculite was observed in nine samples based on a qualitative assessment. Vermiculite was not observed in 21 samples based on a qualitative assessment. Information on vermiculite was not available for 46 samples.

- One bulk material sample was collected as part of the CSS from chinking around a basement chimney. This sample was analyzed by PLM-9002 and was non-detect for tremolite/actinolite.

3.4 Contamination Assessments at Specialty Properties

Some properties within OU4 required assessments, which differed from established protocol due to their unique history of contamination or special interest as a public area. In such cases, the traditional investigation process could not adequately evaluate the extent of contamination at these so-called "Specialty Properties," and thus alternative assessment methods were utilized in order to determine possible future removal/remedial action. Investigations conducted at these unique properties in OU4 are described in the following section, which details all Specialty Property contamination assessments performed. The locations of all Specialty Properties within OU4 are provided in Figure 3-1. Samples collected to facilitate the removal process are presented in Section 3.33.

3.4.1 Kootenai Bluffs Subdivision

The Kootenai Bluffs Subdivision is located on the west side of the Kootenai River, directly across the river from the former Screening Plant (Figure 3-1). When the vermiculite mine was in operation, a portion of the property was used by Grace as a conveyor unloading station. The sorted vermiculite was received from the Screening Plant via a conveyor constructed across the Kootenai River and loaded onto trucks or railroad cars for distribution to numerous expansion plants throughout the United States. The remainder of the bluffs property consisted of undeveloped land that does not appear to have been associated with previous commercial operations of the vermiculite mine. Due to the property's affiliation with the former Screening Plant, the Kootenai Bluffs Subdivision was formerly classified as OU2. The subdivision consists of 12 lots: Lots 1 and 2 are privately owned and have been developed; Lots 3 and 4 are vacant and privately owned; KDC (a subsidiary of Grace) owns the remaining eight lots.

Characterization of the Kootenai Bluffs Subdivision began in December 1999, and continued into July 2001, with subsequent investigations occurring in 2006 and 2009. Soil samples were collected from the conveyor unloading station, several stockpiles, test pits, accessible land that was not heavily wooded and from the area surrounding a proposed building site. In addition, an indoor inspection was completed within each building present within the investigation limits.

A detailed summary of sample collection events through 2006, as well as the locations and results for the individual samples collected during these investigations is presented in the *Final Data Summary Report for Operable Unit 2: Former Screening Plant and Surrounding Area* (CDM Smith 2008b). A detailed summary of the 2009 sample collection event, as well as the location and results for the individual samples collected during this investigation are presented in the *Wise Property and Kootenai Bluffs Subdivision Summary Memorandum* (CDM Smith 2009a).

Results for soil samples collected from the Kootenai Bluffs Subdivision are summarized in Table 3-6. Refer to Appendix A for additional information on individual sample details and analytical results. Results are summarized below in brief:

- A total of 182 surface soil samples were collected during the assessment of the Kootenai Bluffs Subdivision. LA was detected at a frequency of 3% for 63 samples as trace by PLM-VE. LA was not detected in 55 samples by PLM-Grav. Tremolite/actinolite was detected at a frequency of 51% for 119 samples ranging from <1% to 10% by PLM-9002. Vermiculite was observed in 11 samples based on a qualitative assessment and two samples based on quantitative assessment. Vermiculite was not observed in 122 samples based on a qualitative assessment. Information on vermiculite was not available for 47 samples.

- A total of 13 subsurface soil samples were collected during the assessment of the Kootenai Bluffs Subdivision. Tremolite/actinolite was detected at a frequency of 62% for 13 samples with concentrations ranging from <1% to 7% by PLM-9002. Vermiculite was observed in one sample based on a qualitative assessment. Information on vermiculite was not available for 12 samples.

3.4.2 Kootenai Valley Head Start

Located at 263 Indian Head Road (Figure 3-1), Kootenai Valley Head Start is the location of the former Plummer Elementary School and was first investigated in January 2000 as part of the Phase 1 investigation. During the inspection of the building, vermiculite insulation was not observed in the attic. Air, dust and soil characterization samples were collected, handled, and analyzed in accordance with the *Phase 1 QAPP* (EPA 1999, 2000b). Results for samples collected from Kootenai Valley Head Start are summarized in Table 3-7. Refer to Appendix A for additional information on individual sample details and analytical results. Results are summarized below in brief:

- A total of four stationary indoor air samples were collected during the initial assessment in January 2000. Total LA was not detected in any of the samples by TEM analysis.
- A total of 21 stationary outdoor air samples were collected in January through November of 2000. Total LA was detected at a frequency of 5% with a concentration of 0.00093 s/cc by TEM analysis.
- A total of four dust samples were collected in January 2000 from the following locations within the school building: gym, janitor's closet, and window sills of two classrooms. Total LA was not detected in any of the samples by TEM analysis.
- A total of 57 surface soil samples were collected in 2001 during investigation activities. LA was detected at a frequency of 5% for 43 samples with concentrations of trace by PLM-VE. LA was detected at a frequency of 6% for 35 samples ranging in concentrations from greater than trace to 100% by PLM-Grav. Tremolite/actinolite was detected at a frequency of 12% for 57 samples ranging in concentration from <1% to 5% by PLM-9002. Vermiculite was observed in five samples based on a qualitative assessment. Vermiculite was not observed in six samples based on a qualitative assessment. Information on vermiculite was not available for 46 samples.
- A total of three subsurface soil samples were collected in 2002 during investigation activities. LA was not detected in one sample by PLM-VE and PLM-Grav. Tremolite/actinolite was detected at a frequency of 67% for three samples ranging in concentration from <1% to 7% by PLM-9002. Vermiculite was observed in two samples based on a qualitative assessment. Information on vermiculite was not available for one sample.

3.4.3 Libby Elementary School

Located at 700 Idaho Avenue (Figure 3-1) and formerly known as Asa Wood Elementary School, Libby Elementary School was first investigated in January 2000 as part of the Phase 1 investigation. An inspection of the building was completed, but vermiculite insulation was not observed in the attic. Air, dust, and soil characterization samples were collected, handled, and analyzed in accordance with the *Phase 1 QAPP* (EPA 1999, 2000b). Results for samples collected from Libby Elementary School are summarized in Table 3-8. Refer to Appendix A for additional information on individual sample details and analytical results. Results are summarized below in brief:

- A total of six stationary indoor air samples were collected during the initial assessment in January 2000. Total LA was not detected in any of the samples by TEM analysis.
- A total of six dust samples were collected in January 2000 from the following locations within the school building: boiler room, stage, and window sills of the stage, front office, music room, and one classroom. Total LA was not detected in any of the samples by TEM analysis.
- In March 2001, four grab subsurface and nine grab surface soil samples were collected from the play areas surrounding the school. These soil samples were archived and have not been analyzed.
- In June 2001, an additional 28 surface soil samples were collected from the yard and play areas surrounding the school. LA was detected at a frequency of 9% for 23 samples with concentrations of trace by PLM-VE. LA was not detected in 22 samples by PLM-Grav. Tremolite/actinolite was detected at a frequency of 7% for 28 samples at concentration of <1% by PLM-9002. Vermiculite was not observed in 19 samples based on a qualitative assessment. Information on vermiculite was not available for nine samples and therefore was assumed not to be present.
- Also in June 2001, three subsurface soil samples were collected from the yard and play areas surrounding the school. LA was detected at a frequency of 33% for three samples with a concentration of trace by PLM-VE. LA was not detected in two samples by PLM-Grav. Tremolite/actinolite was not detected in three samples by PLM-9002. Information on vermiculite was not available for any sample.

3.4.4 Libby Middle School

Located at 101 Ski Road (Figure 3-1), Libby Middle School was first investigated in January 2000 as part of the Phase 1 investigation. During the inspection of the building, vermiculite insulation was not observed in the attic. Air, dust, and soil characterization samples were collected, handled, and analyzed in accordance with the *Phase 1 QAPP* (EPA 1999, 2000b). Results for samples collected from Libby Middle School are summarized in Table 3-9. Refer to Appendix A for additional information on individual sample details and analytical results. Results are summarized below in brief:

- A total of eight stationary indoor air samples were collected during the initial assessment in January 2000 and a subsequent sampling in September 2001. Total LA was not detected in any of the samples by TEM analysis.
- A total of nine dust samples were collected in January 2000 and March 2009 from the following locations: south end of auditorium, entrance to gym, and window sills of five classrooms, and the high jump mat on the athletic field after it was determined that the mat originated from Libby High School. Total LA was detected at a frequency of 22% ranging in concentrations from 52 s/cm^2 to 790 s/cm^2 by TEM analysis.
- A total of 155 surface soil samples were collected in 2001 during outdoor inspections of the track, an additional three feet on the inner and outer sides of the track, and the play areas/yard surrounding the school. LA was detected at a frequency of 6% for 117 samples with concentrations of trace by PLM-VE. LA was not detected in 95 samples by PLM-Grav. Tremolite/actinolite was detected at a frequency of 11% for 155 samples (203 analyses) at concentrations ranging from <1% to 15% by PLM-9002. Vermiculite was observed in 11 samples based on a qualitative assessment. Vermiculite was not observed in 111 samples based on a qualitative assessment. Information on vermiculite was not available for 33 samples.

- A total of 25 subsurface soil samples were collected in 2001 during outdoor inspections of the track, an additional three feet on the inner and outer sides of the track, and the play areas/yard surrounding the school. LA was detected at a frequency of 22% for nine samples with concentrations of trace by PLM-VE. LA was not detected in eight samples by PLM-Grav. Tremolite/actinolite was detected at a frequency of 52% for 25 samples at concentrations ranging from <1% to 7% by PLM-9002. Vermiculite was observed in three samples based on a qualitative assessment. Vermiculite was not observed in five samples based on a qualitative assessment. Information on vermiculite was not available for 17 samples.

3.4.5 Libby High School

Located at 150 Education Way (Figure 3-1), Libby High School was first investigated in January 2000 as part of the Phase 1 investigation. During the inspection of the building, vermiculite insulation was not observed in the attic. Air, dust, soil, and bulk characterization samples were collected, handled, and analyzed in accordance with the *Phase 1 QAPP* (EPA 1999, 2000b). Results for samples collected from Libby High School are summarized in Table 3-10. Refer to Appendix A for additional information on individual sample details and analytical results. Results are summarized below in brief:

- A total of 11 indoor stationary air samples were collected during the initial inspection in January 2000 and June 2001. Total LA was not detected in any of the samples by TEM analysis.
- One outdoor stationary air sample was collected in June 2001. Total LA was not detected in this sample by TEM analysis.
- A total of 18 dust samples were collected from the various locations within the school building and outbuildings surrounding the track. Total LA was detected at a frequency of 39% with concentrations ranging from 320 s/cm^2 to 42,000 s/cm^2 by TEM analysis.
- A total of 208 surface soil samples were collected in 2001 during outdoor inspections of the track, an additional three feet on the inner and outer sides of the track, and the yard surrounding the school. LA was detected at a frequency of 13% for 146 samples (149 analyses) with concentrations ranging from trace to <1% by PLM-VE. LA was detected at a frequency of 1% for 77 samples with one sample reporting trace by PLM-Grav. Tremolite/actinolite was detected at a frequency of 21% for 208 samples (214 analyses) at concentrations ranging from <1% to 5% by PLM-9002. Vermiculite was observed in eight samples based on a qualitative assessment. Vermiculite was not observed in 149 samples based on a qualitative assessment. Information on vermiculite was not available for 51 samples.
- A total of 27 subsurface soil samples were collected in 2001 during outdoor inspections of the track, an additional three feet on the inner and outer sides of the track, and the yard surrounding the school. LA was not detected in 10 samples by PLM-VE. LA was not detected in six samples by PLM-Grav. Tremolite/actinolite was detected at a frequency of 63% for 27 samples at concentrations ranging from <1% to 8% by PLM-9002. Vermiculite was observed in two samples based on a qualitative assessment. Vermiculite was not observed in five samples based on a qualitative assessment. Information on vermiculite was not available for 20 samples.

3.4.6 Libby School District Administration Building

Located at 724 Louisiana Avenue (Figure 3-1), the Libby School District Administration Building was first investigated in January 2000 as part of the Phase 1 investigation. An inspection of the building was completed, and vermiculite insulation was observed in the attic. Air, dust, and soil characterization samples were collected, handled, and analyzed in accordance with the *Phase 1 QAPP* (EPA 1999, 2000b) and *CSS SAP, Revision 1* (CDM Smith 2003a). Results for samples collected from the Libby School District Administration Building are summarized in Table 3-11. Refer to Appendix A for additional information on individual sample details and analytical results. Results are summarized below in brief:

- A total of five indoor stationary air samples were collected during the initial inspection in January 2000. Total LA was detected at a frequency of 20% with a concentration of 0.00081 s/cc by TEM analysis.
- A total of seven vermiculite insulation samples were collected from insulation observed in the attic of the old portion of the building in June 2001. Tremolite/actinolite was detected at a frequency of 29% at <1% by PLM-9002.
- A total of seven dust samples were collected from the windowsills of the following areas: board of trustee's room, business office, community interagency office, south end of hallway, and electrical closet in January 2000 and from the old and new sections of the building in June 2001. Total LA was not detected in any of the samples by TEM analysis.
- A total of 16 surface soil samples were collected in 2001 and 2003 from the play area/yard surrounding the building, the driveway and side yard. LA was not detected in 10 samples by PLM-VE. LA was not detected in six samples by PLM-Grav. Tremolite/actinolite was not detected in eight samples (12 analyses) by PLM-9002. Vermiculite was not observed in four samples based on a qualitative assessment. Information on vermiculite was not available for 12 samples.
- A total of two subsurface soil samples were collected in 2001 and 2003 from the play area/yard surrounding the building, the driveway and side yard. LA was not detected in one sample by PLM-Grav. Tremolite/actinolite was not detected in two samples by PLM-9002. Information on vermiculite was not available for two samples.

3.4.7 McGrade Center

Located at 899 Farm to Market Road (Figure 3-1), the McGrade Center is the location of the former McGrade Elementary School and was first investigated in January 2000 as part of the Phase 1 investigation. During the inspection of the building, vermiculite insulation was not observed in the attic. Air, dust, and soil characterization samples were collected, handled, and analyzed in accordance with the *Phase 1 QAPP* (EPA 1999, 2000b). Results for samples collected from the McGrade Center are summarized in Table 3-12. Refer to Appendix A for additional information on individual sample details and analytical results. Results are summarized below in brief:

- A total of four indoor stationary air samples were collected during the initial inspection in January 2000. Total LA was detected at a frequency of 25% with a concentration of 0.00085 s/cc by TEM analysis.
- A total of 21 outdoor ambient air samples were collected during the initial inspection in January 2000 and continuing through November 2000. Total LA was detected at a frequency of 19% with a concentrations ranging from 0.000096 s/cc to 0.0017 s/cc by TEM analysis.

- A total of four dust samples were collected from the windowsills of the following areas: janitor's room, gym, and window sills of rooms 12 and 8 in January 2000. Total LA was not detected in any of the samples by TEM analysis.
- A total of 38 surface soil samples were collected from the play area/yard surrounding the building and from the adjacent Jerry Dean Park in 2001. LA was detected at a frequency of 3% in 29 samples with one sample reported as trace by PLM-VE. LA was not detected in 22 samples by PLM-Grav. Tremolite/actinolite was detected at a frequency of 3% in 38 samples with one sample reported as <1% by PLM-9002. Vermiculite was not observed in 17 samples based on a qualitative assessment. Information on vermiculite was not available for 21 samples.
- One subsurface soil sample was collected near the basketball court in 2001. LA was not detected in this sample by PLM-VE or PLM-Grav. Tremolite/actinolite was not detected by PLM-9002. Additional subsurface samples were collected, but have been archived. Vermiculite was not observed in the sample based on a qualitative assessment.

3.4.8 Cemetery Park Ball Fields

Located at 855 Crotteau Road (Figure 3-1), contamination at the Cemetery Park Ball Fields has been investigated during both Phase 1 and CSS. Investigations at the park began in 2002 to address suspicions of contaminated backfill on the ball fields and concerns of children being potentially exposed to LA during the baseball season.

According to an interview conducted in 2002, prior to the construction of the baseball fields, the area was undeveloped and mostly under water (i.e., a swamp). The area was backfilled in 1995 by the City of Libby. It was estimated that approximately two to three feet of riprap and three to five feet of common fill were used as backfill throughout the area. This area was then backfilled with six to eight inches of topsoil and the parking lots were backfilled with gravel. The sources of the backfill used are unknown.

Visual inspections were performed to determine if vermiculite and/or LA were present in the park, but vermiculite was not observed during the soil sampling events. Air, dust, and soil characterization samples were collected, handled, and analyzed in accordance with the *Phase 1 QAPP* (EPA 2000b), *CSS SAP* (CDM Smith 2002a), and *Final Sampling and Analysis Plan Addendum for the Cemetery Park Ball Fields* (CDM Smith 2002b). Results for samples collected from the Cemetery Park Ball Fields are summarized in Table 3-13. A detailed summary of the sample collection events, as well as the location and results for the individual samples are presented in the *Final Summary Report for the Cemetery Park Ball Fields* (CDM Smith 2005a). Refer to Appendix A for additional information on individual sample details and analytical results. Results are summarized below in brief:

- One stationary air sample was collected during the initial inspection in January. Total LA was not detected in this sample by TEM analysis.
- A total of five dust samples were collected from the Cemetery Park Ball Fields concession stand and equipment stored in the stand. Total LA was detected at a frequency of 40% with concentrations ranging from 3,500 s/cm^2 to 5,900 s/cm^2 by TEM analysis.
- A total of 20 surface soil samples were collected from the ball fields, walkway, parking lots, ball field and wooded areas in May and August 2002. LA was not detected in 20 samples by PLM-VE or 19 samples by PLM-Grav. Vermiculite was not observed in 12 samples based on a qualitative assessment. Information on vermiculite was not available for eight samples.

- A total of 12 subsurface soil samples were collected and co-located with the surface samples that were collected. LA was not detected in any of the samples by PLM-VE or PLM-Grav. Tremolite/actinolite was not detected in any of the samples by PLM-9002. Information on vermiculite was not available for 12 samples.

3.4.9 St. John's Rehabilitation Center and Helipad Field

The St. John's Rehabilitation Center and Helipad Field is located at 308 East 2nd Street and is illustrated on Figure 3-1. Historical activities at the Helipad field include a Grace vermiculite bagging facility and subsequent City of Libby sports/recreation field. All investigation activities were conducted by CDM Smith in accordance with the *CSS SAP, Revision 1* (CDM Smith 2003a).

As part of the initial investigation, the rehabilitation center and two sheds were inspected to determine if vermiculite insulation or building materials were present. Vermiculite insulation was not observed in any of the three structures. Results for samples collected from St. John's Rehabilitation Center and Helipad Field are summarized in Table 3-14. A detailed summary of the sample collection event, as well as the location and results for the individual samples are presented in the *Draft Summary Report for the St. John's Lutheran Hospital Rehabilitation Center and Helipad Field* (CDM Smith 2006c). Refer to Appendix A for additional information on individual sample details and analytical results. Results are summarized below in brief:

- A total of two outdoor stationary samples were collected near the south/southwest edge of Noble Contracting activities when St. John's Hospital began construction of a new building on the property in May 2006. Total LA was not detected in either sample by TEM analysis.

- A total of 17 surface soil samples were collected to characterize the yard and flowerbeds surrounding the rehabilitation center in June 2002 and again in October 2004 to characterize the field north and east of the rehabilitation center surrounding the Helipad. LA was detected at a frequency of 41% for 17 samples with levels of trace to <1% by PLM-VE. LA was not detected in eight samples by PLM-Grav. Vermiculite was observed in 10 samples based on a qualitative assessment. Vermiculite was not observed in two samples based on a qualitative assessment.

3.4.10 Libby Drive-In Theater

The Libby Drive-In Theater is located at 1144 U.S. Highway 2 (Figure 3-1) and consistent with other areas of OU4, vermiculite may have been used as base and/or fill material throughout the drive-in area. In September 2003, the EPA conducted an investigation to determine the presence of vermiculite and/or LA at the property. All investigation activities were conducted in accordance with the *CSS SAP, Revision 1* (CDM Smith 2003a), and *Final Sampling and Analysis Plan Addendum for the Libby Drive-In Theater* (CDM Smith 2002c).

As part of the investigation, the ticket booth and concession stand were inspected to determine if vermiculite insulation or building materials were present. A visual inspection of both structures on the property was conducted and no vermiculite insulation was observed in either of the structures.

In addition, a visual inspection was performed during the soil sampling efforts to determine if any vermiculite was present in soils. No vermiculite was observed during the soil sampling events. A detailed summary of the sample collection event, as well as the location and results for the individual samples are presented in the *Final Summary Report for the Libby Drive-In Theater* (CDM Smith 2005b). Results for samples collected from the Libby Drive-In Theater are summarized in Table 3-15. Refer to

Appendix A for additional information on individual sample details and analytical results. Results are summarized below in brief:

- A total of 19 surface soil samples were collected in September 2003. LA was not detected in 19 samples by PLM-VE or 19 samples by PLM-Grav. Vermiculite was not observed in 18 samples based on a qualitative assessment. Information on vermiculite was not available for one sample.

In the summer of 2007, a severe thunderstorm damaged the property and the drive-in was closed indefinitely.

3.4.11 Cabinet View Country Club

During 2004, a CSS investigation was conducted at the local golf course, Cabinet View Country Club (CVCC), located at 458 Cabinet View Country Club Road (Figure 3-1). In addition to a verbal interview, visual inspections were performed and soil and dust samples collected to determine the presence of vermiculite and/or LA throughout the golf course club house, pump house, greens, fairways, tee boxes, and sand traps. Field activities were completed in accordance with the *CSS SAP, Revision* 1 (CDM Smith 2003a) and *Final Sampling and Analysis Plan Addendum for the Cabinet View Country Club* (CDM Smith 2004a).

Results for samples collected from the CVCC are summarized in Table 3-16. Refer to Appendix A for additional information on individual sample details and analytical results. Results are summarized below in brief:

- One indoor dust sample was collected from the pump house in 2004. Total LA was not detected in this sample by TEM analysis.
- A total of 79 surface soil samples were collected at the CVCC golf course in 2004 and 2008. LA was detected at a frequency of 39% in 79 samples ranging in concentrations from trace to <1% by PLM-VE. LA was not detected in 13 samples by PLM-Grav. Tremolite/actinolite was not detected in one sample by PLM-9002. Vermiculite was observed in five samples based on a qualitative assessment. Vermiculite was not observed in 71 samples based on a qualitative assessment. Information for vermiculite was not available for three samples.
- A total of 10 subsurface soil samples were collected at the CVCC golf course in 2004. LA was detected at a frequency of 30% in 10 samples with trace concentrations of LA by PLM-VE. LA was not detected in eight samples by PLM-Grav. Vermiculite was not observed any sample based on a qualitative assessment.

Vermiculite was not observed in the club house; however, it was observed in a portion of the pump house attic and sifting from the walls of the original section of that building. A detailed summary of the sample collection event, as well as the location and results for the individual samples are presented in the *Final Summary Report for the Cabinet View Country Club* (CDM Smith 2005c).

3.4.12 J. Neils Park

J. Neils Park is located north of the Kootenai River, approximately one mile along Highway 37 (Figure 3-1). Consistent with other areas of OU4, vermiculite may have been used as base and/or fill material throughout the J. Neils Park paths, playground areas, sport fields, parking areas and concession areas. In September 2003, the EPA conducted an investigation to determine the presence of vermiculite and/or LA at the property. All investigation activities were conducted in accordance

with the *CSS SAP, Revision 1* (CDM Smith 2003a), and *Final Sampling and Analysis Plan Addendum for J. Neils Park and State Highway 37* (CDM Smith 2003c).

Initially, a visual inspection of J. Neils Park was performed in August 2002 to determine if any vermiculite was present. All structures were inspected and vermiculite insulation was not observed in any of the structures on the property. Small amounts of vermiculite were observed on two ball fields, between the bathrooms and playground, and at the entrance to the horse arena.

Soil sampling at J. Neils Park was conducted in two separate events: September 2003 and March 2005. Initially, the park was divided into four subareas including the pathways (i.e., horse path, walking path, and access road), the former airfield area, the forested area, and the areas where visible vermiculite was identified during the initial visual inspection. There was no evidence at the time of sampling to indicate that the forested area contained LA; therefore, only the cleared area was sampled. In total, 67 composite surface soil samples were collected during the September 2003 investigation. Vermiculite was not observed during the sampling event.

Following the sampling event in September 2003, the City of Libby contacted the EPA regarding maintenance on the ball fields prior to the spring baseball season. Surface soil samples were collected from the infield portion of each ball field to further define the nature and extent of contamination.

Results for samples collected from J. Neils Park are summarized in Table 3-17. Refer to Appendix A for additional information on individual sample details and analytical results. Results are summarized below in brief:

- A total of 79 surface soil samples were collected at J. Neils Park in 2003 and 2005. LA was detected at a frequency of 6% in 79 samples ranging in concentrations from trace to <1% by PLM-VE. LA was not detected in 64 samples (78 analyses) by PLM-Grav. Vermiculite was not observed in 67 samples based on a qualitative assessment. Information for vermiculite was not available for 12 samples.

A detailed summary of the sample collection events, as well as the locations and results for the individual samples are presented in the *Final Summary Report for the J. Neils Park and State Highway 37 Investigations, Revision 1* (CDM Smith 2005d).

3.4.13 City of Libby Alleys

In September 2002, in conjunction with CSS activities at 101 Mineral Avenue, a surface soil sample was collected from the alley adjacent to the property (Alley #31). In 2003, a full CSS investigation involving a verbal interview, visual inspection for vermiculite, and surface soil and outdoor ambient air sampling was conducted at Libby's alleys. Objectives of this investigation were to determine the presence of vermiculite and/or LA in the alleys and to determine the presence of LA in airborne dust disturbed by normal alley traffic. Activities were conducted in accordance with the *CSS SAP, Revision 1* (CDM Smith 2003a), and *Final Sampling and Analysis Plan Addendum for the City of Libby Alley Investigation* (CDM Smith 2003d). Interview, inspection, and soil sampling activities took place in October 2003; air sampling was conducted in August 2005.

A detailed summary of the sample collection events, as well as the location and results for the individual samples are presented in the *Final Summary Report for the City of Libby Alley Investigation* (CDM Smith 2005e). Vermiculite was observed in 25 of Libby's 128 alleys. All 25 alleys had a property adjacent to the alley that also contained visible vermiculite. That is, the vermiculite appeared to have migrated into the alley from an adjacent property. It is not suspected that vermiculite was used as a

base material or surface material for alley construction. The locations of visible vermiculite and descriptions of each alley type are shown on Figure 3-2.

Results for samples collected from the city of Libby alleys are summarized in Table 3-18. Refer to Appendix A for additional information on individual sample details and analytical results. Results are summarized below in brief:

- A total of 30 outdoor stationary air samples were collected from eight randomly selected alleys in 2005. Total LA was detected at a frequency of 10% with concentrations ranging from 0.00095 to 0.0010 s/cc by TEM analysis.
- A total of 95 surface soil samples were collected from the city of Libby alleys in 2003. LA was detected at a frequency of 1% in 95 samples with one sample reported as trace by PLM-VE. LA was not detected in 95 samples by PLM-Grav. Only one sample was analyzed by PLM-9002; tremolite/actinolite was detected in one sample at <1% by PLM-9002. Vermiculite was observed in 23 samples based on a qualitative assessment. Vermiculite was not observed in 73 samples based on a qualitative assessment.

Vermiculite and LA contamination in Libby alleys is currently being addressed on a case-by-case basis during removals at adjacent properties.

3.4.14 Creeks

The following sections describe the creek screening investigation activities that have occurred in 2007 and 2008. All creeks are perennial streams and experience significant flow fluctuations during the spring and following heavy precipitation events. As a result, the creeks have had riprap placed at various sections by the United States Army Corps of Engineers (USACE), Lincoln County, the City of Libby, and/or private land owners to control erosion; however, it was suspected that much of this material contained LA. The creek investigations focused on areas near overpasses, bridges, and along roadways, in residential backyards, and other populated areas. The locations and portion of each creek investigated is illustrated on Figure 3-3.

Additional surface water and sediment samples were collected in the spring and fall of 2012 to characterize the nature and extent of potential LA contamination in surface water and sediment and evaluate potential ecological and human health risks. Results for these samples are summarized in Section 3.22.

3.4.14.1 Flower Creek

Flower Creek is centrally located in the city of Libby and discharges runoff from local forested, rural, and urban areas to the Kootenai River. Headwaters of the creek originate within the Cabinet Mountain Wilderness.

In August 2007, an initial investigation was completed along an approximate 2.5-mile section of the creek adjacent to residential and commercial properties that flows through the immediate Libby area. This portion of the creek is predominantly comprised of washed river rock, native vegetation, and other native fill materials. The spatial boundaries of the investigation were as follows:

- Upstream Limit: Southern property boundary of 823 Flower Creek Road
- Downstream Limit: Outlet to the Kootenai River

The results from the initial investigation upstream of the bridge indicated that six primary locations contained LA-contaminated rock material. The contaminated material observed in all upstream locations exhibited similar physical characterictics. The material appeared to have been taken from a similar unknown source location and placed along the creek banks during rebuild/stabilization efforts, and did not appear to be native to the creek bed or immediate surrounding areas. A visual inspection for suspect source material was conducted downstream of the bridge to the Kootenai River and no LA contaminated material was observed.

3.4.14.2 Granite Creek

Granite Creek is a tributary of Libby Creek in the town of Libby, Montana and discharges runoff from local forested, rural, and urban areas to the Kootenai River. Headwaters of the creek originate within the Cabinet Mountain Wilderness. The creek runs along the west side of Highway 2 and is located approximately 1.25 miles east of Flower Creek. A 1,365 foot long levee is located along the west bank of Granite Creek and protects residential and public use land including 10 residential structures and Highway 2. The levee is constructed with earthen material and is armored with riprap on the riverward side.

An approximate 2.5 mile section of Granite Creek from Cherry Creek Road to the confluence with Libby Creek was investigated for LA contaminated material in 2007. Findings from the investigations revealed that LA material was observed along the western bank on the south side of the Highway 2 Bridge.

Based on the investigation findings at the Granite Creek, additional characterization activities (i.e., pre-design inspection [PDI]) were conducted. This additional work is described in Section 3.32.9.2 of this report.

3.4.14.3 Pipe Creek (Lower Section)

Pipe Creek is located northwest of the town of Libby, Montana and discharges runoff from local forested and rural areas to the Kootenai River. Headwaters of the creek originate within mountainous areas north of Libby.

An approximate 1-mile section of Pipe Creek, starting from the Kootenai River, was investigated for LA contaminated material in 2008. Findings from the investigation revealed that LA-contaminated material composed mainly of riprap was observed along the northern bank of Pipe Creek adjacent to properties at 3623 Kootenai River Road and 3737 Kootenai River Road.

3.4.14.4 Libby Creek

Libby Creek is located southeast of the town center of Libby, Montana and discharges runoff from local forested and rural areas to the Kootenai River. Headwaters of the creek originate within the Cabinet Mountain Wilderness.

In October 2007, a portion of Libby Creek that flows along the eastern boundary of the former Stimson Lumber Mill site was visually assessed for the presence of vermiculite and other mine-related materials. Only two visual inspection points reported the presence of low-level vermiculite.

Results for samples collected from Libby Creek are summarized in Table 3-19. Refer to Appendix A for additional information on individual sample details and analytical results. Results are summarized below in brief:

- A total of 23 surface soil samples were collected from each side of the Libby Creek bank (roughly every 400 linear feet). LA was not detected in 23 samples (24 analyses) by PLM-VE. LA was not detected in five samples by PLM-Grav. Vermiculite was observed in two samples based on a quantitative assessment. Vermiculite was not observed in 21 samples based on a qualitative assessment.

In 2008, an approximate 6.8-mile section of Libby Creek, beginning from the Kootenai River and an approximate 0.2-mile section of Libby Creek near Hammer Road, was investigated for LA-contaminated material. Findings from the investigation revealed that LA-contaminated material, composed mainly of riprap, was observed along the eastern bank of Libby Creek approximately 700 feet south of the Champion Haul Road Bridge.

Based on the investigation findings at the Libby Creek, additional characterization activities (i.e., PDI) were conducted. This additional work is described in Section 3.32.9.4 of this report.

3.4.14.5 Other OU4 Creeks

Other creeks investigated in 2008 included Pipe Creek (Upper Section), Parmenter Creek, Doak Creek, Bobtail Creek, Cedar Creek, and Quartz Creek. Findings from the investigation revealed that these creeks did not contain visible LA-contaminated materials.

3.4.15 Highway 37 Embankment

In 2007, the northeast portion of the OU1 Area 3 embankment was investigated for LA. Initially, the entire embankment area was addressed as part of OU1; however, due to an adjustment of the OU1 site boundary, the northeastern portion was allocated to OU4. Results for samples collected from the embankment are summarized in Table 3-20. Refer to Appendix A for additional information on individual sample details and analytical results. Results are summarized below in brief:

- A total of four surface soil samples were collected from the embankment in 2007. LA was detected at a frequency of 25% in four samples with a concentration of <1% by PLM-VE. LA was not detected in two samples by PLM-Grav. Vermiculite was not observed in two samples based on a qualitative assessment. Vermiculite was not observed in two samples based on a quantitative assessment.

3.4.16 Johnston Acres Subdivision

In 2004, the need to investigate the Johnston Acres subdivision arose when the EPA learned that the City of Libby was moving forward on a civil works project to replace aging water lines and transfer residential properties from septic to city sewer within the subdivision. Information gathered during the CSS at properties within the subdivision, indicated that waste rock from the mine may have been brought in and used as fill material. The location of the Johnston Acres subdivision is depicted on Figure 3-1.

The EPA decided to conduct an investigation of the subdivision to ensure that the city contractor was working in safe conditions and to prevent the potential spread of contamination. Based on this information, a sampling plan was established to assess whether waste rock material existed within the Johnston Acres subdivision, and if so, where the waste rock material was located. All investigation activities were conducted in accordance with the *CSS SAP, Revision 1* (CDM Smith 2003a), and *Johnston Acres Field Investigation Memorandum* (CDM Smith 2005f).

In January 2005, the investigation targeted the City's proposed areas of excavation and included yard samples adjacent to the street as well as street samples from the right-of-way. Direct Push Technology was used to advance 44 borings to a minimum of 6 feet bgs and a maximum of 15 feet bgs (depending on the depth of native soil). Cores were visually inspected for waste rock material and vermiculite.

In addition, a total of 45 grab soil samples were collected from the borings to determine the nature and extent of LA. A detailed summary of the sample collection event, as well as the location and results for the individual samples are presented in the *Draft Summary Report for the Johnston Acres Field Investigation* (CDM Smith 2005g). Results for samples collected from the subdivision are summarized in Table 3-21. Refer to Appendix A for additional information on individual sample details and analytical results. Results are summarized below in brief:

- A total of 15 surface soil samples were collected at the subdivision in 2005. LA was detected at a frequency of 13% for 15 samples (16 analyses) with trace concentrations of LA by PLM-VE. LA was not detected in 13 samples by PLM-Grav. Vermiculite was observed in one sample based on a qualitative assessment. Information on vermiculite was not available for 14 samples.
- A total of 30 subsurface soil samples were collected at the subdivision in 2005. LA was detected at a frequency of 9% for 30 samples (34 analyses) with trace concentrations of LA by PLM-VE. LA was not detected in 27 samples by PLM-Grav. Information on vermiculite was not available for any subsurface sample.

3.4.17 Former Concrete Plant

The former concrete plant property (Figure 3-1) encompasses approximately 24 acres and includes two residential units, a large three bay open structure, a concrete scrap pile, a large concrete foundation, abandoned concrete equipment, two underground storage tanks, and several abandoned wooden structures. Other structures on the property have collapsed. The former concrete plant property consists of three addresses: 1080 U.S. Highway 2, 31425 U.S. Highway 2, and 31445 U.S. Highway 2.

In 2002, each of the residential units was investigated during the CSS in accordance with the *CSS SAP* (CDM Smith 2002a). Surface soil samples were collected from the yards and driveways. Vermiculite was observed in the yards, flowerbeds, and garden and vermiculite insulation was observed in the attics of both residences.

In 2003, the entire property was divided into 150-foot by 150-foot grids and surface soil samples were collected from each of the 42 grids. Vermiculite was observed in concrete in the concrete scrap pile, but was not observed in any other areas. The investigation of the former concrete plant was conducted in accordance with the *CSS SAP, Revision 1* (CDM Smith 2003a), and *Draft Sampling and Analysis Plan Addendum for the Former Concrete Plant Investigation* (CDM Smith 2005h). Results for samples collected from the former concrete plant are summarized in Table 3-22. Refer to Appendix A for additional information on individual sample details and analytical results. Results are summarized below in brief:

- A total of 45 surface soil samples were collected at the former concrete plant properties in 2002 and 2003. LA was detected at a frequency of 9% for 45 samples (46 analyses) ranging in concentrations from trace to <1% by PLM-VE. LA was not detected in 20 samples by PLM-Grav. Vermiculite was observed in two samples based on a qualitative assessment. Vermiculite was not observed in 40 samples based on a qualitative assessment. Information on vermiculite was not available for three samples.

3.4.18 Former Landfill

The City of Libby Former Landfill (Figure 3-1), located at 255 County Shop Road, encompasses approximately five acres and is currently undeveloped, with portions of overgrown vegetation. The northern portion of the property remains heavily wooded. The property operated as a dump and burn landfill prior to 1970. The majority of the operations were confined to the southwest section of the property. Waste accepted during operation consisted mainly of municipal waste. Additional wastes disposed of at the landfill included snow removal debris and old vehicles. Old septic trenches are present in the northern section of the property. The landfill was unregulated during operation and the exact nature of the debris is unknown. In 2003, an investigation of the former landfill began and all activities were conducted in accordance with the *CSS SAP, Revision 1* (CDM Smith 2003a), and *Draft Sampling and Analysis Plan Addendum for the Former Landfill Site Investigation* (CDM Smith 2005i).

During the initial visit in September 2003, vermiculite was observed along a dirt path running east to west through the property and in a debris pile in the wooded portion of the property. Two surface soil samples were collected from the driveway and yard. In June 2006, the property was divided into 100-foot by 100-foot grids and surface soil samples were collected from each of the 66 grids.

Results for samples collected from the former landfill are summarized in Table 3-23. Refer to Appendix A for additional information on individual sample details and analytical results. Results are summarized below in brief:

- A total of 68 surface soil samples were collected at the former landfill in 2003 and 2006. LA was detected at a frequency of 9% for 68 samples ranging in concentrations from trace to 1% by PLM-VE. LA was not detected in seven samples by PLM-Grav. Vermiculite was observed in nine samples based on a qualitative assessment. Vermiculite was not observed in 57 samples based on a qualitative assessment. Information on vermiculite was not available for two samples.

3.4.19 Lincoln County Landfill

A Class IV asbestos landfill was constructed in 2002 for the purposes of disposing asbestos-containing material (ACM) generated during the EPA removal actions for the Libby Site. The Class IV asbestos landfill is located west of the existing Lincoln County Class II/III solid waste landfill in Libby, Montana (Figure 3-1). The landfill was designed with four distinct landfill cells, each able to accept waste materials consisting of double-bagged vermiculite, bulk vermiculite insulation, LA-contaminated soils, and LA-contaminated demolition debris. Currently, only one cell has been excavated and continues to be in use. Additional cells may be excavated depending on anticipated future disposal estimates and cell capacity. Additional information on the construction, operations, and maintenance of the asbestos landfill can be found in the *Lincoln County Class IV Asbestos Landfill Operations Plan, Revision 2* (CDM Smith 2008a).

Currently, only vermiculite, LA-contaminated insulation and building debris, and spent PPE are disposed of at the landfill. Contaminated soil is disposed of at OU3. In some isolated cases, LA-contaminated soils and or material may have been placed at the cell when OU3 was closed due to weather and road conditions during the winter months.

The following sections describe the various sampling events that have taken place at the Lincoln County Landfill. Results for air and soil samples collected from the Lincoln County landfill are summarized in Table 3-24. Refer to Appendix A for additional information on individual sample details and analytical results.

3.4.19.1 Air

An initial ambient air sampling effort was conducted in June 2001. Four stationary ambient air locations were selected throughout the landfill and sampled for three consecutive days. The four locations include the main entrance, mulch pile, soil pile, and a location directly north of the municipal waste landfill. All samples were collected in accordance with the *Phase 1 QAPP* (EPA 2000b). Results for samples collected from the landfill are summarized in Table 3-24. Refer to Appendix A for additional information on individual sample details and analytical results. Results are summarized below in brief:

- A total of 11 outdoor stationary air samples were collected in 2001. Total LA was not detected in any of the samples by TEM analysis.

3.4.19.2 Soil

2001 Compost Stockpile Area Soil Sampling

Initial sampling at the Lincoln County Landfill occurred in March 2000 when surface and subsurface soil samples were collected from an area where the county prepared and stockpiled compost material. Initial inspections of the compost stockpiles revealed vermiculite throughout the material. The purpose of the sampling was to determine if the compost material contained LA. Three grab samples were collected from the compost material and 28 grab samples were collected from 14 locations where the compost was produced; one surface and one subsurface from the each location. All samples were collected in accordance with the *Phase 1 QAPP* (EPA 2000b).

Additional soil samples were collected in 2004 from the compost stockpile and are discussed below. Currently, the compost area is considered to be contaminated with LA and is fenced off from general landfill use. The county anticipates using the area for future municipal waste disposal and is currently working with the EPA on developing a plan to cover the contaminated soil prior to use.

Pre-Construction Soil Sampling

Prior to the asbestos landfill cell construction, 29 surface soil samples were collected leading from the landfill entrance to the asbestos cell July 2002. The purpose of this sampling was to obtain baseline levels of LA along roadways leading to the new cell where haul trucks containing vermiculite insulation would travel. One soil sample was collected from an adjacent draining ditch at the landfill entrance.

During the installation of two groundwater monitoring wells in 2002, two grab soil samples were collected from each of the proposed locations and analyzed for asbestos. One grab surface sample was collected from each well during development from 0 to 24 inches bgs, and another grab subsurface soil sample was collected approximately 118 to 124 inches bgs.

Trash Area Clearance Soil Sample

In August 2003, the EPA was notified that vermiculite was disposed of on the south side of the municipal waste trash pile. The EPA removed the vermiculite and properly disposed of it in the asbestos cell. Once the vermiculite was removed, one surface soil sample was collected from the area where the vermiculite was removed. The sample was collected in accordance with the *Phase 1 QAPP* (EPA 2000b).

2004 Compost Stockpile Area Soil Sampling

During the ongoing investigation activities in Libby, vermiculite was observed in compost material obtained from the Lincoln County Landfill by local residents. Samples of the compost material and soil from the compost area were collected during the 2001 Phase 1 activities as described above. More recent sampling was conducted in May 2004 at the compost stockpile area consistent with the CSS sample collection and analytical procedures. Twenty-one 5-point composite soil samples were collected from areas previously used for mixing, stockpiling, and pick-up of compost materials. All samples were collected in accordance with the *CSS SAP, Revision 1* (CDM Smith 2003a). A detailed summary of the sample collection event, as well as the location and results for the individual samples collected at the compost stockpile area are presented in the *Compost Stockpile Area Sampling Memorandum* (CDM Smith 2004b).

Results

Results for samples collected from the landfill are summarized in Table 3-24, stratified by sampling effort. Refer to Appendix A for additional information on individual sample details and analytical results. Results are summarized below in brief:

- A total of 72 surface soil samples were collected from the landfill. LA was detected at a frequency of 60% for 21 samples (22 analyses) ranging in concentration from trace to <1% by PLM-VE. LA was not detected in 20 samples by PLM-Grav. Tremolite/actinolite was detected at a frequency of 27% in 51 samples ranging in concentration from <1% to 3% by PLM-9002. Vermiculite was observed in 31 samples based on a qualitative assessment. Vermiculite was not observed in 30 samples based on a qualitative assessment. Information on vermiculite was not available for 12 samples.

- A total of 17 subsurface soil samples were collected from the landfill. Tremolite/actinolite was detected at a frequency of 29% in 17 samples at concentration of <1% by PLM-9002. Vermiculite was observed in three samples based on a qualitative assessment. Information on vermiculite was not available for 14 samples.

3.4.19.3 Asbestos Cell Capacity

Approximately 46,530 bank cubic yards (BCY) of ACM (i.e., vermiculite, LA-contaminated building material, spent PPE, and plastic sheeting, etc.) have been disposed of in the Lincoln Country Class IV asbestos landfill since its construction as of 2012. Additionally, 5,230 cubic yards (yd^3) of LA-contaminated riprap from the creeks were disposed of in the landfill during the 2008 and 2009 construction season.

In order to estimate landfill capacity needs, it was necessary to estimate the remaining removal actions requiring disposal at the landfill, and future compaction of disposed materials. Several assumptions were made regarding the remaining number of known interior removal actions at OU4 and OU7, anticipated removal actions arising from properties yet to be investigated, and slope requirements to ensure positive drainage. It can be assumed that the present capacity of the cell is sufficient to accommodate all the remaining waste and the cell has surplus space for unforeseen disposal needs. The excess capacity was estimated at approximately 35,000 BCY as of 2012.

Assumptions and calculations regarding future landfill requirements are provided in Appendix C. These estimates assume that only vermiculite and associated LA-contaminated debris are disposed of in the landfill and all soils are transported and disposed of at the former mine. If in the future, changes in the disposal operation are considered, the calculations will have to be adjusted to reflect the additional volumes.

3.4.20 Borrow Sources

Once LA-contaminated soil is removed from properties, various types of fill materials are used to backfill excavated areas. In general, fill materials consist of topsoil and topsoil amendments, common fill, structural fill, and sand. Prior to use, samples are collected from borrow sources, either *in situ* or stockpiled, to determine if it contains LA, organic, and inorganic contaminants (above background levels), and to ensure it meets project-specific physical characteristics. Given the agitated nature of borrow sources, all samples collected are considered subsurface.

3.4.20.1 Fill Material Parameters

All fill materials are sampled for LA in 3,000 yd^3 increments. In addition, all fill materials are sampled for a suite of organic and inorganic parameters in 5,000 yd^3 increments (sand and topsoil amendments are sampled once per season). Topsoil is sampled for a suite of agronomy parameters and common fill is sampled for gradation to determine if it meets project specifications. The following table outlines fill material sample frequency:

Parameter	Frequency	Acceptable Limit
LA	3,000 yd^3	Non-detect by PLM
Organic/inorganic analyses[1]	6,000 yd^3	At or below background levels[2]
Agronomy[3] (topsoil only)	3,000 yd^3	Within contract specifications
Gradation[4] (common fill only)	3,000 yd^3	Within contract specifications

Notes:
LA - Libby Amphibole; yd^3 - cubic yards
[1]EPA Contract Laboratory Program Target Analyte List Volatile organic compounds, semi-volatile organic compounds, polychlorinated biphenyls, pesticides, and target analyte list metals.
[2]Results were compared to the soil contamination action limits based on Montana Department of Environmental Quality (MDEQ) background concentrations for arsenic in soil (MDEQ 2005) and EPA Region 9 regional screening levels for residential soil (http://www.epa.gov/region9/superfund/prg/index.html).
[3]Agronomy analyses include soil texture, pH, organic matter, sodium absorption ratio, electrical conductivity, cation exchange capacity, plant available nitrogen, phosphorus, and potassium, and carbon-to-nitrogen ratio.
[4]Gradation is performed on common fill on the 2-inch, No. 4, 40, and 200 sieves. Gradation is performed on structural fill on the 1.5-inch, No. 4, and 200 sieves.

Results of these tests were evaluated by qualified project personnel prior to government use. Once it was determined the fill material met project specific requirements, it was used for restoration purposes.

Topsoil Parameters

Topsoil specifications for OU4 restoration efforts have changed over the course of the project. Changes were made, based on lessons learned and availability of topsoil in the Kootenai Valley, to improve topsoil performance for settling, drainage, and sustaining restoration efforts (e.g., sod, hydroseed, shrubs, etc.). As of December 2013, six different topsoil specifications have been used:

- 2002 Topsoil Specification – Used 2002 through June 2005
- June 2005 Topsoil Specification – Used June 2005 through 2006

- January 2006 Topsoil Specification – Used 2007 through October 2009
- 2009 Topsoil Specification – Used October 2009 through February 2011
- 2011 Topsoil Specification – Used March 2011 through February 2012
- 2012 Topsoil Specification – Used March 2012 to present

Common Fill Parameters

Common fill specifications for OU4 restoration efforts have changed over the course of the project. Changes were made, based on lessons learned and availability of common fill in the Kootenai Valley, to improve drainage, compaction, and sustaining restoration efforts. As of December 2013, four different common fill specifications have been used:

- Section 02200: Residential Earthwork – Used 2002 through 2008
- 2009 Common Fill Specification – Used 2009 through February 2011
- 2011 Common Fill Specification – Used March 2011 to February 2012
- 2012 Common Fill Specification – Used March 2012 to present

Structural Fill Parameters

Historically, there have not been any parameters established for evaluating structural fill material. Structural fill material generally consists of ¾-inch minus material that is available from local suppliers. Gradation samples were collected for informational purposes only and not compared to any standard. A specification is currently being developed and will be finalized in the *2014 Fill Material Sampling and Analysis Plan*.

3.4.20.2 Fill Material Sampling

Samples were generally collected in a two-step process; asbestos content followed by contract-specific parameters and a suite of organic and inorganic parameters as described above. Topsoil source areas were sampled either in situ (unblended with amendments) or stockpiled (unblended or blended with amendments). In some cases, topsoil amendments (e.g., mulch, sand, etc.) were sampled prior to mixing so as to not taint the stockpile with contaminated additives. Common fill, structural fill, and sand were generally sampled from the suppliers' source stockpiles.

Prior to 2008, LA samples collected from potential fill material source areas were analyzed by PLM-9002. On occasion, some samples (14 of 207 samples) collected prior to 2008, were analyzed by PLM-VE. Beginning in 2008, at the direction of the EPA, all fill material samples collected for LA were analyzed by PLM-VE.

Results for samples collected from the borrow sources are summarized in Table 3-25. Refer to Appendix A for additional information on individual sample details and analytical results. Results are summarized below in brief:

- A total of 632 soil samples were collected from the borrow sources. LA was detected at a frequency of 4% for 536 samples (539 analyses) with trace concentrations by PLM-VE. LA was not detected in 330 samples by PLM-Grav. Tremolite/actinolite was detected at a frequency of 2% in 109 samples with concentrations of <1% by PLM-9002. Vermiculite was not observed in 46 samples based on a qualitative assessment. Vermiculite was not observed in 438 samples

based on a quantitative assessment. Information on vermiculite was not available for 148 samples.

- A total of 90 subsurface soil samples were collected from the borrow sources. LA was not detected in nine samples by PLM-VE or in two samples by PLM-Grav. Tremolite/actinolite was detected at a frequency of 1% in 81 samples with one sample at a concentration of <1% by PLM-9002. Vermiculite was not observed in nine samples based on a qualitative assessment. Information on vermiculite was not available for 81 samples.

If the sample result for the fill material source was non-detect for LA, contract-specific (i.e., agronomy or gradation) and organic/inorganic samples were collected. The fill material samples analyzed for other parameters (i.e., organic/inorganic analyses, agronomy, and gradation) are not available in the project database, but are available upon request.

3.4.20.3 Borrow Source and Fill Material Locations

Several source areas throughout OU4 were sampled as potential fill material source pits. Not all areas sampled were used for fill material as many locations were sampled prior to contract award, at the government's request. In addition, fill material source areas with detectable levels of LA were either not used or a different location was selected and re-sampled. Each of the borrow sources sampled in the Kootenai Valley is shown on Figure 3-4.

3.4.21 Periodic Monitoring at Project-Related Facilities

The EPA performs periodic monitoring at several OU4 locations at which activities are conducted that may increase the potential for LA contamination. The purpose of the monitoring is for personnel H&S, and, as applicable, to help ensure project samples and equipment are handled in atmospheres free of LA. The locations where periodic monitoring has been or currently is conducted are:

- 107 West 4th Street (onsite asbestos laboratory)
- 501 Mineral Avenue (former EPA Information Center location)
- 108 East 9th Street (current EPA Information Center location)
- 115 and 119 East 6th Avenue (Libby Fire Department)
- 1263 Highway 37 (Libby sample warehouse)
- 318 Louisiana Avenue (former CDM Smith office)[8]
- 1673 Highway 37 (former MARCOR office)
- 32000 US Highway 2 (Environmental Restoration)

Monitoring typically consists of collecting indoor ambient air samples, although indoor dust samples have also been collected. If any sample yields detectable levels of LA, work and housekeeping practices may be evaluated and the work area cleaned.

[8] The current CDM Smith office is periodically monitored, and was assessed in the OU5 RI report (HDR Engineering, Inc. and Syracuse Research Corp. 2010).

Results for samples collected from the project-related facilities are summarized in Table 3-26. Refer to Appendix A for additional information on individual sample details and analytical results. Results are summarized below in brief:

- A total of 643 stationary indoor air samples were collected during the periodic monitoring activities. LA was detected at a frequency of 2% ranging in concentrations ranging from 0.0027 s/cc to 0.015 s/cc by TEM analysis.
- A total of 190 indoor dust samples were collected during the periodic monitoring activities. Total LA was detected at a frequency of 5% ranging in concentrations from 36 s/cm^2 to 570 s/cm^2 by TEM analysis.

3.5 Natural Resource Conservation Service

In 2002, the Natural Resource Conservation Service requested several samples of vermiculite for their use. Samples of exfoliated vermiculite, unprocessed vermiculite, and processed vermiculite were identified and sent offsite. Analytical results for these samples are not available in the project database.

3.6 Sediment Core Pilot Study

In June 2002, the EPA began a pilot study to assess sediment deposition in several lakes surrounding the Kootenai Valley. A total of 69 core samples were collected from Flower Lake and St. Mary's Lake. Flower Lake is located approximately 4.25 miles southwest of Libby. St. Mary's Lake is located approximately 9.5 miles northwest of Libby. Sediment cores were collected in accordance with *Sampling and Quality Assurance Project Plan for Measurement of Historic Fiber Deposition Rates in Sediment* (EPA 2002b). Analytical results for these samples are not available in the project database.

3.7 Post Cleanup Evaluation Study

Post-cleanup evaluation sampling was performed between November 2003 and February 2004 in accordance with the *Final Sampling and Analysis Plan Addendum, Post Cleanup Evaluation Sampling* (CDM Smith 2003e). Three types of field samples (stationary indoor air, personal air, and dust) were collected during the cleanup evaluation (CE) activities.

The purpose of the evaluation was to:

- Determine the magnitude of post-cleanup residual contamination levels under varying conditions.
- Understand the length of time that indoor contamination levels may remain below the acceptable removal criteria under varying conditions.
- Evaluate if certain residual sources such as dust inside air ducts and furnaces, or in carpets and upholstery, may result in recontamination of indoor dust.

Thirty-one houses were included in the CE and their selection was prioritized according to the six criteria listed below. A detailed explanation of the distribution, including number and percentage, of the 31 properties related to each of the criteria is available in the *Final Post Cleanup Evaluation Sampling Technical Memorandum* (CDM Smith 2004c).

- Interior cleaning must have occurred – this could be a vermiculite insulation removal, an interior cleaning due to visible vermiculite in the living space, elevated dust results, or both.
- Since a limited number of houses in the area use forced air heating, these houses were preferentially included. Houses that use radiant heating were also sampled.
- Houses where vermiculite was left in place (i.e., walls, crawlspaces, subfloors).
- Properties that had a longer duration between the original cleanup and the CE.
- Properties where an interior cleaning was conducted due to high dust results, but carpeting was not removed.
- Properties that, in addition to an indoor removal action, had an outdoor removal requiring removal of most of the yard.

Results for samples during CE activities are summarized in Table 3-27. Refer to Appendix A for additional information on individual sample details and analytical results. Results are summarized below in brief:

- At total of eight indoor personal air samples were collected during CE activities. Total LA and PCME LA were detected at a frequency of 13% with a concentration of 0.00015 s/cc by TEM analysis.
- At total of 69 indoor stationary air samples were collected during CE activities. Total LA was detected at a frequency of 6% and PCME LA was detected at a frequency of 3% with concentrations of 0.00015 s/cc by TEM analysis.
- A total of 32 dust samples were collected during the CE activities. Total LA was not detected in any of the samples by TEM analysis.

3.8 Supplemental Remedial Investigation

3.8.1 Overview

As part of the ongoing response in Libby, the EPA identified a number of uncertainties and data gaps that required further investigation, and developed a Supplemental Remedial Investigation Quality Assurance Project Plan (hereafter referred to as "SQAPP") to guide the collection of additional data needed to help strengthen final decision-making at the Libby Site. SQAPP sampling was conducted between June 2005 and October 2006 and air, dust, and soil samples were collected, handled, and analyzed in accordance with the *Final Supplemental Remedial Investigation Quality Assurance Project Plan* (EPA 2005a). Twelve areas of investigation, or "tasks", were identified in the SQAPP, and involved sample collection at 58 properties (Figure 3-5):

- Task 1: Estimation of Soil Contribution to Indoor Dust
- Task 2: Estimation of Dust to Indoor Air Transfer
- Task 3: Estimation of Soil to Outdoor Air Transfer
- Task 4: Detection Limits for Soil Methods
- Task 5: Concentration in Soil that is Non-detect by PLM-VE

- Tasks 6-9: Time Trends in Asbestos Levels in Air and Dust in Buildings with Indoor Removals
- Task 10: Dust Concentrations under Carpets
- Task 11: Safety Factor
- Task 12: Re-analysis of Ambient Air and Perimeter Air Samples

The first group of tasks (Tasks 1-3) was mainly designed to help improve the EPA's ability to evaluate human exposure to asbestos in houses and residential environments; the second group of tasks (Task 4-5) was designed to evaluate analytical methods for soil, the third group of tasks (Tasks 6-12) was designed to help evaluate the efficacy of the EPA's removal activities.

3.8.2 Results

The results of this investigation were extensively summarized in the *Summary Report for Data Collected under the Supplemental Remedial Investigation Quality Assurance Plan* (EPA 2007b) and can also be found in Table 3-28. Refer to Appendix A for additional information on individual sample details and analytical results. Results are summarized below in brief:

- A total of 46 stationary indoor air samples were collected during the SQAPP investigation activities. Total LA was detected at a frequency of 72% ranging in concentrations from 0.000048 s/cc to 0.0025 s/cc by TEM analysis. PCME LA was detected at a frequency of 57% ranging in concentrations from 0.000049 s/cc to 0.00055 s/cc by TEM analysis.
- A total of 24 personal indoor air samples were collected during the SQAPP investigation activities. Total LA was detected at a frequency of 63% ranging in concentrations from 0.00013 s/cc to 0.0066 s/cc by TEM analysis. PCME LA was detected at a frequency of 25% ranging in concentrations from 0.00025 s/cc to 0.0013 s/cc by TEM analysis.
- A total of 90 stationary outdoor air samples were collected during the SQAPP investigation activities. Total LA was detected at a frequency of 20% ranging in concentrations from 0.00088 s/cc to 0.69 s/cc by TEM analysis. PCME LA was detected at a frequency of 17% ranging in concentrations from 0.00095 s/cc to 0.21 s/cc by TEM analysis.
- A total of 62 personal outdoor air samples were collected during the SQAPP investigation activities. Total LA was detected at a frequency of 55% ranging in concentrations from 0.00085 s/cc to 1.4 s/cc by TEM analysis. PCME LA was detected at a frequency of 45% ranging in concentrations from 0.00091 s/cc to 0.73 s/cc by TEM analysis.
- A total of 43 dust samples were collected during the SQAPP investigation activities. Total LA was detected at a frequency of 42% ranging in concentrations from 3.9 s/cm^2 to 1,600 s/cm^2.
- A total of 71 surface soil samples were collected during the SQAPP investigation activities. LA was detected at a frequency of 48% ranging in concentrations from trace to 1% by PLM-VE. LA was not detected in four samples by PLM-Grav. Vermiculite was observed in 20 samples based on a qualitative assessment. Vermiculite was not observed in 24 samples based on a qualitative assessment. Information for vermiculite was not available for 27 samples.

3.8.3 Conclusions

Releases from Outdoor Soil to Air

When outdoor soil that contains LA is disturbed (e.g., by raking, mowing, or digging), LA fibers are released into the breathing zone of the person who is causing the soil disturbance. The concentration of fibers that is released into the air is highly variable, both within and between differing types of disturbance activities, but there is a clear trend for levels in air to increase as the levels in soil (as measured by PLM-VE) increase.

Exposures in Indoor Air

Measurement of LA levels in indoor air of residences in Libby reveals that concentrations are usually higher in the breathing zone of the individual (measured using personal air monitors) than in general room air (measured using stationary monitors), and that levels are generally higher when individuals are engaged in active behaviors (cleaning, sweeping, moving about) than in passive behaviors (sitting, reading, etc.).

Dust as a Predictor of Indoor Air Exposures

The EPA began the SQAPP investigation with the assumption that the main source of LA in indoor air was likely to be contaminated indoor dust that was re-suspended into indoor air by human activity or by mechanical forces (e.g., air flow from a furnace). However, paired measurements of indoor air and indoor dust collected during the SQAPP did not reveal any clear relationship. The basis for this apparent lack of correlation is not known.

The OU4 residential ABS program attempted to augment this dataset with additional information gathered through active and passive scripted behaviors in order to help determine exposure sources to indoor air. The ABS activities are described in Section 3.14.

Levels of LA in Outdoor Ambient Air

One exposure pathway that applies to all people in Libby is inhalation of outdoor ambient air. Prior to the SQAPP, a total of 404 outdoor ambient air samples had been collected, but most of these were not analyzed with an analytical sensitivity needed to provide an accurate estimate of the true concentration. Therefore, as part of the SQAPP, a subset of 33 of these samples was selected for supplemental analysis to achieve an analytical sensitivity that was about 25 times lower than the original sensitivity. Comparing the original results to the re-analyses indicated that the estimated mean value decreased about two-fold (from 0.00055 s/cc to 0.00021 s/cc for total LA), and uncertainty around each value narrowed substantially.

Transfer of Soil into Indoor Dust

The EPA generally assumes that outdoor soil is an important contributor to indoor dust. That is, if outdoor soil is contaminated with LA, any soil that is tracked into houses may contaminate the indoor environments. The SQAPP data collected suggested that the amount of soil transferred to indoor dust depends upon the condition of yards and the number of people and pets entering/exiting houses on a regular basis. On average, the outdoor soil to indoor dust transfer factor was about 0.002 grams per square centimeter of soil (g soil/cm^2). However, application of this transfer factor yields predicted levels of LA in indoor dust that are substantially higher than measured levels, which indicates that the factor cannot be used to reliably predict levels of LA in indoor dust.

LA Levels in Soil that is Non-detect by PLM

The EPA uses PLM-VE to estimate levels of LA in soil in Libby. This is a semi-quantitative method that reports a sample as non-detect when the microscopist cannot observe any LA in the sample. However, from the studies of outdoor soil disturbance, it is evident that soils that are non-detect can release LA fibers to air. For this reason, the EPA used more powerful electron microscopy methods to estimate the average level of LA in soils that were reported as non-detect by PLM-VE. The results were variable between samples, but the average LA concentration was approximately 0.05% by mass.

LA Levels in Dust Under Carpets

One source of potential concern for indoor exposures is LA fibers that may be trapped under carpets. In order to obtain preliminary data, the EPA sampled dust under 12 carpets in Libby. Four of the samples contained detectable levels of LA, with observed total LA concentrations ranging from 180 to 1,600 s/cm^2. These all occurred in carpets that were more than 10 years old. While the small amount of data collected from this pilot-scale investigation is too limited to draw firm conclusions, these results indicate that LA may occur in dust under some carpets, with an apparent tendency for levels to be higher for older carpets. The degree to which dust under carpets contributes to levels of LA in indoor air is not known, and more data would be needed to determine whether dust under carpets represents a significant residual source of LA in indoor air.

Time Trends in Air and Dust after Removal is Completed

In order to determine if a property cleanup remains effective over time, the EPA collected indoor air and dust data for a period of up to 16 months following indoor cleanup at four properties. No upward time trends in dust were apparent, but an increase in LA concentrations in indoor air did occur in two houses after 16 months. The reason for this apparent increase is not known. Additional long-term monitoring would be needed to provide information on whether potential recontamination is occurring due to residual sources.

Releases to Air from EPA Removal Activities

The EPA employs a range of strategies to minimize releases of asbestos during soil removal activities. In order to evaluate the effectiveness of these control strategies, the EPA routinely collects samples of air from monitors placed around the perimeters of removal activities. In general, the detection frequency of LA in these samples is low, and there is an apparent tendency for air concentrations in more recent years to be lower than concentrations the earlier years. This trend is suspected to be attributable to the fact that the level of contamination in soil and waste material was higher at the first locations that were addressed (the Screening and Export Plants) in earlier years than at the residential and commercial areas that are currently being addressed. However, analytical sensitivities for many of these perimeter air samples were too high to support reliable conclusions on the actual concentration values in the air. Therefore, as part of the SQAPP, 20 perimeter air samples were re-analyzed to obtain an analytical sensitivity that was about five-fold lower than in the original samples. The mean concentration based on the re-analyses (0.0005 s/cc for total LA) is about four-fold lower than was estimated previously for the same samples, and within a factor of about two of the average value in outdoor ambient air.

3.9 Cumulative Exposure Assessment

Prior to December 2005, most of the air sample data collected by the EPA used stationary air monitors at specific locations around the Libby Site. Because no data had been collected for individuals with varying levels of LA exposure at multiple indoor and outdoor locations, the EPA implemented an investigation to measure such exposure. The pilot investigation was intended to provide information on the cumulative exposures that are experienced by the EPA staff and/or contractors that are moving around town, but not directly involved in vermiculite or asbestos removal activities.

Eleven personal air samples were collected in December 2005 in accordance with the *Sampling and Analysis Plan for Cumulative Inhalation Exposures in Libby, Montana* (EPA 2005b). Refer to Appendix A for additional information on individual sample details and analytical results. Results are summarized below in brief:

- A total of 11 personal air samples were collected as part of the cumulative exposure assessment sampling. Total LA was detected at a frequency of 27% and PCME LA was detected at a frequency of 18% with concentrations ranging from 0.000094 s/cc to 0.00010 s/cc by TEM analysis.

Due to the complexity of collecting personal air samples over prolonged periods of time (i.e., days) and the inability to correlate sampling results to specific activities that may cause exposure, no additional cumulative exposure sampling was conducted. Rather, ABS, as discussed in Section 3.14 of this report, was initiated to gather exposure data at OU4 for use in risk assessment.

3.10 Ambient Air Program

3.10.1 2000 to 2003 Summary

One pathway of exposure that applies to all residents and workers in Libby is inhalation LA in ambient outdoor air. Beginning around 2000 and continuing through 2003, the EPA collected outdoor ambient air samples of opportunity (or in conjunction with removal monitoring activities and existing air monitoring programs) at a number of locations around Libby. While these samples were not collected under a SAP specifically designed to determine outdoor ambient air levels, the data were culled from various collection efforts in order to gain an initial understanding of the levels of LA typically observed in outdoor air.

One group of opportunistic samples was collected from an existing air monitoring station maintained by the Lincoln County Environmental Health Department (LCEH). LCEH personnel collected outdoor ambient air samples between September 2001 and September 2002 from the station located at the Lincoln County Courthouse Annex building, which serves as the state's particulate matter monitoring site (AIRS Site 30-053-0018). This air monitoring station is located in the downtown area of Libby (418 Mineral Avenue) and is approximately 25 feet above street level.

Air samples collected by the EPA personnel or contractors during the 2000 to 2003 time period were collected in accordance with the following guidance documents:

- *Phase 1 QAPP* (EPA 2000b)
- *Removal Action Sampling and Analysis Plan for Confirmation Sampling of Soil and Perimeter and Personal Sampling of Air for Asbestos* (CDM Smith 2000)

- *Property-Specific Sampling and Analysis Plan for Air and Dust Sampling for Stimson Lumber Company* (CDM Smith 2002d)
- *Final Response Action Sampling and Analysis Plan* (hereafter referred to as the *RA SAP*) (CDM Smith 2003f)

Sample location was determined by field personnel at the time of sample collection. Factors such as wind direction, location of contaminant, and exclusion zone boundary are considered when the air sample is positioned.

3.10.1.1 Results

The results of this investigation are summarized in an internal draft report prepared in 2004 (CDM Smith 2004d) and can also be found in Table 3-29. Refer to Appendix A for additional information on individual sample details and analytical results. Results are summarized below in brief:

- At total of 405 stationary ambient air samples were collected at 22 locations in and around Libby as part of the 2000 to 2003 sampling activities. Total LA was detected at a frequency of 17% with concentrations ranging from 0.000071 s/cc to 0.033 s/cc by TEM analysis. PCME LA was detected at a frequency of 5% with concentrations ranging from 0.000094 s/cc to 0.011 s/cc by TEM analysis.

3.10.1.2 Conclusions

The conclusions of the CDM Smith (2004d) draft report were:

- LA fibers were found to occur in outdoor ambient air samples collected around the Libby community.
- Sources of the LA fibers found in outdoor ambient air in Libby could not be identified with certainty, but windborne transport of fibers present in soils and dust around the community was identified as one component that was likely to be significant.
- Concentration levels did not appear to be substantially different at different locations within the main residential-commercial section of Libby, but there was a slight tendency for values to be higher in areas closest to the mine.
- Data were too limited to determine if any time trend towards changing levels in outdoor ambient air was occurring as a result of ongoing EPA removal activities.

The EPA reviewed the draft report, and identified a number of limitations (CDM Smith 2006d). In general, it was determined that the data were not sufficiently extensive or representative in time and space to draw strong conclusions regarding the true levels of exposure and risk from ambient air. Consequently, the EPA determined that there was a need for the collection of additional ambient air data that would be sufficiently representative and of adequate quality to estimate human health risks associated with inhalation of LA in outdoor ambient air in and around the City of Libby, and to characterize spatial patterns and temporal trends of LA occurrence in outdoor ambient air. These additional data were collected during the 2006 to 2008 ambient air investigation (Section 3.10.2).

3.10.2 2006 to 2008 Summary

As mentioned in Section 3.10.1, ambient air samples collected before 2006 were insufficient to provide spatial and temporal representativeness. An OU4 ambient air investigation was conducted from October 2006 to June 2008 in accordance with the *Final Sampling and Analysis Plan for Outdoor Ambient Air Monitoring at the Libby Asbestos Site* (*Ambient Air SAP*) (CDM Smith 2006d), and *Final Sampling and Analysis for Outdoor Ambient Air Monitoring at the Libby Asbestos Site, Revision 1* (CDM Smith 2006e).

October 2006 to September 2007 Sample Design

Outdoor ambient air sampling began in October 2006 at 14 sampling stations in the community of Libby (Figure 3-6) and at two off-site reference stations in Eureka and Helena, Montana. The number and location of stations in Libby were selected so that the investigation area could be divided into four sub-areas (north, east, central, south) to allow for evaluation of spatial variability in long-term averages. The purpose of the stations in Eureka and Helena was to establish a frame of reference to which observations in Libby could be compared.

The location of one station in Libby was changed after 16 sampling events (on March 28, 2007) due to repeated vandalism. The new station (J. Neils Park) was located a short distance south of the original station (1427 Highway 37).

Outdoor ambient air samples were collected and equipment was calibrated in accordance with SOP CDM-LIBBY-07, *Collection of Outdoor Ambient Air Samples,* for asbestos air sampling. At each of the stations in Libby, samples were collected over a 6-day interval, with five days between each interval.

Two samples were collected at each station. One sample was collected at a flow rate of 1.4 liters per minute (L/min), which resulted in a total volume over six days of about 14,000 liters. This sample is referred to as the high volume sample. Additionally, a second sample was collected at a flow rate of 1.0 L/min over the same period of time and is referred to as the low volume sample. This sample was collected to serve as a backup for use if the high volume sample was overloaded or damaged.

Samples were collected using 25-millimeter (mm) diameter, 0.8-µm pore size mixed cellulose ester (MCE) filter cassettes. In order to investigate whether the choice of pore size was an important determinant of observed concentrations, samples using 0.45-µm pore size filters were collected intermittently at selected stations. These stations were selected so that sampling stations from the each sub-area were represented.

Samples were collected at approximately five to six feet above ground level at all stations. This height was selected because it represents the breathing zone height of most adults. In order to investigate whether levels might be different at a child's breathing height, samples were intermittently collected three feet above ground level at selected sampling locations. As above, these locations were selected to represent each sub-area.

September 2007 to June 2008 Sample Design

At the conclusion of the first year of sampling, the sampling design was reevaluated and only seven of the original stations were retained for continued long-term monitoring into year 2 (after September 16, 2007). Likewise, of the two original reference stations, only one (Helena) was retained for continued monitoring.

Samples collected after September 16, 2007 were collected using the same equipment and techniques as described above. However, the sampling schedule was revised to be five days of sample collection followed by 10 off (non-collection) days. Originally, it was planned that monitoring would continue at all of these stations for one additional year. However, because the observed concentration values continued to be relatively low, sampling at the OU4 stations was discontinued in December 2007, while sampling at the OU2, OU6, and Helena stations continued through June 2008.

3.10.2.1 Results

The results of this investigation were summarized in the *Summary of Outdoor Ambient Air Monitoring for Asbestos at the Libby Asbestos Site, Libby, Montana (October 2006 to June 2008)* (EPA 2009c). The results for samples collected in Libby can be found in Table 3-29. Refer to Appendix A for additional information on individual sample details and analytical results. Results are summarized below in brief:

- A total of 648 stationary air samples were collected as part of the 2006 to 2008 ambient air sampling activities. Total LA was detected at a frequency of 14% with concentrations ranging from 0.000035 s/cc to 0.00053 s/cc by TEM analysis. PCME LA was detected at a frequency of 9% with concentrations ranging from 0.000035 s/cc to 0.00023 s/cc by TEM analysis.

3.10.2.2 Conclusions

The conclusions from EPA (2009c) include the following:

- Concentration levels of total LA in ambient air tend to be very low in winter and higher in the middle to late summer, when conditions are usually dry and dusty.
- Mean concentrations of total LA tend to be somewhat higher in the northern and eastern portion of Libby than in the central and southern regions, although these differences were not statistically significant.

3.10.3 2010 to 2013 Summary

May 2010 to April 2011 Sample Design

The EPA resumed the OU4 outdoor ambient air sampling program from May 2010 through April 2011 at six locations along major transportation corridors within OU4 (CDM Smith 2010a). The six sampling locations were positioned along the main transportation routes, as shown on Figure 3-6. Care was given to select locations where public safety and security of sampling equipment was optimized (i.e., positioned away from foot and actual vehicle traffic), and where electricity was accessible.

Samples were collected in accordance with SOP CDM-LIBBY-12, Revision 1, *Collection of Outdoor Ambient Air Samples,* on a continuous 5-day (approximately 120-hour) interval prescribed in the *Ambient Air SAP* (CDM Smith 2006d) to ensure a target volume of 14,000 liters per sample was gathered. Each 5-day period is referred to as a "sampling event". One high volume sample and one low volume sample was collected over the same period of time during each sampling event at each station with target flow rates of 2.0 and 1.5 L/min, respectively. Samples were collected solely using 25-mm diameter, 0.8-µm filter pore size MCE filter cassettes; no samples were collected on filters with a 0.45-µm filter pore size. Samples, including field and co-located samples, were collected solely from a height representing the adult breathing zone; no child-height samples were collected.

During October and November 2010, sampling occurred twice per month at each station, for a total of four sampling events on an approximate 15-day (5 days on and 10 days off) schedule. The October/November schedule focused on days when the EPA response action truck hauling was in progress (typically Monday through Saturday). From December 2010 through April 2011, sampling occurred once monthly at each station, for a total of five sampling events.

June 2011 to April 2012 Sample Design

The June 2011 through April 2012 ambient air program focused on sample collection within the core of OU4, specifically, in areas where removal activities were occurring, and served as preparation for the development of a long-term ambient air sampling program (CDM Smith 2011b). This ambient air sampling program employed five stationary sampling stations and one mobile station. The mobile station was intended to represent ambient air within general areas where removal activities were in progress. Samples were collected using the same equipment and techniques as described above in the 2010-2011 program.

During June 2011, one sampling event was conducted at the five stationary ambient air sampling locations and the mobile station. From July 2011 through November 2011, sampling occurred twice per month at each of the six stations (five stationary and one mobile). The June through November schedule focused on days when the EPA response action work was in progress (typically Monday through Saturday). From December 2011 through April 2012, sampling occurred once monthly at each station. This resulted in a total of 16 sampling events at the stationary locations and 15 events at the mobile station.

May 2012 to March 2013 Sample Design

The May 2012 through March 2013 ambient air sampling program employed five stationary sampling stations and one mobile station (CDM Smith 2012a). This strategy was unchanged from the 2011-2012 program. Samples were collected using the same equipment and techniques as described above.

From May 2012 through October 2012 (the full months of the 2012 removal field season), sampling occurred twice per month at each of the six ambient air stations (five stationary and one mobile). This schedule focused on days when the EPA removal activities were in progress (typically Monday through Friday). From November 2012 through March 2013 (the off-season), sampling occurred once monthly at each of the five stationary stations (samples were not collected from the mobile station when removal activities ceased for the season). This resulted in a total of 17 sampling events at the stationary locations and 12 events at the mobile station.

April 2013 to August 2013 Sample Design

The June 2013 through August 2013 ambient air sampling program employed three fixed locations representing northerly, southerly, and westerly ambient air conditions within OU4 (CDM Smith 2013a). Samples were collected using the same equipment and techniques as described above.

The Asbestos Resource Program (ARP) was developed by the City-County Board of Health for Lincoln County through a cooperative agreement with the EPA. Beginning in September 2013, as required under the Cooperative Agreement, the ARP assumed outdoor ambient air sampling activities (CDM Smith 2013b).

3.10.3.1 Results

The results of this investigation are summarized in the *Summary of Outdoor Ambient Air Monitoring for Asbestos at the Libby Asbestos Site, Libby, Montana Addendum (May 2010 to August 2013)* (EPA 2014b) and can be found in Table 3-29. Refer to Appendix A for additional information on individual sample details and analytical results. Results are summarized below in brief:

- At total of 380 stationary air samples were collected as part of the 2010 to 2013 ambient air sampling activities. Total LA was detected at a frequency of 18% with concentrations ranging from 0.000031 s/cc to 0.0027 s/cc by TEM analysis. PCME LA was detected at a frequency of 12% with concentrations ranging from 0.000034 s/cc to 0.00035 s/cc by TEM analysis.

3.10.3.2 Conclusions

The conclusions from EPA (2014b) include the following:

- Concentration levels of total LA in ambient air tend to be lower in the winter when roads are snow-packed and removal activity is decreased, and higher in the middle to late summer, when conditions are usually dry and dusty.
- Mean concentrations of total LA tend to be somewhat higher in the northern and eastern portion of Libby than in the central and southern regions, although these differences were not statistically significant.
- Mean concentrations of total LA at mobile stations that have been placed near removal activities were not statistically different than the sample stations located along transportation corridors.
- Ambient air data were measured at 60 Port Blvd throughout most of the ambient air program beginning in October 2006 to March 2013. Measured concentrations at this station have remained relatively constant with seasonal variations throughout the program.

3.11 Demolition Study

Monitoring activities were completed for building demolitions in 2005 and 2006 to assess whether demolition activities released asbestos into the environment. Real-time monitoring and environmental monitoring during building demolition were completed in accordance with the *General Sampling and Analysis Plan for Assessing Asbestos Release from Building Demolition at the Libby, Montana, Superfund Site* (EPA 2005c) for the demolitions in 2005 and in accordance with the *General Workplan for Building Demolition at the Libby, Montana, Superfund Site – Revision 1* (EPA 2006d) for the demolitions in 2006. EPA updated the general sampling and analysis workplan for 2006 to optimize the data quality objectives and study design based on the results and conclusions of the 2005 demolitions. This section summarizes the data and results collected during the building demolition investigations.

3.11.1 Monitoring Activities

Real-time monitoring consisted of three activities: wind speed and direction monitoring, dust in the air, and visual observations. Wind speed and direction were recorded continuously using electronic instruments. If the average wind speed exceeded 10 miles per hour (mph) over a five minute period, building demolition was halted until wind speed decreased. Dust levels in the air were monitored at several locations around the perimeter of the demolition site using Real-Time Air Monitors (RAMs) in accordance with SOP EPA-LIBBY-03. If the signal from any RAM exceeded five milligrams per cubic meter (mg/m^3) (the OSHA standard for nuisance dust), demolition activities were halted until

application of water to the building reduced dust levels to an acceptable amount. During demolition, the project supervisor carefully watched for evidence of visible dust moving to off-site locations. If this occurred, demolition activities were halted until application of water to the building reduced levels to an acceptable amount (SRC 2006; SRC 2007).

A series of environmental samples were collected and analyzed for asbestos to determine: 1) if a release of asbestos occurred as a result of building demolition activities, and 2) if so, did the release cause environmental contamination that is large enough to be of potential human health concern and warrant remedial action. If the demolition activity did not result in increments in LA concentrations in outdoor soil or indoor dust that were larger than 5% of the action levels set forth under the *Draft Final Libby Asbestos Site Residential/Commercial Action Level and Clearance Criteria Technical Memorandum* (EPA 2003c), then it was concluded that the demolition did not cause any releases that warrant remedial action (SRC 2007). Environmental samples consisted of personal air monitors for workers, perimeter stationary air monitors, outdoor settled dust, and indoor settled dust at nearby buildings during demolition. Perimeter stationary air monitors were set up in a network that consisted of an inner ring (engineering control located close to building demolition), middle ring (located at approximate property perimeter), and outer ring (located 50 to 75 feet beyond the middle ring). In addition, reference stationary air monitor locations were located one quarter to one half mile away from the demolition site. On-site soils were sampled after building demolition was complete (SRC 2006; SRC 2007).

3.11.2 2005 Building Demolitions Results

Monitoring took place at two properties during the 2005 building demolitions. Demolition activities at Property 1 were conducted from June 21-28, 2005. Demolition activities at Property 2 were conducted from July 11-20, 2005. In order to limit analytical costs, only a subset of samples collected was submitted for analyses.

The results of this investigation are summarized in the draft report *Assessing Asbestos Release from Building Demolition at the Libby, Montana, Superfund Site* (SRC 2006) and can also be found in Table 3-30. Refer to Appendix A for additional information on individual sample details and analytical results. Results are summarized below in brief.

Property 1

- A total of 66 air samples were analyzed during demolition activities. Total LA was detected at a frequency of 70% ranging in concentrations from 0.000094 s/cc to 0.037 s/ cc by TEM analysis.
- A total of 43 dust samples were analyzed during demolition activities. Total LA was detected at a frequency of 33% ranging in concentrations from 100 s/cm^2 to 7,100 s/cm^2 by TEM analysis.
- A total of three soil samples were analyzed during demolition activities. Tremolite/actinolite was not detected in any samples by PLM-9002. Vermiculite was observed in all samples based on a qualitative assessment.

Property 2

- A total of 73 air samples were analyzed during demolition activities. Total LA was detected at a frequency of 38% ranging in concentrations from 0.000096 s/cc to 0.0044 s/ cc by TEM analysis.

- A total of 58 dust samples were analyzed during demolition activities. Total LA was detected at a frequency of 9% ranging in concentrations from 110 s/cm^2 to 140 s/cm^2 by TEM analysis.
- A total of nine soil samples were analyzed during demolition activities. Tremolite/actinolite was not detected in any samples by PLM-9002. Vermiculite was observed in all samples based on a qualitative assessment.

3.11.3 2006 Building Demolitions Results

Monitoring took place at two properties during the 2006 building demolitions. Demolition activities at Property 3 were conducted from October 3-11, 2006. Demolition activities at Property 4 were conducted from October 5-12, 2006. In order to limit analytical costs, only a subset of samples collected was submitted for analyses.

The results of this investigation are summarized in the draft report *Assessing Asbestos Release from Building Demolition at the Libby, Montana, Superfund Site: October 2006 Demolitions* (SRC 2007) and can also be found in Table 3-30. Refer to Appendix A for additional information on individual sample details and analytical results. Results are summarized below in brief.

Property 3

- A total of 88 air samples were analyzed during demolition activities. Total LA was detected at a frequency of 1% with a concentration of 0.00095 s/cc by TEM analysis.
- A total of 35 dust samples were analyzed during demolition activities. Total LA was detected at a frequency of 11% ranging in concentrations from 25 s/cm^2 to 47 s/cm^2 by TEM analysis.
- A total of five soil samples were analyzed during demolition activities. Tremolite/actinolite was not detected in any samples by PLM-9002. Vermiculite was observed in two samples based on a qualitative assessment. Information on vermiculite was not available for three samples.

Property 4

- A total of 46 air samples were analyzed during demolition activities. Total LA was not detected in any of the samples by TEM analysis.
- A total of seven dust samples were analyzed during demolition activities. Total LA was detected at a frequency of 57% ranging in concentrations from 25 s/cm^2 to 130 s/cm^2 by TEM analysis.
- A total of four soil samples were analyzed during demolition activities. Tremolite/actinolite was detected at a frequency of 25% with a concentration of <1% by PLM-9002. Information on vermiculite was not available for all samples.

3.11.4 Conclusions

The following conclusions were presented in EPA 2006 and EPA 2007.

Property 1

Demolition activities may have resulted in temporary LA releases on the first day of demolition (Work Day 1). These releases appear to have been relatively limited in spatial extent (likely restricted to within 1 block of the demolition site). Personal air monitoring data show that site worker exposures would not have resulted in adverse health effects. The environmental monitoring results show that any releases of LA due to demolition activities were well below residential levels of concern and did not result in quantifiable impacts to residual soils. Therefore, short-term releases of LA due to

demolition activities were not of potential concern to site workers, nearby residents, or business patrons.

Property 2

Demolition activities may have resulted in LA releases on the first day of demolition (Work Day 1). These releases appear to have been relatively limited in spatial extent, usually not extending beyond the inner ring of monitoring (the inner ring monitors were placed approximately 50 feet away from the building). Because the closest neighboring building is about 100 yards away, it is highly unlikely that releases would have impacted nearby residences or buildings. Personal air monitoring results show that worker exposures due to demolition activities would not have caused adverse effects. In addition, environmental monitoring results show that measured LA levels in air and settled dust were well below residential levels of concern and did not result in quantifiable impacts to soils in the surrounding yard. Based on these results, short-term releases of LA due to demolition activities were not of potential concern to site workers or nearby residents.

Property 3

Demolition activities appear to have resulted in temporary LA releases. Personal air monitoring data show that site worker exposures would not be expected to result in adverse health effects. The environmental monitoring results show that any releases of LA due to demolition activities were well below residential levels of concern and did not result in quantifiable impacts to residual soils. Therefore, short-term releases of LA due to demolition activities were not of potential concern to site workers or nearby residents.

Property 4

Demolition activities appear to have resulted in temporary LA releases. Personal air monitoring data show that site worker exposures would not be expected to result in adverse health effects. The environmental monitoring results show that any releases of LA due to demolition activities were well below residential levels of concern and did not result in quantifiable impacts to residual soils. Therefore, short-term releases of LA due to demolition activities were not of potential concern to site workers or nearby residents.

3.12 Dust Pilot Study

In order to investigate the usefulness and reproducibility of dust sample results collected at OU4, a dust pilot study was initiated in 2007 in accordance with the *Dust Composite Sampling Pilot Study* (CDM Smith 2007a).

It is generally believed that LA contamination in indoor dust is likely to be an important contributor to LA contamination in indoor air. However, it is expected that the level of LA in indoor dust (expressed as total LA s/cm^2) may not be constant throughout houses, and that there may be differences between sub-locations. The purpose of the pilot study was to:

- Investigate whether or not there is substantial variability in LA levels in dust loading (s/cm^2) as a function of the "accessibility" of an area, and/or the nature of the surface (porous vs. hard).
- Determine if collecting a dust sample based on a large number of sub-locations (30) will yield a sample that is more nearly representative of a floor than a set of six sub-locations. If so, the degree of difference in the two approaches was investigated in two ways:

- **a)** Investigate the degree of correlation between the results of the paired (same floor) 30-point composites and the mean of two 3-point composites.
- **b)** Investigate the relative precision of the two approaches. That is, at a number of properties, two 30-point composites and two sets of two 3-point composites were collected.

- Determine if the length of collection time is a source of potential variation in sample results by pairing 30-point composite samples using 30-second vs. 120-second vacuuming times per template.

To answer the objective questions, dust samples were collected from areas classified on a scale of accessibility, and secondarily on a scale of surface porosity. This approach was designed by the EPA and used during assessments of residential properties after the World Trade Center attacks:

- Accessible areas refer to locations in houses that are readily accessible to residents on a routine basis. These areas are the most likely to be the locations of routine exposure, and are also the most likely to undergo routine cleaning.
  - **a)** Porous surfaces (e.g., carpet, upholstered furniture, drapes, etc.)
  - **b)** Non-porous surfaces (e.g., linoleum floors, hardwood floors, counter and table tops, window sills, etc.).
- Infrequently accessed areas refer to locations that a resident would access only intermittently. These are areas where dust cleaning will be less frequent and where dust (and LA) may accumulate (i.e., tops of shelves, entertainment centers, and refrigerators, beneath furniture, inside cabinets, etc.).
- Inaccessible areas refer to locations that a resident would access only on a very infrequent basis. These areas are likely to be cleaned very rarely, and hence may be locations where LA may have built up over an extended period of time (i.e., behind refrigerators or other large infrequently moved objects, inside forced air floor or ceiling vents, corners of closets, etc.).

To the extent possible, the sub-locations were representative of each type of accessibility area. A total of 16 samples were collected from each of ten properties using the microvacuum sampling method described in the *Dust Composite Sampling Pilot Study* (CDM Smith 2007a). These samples consisted of the following:

- **Accessible Target Areas (Porous Surfaces):** One (parent) sample and one field duplicate sample, each collected as a 12-point composite to represent frequently accessed areas with porous surfaces on the selected floor.
- **Accessible Target Areas (Non-Porous Surfaces):** One (parent) sample and one field duplicate sample, each collected as a 12-point composite to represent frequently accessed areas of non-porous surfaces on the selected floor.
- **Infrequent Target Areas:** One (parent) sample and one field duplicate sample, each collected as a 12-point composite, to represent infrequently accessed areas on the selected floor.
- **Inaccessible Target Areas:** One (parent) sample and one field duplicate sample, each collected as a 6-point composite, to represent inaccessible areas on the selected floor. If six inaccessible

sub-sample locations were not identified, the total number of sub-locations was reduced as long as all available areas were included in the sub-locations.

- **Whole-Floor Composite (30-Second Sampling):** One primary (parent) sample and one field duplicate sample, each a 30-point composite sample, collected from 30 templates placed in locations selected to represent the entire floor.
- **Whole-Floor Composite (120-Second Sampling):** One primary (parent) sample and one field duplicate sample, each a 30-point composite sample, will be collected as described above, except that each of the 30 sub-locations will be collected using a vacuuming time of 120 seconds. The sampling locations for these templates were co-located with the sub-locations for the 30-second composites (above).
- **High Traffic Areas:** One primary (parent) sample and one field duplicate, each a 3- point composite, from high traffic areas on the selected floor. Each sub-location in the 3- point composite sample was collected for a sampling duration of two minutes according to the standard protocol (EPA 2003b).
- **Horizontal Surfaces:** One primary (parent) sample and one field duplicate sample, each a 3-point composite, from horizontal surfaces on the selected floor. Each sub-location in the 3-point composite sample was collected for a sampling durations of two minutes according to the standard protocol (EPA 2003b).

Each sub-location consisted of a 100 cm^2 area specified using disposable paper templates for measurement. The pilot study was completed using sampling procedures described in ASTM D5755-03 and SOP CDM-LIBBY-10, *Project-Specific Guidance Document for the Collection of Dust Samples*.

Although the dust pilot study results are not summarized in the project database, the analytical results for individual samples are available in Appendix D. Results are summarized below in brief:

- A total of 160 samples were collected as part of the dust pilot study, of which 154 samples were analyzed. Total LA was detected in 16% of the samples with concentrations ranging from 6 s/cm^2 to 77 s/cm^2.

After initial results were received and evaluated, the EPA determined the data set for the 154 samples was adequate for data interpretation. The low LA concentrations observed along with the inability to collect reproducible samples, resulted in the EPA eliminating the collection of dust samples for property investigations as of July 2007 (EPA 2011d).

3.13 Creek Activity-Based Sampling

In August 2007, the EPA conducted ABS along Flower Creek in order to collect additional data to support risk management decisions and to more accurately represent long-term health risks from exposure to LA in exposed sediments along the creek banks. Sampling was conducted on two days, August 22nd and 23rd, to represent the hottest, driest period of the year.

During the ABS event, personnel performed a scripted behavior, which involved moving rocks found along the creek bank and forming piles, then moving the rocks back to their original location. This was repeated for two separate two-hour scenarios each day while personal air samples were collected from the sampler's breathing zone. Results are summarized below in brief:

- A total of six ABS air samples were collected from Libby Creek in 2007. Total LA was detected at a frequency of 83% with concentrations ranging from 0.84 s/cc to 3.8 s/cc by TEM analysis. PCME LA was detected at a frequency of 83% with concentrations ranging from 0.17 s/cc to 1.4 s/cc by TEM analysis.

3.14 Residential Activity-Based Sampling

As discussed in Section 3.8, the EPA collected data in 2005 as part of the SQAPP to evaluate human exposure to LA and the efficacy of removal activities. Although the data widely varied, a discernible correlation between increasing LA levels in soil (by PLM-VE) and increasing levels of LA in air was determined. While informative, these initial data were not sufficient to support reliable risk assessment or risk management decisions because of the following (EPA 2007b):

- Not enough samples were collected to adequately limit statistical uncertainty.
- Not enough samples were collected to ensure adequate spatial and temporal (seasonal) representativeness of the data.
- Scenario locations were stratified solely on the analytical results by PLM-VE and did not consider the presence of visible vermiculite in soil.
- The PLM-VE method, which has a practical quantitation limit of about 0.2% for LA, may not be sensitive enough to identify levels in soils that, when disturbed, generate asbestos levels in air that are of potential concern.

Therefore, in 2007, the EPA began collecting additional data to support risk management decisions and to further evaluate the efficacy and protectiveness of the removal strategy. The locations of participating properties in outdoor ABS or indoor ABS programs are shown on Figure 3-7 and Figure 3-8, respectively.

3.14.1 2007-2008 Residential Activity-Based Sampling

The 2007-2008 ABS program consisted of both indoor and outdoor sampling at properties where the EPA had previously investigated LA sources and had either taken removal action or determined that no removal action was needed under the current removal action protocol. In both circumstances, these properties are referred to as “post-removal” throughout Section 3.14.

The primary objective of the 2007-2008 ABS program was to determine if indoor and outdoor risks at post-removal properties were within acceptable limits. The EPA theorized that inhalation of air in the immediate vicinity of an active source disturbance was the most important exposure pathway for residents and workers at OU4. Personal air samples were collected instead of stationary air samples to more closely represent the breathing zone of individuals engaged in the scripted activities and more closely simulate the potential exposure of residents to LA. The secondary ABS objective was to collect representative data about characteristics of property contamination in order to develop a method for predicting indoor and outdoor air measurements at other properties at OU4 and help guide future removal and remedial decisions at the Libby Site. For this reason, dust and soil samples were also collected as part of the ABS program in an attempt to quantify LA concentrations in the source materials that were disturbed during ABS activities. This section summarizes the rationale and sampling procedures for the 2007-2008 ABS program, which are presented in the *Sampling and Analysis Plan for Activity-Based Indoor Air Exposures in Operable Unit 4* (EPA 2007c) and *Sampling And Analysis Plan for Activity-Based Outdoor Air Exposures in Operable Unit 4* (EPA 2007d).

3.14.1.1 Indoor Activity-Based Sampling

Indoor removal actions primarily consist of the removal of accessible vermiculite insulation from attics or living spaces and the removal of contaminated dust. However, at post-removal properties, several possible remaining sources of indoor contamination include the following:

- Releases from residual indoor sources remaining post-removal:
  - **a)** residual levels of vermiculite insulation or LA in areas not removed during the removal (e.g., including floor, carpets, upholstery, air ducts);
  - **b)** vermiculite insulation remaining in walls; and
  - **c)** residual levels of LA or vermiculite insulation in areas that were cleaned.
- Transfer of contaminated soil into houses. Visible vermiculite in non-specific use areas (NSUA), common use areas (yards not designated as a specific use area), and soils with <1% LA may remain at properties where a removal action has not taken place. Visible vermiculite may also be present in NSUAs at properties where a removal action was completed prior to 2007.
- Exchange of indoor and outdoor air through windows and ventilation systems.
- Transfer of contamination from sources outside post-removal properties.

In order to more accurately represent long-term averages of indoor LA air concentrations and to represent the seasonal variability that may affect the releasability of LA fibers, ABS was repeated at each of 80 participating houses once a quarter over one year. The first indoor ABS event began in July 2007 and the fourth indoor ABS event ended in June 2008. The sections below summarize the process for property selection and sample collection.

3.14.1.2 Property Selection

Properties selected were grouped into two main categories: those where an outdoor removal action had been completed and those where an outdoor soil removal action was not warranted based on current removal criteria. Within each category there were additional criteria based the level and extent of residual LA contamination in outdoor soil and geographical representativeness.

Initial property selection was based on CSS findings combined with the removal action history of each location. However, due to the variations in soil sample collection and visual vermiculite inspection procedures of previous investigations, each potential property was re-inspected for outdoor vermiculite in May 2007 and two soil samples were collected – one from NSUAs and one from SUAs. Analytical results were compiled with visual inspection results to stratify each property into one of four categories as shown in the table below:

Category	Did Outdoor Soil Removal Take Place?	Post-Removal Surface Soil		
		VCS		PLM Detect
1	No	-	and	-
2		+	or	+
3	Yes	-	and	-
4		+	and	-

Notes:

VCS = vermiculite-containing soil; PLM = polarized light microscopy; + = VCS present or LA detected by PLM; - = VCS is not present or LA is not detected by PLM

In total, 94 potential properties were inspected for visible vermiculite and soil sampled, but only 81 properties progressed to the ABS portion of the program, with properties representative of each geographical region of OU4 (north, central, south).

After the final set of properties was identified, data were collected through verbal interviews with homeowners to address other residual sources that may contribute to LA in indoor air in post-removal properties (e.g., carpets, upholstery, air ducts, and vermiculite insulation in walls). Information collected regarding residual sources was captured on the *ABS Property Background and Sampling Form*. This information was collected to evaluate potential trends in indoor air concentrations of LA to any specific contamination category, and to help guide potential modifications to the removal process.

3.14.1.3 Soil Collection

As part of the property selection process mentioned above, two soil samples were collected from each potential ABS property. Each soil sample was a 30-point composite collected from the surface. One sample was collected as a composite across all SUAs (zero to six inches bgs) and one sample was collected as a composite across all NSUAs (zero to three inches bgs). Soil sampling characterized the property as a whole, and composite locations were selected at random without regard to previous excavations or analytical soil results. The visible vermiculite and LA data derived from the preliminary inspections provided characterization of residual outdoor soil levels to support the assessment of whether residual vermiculite-containing soil (VCS) or LA in outdoor soil poses a continuing source to indoor dust or air. Collected soil samples were analyzed for LA by the Libby-specific PLM methods (i.e., PLM-VE, PLM-Grav).

In addition to soil sample collection, entire properties were inspected for visible vermiculite at a maximum density of one point per 100 ft^2 as described in CDM-LIBBY-06, *Site-Specific SOP for Semi-Quantitative Visual Estimation of Vermiculite in Soils at Residential and Commercial Properties, Revision 1*. Locations of visible vermiculite were documented on a *Visual Vermiculite Estimation Form* (VVEF) and annotated on a field sketch.

3.14.1.4 Scripted Activities

While there are a wide variety of indoor activities that may be performed inside OU4 properties, it was not the intent to collect data under every possible combination of activity and source disturbance. Rather, samples were representative of two generic conditions (active and passive behaviors) at each of the four property categories. Active behaviors included a wide range of indoor activities in which an actor was moving about buildings and potentially disturbing indoor sources (i.e., walking, sitting down on upholstered chairs, sweeping, and/or vacuuming). During active sampling, the actor had the highest tendency to disturb source materials. Passive behaviors involved very limited movement and simulated homeowner activities, such as sitting and reading books, watching television, or working at desks. During passive sampling, the actors had the lowest tendency to disturb source materials.

During each of the quarterly sampling events, actors simulated active and passive behaviors during two separate four-hour periods. In order to ensure that each four-hour sample was spatially representative of houses, each sample was collected from all living spaces on each floor of the house. The total sampling time (four hours) for each behavior (passive and active) was divided evenly among the total number of rooms in which routine living activities were expected to occur (i.e., smaller rooms such as closets, utility rooms, bathrooms were not included). The time spent per room was then equally subdivided among the number of activities to perform depending on site conditions.

3.14.1.5 Air Sampling

Two personal air samples were collected during each 4-hour sampling period, one to serve as a backup in case the other failed, was damaged, or was lost. The target flow rates for sample collection were 10 and 3 L/min resulting in target volumes of 2,400 and 720 L, respectively. Each air sample was collected on a 0.8-µm pore size, 25-mm MCE filter and the sampling cassette was oriented face down in the breathing zone of each actor.

As mentioned above, 81 properties were initially included in Event 1 so that a full set of 80 properties could continue in the program if one homeowner withdrew from the year-long commitment. Air samples were analyzed by TEM ISO to a target sensitivity of 0.0002 cc^{-1}.

3.14.1.6 Dust Sampling

Data on pre-removal indoor dust levels were collected at each removal property as part of the CSS or PDI prior to 2007, but post-removal dust samples were not collected, even when an indoor dust removal occurred. Therefore, to characterize residual contamination in dust and potentially correlate indoor air results with indoor dust, dust samples were collected prior to performing scripted behaviors for each quarterly sampling event. Dust samples were composited across all rooms where routine activities were expected to occur. Dust samples were collected using a microvacuum technique and consisted of ten composited locations (four accessible areas, four infrequently accessed areas, and two inaccessible areas) as described in SOP CDM-LIBBY-10, *Project-Specific Guidance Document for the Collection of Dust Samples, Revision 1*. Dust samples were analyzed for asbestos by TEM ISO.

3.14.1.7 Outdoor Activity-Based Sampling

As discussed in greater detail in Section 3.33, outdoor removal actions consist of the removal of visible vermiculite in SUAs, removal of soil with analytical results ≥1%, and removal of soil with analytical results <1% only if an additional removal action level is met at the property. At post-removal properties, the potential sources of outdoor contamination remaining are:

- Visible vermiculite in NSUAs and soil samples with <1% LA remaining at properties where the removal criteria were not met.
- Visible vermiculite remaining in NSUAs at properties where a removal action was completed prior to 2007.
- Transfer of contamination from sources outside the post-removal property.

In order to more accurately represent long-term health risks from exposure to LA in outdoor air near disturbed soil and to represent the seasonal variability that may affect the releasability of LA fibers, outdoor ABS was conducted at each of 75 scenario areas in Summer 2007 and Spring 2008. Separate moisture restrictions (i.e., field moisture deficiency, rainfall totals) were established for both sampling events to ensure sampling conditions were representative of the season and not biased low. Portable weather stations were set up at each property to monitor onsite meteorological conditions (i.e., wind speed, wind direction, relative humidity, temperature, and barometric pressure). The sections below summarize the process for property selection and sample collection.

3.14.1.8 Property Selection

Properties were selected based on the level and extent of residual LA contamination in outdoor soils and geographical representativeness. Historical soil sample results were used to identify known areas of contamination, and areas of clean fill were used as a point of reference against other categories of

soil. Given the current protocol for removal actions at a property, yards (or sub-parts of yards) at post-removal properties were categorized into five types, as follows:

Soil Category	Residual Source	
	PLM-VE Analysis for LA	Visual Presence of Vermiculite
1	None (clean fill has been added)	
2	Bin A (non-detect)	No
3	Bin A (non-detect)	Yes
4	Bin B1 (<0.2%)	Either Yes or No
5	Bin B2 (0.2% - 1%)	Either Yes or No

Notes:
PLM-VE - polarized light microscopy-visual area estimation
LA – Libby Amphibole
< - less than; % - percent

Whenever possible, sampling locations were selected from post-removal properties. However, because an adequate number of sampling locations representing each soil category could not be identified, sub-parts of yards (or scenario areas) meeting the contamination characteristics were identified in properties where a removal action was required.

In total, 75 scenario areas at 62 properties were identified that equally represented the soil categories and each geographical region of OU4 (i.e., north, central, south). Of the 62 properties, 39 were classified as post-removal and only the sub-parts of the remaining properties that were post-removal were used for ABS. Thus, a single ABS property could satisfy multiple contamination categories in different sub-parts of the yard.

3.14.1.9 Scripted Activities

While there are a wide variety of outdoor activities that may be performed at residential properties, it was not the intent to collect data under every possible combination of activity and source disturbance. Rather, samples were representative of three standardized soil disturbance activities at each of the five soil categories. Each activity was considered a realistic example of relatively vigorous disturbances:

- Raking the lawn or yard with a metal-tined leaf rake
- Digging in the soil with a shovel and pail (simulating a child's play)
- Mowing the yard with a gasoline powered rotary lawn mover

During each of the two sampling events, actors simulated the three activities during separate two-hour periods at each scenario area. Activities were performed in the same sequence of raking, digging, and mowing. At properties where multiple soil categories were present (e.g., sub-parts of yard with clean fill as well as sub-parts of yard with visual vermiculite that were sampled non-detect by PLM) the scenario area with the lowest anticipated contamination was sampled first. Additionally, indoor and outdoor ABS activities were conducted on separate days if the homeowner participated in both programs.

3.14.1.10 Air Sampling

Two personal air samples were collected during each two-hour sampling period, one to serve as a backup in case the other failed, was damaged, or was lost. The target flow rates for sample collection were 10 and 3 L/min resulting in target volumes of 1,200 and 360 L, respectively. Each air sample was collected on a 0.8-µm pore size, 25-mm MCE filter and the sampling cassette was oriented face down in the breathing zone of the actor. Air samples were analyzed by TEM ISO to a target sensitivity of 0.001 cc^{-1}.

3.14.1.11 Soil Sampling

Before scripted behaviors were performed in each sampling event, one soil sample was collected from each scenario area to characterize residual soil contamination and allow for the correlation of outdoor air results with outdoor soil. One 30-point composite surface soil sample was collected for each scenario area in accordance with SOP CDM-LIBBY-05, *Site-Specific SOP for Soil Sample Collection, Revision 2*. Each soil sample was analyzed for LA by PLM. Because the goal of the investigation was to evaluate releases of LA to air during soil disturbance activities, water was not used during sample collection for dust suppression.

In addition to soil sample collection, each scenario area was inspected for visible vermiculite in accordance with SOP CDM-LIBBY-06, *Site-Specific SOP for Semi-Quantitative Visual Estimation of Vermiculite in Soils at Residential and Commercial Properties, Revision 1*. Locations of visible vermiculite were annotated on a field sketch.

During the second ABS event (Spring 2008), an additional soil sample was collected at each scenario area from the two digging sub-locations to provide a better characterization of the LA concentrations in the digging sub-locations. These composited samples were collected from the surface and followed the collection and visual inspection protocols referenced above.

3.14.1.12 Soil Condition Data

The amount of dust (and asbestos) released during soil disturbance activities will depend, in part, on the condition of the soil at the time of the ABS event. In order to help characterize this source of variability, and potentially to allow for some degree of normalization between locations, the following data items were collected for each scenario area:

- Nature and extent of soil vegetative cover
- Dust levels in air using RAMs set up in the immediate proximity of the ABS disturbance
- Soil moisture
- Soil texture

3.14.1.13 Results

The results of this investigation are summarized in the *Activity-Based Sampling Summary Report* (EPA 2010a) and can also be found in Table 3-31. It should be noted that multiple soil samples from this ABS investigation underwent a re-analysis by PLM-VE in 2013. As a result, the total number of analyses is greater than the total number of samples collected. Refer to Appendix A for additional information on individual sample details and analytical results. Results are summarized below in brief.

Indoor ABS

- A total of 195 surface soil samples were collected during the indoor 2007-2008 ABS activities. LA was detected at a frequency of 17% in 195 samples (350 analyses) with trace concentrations by PLM-VE. LA was not detected in 121 samples by PLM-Grav. Vermiculite was observed in 74 samples based on a quantitative assessment. Vermiculite was not observed in 121 samples based on a quantitative assessment.

- A total of 321 active personal air samples were collected during the 2007-2008 indoor ABS activities. Total LA was detected at a frequency of 53% ranging in concentrations from 0.00017 s/cc to 0.05 s/cc by TEM analysis. PCME LA was detected at a frequency of 37% ranging in concentrations from 0.00017 s/cc to 0.0097 s/cc by TEM analysis.

- A total of 321 passive personal air samples were collected during the 2007-2008 indoor ABS activities. Total LA was detected at a frequency of 23% ranging in concentrations from 0.00013 s/cc to 0.033 s/cc by TEM analysis. PCME LA was detected at a frequency of 12% ranging in concentrations from 0.00013 s/cc to 0.0099 s/cc by TEM analysis.

- A total of 354 indoor dust air samples were collected during the 2007-2008 ABS activities. Total LA was detected at a frequency of 3% ranging in concentrations from 6.3 s/cm^2 to 79 s/cm^2 by TEM analysis.

Outdoor ABS

- A total of 237 surface soil samples were collected during the 2007-2008 outdoor ABS activities. LA was detected at a frequency of 30% in 237 samples (431 analyses) with concentrations ranging from trace to 1% by PLM-VE. LA was not detected in 38 samples by PLM-Grav. Vermiculite was observed in 127 samples based on a quantitative assessment. Vermiculite was not observed in 108 samples based on a quantitative assessment. Information on vermiculite was not available for two samples and has not been assumed to be present or absent because it is known the data were not collected.

- A total of 460 personal air samples were collected during the 2007-2008 outdoor ABS activities. Total LA was detected at a frequency of 69% ranging in concentrations from 0.00046 s/cc to 58 s/cc by TEM analysis. PCME LA was detected at a frequency of 59% ranging in concentrations from 0.00048 s/cc to 21 s/cc by TEM analysis.

3.14.1.14 Conclusions

Indoor ABS

On average, the concentration values associated with active behaviors were higher than for passive behaviors, supporting the concept that disturbance of an indoor source such as contaminated indoor dust, is one contributing factor to indoor air levels of LA. Indoor air levels of LA tended to be lowest during the winter and highest during the summer for both active and passive behaviors.

It was not possible to establish a quantitative relationship between LA levels in indoor air and indoor dust because nearly all of the dust samples were non-detect for LA.

A weak correlation could be detected between average indoor air concentrations of PCME LA and the level of LA in outdoor soil. These results support the concept that outdoor soil is a source that contributes to indoor air contamination. However, a regression analysis suggested that other sources besides outdoor soil may also be important.

Outdoor ABS

On average, the concentration values associated with mowing and digging tended to be similar, while the values for raking tended to be somewhat lower. There was high variability between sampling rounds, with Round 1 (summer) tending to yield higher concentration values than Round 2 (spring). In general, the average concentration of PCME LA in ABS air tended to increase as a function of increasing levels of LA in soil.

3.14.2 Experimental ABS Air Samples

In June 2008, the EPA's Office of Research and Development (ORD) selected four outdoor ABS properties for studying the releasable asbestos field sampler (RAFS) unit. The RAFS is a field sampling device designed to collect air samples while the unit performed mechanical soil raking activities. Historically, the four properties had no detectable levels of LA in soil by PLM-VE but had localized areas of visible vermiculite. RAFS air samples were collected by the EPA ORD within 24 hours of outdoor ABS in accordance with the *Quality Assurance Project Plan: Phase 2 - Evaluation of the Aerosolization of Asbestos and Related Fibers from Bulk Materials* (EPA 2009d). In total, 15 air samples (24 analyses) were analyzed by TEM ISO, and analytical results for all samples were non-detect for LA. Refer to Appendix A for additional information on individual sample details and analytical results.

Additional RAFS air samples were subsequently collected at other Libby Site locations in 2009 and 2010; however, these data are not available in the project database. Therefore, the results for these samples are not summarized in this report.

3.14.3 2010 Residential Activity-Based Sampling

In 2010, the EPA conducted several outdoor ABS investigations in OU4 to evaluate potential residential exposures during realistic and representative soil disturbance activities. These outdoor ABS investigations consisted of five different sampling scenarios. The specific objectives and investigation designs of each sampling scenario are described in the governing SAP, *Sampling and Analysis Plan, Supplemental Activity-Based Sampling* (EPA 2010b).

3.14.3.1 Study Design

The five sampling scenarios performed to evaluate potential LA exposures are summarized below. For all scenarios, the ABS actor wore two different types of sampling pumps. The primary air sample was collected using a sampling pump operating at a high flow rate (approximately four L/min). A backup air sample was collected using a sampling pump operating at a low flow rate (approximately two L/min). The samples are filter replicates (i.e., each filter represents the same sample collection duration, but different total sample air volumes).

Scenario 1: Working in Residential Yards: This scenario was developed to evaluate disturbances of residential yard soil through raking, mowing, and digging. ABS was conducted for each of three yard disturbance activities – mowing the lawn with a power mower, raking the lawn with a metal-tined rake, and digging a hole using a long shovel (e.g., to simulate sprinkler maintenance).

Ten residential properties were selected for evaluation from each of four different property categories, depending upon the outdoor clean-up status and soil conditions:

- Category 1 - no soil clean-up required, with PLM-VE Bin B1 in yard
- Category 2 - soil clean-up complete; no visible vermiculite

- Category 3 - soil clean-up complete; visible vermiculite present
- Category 4 - soil clean-up still required, with PLM-VE Bin B2 or Bin C in yard

These four categories were selected to be representative of the range of soil conditions that may be present in yards at residential properties in Libby based on the soil removal action levels in place in 2010 (EPA 2003c).

During each sampling event, a single ABS air sample was collected at each property, representing a composite across all three soil disturbance scenarios (mowing, raking, and digging). Each disturbance scenario was performed for about 20 minutes (i.e., the ABS air sample had a total sampling duration of 60 minutes). The mowing and raking ABS disturbance activities were performed on a yard-wide basis, to reduce the amount of localized stress in one area. The digging scenario was representative of an adult performing sprinkler maintenance activities (i.e., digging in the soil with a long shovel and a trowel). The actor utilized a long-handled shovel to remove soil from a one-foot by one-foot square area for 4.5 minutes. The soil was temporarily staged on a tarp adjacent to the digging site. The actor then knelt down and continued digging with a trowel for an additional 4.5 minutes. The depth attained in each digging location was documented in the field logbook.

During each sampling event, one 30-point composite surface soil sample was collected to be representative of the entire ABS area. The sampling points within the 30-point composite included the two sub-locations selected for digging.

Three sampling events were conducted at each property in the summer of 2010, with events spaced about one to four weeks apart. Event 1 occurred in July 2010, Event 2 occurred in August 2010, and Event 3 occurred in September 2010.

Scenario 2: Working in Residential Gardens: This scenario was developed to evaluate digging disturbances of residential garden soil. ABS was conducted on a garden-wide basis and sampling duration was about 60 minutes. To reduce the amount of localized stress in one area, the digging was performed in six discrete locations distributed evenly within the garden with 10 minutes spent at each location. The digging scenario was representative of an adult gardening (i.e., digging in the soil with e.g., trowel, cultivator, soil rake, hands) to disturb the soil to a depth of 12 inches bgs.

Ten residential properties were selected for each of two different categories of residential properties that were evaluated as follows:

- Vis -: No soil removal required in the garden; no visible vermiculite present in the garden
- Vis +: Soil removal is needed in the garden; visible vermiculite present in the garden.

Many of these properties were the same as the properties selected for the yard or driveway scenarios. Three sampling events were conducted at each property in the summer of 2010, with events spaced 5 to 44 days apart. In general, Event 1 occurred in July 2010, Event 2 occurred in August 2010, and Event 3 occurred in September 2010.

During each sampling event, a single ABS air sample was collected at each property, representing a composite across both soil disturbance scenarios. Also, one 30-point composite surface soil sample was collected to be representative of the entire ABS area.

Scenario 3: Child Playing on Unpaved Driveway: This scenario was developed to evaluate disturbances that may reasonably occur on a gravel or dirt driveway, such as children riding bicycles, playing with toys, playing basketball, etc. ABS was conducted on the selected driveway and had a sampling duration of about 60 minutes (i.e., 30 minutes digging and 30 minutes of biking). The child digging activity was conducted with the actor sitting on the ground while digging or scraping the top two to six inches of the surface, pushing soil/rock to the side, and then replacing it for a period of approximately five minutes. This activity was repeated over a total of six discrete locations evenly distributed across the entire driveway. For the child biking activity, the actor rode a small non-motorized vehicle (e.g., bicycle or tricycle) with minimal ground clearance across the driveway in straight lines covering the entire area of the driveway for 30 minutes. The air cassette was worn 22 inches above the ground to better represent a child's breathing zone while tricycling and moved to the actor's right shoulder for the digging portion to simulate a child's breathing zone while seated and digging/playing.

Ten residential properties were selected for each of two different categories of residential properties that were evaluated as follows:

- Vis -: Driveways without visible vermiculite
- Vis +: Driveways with visible vermiculite.

Many of these properties were the same as the properties selected for the yard or garden scenarios. A total of ten properties were evaluated for each category, and three ABS events were conducted at each property. The three sampling events were spaced 5 to 44 days apart. In general, Event 1 occurred in July 2010, Event 2 occurred in August 2010, and Event 3 occurred in September 2010.

During each sampling event, a single ABS air sample was collected at each property, representing a composite across both activities (digging and biking). Also, one 30-point composite surface soil sample was collected to be representative of the entire ABS area.

Scenario 4: Driving on Roads in Libby: This scenario was developed to evaluate exposures from driving in a car on roads and alleys in the City of Libby. The driving activity was conducted with the actor driving a full-size automobile (car or truck) for a period of 120 minutes within OU4. Both paved roads and unpaved roads/alleys were traveled during this time interval with travel evenly distributed throughout the bounded area. The actor maintained a reasonable speed during the activity, following all posted speed limits. During sample collection, the two front windows of the vehicle were fully open, and the two back windows were open approximately one inch. All samples were collected from the right shoulder of the actor.

A total of 20 driving events were conducted. Because it was not be possible to travel every road within the bounded area during each sampling event, each event covered areas missed in previous events such that the sum of all 20 events comprehensively covered the entire city. The specific driving routes were documented utilizing a portable global positioning system (GPS) unit to record the route. Figure 3-9 provides a map of the roads that were traveled during the ABS events.

Scenario 5: Riding Bicycles in Libby: This scenario was developed to evaluate exposures from riding bicycles on roads and trails in Libby. The biking activity was conducted with two actors riding non-motorized, two-wheeled bicycles equipped for use on non-paved roads for a period of 60 minutes. In addition, a bicycle trailer built to transport a 50-pound child, was affixed to the back of one of the bicycles for the entire event and an air monitor was mounted inside the trailer. Two types of samples were collected as part of this scenario – adult riders and within trailers (to represent potential child exposures).

For each predetermined route of paved and unpaved trails shown on Figure 3-10, a pair of two riders, with air samplers mounted to the bicycle and the monitoring cassette affixed in the breathing zone, traveled in single file along the bicycle path. The distance between the riders varied based on visibility, terrain, and safety considerations. Riders alternated positions (lead and trailing) throughout the scenario, with the trailing riders trying to ride in the dust cloud of the rider in front as much as is safe and practical. During these events, the bicycle riders varied their speed between 3 and 15 mph, with an average speed of 8 mph.

A total of ten sampling events were conducted in each of three sectors within Libby, resulting in 60 ABS air samples from the adult riders and 30 ABS air samples for the bicycle trailer samples.

3.14.3.2 Supplemental Analysis

Prior to 2011, ABS studies were designed to meet analytical requirements based on the inhalation unit risk (IUR) for asbestos provided in EPA (2008b). In 2011, the EPA proposed new cancer and non-cancer toxicity values that are specific to LA (EPA 2011a). These are draft values that are currently undergoing review. The analytical requirements needed to support risk calculations based on the draft LA-specific non-cancer reference concentration (RfC) are lower than those originally specified in earlier (pre-2011) ABS studies.

Therefore, in 2012, the EPA determined that supplemental TEM-ISO analysis for a subset of the 2010 outdoor ABS air samples was necessary to achieve lower analytical sensitivities to support reliable risk management decision-making for the human health risk assessment (HHRA) (CDM Smith 2012b,c). The supplemental analysis conducted in 2013 did not require field collection of new samples; instead, the filters collected in 2010 were taken from storage and a supplemental analysis was performed (i.e., additional grid openings were examined) to achieve a revised sensitivity that was lower than originally achieved. Because of the high number of grid openings needed to achieve the revised sensitivity, the supplemental analysis of ABS samples utilized counting protocols for recording PCME structures only. As a result, the detection frequency for PCME LA may be higher than total LA.

3.14.3.3 Results

The results of this investigation are summarized in the *Data Summary Report: 2010 Residential Activity-Based Sampling* (EPA 2013b) and can also be found in Table 3-32. Refer to Appendix A for additional information on individual sample details and analytical results. Results are summarized below in brief:

Air

- A total of 120 personal air samples were collected during Scenario 1 of the 2010 ABS activities. Total LA was detected at a frequency of 3% with concentrations of 0.0040 s/cc by TEM analysis. PCME LA was detected at a frequency of 8% ranging in concentrations from 0.00099 s/cc to 0.0038 s/cc by TEM analysis.

- A total of 60 personal air samples were collected during Scenario 2 of the 2010 ABS activities. Total LA was detected at a frequency of 8% ranging in concentrations from 0.0029 s/cc to 0.0030 s/cc by TEM analysis. PCME LA was detected at a frequency of 17% ranging in concentrations from 0.00089 s/cc to 0.0040 s/cc by TEM analysis.
- A total of 61 personal air samples were collected during Scenario 3 of the 2010 ABS activities. Total LA was detected at a frequency of 5% ranging in concentrations from 0.013 s/cc to 0.18 s/cc by TEM analysis. PCME LA was detected at a frequency of 5% ranging in concentrations from 0.0094 s/cc to 0.076 s/cc by TEM analysis.
- A total of 20 personal air samples were collected during Scenario 4 of the 2010 ABS activities. Total and PCME LA were not detected in any of the samples by TEM analysis.
- A total of 90 personal air samples were collected during Scenario 5 of the 2010 ABS activities. Total and PCME LA were not detected in any of the samples by TEM analysis.

Soil

- A total of 29 surface soil samples were collected during the 2010 ABS pre-screening activities. LA was detected at a frequency of 59% in 29 samples ranging in concentrations from trace to <1% by PLM-VE. LA was not detected in two samples by PLM-Grav. Vermiculite was observed in 16 samples based on a quantitative assessment. Vermiculite was not observed in 13 samples based on a quantitative assessment.
- A total of 127 surface soil samples were collected during Scenario 1 of the 2010 ABS activities. LA was detected at a frequency of 35% in 127 samples ranging in concentrations from trace to <1% by PLM-VE. LA was not detected in one sample by PLM-Grav. Vermiculite was observed in 60 samples based on a quantitative assessment. Vermiculite was not observed in 67 samples based on a quantitative assessment.
- A total of 66 surface soil samples were collected during Scenario 2 of the 2010 ABS activities. LA was detected at a frequency of 38% in 66 samples ranging in concentrations from trace to 2% by PLM-VE. LA was detected at a frequency of 50% with one sample reported as trace by PLM-Grav. Vermiculite was observed in 32 samples based on a quantitative assessment. Vermiculite was not observed in 34 samples based on a quantitative assessment.
- A total of 61 surface soil samples were collected during Scenario 3 of the 2010 ABS activities. LA was detected at a frequency of 26% in 61 samples ranging in concentrations from trace to 1% by PLM-VE. LA was detected at a frequency of 11% for 55 samples at trace concentrations by PLM-Grav. Vermiculite was observed in 25 samples based on a quantitative assessment. Vermiculite was not observed in 36 samples based on a quantitative assessment.

3.14.3.4 Conclusions

Most of the ABS air samples were non-detect; however, the detection frequency increased for samples that underwent supplemental evaluation. Although the data are limited due to a high frequency of non-detects, ABS air concentrations tended to be higher for locations where LA was detected in soil than locations that were non-detect.

3.14.4 2011 Residential Activity-Based Sampling

In 2011, the EPA again conducted several residential ABS investigations in OU4 to evaluate potential exposures from the disturbance of yard soils at residential properties in Libby. These residential ABS investigations consisted of four different sampling scenarios. The specific objectives and investigation designs of each sampling scenario are described in the governing SAP, *2011 Residential Activity-Based Sampling SAP* (EPA 2011b).

3.14.4.1 Study Design

Four sampling scenarios were performed to evaluate potential LA exposures to residents who disturb soils during typical yard work scenarios (i.e., raking, mowing, and digging).

Scenario 1: This scenario evaluated potential differences in measured ABS LA air concentrations as a function of the various ABS scripts used to perform the raking, mowing, and digging disturbance activities. Ten residential properties were selected for evaluation in Scenario 1. All of the selected properties were evaluated in 2007/2008 as part of the OU4 residential outdoor ABS investigation (EPA 2010a). A total of three sampling events were conducted at each property in the summer of 2011, with events spaced approximately two weeks apart. Event 1 occurred in mid-July 2011, Event 2 occurred in early August 2011, and Event 3 occurred in mid-August 2011. During each event, ABS activities were performed utilizing the same "high intensity" and "low intensity" ABS scripts as used in 2007/2008 and 2010, respectively.

During each sampling event, a single "low intensity" ABS air sample was collected at each property, representing a composite across all three soil disturbance scenarios (mowing, raking, and digging). The digging scenario was representative of an adult performing sprinkler maintenance activities (i.e., digging in the soil with a long shovel and a trowel). Each disturbance scenario was performed for 20 minutes (i.e., the ABS air sample had a total sampling duration of 60 minutes).

During each sampling event, two soil samples were collected. One 30-point composite surface soil sample was collected to be representative of the entire ABS area. The sampling points within the 30-point composite included the two sub-locations selected for digging as part of the "low intensity" ABS script. In addition, one 2-point composite sample was collected to represent the two sub-locations selected for digging as part of the "high intensity" ABS script.

Scenario 2: This scenario was a replication of the outdoor ABS yard investigation conducted in 2010 to evaluate potential differences in measured ABS LA air concentrations at a given property across sampling years. Ten residential properties were selected for evaluation. All of the selected properties were evaluated in 2010 as part of the OU4 residential outdoor ABS investigation (EPA 2010b). A total of three sampling events were conducted at each property in the summer of 2011. During each event, ABS activities were conducted using an ABS script that was the same as that used in the 2010 residential yard ABS sampling efforts (EPA 2010b). In brief, a single ABS air sample was collected from each property, representing a composite of ABS soil disturbance activities (i.e., raking, digging, and mowing). Each disturbance activity was performed for 20 minutes (i.e., a total sampling duration of one hour for each composite ABS air sample).

During each event, one 30-point composite surface soil sample was collected to be representative of the entire yard. The sampling points within the 30-point composite included the two sub-locations selected for digging.

Scenario 3: This scenario evaluated potential differences in measured ABS LA air concentrations during mowing activities that were conducted on yards pre- and post-irrigation. Three residential properties were selected for evaluation. These properties were selected because measured ABS air concentrations during the mowing activity conducted as part of the 2007/2008 ABS investigation (EPA 2010a) reported detected levels of LA. Two types of ABS air samples were collected from each property. One sample was collected under "without irrigation" conditions (i.e., lawn had not been irrigated for at least 36 hours prior to ABS) and the other sample was collected immediately following irrigation.

A total of six sampling events were performed at each property, three events with irrigation and three events without irrigation. One event was conducted every two weeks in the summer of 2011, with the type of event performed (with or without irrigation) alternating between events. Each mowing event was a "one-pass"[9] mowing of the entire yard (there was no specified sampling duration).

During each event, one 30-point composite surface soil sample was collected to be representative of the entire yard.

Scenario 4: This scenario evaluated potential LA exposures at residential properties where previous removal activities occurred over the entire yard (i.e., curb-to-curb removal). Eleven[10] residential properties were selected for evaluation. These properties were selected because they had undergone a "curb-to-curb" yard removal between 2008 and 2010. A total of three sampling events were conducted at each property in the summer of 2011. During each event, ABS activities were conducted using an ABS script that was similar to the 2010 residential yard ABS script, except that the sampling duration of each scenario was extended to be more representative of expected residential conditions. In brief, for each event, a single ABS air sample was collected from each property, representing a composite of ABS soil disturbance activities (i.e., raking, digging, and mowing). The mowing portion of the composite represented a one-pass mowing of the entire yard (there was no specified sampling duration). The raking portion of the composite represented a one-pass raking of the entire yard (there was no specified sampling duration). The digging portion of the composite represented digging a hole at each of two to six locations, simulating sprinkler maintenance activities (i.e., digging with a long shovel and trowel).

During each event, one 30-point composite surface soil sample was collected to be representative of the entire yard. The sampling points within the 30-point composite included the sub-locations selected for digging.

With the exception of Scenario 1, the ABS actor wore two different types of sampling pumps. The primary air sample was collected using a sampling pump operating at a high flow rate (5.5 L/min). A backup air sample was collected using a sampling pump operating at a low flow rate (2 L/min). The samples are filter replicates (i.e., each filter represents the same sample collection duration, but different total sample air volumes).

---

[9] The entire yard was mowed once, without re-mowing areas that had already been mowed.

[10] The original investigation design identified a target of ten properties. However, one of the original ten properties selected dropped out of the investigation after the first sampling event. Thus, one additional property was added to achieve the investigation objectives.

3.14.4.2 Results

The results of this investigation are summarized in the *Data Summary Report 2011 Residential Activity-Based Sampling* (EPA 2013c) and can also be found in Table 3-33. Refer to Appendix A for additional information on individual sample details and analytical results. Results are summarized below in brief:

Air

- A total of 80 personal outdoor air samples were collected during Scenario 1 of the 2011 ABS activities. PCME LA was detected at a frequency of 71% ranging in concentrations from 0.00011 s/cc to 0.40 s/cc by TEM analysis.
- A total of 31 personal outdoor air samples were collected during Scenario 2 of the 2011 ABS activities. PCME LA was detected at a frequency of 32% ranging in concentrations from 0.00021 s/cc to 0.044 s/cc by TEM analysis.
- A total of 18 personal outdoor air samples were collected during Scenario 3 of the 2011 ABS activities. PCME LA was detected at a frequency of 28% ranging in concentrations from 0.00022 s/cc to 0.00064 s/cc by TEM analysis.
- A total of 31 personal outdoor air samples were collected during Scenario 4 of the 2011 ABS activities. PCME LA was detected at a frequency of 26% ranging in concentrations from 0.00011 s/cc to 0.012 s/cc by TEM analysis.

Soil

- A total of 61 surface soil samples were collected during Scenario 1 of the 2011 ABS activities. LA was detected at a frequency of 56% ranging in concentrations from trace to 2% by PLM-VE. Vermiculite was observed in 22 samples based on a quantitative assessment. Vermiculite was not observed in 39 samples based on a quantitative assessment.
- A total of 33 surface soil samples were collected during Scenario 2 of the 2011 ABS activities. LA was detected at a frequency of 58% ranging in concentrations from trace to <1% by PLM-VE. Vermiculite was observed in 15 samples based on a quantitative assessment. Vermiculite was not observed in 18 samples based on a quantitative assessment.
- A total of 20 surface soil samples were collected during Scenario 3 of the 2011 ABS activities. LA was detected at a frequency of 40% with trace concentrations by PLM-VE. Vermiculite was observed in three samples based on a quantitative assessment. Vermiculite was not observed in 17 samples based on a quantitative assessment.
- A total of 33 surface soil samples were collected during Scenario 4 of the 2011 ABS activities. LA was detected at a frequency of 3% with trace concentrations by PLM-VE. Vermiculite was observed in two samples based on a quantitative assessment. Vermiculite was not observed in 31 samples based on a quantitative assessment.

3.14.4.3 Conclusions

- ABS air samples collected using a “high intensity” ABS script have higher PCME LA air concentrations than samples collected using a “low intensity” ABS script. In general, “high intensity” ABS air concentrations tended to be higher by a factor of about 10.

- ABS air concentrations measured in the summer of 2007 were higher than those measured in the summer of 2011 for nearly all ABS samples regardless of the scenario (raking/mowing/digging). The most likely explanation for these differences is that they demonstrate the inherent variability in ABS air due to temporal changes in meteorological and environmental conditions.
- In general, the mean ABS PCME LA air concentrations are similar between the 2010 investigation and the 2011 investigation.
- Irrigation of the lawn prior to mowing did not appear to reduce the concentration of PCME LA asbestos in air during mowing activities; however, interpretation of these results is confounded by several limitations in the original investigation design. Although the properties were selected because total LA was detected previously in the 2007/2008 ABS air samples, the levels of PCME LA measured for the three selected properties tended to be on the lower end of the range of detected concentrations. In addition, LA concentrations in soil for the three selected properties also tended to be low, with reported concentrations tending to be primarily non-detect by PLM-VE, and no or low levels of visible vermiculite were noted. Furthermore, because the with/without irrigation events were separated in time, it appears that temporal variability in environmental soil conditions may have played a larger role than irrigation in affecting soil moisture.
- In general, PCME LA concentrations in air tended to be relatively low for most samples collected at curb-to-curb properties, with concentrations usually less than about 0.001 PCME LA s/cc. Because LA was detected at curb-to-curb properties, assuming there was no re-contamination of the property following the soil cleanup action, this suggests that soils used as topsoil fill may contain low levels of LA (below that which can be reliably detected by PLM-VE or observed via visible vermiculite inspection in the field) that are not mining-related.

3.14.5 2013 Residential Activity-Based Sampling

In 2013, the EPA conducted additional indoor ABS investigations in OU4 to evaluate potential exposures during active and passive behavior activities for two different scenarios. The specific objectives and investigation designs of each sampling scenario are described in the governing SAP/QAPP, *2013 Indoor Activity-Based Sampling* (EPA 2013d). Specifics on sample collection procedures and conclusions are detailed in the *Data Summary Report 2013 Indoor Activity-Based Sampling* (EPA 2014c).

3.14.5.1 Study Design

The indoor ABS investigations consisted of two different sampling scenarios:

Scenario 1 – Curb-to-Curb Properties: The objective of Scenario 1 was to collect indoor ABS data to evaluate the efficacy and protectiveness of a "curb-to-curb" yard removal (i.e., the entire yard was removed and replaced with fill material). Thus, only those OU4 properties that have undergone a curb-to-curb yard removal were eligible for selection. Because it is likely that there is some lag time between when the curb-to-curb removal is performed and when the effects of this removal influence indoor air conditions inside the property, only those properties where removals were performed prior to 2011 were selected. Two indoor ABS events were performed – one in the winter 2013 and one in the summer 2013. A total of 10 curb-to-curb properties were selected for evaluation.

Scenario 2 – 2007/08 Re-evaluation: The objective of Scenario 2 was to compare LA air concentrations from the indoor ABS conducted in 2007/2008 to concentrations measured in 2013. Therefore, properties selected for evaluation in this investigation were selected from the list of properties originally evaluated in 2007/2008 as part of the indoor ABS evaluation (EPA 2010a). As noted above in Section 3.14.1, properties selected for indoor ABS evaluation in 2007/2008 were drawn from four property categories, depending upon their outdoor soil removal status and the post-removal soil conditions. (Selected properties included properties where interior removals had been performed and properties where no removal was deemed necessary.) One indoor ABS event was performed in the summer of 2013. A total of 10 properties were selected for evaluation; five properties where outdoor soil removal activities were performed and five properties where an outdoor soil removal was not deemed necessary. Each property sampled had two four-hour samples collected to represent indoor air levels during two types of activity – passive behaviors and active behaviors (see Section 3.14.1).

3.14.5.2 Results

Table 3-34 presents a summary of all active and passive indoor air samples for Scenarios 1 and 2. Refer to Appendix A for additional information on individual sample details and analytical results. Results are summarized below in brief.

- A total of 20 active indoor air samples were collected during Scenario 1 of the 2013 ABS activities. PCME LA was detected at a frequency of 50% ranging in concentrations from 0.000040 s/cc to 0.00083 s/cc by TEM analysis.
- A total of 20 passive indoor air samples were collected during Scenario 1 of the 2013 ABS activities. PCME LA was detected at a frequency of 45% ranging in concentrations from 0.000032 s/cc to 0.00024 s/cc by TEM analysis.
- A total of 10 active indoor air samples were collected during Scenario 2 of the 2013 ABS activities. PCME LA was detected at a frequency of 40% ranging in concentrations from 0.000040 s/cc to 0.00056 s/cc by TEM analysis.
- A total of 10 passive indoor air samples were collected during Scenario 2 of the 2013 ABS activities. PCME LA was detected at a frequency of 40% ranging in concentrations from 0.000030 s/cc to 0.000088 s/cc by TEM analysis.

3.14.5.3 Conclusions

Conclusions for Scenario 1 and Scenario 2 are presented below.

Scenario 1 – Curb-to-Curb Properties: A comparison of results for the two ABS scripts (active and passive) reveals that there is a tendency for ABS air samples collected using an active ABS script to have higher PCME LA air concentrations than samples collected using a passive ABS script. This supports the concept that disturbance of an indoor source, such as contaminated indoor dust, is one contributing factor to indoor air levels of LA.

A comparison of results for ABS samples by season reveals that on average, indoor air levels of PCME LA tended to be lowest during the summer and highest during the winter for both active and passive behaviors at curb-to-curb properties, which differs from the seasonal patterns noted in earlier indoor ABS studies. This is likely because track-in of LA-containing soils from the yard during the summer months is no longer occurring at curb-to-curb properties.

Scenario 2 – 2007/08 Re-evaluation: A comparison of results for the two ABS scripts (active and passive) reveals that there is a tendency for ABS air samples collected using an active ABS script to have higher PCME LA air concentrations than samples collected using a passive ABS script. In addition, the passive and/or the active ABS air concentrations were higher in 2007 than in 2013 for more than half of all properties sampled. Because the same property was evaluated in both years using the same ABS script, the most likely explanation for these differences is that indoor air concentrations have decreased over time, but may also be due to the inherent variability in ABS air results. This decrease over time could be due to continual cleaning by residents after interior removals and cleanings have taken place, thereby reducing residual levels of LA over time.

3.15 USGS Background Soil Study

When LA levels exceed the EPA's current removal criteria, the contaminated soils are removed and replaced with clean fill collected from borrow pits (Section 3.4.20). However, the analytical results for the 2007-2008 outdoor ABS program (Section 3.14.1) and the curb-to-curb ABS in 2011 (Section 3.14.4) indicate that LA fibers were detected in air at locations characterized as clean fill material in which LA was not detected by PLM-VE and where no vermiculite was identified during visual soil inspection. It was not known whether these LA fibers were attributable to unrecognized anthropogenic sources, such as historic mining activities or recontamination, or whether the fibers were geologic (naturally-occurring) in origin.

In order to investigate geologic factors that could have contributed to low levels of LA in background soils, a geological investigation of sources and levels of LA in the Kootenai Valley was conducted in June 2008 in accordance with the *Study Design to Pilot Reconnaissance Activities for the Characterization of Geological Sources of Libby Amphibole in Libby Valley Soils* (EPA 2008c).

Soil samples for the USGS background study were collected from three borrow sources within the Kootenai Valley (Figure 3-11). One of the locations evaluated (Remp's Pit) had been used as a source of clean fill material during removals. The USGS selected specific sampling locations and soil horizons based on a review of geologic maps, literature, field observations and professional judgment.

At each borrow source, the number and location of samples was determined in the field based on a consideration of the visible geology. Typically, the vertical face at each area was cleaned of loose debris, and the USGS technical lead inspected the face and identified strata representing different ages and different modes of formation.

All soil samples selected for analysis were analyzed by scanning electron microscopy (SEM) in accordance with SOP SRC-LIBBY-02 (Revision 2), *Reflectance Spectroscopy Screening for Asbestos in Soil*. A total of 70 field samples were collected from three study locations as part of this study.

The results of this investigation are not available in the project database, but are presented in *Examination of Libby, Montana, Fill Material for Background Levels of Amphibole from the Rainy Creek Complex using Scanning Electron Microscopy and X-Ray Analysis* (Adams *et al*. 2010). In general, background levels for LA were non-detect with the exception of four samples. Measured concentrations of LA were: 0.059% to 0.082% (by mass) at 2,186 feet elevation from the Lower Sand Pit; non-detect to 0.037% at 2,126 ft elevation; and 0.023% to 0.050% at 2,130 ft elevation from the Clay Pits; and 0.004% to 0.047% at 22 inches below 2,070 ft elevation.

Additional evaluations of Libby background soils were performed later in the project and are summarized in Section 3.20.

3.16 School Investigation

In June and July of 2008, the five current public school buildings in Libby were inspected for visible vermiculite products and a limited number of outdoor soil samples were collected. The objectives of these inspections were to: 1) identify sources or exposure pathways within the indoor and outdoor portions of the school buildings; 2) delineate each school into preliminary sampling zones based on shared airspaces and usage; and to 3) conduct outdoor inspections in areas of new construction and/or soil disturbances. All work was conducted in accordance with the *Final Technical Memorandum, Libby Public School Inspection, Libby, Montana* (CDM Smith 2008c).

The inspections focused on identifying and documenting the location of vermiculite or vermiculite insulation within the buildings; checking open walls, ceilings, and floor penetrations for vermiculite insulation or VCBM; and inspecting outdoor walls and perimeter soils for vermiculite or vermiculite insulation. A detailed summary of the June 2008 school inspections, including figures illustrating the air zones and locations of source materials are available in *Libby Schools Visual Vermiculite Investigation Summary* (CDM Smith 2008d). All visual inspections were performed in accordance with SOP CDM-LIBBY-06 (Revision 1), *Site-Specific SOP for Semi-Quantitative Visual Estimation of Vermiculite in Soil*.

Based on the air zones delineated during the June 2008 school inspections, an indoor air SAP, *Final Sampling and Analysis Plan Libby Public Schools - Stationary Air Sample Collection* (EPA 2008d) was developed for the public schools. Delineation of the air sampling zones considered the following general elements:

- Whether a given area is populated primarily by students (e.g., classrooms) or faculty (e.g., administrative offices)
- Physical features such as fire breaks or building wings
- Room or area usage (e.g., metal shop vs. classroom)
- Ceiling height (e.g., auditorium or gym vs. classrooms)
- Other factors that could affect sample results including, but not necessarily limited to, the presence of sprayed on fireproofing, possible presence of VCBMs, dusty conditions (e.g., in a wood shop), etc.

The purpose of the sampling event was to collect indoor stationary air samples to support an evaluation of LA concentrations in the air at the public schools in Libby. Sampling was conducted during normal school hours and was intended to be representative of typical indoor conditions at each school.

In December 2008, a total of 51 indoor stationary samples were collected in accordance with the *Final Sampling and Analysis Plan for Libby Public Schools – Stationary Air Sample Collection* (EPA 2008d). Five air samples were collected from each school over two consecutive school days. The sampling cassettes were placed at a level corresponding to the breathing zone of the students in the room for each sampling location. Sample collection was suspended during extended periods of inactivity. A detailed summary of the December 2008 air sample collection is available in the *Libby Public Schools – Stationary Air Sampling Investigation Summary* (CDM Smith 2009b).

Table 3-35 presents a summary of the analytical results for all air and soil samples collected as part of this investigation. Refer to Appendix A for additional information on individual sample details and analytical results. Results are summarized below in brief for each school.

3.16.1 Kootenai Valley Head Start

Findings of the investigation at Kootenai Valley Head Start for the inspection of visible vermiculite products and air sample collection are described below:

- Moderate levels of vermiculite were identified in two five-gallon buckets of sand in a storage room south of the main gym area. One of the buckets had three toy shovels in it and a small quantity of this sand had spilled on the floor nearby. Low levels of vermiculite were also observed in the soil of a houseplant in the northwest office. Vermiculite was not observed on the exterior of the building during the inspection.
- A total of 10 indoor stationary air samples were collected. Total and PCME LA were not detected in any of the samples by TEM analysis.

3.16.2 Libby Elementary School

Findings of the investigation at Libby Elementary School for the inspection of visible vermiculite products, soil sample collection, and air sample collection are described below:

- Vermiculite or vermiculite insulation was not observed during the indoor and outdoor perimeter inspection even though the cinderblock walls are known to contain vermiculite insulation. VCBM was identified in the form of wall plaster in the east wing and wall plaster at the north side of the stage. The plaster in both locations was in good condition and not friable.
- Inspection for visible vermiculite was performed during soil sample collection in areas of the school with previously detected levels of LA. Low levels of visible vermiculite were observed in five of the soil sample locations and one of the areas with previously detected concentrations of LA. A detailed summary of this sample collection event, as well as the location of analytical and visual inspection results can be found in *Libby Schools Visual Vermiculite Investigation Summary* (CDM Smith 2008d). A total of 18 surface soil samples were collected along the walking path and from the recently constructed playground. LA was detected at a frequency of 10% in 18 samples (21 analyses) at trace levels by PLM-VE. LA was not detected in two samples by PLM-Grav. Vermiculite was observed in five samples based on a quantitative assessment. Vermiculite was not observed in 11 samples based on a quantitative assessment. Vermiculite was not observed in two samples based on a qualitative assessment.
- A total of 10 indoor stationary air samples were collected. Total and PCME LA were detected at a frequency of 10% with a concentration of 0.00059 s/cc by TEM analysis.

3.16.3 Libby Middle School

Findings of the investigation at Libby Middle School for the inspection of visible vermiculite products, soil sample collection, and air sample collection are described below:

- Vermiculite was observed in two locations in the Yellow Wing of the school. One piece of vermiculite was identified underneath a sink and subsequently disposed of as investigation-derived waste (IDW). A potential source for the material could not be identified. Vermiculite was also identified in a plastic planter pot in one of the classrooms.

- An outdoor inspection for vermiculite was performed in areas of new construction (e.g., water line installation) and during a scheduled excavation to repair a sprinkler on the football field. Soil samples were not collected due to the limited size of the areas and observation of only one flake of vermiculite.
- A total of four surface soil samples were collected from the playground areas, the amphitheater, and a recently excavated area where vermiculite was observed during the June 2008 inspection. The EPA was contacted by a resident who identified vermiculite within the playground east of the school that was not part of the initial inspection. LA was not detected in any of the four samples analyzed by PLM-VE. LA was not detected in one sample by PLM-Grav. Vermiculite was observed in all four surface soil samples based on a quantitative assessment.
- A total of 10 indoor stationary air samples were collected. Total and PCME LA were detected at a frequency of 10% with a concentration of 0.00051 s/cc by TEM analysis.

3.16.4 Libby High School

Findings of the investigation at Libby High School for the inspection of visible vermiculite products and air sample collection are described below:

- Vermiculite was observed beneath the wood floors in the two greenhouses, in several plastic flowerpots, and two flakes were observed in outside soils at the northeast corner of the building.
- A total of 11 indoor stationary air samples were collected. Total and PCME LA were not detected in any of the samples by TEM analysis.

3.16.5 Libby School District Administration Building

Findings of the investigation at Libby School District Administration Building for the inspection of visible vermiculite products and air sample collection are described below:

- Vermiculite was not observed in the interior or the exterior of the building. However, VCBM was identified in the form of wall plaster located in the second floor storage room. The plaster was in good condition and not friable.
- A total of 10 indoor stationary air samples were collected. Total and PCME LA were not detected in any of the samples by TEM analysis.

3.17 School Activity-Based Sampling

In August and September of 2009, ABS was conducted at the five current public school buildings in Libby. ABS was completed in accordance with the *Final Sampling and Analysis for Activity-Based Outdoor Air Exposures at Libby Public Schools* (CDM Smith 2009c).

There are a number of schools in Libby where portions of the grounds are known to have been contaminated with vermiculite or other LA-containing mine waste. Much of this outdoor contamination had been removed before the initiation of the school ABS investigation. ABS data was collected to evaluate whether the removals that had been performed were sufficient to provide adequate health protection to students and staff at the schools. The goal of the investigation was to collect sufficient data to allow a reliable evaluation of the potential health risks to students and maintenance staff that may be exposed to LA while engaged in a range of normal outdoor activities that occur on the school grounds.

Outdoor air samples were collected using ABS scenarios that simulated either student activities at the schools or outdoor maintenance work performed by the maintenance staff. Areas selected for characterizing student exposures focused on locations used for outdoor play or sports activities, while maintenance workers were assumed to be exposed over most of the school grounds. Standardized activities considered to be examples of typical disturbances based on interviews with the school administrators included:

- Students playing soccer, football, baseball, and Frisbee®
- Students swinging on a swing set
- Students walking/running over various ground materials (i.e., playground, field, sand)
- Maintenance workers digging, raking, and mowing various ground materials (e.g., playground, field, sand), and sweeping hard surfaces
- Maintenance workers power sweeping parking lots

Composite soil samples were collected from each scenario area that was not covered by asphalt, concrete, or gravel. Additionally, samples representing scenario areas that span the entire school were collected such that they did not include the smaller scenario areas previously sampled (i.e. a school-wide soil sample did not contain the same composite point locations as the soil sample collected from the soccer field).

Sample results for each media type are presented in Table 3-36 for outdoor ABS air and soil respectively. Results for each media type are summarized below in brief for each school. Supplemental analyses were conducted for a sub-set of samples to achieve a lower sensitivity. The results in Table 3-36 contain these results.

3.17.1 Kootenai Valley Head Start

- A total of six student and six maintenance worker outdoor ABS air samples were collected at Kootenai Valley Head Start as part of the public schools ABS investigation. For student ABS, total LA and PCME LA were not detected by TEM analysis. For maintenance worker ABS, total LA was detected at a frequency of 33% ranging in concentrations from 0.000076 s/cc to 0.0022 s/cc. PCME LA was detected at a frequency of 17% with a concentration of 0.0022 s/cc.
- A total of eight surface soil samples were collected at Kootenai Valley Head Start. LA was detected at a frequency of 78% for eight samples (nine analyses) at a concentration of trace by PLM-VE. LA was not detected in four samples by PLM-Grav. Vermiculite was observed in one sample based on a quantitative assessment. Vermiculite was not observed in seven samples based on a qualitative assessment.

3.17.2 Libby Elementary School

- A total of nine student and six maintenance outdoor worker ABS air samples were collected at the Libby Elementary School. For student ABS, total LA was detected at a frequency of 22% ranging in concentrations from 0.021 s/cc to 0.039 s/cc by TEM analysis. PCME LA was detected at a frequency of 22% ranging in concentrations from 0.0030 s/cc to 0.039 s/cc by TEM analysis. For maintenance worker ABS, total LA and PCME LA were not detected in any of the samples by TEM analysis.

- A total of nine surface soil samples were collected at the Libby Elementary School. LA was detected at a frequency of 50% for nine samples (10 analyses) with a concentration of trace by PLM-VE. LA was not detected in six samples by PLM-Grav. Vermiculite was observed in two samples based on a quantitative assessment. Vermiculite was not observed in seven samples based on a qualitative assessment.

3.17.3 Libby Middle School

- A total of six student and six maintenance worker ABS air samples were collected at the Libby Middle School. For student ABS, total LA was detected at a frequency of 33% ranging in concentrations from 0.011 s/cc to 0.039 s/cc by TEM analysis. PCME LA was detected at a frequency of 33% ranging in concentrations from 0.011 s/cc to 0.020 s/cc by TEM analysis. For maintenance worker ABS, total LA was detected at a frequency of 17% with a concentration of 0.0028 s/cc by TEM analysis. PCME LA was not detected in any of the samples by TEM analysis.

- A total of 10 surface soil samples were collected at Libby Middle School. LA was detected at a frequency of 64% for 10 samples (11 analyses) at a concentration of trace by PLM-VE. LA was not detected in seven samples by PLM-Grav. Vermiculite was not observed in any of the samples based on a qualitative assessment.

3.17.4 Libby High School

- A total of six student and seven maintenance worker ABS air samples were collected at the Libby High School. For student ABS, total LA and PCME LA were detected at a frequency of 17% with a concentration of 0.0025 s/cc by TEM analysis. For maintenance worker ABS, total LA and PCME LA were not detected in any of the samples by TEM analysis.

- A total of nine soil samples were collected at Libby High School. LA was detected at a frequency of 90% in nine samples (10 analyses) at a concentration of trace by PLM-VE. LA was not detected in three samples by PLM-Grav. Vermiculite was observed in two samples based on a quantitative assessment. Vermiculite was not observed in seven samples based on a qualitative assessment.

- A total of three maintenance worker ABS air samples were collected from the Libby Public Schools Admin Building and Libby High School as part of the power sweeping ABS scenario. Total LA and PCME were not detected in any of the samples by TEM analysis.

3.17.5 Libby School District Administration Building

- A total of three student and six maintenance worker ABS air samples were collected at the Libby Public Schools Administration Building. For student ABS, total and PCME LA were not detected in any of the samples by TEM analysis. For maintenance worker ABS, total LA was detected at a frequency of 17% with a concentration of 0.00042 s/cc. PCME LA was detected at a frequency of 17% with a concentration of 0.00014 s/cc.

- A total of eight surface soil samples were collected at the Libby Public Schools Administration Building. LA was detected at a frequency of 67% for eight samples (nine analyses) at a concentration of trace by PLM-VE. No PLM-Grav analyses were performed. Vermiculite was observed in one sample based on a quantitative assessment. Vermiculite was not observed in seven samples based on a qualitative assessment.

- As noted in Section 3.17.5, a total of three maintenance worker ABS air samples were collected from the Libby Public Schools Admin Building and Libby High School as part of the power sweeping ABS scenario. Total LA and PCME LA were not detected in any of the samples by TEM analysis.

3.18 Limited-Use Area Activity-Based Sampling

Previous outdoor ABS efforts collected at residential properties have focused on common-use areas (CUAs), such as yards, and specific-use areas (SUAs), such as driveways, gardens, and flowerbeds. However, no outdoor ABS data had been collected from limited-use areas (LUAs). LUAs include portions of a property that are accessed, utilized, and maintained on a limited basis (e.g. pastures, maintained/mowed fields). Thus, the purpose of this sampling scenario was to collect outdoor ABS air data from LUAs at a property. Detailed information on this sampling investigation, including data quality objectives (DQOs) and study designs, are provided in the governing SAP, *2011 Miscellaneous Activity-Based Sampling SAP* (CDM Smith 2012d).

Ten ABS areas were selected for evaluation from seven residential properties (for three properties, two different LUAs were evaluated). Five ABS areas were selected from each of the following categories (based on previously collected soil samples for the LUA):

- Category 1: PLM-VE Bin A (non-detect) and visible vermiculite is not present (Vis-); a removal may or may not have taken place in the LUA.
- Category 2: PLM-VE Bin B1 (<0.2% LA) or greater reported and/or visible vermiculite is present (Vis+); a removal may or may not have taken place in the LUA.

A total of three sampling events were performed at each ABS area in the late summer of 2011. Two actors rode all-terrain vehicles (ATVs) for a duration of one hour. Rider engaged in activities for 30 minutes that were representative of riding in a single-file line (i.e., one rider leading, one rider following), with the leader/follower switching positions after 15 minutes. Riders rode separately for the remaining 30 minutes and covered as much of the LUA as possible. During each event, one surficial 30-point composite soil sample was collected to be representative of the entire LUA.

The results of this investigation are summarized in the *Data Summary Report: 2011 Residential Activity-Based Sampling* (EPA 2013c) and can also be found in Table 3-37. Refer to Appendix A for additional information on individual sample details and analytical results. Results are summarized below in brief.

- A total of 30 outdoor personal air samples were collected from LUAs at Category 1 properties in 2011. PCME LA was detected at a frequency of 37% ranging in concentrations from 0.0017 to 0.016 s/ cc by TEM analysis.
- A total of 30 outdoor personal air samples were collected from LUAs at Category 2 properties in 2011. PCME LA was detected at a frequency of 37% ranging in concentrations from 0.0017 s/cc to 0.017 s/ cc by TEM analysis.
- A total of 16 surface soil samples were collected from LUAs at Category 1 properties. LA was detected at a frequency of 13% with trace concentrations by PLM-VE analysis. Vermiculite was not observed in any sample based on a quantitative assessment.

- A total of 16 surface soil samples were collected from LUAs at Category 2 properties. LA was detected at a frequency of 44% with trace concentrations by PLM-VE analysis. Vermiculite was not observed in any sample based on a quantitative assessment.

In conclusion, both Category 1 and Category 2 soils had LA detected at trace levels, with a higher frequency of LA detected in Category 2 soils. Because samples from Category 1 areas were historically non-detect, this demonstrates the variability that can be observed in sampling of LUAs. In addition, when ABS air concentrations are grouped according to soil condition (non-detect versus trace by PLM-VE), average ABS air concentrations are generally similar. The average ABS air concentration for LUA areas that were non-detect was 0.0028 PCME LA s/cc whereas the average ABS air concentration for LUA areas that were trace was 0.0033 PCME LA s/cc.

3.19 Woodchip Activity-Based Sampling

Wood chips from OU5 have been used as landscape mulch at residential properties in OU4. In October 2007, 100 bulk samples were collected from wood chip piles. A subset of these samples (20) were analyzed for LA using a qualitative analysis method in accordance with site-specific SOP EPA-LIBBY-10. Results showed that LA was present in 5 of 20 wood chip samples (CDM Smith 2008e). However, results based on this qualitative analysis method do not provide information on whether or not disturbance of wood chips under typical residential disturbance scenarios would result in unacceptable inhalation exposure. Therefore, data was needed to provide information on LA concentrations in air resulting from disturbances of wood chip materials derived from the OU5 wood chip piles.

Thus, the purpose of this sampling scenario was to collect outdoor ABS air data during disturbances of wood chip materials. Detailed information on this sampling investigation, including DQOs and study designs, are provided in the governing SAP, *2011 Miscellaneous Activity-Based Sampling SAP* (CDM Smith 2012d).

There are two wood chip piles located at OU5. LA levels within the wood chip piles are likely to vary spatially. Because it was not known how variable LA levels were within each pile, wood chip materials were obtained from five sub-locations which spanned a range of depths within each pile. At each sub-location, enough wood chip material was obtained such that a 100 ft^2 area could be covered to a depth of six inches.

Three ABS sampling events took place over each sub-location. Prior to each ABS sampling event over the wood chip sub-locations, a single 30-point composite wood chip sample was collected. The amount of visible vermiculite at each sampling point was also recorded.

A data summary report on the results of the wood chip ABS investigation has not been completed. The results of this investigation can be found in Table 3-38. Refer to Appendix A for additional information on individual sample details and analytical results. Results are summarized below in brief.

- A total of 15 wood chip ABS air samples were collected during the wood chip ABS investigation activities. PCME LA was not detected in any of the samples by TEM analysis.
- A total of 17 wood chip samples were collected during the wood chip ABS investigation activities. Total LA was detected at a frequency of 6% with a concentration of 230,000 s/g by TEM analysis.

In conclusion, although low levels of LA were present in the wood chips, PCME LA was not detected in any ABS air samples when wood chip material was disturbed.

3.20 Background and Borrow Source Activity-Based Sampling

Background and borrow source ABS was completed in accordance with the *Sampling and Analysis Plan 2011 Miscellaneous Activity-Based Sampling, Revision 2* (CDM Smith 2012d). ABS activities and field sampling were completed in September 2011. This section summarizes the data and results collected during the background and borrow source ABS investigation.

3.20.1 Background Soil ABS Investigation

The September 2011 background soil investigation was performed in 11 areas (A-K; see Figure 3-11). This investigation included the collection of ABS air samples during activities simulating a child digging and playing in the dirt (CDM Smith 2012d). Three digging ABS events were performed for each background area. An aliquot of collected soil was prepared by FBAS, using the rock flour preparation technique, and analyzed by TEM ISO. The background areas were selected using the following criteria:

- Locations were to be on County, State or Federal land to facilitate access
- Locations were to be in the Kootenai Valley at an elevation that was not higher than the maximum level of the historic glacial lake level (i.e., 2,450 feet above mean sea level)[Langer et al., 2010]
- Locations were to be situated in an upwind or crosswind direction relative to the mine and/or known processing areas (e.g., former Export Plant)
- There was to be no evidence of historic or recent anthropogenic activities (in the past 50-100 years) that would have resulted in substantial disturbance or mixing of soil
- Locations were not to be within about 100 meters of any known or suspected local vermiculite emission sources (e.g., railroads, highways, vermiculite processing areas)

3.20.2 Borrow Soil ABS Investigation

In September 2011, the EPA conducted an investigation (CDM Smith 2012d) to provide information on LA concentrations in soils from topsoil borrow sources that have been used as fill material at Libby.

This investigation evaluated multiple topsoil borrow sources located throughout the Kootenai Valley, including the Boothman Pit, the Fink Pit, the Feller Pit, and the Noble Ranch House Pit #1 outside of Libby. Figure 3-11 shows the location of the topsoil borrow source areas that were evaluated in this investigation. This investigation included the collection of ABS air samples during activities simulating a child digging and playing in the dirt (CDM Smith 2012d). An aliquot of collected soil was prepared by FBAS, using the rock flour preparation technique, and analyzed by TEM ISO. During the FBAS preparation, three replicate filters were prepared for each soil sample and analyzed by three different laboratories.

3.20.3 Results

The results of this investigation are summarized in the *Background Soil Summary Report* (EPA 2013e) and can also be found in Table 3-39. Refer to Appendix A for additional information on individual sample details and analytical results. Results are summarized below in brief.

Background Soil

- A total of 33 ABS air samples were collected during background soil investigation activities. PCME LA was detected at a frequency of 21% ranging in concentrations from 0.00044 s/cc to 0.048 s/cc by TEM analysis.
- A total of 35 soil samples were collected during background soil investigation activities. Total LA was detected at a frequency of 97% ranging in concentrations from 62,000 s/g to 4,600,000 s/g following FBAS preparation and TEM analysis. Vermiculite was not observed in any sample based on a quantitative assessment.

Borrow Soil

- A total of 12 ABS air samples were collected during borrow source soil investigation activities. PCME LA was detected at a frequency of 33% ranging in concentrations from 0.000096 s/cc to 0.00020 s/cc by TEM analysis.
- A total of 13 soil samples were collected during borrow source soil investigation activities. Total LA was detected in all samples ranging in concentrations from 31,000 s/g to 1,300,000 s/g following FBAS preparation and TEM analysis. Vermiculite was not observed in any sample based on a quantitative assessment.

These results support the conclusion there is a non-zero level of LA in soils within the Kootenai Valley that does not appear to be attributable to vermiculite mining and processing activities at the Libby Site. In addition, when these low levels of LA (estimated to be less than about 0.02% by mass) found in background and borrow soil are disturbed during ABS activities, LA may be released into the air.

3.21 Nature and Extent of LA in Tree Bark and Duff from the Forest

Previous investigations conducted at the Libby Site have demonstrated that LA is present in environmental source media (e.g., soil, tree bark, duff material) at locations in and around the mine. Sampling of soil, tree bark, and duff in the forested areas surrounding the mine occurred as part of the *Phase I Sampling and Analysis Plan for Operable Unit 3* (EPA 2007e). Results of this sampling revealed that LA contamination extends well beyond areas that were historically actively mined (EPA 2013f). Because LA contamination has been demonstrated to extend beyond areas where mining operations took place, the extent of LA contamination in the Kootenai Valley is unknown.

In 2012, the EPA conducted an investigation to characterize the nature and extent of LA contamination in the forested areas surrounding the Libby Site (EPA 2012d). The purpose of the investigation was to collect data on LA contamination in tree bark and forest duff that can be used to evaluate the nature and extent of LA levels in the forested areas surrounding the Libby Site. Detailed information on this sampling investigation, including investigation-specific DQOs are provided in the governing SAP/QAPP, *Nature and Extent of LA Contamination in the Forest* (EPA 2012d).

A total of 51 locations were sampled from within a two-mile buffer extending beyond the NPL boundary located east of Kootenai Falls (Figure 3-12). Sampling locations were placed in areas accessible via United States Forest Service (USFS) roads with adequate tree cover. To the extent possible, the precise sampling locations were placed in open areas that were not likely to have been substantially shielded from airborne deposition of asbestos by local features.

Tree bark and duff samples were collected from October 8 to 18, 2012. For each of the 51 locations, sampling began with the collection of one tree bark composite sample (comprised of individual cores from three different trees). Following bark collection, one duff composite sample was collected, collecting duff materials near each of the three trees sampled for tree bark.

The results of this investigation are summarized in the *Data Summary Report: Nature and Extent of LA Contamination in the Forest* (EPA 2013g) and can also be found in Table 3-40. Refer to Appendix A for additional information on individual sample details and analytical results. Results are summarized below in brief.

- A total of 54 tree bark samples were collected during the nature and extent of LA contamination in the forest investigation activities. Total LA was detected at a frequency of 44% ranging in concentrations from 0.0045 to 2.4 million structures per centimeter squared (Ms/cm^2) by TEM analysis.
- A total of 54 duff samples were collected during the nature and extent of LA contamination in the forest investigation activities. Total LA was detected at a frequency of 39% ranging in concentrations from 0.25 to 20 million structures per gram (Ms/g) by TEM analysis.

LA was detected in tree bark as far as 13.8 miles from the mine, but there were no apparent spatial trends noted (i.e., locations in the downwind direction of the mine did not have concentrations that were different from locations in the upwind or crosswind direction). LA was detected in duff as far as 16.9 miles from the mine. Similar to tree bark, there were no apparent spatial trends in the data; however, it is notable that three of the four duff samples with the highest concentrations of LA were in the downwind direction from the mine.

3.22 Nature and Extent of LA in Surface Water and Sediment

The nature and extent of LA in surface water and sediments investigation sampling was completed in accordance with the *Nature and Extent of LA Contamination in Surface Water and Sediment Sampling and Analysis Plan/Quality Assurance Project Plan* (EPA 2012e). Although extensive surface water and sediment sampling has been conducted in the Rainy Creek watershed as part of the remedial investigation sampling programs for OU3, data for the Kootenai River and its tributaries were limited or absent. Thus, surface water and sediment data were collected in the spring and fall of 2012 to characterize the nature and extent of potential LA contamination in surface water and sediment and outside of the Rainy Creek watershed.

During this investigation, surface water and sediment samples were collected from the Kootenai River and major tributaries to the Kootenai River (Figure 3-13). Because other surface water investigations have shown that LA concentrations are dependent upon flow conditions, this investigation was separated into two sampling efforts to ensure collected surface water data are representative of both high flow (spring) and low flow (fall) conditions. Sediment samples were collected during low flow conditions.

The results of this investigation are summarized in the *Data Summary Report: Nature and Extent of LA Contamination in Surface Water and Sediment* (EPA 2013h) and can also be found in Table 3-41. Refer to Appendix A for additional information on individual sample details and analytical results. Results for samples collected near Libby are summarized below in brief. Results for Kootenai River sampling locations near Troy are not summarized below.

- A total of 15 water samples were collected during high flow conditions. Total LA was detected at a frequency of 20% ranging in concentrations from 0.049 million fibers per liter (MFL) to 0.10 MFL by TEM analysis. LA structures >10 µm were detected at a frequency of 13% ranging in concentrations from 0.049 MFL to 0.050 MFL by TEM analysis.
- A total of 16 water samples were collected during low flow conditions. Total LA was detected at a frequency of 6% at a concentration of 0.022 MFL by TEM analysis. LA structures >10 µm were not detected by TEM analysis.
- A total of 22 sediment samples were collected during the nature and extent of LA in surface water and sediments investigation activities. LA was detected at a frequency of 59% ranging in concentrations from trace to <1% by PLM-VE. LA was not detected in 12 samples by PLM-Grav. Vermiculite was observed in 11 sediment samples based on a quantitative assessment. Vermiculite not was observed in 11 sediment samples based on a quantitative assessment.

Based on the results available, it was not possible to draw any firm conclusions about potential spatial or temporal patterns for surface water or sediment (EPA 2013h). However, it was noted that LA was detected in sediments from the Kootenai River several miles downstream from the confluence with Rainy Creek.

3.23 Tradesperson Activity-Based Sampling

A re-analysis of selected ERS worker air samples was completed in accordance with Scenario 4 of the *Sampling and Analysis Plan 2011 Miscellaneous Activity-Based Sampling* (CDM Smith 2012d). The goal of this investigation was to evaluate potential exposures of local tradespeople to LA in air as a consequence of indoor disturbance activities in Libby. Rather than collect new ABS air samples, a subset of personal air H&S monitoring samples previously collected as part of various response action activities by ERS staff were selected for re-analysis by TEM. The H&S samples were selected to support estimates of long-term exposure and to represent a range of potential indoor disturbance activities. The re-analysis was performed in August and September 2012. This section summarizes the data and results collected during the tradesperson indoor air investigation.

The results of this investigation are summarized in the *Data Summary Report: Tradesperson Indoor Air Re-analysis Results* (EPA 2013i) and can also be found in Table 3-42. Refer to Appendix A for additional information on individual sample details and analytical results. Results are summarized below in brief.

- A total of four H&S air samples collected during bulk removal activities were analyzed during the tradesperson re-analysis study. PCME LA was detected in all samples ranging in concentrations from 0.00099 s/cc to 0.52 s/cc by TEM analysis.
- A total of four H&S air samples collected during demolition activities were analyzed during the tradesperson re-analysis study. PCME LA was detected in all samples ranging in concentrations from 0.00013 s/cc to 0.071 s/cc by TEM analysis.

- A total of five H&S air samples collected during attic detailing activities were analyzed during the tradesperson re-analysis study. PCME LA was detected in all samples ranging in concentrations from 0.00014 s/cc to 0.12 s/cc by TEM analysis.
- A total of four H&S air samples collected during wet wipe/HEPA vacuuming in living spaces were analyzed during the tradesperson re-analysis study. PCME LA was detected in all samples ranging in concentrations from 0.00070 s/cc to 0.076 s/cc by TEM analysis.

Of the disturbance activities performed, those that involved the bulk removal of insulation tended to result in higher airborne concentrations of LA. One possible explanation for this is that workers performing bulk removal activities come into direct contact with ACM (e.g., insulation) during disposal activities. A second explanation is that bulk removal activities frequently take place in attics where air space is confined, therefore increasing the potential for exposure to airborne fibers. Wall demolition activities also have a high probability of exposure to LA due to the generation of airborne particles from asbestos-containing insulation, dry wall, and other ACM.

Attic detailing and wet wiping/high efficiency particulate air (HEPA) vacuuming of living space are activities that are performed after the removal of the majority of ACM from the interior of a home is completed, and are performed prior to clearance sampling. The dataset indicates that, although these activities have a lower intensity of source disturbance, there is still a potential for exposure to LA and other types of asbestos fibers.

3.24 Woodstove Ash Activity-Based Sampling

Woodstove ash ABS was completed in accordance with the *Sampling and Analysis Plan/Quality Assurance Project Plan: Wood-Burning Stove Ash Removal Activity-Based Sampling* (EPA 2012f). The goal of this investigation was to evaluate potential exposures to individuals from exposure to LA in air as a consequence of ash removal from a wood-burning stove. The basic tasks performed as part of this investigation included the burning of locally-collected wood in a wood-burning stove and collecting personal air samples under an ABS sampling scenario that emulated a person emptying the ash from the stove. Wood was gathered from two deadwood trees from each of the following three locations (Figure 3-14):

- OU3 – “Near” location in the vicinity of the mine, located in an area with high LA levels measured in duff and tree bark.
- Flower Creek – “Intermediate” location in the vicinity of Flower Creek.
- Bear Creek – “Far” location a few miles south of Flower Creek.

Tree bark and ash samples were collected prior to the stove-emptying activity to provide information on LA concentrations in source materials. Perimeter stationary air monitoring was also conducted during the wood burning and stove-emptying events to ensure that ABS activities did not result in releases to air outside of the ABS area. ABS activities and field sampling were completed in November 2012. This section summarizes the data and results collected during the woodstove ash ABS investigation.

The results of this investigation are summarized in the *Data Summary Report: Wood-burning Stove Ash Removal* (EPA 2013j) and can also be found in Table 3-43. Refer to Appendix A for additional information on individual sample details and analytical results. Results are summarized below in brief.

ABS Air

- A total of three ABS air samples representative of Bear Creek were collected during the woodstove ash ABS investigation. PCME LA was detected at a frequency of 33% at a concentration of 0.022 s/cc by TEM analysis.
- A total of three ABS air samples representative of Flower Creek were collected during the woodstove ash ABS investigation. PCME LA was detected in all samples ranging in concentrations from 0.0057 s/cc to 0.044 s/cc by TEM analysis.
- A total of three ABS air samples representative of OU3 were collected during the woodstove ash ABS investigation. PCME LA was detected in all samples ranging in concentrations from 0.04 s/cc to 0.84 s/cc by TEM analysis.

Stationary Air

- A total of three stationary air samples collected for 2-day perimeter monitoring were analyzed during the woodstove ash ABS investigation. LA was not detected in any sample by TEM analysis.
- A total of three stationary air samples collected for 6-hour perimeter monitoring were analyzed during the woodstove ash ABS investigation. LA was not detected in any sample by TEM analysis.

Ash

- A total of three ash samples representative of Bear Creek were analyzed during the woodstove ash ABS investigation. Total LA was detected at a frequency of 67% ranging in concentrations from 2.0 Ms/g to 3.3 Ms/g by TEM analysis.
- A total of three ash samples representative of Flower Creek were analyzed during the woodstove ash ABS investigation. Total LA was detected at a frequency of 33% at concentration of 2.0 Ms/g by TEM analysis.
- A total of three ash samples representative of OU3 were analyzed during the woodstove ash ABS investigation. Total LA was detected at a frequency of 67% ranging in concentrations from 50 Ms/g to 56 Ms/g by TEM analysis.

Tree Bark

- A total of four tree bark samples representative of Bear Creek were analyzed during the woodstove ash ABS investigation. Total LA was detected at a frequency of 50% ranging in concentrations from 0.0098 Ms/cm^2 to 0.017 Ms/cm^2 by TEM analysis.
- A total of four tree bark samples representative of Flower Creek were analyzed during the woodstove ash ABS investigation. Total LA was detected at a frequency of 50% ranging in concentrations from 0.0075 Ms/cm^2 to 0.22 Ms/cm^2 by TEM analysis.
- A total of four tree bark samples representative of OU3 were analyzed during the woodstove ash ABS investigation. Total LA was detected at a frequency of 75% ranging in concentrations from 0.50 Ms/cm^2 to 18 Ms/cm^2 by TEM analysis.

As shown, the highest PCME LA air concentrations in ABS air were during activities performed on ash generated from trees collected from OU3. Likewise, the highest tree bark surface loading levels for LA were for the trees collected from within OU3. Detectable levels of LA in ABS air, wood ash, and tree bark tended to decrease as a function of distance from the mine.

3.25 Flowerbed Sampling

The flowerbed sampling investigation was completed in accordance with the *Sampling and Analysis Plan/Quality Assurance Project Plan: Flowerbed Sampling Study* (EPA 2012g). Sampling activities were completed in September 2012. This section summarizes the data and results collected during the flowerbed ABS investigation.

The purpose of this investigation was to collect data that could be used to determine if the presence of visible vermiculite in flowerbeds is a reliable indicator of mine contamination at a property. In previous sampling activities in OU4, soil samples were not collected from flowerbeds in which visible vermiculite was observed during a GPI. This is because the presence of visible vermiculite in flowerbeds (i.e., SUA) is a primary action level for performing a soil removal at the property (EPA 2003c). However, some property owners have indicated that, in cases where visible vermiculite is present in the flowerbed, the soils in the flowerbed were derived from store-bought potting soil, which are not expected to contain LA. This suggests that the identification of visible vermiculite in a flowerbed may not be a reliable indicator of mine contamination (i.e., LA), and that some soil removals could be performed unnecessarily as a consequence of this action level.

A secondary objective of the investigation was to collect data on whether other property information (e.g., year the property was built, homeowner input on flowerbed soil source) could be used to guide decision-making on soil removals for flowerbeds.

The investigation included four tasks designed to address the objectives, however, only samples collected as part of Task 1 and Task 3 fall within the boundaries of OU4; therefore, only results from these tasks are included in this report. All soil samples were analyzed for LA by TEM ISO following preparation by FBAS. In addition, soil samples were also analyzed by the Libby-specific PLM methods.

Task 1

In Task 1, soil samples were collected from flowerbeds at residential properties within Libby where visible vermiculite was present. Criteria for property selection were designed to determine if information on the year that the property was built could be used to guide decisions on whether the presence of visible vermiculite in a flowerbed is an indicator of mine contamination. Two different types of properties were sampled as part of this task – properties built in or prior to 1995 (Category 1) and properties built after 1995 (Category 2). The cut-off date of 1995 was selected because mine operations ceased in 1990; thus, a five-year buffer is provided between when mine operations ceased and when it is likely that mine material was no longer being actively used in flowerbeds. For both categories of property, the following criteria applied:

- Property has had a detailed investigation portion of a GPI (i.e., a primary removal action level was found in a SUA)
- Visible vermiculite was observed in a flowerbed
- Property had NOT gone through a removal

Task 3

In Task 3, LA concentrations were measured in store-bought potting soil, purchased from a local hardware store in Libby, which may be used in flowerbeds following soil removal activities. Three potting soil samples were pulled from the sample archive for re-analysis by TEM. Because there were no previously collected samples of store-bought bagged vermiculite, Task 3 also included the collection of vermiculite samples from two different brands of bagged vermiculite purchased from a local hardware store in Libby.

The results of this investigation are summarized in the *Data Summary Report: Flowerbed Sampling Study* (EPA 2014d) and in Table 3-44. Refer to Appendix A for additional information on individual sample details and analytical results. Results for Task 1 and Task 3 are summarized below in brief.

- A total of six soil samples representative of properties with houses built in or before the year 1995 (Task 1, Category 1) were collected during the flowerbed investigation. Total LA was detected in all samples ranging in concentration from 58,000 s/g to 4,900,000 s/g following FBAS preparation and TEM analysis. LA was detected at a frequency of 67% in six samples at trace concentrations by PLM-VE. Vermiculite was observed in all samples based on a quantitative assessment.

- A total of five soil samples representative of properties with houses built after the year 1995 (Task 1, Category 2) were collected during the flowerbed investigation. Total LA was detected in all samples ranging in concentration from 21,000 s/g to 1,400,000 s/g following FBAS preparation and TEM analysis. LA was detected at a frequency of 40% in five samples at trace concentrations by PLM-VE. Vermiculite was observed in all samples based on a quantitative assessment.

- A total of three soil samples of store-bought Libby potting soil (Task 3) were analyzed during the flowerbed investigation. Total LA was detected at a frequency of 67% for three samples ranging in concentration from 2,600 s/g to 7,900 s/g following FBAS preparation and TEM analysis. LA was detected at a frequency of 33% for three samples at trace concentrations by PLM-VE. Vermiculite was not observed in any of the three samples based on a quantitative assessment.

- A total of two samples of store-bought vermiculite (Task 3) were analyzed during the flowerbed investigation. Total LA was detected in both samples ranging in concentration from 10,000 s/g to 28,000 s/g following FBAS preparation and TEM analysis. Tremolite/actinolite was not detected in either sample by PLM-9002.

Based on these results it was concluded that nearly every soil sample collected from flowerbeds with visible vermiculite showed detected LA in soils based FBAS preparation and TEM analysis. Thus, visible vermiculite appears to be a reliable indicator of LA presence. However, the presence of LA may not necessarily indicate that the contamination is mine-related. Additionally, it appears that neither the year the property was built nor homeowner input on the flowerbed soil source can be used as an indicator for when higher LA levels could be present in flowerbed soils.

3.26 Water Source Study

The water source study was completed in two phases in accordance with the *Water Source Identification Study – Phase I Sampling and Analysis Plan* (EPA 2011c) and the *Water Source Identification Study – Phase II Sampling and Analysis Plan/Quality Assurance Project Plan* (EPA 2012h).

The goal of this study was to identify a new source of water for use during construction activities. Phase I sampling was performed in November 2011 and Phase II sampling was performed in May 2012. Figure 3-15 shows the location of each sampling station. This section summarizes the data and results collected during the water source study.

3.26.1 Phase I (Low Flow) Study

Phase I of the water source study measured asbestos concentrations at each water source candidate location under low flow conditions. The goal was to prioritize, but not exclude, potential water sources. If detectable levels of asbestos were present in some water sources and not others, those sources with detectable levels would be placed lower on the prioritized list of potential sources. Surface water samples were collected at each of the following locations[11] as part of the Phase I sampling program:

1. Libby Creek, upstream of the OU5 fire pond (SP-145700) - sampling point southeast (upstream) of the flume that feeds the OU5 fire pond.
2. Libby Creek, south of the Libby airport (SP-145702) – sampling point northeast of the Hammer Cutoff Road bridge.
3. Pipe Creek, Kootenai River Road (SP–15707) - sampling point on the west side (upstream) of the Kootenai River Road bridge near the standpipe.
4. Pipe Creek, Bobtail Cutoff Road (SP-145709) – sampling point southeast (upstream) of the Bobtail Cutoff Road bridge.
5. Cedar Creek (SP-145706) – sampling point on the west side (upstream) of the US Highway 2 bridge near the standpipe.
6. Cherry Creek (SP-145703) – sampling point downstream of the Granite Creek Road bridge.
7. Kootenai River, upstream of the confluence with Rainy Creek (SP-145711) – sampling point from pump house at the OU2/Flyway property.
8. Granite Creek (SP-145701) – sampling point on the west side of US Highway 2 bridge southwest side of creek.
9. Flower Creek (SP-145704) – sampling point on the west side (upstream) of the Balsam Street bridge on the west side of the creek.
10. Parmenter Creek (SP-145705) – sampling point at the northwest corner of the Dome Mountain Avenue bridge.
11. Quartz Creek (SP-145708) – sampling point upstream of the Kootenai River Road bridge.
12. J. Neils Park (SP-145710) – sampling point at the well vault standpipe in the southeast corner of the soccer fields on County Park Road.

[11] Location #1 in the SAP (i.e., city pump near Cabinet View Country Club) could not be sampled, because the existing pump in the pump house was found to be non-functional, thus this location was excluded from further evaluation.

Sample results for water collected as part of Phase I are presented in Table 3-45 and discussed in more detail below.

3.26.2 Phase II (High Flow) Study

Phase II of the water source study measured asbestos concentrations at each water source candidate location under high flow conditions. Locations #3, #7, #10, and #11 were too far from response activities planned for 2012 and were excluded from further evaluation. For the Phase II study, site managers identified the following additional water source candidates in Troy:

1. Troy county shop hydrant (potable city water)
2. Hydrant located at the corner of West Riverside Avenue across from Roosevelt Park (non-potable water source)
3. During the sampling event, the following opportunistic sampling location was added:
4. 875 US Highway 2 de-watering pump (OU5)

Sample results for water samples collected as part of Phase II are presented in Table 3-45 and discussed in more detail below.

3.26.3 Results

The results of this investigation are summarized in the *Data Summary Report: Water Source Identification Study* (EPA 2013k) and can also be found in Table 3-45. Refer to Appendix A for additional information on individual sample details and analytical results. LA results for water are presented as total LA concentrations and LA concentrations for structures longer than 10 µm, which is the reporting metric for the purposes of comparison to the drinking water maximum contaminant level (MCL) for asbestos. Results are summarized below in brief.

Phase I (low flow):

- A total of 78 water samples were analyzed during the Phase I water source study. LA was not detected in any of the samples by TEM analysis.
- Only one sample, Location # 8 (from the Kootenai River adjacent to KDC flyway pump house), had a detection of asbestos, and it was identified as being chrysotile.

Phase II (high flow):

- A total of 72 water samples were analyzed during the Phase II water source study. LA was detected at a frequency of 35% ranging in concentrations from 0.0092 MFL to 1.0 MFL by TEM analysis for total LA, and at a frequency of 4% ranging in concentrations from 0.013 MFL to 0.043 MFL for LA structures > 10 µm in length.

These results were provided to decision makers to assist in their selection of alternate water sources for use in future removals.

3.27 Comparative Exposure Activity-Based Sampling

Comparative exposure ABS was completed in accordance with the *Sampling and Analysis Plan/Quality Assurance Project Plan: Comparative Exposure – Eureka, Helena, Whitefish* (EPA 2012i). ABS activities and field sampling were completed in August 2012. This section summarizes the data and results collected during the comparative exposure ABS investigation.

The purpose of the investigation was to collect data on LA concentrations in a variety of media from cities outside of the Kootenai Valley that were not expected to be affected by the Libby vermiculite mine in order to provide a frame of reference for comparisons to exposures in Libby. The primary investigation objective was to measure LA concentrations in outdoor ABS air and other environmental source media (e.g., soil, tree bark, duff material) that could be used as a comparison to levels measured in Libby.

Three cities outside of the Kootenai Valley were selected for evaluation – Eureka, Helena, and Whitefish, Montana. An additional location south of Libby near Flower Creek that had potential to be affected by the Libby vermiculite mine was also included in the investigation. At each sampling location, tree bark, duff material, soil composite samples, and two types of ABS air samples (one simulating a child digging and the other simulating of a firefighter digging a fireline by hand), were collected.

Because the Eureka, Helena and Whitefish locations fall outside the boundaries of OU4, only results from Flower Creek are included in this report. The results of this investigation for all locations are summarized in the *Data Summary Report: Comparative Exposure Study* (EPA 2013l). Refer to Appendix A for additional information on individual sample details and analytical results. Results are summarized below in brief:

- One child digging and two fireline digging ABS air sample were collected from Flower Creek during the comparative exposure ABS investigation. PCME LA was not detected in any ABS samples by TEM analysis.
- One tree bark sample and one duff sample was collected from Flower Creek during the comparative exposure ABS investigation. Total LA was detected in both samples with a concentration of 0.063 Ms/cm^2 for tree bark and 2.7 Ms/g for duff by TEM analysis.
- One soil sample from Flower Creek was prepared by the FBAS method prior to analysis by TEM. Total LA was detected in this sample with a concentration of 310,000 s/g. Vermiculite was not observed in the soil sample based on a quantitative assessment.

Although LA was detected in tree bark, duff, and soils from Flower Creek area, LA was not detected in ABS air during disturbances of these potential source materials. Soil concentrations of LA from Flower Creek were about 10 times higher than soils from cities outside the Kootenai Valley (i.e., Eureka, Helena, and Whitefish).

3.28 Tissue Assessment

Although the exposure pathway of primary concern for humans is inhalation of LA, some studies in animals suggest that ingestion of asbestos fibers in water can result in the growth of benign intestinal polyps (National Toxicology Program [NTP] 1985).

In 2012, the EPA conducted an investigation, to determine LA tissue burdens in fish and large game collected from the Libby Site (EPA 2012j). The purpose of the investigation was to collect data on tissue burdens in large game (deer) and fish that could be used to evaluate two potential human ingestion exposure scenarios:

- **Ingestion of Game:** One exposure scenario is the ingestion of edible tissue from hunted game that forages at the Libby Site. Large game, including deer and elk, have been observed at the Libby Site and may be exposed to LA in a variety of potential exposure media. It is possible that these animals may have accumulated LA in their tissues as a result of these exposures.
- **Ingestion of Fish:** Another exposure scenario is the ingestion of LA in edible fish tissue (fillets) from fish caught from local streams and ponds that contain LA.

The level of LA in game tissue is assumed to be related to the concentration of LA in various exposure media (e.g., soil, duff material) and the length of time the animal may have been exposed to these media (i.e., older game animals are likely to have higher tissue concentrations than younger animals). Studies conducted at the Libby Site have shown elevated concentrations of LA in various environmental media at the mine site and in the forested areas surrounding the mine site (i.e., OU3). To ensure that this assessment focused on the high-end of the potential range of exposure conditions, the mine site and forested areas immediately surrounding the mine site were the target sampling locations for the collection of game animals (see Figure 3-16).

The level of LA in fish tissue is assumed to be related to the concentration of LA in surface water and sediment, as well as the length of time the fish may have been exposed to these media (i.e., older fish are likely to have higher tissue concentrations than younger fish). Studies conducted at the Libby Site have shown elevated concentrations of LA in surface water and sediment in the streams and ponds on the mine site (i.e., OU3). The Mill Pond was selected as the target sampling location to ensure that fish tissues were at the high-end of the potential range of exposures due to its known high concentrations of LA and the presence of large fish.

The results of this investigation are summarized in the *Data Summary Report: Fish and Game Tissue Assessment* (EPA 2013m) and can also be found in Table 3-46. Refer to Appendix A for additional information on individual sample details and analytical results. Results are summarized below in brief:

- A total of eight fish samples were collected during the tissue assessment investigation activities. Total LA was detected in all samples ranging in concentrations from 9,400 to 6,400,000 s/g on a wet weight (ww) basis by TEM analysis.
- A total of 13 tissue samples were collected from one animal (a female mule deer) harvested from near the mine site. Inside shoulder and backstrap muscle samples were collected for assessing potential human health risks associated with the ingestion of LA in deer or elk tissue. Other target tissues were also collected to confirm exposures to asbestos including the heart, liver, lung, kidney, and diaphragm. Total LA was not detected in any of the samples by TEM analysis.
- In addition to collecting tissue samples from the deer for the purposes of quantifying LA tissue burdens, tissue samples of muscle, heart, liver, lung, pleura, trachea, diaphragm, large intestine, and kidney were also collected and fixed for examination to provide information on the location of LA fibers in game tissue and the types of specific intercellular interactions and responses to the presence of LA fibers. Total LA was not detected in any of the samples by TEM analysis.

3.29 Porewater in the Tributaries

The purpose of this investigation was to collect sediment porewater samples from locations in tributaries to the Kootenai River in order to compare LA concentrations to effect levels for trout (eggs, alevins) established in a site-specific toxicity studies in support of the ecological risk assessment. The measured porewater LA concentrations are also used to characterize the nature and extent of LA in tributary porewater.

Sampling locations for sediment porewater collection were the same tributary locations as sampled during the *2012 Nature and Extent Study in Surface Water and Sediment* (EPA 2012e; 2013h) as presented in Section 3.22, with the addition of three locations (two in O'Brien Creek and one in the Fisher River) (see Figure 3-17). Sampling locations were added in O'Brien Creek because this tributary is a critical habitat for the bull trout. Although Fisher River was sampled in the 2012 Nature and Extent Study, an additional sampling location was added further upstream for this investigation because the headwaters were thought to be more representative of potential trout spawning habitat. Because these three new sampling locations were not sampled for surface water and sediment, these media were collected to provide additional data to support the characterization of the extent of LA in the sediments and surface water.

This investigation was completed in accordance with the *Sampling and Analysis Plan/Quality Assurance Project Plan, Sediment Porewater Study of Kootenai River Tributaries* (EPA 2013n). Surface water, porewater and sediment samples were collected in May and June 2013. Results for these samples are summarized in Table 3-47. Refer to Appendix A for additional information on individual sample details and analytical results. Results for samples collected near Libby are summarized below in brief. Results for tributaries near Troy are not summarized below.

- A total of 15 porewater samples were collected during the investigation. Total LA was detected at a frequency of 7% in one sample with a concentration of 0.3 MFL by TEM analysis. LA structures >10 µm were not detected in any sample.
- A total of three surface water samples were collected during the investigation. LA was not detected in any of the samples by TEM analysis.
- A total of three sediment samples were collected during investigation activities. LA was detected at a frequency of 33% with trace concentrations in one sample by PLM-VE. LA was not detected in any of the samples by PLM-Grav. Vermiculite was not observed in any sample based on a quantitative assessment.

In 2013, an in-stream eyed egg investigation was performed to establish potential effect levels for trout from exposures to porewater in OU3 streams (EPA 2014e). Concentrations of LA in tributary porewater were much lower than LA concentrations measured in lower Rainy Creek during the OU3 investigation, which ranged from 8 to 70 MFL (based on total LA). Tributary porewater concentrations tended to be similar to those measured in references areas during the OU3 investigation, which ranged from 0.08 to 0.75 MFL (based on total LA). Due to the low detection frequency observed in the tributary porewater samples, no spatial trends in LA concentrations were apparent.

3.30 Removal Status

As emphasized in the previous sections, the general goal of the sampling investigations at OU4 was to provide information about the presence of LA source materials at individual properties. Based upon that information, as well as the removal action levels specified in the *Draft Final Libby Asbestos Site Residential/Commercial Action Level and Clearance Criteria Technical Memorandum* (EPA 2003c) *Amendment A to the Tech Memo* (EPA 2011d), the EPA is able to classify each property as requiring remediation, may require remediation (i.e., more information needed), or not likely requiring remediation. These classifications may change, depending upon the results of the site-wide HHRA, which will be conducted once the toxicity data for LA is finalized. In addition, the data in this RI Report will be used in the FS to evaluate remedial alternatives.

This section discusses this information, which serves as a basis for classifying properties and aids in planning when removal/remediation is required.

3.30.1 Removal Action Decision Criteria

Each property in OU4 may require removal in three general areas: the attic space, the indoor living space, and outdoors. Therefore, three decisions are required for each property to determine the need for, and extent of, removal. Generally, investigative results from each of these areas are treated separately. That is, results may trigger removal in one area (e.g., attic space), but not others.

Removal action levels were established in the *Draft Final Libby Asbestos Site Residential/Commercial Action Level and Clearance Criteria Technical Memorandum* (EPA 2003c) and *Amendment A to the Tech Memo* (EPA 2011d). Table 3-48 outlines the residential/commercial property removal action level (s) for each area through 2013. For each area, a property has to meet only one of the triggering action levels (as opposed to all) for removal to be required in that area. Again, it is important to note that removal criteria and action levels are subject to change and have been continually evaluated throughout the EPA's processes. Final action levels, and the total number of properties requiring removal, will be available after the RI/FS is completed and a ROD is published.

For those properties requiring removal actions, the EPA has adopted additional removal procedures and criteria that will that help ensure only one removal action is conducted at individual properties. For instance, soils with detectable levels of LA <1% are removed from a property if any of the removal action levels listed above are present. Additionally, in 2007, visible vermiculite in NSUAs was also identified for removal if removal was required at the property for other sources of contamination. Beginning in 2011, LUAs, unmaintained fields, or pastures, with low amounts of vermiculite or detectable levels of LA <1% were excluded from the additional removal procedures described above.

3.30.2 Property Organization and Classification

The geospatial organization for the Libby Asbestos Superfund Site is geographic removal zones (GRZs). GRZs are geographic groupings of geounits and were developed to subdivide the OU4 into strategic areas or "neighborhoods". OU4 was subdivided into 24 GRZs (designated 1-24). To the extent possible, the remaining properties within OU4 will be investigated and removals will be performed based on the GRZ approach, meaning properties within lower GRZs (e.g., GRZ 1), are expected to proceed through the removal process before properties in higher GRZs. With this approach, the EPA expects to reduce re-contamination through aerial distribution.

A geounit is cadastral-based and is considered the common spatial unit for the Libby Site. In most cases, a geounit is the same as a tax parcel or right-of-way, such as a street or waterway. The exceptions to this are:

1. Splits: Removal activity has occurred in a portion of a right-of-way necessitating that a smaller polygon be split out from the larger right-of-way polygon, resulting in a new geounit.
2. Merges: Two or more adjacent geounits are owned by the same party and the uses of the geounits are the same, resulting in the geounits being merged into one geounit.
3. Land transactions that occur unbeknownst to the Libby Asbestos Project that cause a tax parcel to be split or merged resulting in the geounits no longer matching the tax parcels.

Under the *Libby Asbestos Superfund Site Data Management Plan* (EPA 2013a), a property is a unit of space for the EPA assessment purposes and is assigned a unique identifier, known as a property ID. To accommodate legacy data, this assessment unit may or may not correspond to parcels; therefore, geounits may have one, multiple, or no associated addresses. Further, one property can be composed of one geounit, or in rare situations, can be composed of multiple geounits. In most cases, one geounit is the equivalent of one tax parcel, which is the equivalent of one property.

3.30.3 Numbers of Properties

As of October 2013, information for 6,716 OU4 properties is in Response Manager. A summary of the removal status of each of these properties is presented below:

- 1,501 total properties are categorized as **Response Action Required;** it may be either an investigation or a removal that is required. Of these properties, 1,240 require an investigation and 264 require a removal.
- 2,646 total properties are categorized as **Investigation Completed** – No Further Action (i.e., no emergency response action levels).
- 1,886 total properties are categorized as **Removal Completed** with no further action required.
- 290 total properties do not require an investigation because the property is all non-use area or otherwise does not require inspection (e.g., fill pits, entirely paved).
- 388 total properties have refused access to the property. These properties could fall into the categories listed above (they could require an investigation and/or removal or they could not require an investigation due to the property use type).

As noted above, properties are associated with a geounit and are grouped in GRZs to facilitate the removal process. For this reason, the removal status for each geounit is displayed on a separate figure for each of GRZs as shown on Figures 3-18 to Figure 3-32. Figure 3-18 includes an overview of the GRZs, while Figure 19 to Figure 32 contains a detailed view of each GRZ.

3.31 Property Inspections

The PDI program began in 2003 and was the process for characterizing properties before removal actions. The objective of the PDI program was to expand on previously collected data in order to more precisely locate and quantify the contamination at each property. PDI activities included the collection of additional soil, bulk, and/or dust samples, the inspection of attics, soil and building materials for

vermiculite, and the production of sketches, measurements, and relevant construction information. The *Exterior Inspection Checklist* (EIC) and *Supplemental Interior Inspection Checklist* (SIIC) forms were developed to standardize the property information collected during a PDI. The information and samples gathered were then used to fully characterize the property against established removal criteria. Following this process, a property-specific removal plan was created which specified the types of removal actions needed at the property.

PDI field activities were performed in accordance with the *Final Draft Pre-Design Inspection Activities Work Plan* (CDM Smith 2003h) with modifications. The inspection protocol was modified several times, with the most significant change being the switch from 5-point to 30-point composite soil samples in 2007.

In 2010, the investigation process was re-named and altered slightly. At present, investigations are collectively referred to as GPIs. GPI field activities are performed in accordance with the *General Property Investigation Sampling and Analysis Plan/Quality Assurance Project Plan* (EPA 2013o). GPI covers both the screening investigation (SI) and detailed investigation (DI) protocols. SIs and DIs are the modern equivalents of the CSS and PDI, respectively. The purpose of the SI is to identify whether an action level is triggered at a property. The purpose of the DI is to delineate contamination at the property and support removal decisions. SIs are more comprehensive than CSS inspections were and characterize all use areas at a property using 30-point composite samples. An *Interior Property Inspection Form (*IPIF) is completed for each primary or secondary building inspected as part of SI activities. An *Occupant Information Form* (OIF) is completed for each primary building on the property. DIs are very similar to post-2007 PDIs except that 5-point non-detect sample results from previous inspections may no longer be used (i.e., those areas with a 5-point non-detect result from a previous investigation must be re-sampled at DI, but did not require re-sampling at PDI). IPIFs and OIFs were developed to standardize the property information collected during a GPI. The *Exterior Property Inspection Form* (EPIF) was a standard form used during GPIs conducted in 2010-2012. The EPIF was eliminated prior to the 2013 GPI season to cut back on duplicative paperwork.

3.31.1 Soil

Land Use Area Designations

Outdoor soils are divided into land use areas for vermiculite inspection and soil sampling. In general, properties are divided into SUAs, NSUAs, and non-use areas (i.e., wooded or unmaintained areas). SUAs were defined as areas most likely to have received vermiculite products, undergo frequent or intense disturbances at the subsurface, and are not generally covered by grass. NSUAs were defined as areas with more generalized homeowner use and where it is less likely to encounter soil disturbances.

Prior to the fall 2007 field season, SUAs included flowerbeds, gardens, planters, stockpiles, and play areas. NSUAs included yards, driveways, alleys, and fields. Beginning in 2007, driveways and alleys were reclassified as SUAs after further evaluation showed the areas were likely to have received vermiculite products, undergo disturbances at the subsurface, and were generally not covered by grass, thus meeting the definition of an SUA.

Prior to Fall 2006, outdoor soils were inspected for vermiculite during soil sample collection and to generally characterize each land use area where soil samples were not collected. In October 2006, a formal and systematic approach for vermiculite inspection was implemented with CDM-LIBBY-06, *Site-specific SOP for Semi-Quantitative Visual Estimation of Vermiculite in Soil*. In general, one visual inspection point (for vermiculite) was performed per 100 ft^2 within each use area. Locations and quantities of vermiculite were documented on *Supplemental Exterior Inspection Checklists* (SEICs). In

2007, the visual vermiculite SOP was revised to require a lower inspection point density in areas with less use (e.g., LUAs such as fields and pastures). Additionally, the SEIC form was renamed to VVEF in order to increase usability of the form by other field programs.

Soil Sample Collection

Similar to the 2002 CSS field activities, from 2003 through 2006, PDI soil samples were collected in accordance with the most recent version of CDM-LIBBY-05, *Site-specific SOP for Soil Sample Collection,* in effect at that time. However, previous soil sampling efforts (Phase 1 and CSS) covered areas as large as 5,445 ft^2. In order to further delineate areas of excavation for removal actions, PDI soil samples were collected from areas no larger than 2,500 ft^2 and consisted of 5-point composite soil samples. SUAs containing vermiculite and areas with vermiculite tailings were not sampled as these areas were identified for removal.

Beginning in April 2006, SUAs containing vermiculite were sampled during the PDI, although a combination of visual vermiculite content and analytical results were used in determining their status for removal.

The following changes to soil sampling procedures have been implemented:

- April 2007 - Soil samples were not collected from SUAs where vermiculite was present as these areas were identified for removal.
- May 2007 - PDI soil sampling changed from 5-point to 30-point composite samples.
- May 2007 - Driveways were considered SUAs during property characterization, based on the similar nature and frequency of use to other SUAs.
- June 2007 - Soil samples were not collected from any areas where vermiculite was observed as these areas were identified for removal.

In total, 27,924 soil samples have been collected during PDI/GPI activities at 2,617 properties. The majority of samples collected have been 5-point or 30-point composite surface soil samples, but a limited number of grab surface samples and subsurface soil samples have also been collected in preparation for removal actions. Table 3-49 summarizes the soil sample results. Results are summarized below in brief.

- A total of 27,895 surface soil samples were collected during the PDI/GPI sampling. LA was detected at a frequency of 18% for 27,875 samples (27,965 analyses) ranging in concentrations from trace to 4% by PLM-VE. LA was detected at a frequency of 1% for 4,381 samples (4,398 analyses) ranging in concentrations from trace to 0.25% by PLM-Grav. Tremolite/actinolite was detected at a frequency of 42% for 23 samples (24 analyses) ranging in concentration from <1% to 10% by PLM-9002. Vermiculite was observed in 1,214 samples based on quantitative assessment. Vermiculite was observed in 1,235 samples based on qualitative assessment. Vermiculite was not observed in 19,419 samples based on quantitative assessment. Vermiculite was not observed in 5,470 samples based on qualitative assessment. Information on vermiculite was not available for 557 samples and therefor assumed to not be present.
- A total of 29 subsurface soil samples were collected during the PDI/GPI sampling. LA was detected at a frequency of 25% for 28 samples with concentrations ranging from trace to <1% by PLM-VE. LA was not detected in 23 samples by PLM-Grav. Tremolite/actinolite was not

detected in one sample by PLM-9002. Vermiculite was observed in six samples based on quantitative assessment .Vermiculite was observed in 11 samples based on qualitative assessment. Vermiculite was not observed in five samples based on quantitative assessment. Vermiculite was not observed in four samples based on qualitative assessment. Information on vermiculite was not available for three samples and therefore assumed to not be present.

3.31.2 Dust

Microvacuum dust samples for PDI activities were collected in accordance with ASTM D5755 with modifications as described in *Final Dust Sampling Protocol for Pre-Design Investigations* (CDM Smith 2003i), which is similar to the 2003 CSS dust sampling. Dust samples collected during the PDI were mainly collected from outbuildings on the property, but also included areas not previously characterized during the CSS (Section 2.4.2). At the request of the EPA, based on conclusions from the Dust Pilot Study (Section 3.12), PDI dust samples were no longer collected after July 2007.

Table 3-49 summarizes the dust sample results. Refer to Appendix A for additional information on individual sample details and analytical results. Results are summarized below in brief:

- A total of 3,835 indoor dust samples were collected during the PDI sampling. Total LA was detected at a frequency of 6% ranging in concentrations from 30 s/ cm^2 to 110,000 s/cm^2.

3.31.3 Bulk Materials

PDI/GPI bulk samples were generally collected from friable building materials containing or suspected of containing vermiculite and/or LA (e.g., plaster, chinking, mortar, pipe wrap). VCBM bulk samples were collected in accordance with 40 CFR Part 763.86, Appendix A – *AHERA Sampling Requirements*. This CFR sampling procedure specifies how many subsamples must be collected per homogeneous sampling area.

Table 3-49 summarizes the bulk sample results. Refer to Appendix A for additional information on individual sample details and analytical results. Results are summarized below in brief:

- A total of 192 samples of bulk building materials were collected during the PDI/GPI sampling. Tremolite/actinolite was detected at a frequency of 27% ranging from <1% to 3% by PLM-9002.

3.32 Pre-Design Inspections/General Property Inspections at Specialty Properties

The following sections describe the PDIs/GPIs performed at the same specialty properties as discussed in the investigation section. The locations of these properties are illustrated on Figure 3-1. Refer to Appendix A for additional information on individual sample details and analytical results.

Due to vermiculite being observed during previous investigation efforts, the EPA directed contractors to complete full detailed investigations to determine if immediate removal action was required. The primary objective of the investigation was to determine the extent of LA and source materials present at Libby schools (CDM Smith 2010b). In August through October 2010, EPA contractors conducted detailed investigations at five major public schools: Kootenai Valley Head Start, Libby Elementary school, Libby Middle School, Libby High School, and the Libby School District Administrative Building. Details surrounding the investigations are provided for each Libby school in their relevant section below.

The removal actions associated with these properties are summarized in Section 3.34.

3.32.1 Kootenai Valley Head Start

In September 2008, EPA contractors returned to the school to collect five grab samples from the sand pails where moderate levels of vermiculite were observed in June of that year. Analytical results for the five soil samples collected were non-detect for LA by PLM-VE. Vermiculite was observed in three of five surface soil samples based on a qualitative assessment. It was later determined that the play sand was locally purchased earlier in 2008 from a local hardware store. Refer to Appendix A for additional information on individual sample details and analytical results.

In September and October 2010, EPA contractors returned to the school again to collect additional soil samples as part of a GPI. Vermiculite was observed in a small portion of the field adjacent to one of the play areas. A total of 131 DI soil samples were collected. LA was detected at a frequency of 37% in 131 samples with trace levels of LA by PLM-VE. LA was not detected in 15 samples by PLM-Grav. Vermiculite was not observed in 117 surface soil samples based on a quantitative assessment. Information on vermiculite was not available for 14 samples.

In November 2013, one surface soil sample was collected as part of a GPI. LA was not detected in this sample by PLM-VE. Vermiculite was not observed in the soil sample based on a qualitative assessment.

3.32.2 Libby Elementary School

In 2009, the Libby Public School Board announced their intent to demolish Libby Elementary School in the spring of 2010 and construct a new facility in the same location. An indoor PDI was completed in December 2009 to locate and quantify the interior and exterior walls that were insulated with vermiculite. The inspection involved drilling and scoping each wall suspected of containing vermiculite. The holes were then sealed.

Vermiculite insulation was observed in the wall cavity of the exterior walls of the west wing (not including the library), the wall cavity of the exterior wall of Room 22A, and the wall cavity of the interior wall (shared between the library, the corridor, and Room 24). Vermiculite-containing plaster was observed as part of the walls of the gym. Vermiculite was also observed on the soil floor of the crawlspace of the west wing.

A total of three 30-point composite soil samples were collected from the main crawlspace. One of the samples collected was non-detect for LA by PLM-VE. The other two samples had trace results for LA by PLM-VE. These activities are described further in *Summary – Pre-design Investigation – Libby Elementary School (formerly Asa Wood) – 700 Idaho Avenue. February 2* (CDM Smith 2010c).

In August and September 2010, EPA contractors returned to the school again to collect additional soil samples as part of a GPI. Vermiculite was observed in one play area and several yard or field-type areas. A total of 121 DI soil samples were collected. LA was detected at a frequency of 24% with trace levels of LA by PLM-VE. LA was not detected in 21 samples by PLM-Grav. Vermiculite was not observed in 115 surface soil samples based on a quantitative assessment. Information on vermiculite was not available for six samples.

In October and December 2013, EPA contractors returned to the school again to collect additional soil samples as part of a GPI. A total of eight detailed investigation samples were collected. LA was detected at a frequency of 25% with trace levels of LA by PLM-VE. Vermiculite was observed in five

samples based on a quantitative assessment. Vermiculite was not observed in three samples based on a quantitative assessment.

3.32.3 Libby Middle School

As noted above, in an effort to expedite removals at the public schools a visual inspection of the SUAs was conducted prior to a full DI. In July 2010 several driveway/parking lots, play areas, walkways/paths, flowerbeds, and an amphitheater were inspected. Low amounts of vermiculite were observed in two of the driveway/parking lot areas and the play area during this visual inspection.

In September 2010, EPA contractors visited the school to collect soil samples as part of a GPI. A total of 265 DI soil samples were collected. LA was detected at a frequency 21% with concentration levels ranging from trace to <1% LA by PLM-VE. LA was not detected in 12 samples by PLM-Grav. Vermiculite was not observed in 244 samples based on a quantitative assessment. Information on vermiculite was not available for 21 samples.

In November 2013, EPA contractors visited the school to collect additional soil samples as part of a GPI. A total of three DI soil samples were collected. LA was not detected by PLM-VE. Vermiculite was observed in one sample based on a quantitative assessment. Vermiculite was not observed in two samples based on a quantitative assessment.

3.32.4 Libby High School

As noted above, in an effort to expedite removals at the public schools a visual inspection of the SUAs was conducted prior to a full DI. In July 2010, several driveway/parking lots, and play areas were inspected. Low amounts of vermiculite were observed in one of the driveway/parking lot areas and one play area (shot put pit) during this visual inspection.

In September 2010, EPA contractors visited the school to collect soil samples as part of a GPI. A total of 212 detailed investigation samples were collected. LA was detected at a frequency 39% with trace levels of LA by PLM-VE. LA was not detected in 10 samples by PLM-Grav. Vermiculite was not observed in 200 samples based on a quantitative assessment. Information on vermiculite was not available for 12 samples.

In July and November 2013, EPA contractors visited the school to collect additional soil samples as part of a GPI. A total of six DI soil samples were collected. LA was detected at a frequency 33% with trace levels of LA by PLM-VE. Vermiculite was observed in four of six surface soil samples based on a quantitative assessment.

3.32.5 Libby School District Administration Building

Conducted concurrently with the April 2003 CSS, measurements were taken to quantify the amount of vermiculite insulation and other insulation requiring removal as part of the indoor PDI and a SIIC was completed. During this investigation, field personnel clarified that vermiculite insulation was only observed in the north addition attic. The south attic was not insulated with vermiculite insulation and did not share airspace with the north attic. Vermiculite insulation was also observed beneath the entrance to the north attic. Thirteen dust samples were collected from the horizontal surfaces and high traffic areas of the ground floor, second floor, basement, and south addition attic. Analytical results for all samples were non-detect for LA by TEM ISO. Refer to Appendix A for additional information on individual sample details and analytical results.

In August 2010, EPA contractors returned to the building again to collect additional soil samples as part of a GPI. Vermiculite was observed in a small portion of the play area. A total of 49 DI soil samples were collected. LA was detected at a frequency of 45% with trace levels of LA by PLM-VE. LA was not detected in seven samples by PLM-Grav. Vermiculite was not observed in 39 surface soil samples based on a quantitative assessment. Information on vermiculite was not available for 10 samples.

In October 2013, EPA contractors visited the school to collect additional soil samples as part of a GPI. One DI soil sample was collected. LA was not detected by PLM-VE. Vermiculite was not observed based on a quantitative assessment.

3.32.6 St. John's Rehabilitation Center and Helipad Field

In 2005, four dust samples were collected from the rehabilitation center and the two sheds within the helipad field as part of the PDI and an EIC was completed. Each structure was inspected for vermiculite insulation and no additional soil sample collection was deemed necessary. The dust samples were collected in accordance with the *Final Draft Pre-Design Inspection Activities Work Plan* (CDM Smith 2003h) with modifications. Analytical results for all four dust samples were non-detect for LA by TEM. Refer to Appendix A for additional information on individual sample details and analytical results.

3.32.7 Cabinet View Country Club

In July 2007, an outdoor PDI was conducted at the CVCC to determine the spatial extent of visible vermiculite and LA on the front nine holes of the golf course. The back nine holes of the golf course were constructed in 2007 and LA-contaminated fill materials were not used during construction. All tee boxes and greens were identified for removal based on the analytical results from the previous soil sampling in 2004 and the presence a vermiculite drainage layer within four inches of the surface.

The golf course was divided into 100-foot by 100-foot grids, and each grid was characterized with one 30-point composite sample. Areas with visible vermiculite were excluded from the sampled area and identified for removal. A total of 268 surface soil samples were collected from the fairways, rough areas, sand traps, and driveway. In May and July 2008, an additional 26 surface soil samples were collected from the open field at the southwest corner of the CVCC property. Refer to Appendix A for additional information on individual sample details and analytical results. Results are summarized below in brief:

- A total of 294 surface soil samples were collected at the CVCC golf course in 2007 and 2008. LA was detected at a frequency of 4% for 293 samples with trace concentrations by PLM-VE. LA was not detected in 12 samples by PLM-Grav. Tremolite/actinolite was not detected in one sample by PLM-9002. Vermiculite was not observed in 292 samples based on a qualitative assessment. Information on vermiculite was not available for two samples.

In addition to the outdoor inspection, the pump house and 12 additional structures on the property were visually inspected for vermiculite insulation. Vermiculite insulation was observed in the pump house along the west side of the property; however, this pump house is no longer owned or operated by CVCC and is currently part of a private residence. Vermiculite insulation was not observed in any of the outbuildings remaining on the CVCC property.

3.32.8 Alleys

Beginning in September 2010, the EPA conducted SI and DI sample collection efforts in the City of Libby and Lincoln County alleys as part of a GPI. Results are summarized in brief below:

- A total of 74 SI soil samples were collected. LA was detected at a frequency of 11% for 74 samples with trace levels of LA by PLM-VE. LA was not detected in 21 samples by PLM-Grav. Vermiculite was not observed in 74 samples based on a quantitative assessment.
- A total of 93 DI soil samples were collected. LA was detected at a frequency of 28% for 93 samples with trace levels of LA by PLM-VE. LA was detected at a frequency of 3% for 36 samples with trace levels of LA by PLM-Grav. Vermiculite was observed in nine samples based on a quantitative assessment. Vermiculite was not observed in 84 samples based on a quantitative assessment.

3.32.9 Creeks

Following the screening investigations, various portions of Flower Creek, Granite Creek, Pipe Creek, and Libby Creek were identified as requiring a PDI to be completed to determine the lateral and vertical extent of the LA contaminated material. Details regarding each inspection are discussed below.

3.32.9.1 Flower Creek

The results from the initial investigation upstream of the bridge indicated that six primary locations contained LA-contaminated rock material. This material was primarily comprised of riprap and gravel.

During the PDI in 2008, the contaminated portions of the creek were visually re-inspected and 14 unique areas were identified. These areas were delineated by staking the upstream and downstream limit of each area. The stakes were eventually surveyed by a professional land surveyor. Due to limited available soil, no soil samples were collected or analyzed for LA.

3.32.9.2 Granite Creek

An approximate 2.5-mile section of Granite Creek from Cherry Creek Road to the confluence with Libby Creek was investigated for LA contaminated material in 2007. Findings from the SI revealed that LA material was observed along the western bank on the south side of the U.S. Highway 2 Bridge.

The focus of the 2008 PDI along Granite Creek was to visually determine extent of LA-contaminated material along the embankments. One large area was identified, and the extent of the contaminated material was staked and surveyed. No soil samples were collected for laboratory analysis.

3.32.9.3 Pipe Creek

An approximate 1-mile section of Pipe Creek, starting from the Kootenai River, was investigated for LA-contaminated material in 2008. Findings from the investigation revealed that LA-contaminated material composed mainly of riprap, was observed along the northern bank of Pipe Creek adjacent to properties at 3623 Kootenai River Road and 3737 Kootenai River Road.

The focus of the 2009 PDI along Pipe Creek was to determine extent of vermiculite and LA along the embankments. Most of the riprap material in this section was comprised of metasediments, precast concrete, concrete debris, and basalt. Four unique areas were identified and the extent of the LA-contaminated material was staked and surveyed. No soil samples were collected for laboratory analysis.

3.32.9.4 Libby Creek

During the SI, an approximate 6.8-mile section of Libby Creek, beginning from the Kootenai River and an approximate 0.2-mile section of Libby Creek near Hammer Road, was investigated for LA-contaminated material. Findings from the investigation revealed that LA-contaminated material composed mainly of riprap was observed along the eastern bank of Libby Creek, approximately 700 feet south of the Champion Haul Road Bridge.

The focus of the 2009 PDI along Libby Creek was to determine extent of vermiculite and amphibole along the embankments. Three unique areas were identified and the extent of the contaminated material was staked and surveyed. Eight soil samples were collected from areas along the surface of the top of the contaminated bank area, which was utilized for access and staging during removal. Analytical results for all soil samples were non-detect for LA by PLM-VE. Vermiculite was not observed in any of the eight samples based on a qualitative assessment.

3.32.10 Former Concrete Plant

In July 2007, a PDI was conducted at the two residences on the former concrete plant property (31425 and 31445 U.S. Highway 2). In addition to visually inspecting the building and soil for visible vermiculite, soil, and dust samples were collected to further delineate contamination for upcoming removal activities. EICs and VVEFs were completed for each residence and a SIIC was completed for 31445 U.S. Highway 2. All samples were collected in accordance with the *Final Draft Pre-Design Inspection Activities Work Plan* (CDM Smith 2003h) with modifications. Refer to Appendix A for additional information on individual sample details and analytical results. Results are summarized below in brief:

- A total of seven surface soil samples were collected from the driveways and yard surrounding the two residences where vermiculite was not observed. LA was not detected in any of the samples by PLM-VE and was not detected in five samples by PLM-Grav. Vermiculite was not observed in any of the soil samples based on a qualitative assessment.
- A total of seven indoor dust samples were collected from the ground floor of each residence, and from the pump house and garage on the property. All dust samples were non-detect for LA by TEM analysis.

3.33 Removal Actions

Each property at OU4 may require removal in three general areas: the attic space, the interior living space, and/or outdoors. The following sections generally describe the removal action process and summarize the completed removal actions at OU4.

3.33.1 Clearance Criteria

As documented in the EPA's Technical Memo (EPA 2003c) and associated amendment (EPA 2011d), removal was considered complete and the property "clean" when the following criteria were met for each of the three general areas:

Attic Space

- No uncontrolled vermiculite insulation remained in accessible areas.
- Any vermiculite insulation remaining was well-contained (i.e., not exposed).

- The average of approximately five samples of disturbed air collected in the attic had detected levels of total LA <0.01 s/cc by TEM AHERA.

Interior Living Space

- No visible vermiculite remained in accessible areas or living space.
- No LA structures were detected in any of approximately five samples of disturbed air on the level(s) or floor(s), indicating disturbed air concentrations are generally <0.001 s/cc by TEM AHERA.

Outdoors

- No visible vermiculite or waste material remained within the area of excavation.
- In excavated areas, soil samples collected at the depth of excavation, (12 inches for general yard areas, 18 inches for SUAs) were non-detect for LA by PLM. If the maximum design depth was reached, soil samples collected at the bottom of excavation were <1% LA by PLM.

If any of the above criteria could not be met, re-cleaning, additional excavation or other steps were implemented and the collection of clearance samples was repeated. Additional excavation continued (generally to a maximum depth of three feet below ground surface) if gross contamination was observed or if analytical results indicated levels of LA ≥1% by PLM.

The EPA's removal approach (EPA 2003c) considers not only the presence of source materials and the concentration of LA within them, but also the likelihood that these source materials may be disturbed. Based upon this approach, some source materials that are less likely to be disturbed may be left in place (such as in walls, below hard surfaces, and at depth). In some situations, the EPA may remove or further isolate such materials to prevent even infrequent exposures, depending on the situation.

The following sections describe the types of removal activities performed at typical residential and commercial properties within OU4. Removal activities are separated into the general categories of indoor, outdoor, and structure demolition, and further separated by general removal locations (e.g., attic, living space, understructure, outdoor soils). Removal activities are described in each iteration of the *Response Action Work Plan* (RAWP) (CDM Smith 2000; 2003g; 2007b; 2008g, PRI-ER 2010; 2011; 2012; 2013).

3.33.2 Indoor Removal Actions

Indoor removal activities generally involved the removal of vermiculite insulation, ACM, contaminated dust, or contaminated building materials from a structure, typically consisting of a residence, business, and/or associated outbuilding (e.g., garage, shop, or shed).

3.33.2.1 Areas of Exposed Vermiculite Insulation

Primarily, vermiculite insulation has been removed from accessible attic spaces. As established by the EPA removal criteria, other insulation such as fiberglass or cellulose, if in contact or sharing airspace with vermiculite insulation, was also removed. Following bulk insulation removal, the surfaces of the attic were detailed, and inaccessible insulation was sealed in place with a clear, project-approved encapsulant or physical barriers.

Although the majority of vermiculite insulation has been encountered in attic spaces, vermiculite insulation has also been removed from certain contained areas (e.g., walls, floors, and ceilings) when the property owner intended to remodel their house or business immediately following the removal

or where building materials were in extremely poor condition (e.g., building materials failing causing vermiculite to be exposed). Blocking activities were performed and encapsulant applied as necessary to seal inaccessible insulation in place.

When removal activities were completed, properties were restored to their pre-removal conditions or equivalent. Attic restoration included restoring attic accesses and installing comparable insulation. Restoration was typically not required in areas to be remodeled.

3.33.2.2 Building Material Demolition

This activity is considered distinct from an outdoor structure demolition, in which an entire structure is dismantled and removed.

Building material demolition occurred when vermiculite insulation within a building could not be readily accessed for removal. Typically, this vermiculite insulation created a potential exposure pathway because of the following: it was inadequately sealed in place in its current condition; the building materials surrounding it were in poor condition (e.g., building materials failing causing vermiculite to be exposed); or the residents had remodeling plans, which entailed disturbing the vermiculite.

In these cases, certain building materials (e.g., lumber, plaster, and drywall) were dismantled by cutting, sawing, and other intrusive methods in order to properly access and remove the vermiculite insulation.

Following removal, any remaining inaccessible vermiculite insulation was sealed in place by applying encapsulant and installing physical barriers. Air clearance samples were collected upon completion of insulation removal.

When removal activities were completed, all demolished building materials were restored, unless remodeling activities were planned by the resident.

3.33.2.3 Interior Cleaning

When significant quantities of vermiculite insulation were observed within a living space, or when analytical results showed detectable dust levels of total LA exceeding 5,000 s/cm^2, a containment area was constructed and a full interior cleaning was performed within areas that met removal criteria (EPA 2003c). All surfaces (horizontal and vertical) and items within the designated containment area were vacuumed (vacuums were equipped with HEPA filters) and/or wet-wiped. All items that were in contact with vermiculite insulation were cleaned or disposed. In general, upholstered surfaces, carpets, and clothing were not disposed of, and remained in place. Encapsulant was applied in suitable areas.

Following removal activities, air clearance samples were collected in accordance with the *RA SAP* (CDM Smith 2003f), *RA SAP, Revision 1* (CDM Smith 2008h), *RA SAP, Revision 2* (CDM Smith 2011c), or *RA SAP, Revision 3* (CDM Smith 2013c), until clearance criteria were met. Each containment area had its own clearance sampling event. Approximately 8,500 indoor air clearance samples have been collected and these samples are included electronically in Appendix A.

Beginning in April 2005, a process was developed to remove isolated releases of vermiculite insulation in living spaces. These small-scale vermiculite removals (SSVR) relied on dust sample results to govern whether a full interior cleaning, a small contained cleaning, or an uncontained cleaning was required. Contained cleanings required the collection of indoor air clearance samples before containment could be dismantled. Uncontained cleanings did not require confirmation air

sampling. SSVRs continued on a limited basis until July 2007 when dust sample collection was suspended. The process of identifying properties suitable for SSVR cleanings is outlined in the *Small Scale Vermiculite Removal Memorandum* (CDM Smith 2005j).

When removal activities were completed, properties were restored to their pre-removal conditions or equivalent. Restoration activities consisted of returning household items to their original locations.

3.33.2.4 Indoor Soils

VCS and/or LA-contaminated soils were removed from the understructures of buildings (i.e., basements, crawlspaces) depending on the frequency of use.

When the required excavation depth was met, typically between zero and six inches, and soil remaining in the excavation area was expected to meet soil clearance criteria, soil samples were collected in accordance with the *RA SAP* (CDM Smith 2003f), *RA SAP, Revision 1* (CDM Smith 2008h), *RA SAP, Revision 2* (CDM Smith 2011c), or *RA SAP, Revision 3* (CDM Smith 2013c), until clearance criteria were met. On occasion, indoor air clearance samples were collected in lieu of indoor soil clearance samples and the area was encapsulated with a hard surfacing capping material or high density polyethylene sheeting. A total of 53 indoor soil samples have been collected and analyzed by PLM. These samples are included electronically in Appendix A.

Excavation depths that differed from those stated in the property-specific work plans were documented. Hard surfacing capping material or polyethylene sheeting was applied as a means of encapsulating remaining LA contamination within soils that were difficult to access. In rare cases, a liner covered with compacted gravel was used to encapsulate the remaining soil.

When removal activities were completed, properties were restored to their pre-removal conditions or equivalent. Soil restoration activities consisted of backfilling, grading, and compaction.

3.33.3 Outdoor Removal Actions

Outdoor removal activities generally involved the removal of contaminated soil, rocks, or associated debris. Typical removal locations included yard, flowerbed, garden, or driveway areas.

Typical excavation depths were as follows:

Location	Required Excavation Depth
Yard	12 inches
Flowerbed	18 inches[1] or 12 inches
Garden	18 inches
Driveway	12 inches[2] or 6 inches

[1] In 2007, this depth was modified to 12 inches per the direction of the EPA.
[2] In 2013, this depth was modified to 6 inches per the direction of the EPA (CDM Smith 2013c).

During contaminated soil removal, the perimeter of the exclusion zone was monitored for asbestos structure migration by collection of stationary air samples from the downwind direction at the exclusion zone boundary. Approximately 7,200 outdoor perimeter air samples have been collected in and analyzed by TEM accordance with the *RA SAP* (CDM Smith 2003f), *RA SAP, Revision 1* (CDM Smith 2008h), *RA SAP, Revision 2* (CDM Smith 2011c), or *RA SAP, Revision 3* (CDM Smith 2013c). Refer to Appendix A for additional information on individual sample details and analytical results.

When the required excavation depth was met and soil remaining in the excavation area was expected to meet soil clearance criteria, soil clearance samples were collected in accordance with the *RA SAP* (CDM Smith 2003f), *RA SAP, Revision 1* (CDM Smith 2008h), *RA SAP, Revision 2* (CDM Smith 2011c), or *RA SAP, Revision 3* (CDM Smith 2013c). Soil clearance samples were then analyzed by PLM-9002. Approximately 11,500 outdoor soil samples have been collected and these samples are included electronically in Appendix A.

Excavation depths that differed from those stated in the property-specific work plans were documented. When removal activities were completed, properties were restored to their pre-removal conditions or equivalent. Outdoor restoration activities consisted of backfilling, grading, compaction, installation of fences, and landscaping.

3.33.4 Structure Demolition

Structure demolitions involved the physical removal of structures contaminated with LA or VCBM. Heavy equipment was utilized to dismantle the buildings through controlled methods.

Perimeter air and settled dust (or "dustfall") samples were collected in configurations surrounding the demolition site. Dustfall samples are open-topped containers with a specified volume of liquid at the base that collects particulates over various time intervals that settle out of the air. Approximately 260 dustfall samples have been collected and analyzed in accordance with the *General Sampling and Analysis Plan for Assessing Asbestos Release from Building Demolition at the Libby, Montana Superfund Site* (EPA 2005c) and the *General Workplan for Building Demolition at the Libby, Montana, Superfund Site, Revision 2* (EPA 2007f). In 2007, dustfall samples were excluded and the numbers of perimeter samples collected at each demolition site were decreased per direction by the EPA. Refer to Appendix A for additional information on individual sample details and analytical results.

Following demolition, an area encompassing the structure's footprint was excavated, typically to a depth of 12 inches, and soil clearance samples were collected in accordance with the *RA SAP* (CDM Smith 2003f), *RA SAP, Revision 1* (CDM Smith 2008h), *RA SAP, Revision 2* (CDM Smith 2011c), or *RA SAP, Revision 3* (CDM Smith 2013c). The number of soil samples collected from the footprint of demolished structures is included in the total presented in Section 3.33.3. Refer to Appendix A for additional information on individual sample details and analytical results.

Restoration activities consisted of backfilling, grading, and compaction but did not require restoration of the demolished structure.

3.33.5 Disposal of Contaminated Materials

Contamination removed during these removal activities was typically disposed in one of two locations, depending on the material. Generally all VCS removed was disposed of at the former vermiculite mine in OU3, and all vermiculite-containing insulation and VCBM removed was disposed of at the Lincoln County Class IV asbestos landfill.

3.33.6 Completed Properties

A property is classified as "completed" when a removal action has taken place and all contamination, as defined in the EPA's Technical Memo (EPA 2003c), is addressed. Upon completion, a summary of removal activities for each property are documented on a *Property Closeout Checklist* (PCC).

Between 2001 and October 2013, a total of 1,886 properties have been completed. Note that for 297 properties, multiple removal actions have taken place so the total presented in the table below is greater than 1,886. The following table shows the total removals, by removal type.

Type of Removal Activity	Number of Properties
Indoor	250
Outdoor	966
Combination (e.g., Indoor and Outdoor or Outdoor and Demolition)	692
Total	1,908

Additional contamination identified after the initial removal action (e.g., vermiculite insulation exposed due to homeowner remodeling, results of post-removal or risk-assessment based sampling programs) will not alter a property's completion status. The additional contamination may be addressed in the short term, as a "quick response" under the ERS program, or later, as part of a modified response action program if the EPA's removal criteria are changed.

Partially Completed Removal Actions

Quick responses are a necessary component of the removal action program that provides the EPA with a means to quickly address unexpected releases of vermiculite and mitigate potential exposures to LA. Quick responses can occur at properties at any stage in the investigation, design, or removal phase, including completed properties and properties where an initial contamination screening has not occurred.

Quick responses are most commonly encountered during building repair, remodeling, maintenance, utility servicing, installation, and construction. The process governing the ERS program is documented in the *Environmental Resource Specialist Plan* (CDM Smith 2009d) and *Environmental Resource Specialist Plan, Revision 1*(CDM Smith 2013d).

Although quick responses and other partial removal actions have been conducted at many properties since 2001, 188 properties have had contamination partially addressed without undergoing a complete removal action. The level of severity for a quick response varies significantly; however, small releases of vermiculite insulation that are removed with a HEPA vacuum and that do not require mobilization of an abatement contractor are not classified as partial removal actions. The summary of removal activities for partial removal actions is also documented for each property on a PCC form.

3.34 Removal Actions at Specialty Properties

The following sections describe removal actions performed through October 2013 at specialty properties within OU4. The locations of these properties are shown on Figure 3-1.

3.34.1 Libby High School

The track and a portion of the tennis courts were excavated in June 2001 and rebuilt in 2002. VCS and/or LA contaminated soil was excavated to an average depth of two feet. Perimeter air monitoring samples were collected over the duration of the removal. Once the native soils were reached, confirmation samples were collected to ensure the contamination was removed. If LA was detected in any confirmation sample by PLM-9002, an additional four to six inches was excavated and the area was retested until LA was not detected by PLM-9002 at depth. The track was then reconstructed with structural fill, a geotextile fabric, crushed stone, and a one-inch layer of finish course paving.

Interior cleanings were triggered at the football field storage building, snack bar, press box, visitors' coach box, storage garage, and bleachers due to elevated LA levels in collected dust samples. Air clearance samples were collected following the cleanings. The EPA purchased new football, track, and vending machine equipment for the school.

In December 2008, indoor removal activities addressed contamination identified in two greenhouses attached to the school.

The removal activities included: dismantling and removing drawers from a shelving unit; cleaning miscellaneous items; temporarily removing wooden flooring; removing soil within planters and flowerpots; and excavating the soil to a depth of three inches. Soil confirmation samples were then collected and an interior cleaning of both greenhouses performed. Air clearance samples were collected following the interior cleanings. Restoration included backfilling the excavation, replacing the removed flooring, and replacing the demolished shelving in-kind.

A removal action was conducted in August 2010 at Libby High School as a result of visible vermiculite identified in specific use areas during the GPI visual inspection in July 2010. The west shot put pit and the driveway/parking lot north and east of the welding shop were excavated in August 2010. A damaged section of sidewalk adjacent to the welding shop was also removed due to visible vermiculite in the sidewalls of the excavation immediately adjacent to the sidewalk. All VCS contaminated soil was excavated to the design depth of 12 inches bgs with the exception of the area under the damaged sidewalk, which was excavated to a depth between 18 and 30 inches bgs. Confirmation soil samples were collected from the floor of the excavation prior to backfill. All confirmation soil samples were non-detect for LA by PLM-9002 except the two samples collected from beneath the damaged sidewalk and the area west of the damaged sidewalk that both contained <1% LA. All removal areas were restored in kind.

During the August 2010 removal activities, the third party QA person identified low amounts of visible vermiculite in the east shot put pit. Per direction by the EPA, the east shot put pit was not excavated and visible vermiculite remains at the surface in this location.

3.34.2 Kootenai Valley Head Start

Outdoor removal activities at the former ice rink began in July 2001. Initially, four test pits were excavated to determine the lateral extent of the contamination surrounding the former ice rink. Vermiculite was only observed in the first test pit; therefore, an additional test pit was excavated five feet away from the location of the observed vermiculite. VCS was then excavated from the former ice rink. On average, the total depth of exaction was 12 inches. Once the design depth was reached, confirmation samples were collected to ensure the contamination was removed. If LA was detected in any confirmation sample by PLM-9002, an additional 12 inches was excavated and the area was retested until LA was not detected at depth.

Perimeter air samples were collected during the 2001 removal event.

Due to vermiculite observed in the former pond area, an additional outdoor removal began in October 2002. During excavation, a vein of mine tailings was observed approximately 15 feet from the former ice rink. Test pits were excavated to determine the lateral extent of this vein, and the excavation extended to include these new areas. Adjacent to the asphalt along Education Way, the depth of the excavation reached 24 inches when a 1-2 inch layer of vermiculite was observed. This layer of vermiculite was removed to the extent possible, but it was noted that the material extended

underneath this asphalt for an unknown distance. Confirmation soil samples were collected at depth to ensure all accessible contamination had been removed.

Perimeter air samples were collected during the 2002 removal event.

During the June 2008 inspections, vermiculite was identified in two five-gallon buckets of sand in a storage room south of the main gym area. The sand was locally purchased as play sand at a building supply store. One of the buckets had three toy shovels in it and a small quantity of this sand was spilled on the floor nearby. Vermiculite was also observed in the soil of a houseplant in the northwest office.

In September 2008, EPA contractors returned to the school and discovered one of the sand pails being used in a classroom. All pails of sand were removed from the school, the area surrounding the play table was HEPA-vacuumed, and the carpet underneath the table was removed. Vermiculite insulation was also observed during this supplemental visit along the wall in the parent's waiting room. Presumably, the insulation came from the exterior cinderblock wall. An interior cleaning was performed in the supply closet in the parent's waiting room and the storage room at the south end of the gymnasium.

3.34.3 Libby Middle School

Outdoor removal activities of the Libby Middle School track began in August 2001. Although the excavation was completed by the end of September 2001, the track was not rebuilt until 2002. VCS and/or LA-contaminated soil was excavated to an average depth of two feet, or six inches below the visual change in strata below the contaminated layer. Perimeter air monitoring samples were collected over the duration of the removal. Once the final depth had been reached, confirmation samples were collected and analyzed by PLM-9002 to ensure the contamination was removed. If LA was detected in any confirmation sample, an additional four to six inches was excavated and the area was retested until LA was not detected at depth. The track was then reconstructed with structural fill, a geotextile fabric, crushed stone, and a one-inch layer of finish course paving.

In June 2004, gross quantities of vermiculite were observed on the steep bank in the southeast corner of the school grounds near the fence line of 906 West Balsam Street. An urgent unscheduled removal of this area was performed and completed on August 26, 2004. VCS was removed to a depth of 12 inches and confirmation samples were collected to ensure the contamination was removed. The area was restored to grade with backfill materials and hydroseeded.

In April 2009, the EPA removed the high jump mat from the Middle School's athletic field and replaced it in-kind.

A removal action was conducted in August 2010 at Libby Middle School as a result of visible vermiculite identified in SUAs during the GPI visual inspection in July 2010. The parking lots at the southwest and southeast corners of the Libby Middle School property, the walkway extending north from the southeast parking lot, and the playground area east of the gymnasium were excavated in August 2010. All VCS was excavated to the design depth of 12 inches bgs. Confirmation soil samples were collected from the floor of the excavation prior to backfill. All confirmation soil samples were non-detect for LA by PLM-9002. The parking lots and walkway were restored with structural fill. The playground area was restored with eight inches of ¾-inch minus crushed material and four inches of pea gravel, except under the swing sets which were restored with four inches of ¾-inch minus crushed material and eight inches of pea gravel.

3.34.4 Libby Elementary School

In February 2008, vermiculite insulation spilled onto the ground from an exterior wall that was punctured by a piece of snow removal equipment. The insulation was removed from the surface of the snow as part of a quick response removal. The hole in the exterior wall was blocked with foam blue board and sealed with mortar. Soil clearance samples were not collected to confirm the removal because the area was snow-covered.

3.34.5 Kootenai Bluffs Subdivision

Based on visual inspections and the results of pre-removal surface and subsurface soil sampling at the Kootenai Bluffs Subdivision, the EPA determined that an outdoor removal action was required.

The EPA conducted this work between August 9 and November 18, 2001, in accordance with the *Final Removal Action Work Plan for the Kootenai Bluff Property* (CDM Smith 2001). In general, VCS was excavated to a depth of 18 inches throughout the removal areas. In accordance with the work plan, additional six-inch lifts were removed if PLM-9002 results detected LA at concentrations ≥1%.

Following excavation and confirmation soil sampling, the area was restored with appropriate backfill materials.

3.34.6 Cemetery Park Ball Fields

Indoor removal activities of the concession stand began in May 2002 due to elevated dust levels and were completed in June 2002. Work performed consisted of an interior cleaning of the concession stand, including equipment inside the stand. The stand and sports equipment were HEPA-vacuumed and/or wet-wiped. Air clearance samples were collected from the concession stand after the interior cleaning. Restoration included returning items to their original location.

3.34.7 Libby School District Administration Building

Indoor removal activities of the Administration Building attic began in July 2003 and were completed by the end of August 2003. Work performed consisted of vermiculite and fiberglass insulation removal from the north addition attic and an interior cleaning of the storage room, closet and entryway of the northeast classroom. Once the insulation was removed, the attic was detailed and encapsulated.

Air clearance samples were collected from the storage room after the interior cleaning and from the attic after the insulation removal. Restoration included installing insulation and returning items to their original location.

3.34.8 Johnston Acres Subdivision

Although the initial subsurface investigation of the Johnston Acres Subdivision (Section 3.4.16) did not confirm the presence of contaminated fill material, several areas of contamination were encountered during the waterline replacement in 2005.

- 1408 Washington Avenue – a two to six inch vein of vermiculite was encountered between the topsoil and native soil layers.
- 1417 Washington Avenue – vermiculite was encountered south of the house surrounding the existing water pipes.
- 131 West Larch Street – a vein of visible vermiculite was encountered approximately 12 inches bgs in a trench perpendicular to Larch Street.

- 1511 Main Avenue – vermiculite was observed on the surface of the soil from the water line along Main Avenue to the yard of 1511.

In each situation, the EPA removed the contaminated soil to ensure the waterline installation could safely continue without spreading contamination. Soil clearance samples were not collected during these partial removal actions. Restoration was performed by the waterline contractor once their installation was completed.

3.34.9 St. John's Rehabilitation Center and Helipad Field

Outdoor removal activities of the helipad field began in August 2005 and ended in October 2005. VCS and/or soil with detectable levels of LA by PLM were excavated to depths of 12 inches to 36 inches. Pocket-like sections with gross quantities of vermiculite were observed in many locations on the property during excavation. In addition, contaminated soil was removed from the planter boxes at the rear of the Rehabilitation Center. Perimeter air samples were collected throughout the duration of the removal, and soil clearance samples were collected following completion of excavation.

The north half of the property was restored with common fill, topsoil, and hydroseed to replicate the landscape's original state. No restoration was required in the south half of the property due to pending construction plans for a new facility; the EPA accordingly left a stockpile of topsoil to be used at the discretion of the hospital. In addition, gravel was placed to restore a haul road along the west edge of the property. A detailed summary of this removal action is presented in the *2005 CDM Oversight Activities Conducted at the St. John's Hospital Helipad Property in Libby, Montana Memorandum* (CDM Smith 2005k).

3.34.10 J. Neils Park

In September 2005, outdoor removal activities began at the infield portions of fields 1 and 2 (i.e., the softball fields). Removal work performed included excavation of VCS to depths of 12 to 18 inches. Perimeter air samples were collected during removal work. Soil clearance samples were collected following excavation. Restoration of the areas included placement and compaction of common fill and ¾-inch minus rock.

Additional outdoor removal activities began in June 2008 when vermiculite was observed at the soccer field in the northeast portion of the park. Removal work performed included removal of soil stockpiles along the west edge of the area, and excavation of VCS at the soccer field location to depths of 6 to 12 inches. Perimeter air samples were collected during the removal work. Soil clearance samples were collected following removal and excavation. Restoration of the removal areas was not required.

3.34.11 City of Libby Alleys

Removal actions have taken place at five alleys within the city limits. Each alley was excavated to a depth of 12 inches to remove VCS and/or soil with detectable levels of LA by PLM. Refer to Figure 3-2 for the locations of the alleys discussed below:

- In 2007, outdoor removal activities were completed at Alley #124 (June), Alley #111 (September), and Alley #109 (October).
- In 2008, outdoor removal activities were completed at Alley #31 (May).
- In 2009, outdoor removal activities were completed at Alley #61 (August).

- In 2011, outdoor removal activities were completed at Alley #121 (May), Alley #61 (August), Alley #101 (October), Alley #106 (October), and Alley #104 (November).
- In 2012, outdoor removal activities were completed at Alley #104 (April), Alley #101 (April), Alley #57 (May), Alley #13 (June), Alley #103 (July), Alley #205 (August), Alley #19 (September), and Alley# 107 (September).

In each alley removal, perimeter air samples were collected during removal work, and soil clearance samples were collected following completion of excavation. Alley restoration included placement and compaction of residential fill and structural fill.

3.34.12 Creeks

Flower Creek

Completed under the Emergency and Rapid Response Services (ERRS) Contract, the removal actions included the removal of LA-contaminated riprap material from along the creek embankments as directed in the addendum to the RAWP for Flower Creek, *Addendum to the Response Action Work Plan Flower Creek Removal Plan* (CDM Smith 2008i), and by the onsite Government representative. A total of approximately 2,600 yd^3 of contaminated soil and riprap material was removed. When the required excavation depth was met and soil remaining in the excavation area was expected to meet soil clearance criteria, soil clearance samples were collected in accordance with the RA SAP, *Revision 1* (CDM Smith 2008h) and analyzed by PLM-9002. A total of 20 soil clearance samples were collected during the removal action; however, four excavated areas were not sampled.

Following clearance of the excavated areas, the creek embankments were restored to their pre-removal condition.

Granite Creek

Completed under the ERRS Contract, the removal actions included the removal of LA-contaminated riprap material from along the west creek embankment and along the access road and staging area as directed in the Addendum to the RAWP for Granite Creek, *Addendum to the Response Action Work Plan Granite Creek Removal Plan* (CDM Smith 2008j), and by the onsite Government representative. A total of approximately 3,370 yd^3 of contaminated soil and riprap material was removed. In excavation areas where soil was exposed and when the required excavation depth was met and soil remaining in the excavation area was expected to meet soil clearance criteria, soil clearance samples were collected in accordance with the *RA SAP, Revision 1* (CDM Smith 2008h) and analyzed by PLM-9002. A total of 11 soil clearance samples were collected during the removal action. In addition, where LA-contaminated riprap was left in place, shotcrete was applied to coat the riprap to provide additional protection against the release of LA fibers.

Following clearance of the excavated areas and the application of shotcrete, the creek embankment was restored to its pre-removal condition. Additional riprap protection was installed to repair the existing toe of the embankment that had been washed out.

Pipe Creek (Lower Section)

The removal actions included the removal of LA contaminated riprap material from two bank locations adjacent to 3623 Kootenai River Road and 3737 Kootenai River Road as directed in the Addendum to the RAWP for Pipe Creek, *Addendum to the Response Action Work Plan Pipe Creek Removal Plan* (CDM Smith 2009e). A total of approximately 357 yd^3 of contaminated soil and 20 truckloads of contaminated riprap material were removed. In excavation areas where soil was

exposed and when the required excavation depth was met and soil remaining in the excavation area was expected to meet soil clearance criteria, soil clearance samples were collected in accordance with the *RA SAP, Revision 1* (CDM Smith 2008h) and analyzed by PLM-9002. Two soil clearance samples were collected during the removal action.

Following clearance of the excavated areas, the creek embankments were restored to their pre-removal condition.

Libby Creek

The removal actions performed in August 2009 included the removal of LA contaminated riprap material from along the eastern bank of Libby Creek approximately 700 feet south of the Champion Hal Road Bridge, as directed in the Addendum to the RAWP for Libby Creek, *Addendum to the Response Action Work Plan Libby Creek Removal Plan* (CDM Smith 2009f). A total of approximately 499 yd^3 of contaminated soil and 95 truckloads of contaminated riprap material were removed. In excavation areas where soil was exposed and when the required excavation depth was met and soil remaining in the excavation area was expected to meet soil clearance criteria, soil clearance samples were collected in accordance with the *RA SAP, Revision 1* (CDM Smith 2008h) and analyzed by PLM-9002. A total of nine soil clearance samples were collected during the removal action.

Following clearance of the excavated areas, the creek embankments were restored to their pre-removal condition.

3.34.13 Former Concrete Plant

In June 2009, indoor and outdoor removal activities began at the residential portions of the former concrete plant (i.e., U.S. Highway 2 and 31445 U.S. Highway 2). Work performed at 31425 U.S. Highway 2 consisted of vermiculite and fiberglass insulation removal, an interior cleaning of the ground floor, and excavation of VCS and/or soil with detectable levels of LA from the yard and flowerbeds. Work performed at 31445 U.S. Highway 2 consisted of excavation of contaminated soil from the yard and flowerbeds only. Soils were removed to a depth of 12 inches in the yard and flowerbeds. A concrete pad, concrete cistern, and barbed wire fence were removed without replacement.

Air clearance samples were collected from the ground floor of 31425 U.S. Highway 2 after the interior cleaning and from the attic after the insulation removal. Perimeter air samples were collected during the outdoor removal work, and soil clearance samples were collected following completion of excavation. Property restoration included placement and compaction of topsoil, residential fill, and structural fill.

3.34.14 Cabinet View Country Club

Outdoor removal activities began in August 2009 and ended in October 2009. Removal activities included: excavation of VCS from areas throughout the #1-9 fairways and greens and around facility buildings; demolition of a shed; and stump removal. VCS was excavated to depths of 12 to 48 inches. Perimeter air samples were collected during the removal. Soil clearance samples were collected following completion of excavation.

Golf course restoration included placement and compaction of fill material and topsoil.

Section 4

Physical Characteristics of the Study Area

The Libby Site encompasses an area of roughly 200 square miles (mi^2) centered around Libby, Montana. The City of Libby is concentrated in the valley formed by the Cabinet Mountain range and Kootenai River (Figure 1-4). The sections below describe in detail the physical characteristics of the Libby Site.

4.1 Physical Setting

Libby consists of a small "downtown" core with populated areas spreading in several directions, primarily along highways and stream valleys (Figure 1-3). Businesses are focused in the downtown core and along U.S. Highway 2 and Highway 37. The size and construction of typical residential and commercial structures in the area varies considerably, but there are numerous older buildings in various states of disrepair. Roughly 78% of residential properties were built prior to 1990 and 40% were built prior to 1960 (U.S. Census Bureau 2012).

Local tax records and other information suggest there are approximately 5,500 individual residential, commercial, and public properties in OU4 (Montana Cadastral 2013). Property inspections by the EPA indicate the presence of significant numbers of houses with "non-standard" construction, and deteriorating conditions. Most residential yards are grass-covered and vegetated, but bare or thin areas are not uncommon.

Libby is situated along the Kootenai River, at the confluence of several smaller creeks, in a relatively narrow river valley. Mountains and National forest land surround the Kootenai Valley on all sides: the Cabinet Mountains to the south, the Purcell Mountains to the north, and the Salish Mountains to the east. The elevation of Libby is approximately 2,000 feet above sea level. The area is primarily coniferous forest and heavily vegetated. The biome classification for the Kootenai Valley is the taiga, which is also known as the northern coniferous forest or boreal forest biome.

4.2 Climate

Libby has a relatively moist climate, with annual precipitation in the valley averaging slightly over 20 inches (this includes approximately 60 inches of snowfall). Surrounding higher elevations receive significantly more precipitation. During the winter months, moist Pacific air masses generally dominate, serving to moderate temperatures and bring abundant humidity, rain, and snow. Colder, continental air masses occasionally drop temperatures significantly, but generally only for shorter periods. The average temperature in December and January are 25 to 30 degrees Fahrenheit (°F).

During summer, the climate is warmer and dryer, with only occasional rain showers and significantly lower humidity and soil moistures. High temperatures of greater than 90°F are common. The average temperature in July is approximately 65 to 70°F. Spring and fall are transition periods.

Due to its valley location along the Kootenai River and downstream of the Libby dam, fog is common in the Kootenai Valley. This effect is most pronounced during winter and in the mornings. Inversions, which trap stagnant air in the valley, are also common. Winds in the Kootenai Valley are generally light, averaging approximately six to seven mph. Prevailing winds are from the southwest (Figure 4-1), but

daily wind direction is significantly affected by temperature differences brought about by the large amount of vertical relief surrounding the area.

4.3 Surface Water Hydrology

The Kootenai Valley and OU4 are contained within the Kootenai drainage basin and the Kootenai River and Fisher River sub-basins. The Kootenai drainage basin is contained in both Canada and the United States encompassing about 18,000 mi^2 or 11,520,000 acres.

The Kootenai River, which transects OU4 (Figure 1-3), has its origins in British Columbia's Kootenay National Park in Canada. From there, it flows 485 miles into northwest Montana and through the towns of Libby and Troy. From there, it flows into northern Idaho, then back into Canada and Kootenay Lake. Ultimately, it joins with the Columbia River. Seventeen miles north of Libby, the river is held back by the Libby Dam, creating a 90-mile long reservoir called Lake Koocanusa which reaches into Canada (LibbyMT.com, 2013).

Major tributaries to the Kootenai River below Libby Dam include the Fisher River (average daily discharge 425 cubic feet per second [cfs] over the last ten years) and the Yaak River (average daily discharge 769 cfs over the last ten years) (USGS.gov, 2014). Kootenai River tributaries are characteristically high-gradient mountain streams with bed material consisting of various mixtures of sand, gravel, rubble, boulders, and drifting amounts of clay and silt, predominantly of glacio-lacustrine origin. Fine materials, due to their instability during periods of high stream discharge, are continually abraded and redeposited as gravel bars, forming braided channels with alternating riffles and pools. Stream flow in unregulated tributaries generally peaks in May and June after the onset of snow melt, then declines to low flows from November through March. Flows also peak with rain-on-snow events. Kootenai Falls, a 200-foot-high waterfall and a natural fish-migration barrier, is located 11 miles downstream of Libby, Montana.

The Kootenai River is the second largest tributary to the Columbia River in terms of runoff volume, third in terms of drainage area. The Kootenai Basin is largely mountainous and dominated by three major ranges. The Rocky Mountain Range and its offshoot, the Flathead Range, constitute the eastern boundary; the Purcell Range roughly bisects it from north to south. The Selkirk and Cabinet ranges mark the western boundary. Elevations reach a maximum of about 12,000 feet with most summit elevations between 6,000 and 7,500 feet. Except for a few areas, the entire watershed is heavily forested (LibbyMT.com, 2013).

As previously stated, Libby has a relatively moist climate with annual valley precipitation slightly over 20 inches. Higher elevations receive significantly more precipitation and account for much of the creek flow. Seasonal fluctuations cause varying levels of runoff and creek flow. Typically, runoff is most significant in spring when snow at higher elevations begins to melt. Summer precipitation does occur; however, typical summer weather is hot and dry and creek flow is moderated by high elevation lakes.

4.4 Geology and Soils

The mountains surrounding the Kootenai Valley are generally composed of folded, faulted, and metamorphosed blocks of Precambrian sedimentary rocks and minor basaltic intrusions. Primary rock types are meta-sedimentary argillites, quartzites, and marbles (Ferreira *et al.* 1992).

The vermiculite deposit at Vermiculite Mountain is located approximately seven miles northwest of Libby in the Rainy Creek drainage. The vermiculite deposit specific to the Libby vermiculite mine is classified as a deposit within a large ultramafic intrusion, such as pyroxenite plutons, which is zoned and cut by syenite or alkalic granite and by carbonatitic rock and pegmatite. The formation of vermiculite and asbestiform amphiboles in the Libby mine deposit has been assessed to be the result of the hydrothermal alteration of augite by high-temperature silica-rich solutions (Larsen and Pardee 1929; Boettcher 1967; Van Gosen *et al.* 2002; Meeker *et al.* 2003).

The Vermiculite Mountain deposit is contained within the Rainy Creek alkaline-ultramafic complex. The Rainy Creek complex is described as the upper portion of a hydrothermally altered alkalic igneous complex composed primarily of magnetite pyroxenite, biotite pyroxenite, and biotitite (Boettcher 1967). The original ultramafic body is an intrusion into the Precambrian Belt Series of northwestern Montana, likely deposited during the early Cretaceous Period (Langer *et al.* 2010). A syenite body southwest of and adjacent to the altered pyroxenite is associated with numerous syenite dikes that cut the pyroxenites. Generally, the Vermiculite Mountain amphiboles are classified as one of three main types including, in order of decreasing abundance, winchite (approximately 84%), richterite (approximately 11%), and tremolite (approximately 6%). Other minerals include magnesio-riebeckite, edenite, and magnesio-arfvedsonite (Meeker *et al.* 2003). Generally, Vermiculite Mountain amphiboles occur as either vein-fillings or replacement of the primary pyroxene of the Rainy Creek complex. Traditionally, amphibole asbestos is believed to occur as a vein-filling mineral formed during hydrothermal or low-temperature alteration. The amphiboles in samples from Vermiculite Mountain appear to be forming as direct replacements of pyroxene through fluid infiltration in microfractures (Meeker *et al.* 2003).

During Pleistocene time, the Kootenai Valley was located beneath glacial Lake Kootenai, which was present as a result of glacial advances from the most recent Pinedale glacial advance more than 16,000 years ago (Langer *et al.* 2010). Glacial advances scoured what is now Vermiculite Mountain and deposited sediments in the Rainy Creek delta of glacial Lake Kootenai. When the glaciers receded, Lake Kootenai gradually drained, resulting in erosion of the Rainy Creek delta and redeposition of glacial sediments down the entire Kootenai River drainage below the elevation of 2,450 feet above mean sea level (AMSL) (Locke and Smith 2004; Smith 2006). Glacial Lake Kootenai finally drained around 11,000 years ago (Ehlers and Gibbard 1996) and the Kootenai River occupied its present channel. The presence of amphibole asbestos in alluvial sediment layers has been demonstrated at several locations in the Kootenai Valley (Adams *et al.* 2010). The USGS (Adams *et al.* 2010) reported the presence of multiple layers of glacial sediments containing amphibole material from Vermiculite Mountain in active gravel quarries near Libby. The USGS also reported that some soils from a sample area within the valley contained a range of 0.004% to 0.047% LA (by mass) (see Section 3.15).

The sequence of events that occurred as Pleistocene glaciation waned and ice receded to the north includes deposition of lacustrine and glacial outwash sediments sourced from multiple locations, including the area of Vermiculite Mountain, as well as locations to the south, southeast, and north of the Kootenai Valley (Langer *et al.* 2010). Amphibole asbestos eroded by glaciation was deposited as glacial outwash in the vicinity of Rainy Creek and as lacustrine sediments in nearby areas of glacial Lake Kootenai. Additionally, some of this sediment was dispersed more broadly in downstream locations during erosion and redeposition associated with changing lake levels as the ice receded and temporarily re-advanced. Much of the glacial outwash and lacustrine sediments observed in the Kootenai Valley were derived from locations other than Vermiculite Mountain. For example, sediment sources in the Libby area other than Vermiculite Mountain include Pipe Creek and Quartz Creek north of Libby, as well as sources south and southeast of Libby.

It is possible that large amounts of material containing amphibole asbestos were eroded from Vermiculite Mountain during Pleistocene glaciation and this material was subsequently deposited over a broad area through deposition of glacial outwash and lacustrine sediments. Sediment samples from glacial deposits analyzed by Langer *et al.* (2010) show that Pleistocene glaciation likely resulted in amphibole asbestos from Vermiculite Mountain being deposited in lacustrine sediments in glacial Lake Kootenai and re-deposited during a re-advance of the Purcell Trench Glacier lobe. Two thin, discrete lake bottom deposits have been determined to contain LA-bearing sediments but these layers are covered in most places with more than 30 meters of other fine-grained sediments that do not contain LA from Vermiculite Mountain (Langer *et al.* 2010). The distribution of lacustrine sediment layers that potentially contain LA from Vermiculite Mountain was described in Langer *et al.* (2010). Ongoing erosion of the lacustrine sediment exposures, as well as disturbance of sediments by human activity, likely resulted in additional dispersal of glacial deposits that potentially contain amphibole asbestos.

Some soils in the Kootenai Valley have formed in lacustrine sediments, glacial till, loess, and loess that has been influenced by volcanic ash. The sediments and till are largely derived from the pre-Cambrian sedimentary rocks. Much of the soil within the Libby and Troy communities has been modified by residential construction, industrial operations, and residential activities. These modifications include soil disturbance during construction, road building, railroad operations, gardening, incorporating vermiculite into the soil, and other activities.

The remnant lacustrine sediment terraces that surround Libby and Troy generally have a fine-silty textured surface layer and are underlain by silt loam and clay loam texture sediments (U.S. Department of Agriculture [USDA] 1995). The fine-textured surface layers have developed directly from loess, or from mixtures of loess and glacial deposited materials, including lacustrine sediments. The loess in the Kootenai Valley has generally been influenced by volcanic ash depositions. The primary soil type in Libby (USDA soil unit 103) has developed in alluvial deposits and has a surface layer of gravelly silt loam. This soil is underlain by stratified alluvial deposits of sand, silt, and gravel (USDA 1995). The main soil type in Troy (USDA soil unit 108) developed on lacustrine and glacial outwash terraces and has a silt loam surface texture.

X-ray powder diffraction (XRD) analyses by the USGS of shallow, subsurface soil from more than 10 sites in the Libby area show that it is composed of major (greater than 20%) quartz, minor (5% to 20%) muscovite (or illite) and albitic feldspar; and trace (less than 5%) orthoclase, clinoclore, non-fibrous amphibole (likely magnesio-hornblende), calcite, amorphous material (probably organic), and possible pyrite and hematite. Other minerals are likely present at levels below 0.5% and are generally not detectable by routine XRD analysis. These mineral components represent the average components for the area and likely vary to some extent depending on local conditions. Surface soil contains the above components with the addition of more organic material (Van Gosen *et al.* 2002).

4.5 Hydrogeology

The Libby basin is hydrologically bound to the west by the pre-Cambrian bedrock, to the north by the Kootenai River and to the east by Libby Creek. The southern boundary of the basin extends under the high terrace of glacial lake bed sediments and with the alluvium of Libby Creek (Woodward-Clyde Consultants 1988).

The sediments overlying bedrock in the vicinity of the City of Libby are of glacial, glaciofluvial, or alluvial origins. The Libby Site stratigraphy is characterized by lenses of interbedded units consisting of gravels, sands, and silty to clayey gravels and sands. These units are the result of numerous episodes of alluvial and glacial erosion and deposition.

Types of depositional environments likely to have existed in the Kootenai Valley include braided stream, overbank, splay, point bar, till, moraine, outwash, loess (aeolian), channel, and lacustrine. These environments moved in time and space, occurred contemporaneously, cancelled each other out (by erosion) and varied drastically in the level of energy and capacity to sort the available clastic material (Woodward-Clyde Consultants 1988).

4.6 Demography and Land Use

Based on population estimates from 2012 (United States Census Bureau, 2013), approximately 2,600 people reside within the city limits of Libby, and approximately 10,000 people reside in the general area of Libby (zip code 59923), which includes the populated areas outside the city limits. Approximately 1,000 people reside within the city limits of Troy.

Some notable trends and statistics are:

- **Age**. As of the 2010 census, the median age of residents of Lincoln County is approximately 49 years, which is higher than the median age for the state (38 years). Approximately 11.6% of residents are under the age of 18 (United States Census Bureau, 2013).
- **Education**. Approximately 13% of Lincoln County residents 25 years or older do not have a high school diploma, as compared to the state average of 8% (United States Census Bureau, 2013).
- **Household Income**. The median household income was approximately $32,000 based on data collected from 2007 to 2011, among the lowest in Montana and far below the state average ($45,000). Approximately 20% of families live below the poverty level (United States Census Bureau, 2013).
- **Employment**. Unemployment in Lincoln County was estimated to be 11.5% based on data collected from 2007 to 2011. It is one of the highest in the state and is well above the 6.4% state average (United States Census Bureau, 2013). The largest historic employers in Libby, the former vermiculite mine and the former Stimson Lumber Mill, have closed, resulting in the loss of hundreds of jobs over the past several decades.
- **Stability**. Lincoln County's population is relatively stable. For instance, data collected in 2007 to 2011 report that nearly 12% of households reported living in the same housing unit since at least 1970 (United States Census Bureau, 2013). During a health screening conducted by ATSDR in 2000, roughly 74% of those surveyed reported living in Libby area for more than 15 years (ATSDR 2001).

4.7 Ecology

4.7.1 Terrestrial Animals

According to the United States Forest Service, the forested areas surrounding Libby have a great diversity of over 350 species of fish, mammals, birds, reptiles, and amphibians.

Even though there are a variety of animals present in the forested areas surrounding Libby, it is unlikely that many of these animals would be encountered in developed areas that are inhabited by humans and generally free of dense forests.

4.7.2 Terrestrial Plants

Libby and the surrounding area exhibit tree and grass plant species that are dominant within the Kootenai National Forest. Data for the Kootenai National Forest indicate Douglas fir forest type is the most common, covering nearly 35% of the National Forest land area. Next in abundance are the lodgepole pine forest and spruce-fir forest types at 17% each, and the western larch forest type at 11%. Other tree species reported in the area are the Black Cottonwood (*Populus trichocarpa*), Quaking Aspen (*Populus tremuloides*), Western Paper Birch (*Betula papyrifera var. occidentalis*) and Pacific Yew (*Taxus brevifolia*) (USDAFSR1 2008).

4.7.3 Presence of Threatened, Endangered, and Protected Species

Threatened, endangered, and protected species that have been observed within OU4 include grizzly bear, Canada lynx, and bald eagle[12]. All of these animals have either been observed or have a likely possibility to be encountered in areas of OU4.

While only about 30-40 grizzly bears exist on the surrounding Kootenai National Forest, these bears have been observed within areas of OU4. The population of Canada lynx in the surrounding OU4 forest is currently being studied. Bald eagles have been seen throughout the Libby Site[13].

---

[12] http://www.fs.fed.us/r1/kootenai/resources/wildlife/wildlife.shtml

[13] http://www.fs.fed.us/r1/kootenai/resources/wildlife/wildlife.shtml

Section 5

Nature and Extent of Contamination

This section summarizes the nature and extent of LA in OU4 and is organized to present results for each of the contaminated media of potential concern discussed in Section 3. Because conditions at the Libby Site are continually changing due to removal activities, the data summaries presented below exclude contamination already addressed during removals and presents data that represent the current status of OU4 (as of the end of the 2013 calendar year) to the extent possible. A property where a removal action has been completed is referred to as "post-removal." Partial removal actions are treated similarly to a property where no removal action has taken place and all results are considered present condition.

5.1 Indoor Air

It is not possible to estimate the remaining concentration of LA in indoor air based solely on whether or when a removal action has been completed, the levels of LA in indoor source materials (e.g. dust), or the characteristics/history of the property. However, indoor air measured during indoor ABS activities (at post-removal properties or properties not requiring a removal) reveals concentrations of total LA ranging from 0.000030 to 0.033 s/cc for air under passive conditions and 0.00017 to 0.050 s/cc for air under active conditions as presented in Section 3.14.

5.2 Outdoor Air

5.2.1 Ambient Air

Data collected during the Ambient Air program from 2006 to present (as presented in Section 3.10) indicate that recent ambient air levels have remained relatively constant over time with detected total LA concentrations in the community ranging from 0.000035 s/cc to 0.00053 s/cc and detected concentrations of 0.000031 s/cc to 0.0027 s/cc near transportation corridors and removal activities.

5.2.2 Outdoor ABS Air

Concentrations of LA in outdoor air near soil-disturbance activities span several orders of magnitude, depending on the intensity of the disturbance scenario, location of the disturbance, level of LA in the disturbed soil, and soil conditions (e.g., moisture content, vegetative cover). Detected total LA concentrations range from 0.00011 s/cc to 58 s/cc in outdoor ABS air for properties in a post-removal condition as presented in Section 3.14. Disturbance activities ranked as "high intensity" (e.g., outdoor ABS performed in 2007 and 2008) resulted in higher levels of total LA in outdoor ABS air, whereas activities ranked as "typical intensity" (e.g., outdoor ABS performed in 2010) resulted in lower levels of total LA in outdoor ABS Air. In general, outdoor ABS air concentrations tended to increase as LA levels in the disturbed soil increased.

5.3 Vermiculite Insulation

Based on the results of the Phase 1 investigation, *Technical Memorandum 2, Occurrence of Asbestos in Libby Vermiculite Insulation* (SRC 2002) (hereafter referred to as Tech Memo 2) was written to assess the reliability of the assumption that all samples of vermiculite insulation should be considered a potential source of LA. The findings of Tech Memo 2 included the following:

- It is reasonable and appropriate to assume that vermiculite insulation at the Libby Site is a probable source of LA, and that individual analysis of each sample for vermiculite insulation is not necessary or cost effective for making decisions regarding the potential risk from this material at the Libby Site.
- There is not a clear spatial pattern, either for the occurrence of vermiculite insulation or for the level of LA reported in the vermiculite insulation.

Several reports have been written summarizing the estimated content of asbestos content in vermiculite from the mine to be from one to over 6% asbestos (Chatfield 2001, EPA 2000c, Versar, Inc. 2003).

Because of the findings presented in Tech Memo 2, sampling vermiculite insulation for determining the concentration of LA is not required. Therefore, the extent of vermiculite insulation in accessible areas is not fully characterized in OU4 because some properties have not been completely characterized. These properties will be investigated in the future so that the extent of any vermiculite insulation requiring removal action can be determined.

The extent of vermiculite insulation in walls at properties located within OU4 has not been fully characterized. The majority of properties were inspected as part of the CSS during the 2002 and 2003 field seasons; however, there was not sufficient time during that period to inspect every property. Between 2004 and 2006, CSS investigations were only performed on a limited basis, and there are approximately 450 properties requiring an initial contamination assessment. Additionally, approximately 400 properties refused participation in the CSS or were unable to be contacted after five attempts. Additionally, properties may not be fully characterized because of the limitations of inspecting contained spaces. In following the removal criteria, accessible vermiculite insulation has been the focus of investigations, design activities, and removal actions. Intrusive methods (e.g., drilling, scoping) are seldom used to characterize vermiculite insulation in walls. Therefore, the number of properties where vermiculite insulation could be identified in walls is difficult to estimate.

5.4 Bulk Materials

The extent of LA-containing bulk materials at properties located within OU4 has not been fully characterized. This is because of the incompletely characterized properties, as discussed in Section 8.1.5. These properties may be investigated in the future during the remedial phase so that any additional LA-containing bulk material and/or required remedial action can be determined.

5.5 Indoor Dust

Most properties with dust samples that have had detectable levels of total LA above 5,000 s/cm^2 have had an interior cleaning. Properties for which an interior cleaning has not been performed have total LA detected in dust ranging up to 113,000 s/cm^2. All 13 properties with at least one dust sample $\geq$ 5,000 s/cm^2 have been placed in the queue for removal or are being further investigated. The remaining properties where dust samples have been collected with detectable levels of LA are below the action level of 5,000 s/cm^2.

Note that properties where an interior cleaning occurred may contain residual levels of LA in dust if the location of the interior cleaning differed from the area of dust sample collection.

5.6 Surface Soil

LA-contaminated surface soil has been removed during outdoor removal actions at 1,481 properties. Table 5-1 presents a summary what could remain at properties with an outdoor removal during each of the different phases of removal procedures. In general, for properties that have had a removal, the following should be true:

- For SUAs, surface soil conditions should be non-detect for LA by PLM and visible vermiculite should not be present at properties for all properties with removals that took place from 2003 to 2013.
- For NSUAs, surface soil conditions should be non-detect for LA by PLM. Visible vermiculite may remain at properties that had a removal from 2003-2006, but it should not remain for properties that had a removal from 2007-2013.
- For LUAs, surface soil conditions should be non-detect for LA by PLM for removals that took place between 2003 and 2010. Visible vermiculite may remain at properties that had a removal from 2003-2006, but it should not remain for properties that had a removal from 2007-2010. For LUAs at properties that had a removal from 2011 to 2013, surface soil conditions should range from non-detect to <1% LA and may or may not contain low levels of visible vermiculite.

Table 5-1 also shows what conditions could be present at properties that have never had a removal, but have been investigated. As seen, there should not be levels of LA that are ≥1% in any use area type and visible vermiculite should not be present in SUAs. There are approximately 3,500 properties where a removal has not taken place, but soil samples have been collected. Surface soil conditions at these properties have LA concentrations that range from non-detect up to 3% by PLM-VE. Visible vermiculite has been observed at approximately 20% of the properties (based on both a qualitative and quantitative evaluation). All properties with at least one primary removal trigger met are in queue for future removal actions.

5.7 Subsurface Soil

A limited amount of subsurface soil has been removed during outdoor removal actions because the clearance criteria allow for soils <1% LA to remain at depth (maximum depth of 36 inches). Detectable levels of LA in subsurface soil remains at 567 post-removal properties.

On occasion, when property-specific conditions did not allow for additional excavation to the prescribed maximum depth of 36 inches, or a deeper maximum excavation depth was prescribed and/or achieved, subsurface soils may contain levels of LA ≥1%. Approximately 25 properties contain ≥1% LA in subsurface soils.

5.8 Sediment

Although the final OU4 NPL boundary is yet to be determined, information regarding LA levels in sediments in the Libby vicinity was gathered and presented in Section 3.22 of this report. This investigation revealed that LA has been detected at trace levels to <1% in sediment (from various tributaries and the Kootenai River).

5.9 Surface Water

As with sediment, information was gathered regarding LA levels in surface water from various tributaries and the Kootenai River and presented in Section 3.22 of this report. Total LA was detected at levels ranging from 0.022 to 0.1 MFL. LA > 10 µm was detected at levels ranging from 0.049 to 0.05 MFL.

5.10 Groundwater

A total of 62 groundwater samples have been collected at OU4. The majority of the samples (N = 55) have been collected from the Lincoln County Landfill as part of the semiannual groundwater monitoring activities, while the remaining seven samples were collected from private residences.

Of the 62 samples collected, 3 samples from the Lincoln County Landfill reported detectable total LA with concentrations ranging from 0.0026 to 0.088 MFL. One sample collected from a residence reported one total LA structure, but the concentration of total LA in the sample is unknown due to incomplete analytical information. No samples had LA structures detected that were > 10 µm.

This data set, along with information regarding LA levels in surface water, does not indicate that levels of LA in water are of concern. Therefore additional investigation is not warranted.

5.11 Porewater

Porewater was collected from the same locations as surface water and sediment in the tributaries of the Kootenai River as well as three additional locations. Total LA was detected in one sample at 0.30 MFL as presented in Section 3.29.

5.12 Tree Bark and Duff in the Forest

Tree bark and duff samples were collected from within a two-mile buffer extending beyond the current NPL boundary located east of Kootenai Falls as presented in Section 3.21. Concentrations of LA range from 0.0045 to 2.4 Ms/cm^2 in tree bark and from 0.25 to 20 Ms/g in duff.

5.13 Tissue

Data regarding LA levels in tissue are not available for OU4, fish tissue and game samples have only been collected from OU3. It may be practical to assume that levels in tissue associated with OU4 are lower than OU3 because levels of LA in source materials (surface water, sediment, and soil) are higher in OU3 than in OU4. All game samples were non-detect for LA and detected concentrations of total LA in fish ranged from 9,400 to 6,400,000 s/g ww as presented in Section 3.28.

Section 6

Contaminant Fate and Transport

Evaluation of fate and transport of contaminants is based on results of site physical characteristics, source characteristics, and extent of contamination investigations. This section provides a discussion of the important factors involved in fate and transport of LA in OU4.

6.1 Releases to the Environment

Asbestos occurs naturally in the environment and may be released to water and air from erosion and the weathering of natural deposits of asbestos-bearing rocks. However, asbestos is more likely to be released to the environment when these natural deposits are disturbed, such as during mining operations. Asbestos is released to the environment from the crushing, screening, and milling of ore, the processing of asbestos products, the use of asbestos-containing materials, and the transport and disposal of asbestos-containing wastes (ATSDR 2001).

6.2 Transport and Deposition

Once asbestos fibers enter the environment, from either a natural or artificial sources, they tend to settle out of the air or water and deposit onto soil and sediment (EPA 1979; Millette 1979). Asbestos fibers can be re-suspended into the air or water following soil and sediment disturbances. The rate at which asbestos particles settle out of the air or water depends on their size. Jaenicke (1980) reported that the residence time for a particle to remain airborne is shortest for the smallest particles (0.001 µm in diameter) and largest particles (100 µm in diameter), and greatest for particles ranging from 0.1-1 µm in diameter. Fibers in this size range could be transported long distances in air. Thin asbestos fibers could remain airborne for hours or even days before settling (Webber *et al*. 2006).

In water, asbestos fibers may also travel long distances from the point of origin, depending on the surface chemistry and detailed mineralogy of the fiber (EPA 1979). For example, tailings containing asbestos from taconite mining were released into Lake Superior and asbestos fibers were detected in the drinking water of Duluth, Minnesota, about 75 miles away from the point source (EPA 1979). Studies have shown that asbestos concentrations in surface water near natural chrysotile deposits in California are usually highest during or after rain events, which reflects re-entrainment of asbestos from river sediments and watershed erosion (Webber and Covey 1991). At the Libby Site, surface water monitoring of streams near the mine (OU3) show similar results; LA concentrations in water tend to vary seasonally, with the highest concentrations reported in the spring during periods of runoff. After eroded asbestos-contaminated soils enter the water, asbestos fibers will remain suspended in the water column even after soil particles have settled. Pilot studies to evaluate methods for concentrating LA fibers in soil using water elutriation demonstrated that most soil particles greater than three µm in size had settled out after three hours, while the asbestos fibers remained in suspension (TechLaw, Inc. 2011). Fiber interaction with natural organic matter may increase their precipitation (ATSDR 2001; EPA 1979). Studies have shown that asbestos fibers in water will adhere to algae, perhaps due to the positive surface charge of the fibers, which results in clumping and increased settling (Webber and Covey 1991). Because there may be a range of asbestos fiber sizes in water, and settling time differs by size, there may be a vertical distribution of asbestos fibers in large bodies of water (Chatfield and Dillon 1983). Even after settling, asbestos fibers in sediment can be re-entrained into water following sediment disturbances.

In soils, asbestos will tend to be retained at or near the surface. Movement of asbestos fibers through soils or from soil to surface water occurs during runoff or erosion. Asbestos fibers in soil are fairly immobile, and fibers less than two µm in diameter will tend to move at the same rate as clays (i.e., about 1-10 centimeters per 3,000-40,000 years) (EPA 1979). Asbestos fibers in soil can become suspended into the air by disturbing the contaminated soil. The releasability of asbestos from soil to air depends upon many factors, including the soil moisture content (drier conditions tend to increase releasability), vegetation coverage and condition (lush plant cover will tend to decrease releasability), and the intensity of the disturbance activity (higher intensity activities will yield higher releases).

Studies have also shown that asbestos fibers may also settle onto the outer surface of trees (bark) and become a reservoir for potential asbestos exposure (Ward *et al.* 2006; 2012). As described in Section 3.21, extensive data on LA levels on the bark surface of trees has been collected in the forested area near the mine site and along the NPL boundary (EPA 2013g). These data showed that tree bark surface loading levels of LA tended to be highest on trees collected closest to the mine (within about 3-4 miles), but fibers were also detected on trees located even 13 miles from the mine site (EPA 2013g). Asbestos fibers on the bark surface can become re-suspended to air following bark disturbances, such as during logging operations. Studies have also shown that asbestos fibers can become concentrated in ash following the burning of asbestos-contaminated wood (see Section 3.24) (EPA 2013j; Ward *et al.* 2009), which itself can become a source of potential exposure.

Lastly, asbestos can be suspended into indoor air when source material (insulation, dust, carpets, etc.) is disturbed by cleaning, renovation, or other general disruption.

6.3 Transformation and Degradation in the Environment

Asbestos fibers are non-volatile and insoluble. They are transported and distributed by air and water and tend to persist under typical environmental conditions (ATSDR 2001). In general, asbestos is exceptionally resistant to thermal degradation and chemical attack. However, there are differences in the ability of different types of asbestos to persist in the environment. For instance, chrysotile asbestos is expected to degrade more readily than amphibole asbestos under certain environmental conditions (e.g., acidic environments) (ATSDR 2001). Possible transformation and degradation in are discussed for each environmental medium in the following subsections.

Air: Asbestos particles are not known to undergo any significant transformation or degradation in air (ATSDR 2001).

Water: Asbestos fibers are relatively stable in water and are not prone to significant chemical or biological degradation. However, some asbestos fibers may undergo chemical alteration and adsorb additional organic agents. In general, asbestos does not volatilize from water surfaces. In water, at low pH, chrysotile asbestos may undergo some dissolution, as magnesium hydroxide leaches from the outer brucite layer, but amphibole asbestos is expected to persist in aquatic environments virtually unchanged for long periods of time (ATSDR 2001).

Soil: In general, asbestos fibers are not known to undergo significant transformation or degradation in soil (ATSDR 2001).

Bulk ACM: Bulk ACM is subject to physical degradation through crushing or erosion that can generate fibers that are more mobile than the original material (ATSDR 2001).

Section 7

Risk Assessment

An evaluation of potential exposures to and risks from LA will be included in the site-wide human and ecological risk assessments for the Libby Asbestos Superfund Site. The site-wide risk assessments are stand-alone documents that support the FS and ROD. As such, OU-specific risk assessment reports have not been developed. The *Site-Wide Human Health Risk Assessment* will evaluate potential risks to humans from exposures to LA under a variety of different exposure scenarios, including both indoor and outdoor exposure scenarios that may occur at the Libby Site. Potential risks will be evaluated both alone and across multiple exposure scenarios as part of a cumulative exposure assessment. The *Site-Wide Ecological Risk Assessment* will evaluate potential risks to aquatic and terrestrial ecological receptors from exposures to LA that may be present in the environment at the Libby Site. Refer to the respective site-wide risk assessment reports to provide information on potential exposures and risks from LA to human and ecological receptors.

This page left blank intentionally

Section 8

Summary and Conclusions

This section includes the summary and conclusions related to all data presented in this report and the associated appendices.

8.1 Summary

8.1.1 Background

The main contaminant of concern at the Libby Site is asbestos. The vermiculite deposit seven miles northwest of Libby contains a distinct form of naturally-occurring amphibole asbestos that is comprised of a range of mineral types and morphologies, which is referred to as LA. The term LA refers generally to amphibole materials that originated in the Libby vermiculite deposit, have the ability to form durable, long, and thin structures that are generally respirable, can reasonably be expected to cause disease, and hence are considered the contaminant of concern at the Libby Site.

The Libby vermiculite deposit was mined from the 1920s until 1990. The mine began limited operations in the 1920s and was operated on a larger scale by Grace from approximately 1963 to 1990. While the mine was in operation, it is estimated that the milling process released more than 5,000 pounds of asbestos into the atmosphere every day. In addition to contamination directly related to vermiculite processing operations, waste products and off-specification materials were made available to the general public on a large scale.

Vermiculite products and wastes were used in thousands of private residences, businesses, and public buildings across the Libby Site. Vermiculite insulation, both commercially purchased and/or obtained otherwise, was used at a high rate in Libby buildings. In the course of Superfund investigations, the EPA has encountered vermiculite used as an additive in mortar, plaster, and concrete; as insulation in attic and walls; in soils at depth around septic tanks, tree roots, underground pipe trenches, building foundations; and in surface soils in gardens, yards, driveways, and play areas.

8.1.2 Investigations

In November 1999, the EPA responded to requests from the State of Montana, Lincoln County Health Board to investigate the potential exposure to asbestos related to the former mine operations and vermiculite processing. These initial investigations revealed two significant findings:

- There were a large number of current and historic cases of asbestos related diseases centered around Libby, Montana.
- The likelihood was high that significant amounts of asbestos-contaminated vermiculite were present in and around Libby.

These findings led the EPA to initiate a larger scale rapid investigation in December 1999 (Phase 1 investigation discussed in Section 3.1) to meet the following goals:

- Obtain information on airborne asbestos levels in Libby in order to judge whether time-critical intervention is needed to protect public health.

- Obtain data on asbestos levels in potential source materials (at the Export Plant and Screening Plant), and identify the most appropriate analytical methods to screen and quantify asbestos in source materials.

Additional investigations, detailed in Section 3, from 2000 to present have been conducted to determine the nature and extent of LA-containing source materials in OU4. LA has been observed in all media investigated. Within OU4, the location of LA and LA-containing source materials does not appear to have an observable spatial pattern of concentrations; rather contamination is specific to the history of each property.

8.1.3 Property Category Status

As of October 2013, information for 6,716 OU4 properties is in Response Manager. A summary of the removal status of each of these properties is presented below:

- 1,504 total properties are categorized as **Response Action Required,** which may either be an investigation or a removal. Of these properties, 1,240 require an investigation and 264 require a removal.
- 2,646 total properties are categorized as **Investigation Completed** – No Further Action (i.e., no emergency response action levels or other conditions suggesting contamination was observed or detected).
- 1,886 total properties are categorized as **Removal Completed** with no further action required.
- 290 total properties do not require an investigation because the property is all non-use area or otherwise does not require inspection (e.g., fill pits, entirely paved).
- 388 total properties have refused access to the property. These properties may fall into the categories listed above (may require an investigation and/or removal or not require an investigation due to the property use type).

These numbers are based on the visual presence of vermiculite in an attic, living space, SUA or NSUA and combined with the analytical results for soil and dust samples collected during Phase 1, CSS, Post Cleanup Evaluation, SQAPP, PDI/GPI, and residential ABS. It is important to reiterate that prior to Fall 2006, no formalized approach to inspect or quantify vermiculite in soil existed.

8.1.4 Removal Status

Between 2001 and October 2013, a total of 1,886 properties have had removals completed according to data available in Response Manager. The following table shows the total amount of removals, by removal type.

Type of Removal Activity	Number of Properties
Indoor	250
Outdoor	966
Combination (e.g., Indoor and Outdoor or Outdoor and Demolition)	692
Total	1,908

8.1.5 Potential Data Gaps

8.1.5.1 Uncharacterized Properties

As discussed in Section 3.3, the majority of properties were inspected as part of the CSS during the 2002 and 2003 field seasons; however, there was not sufficient time during that period to inspect every property in Libby. Between 2004 and 2006, CSS investigations were only performed on a limited basis, and there are approximately 450 properties requiring an initial contamination assessment. Additionally, approximately 400 properties refused participation in the CSS or were unable to be contacted after five attempts. Since this time period, the EPA has continued to attempt to characterized properties within OU4 through the GPI process, but has not been successful for approximately 338 properties.

8.1.5.2 Partially-Characterized Properties

As the EPA responds to ERS requests at properties without initial contamination assessments, only those areas of immediate concern are addressed. That is, a full indoor and outdoor site characterization is not conducted at properties where a homeowner intends to remodel only a specific area. Instead, an inspection is performed to the extent that will allow the homeowner to safely execute their plans while mitigating risks of exposure and cross-contamination, and the remainder of the property will be inspected when full-scale contamination assessments are resumed.

An additional source of partially-characterized properties stems from CSS inspections where the owners denied access to a portion of the property, usually the interior of the house. At the conclusion of the CSS, the attics of approximately 50 properties were not inspected at the owner's request or because the area was inaccessible.

8.1.5.3 Properties Outside Current OU4 NPL Boundary

The initial OU4 NPL boundary was established in 2002 as a tool to guide sampling activities. Properties within the boundary were the focus of investigations, but a limited number of properties outside the established boundary have also been investigated. Investigations of properties outside the established boundary have generally been in response to homeowner inquiries or reports of contamination.

The majority of areas excluded from OU4 are undeveloped and uninhabited. However, two areas of the Kootenai Valley that are well established are along U.S. Highway 2 (south of Libby) and Pipe Creek Road (north of Libby) and could possibly be included in the final OU4 NPL boundary. If these areas are included, additional properties would require a SI.

8.1.5.4 Visible Vermiculite in Soils

Properties were inspected for visible vermiculite during the CSS, before a formalized approach for identification and quantification of vermiculite in soils was implemented at the Libby Site. Visible vermiculite was inconsistently noted on a qualitative basis. Beginning in fall 2006, inspections for visible vermiculite were standardized by implementing CDM-LIBBY-06, *Site-Specific SOP for Semi-Quantitative Visual Estimation of Vermiculite in Soils at Residential and Commercial Properties* and quantitatively estimated. Because of the qualitative method for recording visible vermiculite prior to the fall of 2006, very limited data is available on the nature and extent of vermiculite in outdoor soils that remains at OU4 properties.

8.1.5.5 Potential Exposure Pathways

The site-wide risk assessments will attempt to identify any potential exposure pathways that have not been evaluated as part of this RI report. At this time, there are no obvious data gaps for pathways not evaluated due to the extensive sampling that has occurred for the numerous investigations in OU4.

8.2 Conclusions

LA has been observed in every media sampled at the Libby Site. Since 2000, the EPA has performed numerous indoor and outdoor removals to address LA contamination in OU4; however, LA-containing source materials are still present under current conditions. Conclusions regarding risk associated with the levels observed will be provided in site-wide risk assessments to be completed separate from this RI report. The information provided in these risk assessments will be used to develop a FS that will contain multiple preliminary remedial action objectives. ARARs represent the Federal and State standards, requirements, criteria, or limitations that must be met by any Superfund remedial action.

Section 9

References

Adams, D.T., Langer, W.H., Hoefen, T.M., Van Gosen, B.F., and Meeker, G.P., 2010, Examination of Libby, Montana, fill material for background levels of amphibole from the Rainy Creek complex using scanning electron microscopy and X-ray microanalysis: U.S. Geological Survey Open-File Report 2010-1056, 10 p.

Amandus, H.E., and Wheeler, R. 1987. The Morbidity and Mortality of Vermiculite Miners and Millers Exposed to Tremolite-Actinolite: Part II. Mortality. Am. J. Ind. Med. 11:15-26.

Amandus, H.E., Wheeler, P.E., Jankovic, J., and Tucker, J. 1987. The Morbidity and Mortality of Vermiculite Miners and Millers Exposed to Tremolite-Actinolite: Part I. Exposure Estimates. Am J Ind. Med 11:1-14.

Antao, V.C.,Larson, T.C., Horton, D.K. 2012. Libby vermiculite exposure and risk of developing asbestos-related lung and pleural diseases. Current Opinion in Pulmonary Medicine 18(2):161-167.

ASTM. 2009. ASTM D5755-03. Standard Test Method for Microvacuum Sampling and Indirect Analysis of Dust by Transmission Electron Microscopy for Asbestos Structure Number Surface Loading.

ATSDR. 2001. Year 2000 Medical Testing of Individuals Potentially Exposed to Asbestiform Minerals Associated with Vermiculite in Libby, Montana. August 23. A Report to the Community.

_____. 2002a. Review of Asbestos-Related Abnormalities Among a Group of Patients from Libby, Montana. August.

_____. 2002b. Mortality in Libby, Montana, 1979 to 1998. August 8.

_____. 2003. Public Health Assessment for the Libby Asbestos NPL Site. May 15.

Boettcher, A.L. 1967. The Rainy Creek alkaline—Ultramafic igneous complex near Libby, Montana, Part I—Ultramafic rocks and fenite. Journal of Geology 75:526–553.

CB&I. 2014. Annual QA/QC Summary Report (2010-2012) for Task Order 2019 Auality Assurance (QA) Support for the Libby Asbestos Site. In preparation (2014).

CDM Smith (formerly CDM). 2000. Removal Action Sampling and Analysis Plan for Confirmation Soil Sampling of Soil and Perimeter and Personal Sampling of Air for Asbestos. September.

_____. 2001. Final Removal Action Work Plan for Kootenai Bluff Property. August 14.

_____. 2002a. Final Sampling and Analysis Plan, Remedial Investigation, Contaminant Screening Study, Libby Asbestos Site, Operable Unit 4, Libby, Montana. April.

_____. 2002b. Final Sampling and Analysis Plan Addendum for the Cemetery Park Ball Fields. July.

_____. 2002c. Final Sampling and Analysis Plan Addendum for the Libby Drive-In Theater. September.

_____. 2002d. Property-Specific Sampling and Analysis Plan for Air and Dust Sampling for Stimson Lumber Company, Libby Asbestos Project. August 23.

_____. 2003a. Final Sampling and Analysis Plan, Remedial Investigation, Contaminant Screening Study, Libby Asbestos Site, Operable Unit 4, Libby, Montana. Revision 1. May 16.

_____. 2003b. Final Sampling and Analysis Plan, Remedial Investigation. May 19.

_____. 2003c. Final Sampling and Analysis Plan Addendum for J. Neils Park and State Highway 37, Contaminant Screening Study, Libby Asbestos Site, Operable Unit 4, Libby, Montana. July.

_____. 2003d. Final Sampling and Analysis Plan Addendum for the City of Libby Alley Investigation, Contaminant Screening Study, Libby Asbestos Site. Operable Unit 4. Libby, Montana. October 14.

_____. 2003e. Final Sampling and Analysis Plan Addendum, Post Cleanup Evaluation Sampling, Contaminant Screening Study, Libby Asbestos Site. Operable Unit 4. Libby, Montana. December.

_____. 2003f. Final Draft Action Sampling and Analysis Plan for Libby Asbestos Site, Libby, Montana. November

_____. 2003g. Final Draft Response Action Work Plan, Libby Asbestos Project, Libby, Montana. November.

_____. 2003h. Final Draft Pre-Design Inspection Activities Work Plan. November.

_____. 2003i. Final Dust Sampling Protocol for Pre-Design Investigations, Libby Asbestos Project. November.

_____. 2004a. Final Sampling and Analysis Plan Addendum for the Cabinet View Country Club, Contaminant Screening Study, Libby Asbestos Site. Operable Unit 4. Libby, Montana. August 16.

_____. 2004b. Compost Stockpile Area Sampling Memorandum, Lincoln County Landfill, Libby, Montana. September 16.

_____. 2004c. Final Post Cleanup Evaluation Sampling Technical Memorandum, Contaminant Screening Study, Libby Asbestos Site. Operable Unit 4. Libby, Montana. September.

_____. 2004d. Draft Final Ambient and Perimeter Air Monitoring Summary for the Period 2000–2003 Technical Memorandum, Libby, Montana. May.

_____. 2005a. Final Summary Report for the Cemetery Park Ball Fields, Contaminant Screening Study, Libby Asbestos Site, Operable Unit 4, Libby, Montana. November.

_____. 2005b. Final Summary Report for the Libby Drive-In Theater, Contaminant Screening Study, Libby Asbestos Site. Operable Unit 4. Libby, Montana. December.

_____. 2005c. Final Summary Report for the Cabinet View Country Club, Contaminant Screening Study, Libby Asbestos Site. Operable Unit 4. Libby, Montana. April 21.

_____. 2005d. Final Summary Report for the J. Neils Park and Montana State Highway 37 Investigations, Revision 1, Contaminant Screening Study, Libby Asbestos Site, Operable Unit 4, Libby, Montana. November.

_____. 2005e. Final Summary Report for the City of Libby Alley Investigation, Contaminant Screening Study, Libby Asbestos Site, Operable Unit 4, Libby, Montana. November.

_____. 2005f. Johnston Acres Field Investigation Memorandum. January 7.

_____. 2005g. Draft Summary Report for the Johnston Acres Field Investigation. August.

_____. 2005h. Draft Sampling and Analysis Plan Addendum for the Former Concrete Plant Investigation, Contaminant Screening Study, Libby Asbestos Site. Operable Unit 4. Libby, Montana. December.

_____. 2005i. Draft Sampling and Analysis Plan Addendum for the Former Landfill Site Investigation, Contaminant Screening Study, Libby Asbestos Site. Operable Unit 4. Libby, Montana. December.

_____. 2005j. Small Scale Vermiculite Removal Memorandum. April 12.

_____. 2005k. CDM Oversight Activities Conducted at the St. John's Hospital Helipad Property in Libby, Montana Memorandum. December 16.

_____. 2006a. Comprehensive Site Health and Safety Program, Libby, Montana, Revision 5. December.

_____. 2006b. Contaminant Screening Study, Final Technical Memorandum, Libby Asbestos Site, Operable Unit 4, Libby, Montana. January 31.

_____. 2006c. Draft Summary Report for the St. John's Lutheran Hospital Rehabilitation Center and Helipad Field, Contaminant Screening Study, Libby Asbestos Site. Operable Unit 4. Libby, Montana. February.

_____. 2006d. Final Sampling and Analysis Plan for Outdoor Ambient Air Monitoring at the Libby Asbestos Site, Operable Unit 4, Libby, Montana. September 28.

_____. 2006e. Final Sampling and Analysis Plan for Outdoor Ambient Air Monitoring at the Libby Asbestos Site, Revision 1, Operable Unit 4, Libby, Montana. December 7.

_____. 2007a. Dust Composite Sampling Pilot Study, Libby Asbestos Project. May 16.

_____. 2007b. Response Action Work Plan, Revision 1, Libby Asbestos Project, Libby, Montana. April

_____. 2008a. Lincoln County Class IV Asbestos Landfill Operations Plan, Revision 2. February.

_____. 2008b. Final Data Summary Report for Operable Unit 2, Former Screening Plant and Surrounding Area. May 13.

_____. 2008c. Final Technical Memorandum, Libby Public School Inspection, Libby, Montana. June 17.

_____. 2008d. Libby Schools Visual Vermiculite Investigation Summary Memorandum. July 28.

_____. 2008e. Final Sampling Summary Report 2007 Investigations Operable Unit 5 – Former Stimson Lumber Company. July 25.

_____. 2008g. Response Action Work Plan, Revision 2, with modification, Libby Asbestos Project, Libby, Montana. February.

_____. 2008h. Response Action Sampling and Analysis Plan, Revision 1, Libby Asbestos Project, Libby, Montana. April 9.

_____. 2008i. Addendum to the Response Action Work Plan Flower Creek Removal Plan Libby, Montana. June 20.

_____. 2008j. Addendum to the Response Action Work Plan Granite Creek Removal Plan Libby, Montana. July 18.

_____. 2009a. Wise Property and Kootenai Bluffs Subdivision Summary Memorandum. September 4.

_____. 2009b. Libby Public Schools – Stationary Air Sampling Investigation Summary Memorandum. May 15.

_____. 2009c. Final Sampling and Analysis Plan for Activity-Based Outdoor Air Exposures at Libby Public Schools. July 17.

_____. 2009d. Environmental Resource Specialist Plan, Libby Asbestos Project. April.

_____. 2009e. Addendum to the Response Action Work Plan Pipe Creek Removal Plan Libby, Montana. June 5.

_____. 2009f. Addendum to the Response Action Work Plan Libby Creek Removal Plan Libby, Montana. June 5.

_____. 2010a. Technical Memorandum (original), OU4 Outdoor Ambient Air Sampling Program for Libby Asbestos Superfund Site, 2010-2011. October 1.

_____. 2010b. Technical Memorandum, 2010 Libby Public Schools Investigation Plan, Libby asbestos Site, Libby, Montana. June 29.

_____. 2010c. Summary – Pre-design Investigation – Libby Elementary School (formerly Asa Wood) – 700 Idaho Avenue. February 2.

_____. 2011a. Comprehensive Accident Prevention Plan Libby Asbestos Project Libby, Montana. April.

_____. 2011b. Technical Memorandum, Revision 1, OU4 Outdoor Ambient Air Sampling Program for Libby Asbestos Superfund Site, 2011-2012. June 20.

_____. 2011c. Response Action Sampling and Analysis Plan. Revision 2, Libby Asbestos Project, Libby, Montana. June.

CDM Smith. 2012a. Technical Memorandum, Revision 2, OU4 Outdoor Ambient Air Sampling Program Libby Asbestos Superfund Site, for 2012-2013. April 24.

_____. 2012b. Memorandum: OU4 Outdoor ABS Supplemental Analysis Recommendations. Provided to EPA Region 8 from CDM Smith, dated October 3, 2012.

_____. 2012c. Memorandum: 2010 Outdoor ABS Supplemental Analysis Recommendations, Libby Asbestos Superfund Site, Operable Unit 4. Provided to EPA Region 8 from CDM Smith, dated November 6, 2012.

_____. 2012d. Sampling and Analysis Plan: 2011 Miscellaneous Activity-based Sampling, Libby Asbestos Site, Operable Unit 4, Libby, Montana. Revision 2 – June 2012.

_____. 2013a. Technical Memorandum, Revision 1, OU4 Outdoor Ambient Air Sampling Program Libby Asbestos Superfund Site, for 2013-2014. April 9.

_____. 2013b. Technical Memorandum, Libby Asbestos Superfund Site, Outdoor Ambient Air Sampling, Transition to Lincoln County Asbestos Resource Program. September.

_____. 2013c. Response Action Sampling and Analysis Plan. Revision 3, Libby Asbestos Project, Libby, Montana. April.

_____. 2013d. Environmental Resource Specialist Plan Revision 1, Libby Asbestos Project. January.

Chatfield, E. J., and M. J. Dillon. 1983. EPA Method 100.1: Analytical method for determination of asbestos fibers in water. U.S. Environmental Protection Agency, Office of Research and Development, Environmental Research Laboratory. EPA/600/4-83/043. September.

Chatfield, E. J. 2001. Review of Sampling and Analysis of Consumer Garden Products that Contain Vermiculite. EPA 744-R-00-010, August, 2000. Presented at The Vermiculite Association Vermiculite Conference 2001. November 15.

EPA. 1979. *Water-Related Environmental Fate of 129 Priority Pollutants. Volume I*. EPA-440/4 79-029a. Washington, DC, December 1979.

_____. 1987. Appendix A to Subpart E of 40 CFR Part 763. Interim TEM Analytical Methods - Mandatory and Nonmandatory - and Mandatory Section to Determine Completion of Response Actions (AHERA). Final Register 52:41857. October 30.

_____. 1988. Guidance for Conducting Remedial Investigations and Feasibility Studies Under the Comprehensive Environmental Response Compensation and Liability Act, Interim Final. Office of Solid Waste and Emergency Response Directive 9355.3-01. EPA/540/G-89/004. October.

_____. 1993. Method for the Determination of Asbestos in Bulk Building Materials. EPA/600/R-93/116. July 1993.

_____. 1994. EPA 100.2. Determination of Asbestos Structures Over 10mm in Length in Drinking Water. June.

_____. 1999. Sampling and Quality Assurance Project Plan for Libby, Montana Environmental Monitoring for Asbestos (*Phase 1 QAPP*). December 6.

_____. 2000a. Action Memorandum: Request for a Time Critical Removal Action Approval and Exemption from the 12-month, $2-million Statutory Limit at the Libby Asbestos Site- Export Plant and Screening Plant former Processing Areas, Libby, Lincoln County, Montana. May 23.

_____. 2000b. Sampling and Quality Assurance Project Plan, Revision 1, for Libby, Montana Environmental Monitoring for Asbestos (*Phase 1 QAPP*). January 4.

_____. 2000c. Sampling and Analysis of Consumer Garden Products that Contain Vermiculite. EPA-744-R-00-010. August.

_____. 2001a. Action Memorandum Amendment: Request for headquarters approval of a ceiling increase beyond $6 million and a modification to the proposed scope of response for the Time-Critical Removal Action at the Libby Asbestos Site – Libby, Lincoln County, Montana. July 20.

_____. 2001b. Phase 2 Sampling and Quality Assurance Project Plan for Libby, Montana. Environmental Monitoring for Asbestos. Evaluation of Exposure to Airborne Asbestos Fibers During Routine and Special Activities. March 1.

_____. 2002a. Action Memorandum Amendment for the Time Critical Removal Action at the Libby Asbestos Site – Libby, Lincoln County, Montana. May 2.

_____. 2002b. Sampling and Quality Assurance Project Plan for Measurement of Historic Fiber Deposition Rates in Sediment.

_____. 2003a. Quality Assurance Project Plan, Performance Evaluation Study for Analytical Methods in Soil, Part B, Revision 1. January 24.

_____. 2003b. Sampling and Analysis Plan for Indoor Dust for Use at the Libby, Montana Superfund Site. August 7.

_____. 2003c. Draft Final Libby Asbestos Site Residential/Commercial Action Level and Clearance Criteria Technical Memorandum. December 15.

_____. 2005a. Final Supplemental Remedial Investigation Quality Assurance Project Plan. June 24.

_____. 2005b. Sampling and Analysis Plan for Cumulative Inhalation Exposures in Libby, Montana. November 7.

_____. 2005c. General Sampling and Analysis Plan for Assessing Asbestos Release from Building Demolition at the Libby, Montana Superfund Site. May 4.

_____. 2006a. Action Memorandum Amendment Requesting Formal Approval of a Ceiling Increase for the Time-Critical Removal Action at the Libby Asbestos Site – Libby, Lincoln County, Montana. May 15.

_____. 2006b. Action Memorandum Amendment for a Time-Critical Removal Action at the Libby Asbestos Site, OU7, Troy, Montana. June 27.

_____. 2006c. Phase 2 Study Data Summary Report for Libby Montana Environmental Monitoring for Asbestos Evaluation of Exposure to Airborn Asbestos Fibers during Routine and Special Activities., Prepared by USEPA Region 8 with technical assistance from Syracuse Research Corporation. March 2006.

_____. 2006d. General Workplan for Building Demolition at the Libby, Montana, Superfund Site. Revision 1. September.

_____. 2007a. Technical Memo 11: Guidance for Data Reduction for TEM Results for Libby Amphibole in Air and Dust Samples at the Libby Superfund Site. January 2007.

_____. 2007b. Summary Report for Data Collected under the Supplemental Remedial Investigation Quality Assurance Project Plan. October.

_____. 2007c. Sampling and Analysis Plan for Activity-Based Indoor Air Exposures, Operable Unit 4, Libby, Montana, Superfund Site. July 6.

_____. 2007d. Sampling and Analysis Plan for Activity-Based Outdoor Air Exposures, Operable Unit 4, Libby, Montana, Superfund Site. July 6.

_____. 2007e. Phase I Sampling and Analysis Plan for Operable Unit 3, Libby Asbestos Superfund Site. Prepared by the U.S. Environmental Protection Agency with Technical Assistance from Syracuse Research Company. September 26, 2007.

_____. 2007f. General Workplan for Building Demolition at the Libby, Montana, Superfund Site, Revision 2. May 17.

_____. 2008a. Action Memorandum Amendment Request: Approval to Address Amphibole Asbestos Contamination in Certain Creeks for the Time-Critical Removal Action at the Libby Asbestos Site – Libby, Lincoln County, Montana. September 24.

_____. 2008b. Performance Evaluation of Laboratory Methods for the Analysis of Asbestos in Soil at the Libby, Montana Superfund Site. Draft in prepartation. October 2008.

_____. 2008c. Study Design to Pilot Reconnaissance Activities for the Characterization of Geological Sources of Libby Amphibole in Libby Valley Soils. June 9.

_____. 2008d. Final Sampling and Analysis Plan Libby Public Schools - Stationary Air Sample Collection. Prepared by U.S. Department of Transportation and CDM Federal Programs Corporation with Technical Assistance from SRC, Inc. December 5, 2008.

_____. 2009a. Action Memorandum Amendment Request: Approval of a Ceiling Increase for the Time-Critical Removal Action at the Libby Asbestos Site – Libby, Lincoln County, Montana. June 17.

_____. 2009b. Action Memorandum Amendment Requesting Approval to Address Amphibole Asbestos Contamination at the Cabinet View Country Club Golf Course for the Time-Critical Removal Action at the Libby Asbestos Site – Libby, Lincoln County, Montana. August 4.

_____. 2009c. Summary of Outdoor Ambient Air Monitoring for Asbestos at the Libby Asbestos Site, Libby, Montana. October 2006 to June 2008. February 9.

_____. 2009d. Quality Assurance Project Plan: Phase 2 – Evaluation of the Aerosolization of Asbestos and Related Fibers from Bulk Materials. November 4.

_____, 2010a. *Activity-Based Sampling Summary Report, Operable Unit 4, Libby, Montana, Superfund Site.* U.S. Environmental Protection Agency, Region 8, Denver, CO. June 2, 2010.

_____. 2010b. *Sampling and Analysis Plan: Supplemental Activity-based Sampling, Operable Unit 4, Libby Asbestos Superfund Site*. U.S. Environmental Protection Agency, Region 8. June 18, 2010.

_____. 2011a. *Toxicological Review of Libby Amphibole Asbestos*. Submitted to the Scientific Advisory Board (SAB). U.S. Environmental Protection Agency, Washington D.C. EPA/635/R-11/002A. External Review Draft – August.

_____. 2011b. *Sampling and Analysis Plan, 2011 Residential Activity-based Sampling, Libby Asbestos Site, Operable Unit 4.* U.S. Environmental Protection Agency, Region 8. July.

_____. 2011c. *Water Source Identification Study – Phase I, Sampling and Analysis Plan, Libby Asbestos Superfund Site, Libby, Montana.* U.S. Environmental Protection Agency, Region 8. November.

_____. 2011d. Amendment A to Libby Asbestos Site Residential/Commercial Cleanup Action Level and Clearance Criteria Technical Memorandum, Libby Asbestos Project. April.

_____. 2012a. Amendment A to Libby Asbestos Site Residential/Commercial Cleanup Action Level and Clearance Criteria Technical Memorandum, Libby Asbestos Project. March.

_____. 2012b. Amendment A to Libby Asbestos Site Residential/Commercial Cleanup Action Level and Clearance Criteria Technical Memorandum, Libby Asbestos Project. August.

_____. 2012c. *Quality Assurance and Quality Control Summary Report (1999-2009) for the Libby Asbestos Superfund Site*. U.S. Environmental Protection Agency, Region 8. December.

_____. 2012d. *Sampling and Analysis Plan/Quality Assurance Project Plan: Nature and Extent of LA Contamination in the Forest. Libby Asbestos Site, Operable Unit 4*. U.S. Environmental Protection Agency, Region 8. Revision 0 – August 2012

_____. 2012e. *Nature and Extent of LA Contamination in Surface Water and Sediment Sampling and Analysis Plan/Quality Assurance Project Plan Libby Asbestos Superfund Site, Operable Unit 4 Libby, Montana.* May.

_____. 2012f. *Sampling and Analysis Plan/Quality Assurance Project Plan: Wood-Burning Stove Ash Removal Activity-Based Sampling, Libby Asbestos Site, Operable Unit 4.* U.S. Environmental Protection Agency, Region 8. November.

_____. 2012g. *Sampling and Analysis Plan/Quality Assurance Project Plan: Flowerbed Sampling Study, Libby Asbestos Site, Operable Unit 4.* U.S. Environmental Protection Agency, Region 8. August.

_____. 2012h. *Water Source Identification Study – Phase II, Sampling and Analysis Plan/Quality Assurance Project Plan, Libby Asbestos Superfund Site, Libby, Montana.* U.S. Environmental Protection Agency, Region 8. April.

_____. 2012i. *Sampling and Analysis Plan/Quality Assurance Project Plan, Comparative Exposure – Eureka, Helena, Whitefish, Libby Asbestos Superfund Site, Operable Unit 4.* U.S. Environmental Protection Agency, Region 8. Revision 1 - July.

_____. 2012j. *Sampling and Analysis Plan/Quality Assurance Project Plan: Fish and Game Tissue Assessment. Libby Asbestos Site, Operable Unit 4.* U.S. Environmental Protection Agency, Region 8. Revision 1 – October.

_____. 2013a. EPA Data Management Plan Libby Asbestos Superfund Site Versions 1.1. EPA Emergency Response Data Team and EPA Region 8 EPR Data Systems Team. August.

_____. 2013b. *Data Summary Report: 2010 Residential Activity-Based Sampling, Libby Asbestos Superfund Site, Operable Unit 4, Libby, Montana.* U.S. Environmental Protection Agency, Region 8. Working Draft - October.

_____. 2013c. *Data Summary Report: 2011 Residential Activity-Based Sampling, Libby Asbestos Superfund Site, Operable Unit 4, Libby, Montana.* U.S. Environmental Protection Agency, Region 8. Working Draft - May.

_____. 2013d. *Sampling and Analysis Plan/Quality Assurance Project Plan: 2013 Indoor Activity-Based Sampling, Libby Asbestos Superfund Site, Operable Unit 4.* U.S. Environmental Protection Agency, Region 8. February.

_____. 2013e. *Background Soil Summary Report, Libby Asbestos Superfund Site, Libby, Montana.* U.S. Environmental Protection Agency, Region 8. Working draft – June.

_____. 2013f. *Libby Asbestos Superfund Site Operable Unit 3 Data Summary Report: 2007 to 2011*. U.S. Environmental Protection Agency, Region 8. November.

_____. 2013g. *Data Summary Report: Nature and Extent of LA Contamination in the Forest.* U.S. Environmental Protection Agency, Region 8. August.

_____. 2013h. *Data Summary Report: Nature and Extent of LA Contamination in Surface Water and Sediment. Libby Asbestos Superfund Site, Operable Unit 4. Libby, Montana*. U.S. Environmental Protection Agency, Region 8. March.

_____. 2013i. *Data Summary Report: Tradesperson Indoor Air Re-analysis Results, Libby Asbestos Superfund Site, Operable Unit 4, Libby, Montana.* U.S. Environmental Protection Agency, Region 8. October.

_____. 2013j. *Data Summary Report: Wood-burning Stove Ash Removal, Activity Based Sampling, Libby Asbestos Superfund Site, Operable Unit 4, Libby, Montana.* U.S. Environmental Protection Agency, Region 8. August.

_____. 2013k. *Data Summary Report: Water Source Identification Study, Libby Asbestos Superfund Site, Libby, Montana*. U.S. Environmental Protection Agency, Region 8. June.

_____. 2013l. *Data Summary Report: Comparative Exposure Study, Libby Asbestos Superfund Site, Operable Unit 4.* U.S. Environmental Protection Agency, Region 8. July.

_____. 2013m. *Data Summary Report: Fish and Game Tissue Assessment, Libby Asbestos Superfund Site, Libby, Montana.* U.S. Environmental Protection Agency, Region 8. June.

_____. 2013n. *Sampling and Analysis Plan/Quality Assurance Project Plan: Sediment Porewater Study of Kootenai River Tributaries, Libby Asbestos Superfund Site, Operable Unit 4, Libby, Montana.* U.S. Environmental Protection Agency, Region 8. May.

_____. 2013o. *General Property Investigation Sampling and Analysis Pan/Quality Assurance Project Plan. Libby Asbestos Superfund Site, Operable Unit 4.* Libby, Montana. U.S. Environmental Protection Agency, Region 8. April.

_____. 2014a. *Quality Assurance and Quality Control Summary Report 2010-2013.* U.S. Environmental Protection Agency, Region 8. May.

_____. 2014b. *Summary of Outdoor Ambient Air Monitoring for Asbestos at the Libby Asbestos Superfund Site, Libby, Montana, May 2010 to August 2013, Addendum.* U.S. Environmental Protection Agency, Region 8. February.

_____. 2014c. *Data Summary Report: 2013 Indoor Activity-Based Sampling, Libby Asbestos Superfund Site, Operable Unit 4, Libby, Montana.* U.S. Environmental Protection Agency, Region 8. April.

_____. 2014d. *Data Summary Report: Flowerbed Sampling Study, Libby Asbestos Superfund Site, Operable Unit 4. Libby, Montana: Working Draft*. U.S. Environmental Protection Agency, Region 8. March.

_____. 2014e. *Libby Asbestos Superfund Site Operable Unit 3 Data Summary Report: 2013 Addendum*. U.S. Environmental Protection Agency, Region 8. In preparation (2014).

Elhers, J. and Gibbard, P.L.. 1996. Quaternary and Glacial Geology. John Wiley and Sons, Inc. ISBN 0471955760. 590 pp.

Ferreira, R.F., Adams, D.B., Davis R.E. 1992. USGS Water Resources Investigation #91-4134, Development of thermal models for Hungry Horse Reservoir and Lake Koocanusa, Northwestern Montana and British Columbia.

HDR Engineering, Inc. and Syracuse Research Corp. 2010. Remedial Investigation Report Operable Unit 5 Libby Asbestos National Priorities List Site. September 2010.

ISO. 1995. ISO 10312:1999(E). Ambient Air - Determination of Asbestos Fibers - Direct Transfer TEM Method. May 1.

Jaenicke R. 1980. Natural aerosols. *Annals of the New York Academy of Sciences*. 338: 317-325.

Januch *et al*. 2013. Evaluation of a Fluidized Bed Asbestos Segregator Preparation Method for the Analysis of Low-levels of Asbestos in Soil and Other Solid Media. Analytical Methods. 5: 1658-1668.

Langer , W. H., Van Gosen, B. S., Meeker, G. P., Adams, D. T., and Hoefen, T. M. 2010. The dispersion of fibrous amphiboles by glacial processes in the area surrounding Libby, Montana, USA. Environmental Earth Science 64:157-168.

Larsen, E.S. and Pardee, J.J. 1929. The stock of alkaline rocks near Libby, Montana. Journal of Geology 37:97-112.

Larson, T.C., Meyer, C.A., Kapil, V., Gurney, J.W., Tarver, R.D., Black, C.B., and Lockey, J.E. 2010. Workers with Libby Amphibole Exposure: Retrospective Identification and Progression of Radiographic Changes. Radiology 255(3):924-933.

Larson, T.C., Lewin, M., Gottschall, E.B., Antao, V.C., Kapil, V., Rose, C.S. 2012a. Associations between radiographic findings and spirometry in a community exposed to Libby amphibole. Occup. Environ Med. 69(5):361-6.

Larson, T.C., Antao, A.C., Bove, F.J., Cusack, C. 2012b. Association Between Cumulative Fiber Exposure and Respiratory Outcomes Among Libby Vermiculite Workers. J. Occup. Environ. Med. 54(1): 56-63.

Leake BE, Woolley AR, Arps CES, Birch WD, Gilbert MC, Grice JD, Hawthorne FC, Kato A, Kisch HJ, Krivovichev VG, Linthout K, laird J, Mandarino JA, Maresch WV, Nickel EH, Rock NMS, Schumacher JC,

Smith DC, Stephenson NCN, Ungaretti L, Whittaker EJW, Youzhi G. 1997. Nomenclature of the amphiboles: Report of the subcommittee on amphiboles of the International Mineralogical Association, Commission on New Minerals and Mineral names. American Mineralogist 82:1019-1037.

LibbyMT.com. 2013. Libby, Montana and Kootenai River Country, Kootenai River. Accessed at: http://www.libbymt.com/areaattractions/kootenairiver.htm, on November 15, 2013.

Locke W., and Smith L.N. 2004. Pleistocene mountain glaciation in Montana, USA. In: Ehlers J, Gibbard PL (eds) Quaternary Glaciations—Extent And Chronology, Part II—North America: Developments In Quaternary Science 2. Elsevier, Amsterdam, pp 125–129.

McDonald, J.C., McDonald, A.D., Armstrong, B., and Sebastien, P. 1986. Cohort Study of Mortality of Vermiculite Miners Exposed to Tremolite. Brit. J. Ind. Med 43:436-444.

McDonald, J.C., Harris, J., Armstrong, B. 2004. *Mortality in a cohort of vermiculite miners exposed to fibrous Amphibole in Libby, Montana*. Occup. Environ. Med. 61:363-366.

MDEQ. 2005.

Meeker GP, Bern AM, Brownfield IK, Lowers HA, Sutley SJ, Hoeffen TM, Vance JS. 2003. *The Composition and Morphology of Amphiboles from the Rainy Creek Complex, Near Libby, Montana.* American Mineralogist 88:1955-1969.

Millette, J. R. 1979*. Exposure to Asbestos from Drinking Water in the United States.* Environmental Health Effects Research Report (1979) EPA 600/1-79- 150

Montana Cadastral. 2013. Lincoln County Database. Accessed at: http://svc.mt.gov/msl/mtcadastral/. Accessed on October 31, 2013.

NIOSH. 1994a. PCM NIOSH 7400(a), Issue 2. Asbestos and Other Fibers by PCM. August 15.

NIOSH. 1994b. PLM NIOSH 9002, Issue 2. Asbestos (bulk) by PLM. August 15.

National Toxicology Program (NTP). 1985. *Technical report series no. 295. Toxicology and carcinogenesis studies of chrysotile asbestos (CAS No. 12001-29-5) in F344/N rats (feed studies)*. Research Triangle Park, NC: U.S. Department of Health and Human Services, Public Health Service, National Institutes of Health. NIH Publication No. 86-2551.

Peipins, L.A., Lewin, M., Campolucci, S., Lybarger, J.A., Kapil, V., Middleton, D., Miller, A., Weis, C., Spence, M., and Black, B., 2003. Radiographic Abnormalities and Exposure to Asbestos-Contaminated Vermiculite in the Community of Libby, Montana, USA. Environmental Health Perspectives 111:1753-1759.

PRI-ER. 2010. Draft Final Response Action Work Plan, Libby Asbestos Site, Libby, Montana. May.

PRI-ER. 2011. Response Action Work Plan. Libby Asbestos Site, Libby, Montana. Revision 3. June.

PRI-ER. 2012. Response Action Work Plan. Libby Asbestos Site, Libby, Montana. Revision 4. April.

PRI-ER. 2013. Response Action Work Plan. Libby Asbestos Site, Libby, Montana. Revision 5. March.

Smith, L.N. 2006. Pleistocene glacial deposits in the Libby and Lake River Valley Areas, Lincoln County, Montana. Northwest Geology 35:87–90.

SRC. 2002. Technical Memorandum 2, Occurrence of Asbestos in Libby Vermiculite Insulation. May 16.

SRC. 2006. Draft Assessing Asbestos Release from Building Demolition at the Libby, Montana, Superfund Site. February.

SRC. 2007. Draft Assessing Asbestos Release from Building Demolition at the Libby, Montana, Superfund Site: October 2006 Demolitions. April.

Sullivan PA. 2007. Vermiculite, Respiratory Disease and Asbestos Exposure in Libby, Montana: Update of a Cohort Mortality Study. Environmental Health Perspectives doi:10.1289/ehp.9481 available online at http://dx.doi.org.

Techlaw. 2007. Revision D Soil Preparation Work Plan, Libby Asbestos Site – Operable Unit 7, Troy, Montana. March 2007.

TechLaw. 2011. Controlling Matrix Interference Effects of Rock Flour in the Fluidized Bed Method for Analysis of Asbestos in Soil. August 2011.

United States Census Bureau. 2013. Census 2012 Information. Accessed at quickfacts.census.gov on November 15, 2013.

USDA (U. S. Department of Agriculture), Forest Service and Natural Resources Conservation Service. 1995. Soil Survey of Kootenai National Forest Area, Montana and Idaho. September.

USDAFSR1 (U.S. Department of Agriculture Forest Service Region 1). 2008. <http://www.fs.fed.us/r1/kootenai/resources/plants/graphs.shtml>

USGS.gov. 2014. http://waterdata.usgs.gov/MT/nwis/current/?type=flow. Accessed on June 13, 2014.

Van Gosen, B.S., Lowers H.A., Bush A.L. , Meeker G.P., Plumlee G.S., Brownfield I.K., and Sutley S.J. 2002. Reconnaissance Study of the Geology of U.S. Vermiculite Deposits - Are Asbestos Minerals Common Constituents? U.S. Geological Survey Bulletin 2192. http://pubs.usgs.gov/bul/b2192/b2192.pdf

Versar, Inc. 2003. Pilot Study to Estimate Asbestos Exposure from Vermiculite Attic Insulation. Research Conducted in 2001 and 2002. May.

Ward, T.J., T. Spear, J. Hart, C. Noonan, A. Holian, M. Getman, and J. S. Webber. 2006. Trees as reservoirs for amphibole fibers in Libby, Montana. Science of the Total Environment 367: 460-465.

Ward, T.J., J.F. Hart, T.M. Spear, B.J. Meyer, and J. S. Webber. 2009. Fate of Libby amphibole fibers when burning contaminated firewood. Environ. Sci. Technol. 43:2878-2883.

Ward, T.J., T.M. Spear, J.F. Hart, J.S. Webber, and M.I. Elashheb. 2012. Amphibole asbestos in tree bark—a review of findings for this inhalational exposure source in Libby, Montana. Journal of Occupational and Environmental Hygiene 9:387-397.

Webber, J.S. and J.R. Covey. 1991. Asbestos in Water. Critical Reviews in Environmental Control 21(3,4):331-371.

Webber, J.S., M. Getman, T.J. Ward. 2006. Evidence and reconstruction of airborne asbestos from unconventional environmental samples. Inhalation Toxicology 18:969-973.

Webber, J. S., Blake, D. J., Ward, T. J., & Pfau, J. C. 2008. Separation and characterization of respirable amphibole fibers from Libby, Montana. *Inhalation Toxicology* 20(8):733-740.

Whitehouse, AC, Black, Heppe, MS, Ruckdeschel, J, Levin, SM. 2008. Environmental exposure to Libby asbestos and mesotheliomas. Amer. J Ind. Med. 51:877-880.

Whitehouse, AC. 2004. Asbestos- Related Pleural Disease due to Tremolite Associated with Progressive Loss of Lung Function: Serial Observations in 123 Miners, Family Members, and Residents of Libby, Montana. American Journal of Industrial Hygiene, 46: 219-225.

Woodward-Clyde Consultants. 1988. Phase IV, Step 3 Remedial Investigation Report. Libby, Montana Groundwater Contamination Site. April 1988. Prepared for Champion International Stamford, CT by Woodward-Clyde Consultants.

This page left blank intentionally

Tables

TABLE 2-1. LIBBY OU4 SAMPLING EVENT DESCRIPTIONS

Investigation/Action	Activity Description
1999 – 2013	**Investigations**
1999	Phase 1
2001	Phase 2
2002	Contaminant Screening Study
Various	Contamination Assessments at Special Properties
2002	Natural Resource Conservation Service
2002	Sediment Core Pilot Study
2003	Post Cleanup Evaluation
2005-2006	Supplemental Remedial Investigation (SQAPP)
2005	Cumulative Risk Assessment
2006	Building Demolition
2006-2008, 2010-Present	Outdoor Ambient Air Program
2007	Dust Pilot Study
2007, 2008, 2010, 2011, 2013	Residential ABS
2008	Libby Background Soil Study
2008	School Investigation
2009	School ABS
2011	Woodchip ABS
2011	Limited Use Area (LUA) ABS
2011	Background and Borrow Source ABS
2012	Nature and Extent of LA in Tree Bark and Duff from the Forest
2012	Nature and Extent of LA in Surface Water
2012	Tradesperson ABS
2012	Woodstove ABS
2012	Flowerbed ABS
2011-2012	Water Source Study (Phase I and II)
2012	Comparative Exposure ABS
2012	Tissue Assessment
2013	Porewater in the Tributaries
2003 – 2013	**Removal Design**
2001 – 2013	**Removal Actions**

Note:

ABS = activity-based sampling; LA = Libby amphibole asbestos; OU = operable unit; SQAPP = Supplemental Quality Assurance Plan

TABLE 2-2. PLM-VE CLASSIFICATION BINS

Bin	Meaning
A	No LA detected. Bin A results are recorded by the analyst as "ND" for non-detect.
B1	LA detected, but at a level estimated to be lower than 0.2%. Bin B1 results are recorded by the analyst as "Trace."
B2	LA detected at a concentration estimated to be less than (<) 1% but greater than or equal to (≥) approximately 0.2%. Bin B2 results are recorded by the analyst as "<1%."
C	LA detected at a concentration estimated to be ≥1%. Bin C results are recorded by the analyst as "1%," "2%," etc.

Note:

LA = Libby amphibole asbestos; PLM-VE - polarized light microscopy visual area estimation; % = percent.

TABLE 3-1. INITIAL PHASE I INVESTIGATION RESULTS

Panel A. Stationary Air

Sample Type	N Samples	Total LA Concentration Results (TEM)*		
		N Detected	Detection Frequency	Range of Detected Conc (s/cc)
Indoor Air	256	85	33%	0.0002 - 0.54
Outdoor Air	102	13	13%	0.000096 - 0.0017

Panel B. Vermiculte Insulation

Sample Type	N Samples	N Analyses	Trem/Actn Results (PLM-9002)					
			N Detected	Detection Frequency	N ND	N < 1%	N ≥ 1%	Max %
Grab	112	112	75	67%	37	68	7	5

Panel C. Bulk Building Material

Sample Type	N Samples	N Analyses	Trem/Actn Results (PLM-9002)					
			N Detected	Detection Frequency	N ND	N <1%	N ≥ 1%	Max %
Grab	33	33	4	12%	29	3	1	1.5

Panel D. Dust

Sample Type	N Samples	Total LA Concentration Results (ASTM/TEM)*		
		N Detected	Detection Frequency	Range of Detected Conc (s/cm^2)
Indoor Dust	2,127	316	15%	30 - 570000

Panel E. Soil

Sample Type	N Samples	N Analyses	LA Bin Results (PLM-VE)						
			N Detected	Detection Frequency	N Bin A (ND)	N Bin B1 (Tr)	N Bin B2 (<1%)	N Bin C (≥1%)	Max %
Surface Soil	1,175	1,178	141	12%	1,037	120	14	7	3
Subsurface Soil	49	49	8	16%	41	7	1	0	NA

Sample Type	N Samples	N Analyses	LA Results (PLM-Grav)					
			N Detected	Detection Frequency	N ND	N Tr	N > Tr	Max %
Surface Soil	692	696	17	2%	679	14	3	100
Subsurface Soil	39	39	0	0%	39	0	0	NA

Sample Type	N Samples	N Analyses	Trem/Actn Results (PLM-9002)					
			N Detected	Detection Frequency	N ND	N <1%	N ≥ 1%	Max %
Surface Soil	2,236	2,329	646	28%	1683	575	71	15
Subsurface Soil	133	135	58	43%	77	36	22	10

Note:

ASTM - American Society of Testing and Materials; Conc - concentration; LA - Libby amphibole asbestos; max - maximum; NA - not applicable; N - number; ND - non-detect; PLM - polarized light microscopy; PLM-Grav - polarized light microscopy gravimetric; PLM-VE - polarized light microscopy visual area estimation; s/cc- structures per cubic centimeter; s/cm^2 - structures per square centimeter; TEM - transmission electron microscopy; Tr - trace; Trem/Actn - tremolite/actinolite; < - less than; ≥ - greater than or equal to; % - percent.

**TEM results are presented based on the pooled result, as applicable.*

TABLE 3-2. SUBSEQUENT PHASE I INVESTIGATION RESULTS

Panel A. Indoor Stationary Air

Sample Type	N Samples	Total LA Concentration Results (TEM)*		
		N Detected	Detection Frequency	Range of Detected Conc (s/cc)
Indoor Air	820	24	3%	0.00058 - 0.032

Panel B. Vermiculte Insulation

Sample Type	N Samples	N Analyses	Trem/Actn Results (PLM-9002)					
			N Detected	Detection Frequency	N ND	N <1%	N ≥1%	Max %
Grab	5	5	5	100%	0	0	5	3

Panel C. Bulk Building Material

Sample Type	N Samples	N Analyses	Trem/Actn Results (PLM-9002)					
			N Detected	Detection Frequency	N ND	N <1%	N ≥ 1%	Max %
Grab	84	113	16	9%	94	9	1	2

Panel D. Dust

Sample Type	N Samples	Total LA Concentration Results (TEM)*		
		N Detected	Detection Frequency	Range of Detected Conc (s/cm^2)
Indoor Dust	383	37	10%	36 - 47000

Panel E. Soil

Sample Type	N Samples	N Analyses	LA Bin Results (PLM-VE)						
			N Detected	Detection Frequency	N Bin A (ND)	N Bin B1 (Tr)	N Bin B2 (<1%)	N Bin C (≥1%)	Max %
Surface Soil	38	38	6	16%	32	5	1	0	NA
Subsurface Soil	3	3	2	67%	1	1	0	1	1

Sample Type	N Samples	N Analyses	LA Results (PLM-Grav)					
			N Detected	Detection Frequency	N ND	N Tr	N > Tr	Max %
Surface Soil	27	27	0	0%	27	0	0	NA
Subsurface Soil	1	1	0	0%	1	0	0	NA

Sample Type	N Samples	N Analyses	Trem/Actn Results (PLM-9002)					
			N Detected	Detection Frequency	N ND	N <1%	N ≥ 1%	Max %
Surface Soil	159	159	17	11%	142	12	5	70
Subsurface Soil	25	25	5	20%	20	1	4	10

Panel F. Water

Sample Type	N Samples	Total LA Concentration Results (TEM)*		
		N Detected	Detection Frequency	Range of Detected Conc (s/L)
Tap/Spigot	2	0	0%	NA

Note:

Conc - concentration; LA – Libby amphibole asbestos; max - maximum; NA - not applicable; N - number; ND - non-detect; PLM - polarized light microscopy; PLM-Grav - polarized light microscopy gravimetric; PLM-VE - polarized light microscopy visual area estimation; s/cc – structures per cubic centimeter; s/cm^2 - structures per square centimeter; s/L - structures per liter; TEM – transmission electron microscopy; Tr - trace; Trem/Actn - tremolite/actinolite; < - less than; ≥ - greater than or equal to; > - greater than; % - percent.

**TEM results are presented based on the pooled result, as applicable.*

TABLE 3-3. PHASE II INVESTIGATION RESULTS FOR AIR SAMPLES

Panel A. Scenario 1 Routine Activities

Matrix	Sample Type	Collection Timing	N Samples	Total LA Concentration Results (TEM)*		
				N Detected	Detection Frequency	Range of Detected Conc (s/cc)
Indoor Air	Personal, Full Period	During	16	10	63%	0.000064 - 0.0013
	Stationary	During	28	17	61%	0.000076 - 0.0016

Panel B. Scenario 2 Active Cleaning

Matrix	Sample Type	Collection Timing	N Samples	Total LA Concentration Results (TEM)*		
				N Detected	Detection Frequency	Range of Detected Conc (s/cc)
Indoor Air	Personal, Full Period	During	42	22	52%	0.00074 - 0.25
		Post (Decon)	35	7	20%	0.001 - 0.014
	Personal, Full Period	During	78	16	21%	0.0068 - 0.066
		Post (Decon)	36	0	0%	NA
	Stationary	Pre	38	6	16%	0.00076 - 0.044
		During	35	19	54%	0.00085 - 0.065
		Post	15	0	0%	NA
		Clearance	37	3	8%	0.00086 - 0.0026
Outdoor Air	Personal, Full Period	During	2	2	100%	0.003 - 0.0062
	Personal, Excursion	During	1	0	0%	NA
	Stationary	During	1	1	100%	0.04

Panel C. Scenario 3 Vermiculite Disturbance

Matrix	Sample Type	Collection Timing	N Samples	Total LA Concentration Results (TEM)*		
				N Detected	Detection Frequency	Range of Detected Conc (s/cc)
Indoor Air	Personal, Full Period	Pre (Staging)	4	2	50%	0.28 - 3.1
		During	21	16	76%	0.0045 - 1.6
		Post (Decon)	6	1	17%	0.011
	Personal, Excursion	Pre (Staging)	2	0	0%	NA
		During	37	18	49%	0.033 - 9.2
		Post (Decon)	6	0	0%	NA
	Personal, Excursion	Pre (Staging)	8	4	50%	0.0014 - 0.29
		During	15	6	40%	0.00059 - 2.4
		Post (Decon)	10	1	10%	0.0033
		Clearance	27	5	19%	0.00039 - 0.0068
Outdoor Air	Stationary	During	40	3	8%	0.0021 - 0.0083

Panel D. Scenario 4 Rototilling

Matrix	Sample Type	Collection Timing	N Samples	Total LA Concentration Results (TEM)*		
				N Detected	Detection Frequency	Range of Detected Conc (s/cc)
Outdoor Air	Personal, Full Period	During	2	2	100%	0.029 - 0.17
	Personal, Excursion	During	3	2	67%	0.035 - 0.046
	Stationary	Pre	4	0	0%	NA
		During	4	2	50%	0.0027 - 0.0077
		Post	4	0	0%	NA

Note:

Conc - concentration; LA – Libby amphibole asbestos; NA - not applicable; N - number; s/cc - structures per cubic centimeter; SQAPP - Supplemental Remedial Investigation Quality Assurance Project Plan; TEM – transmission electron microscopy; % - percent.

**TEM results are presented based on the pooled result and may not match those that have been reported in the Phase 2 report (EPA 2006c). The pooled results will contain analyses that were performed as part of the SQAPP.*

TABLE 3-4. PHASE II INVESTIGATION RESULTS FOR SOURCE MATERIAL SAMPLES

Panel A. Vermiculte Insulation

Sample Type	N Samples	N Analyses	Trem/Actn Results (PLM-9002)					
			N Detected	Detection Frequency	ND	<1%	≥1%	Max %
Grab	10	12	9	75%	3	9	0	NA

Panel B. Dust

Scenario	Sample Type	Collection Timing	N Samples	Total LA Concentration Results (TEM)*		
				N Detected	Detection Frequency	Range of Detected Conc (s/cm^2)
Scenario 2	Surficial Composite	Pre	21	15	71%	19 - 320000
		Post	17	4	24%	300 - 8500
	Dust Pile	Post	6	4	67%	3500 - 30000
Scenario 3	Surficial Composite	Pre	2	0	0%	NA
		Post	1	0	0%	NA

Note:

Conc - concentration; LA – Libby amphibole asbestos; max - maximum; NA - not applicable; N - number; ND - non-detect; PLM - polarized light microscopy; s/cm^2 - structures per square centimeter; SQAPP - Supplemental Remedial Investigation Quality Assurance Project Plan; TEM – transmission electron microscopy; Trem/Actn - tremolite/actinolite; < - less than;≥ - greater than or equal to; % - percent.

**TEM results are presented based on the pooled result and may not match those that have been reported in the Phase 2 report (EPA 2006c). The pooled results will contain analyses that were performed as part of the SQAPP.*

TABLE 3-5. CONTAMINANT SCREENING STUDY

Panel A. Dust

Sample Type	N Samples	Total LA Concentration Results (TEM)*		
		N Detected	Detection Frequency	Range of Detected Conc (s/cm^2)
Indoor Dust	2,056	176	9%	44 - 260000

Panel B. Soil

Sample Type	N Samples	N Analyses	LA Bin Results (PLM-VE)**						
			N Detected	Detection Frequency	N Bin A (ND)	N Bin B1 (Tr)	N Bin B2 (<1%)	N Bin C (≥1%)	Max %
Surface Soil	13,077	13,169	1,101	8%	12,068	993	82	26	6
Subsurface Soil	74	80	9	11%	71	9	0	0	NA

Sample Type	N Samples	N Analyses	LA Results (PLM-Grav)					
			N Detected	Detection Frequency	N ND	N Tr	N > Tr	Max %
Surface Soil	8,260	8,608	74	1%	8,534	54	17	68
Subsurface Soil	51	51	0	0%	51	0	0	NA

Sample Type	N Samples	N Analyses	Trem/Actn Results (PLM-9002)					
			N Detected	Detection Frequency	N ND	N <1%	N ≥ 1%	Max %
Surface Soil	395	398	26	7%	372	26	0	NA
Subsurface Soil	7	7	1	14%	6	1	0	NA

Sample Type	N Samples	N Analyses	Trem/Actn Results (PLM-600)					
			N Detected	Detection Frequency	N ND	N Tr	N > Tr	Max %
Surface Soil	79	84	3	4%	81	3	0	NA

Note:

Conc - concentration; LA – Libby amphibole asbestos; max - maximum; NA - not applicable; N - number; ND - non-detect; PLM - polarized light microscopy; PLM-Grav - polarized light microscopy gravimetric; PLM-VE - polarized light microscopy visual area estimation; s/cm^2 - structures per square centimeter; TEM – transmission electron microscopy; Tr - trace; Trem/Actn - tremolite/actinolite; < - less than; ≥ - greater than or equal to; > - greater than; % - percent.

**TEM results are presented based on the pooled result, as applicable.*

***There are 16 PLM-9002 results presented as Tr, these have been changed to be summarized with PLM-VE because these were analyzed during the time when the PLM-VE method was being developed and and EDD was not available for reporting results for PLM-VE.*

TABLE 3-6. KOOTENAI BLUFFS SUBDIVISION INVESTIGATION

Sample Type	N Samples	N Analyses	LA Bin Results (PLM-VE)						
			N Detected	Detection Frequency	N Bin A (ND)	N Bin B1 (Tr)	N Bin B2 (<1%)	N Bin C (≥1%)	Max %
Surface Soil	63	63	2	3%	61	2	0	0	NA

Sample Type	N Samples	N Analyses	LA Results (PLM-Grav)					
			N Detected	Detection Frequency	N ND	N Tr	N > Tr	Max %
Surface Soil	55	55	0	0%	55	0	0	NA

Sample Type	N Samples	N Analyses	Trem/Actn Results (PLM-9002)					
			N Detected	Detection Frequency	N ND	N <1%	N ≥ 1%	Max %
Surface Soil	119	119	61	51%	58	52	9	10
Subsurface Soil	13	13	8	62%	5	5	3	7

Note:

LA – Libby amphibole asbestos; max - maximum; NA - not applicable; N - number; ND - non-detect; PLM - polarized light microscopy; PLM-Grav - polarized light microscopy gravimetric; PLM-VE - polarized light microscopy visual area estimation; Tr - trace; Trem/Actn - tremolite/actinolite; < - less than; ≥ - greater than or equal to; > - greater than; % - percent.

TABLE 3-7. KOOTENAI VALLEY HEAD START/PLUMMER ELEMENTARY INVESTIGATION

Panel A. Air

Sample Type	N Samples	Total LA Concentration Results (TEM)*		
		N Detected	Detection Frequency	Range of Detected Conc (s/cc)
Indoor Air	4	0	0%	NA
Outdoor Air	21	1	5%	0.00093

Panel B. Dust

Sample Type	N Samples	Total LA Concentration Results (TEM)*		
		N Detected	Detection Frequency	Range of Detected Conc (s/cm^2)
Indoor Dust	4	0	0%	NA

Panel C. Soil

Sample Type	N Samples	N Analyses	LA Bin Results (PLM-VE)						
			N Detected	Detection Frequency	N Bin A (ND)	N Bin B1 (Tr)	N Bin B2 (<1%)	N Bin C (≥1%)	Max %
Surface Soil	43	43	2	5%	41	2	0	0	NA
Subsurface Soil	1	1	0	0%	1	0	0	0	NA

Sample Type	N Samples	N Analyses	LA Results (PLM-Grav)					
			N Detected	Detection Frequency	N ND	N Tr	N > Tr	Max %
Surface Soil	35	35	2	6%	33	0	2	100
Subsurface Soil	1	1	0	0%	1	0	0	NA

Sample Type	N Samples	N Analyses	Trem/Actn Results (PLM-9002)					
			N Detected	Detection Frequency	N ND	N <1%	N ≥ 1%	Max %
Surface Soil	57	57	7	12%	50	5	2	5
Subsurface Soil	3	3	2	67%	1	1	1	7

Note:

Conc - concentration; LA – Libby amphibole asbestos; max - maximum; NA - not applicable; N - number; ND - non-detect; PLM - polarized light microscopy; PLM-Grav - polarized light microscopy gravimetric; PLM-VE - polarized light microscopy visual area estimation; s/cc – structures per cubic centimeter; s/cm^2 - structures per square centimeter; TEM – transmission electron microscopy; Tr - trace; Trem/Actn - tremolite/actinolite; < - less than; ≥ - greater than or equal to; > - greater than; % - percent.

**TEM results are presented based on the pooled result, as applicable.*

TABLE 3-8. LIBBY ELEMENTARY INVESTIGATION

Panel A. Air

Sample Type	N Samples	Total LA Concentration Results (TEM)*		
		N Detected	Detection Frequency	Range of Detected Conc (s/cc)
Indoor Air	6	0	0%	NA

Panel B. Dust

Sample Type	N Samples	Total LA Concentration Results (TEM)*		
		N Detected	Detection Frequency	Range of Detected Conc (s/cm^2)
Indoor Dust	6	0	0%	NA

Panel C. Soil

Sample Type	N Samples	N Analyses	LA Bin Results (PLM-VE)						
			N Detected	Detection Frequency	N Bin A (ND)	N Bin B1 (Tr)	N Bin B2 (<1%)	N Bin C (≥1%)	Max %
Surface Soil	23	23	2	9%	21	2	0	0	NA
Subsurface Soil	3	3	1	33%	2	1	0	0	NA

Sample Type	N Samples	N Analyses	LA Results (PLM-Grav)					
			N Detected	Detection Frequency	N ND	N Tr	N > Tr	Max %
Surface Soil	22	22	0	0%	22	0	0	NA
Subsurface Soil	2	2	0	0%	2	0	0	NA

Sample Type	N Samples	N Analyses	Trem/Actn Results (PLM-9002)					
			N Detected	Detection Frequency	N ND	N <1%	N ≥ 1%	Max %
Surface Soil	28	28	2	7%	26	2	0	NA
Subsurface Soil	3	3	0	0%	3	0	0	NA

Note:

Conc - concentration; LA – Libby amphibole asbestos; max - maximum; NA - not applicable; N - number; ND - non-detect; PLM - polarized light microscopy; PLM-Grav - polarized light microscopy gravimetric; PLM-VE - polarized light microscopy visual area estimation; s/cc – structures per cubic centimeter; s/cm2 - structures per square centimeter; TEM – transmission electron microscopy; Tr - trace; Trem/Actn - tremolite/actinolite; < - less than; ≥ - greater than or equal to; > - greater than; % - percent.

**TEM results are presented based on the pooled result, as applicable.*

TABLE 3-9. LIBBY MIDDLE SCHOOL INVESTIGATION RESULTS

Panel A. Air

Sample Type	N Samples	Total LA Concentration Results (TEM)*		
		N Detected	Detection Frequency	Range of Detected Conc (s/cc)
Indoor Air	8	0	0%	NA

Panel B. Dust

Sample Type	N Samples	Total LA Concentration Results (TEM)*		
		N Detected	Detection Frequency	Range of Detected Conc (s/cm^2)
Indoor Dust	9	2	22%	52 - 790

Panel C. Soil

Sample Type	N Samples	N Analyses	LA Bin Results (PLM-VE)						
			N Detected	Detection Frequency	N Bin A (ND)	N Bin B1 (Tr)	N Bin B2 (<1%)	N Bin C (≥1%)	Max %
Surface Soil	117	117	7	6%	110	7	0	0	NA
Subsurface Soil	9	9	2	22%	7	2	0	0	NA

Sample Type	N Samples	N Analyses	LA Results (PLM-Grav)					
			N Detected	Detection Frequency	N ND	N Tr	N > Tr	Max %
Surface Soil	95	95	0	0%	95	0	0	NA
Subsurface Soil	8	8	0	0%	8	0	0	NA

Sample Type	N Samples	N Analyses	Trem/Actn Results (PLM-9002)					
			N Detected	Detection Frequency	N ND	N <1%	N ≥ 1%	Max %
Surface Soil	155	203	23	11%	180	17	6	15
Subsurface Soil	25	25	13	52%	12	5	8	7

Note:

Conc - concentration; LA – Libby amphibole asbestos; max - maximum; NA - not applicable; N - number; ND - non-detect; PLM - polarized light microscopy; PLM-Grav - polarized light microscopy gravimetric; PLM-VE - polarized light microscopy visual area estimation; s/cc – structures per cubic centimeter; s/cm^2 - structures per square centimeter; TEM – transmission electron microscopy; Tr - trace; Trem/Actn - tremolite/actinolite; < less than; ≥ - greater than or equal to; > - greater than; % - percent.

**TEM results are presented based on the pooled result, as applicable.*

TABLE 3-10. LIBBY HIGH SCHOOL INVESTIGATION

Panel A. Air

Sample Type	N Samples	Total LA Concentration Results (TEM)*		
		N Detected	Detection Frequency	Range of Detected Conc (s/cc)
Indoor Air	11	0	0%	NA
Outdoor Air	1	0	0%	NA

Panel B. Bulk Material

Sample Type	N Samples	N Analyses	Trem/Actn Results (PLM-9002)					
			N Detected	Detection Frequency	N ND	N <1%	N ≥ 1%	Max %
Grab	4	4	0	0%	4	0	0	NA

Panel C. Dust

Sample Type	N Samples	Total LA Concentration Results (TEM)*		
		N Detected	Detection Frequency	Range of Detected Conc (s/cm^2)
Indoor Dust	18	7	39%	320 - 42000

Panel D. Soil

Sample Type	N Samples	N Analyses	LA Bin Results (PLM-VE)						
			N Detected	Detection Frequency	N Bin A (ND)	N Bin B1 (Tr)	N Bin B2 (<1%)	N Bin C (≥1%)	Max %
Surface Soil	146	149	19	13%	130	18	1	0	NA
Subsurface Soil	10	10	0	0%	10	0	0	0	NA

Sample Type	N Samples	N Analyses	LA Results (PLM-Grav)					
			N Detected	Detection Frequency	N ND	N Tr	N > Tr	Max %
Surface Soil	77	77	1	1%	76	1	0	NA
Subsurface Soil	6	6	0	0%	6	0	0	NA

Sample Type	N Samples	N Analyses	Trem/Actn Results (PLM-9002)					
			N Detected	Detection Frequency	N ND	N <1%	N ≥ 1%	Max %
Surface Soil	208	214	44	21%	170	42	2	5
Subsurface Soil	27	27	17	63%	10	11	6	8

Note:

Conc - concentration; LA – Libby amphibole asbestos; max - maximum; NA - not applicable; N - number; ND - non-detect; PLM - polarized light microscopy; PLM-Grav - polarized light microscopy gravimetric; PLM-VE - polarized light microscopy visual area estimation; s/cc – structures per cubic centimeter; s/cm^2 - structures per square centimeter; TEM – transmission electron microscopy; Tr - trace; Trem/Actn - tremolite/actinolite; < less than; ≥ - greater than or equal to; > - greater than; % - percent.

**TEM results are presented based on the pooled result, as applicable.*

TABLE 3-11. LIBBY SCHOOL DISTRICT ADMINISTRATION BUILDING INVESTIGATION

Panel A. Air

Sample Type	N Samples	Total LA Concentration Results (TEM)*		
		N Detected	Detection Frequency	Range of Detected Conc (s/cc)
Indoor Air	5	1	20%	0.00081

Panel B. Vermiculte Insulation

Sample Type	N Samples	N Analyses	Trem/Actn Results (PLM-9002)					
			N Detected	Detection Frequency	N ND	N <1%	N ≥1%	Max %
Grab	7	7	2	29%	5	2	0	NA

Panel C. Dust

Sample Type	N Samples	Total LA Concentration Results (TEM)*		
		N Detected	Detection Frequency	Range of Detected Conc (s/cm^2)
Indoor Dust	7	0	0%	NA

Panel D. Soil

Sample Type	N Samples	N Analyses	LA Bin Results (PLM-VE)						
			N Detected	Detection Frequency	N Bin A (ND)	N Bin B1 (Tr)	N Bin B2 (<1%)	N Bin C (≥1%)	Max %
Surface Soil	10	10	0	0%	10	0	0	0	NA

Sample Type	N Samples	N Analyses	LA Results (PLM-Grav)					
			N Detected	Detection Frequency	N ND	N Tr	N > Tr	Max %
Surface Soil	6	6	0	0%	6	0	0	NA
Subsurface Soil	1	1	0	0%	1	0	0	NA

Sample Type	N Samples	N Analyses	Trem/Actn Results (PLM-9002)					
			N Detected	Detection Frequency	N ND	N <1%	N ≥ 1%	Max %
Surface Soil	8	12	0	0%	12	0	0	NA
Subsurface Soil	2	2	0	0%	2	0	0	NA

Note:

Conc - concentration; LA – Libby amphibole asbestos; max - maximum; NA - not applicable; N - number; ND - non-detect; PLM - polarized light microscopy; PLM-Grav - polarized light microscopy gravimetric; PLM-VE - polarized light microscopy visual area estimation; s/cc – structures per cubic centimeter; s/cm^2 - structures per square centimeter; TEM – transmission electron microscopy; Tr - trace; Trem/Actn - tremolite/actinolite; < - less than; ≥ - greater than or equal to; > - greater than; % - percent.

**TEM results are presented based on the pooled result, as applicable.*

TABLE 3-12. MCGRADE CENTER INVESTIGATION

Panel A. Air

Sample Type	N Samples	Total LA Concentration Results (TEM)*		
		N Detected	Detection Frequency	Range of Detected Conc (s/cc)
Indoor Air	4	1	25%	0.00085
Outdoor Air	21	4	19%	0.000096 - 0.0017

Panel B. Dust

Sample Type	N Samples	Total LA Concentration Results (TEM)*		
		N Detected	Detection Frequency	Range of Detected Conc (s/cm^2)
Indoor Dust	4	0	0%	NA

Panel C. Soil

Sample Type	N Samples	N Analyses	LA Bin Results (PLM-VE)						
			N Detected	Detection Frequency	N Bin A (ND)	N Bin B1 (Tr)	N Bin B2 (<1%)	N Bin C (≥1%)	Max %
Surface Soil	29	29	1	3%	28	1	0	0	NA
Subsurface Soil	1	1	0	0%	1	0	0	0	NA

Sample Type	N Samples	N Analyses	LA Results (PLM-Grav)					
			N Detected	Detection Frequency	N ND	N Tr	N > Tr	Max %
Surface Soil	22	22	0	0%	22	0	0	NA
Subsurface Soil	1	1	0	0%	1	0	0	NA

Sample Type	N Samples	N Analyses	Trem/Actn Results (PLM-9002)					
			N Detected	Detection Frequency	N ND	N <1%	N ≥ 1%	Max %
Surface Soil	38	38	1	3%	37	1	0	NA
Subsurface Soil	1	1	0	0%	1	0	0	NA

Note:

Conc - concentration; LA – Libby amphibole asbestos; max - maximum; NA - not applicable; N - number; ND - non-detect; PLM - polarized light microscopy; PLM-Grav - polarized light microscopy gravimetric; PLM-VE - polarized light microscopy visual area estimation; s/cc – structures per cubic centimeter; s/cm^2 - structures per square centimeter; TEM – transmission electron microscopy; Tr - trace; Trem/Actn - tremolite/actinolite; < - less than; ≥ - greater than or equal to; > - greater than; % - percent.

**TEM results are presented based on the pooled result, as applicable.*

TABLE 3-13. CEMETERY PARK BALL FIELDS INVESTIGATION

Panel A. Air

Sample Type	N Samples	Total LA Concentration Results (TEM)*		
		N Detected	Detection Frequency	Range of Detected Conc (s/cc)
Indoor Air	1	0	0%	NA

Panel B. Dust

Sample Type	N Samples	Total LA Concentration Results (TEM)*		
		N Detected	Detection Frequency	Range of Detected Conc (s/cm^2)
Indoor Dust	5	2	40%	3500 - 5900

Panel C. Soil

Sample Type	N Samples	N Analyses	LA Bin Results (PLM-VE)						
			N Detected	Detection Frequency	N Bin A (ND)	N Bin B1 (Tr)	N Bin B2 (<1%)	N Bin C (≥1%)	Max %
Surface Soil	20	20	0	0%	20	0	0	0	NA
Subsurface Soil	12	12	0	0%	12	0	0	0	NA

Sample Type	N Samples	N Analyses	LA Results (PLM-Grav)					
			N Detected	Detection Frequency	N ND	N Tr	N > Tr	Max %
Surface Soil	19	19	0	0%	19	0	0	NA
Subsurface Soil	12	12	0	0%	12	0	0	NA

Sample Type	N Samples	N Analyses	Trem/Actn Results (PLM-9002)					
			N Detected	Detection Frequency	N ND	N <1%	N ≥ 1%	Max %
Surface Soil	12	12	0	0%	12	0	0	NA

Note:

Conc - concentration; LA - Libby amphibole asbestos; max - maximum; NA - not applicable; N - number; ND - non-detect; PLM - polarized light microscopy; PLM-Grav - polarized light microscopy gravimetric; PLM-VE - polarized light microscopy visual area estimation; s/cc – structures per cubic centimeter; s/cm^2 - structures per square centimeter; TEM - transmission electron microscopy; Tr - trace; Trem/Actn - tremolite/actinolite; < - less than; ≥ - greater than or equal to; > - greater than; % - percent.

**TEM results are presented based on the pooled result, as applicable.*

TABLE 3-14. ST. JOHN'S REHABILITATION CENTER AND HELIPAD FIELD INVESTIGATION RESULTS

Panel A. Air

Sample Type	N Samples	Total LA Concentration Results (TEM)*		
		N Detected	Detection Frequency	Range of Detected Conc (s/cc)
Outdoor Air	2	0	0%	NA

Panel B. Soil

Sample Type	N Samples	N Analyses	LA Bin Results (PLM-VE)						
			N Detected	Detection Frequency	N Bin A (ND)	N Bin B1 (Tr)	N Bin B2 (<1%)	N Bin C (≥1%)	Max %
Surface Soil	17	17	7	41%	10	6	1	0	NA

Sample Type	N Samples	N Analyses	LA Results (PLM-Grav)					
			N Detected	Detection Frequency	N ND	N Tr	N > Tr	Max %
Surface Soil	8	8	0	0%	8	0	0	NA

Note:

Conc - concentration; LA – Libby amphibole asbestos; max - maximum; NA - not applicable; N - number; ND - non-detect; PLM-Grav - polarized light microscopy gravimetric; PLM-VE - polarized light microscopy visual area estimation; s/cc – structures per cubic centimeter; TEM – transmission electron microscopy; Tr - trace; < - less than;≥ - greater than or equal to; > - greater than; % - percent.

**TEM results are presented based on the pooled result, as applicable.*

TABLE 3-15. LIBBY DRIVE-IN THEATER INVESTIGATION RESULTS

Sample Type	N Samples	N Analyses	LA Bin Results (PLM-VE)						
			N Detected	Detection Frequency	N Bin A (ND)	N Bin B1 (Tr)	N Bin B2 (<1%)	N Bin C (≥1%)	Max %
Surface Soil	19	19	0	0%	19	0	0	0	NA

Sample Type	N Samples	N Analyses	LA Results (PLM-Grav)					
			N Detected	Detection Frequency	N ND	N Tr	N > Tr	Max %
Surface Soil	19	19	0	0%	19	0	0	NA

Note:

LA – Libby amphibole asbestos; max - maximum; NA - not applicable; N - number; ND - non-detect; PLM-Grav - polarized light microscopy gravimetric; PLM-VE - polarized light microscopy visual area estimation; Tr -Trace < - less than;≥ - greater than or equal to; > - greater than; % - percent.

TABLE 3-16. CONTAMINATION AT SPECIALTY PROPERTIES - CABINET VIEW COUNTRY CLUB

Panel A. Dust

Sample Type	N Samples	Total LA Concentration Results (TEM)*		
		N Detected	Detection Frequency	Range of Detected Conc (s/cm^2)
Indoor Dust	1	0	0%	NA

Panel B. Soil

Sample Type	N Samples	N Analyses	LA Bin Results (PLM-VE)						
			N Detected	Detection Frequency	N Bin A (ND)	N Bin B1 (Tr)	N Bin B2 (<1%)	N Bin C (≥1%)	Max %
Surface Soil	79	79	31	39%	48	29	2	0	NA
Subsurface Soi	10	10	3	30%	7	3	0	0	NA

Sample Type	N Samples	N Analyses	LA Results (PLM-Grav)					
			N Detected	Detection Frequency	N ND	N Tr	N > Tr	Max %
Surface Soil	13	13	0	0%	13	0	0	NA
Subsurface Soi	8	8	0	0%	8	0	0	NA

Sample Type	N Samples	N Analyses	Trem/Actn Results (PLM-9002)					
			N Detected	Detection Frequency	N ND	N <1%	N ≥ 1%	Max %
Surface Soil	1	1	0	0%	1	0	0	NA

Note:

Conc - concentration; LA - Libby amphibole asbestos; max - maximum; NA - not applicable; N - number; ND - non-detect; PLM - polarized light microscopy; PLM-Grav - polarized light microscopy gravimetric; PLM-VE - polarized light microscopy visual area estimation; s/cm^2 - structures per square centimeter; TEM - transmission electron microscopy; Tr - trace; Trem/Actn - tremolite/actinolite; < - less than; ≥ - greater than or equal to; > - greater than; % - percent.

**TEM results are presented based on the pooled result, as applicable.*

TABLE 3-17. CONTAMINATION AT SPECIALTY PROPERTIES - J. NEILS PARK

Sample Type	N Samples	N Analyses	LA Bin Results (PLM-VE)						
			N Detected	Detection Frequency	N Bin A (ND)	N Bin B1 (Tr)	N Bin B2 (<1%)	N Bin C (≥1%)	Max %
Surface Soil	79	79	5	6%	74	4	1	0	NA

Sample Type	N Samples	N Analyses	LA Results (PLM-Grav)					
			N Detected	Detection Frequency	N ND	N Tr	N > Tr	Max %
Surface Soil	64	78	0	0%	78	0	0	NA

Note:

LA – Libby amphibole asbestos; max - maximum; NA - not applicable; N - number; ND - non-detect; PLM-Grav - polarized light microscopy gravimetric; PLM-VE - polarized light microscopy visual area estimation; Tr - trace; < - less than;≥ - greater than or equal to; > - greater than; % - percent.

TABLE 3-18. CONTAMINATION AT SPECIALTY PROPERTIES - CITY OF LIBBY ALLEYS

Panel A. Air

Sample Type	N Samples	Total LA Concentration Results (TEM)*		
		N Detected	Detection Frequency	Range of Detected Conc (s/cc)
Outdoor Air	30	3	10%	0.00095 - 0.001

Panel B. Soil

Sample Type	N Samples	N Analyses	LA Bin Results (PLM-VE)						
			N Detected	Detection Frequency	N Bin A (ND)	N Bin B1 (Tr)	N Bin B2 (<1%)	N Bin C (≥1%)	Max %
Surface Soil	95	95	1	1%	94	1	0	0	NA

Sample Type	N Samples	N Analyses	LA Results (PLM-Grav)					
			N Detected	Detection Frequency	N ND	N Tr	N > Tr	Max %
Surface Soil	95	95	0	0%	95	0	0	NA

Sample Type	N Samples	N Analyses	Trem/Actn Results (PLM-9002)					
			N Detected	Detection Frequency	N ND	N <1%	N ≥ 1%	Max %
Surface Soil	1	1	1	100%	0	0	1	NA

Note:

Conc - concentration; LA – Libby amphibole asbestos; max - maximum; NA - not applicable; N - number; ND - non-detect; PLM - polarized light microscopy; PLM-Grav - polarized light microscopy gravimetric; PLM-VE - polarized light microscopy visual area estimation; s/cc - structures per cubic centimeter; TEM – transmission electron microscopy; Tr - trace; Trem/Actn - tremolite/actinolite; < - less than;≥ - greater than or equal to; > - greater than; % - percent.

**TEM results are presented based on the pooled result, as applicable.*

TABLE 3-19. CONTAMINATION AT SPECIALTY PROPERTIES - CREEKS

Sample Type	N Samples	N Analyses	LA Bin Results (PLM-VE)						
			N Detected	Detection Frequency	N Bin A (ND)	N Bin B1 (Tr)	N Bin B2 (<1%)	N Bin C (≥1%)	Max %
Surface Soil	23	24	0	0%	24	0	0	0	NA

Sample Type	N Samples	N Analyses	LA Results (PLM-Grav)					
			N Detected	Detection Frequency	N ND	N Tr	N > Tr	Max %
Surface Soil	5	5	0	0%	5	0	0	NA

Note:

LA – Libby amphibole asbestos; max - maximum; NA - not applicable; N - number; ND - non-detect; PLM-Grav - polarized light microscopy gravimetric; PLM-VE - polarized light microscopy visual area estimation; Tr - trace; < - less than;≥ - greater than or equal to; > - greater than; % - percent.

TABLE 3-20. CONTAMINATION AT SPECIALTY PROPERTIES - HIGHWAY 37 EMBANKMENT

Sample Type	N Samples	N Analyses	LA Bin Results (PLM-VE)						
			N Detected	Detection Frequency	N Bin A (ND)	N Bin B1 (Tr)	N Bin B2 (<1%)	N Bin C (≥1%)	Max %
Surface Soil	4	4	1	25%	3	0	1	0	NA

Sample Type	N Samples	N Analyses	LA Results (PLM-Grav)					
			N Detected	Detection Frequency	N ND	N Tr	N > Tr	Max %
Surface Soil	2	2	0	0%	2	0	0	NA

Note:

LA – Libby amphibole asbestos; max - maximum; NA - not applicable; N - number; ND - non-detect; PLM-Grav - polarized light microscopy gravimetric; PLM-VE - polarized light microscopy visual area estimation; Tr - trace; < - less than;≥ - greater than or equal to; > - greater than; % - percent.

TABLE 3-21. CONTAMINATION AT SPECIALTY PROPERTIES - JOHNSTON ACRES SUBDIVISION

Sample Type	N Samples	N Analyses	LA Bin Results (PLM-VE)						
			N Detected	Detection Frequency	N Bin A (ND)	N Bin B1 (Tr)	N Bin B2 (<1%)	N Bin C (≥1%)	Max %
Surface Soil	15	16	2	13%	14	2	0	0	NA
Subsurface Soil	30	34	3	9%	31	3	0	0	NA

Sample Type	N Samples	N Analyses	LA Results (PLM-Grav)					
			N Detected	Detection Frequency	N ND	N Tr	N > Tr	Max %
Surface Soil	13	13	0	0%	13	0	0	NA
Subsurface Soil	27	27	0	0%	27	0	0	NA

Note:

LA – Libby amphibole asbestos; max - maximum; NA - not applicable; N - number; ND - non-detect; PLM-Grav - polarized light microscopy gravimetric; PLM-VE - polarized light microscopy visual area estimation; Tr - trace; < - less than;≥ - greater than or equal to; > - greater than; % - percent.

TABLE 3-22. CONTAMINATION AT SPECIALTY PROPERTIES - FORMER CONCRETE PLANT

Sample Type	N Samples	N Analyses	LA Bin Results (PLM-VE)						
			N Detected	Detection Frequency	N Bin A (ND)	N Bin B1 (Tr)	N Bin B2 (<1%)	N Bin C (≥1%)	Max %
Surface Soil	45	46	4	9%	42	2	2	0	NA

Sample Type	N Samples	N Analyses	LA Results (PLM-Grav)					
			N Detected	Detection Frequency	N ND	N Tr	N > Tr	Max %
Surface Soil	20	20	0	0%	20	0	0	NA

Note:

LA – Libby amphibole asbestos; max - maximum; NA - not applicable; N - number; ND - non-detect; PLM-Grav - polarized light microscopy gravimetric; PLM-VE - polarized light microscopy visual area estimation; Tr - trace; < - less than; ≥ - greater than or equal to; > - greater than; % - percent.

TABLE 3-23. CONTAMINATION AT SPECIALTY PROPERTIES - FORMER LANDFILL

Sample Type	N Samples	N Analyses	LA Bin Results (PLM-VE)						
			N Detected	Detection Frequency	N Bin A (ND)	N Bin B1 (Tr)	N Bin B2 (<1%)	N Bin C (≥1%)	Max %
Surface Soil	68	68	6	9%	62	5	0	1	1

Sample Type	N Samples	N Analyses	LA Results (PLM-Grav)					
			N Detected	Detection Frequency	N ND	N Tr	N > Tr	Max %
Surface Soil	7	7	0	0%	7	0	0	NA

Note:

LA – Libby amphibole asbestos; max - maximum; NA -not applicable; N - number; ND - non-detect; PLM-Grav - polarized light microscopy gravimetric; PLM-VE - polarized light microscopy visual area estimation; Tr - trace; < - less than; ≥ - greater than or equal to; > - greater than; % - percent.

TABLE 3-24. CONTAMINATION AT SPECIALTY PROPERTIES - LINCOLN COUNTY LANDFILL

Panel A. Air

Sample Type	Sample Type	N Samples	Total LA Concentration Results (TEM)*		
			N Detected	Detection Frequency	Range of Detected Conc (s/cc)
Outdoor Air	Stationary	11	0	0%	NA

Panel B. Soil

Sample Type	Sample Event	N Samples	N Analyses	LA Bin Results (PLM-VE)						
				N Detected	Detection Frequency	N Bin A (ND)	N Bin B1 (Tr)	N Bin B2 (<1%)	N Bin C (≥1%)	Max %
Surface Soil	Trash Area Clearance	1	1	0	0%	1	0	0	0	NA
	Compost Stockpile (2004)	20	21	13	62%	8	6	7	0	NA

Sample Type	Sample Event	N Samples	N Analyses	LA Results (PLM-Grav)					
				N Detected	Detection Frequency	N ND	N Tr	N > Tr	Max %
Surface Soil	Trash Area Clearance	1	1	0	0%	1	0	0	NA
	Compost Stockpile (2004)	19	19	0	0%	19	0	0	NA

Sample Type	Sample Event	N Samples	N Analyses	Trem/Actn Results (PLM-9002)					
				N Detected	Detection Frequency	N ND	N <1%	N ≥ 1%	Max %
Surface Soil	Compost Stockpile (2000)	17	17	13	76%	4	13	0	NA
	Pre-Construction	29	29	1	3%	28	0	1	3
	Trash Area Clearance	1	1	0	0%	1	0	0	NA
	Well Development	4	4	0	0%	4	0	0	NA
Subsurface Soil	Compost Stockpile (2000)	14	14	5	36%	9	5	0	NA
	Well Development	3	3	0	0%	3	0	0	NA

Note:

Conc - concentration; LA – Libby amphibole asbestos; max - maximum; NA - not applicable; N - number; ND - non-detect; PLM - polarized light microscopy; PLM-Grav - polarized light microscopy gravimetric; PLM-VE - polarized light microscopy visual area estimation; s/cc – structures per cubic centimeter; TEM – transmission electron microscopy; Tr - trace; Trem/Actn - tremolite/actinolite; < - less than; ≥ - greater than or equal to; > - greater than; % - percent.

**TEM results are presented based on the pooled result, as applicable.*

TABLE 3-25. CONTAMINATION AT SPECIALTY PROPERTIES - BORROW SOURCES

Sample Type	N Samples	N Analyses	LA Bin Results (PLM-VE)						
			N Detected	Detection Frequency	N Bin A (ND)	N Bin B1 (Tr)	N Bin B2 (<1%)	N Bin C (≥1%)	Max %
Surface Soil	536	539	21	4%	518	21	0	0	NA
Subsurface Soil	9	9	0	0%	9	0	0	0	NA

Sample Type	N Samples	N Analyses	LA Results (PLM-Grav)					
			N Detected	Detection Frequency	N ND	N Tr	N > Tr	Max %
Surface Soil	330	330	0	0%	330	0	0	NA
Subsurface Soil	2	2	0	0%	2	0	0	NA

Sample Type	N Samples	N Analyses	Trem/Actn Results (PLM-9002)					
			N Detected	Detection Frequency	N ND	N <1%	N ≥ 1%	Max %
Surface Soil	109	109	2	2%	107	2	0	NA
Subsurface Soil	81	81	1	1%	80	1	0	NA

Note:

LA – Libby amphibole asbestos; max - maximum; NA - not applicable; N - number; ND - non-detect; PLM - polarized light microscopy; PLM-Grav - polarized light microscopy gravimetric; PLM-VE - polarized light microscopy visual area estimation; Tr - trace; Trem/Actn - tremolite/actinolite; < - less than; ≥ - greater than or equal to; > - greater than; % - percent.

TABLE 3-26. CONTAMINATION AT SPECIALTY PROPERTIES - PERIODIC MONITORING AT PROJECT-RELATED FACILITIES

Panel A. Air

Sample Type	N Samples	Total LA Concentration Results (TEM)*		
		N Detected	Detection Frequency	Range of Detected Conc (s/cc)
Indoor Air	643	11	2%	0.0027 - 0.015

Panel B. Dust

Sample Type	N Samples	Total LA Concentration Results (TEM)*		
		N Detected	Detection Frequency	Range of Detected Conc (s/cm^2)
Indoor Dust	190	9	5%	36 - 570

Note:

Conc - concentration; LA – Libby amphibole asbestos; N - number; s/cc – structures per cubic centimeter; s/cm^2 - structures per square centimeter; TEM – transmission electron microscopy; % - percent.

*TEM results are presented based on the pooled result, as applicable.

TABLE 3-27. POST CLEANUP EVALUATION STUDY

Panel A. Air

Sample Type	N Samples	Total LA Concentration Results (TEM)*			PCME LA Concentration Results (TEM)*		
		N Detected	Detection Frequency	Range of Detected Conc (s/cc)	N Detected	Detection Frequency	Range of Detected Conc (s/cc)
Indoor Personal Air	8	1	13%	0.00015	1	13%	0.00015
Indoor Stationary Air	69	4	6%	0.00015	2	3%	0.00015

Panel B. Dust

Sample Type	N Samples	Total LA Concentration Results (TEM)*		
		N Detected	Detection Frequency	Range of Detected Conc (s/cm^2)
Indoor Dust	32	0	0%	NA

Note:

Conc - concentration; LA – Libby amphibole asbestos; N - number; NA - not applicable; PCME - phase contrast microscopy-equivalent; s/cc – structures per cubic centimeter; s/cm^2 - structures per square centimeter; TEM – transmission electron microscopy; % - percent.

**TEM results are presented based on the pooled result, as applicable.*

TABLE 3-28. SUPPLEMENTAL RI (SQAPP)

Panel A. Air

Sample Type	N Samples	Total LA Concentration Results (TEM)*			PCME LA Concentration Results (TEM)*		
		N Detected	Detection Frequency	Range of Detected Conc (s/cc)	N Detected	Detection Frequency	Range of Detected Conc (s/cc)
Indoor Stationary Air	46	33	72%	0.000048 - 0.0025	26	57%	0.000049 - 0.00055
Indoor Personal Air	24	15	63%	0.00013 - 0.0066	6	25%	0.00025 - 0.0013
Outdoor Stationay Air	90	18	20%	0.00088 - 0.69	15	17%	0.00095 - 0.21
Outdoor Personal Air	62	34	55%	0.00085 - 1.4	28	45%	0.00091 - 0.73

Panel B. Dust

Sample Type	N Samples	Total LA Concentration Results (TEM)*		
		N Detected	Detection Frequency	Range of Detected Conc (s/cm^2)
Indoor Dust	43	18	42%	3.9 - 1600

Panel C. Soil

Sample Type	N Samples	N Analyses	LA Bin Results (PLM-VE)						
			N Detected	Detection Frequency	N Bin A (ND)	N Bin B1 (Tr)	N Bin B2 (<1%)	N Bin C (≥1%)	Max %
Surface Soil	71	71	34	48%	37	28	5	1	1

Sample Type	N Samples	N Analyses	LA Results (PLM-Grav)					
			N Detected	Detection Frequency	N ND	N Tr	N > Tr	Max %
Surface Soil	4	4	0	0%	4	0	0	NA

Note:

LA – Libby amphibole asbestos; max - maximum; NA - not applicable; N - number; ND - non-detect; PCME - phase contrast microscopy equivalent; PLM-Grav - polarized light microscopy gravimetric; PLM-VE - polarized light microscopy visual area estimation ;RI - remedial investigation; s/cc – structures per cubic centimeter; s/cm^2 - structures per square centimeter; SQAPP - Supplemental Remedial Investigation Quality Assurance Project Plan; Conc - concentration; TEM – transmission electron microscopy; Tr - trace; < - less than; ≥ - greater than or equal to; > - greater than; % - percent.

**TEM results are presented based on the pooled result, as applicable.*

TABLE 3-29. AMBIENT AIR

Sample Type	Sampling Event	N Samples	Total LA Concentration Results (TEM)*			PCME LA Concentration Results (TEM)*		
			N Detected	Detection Frequency	Range of Detected Conc (s/cc)	N Detected	Detection Frequency	Range of Detected Conc (s/cc)
Outdoor Air	2000 to 2003	405	69	17%	0.000071 - 0.033	20	5%	0.000094 - 0.011
	2006 to 2008	648	88	14%	0.000035 - 0.00053	59	9%	0.000035 - 0.00023
	2010 to 2013	380	67	18%	0.000031 - 0.0027	47	12%	0.000034 - 0.00035

Note:

Conc - concentration; LA – Libby amphibole asbestos; N - number; s/cc – structures per cubic centimeter; PCME - phase contrast microscopy-equivalent; TEM – transmission electron microscopy; % - percent

**TEM results are presented based on the pooled result, as applicable.*

TABLE 3-30. BUILDING DEMOLITION INVESTIGATION RESULTS

Panel A. Air

Year	Property	Period	Sample Type	N Samples	Total LA Concentration Results (TEM)*		
					N Detected	Detection Frequency	Range of Detected Conc (s/cc)
2005	1	Pre-Demo	Onsite	3	0	0%	NA
			Offsite	1	0	0%	NA
		During/ Post-Demo	Inner Ring	12	3	25%	0.0096 - 0.037
			Middle Ring - 6 ft	16	14	88%	0.000094 - 0.00093
			Middle Ring - 12 ft	17	13	76%	0.000098 - 0.0033
			Outer Ring	11	11	100%	0.000096 - 0.0014
			Offsite	6	5	83%	0.0001 - 0.0003
	2	Pre-Demo	Onsite	3	0	0%	NA
			Offsite	1	0	0%	NA
		During/ Post-Demo	Inner Ring	33	10	30%	0.00019 - 0.0044
			Middle Ring - 6 ft	12	9	75%	0.000096 - 0.0008
			Middle Ring - 12 ft	12	5	42%	0.000098 - 0.00079
			Outer Ring	8	3	38%	0.000099 - 0.0001
			Offsite	4	1	25%	0.000098
2006	3	Pre-Demo	Onsite	12	0	0%	NA
			Offsite	4	1	25%	0.00095
		During/ Post-Demo	Inner Ring	30	0	0%	NA
			Middle Ring	24	0	0%	NA
			Outer Ring	12	0	0%	NA
			Offsite	6	0	0%	NA
	4	Pre-Demo	Onsite	12	0	0%	NA
			Offsite	2	0	0%	NA
		During/ Post-Demo	Inner Ring	12	0	0%	NA
			Middle Ring	18	0	0%	NA
			Outer Ring	NA	NA	NA	NA
			Offsite	2	0	0%	NA

Panel B. Dust

Year	Property	Period	Sample Type	N Samples	Total LA Concentration Results (TEM)*		
					N Detected	Detection Frequency	Range of Detected Conc (s/cm^2)
2005	1	Pre-Demo	Onsite	NA	NA	NA	NA
			Offsite - Outdoor	NA	NA	NA	NA
			Offsite - Indoor	4	2	NA	180 - 360
		During/ Post-Demo	Inner Ring	NA	NA	NA	NA
			Middle Ring	20	8	40%	100 - 7100
			Outer Ring	9	3	33%	270 - 2800
			Offsite - Outdoor	3	0	0%	NA
			Offsite - Indoor	7	1	14%	390
	2	Pre-Demo	Onsite	3	0	NA	0
			Offsite - Outdoor	2	0	NA	0
			Offsite - Indoor	3	2	NA	140
		During/ Post-Demo	Inner Ring	16	3	NA	110 - 140
			Middle Ring	13	0	0%	NA
			Outer Ring	7	0	0%	NA
			Offsite - Outdoor	4	0	0%	NA
			Offsite - Indoor	10	0	0%	NA

TABLE 3-30. BUILDING DEMOLITION INVESTIGATION RESULTS

Panel B. Dust (continued)

Year	Property	Period	Sample Type	N Samples	Total LA Concentration Results (TEM)*		
					N Detected	Detection Frequency	Range of Detected Conc (s/cm^2)
2006	3	Pre-Demo	Onsite	6	0	0%	NA
			Offsite - Outdoor	2	0	0%	NA
			Offsite - Indoor	3	1	33%	47
		During/ Post-Demo	Middle Ring	18	2	11%	25
			Outer Ring	6	1	17%	47
			Offsite - Outdoor	NA	NA	NA	NA
			Offsite - Indoor	NA	NA	NA	NA
	4	Pre-Demo	Onsite	NA	NA	NA	NA
			Offsite - Outdoor	NA	NA	NA	NA
			Offsite - Indoor	2	0	0%	NA
		Post-Demo	Middle Ring	5	4	80%	25 - 130
			Outer Ring	NA	NA	NA	NA
			Offsite - Outdoor	NA	NA	NA	NA
			Offsite - Indoor	NA	NA	NA	NA

Panel C. Soil

Year	Property	N Samples	N Analyses	Trem/Actn Results (PLM-9002)					
				N Detected	Detection Frequency	N ND	N <1%	N ≥ 1%	Max %
2005	1	3	3	0	0%	3	0	0	NA
	2	9	9	0	0%	9	0	0	NA
2006	3	5	5	0	0%	5	0	0	NA
	4	4	4	1	25%	3	1	0	NA

Note:

Conc - concentration; Demo - demolition; LA – Libby amphibole asbestos; max - maximum; NA - not applicable; N - number; ND - non-detect; PLM - polarized light microscopy; s/cc – structures per cubic centimeter; s/cm^2 - structures per square centimeter; TEM – transmission electron microscopy; Tr - trace; Trem/Actn - tremolite/actinolite; < - less than; ≥ - greater than or equal to; % - percent.

**TEM results are presented based on the pooled result, as applicable.*

TABLE 3-31. 2007-2008 RESIDENTIAL ACTIVITY-BASED SAMPLING

Panel A. Air

Sample Type	Scenario	N Samples	Total LA Concentration Results (TEM)*			PCME LA Concentration Results (TEM)*		
			N Detected	Detection Frequency	Range of Detected Conc (s/cc)	N Detected	Detection Frequency	Range of Detected Conc (s/cc)
Outdoor ABS Air	Rake, Mow, Dig	460	319	69%	0.00046 - 58	271	59%	0.00048 - 21
Indoor ABS Air	Active	321	171	53%	0.00017 - 0.05	120	37%	0.00017 - 0.0097
	Passive	321	75	23%	0.00013 - 0.033	39	12%	0.00013 - 0.0099

Panel B. Dust

Sample Type	Scenario	N Samples	Total LA Concentration Results (TEM)*		
			N Detected	Detection Frequency	Range of Detected Conc (s/cm^2)
Indoor Dust	NA	354	10	3%	6.3 - 79

Panel C. Soil

Sample Type	Scenario	N Samples	N Analyses	LA Bin Results (PLM-VE)						
				N Detected	Detection Frequency	N Bin A (ND)	N Bin B1 (Tr)	N Bin B2 (<1%)	N Bin C (≥1%)	Max %
Surface Soil	Indoor	195	350	58	17%	292	58	0	0	NA
	Outdoor	237	431	128	30%	303	108	17	3	1

Sample Type	Scenario	N Samples	N Analyses	LA Results (PLM-Grav)					
				N Detected	Detection Frequency	N ND	N Tr	N > Tr	Max %
Surface Soil	Indoor	121	121	0	0%	121	0	0	NA
	Outdoor	38	38	0	0%	38	0	0	NA

Note:

ABS - activity-based sampling; Conc - concentration; LA – Libby amphibole asbestos; max - maximum; NA - not applicable; N - number; ND - non-detect; PCME - phase contrast microscopy-equivalent; PLM-Grav - polarized light microscopy gravimetric; PLM-VE - polarized light microscopy visual area estimation; s/cc – structures per cubic centimeter; s/cm^2 - structures per square centimeter; TEM – transmission electron microscopy; Tr - trace; < - less than; ≥ - greater than or equal to; > - greater than; % - percent.

**TEM results are presented based on the pooled result, as applicable.*

TABLE 3-32. 2010 RESIDENTIAL ACTIVITY-BASED SAMPLING

Panel A. Air

Sample Type	Scenario	N Samples	Total LA Concentration Results (TEM)*			PCME LA Concentration Results (TEM)*		
			N Detected	Detection Frequency	Range of Detected Conc (s/cc)	N Detected	Detection Frequency	Range of Detected Conc (s/cc)
Outdoor ABS Air	1	120	3	3%	0.0040	9	8%	0.00099 - 0.0038
	2	60	5	8%	0.0029 - 0.0030	10	17%	0.00089 - 0.0040
	3	61	3	5%	0.013 - 0.18	3	5%	0.0094 - 0.076
	4	20	0	0%	NA	0	0%	NA
	5	90	0	0%	NA	0	0%	NA

Panel B. Soil

Sample Type	Scenario	N Samples	N Analyses	LA Bin Results (PLM-VE)						
				N Detected	Detection Frequency	N Bin A (ND)	N Bin B1 (Tr)	N Bin B2 (<1%)	N Bin C (≥1%)	Max %
Surface Soil	Pre-Screening	29	29	17	59%	12	15	2	0	NA
	1	127	127	44	35%	83	41	3	0	NA
	2	66	66	25	38%	41	22	2	1	2
	3	61	61	16	26%	45	13	2	1	1

Sample Type	Scenario	N Samples	N Analyses	LA Results (PLM-Grav)					
				N Detected	Detection Frequency	N ND	N Tr	N > Tr	Max %
Surface Soil	Pre-Screening	2	2	0	0%	2	0	0	NA
	1	1	1	0	0%	1	0	0	NA
	2	2	2	1	50%	1	1	0	NA
	3	55	55	6	11%	49	6	0	NA

Note:

ABS - activity-based sampling; Conc - concentration; LA – Libby amphibole asbestos; max - maximum; NA - not applicable; N - number; ND - non-detect; PCME - phase contrast microscopy-equivalent; PLM-Grav - polarized light microscopy gravimetric; PLM-VE - polarized light microscopy visual area estimation; s/cc – structures per cubic centimeter; TEM - transmission electron microscopy; Tr - trace; < - less than; ≥ - greater than or equal to; > - greater than; % - percent.

**TEM results are presented based on the pooled result, as applicable. If results are availble for both the high volume and low volume sample, only the high volume sample result was included in this evaluation.*

TABLE 3-33. 2011 RESIDENTIAL ACTIVITY-BASED SAMPLING

Panel A. Air

Sample Type	Scenario	N Samples	PCME LA Concentration Results (TEM)*		
			N Detected	Detection Frequency	Range of Detected Conc (s/cc)
Outdoor ABS Air	1	80	57	71%	0.00011 - 0.40
	2	31	10	32%	0.00021 - 0.044
	3	18	5	28%	0.00022 - 0.00064
	4	31	8	26%	0.00011 - 0.012

Panel B. Soil

Sample Type	Scenario	N Samples	N Analyses	LA Bin Results (PLM-VE)						
				N Detected	Detection Frequency	N Bin A (ND)	N Bin B1 (Tr)	N Bin B2 (<1%)	N Bin C (≥1%)	Max %
Surface Soil	1	61	61	34	56%	27	26	6	2	2
	2	33	33	19	58%	14	17	2	0	NA
	3	20	20	8	40%	12	8	0	0	NA
	4	33	33	1	3%	32	1	0	0	NA

Note:

ABS - activity-based sampling; Conc - concentration; LA – Libby amphibole asbestos; max - maximum; NA - not applicable; N - number; ND - non-detect; PCME - phase contrast microscopy-equivalent; PLM-VE - polarized light microscopy visual area estimation; s/cc – structures per cubic centimeter; TEM - transmission electron microscopy; Tr - trace; < - less than; ≥ - greater than or equal to; % - percent.

**TEM results are presented based on the pooled result, as applicable.*

TABLE 3-34. 2013 RESIDENTIAL ACTIVITY-BASED SAMPLING

Sample Type	Scenario	ABS Script	N Samples	PCME LA Concentration Results (TEM)*		
				N Detected	Detection Frequency	Range of Detected Conc (s/cc)
Indoor ABS Air	1	Active	20	10	50%	0.00004 - 0.00083
		Passive	20	9	45%	0.000032 - 0.00024
	2	Active	10	4	40%	0.00004 - 0.00056
		Passive	10	4	40%	0.00003 - 0.000088

Note:

ABS - activity-based sampling; Conc - concentration; LA – Libby amphibole asbestos; N - number; PCME - phase contrast microscopy-equivalent; s/cc – structures per cubic centimeter; TEM - transmission electron microscopy; % - percent.

**TEM results are presented based on the pooled result, as applicable.*

TABLE 3-35. SCHOOLS INVESTIGATION

Panel A. Stationary Air

School	N Samples	Total LA Concentration Results (TEM)*			PCME LA Concentration Results (TEM)*		
		N Detected	Detection Frequency	Range of Detected Conc (s/cc)	N Detected	Detection Frequency	Range of Detected Conc (s/cc)
Kootenai Valley Head Start	10	0	0%	NA	0	0%	NA
Libby Elementary School	10	1	10%	0.00059	1	10%	0.00059
Libby Middle School	10	1	10%	0.00051	1	10%	0.00051
Libby High School	11	0	0%	NA	0	0%	NA
Libby School Admin Building	10	0	0%	NA	0	0%	NA

Panel B. Surface Soil

School	N Samples	N Analyses	LA Bin Results (PLM-VE)						
			N Detected	Detection Frequency	N Bin A (ND)	N Bin B1 (Tr)	N Bin B2 (<1%)	N Bin C (≥1%)	Max %
Libby Elementary School	18	21	2	10%	19	2	0	0	NA
Libby Middle School	4	4	0	0%	4	0	0	0	NA

School	N Samples	N Analyses	LA Results (PLM-Grav)					
			N Detected	Detection Frequency	N ND	N Tr	N > Tr	Max %
Libby Elementary School	2	2	0	0%	2	0	0	NA
Libby Middle School	1	1	0	0%	1	0	0	NA

Note:

Conc - concentration; LA – Libby amphibole asbestos; max - maximum; NA - not applicable; N - number; ND - non-detect; PCME - phase contrast microscopy-equivalent; PLM-Grav - polarized light microscopy gravimetric; PLM-VE - polarized light microscopy visual area estimation; s/cc – structures per cubic centimeter; TEM – transmission electron microscopy; Tr - trace; < - less than; ≥ - greater than or equal to; > - greater than; % - percent.

**TEM results are presented based on the pooled result, as applicable.*

TABLE 3-36. PUBLIC SCHOOLS ABS INVESTIGATION

Panel A. Outdoor ABS Air

School	Activity Type	N Samples	Total LA Concentration Results (TEM)*			PCME LA Concentration Results (TEM)*		
			N Detected	Detection Frequency	Range of Detected Conc (s/cc)	N Detected	Detection Frequency	Range of Detected Conc (s/cc)
Libby Elementary School	Student	9	2	22%	0.021 - 0.039	2	22%	0.003 - 0.039
	Maintenance	6	0	0%	NA	0	0%	NA
Libby Middle School	Student	6	2	33%	0.011 - 0.039	2	33%	0.011 - 0.02
	Maintenance	6	1	17%	0.0028	0	0%	NA
Libby High School	Student	6	1	17%	0.0025	1	17%	0.0025
	Maintenance	7	0	0%	NA	0	0%	NA
Libby Admin Building and High School**	Maintenance	3	0	0%	NA	0	0%	NA
Libby Public Schools Admin Building	Student	3	0	0%	NA	0	0%	NA
	Maintenance	6	1	17%	0.00042	1	17%	0.00014
Kootenai Valley Head Start	Student	6	0	0%	NA	0	0%	NA
	Maintenance	6	2	33%	0.000076 - 0.0022	1	17%	0.0022

Panel B. Surface Soil

School	N Samples	N Analyses	LA Bin Results (PLM-VE)						
			N Detected	Detection Frequency	N Bin A (ND)	N Bin B1 (Tr)	N Bin B2 (<1%)	N Bin C (≥1%)	Max %
Libby Elementary School	9	10	5	50%	5	5	0	0	NA
Libby Middle School	10	11	7	64%	4	7	0	0	NA
Libby High School	9	10	9	90%	1	9	0	0	NA
Public Schools Admin Building	8	9	6	67%	3	6	0	0	NA
Kootenai Valley Head Start	8	9	7	78%	2	7	0	0	NA

School	N Samples	N Analyses	LA Results (PLM-Grav)					
			N Detected	Detection Frequency	N ND	N Tr	N > Tr	Max %
Libby Elementary School	6	6	0	0%	6	0	0	NA
Libby Middle School	7	7	0	0%	7	0	0	NA
Libby High School	3	3	0	0%	3	0	0	NA
Kootenai Valley Head Start	4	4	0	0%	4	0	0	NA

Note:

ABS - activity-based sampling; Conc - concentration; LA – Libby amphibole asbestos; max - maximum; NA - not applicable; N - number; ND - non-detect; PCME - phase contrast microscopy-equivalent; PLM-Grav - polarized light microscopy gravimetric; PLM-VE - polarized light microscopy visual area estimation; s/cc – structures per cubic centimeter; TEM – transmission electron microscopy; Tr - trace; < - less than; ≥ - greater than or equal to; > - greater than; % - percent.

**TEM results are presented based on the pooled result, as applicable.*

** The Libby Public Schools Admin Building and Libby High School were sampled together as part of the power sweeping ABS scenario.

TABLE 3-37. LIMITED-USE AREA ACTIVITY-BASED SAMPLING

Panel A. Air

Sample Type	Category	N Samples	PCME LA Concentration Results (TEM)*		
			N Detected	Detection Frequency	Range of Detected Conc (s/cc)
Outdoor ABS Air	1	30	11	37%	0.0017 - 0.016
	2	30	11	37%	0.0017 - 0.017

Panel B. Soil

Sample Type	Category	N Samples	N Analyses	LA Bin Results (PLM-VE)						
				N Detected	Detection Frequency	N Bin A (ND)	N Bin B1 (Tr)	N Bin B2 (<1%)	N Bin C (≥1%)	Max %
Surface Soil	1	16	16	2	13%	14	2	0	0	NA
	2	16	16	7	44%	9	7	0	0	NA

Note:

ABS - activity-based sampling; Conc - concentration; LA – Libby amphibole asbestos; max - maximum; NA - not applicable; N - number; ND - non-detect; PCME - phase contrast microscopy-equivalent; PLM-VE - polarized light microscopy visual area estimation; s/cc - structures per cubic centimeter; TEM – transmission electron microscopy; Tr - trace; < - less than;≥ - greater than or equal to; % - percent.

**TEM results are presented based on the pooled result, as applicable.*

TABLE 3-38. WOOD CHIP ACTIVITY-BASED SAMPLING

Panel A. Air

Sample Type	N Samples	PCME LA Concentration Results (TEM)*		
		N Detected	Detection Frequency	Range of Detected Conc (s/cc)
Outdoor ABS Air	15	0	0%	NA

Panel B. Wood Chips

Sample Type	N Samples	Total LA Concentration Results (TEM)*		
		N Detected	Detection Frequency	Range of Detected Conc (s/g)
Wood Chip	17	1	6%	230000

Note:

ABS - activity-based sampling; Conc - concentration; LA – Libby amphibole asbestos; NA - not applicable; N - number; PCME - phase contrast microscopy-equivalent; s/cc - structures per cubic centimeter; s/g - structures per gram; TEM – transmission electron microscopy; % - percent.

**TEM results are presented based on the pooled result, as applicable.*

TABLE 3-39. BACKGROUND AND BORROW SOURCE ABS INVESTIGATION

Panel A. Air

Sample Type	N Samples	PCME LA Concentration Results (TEM)*		
		N Detected	Detection Frequency	Range of Detected Conc (s/cc)
Background ABS Air	33	7	21%	0.00044 - 0.048
Borrow ABS Air	12	4	33%	0.000096 - 0.0002

Panel B. Surface Soil

Sample Type	N Samples	Total LA Concentration Results (FBAS TEM)*		
		N Detected	Detection Frequency	Range of Detected Conc (s/g)
Background	35	34	97%	62000 - 4600000
Borrow	13	13	100%	31000 - 1300000

Note:

ABS - activity-based sampling; Conc - concentration; LA – Libby amphibole asbestos; N - number; s/cc – structures per cubic centimeter; s/g - structures per gram; FBAS - fluidized bed asbestos segregator; PCME - phase contrast microscopy equivalent; TEM – transmission electron microscopy; % - percent.

**TEM results are presented based on the pooled result, as applicable.*

TABLE 3-40. NATURE AND EXTENT OF LA CONTAMINATION IN THE FOREST INVESTIGATION

Sample Type	N Samples	Total LA Concentration Results (TEM)*		
		N Detected	Detection Frequency	Range of Detected Conc (Ms/cm^2 for tree bark, Ms/g for duff)
Tree Bark	54	24	44%	0.0045 - 2.4
Duff	54	21	39%	0.25 - 20

Note:

Conc - concentration; LA – Libby amphibole asbestos; N - number; Ms/cm^2 - million structures per centimeter squared; Ms/g - million structures per gram; TEM – transmission electron microscopy; % - percent.

*In the case of replicate samples (multiple sub-samples prepared for analysis from one sample), the average of the replicates is summarized. There were five replicate samples of tree bark and five replicate samples of duff.

TABLE 3-41. NATURE AND EXTENT OF LA CONTAMINATION IN SURFACE WATER AND SEDIMENT INVESTIGATION

Panel A. Water

Sample Type	N Samples	Total LA Concentration Results (TEM)*			>10 µm LA Concentration Results (TEM)*		
		N Detected	Detection Frequency	Range of Detected Conc (MFL)	N Detected	Detection Frequency	Range of Detected Conc (MFL)
High Flow	15	3	20%	0.049 - 0.1	2	13%	0.049 - 0.05
Low Flow	16	1	6%	0.022	0	0%	NA

Panel B. Sediment

Sample Type	N Samples	N Analyses	LA Bin Results (PLM-VE)						
			N Detected	Detection Frequency	N Bin A (ND)	N Bin B1 (Tr)	N Bin B2 (<1%)	N Bin C (≥1%)	Max %
Sediment	22	22	13	59%	9	8	5	0	NA

Sample Type	N Samples	N Analyses	LA Results (PLM-Grav)					
			N Detected	Detection Frequency	N ND	N Tr	N > Tr	Max %
Sediment	12	12	0	0%	12	0	0	NA

Notes:

Conc - concentration; LA – Libby amphibole asbestos; max - maximum; NA - not applicable; N - number; ND - non-detect; PLM-Grav - polarized light microscopy gravimetric; PLM-VE - polarized light microscopy visual area estimation; MFL - million fibers per liter; TEM – transmission electron microscopy; Tr - trace; < - less than; ≥ - greater than or equal to; > - greater than; % - percent; µm - micrometers.

**TEM results are presented based on the pooled result, as applicable.*

TABLE 3-42. TRADESPERSON INDOOR AIR RE-ANALYSIS INVESTIGATION RESULTS

Sample Type	N Samples	PCME LA Concentration Results (TEM)*		
		N Detected	Detection Frequency	Range of Detected Conc (s/cc)
Bulk Removal	4	4	100%	0.00099 - 0.12
Demolition	4	4	100%	0.00013 - 0.071
Detailing attic	5	5	100%	0.00014 - 0.12
Wet wipe/HEPA vac living space	4	4	100%	0.0007 - 0.076

Note:

Conc - concentration; HEPA - high efficiency particulate air; LA – Libby amphibole asbestos; N - number; PCME - phase contrast microsopy-equivalent; s/cc – structures per cubic centimeter; TEM – transmission electron microscopy; vac - vacuum; % - percent.

**TEM results are presented based on the pooled result, as applicable.*

TABLE 3-43. WOODSTOVE ABS INVESTIGATION

Panel A. ABS Air

Collection Location	N Samples	PCME LA Concentration Results (TEM)		
		N Detected	Detection Frequency	Range of Detected Conc (s/cc)
Bear Creek	3	1	33%	0.022
Flower Creek	3	3	100%	0.0057 - 0.044
OU3	3	3	100%	0.04 - 0.84

Panel B. Stationary Air

Collection Location	N Samples	Total LA Concentration Results (TEM)			PCME LA Concentration Results (TEM)		
		N Detected	Detection Frequency	Range of Detected Conc (s/cc)	N Detected	Detection Frequency	Range of Detected Conc (s/cc)
2-day Perimeter	3	0	0%	NA	0	0%	NA
6-hr Perimeter	3	0	0%	NA	0	0%	NA

Panel C. Ash

Collection Location	N Samples	Total LA Concentration Results (TEM)*		
		N Detected	Detection Frequency	Range of Detected Conc (Ms/g)
Bear Creek	3	2	67%	2 - 3.3
Flower Creek	3	1	33%	2
OU3	3	2	67%	50 - 56

Panel D. Tree Bark

Collection Location	N Samples	Total LA Concentration Results (TEM)*		
		N Detected	Detection Frequency	Range of Detected Conc (Ms/cm^2)
Bear Creek	4	2	50%	0.0098 - 0.017
Flower Creek	4	2	50%	0.0075 - 0.22
OU3	4	3	75%	0.5 - 18

Note:

ABS - activity-based sampling; Conc - concentration; hr - hour; LA – Libby amphibole asbestos; max - maximum; NA - not applicable; N - number; ND - non-detect; OU3 - operable unit 3; s/cc – structures per cubic centimeter; Ms/cm^2 - million structures per square centimeter; Ms/g - million structures per gram; TEM – transmission electron microscopy; PCME - phase contrast microscopy-equivalent; % - percent.

**TEM results are presented based on the average result across replicates.*

TABLE 3-44. FLOWERBED INVESTIGATION RESULTS

Panel A. Task 1 - Flowerbeds in Libby

Category	N Samples	Total LA Concentration Results (TEM)*		
		N Detected	Detection Frequency	Range of Detected Conc (s/g)
Category 1	6	6	100%	58000 - 4900000
Category 2	5	5	100%	21000 - 1400000

Sample Type	N Samples	N Analyses	LA Bin Results (PLM-VE)						
			N Detected	Detection Frequency	N Bin A (ND)	N Bin B1 (Tr)	N Bin B2 (<1%)	N Bin C (≥1%)	Max %
Category 1	6	6	4	67%	2	4	0	0	NA
Category 2	5	5	2	40%	3	2	0	0	NA

Panel B. Task 3 - Store-Bought Materials from Libby

Category	N Samples	Total LA Concentration Results (TEM)*		
		N Detected	Detection Frequency	Range of Detected Conc (s/g)
Potting Soil	3	2	67%	2600 - 7900
Vermiculite	2	2	100%	10000 - 28000

Sample Type	N Samples	N Analyses	LA Bin Results (PLM-VE)						
			N Detected	Detection Frequency	N Bin A (ND)	N Bin B1 (Tr)	N Bin B2 (<1%)	N Bin C (≥1%)	Max %
Potting Soil	3	3	1	33%	2	1	0	0	NA

Sample Type	N Samples	N Analyses	Trem/Actn Results (PLM-9002)					
			N Detected	Detection Frequency	N ND	N <1%	N ≥ 1%	Max %
Vermiculite	2	2	0	0%	2	0	0	NA

Note:

Conc - concentration; LA – Libby amphibole asbestos; Max - maximum; N - number; ND - non-detect; NA - not applicable; s/g - structures per gram; PLM - polarized light microscopy; PLM-VE - polarized light microscopy visual estimation; Trem/Actn - tremolite/actinolite; TEM – transmission electron microscopy; Tr - trace; < - less than; ≥ - greater than or equal to; % - percent.

**TEM results are presented based on the average across replicates.*

TABLE 3-45. WATER SOURCE INVESTIGATION

Sample Type	N Samples	Total LA Concentration Results (TEM)*			>10 µm LA Concentration Results (TEM)*		
		N Detected	Detection Frequency	Range of Detected Conc (MFL)	N Detected	Detection Frequency	Range of Detected Conc (MFL)
Phase 1 (low flow)	78	0	0%	NA	0	0%	NA
Phase 2 (high flow)	72	25	35%	0.0092 - 1	3	4%	0.013 - 0.043

Note:

Conc - concentration; LA – Libby amphibole asbestos; N - number; NA - not applicable; MFL – million fibers per liter; TEM – transmission electron microscopy; > - greater than; % - percent; µm - micrometers.

**TEM results are presented based on the pooled result, as applicable.*

TABLE 3-46. FISH AND GAME TISSUE ASSESSMENT INVESTIGATION

Sample Type	N Samples	Total LA Concentration Results (TEM)*		
		N Detected	Detection Frequency	Range of Detected Conc (s/g, ww)
Fish	8	8	100%	9400 - 6400000
Game	13	0	0%	NA

Note:
Conc - concentration; LA – Libby amphibole asbestos; NA - not applicable; N - number; s/g, ww - structures per gram, wet weight; TEM – transmission electron microscopy; % - percent.

**TEM results are presented based on the pooled result, as applicable.*

TABLE 3-47. POREWATER IN THE TRIBUTARIES

Panel A. Sediment

Sample Type	N Samples	N Analyses	LA Bin Results (PLM-VE)						
			N Detected	Detection Frequency	N Bin A (ND)	N Bin B1 (Tr)	N Bin B2 (<1%)	N Bin C (≥1%)	Max %
Sediment	3	3	1	33%	2	1	0	0	NA

Sample Type	N Samples	N Analyses	LA Results (PLM-Grav)					
			N Detected	Detection Frequency	N ND	N Tr	N > Tr	Max %
Sediment	3	3	0	0%	3	0	0	NA

Panel B. Water

Sample Type	N Samples	Total LA Concentration Results (TEM)*			>10 µm LA Concentration Results (TEM)*		
		N Detected	Detection Frequency	Range of Detected Conc (MFL)	N Detected	Detection Frequency	Range of Detected Conc (MFL)
Porewater	15	1	7%	0.3	0	0%	NA
Surface Water	3	0	0%	NA	0	0%	NA

Note:

Conc - concentration; LA – Libby amphibole asbestos; max - maximum; MFL - million fibers per liter; NA - not applicable; N - number; ND - non-detect; PLM-Grav - polarized light microscopy gravimetric; PLM-VE - polarized light microscopy visual area estimation; TEM – transmission electron microscopy; Tr - trace; < - less than; ≥ - greater than or equal to; > - greater than; % - percent; µm - micrometers.

**TEM results are presented based on the pooled result, as applicable.*

TABLE 3-48. OVERVIEW OF REMOVAL ACTION LEVELS

Panel A. Indoor

Location	Action Level Trigger	
Attic/Walls	Visual confirmation of open, non-contained, or migrating vermiculite insulation	
Living Space	1) Visual confirmation of vermiculite in the indoor living space	
	2) Dust sample with LA concentration greater than or equal to 5,000 s/cm^2*	

**If dust samples were collected before 2007*

Panel B. Outdoor

Soil Condition	Action Level Trigger					
	SUA	Non-SUA		LUA		
	2003-2013	2003-2006	2007-2013	2003-2006	2006-2010	2011-2013
Bin A (ND)						
Bin B1 (Trace)						
Bin B2 (<1%)						
Bin C (≥1%)						
Vis +		Vis + and PLM +				mod. and high Vis + only
Vis -						

	primary trigger
	conditional trigger

Note:

LA - Libby amphibole; LUA - limited-use area (e.g., pasture, maintained/mowed fields); mod - moderate; ND - non-detect; Non-SUA - non-specific-use area (e.g., yard); PLM - polarized light microscopy, s/cm2 - structures per centimeter squared; SUA - specific-use area (e.g., garden, flowerbed, unpaved driveway, play area); Vis - visible vermiculite; < - less than;≥ - greater than or equal; % - percent.

Primary trigger = if one or more primary triggers are met, a soil cleanup is needed

Conditional trigger = conditional triggers are only are evaluated for properties where a soil cleanup is needed (i.e., a primary trigger is present)

TABLE 3-49. PDI AND GPI RESULTS

Panel A: Bulk Building Material

Sample Type	N Samples	N Analyses	Trem/Actn Results (PLM-9002)					
			N Detected	Detection Frequency	N ND	N <1%	N ≥ 1%	Max %
Grab	192	192	52	27%	140	43	9	3

Panel B. Dust

Sample Type	N Samples	Total LA Concentration Results (TEM)*		
		N Detected	Detection Frequency	Range of Detected Conc (s/cm^2)
Indoor Dust	3,835	236	6%	30 - 110000

Panel C: Soil

Sample Type	N Samples	N Analyses	LA Bin Results (PLM-VE)						
			N Detected	Detection Frequency	N Bin A (ND)	N Bin B1 (Tr)	N Bin B2 (<1%)	N Bin C (≥1%)	Max %
Surface Soil	27,875	27,965	4,932	18%	23,033	4,671	211	50	4
Subsurface Soil	28	28	7	25%	21	6	1	0	NA

Sample Type	N Samples	N Analyses	LA Results (PLM-Grav)					
			N Detected	Detection Frequency	N ND	N Tr	N > Tr	Max %
Surface Soil	4,381	4,398	23	1%	4,375	19	4	0.25
Subsurface Soil	23	23	0	0%	23	0	0	NA

Sample Type	N Samples	N Analyses	Trem/Actn Results (PLM-9002)					
			N Detected	Detection Frequency	N ND	N <1%	N ≥ 1%	Max %
Surface Soil	23	24	10	42%	14	6	4	10
Subsurface Soil	1	1	0	0%	1	0	0	0

Note:

Conc - concentration; GPI; general property investigation; LA – Libby amphibole asbestos; max - maximum; NA - not applicable; N - number; ND - non-detect; PDI - preliminary design investigation; PLM - polarized light microscopy; PLM-Grav - polarized light microscopy gravimetric; PLM-VE - polarized light microscopy visual area estimation; s/cm^2 - structures per square centimeter; TEM – transmission electron microscopy; Tr - trace; Trem/Actn - tremolite/actinolite; < - less than; ≥ - greater than or equal to; > greater than; % - percent.

**TEM results are presented based on the pooled result, as applicable.*

TABLE 5-1. NATURE OF SOIL MATERIALS LEFT IN PLACE

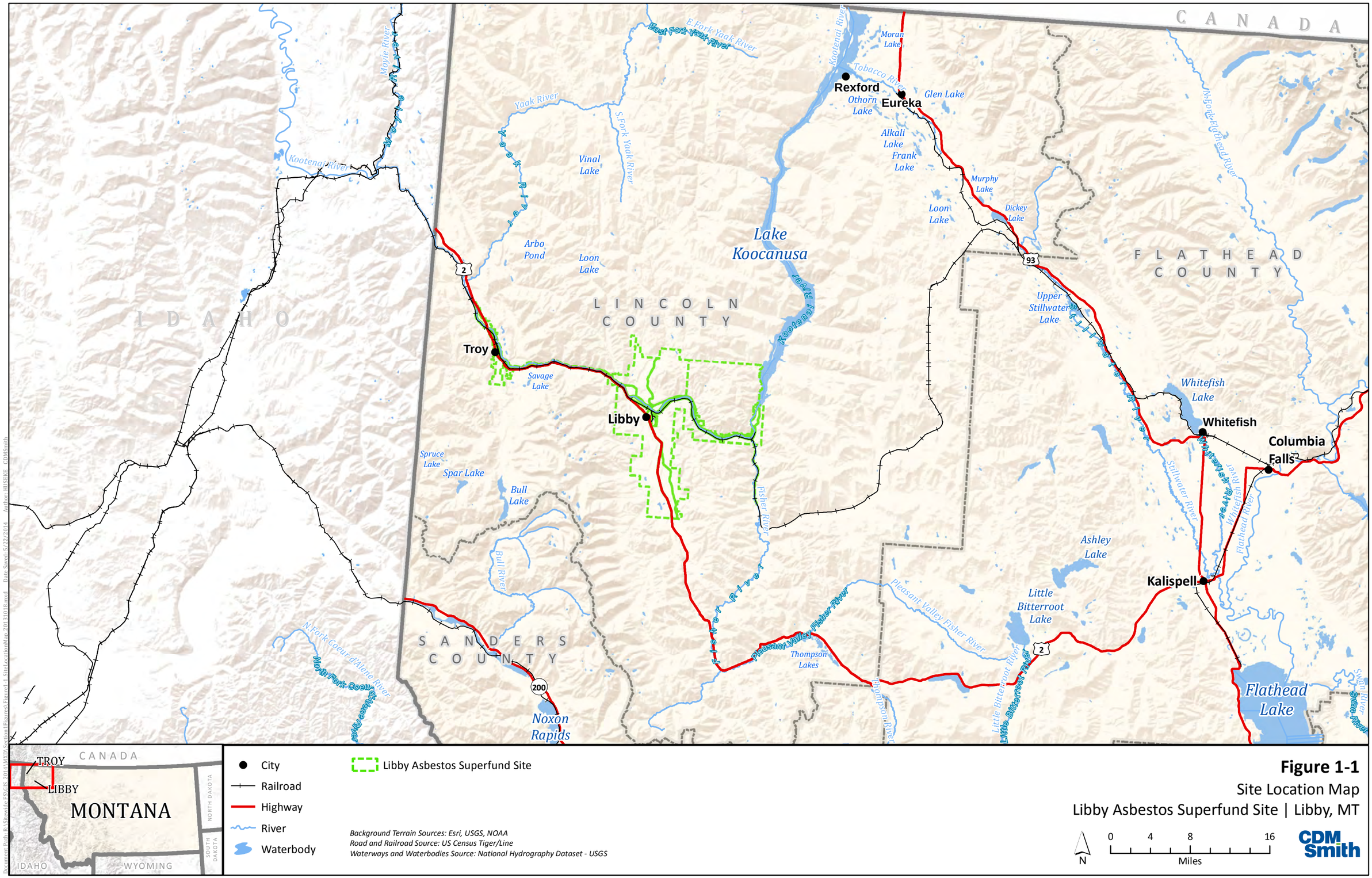
Soil Condition	Properties with a Removal						Properties without a Removal		
	SUA	Non-SUA		LUA			SUA	Non-SUA	LUA
	2003-2013	2003-2006	2007-2013	2003-2006	2006-2010	2011-2013	2003-2013	2003-2013	2003-2013
Bin A (ND)	Vis -	Vis - or Vis +	Vis -	Vis - or Vis +	Vis -	Vis - or low Vis +	Vis -	Vis - or Vis +	Vis - or Vis +
Bin B1 (Trace)						Vis - or low Vis +	Vis -	Vis - or Vis +	Vis - or Vis +
Bin B2 (<1%)						Vis - or low Vis +	Vis -	Vis - or Vis +	Vis - or Vis +
Bin C (≥1%)									

condition may be present

Note:

LUA = limited-use area (e.g., pasture,; Vis = visible vermiculite maintained/mowed fields); ND - non-detect; Non-SUA = non-specific-use area (e.g., yard); SUA = specific-use area (e.g., garden, flowerbed, unpaved driveway, play area); < - less than;≥ - greater than or equal to; % - percent.

Figures



- City
- Railroad
- Highway
- River
- Waterbody
- Libby Asbestos Superfund Site

Background Terrain Sources: Esri, USGS, NOAA
Road and Railroad Source: US Census Tiger/Line
Waterways and Waterbodies Source: National Hydrography Dataset - USGS

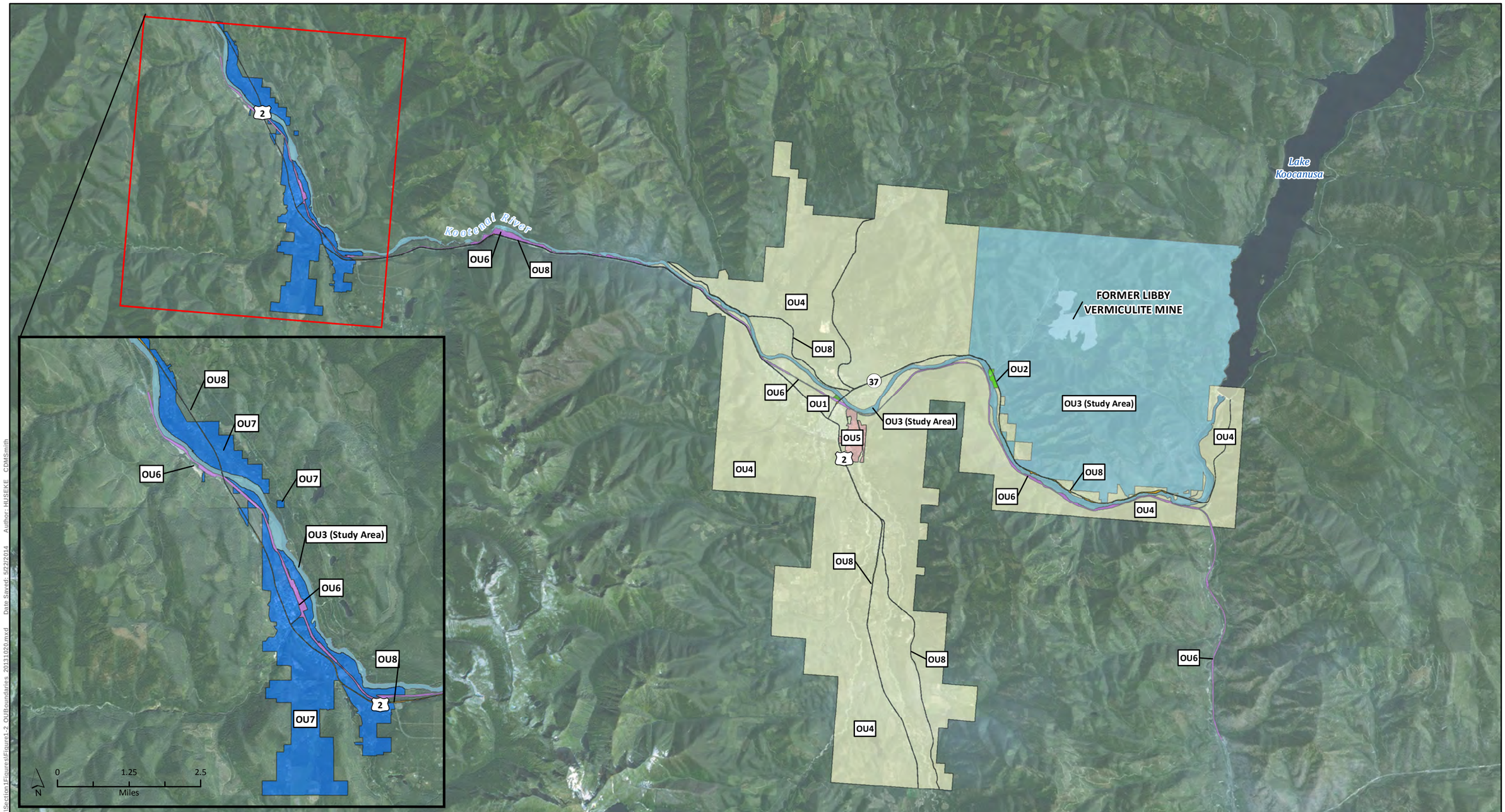
N

0 4 8 16
Miles

CDM Smith

Figure 1-1
Site Location Map
Libby Asbestos Superfund Site | Libby, MT

Document Path: R:\Sitework\ESVCS_2014\MONTANA\Libby\Figures\Figure1-1_SiteLocationMap_20131016.mxd Date Saved: 5/22/2014 Author: HUSEKE CDMSmith



- OU1 - Former Export Plant
- OU2 - Former Screening Plant
- OU3 - Former Libby Vermiculite Mine and Kootenai River (Study Area)
- OU4 - City of Libby
- OU5 - Former Stimson Lumber Company
- OU6 - Burlington Northern and Santa Fe Railroad Corridor
- OU7 - Town of Troy
- OU8 - U.S. and Montana State Highway Corridors

Note(s): EPA established the preliminary study area boundary for the purposes of planning and developing the scope of the RI/FS for OU3. This study boundary may be revised as data are obtained during the RI for OU3 on the nature and extent of environmental contamination associated with releases that may have occured from the mine site and any area (including any structure, soil, air, water, sediment or receptor) impacted by the release and subsequent migration of hazardous substances and/or pollutants or contaminants from such property, including, but not limited to, the mine property, the Kootenai River and sediments therin, Rainy Creek, Rainy Creek Road and areas in which tree bark is contaminated with such hazardous substances and/or pollutants and contaminants. The final boundary of OU3 will be defined by the final EPA-approved RI/FS.

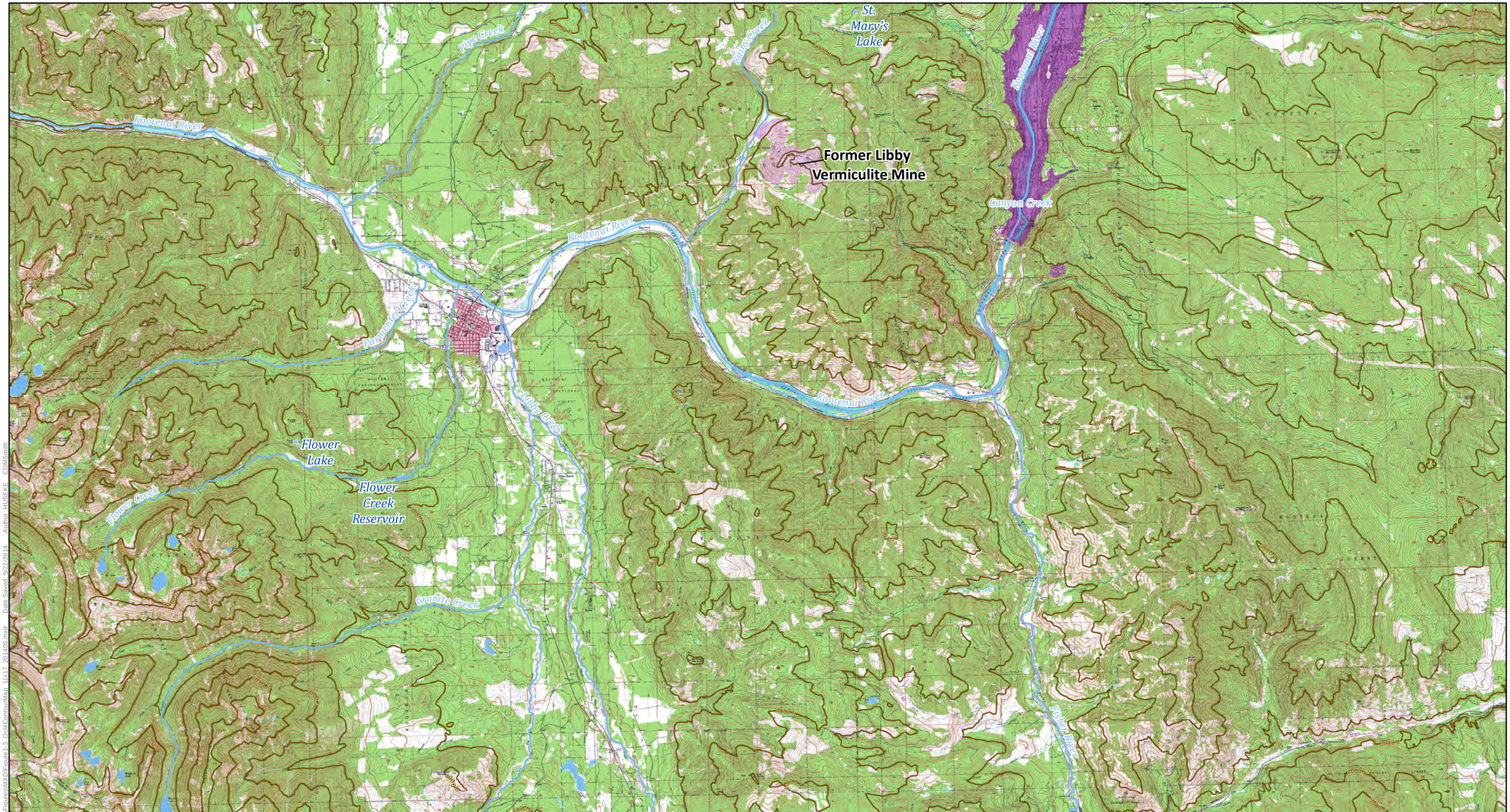
Aerial Sources: Esri, USGS, NOAA
Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
Road and Railroad Source: US Census Tiger/Line
Waterways and Waterbodies Source: National Hydrography Dataset - USGS

Figure 1-2
Operable Unit Boundaries
Libby Asbestos Superfund Site | Libby, MT

N 0 1.25 2.5 5 Miles

CDM Smith

Document Path: R:\Stlewide FS\GIS_2014\MXD\Section1\Figure\Figure1-2_OUBoundaries_20131020.mxd Date Saved: 5/2/2014 Author: HUSEKE CDMSmith



1,000 ft Topographic Line

200 ft Topographic Line

River

Waterbody

Background Topographic Map Source : USGS (DRG)
Waterways and Waterbodies Source: National Hydrography Dataset - USGS

Figure 1-3

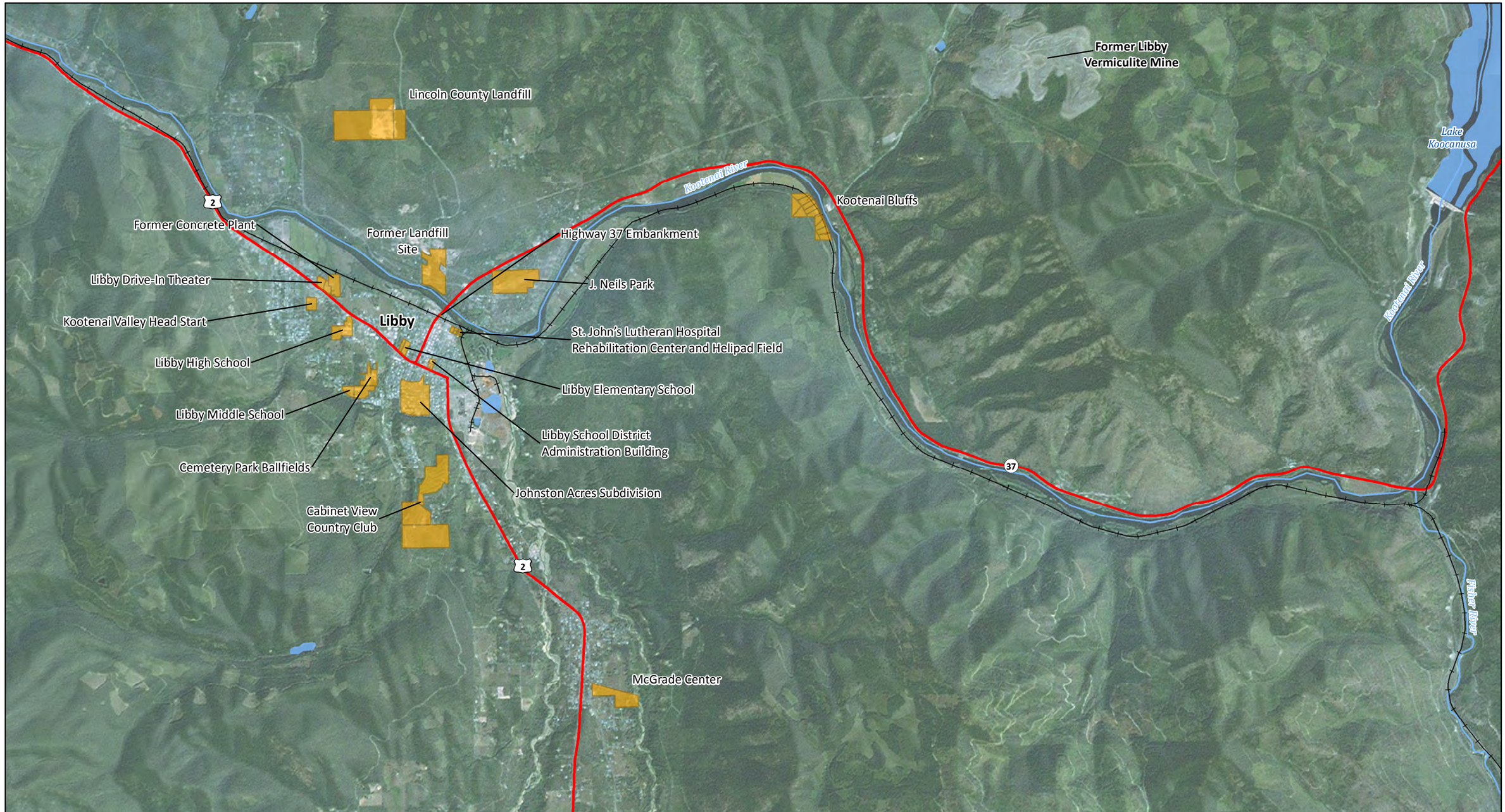
Operable Unit 4 Topographic Contour Map
Libby Asbestos Superfund Site | Libby, MT

N

0 2.5 5
Miles

CDM Smith

Document Path: P:\Libby Asbestos RA Support\RI\Figures\MXD\Figure 1-3 OU4Contour\Map 11x17 20140605.mxd Date Saved: 5/22/2014 Author: HUSEKE CDMSmith



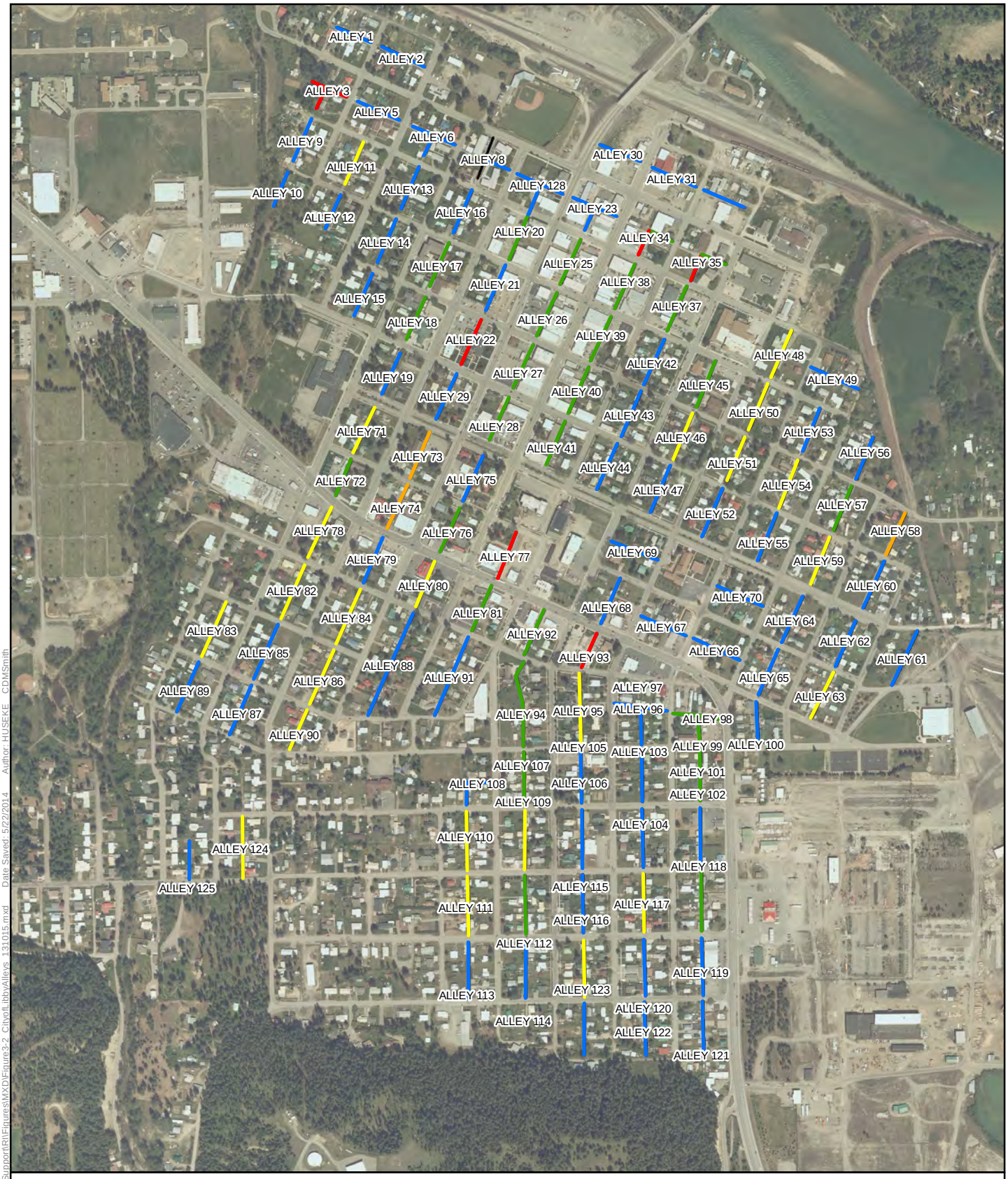
Railroad
Highway
River
Waterbody
Special Interest Property

Aerial Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
Road and Railroad Source: US Census Tiger/Line
Waterways and Waterbodies Source: National Hydrography Dataset - USGS

Figure 3-1
Properties of Special Interest
Libby Asbestos Superfund Site | Libby, MT

N
0 1.25 2.5
Miles

CDM Smith



Alley Sampled, Visible Vermiculite (22)

Alley Sampled, No Visible Vermiculite (69)

Alley Paved, Visible Vermiculite (3)

Alley Paved, No Visible Vermiculite (27)

Alley Not Present (7)

Aerial Image Source: 2002 - Visual Intelligence Systems, Inc.

Figure 3-2

City of Libby Alleys

Libby Asbestos Superfund Site | Libby, MT

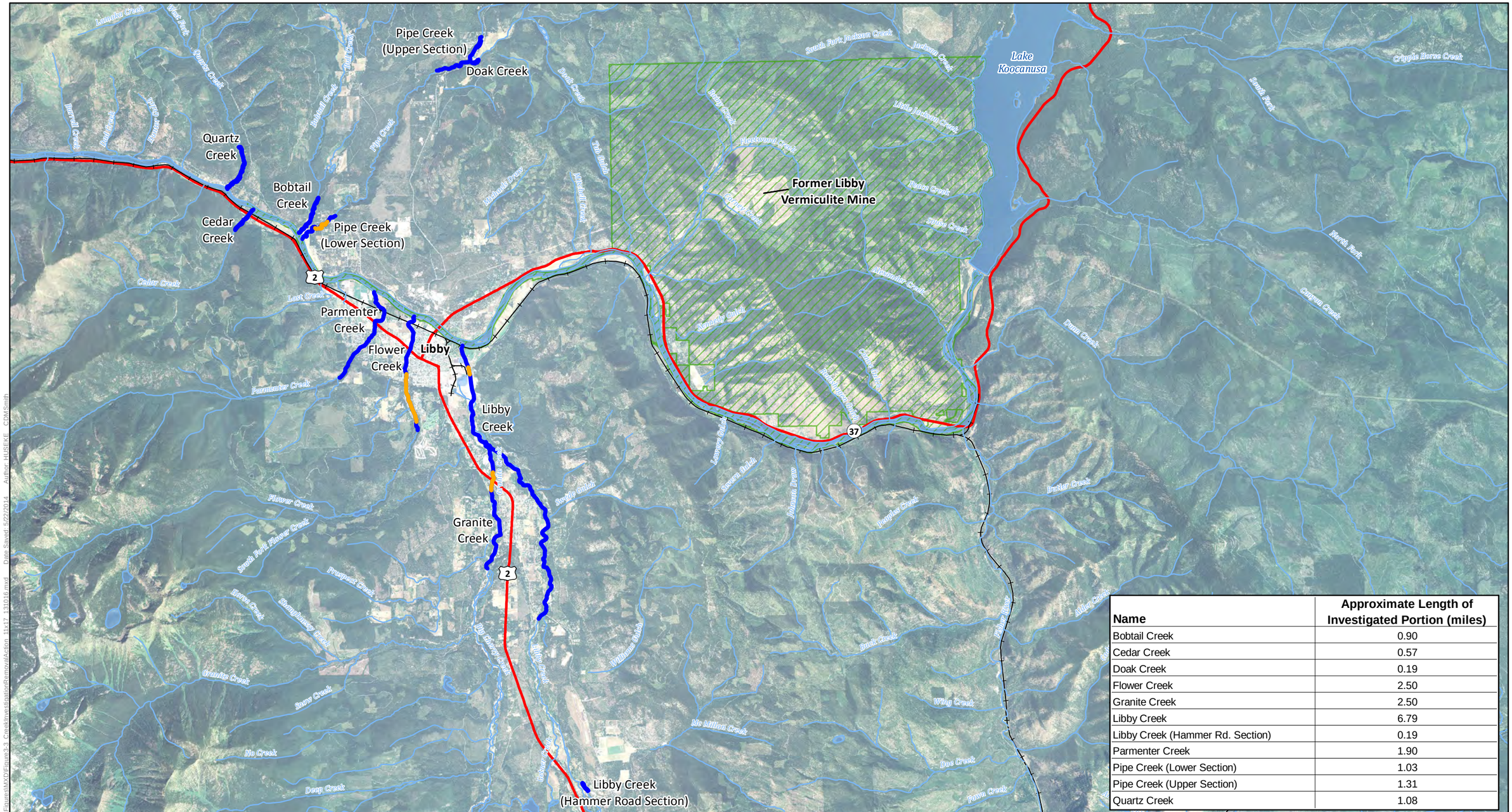
N

0 250 500 1,000 1,500

Feet

CDM Smith

Document Path: P:\Libby Asbestos_RA Support\RI\Figures\MXD\Figure3-2_CityofLibbyAlleys_131015.mxd Date Saved: 5/22/2014 Author: HUSEKE CDMSmith



Name	Approximate Length of Investigated Portion (miles)
Bobtail Creek	0.90
Cedar Creek	0.57
Doak Creek	0.19
Flower Creek	2.50
Granite Creek	2.50
Libby Creek	6.79
Libby Creek (Hammer Rd. Section)	0.19
Parmenter Creek	1.90
Pipe Creek (Lower Section)	1.03
Pipe Creek (Upper Section)	1.31
Quartz Creek	1.08

Railroad
Highway
River
Waterbody
Portion of Creek Investigated
Portion of Creek with Removal Action
OU3 Boundary

Aerial Image Source: 2002 - Visual Intelligence Systems, Inc.
Road and Railroad Source: US Census Tiger/Line
Waterways and Waterbodies Source: National Hydrography Dataset - USGS

Note(s): This OU3 boundary may be revised as data are obtained during the RI for OU3 on the nature and extent of environmental contamination associated with releases that may have occured from the mine site and any area (including any structure, soil, air, water, sediment or receptor) impacted by the release and subsequent migration of hazardous substances and/or pollutants or contaminants from such property, including, but not limited to, the mine property, the Kootenai River and sediments therein, Rainy Creek, Rainy Creek Road and areas in which tree bark is contaminated with such hazardous substances and/or pollutants and contaminants.

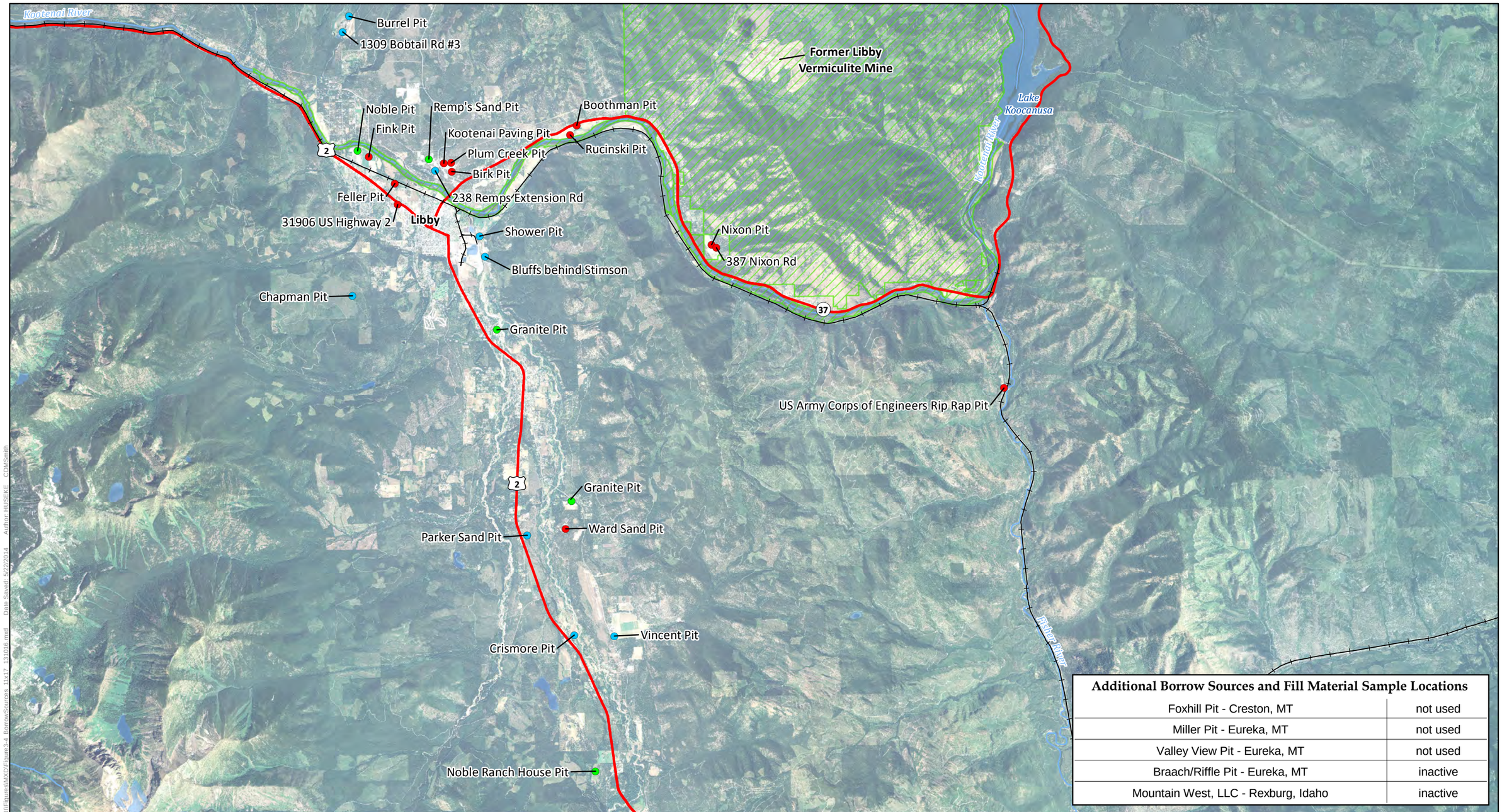
Figure 3-3

OU4 Creek Investigations and Removal Action
Libby Asbestos Superfund Site | Libby, MT

N
0 1.25 2.5 5
Miles

CDM Smith

Document Path: P:\Libby Asbestos RA Support\RI\Figures\MXD\Figure3-3_CreekInvestigationRemovalAction_11x17_131016.mxd Date Saved: 5/22/2014 Author: HUSEKE CDM Smith



Additional Borrow Sources and Fill Material Sample Locations	
Foxhill Pit - Creston, MT	not used
Miller Pit - Eureka, MT	not used
Valley View Pit - Eureka, MT	not used
Braach/Riffle Pit - Eureka, MT	inactive
Mountain West, LLC - Rexburg, Idaho	inactive

Railroad
Highway
River
Waterbody
OU3 Boundary

Borrow Pits
- Active
- Inactive
- Not Used

Aerial Image Source: 2002 - Visual Intelligence Systems, Inc.
Road and Railroad Source: US Census Tiger/Line
Waterways and Waterbodies Source: National Hydrography Dataset - USGS

Note(s): This OU3 boundary may be revised as data are obtained during the RI for OU3 on the nature and extent of environmental contamination associated with releases that may have occured from the mine site and any area (including any structure, soil, air, water, sediment or receptor) impacted by the release and subsequent migration of hazardous substances and/or pollutants or contaminants from such property, including, but not limited to, the mine property, the Kootenai River and sediments therein, Rainy Creek, Rainy Creek Road and areas in which tree bark is contaminated with such hazardous substances and/or pollutants and contaminants.

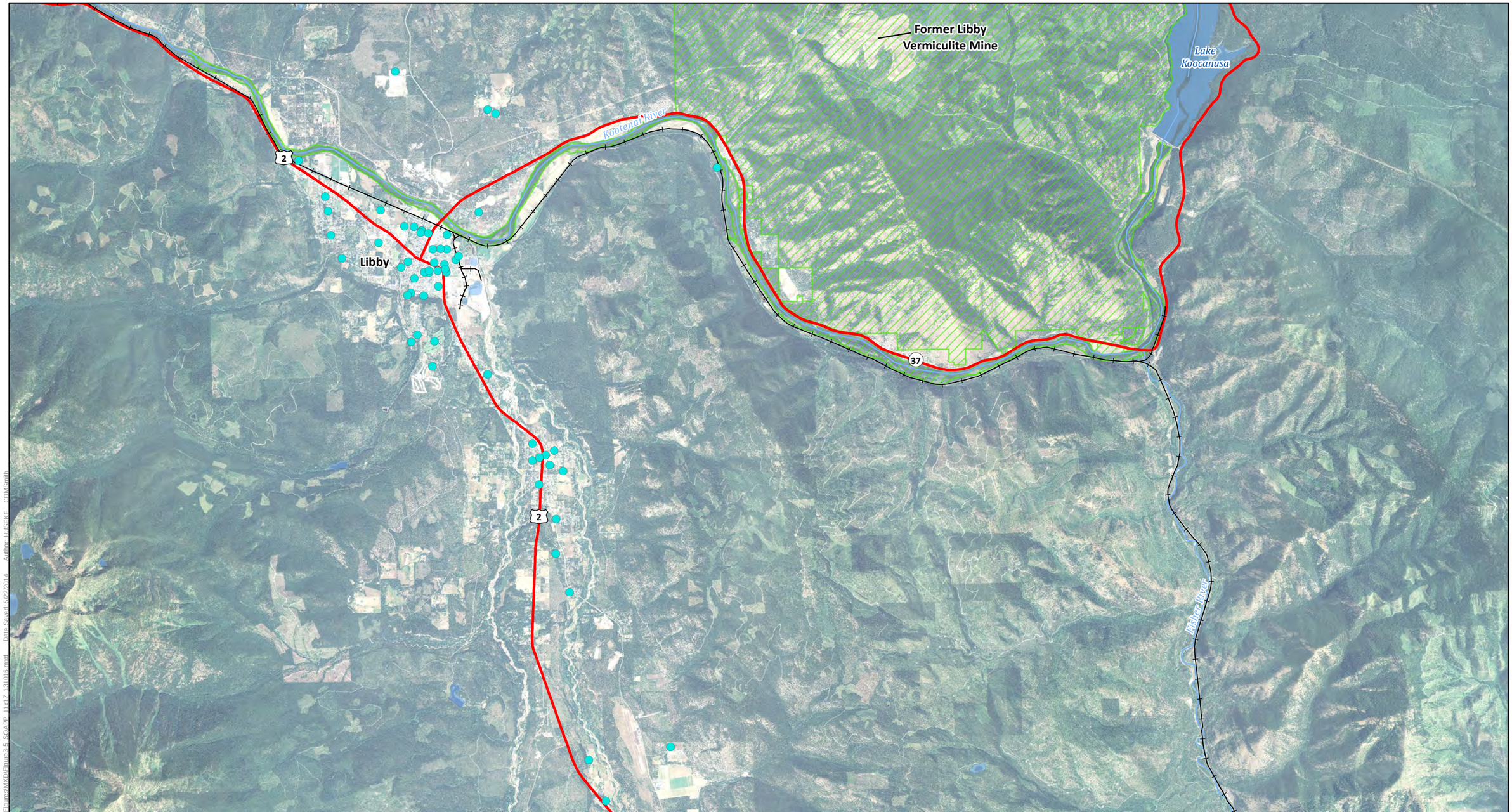
Figure 3-4

Borrow Source and Material Fill Locations
Libby Asbestos Superfund Site | Libby, MT

N
0 1.25 2.5 5
Miles

CDM Smith

Document Path: P:\Libby Asbestos RA Support\RI\Figures\MXD\Figure3-4_BorrowSources_11x17_131016.mxd Date Saved: 9/22/2014 Author: HUSEKE CDMSmith



Railroad
Highway
River
Waterbody

Supplemental Remedial Investigation Property (58 Properties)
OU3 Boundary

Aerial Image Source: 2002 - Visual Intelligence Systems, Inc.
Road and Railroad Source: US Census Tiger/Line
Waterways and Waterbodies Source: National Hydrography Dataset - USGS

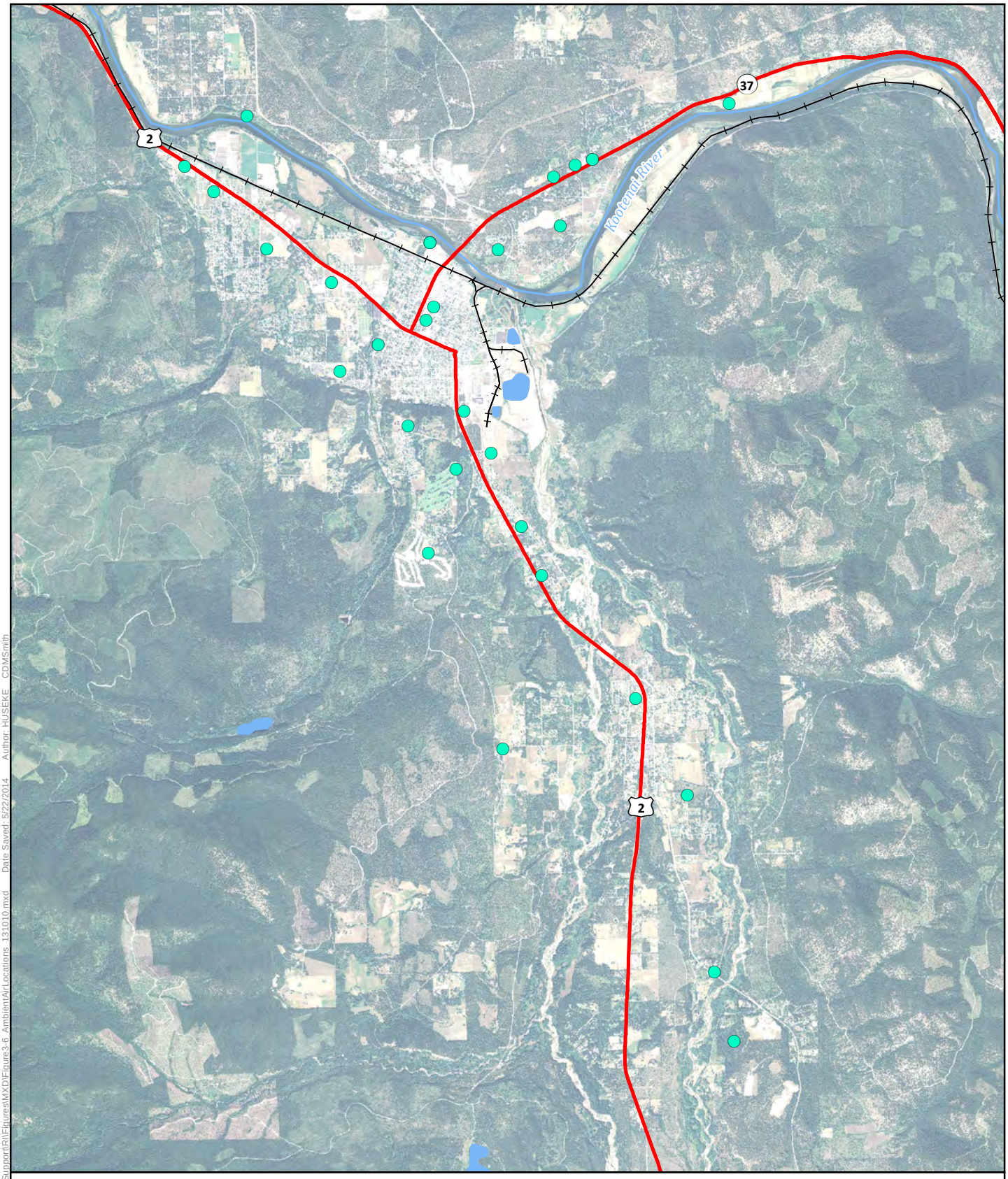
Note(s): This OU3 boundary may be revised as data are obtained during the RI for OU3 on the nature and extent of environmental contamination associated with releases that may have occured from the mine site and any area (including any structure, soil, air, water, sediment or receptor) impacted by the release and subsequent migration of hazardous substances and/or pollutants or contaminants from such property, including, but not limited to, the mine property, the Kootenai River and sediments therein, Rainy Creek, Rainy Creek Road and areas in which tree bark is contaminated with such hazardous substances and/or pollutants and contaminants.

Figure 3-5
Supplemental Remedial Investigation Sampling Properties
Libby Asbestos Superfund Site | Libby, MT

N
0 1.25 2.5 5
Miles

CDM Smith

Document Path: P:\Libby Asbestos_RA Support\RI\Figures\MXD\Figure3-5_SOAPP_11x17_131016.mxd Date Saved: 5/2/2013 Author: HUSEKE CDMSmith



Railroad
Highway
River
Waterbody

Outdoor Ambient Air Locations

Aerial Image Source: 2002 - Visual Intelligence Systems, Inc.
Road and Railroad Source: US Census Tiger/Line
Waterways and Waterbodies Source: National Hydrography Dataset - USGS

Figure 3-6
Outdoor Ambient Air Sampling Locations
Libby Asbestos Superfund Site | Libby, MT

N
0 1.25 2.5
Miles

CDM Smith

Document Path: P:\Libby Asbestos_RA Support\RI\Figures\MXD\Figure3-6_AmbientAirLocations_131010.mxd Date Saved: 5/22/2014 Author: HUSEKE CDMSmith

Railroad
Highway
River
Waterbody
Exterior ABS Properties

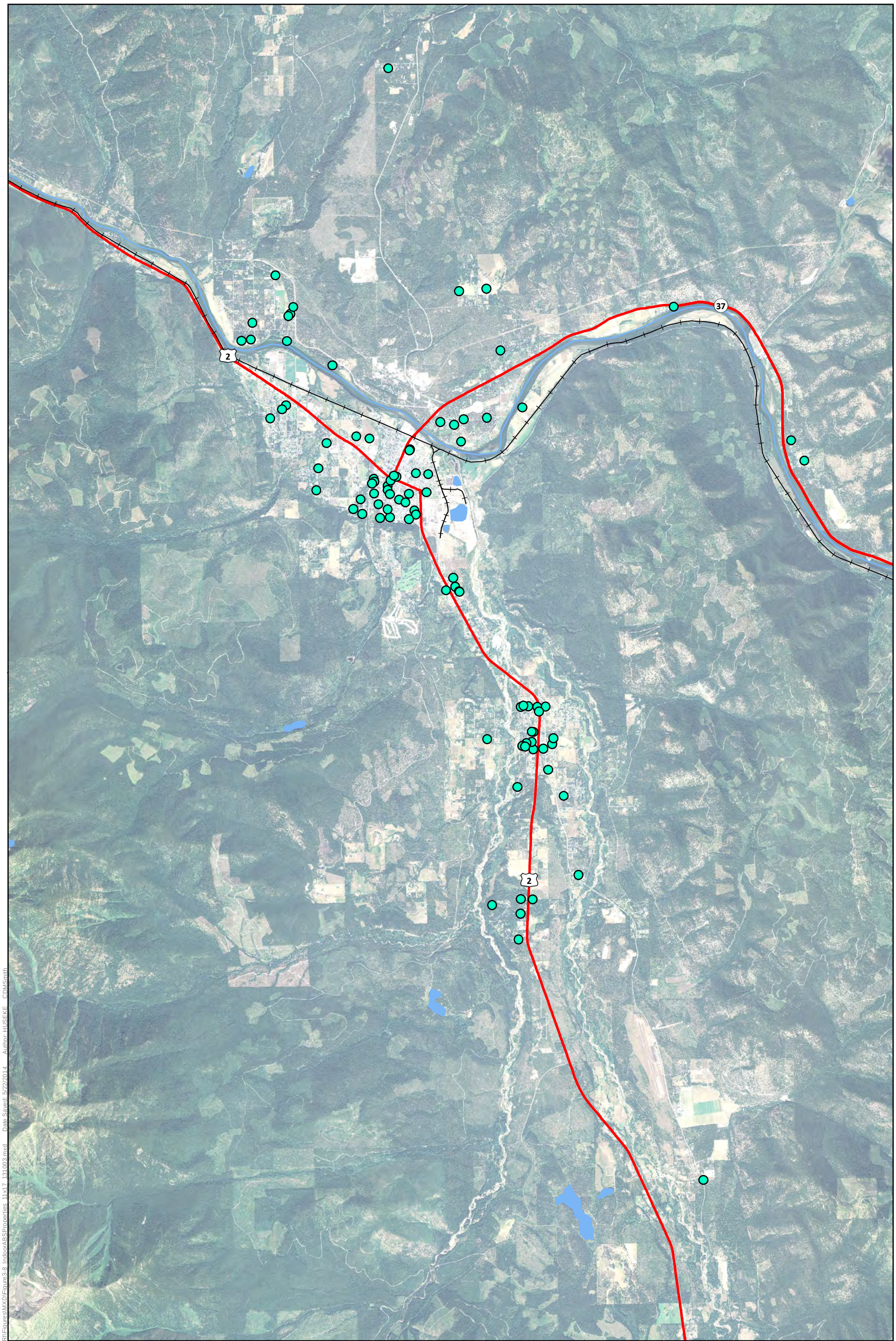
Aerial Image Source: 2002 - Visual Intelligence Systems, Inc.
Road and Railroad Source: US Census Tiger/Line
Waterways and Waterbodies Source: National Hydrography Dataset - USGS

Figure 3-7
Outdoor Activity-Based Sampling Properties
Libby Asbestos Superfund Site | Libby, MT

N
0 1.25 2.5
Miles

CDM Smith

Document Path: P:\Libby Asbestos RA Support\R\Figures\MXD\Figure3-7_OutdoorABSProperties_11x17_131003.mxd Date Saved: 5/22/2014 Author: HUSEKE CDMSmith



Railroad
Highway
River
Waterbody
Interior ABS Properties

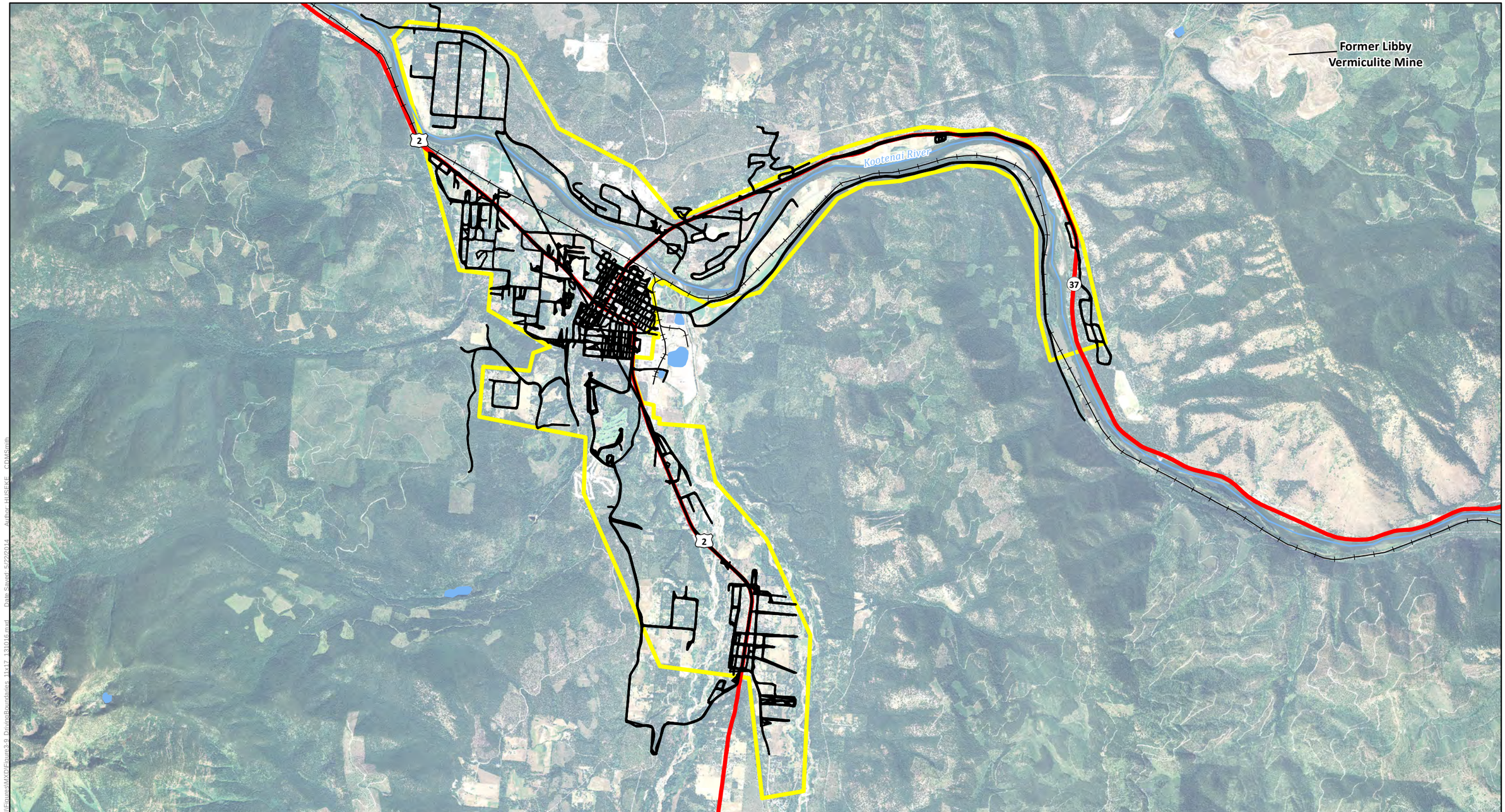
Aerial Image Source: 2002 - Visual Intelligence Systems, Inc.
Road and Railroad Source: US Census Tiger/Line
Waterways and Waterbodies Source: National Hydrography Dataset - USGS

Figure 3-8
Indoor Activity-Based Sampling Properties
Libby Asbestos Superfund Site | Libby, MT

N
0 1.25 2.5
Miles

CDM Smith

Document Path: P:\Libby Asbestos_RA Support\RI\Figures\MXD\Figure3-8_IndoorABSProperties_11x17_131003.mxd Date Saved: 5/22/2014 Author: HUSEKE CDMSmith



Railroad
Highway
River
Waterbody
ABS Driving Track
Driving Boundary

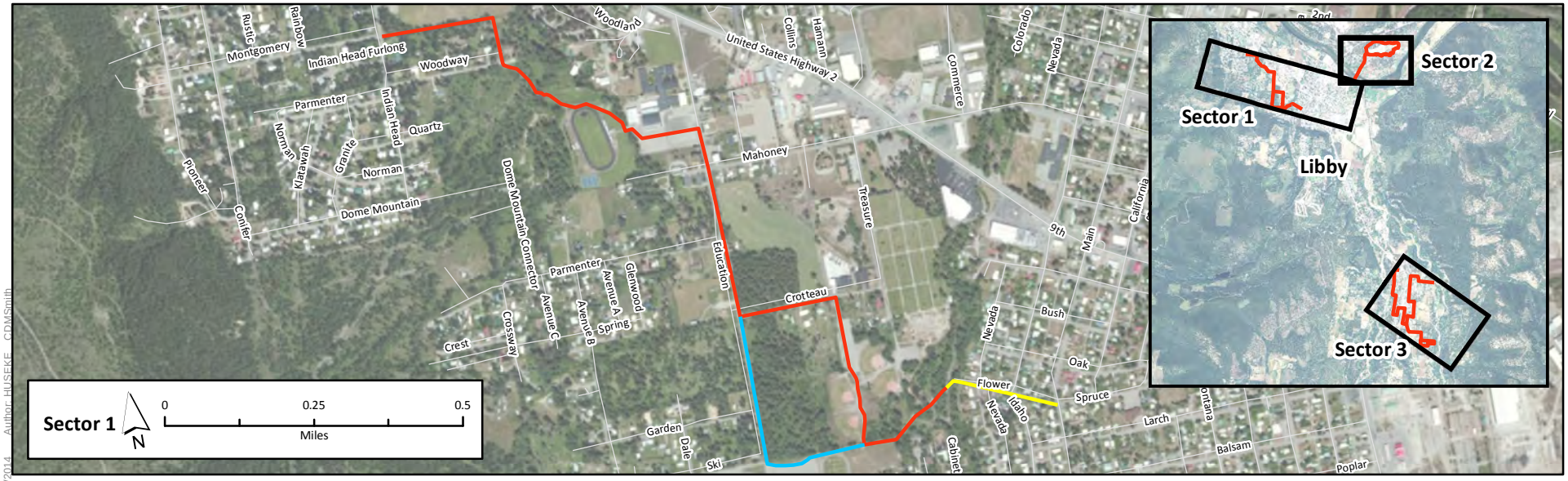
Aerial Image Source: 2002 - Visual Intelligence Systems, Inc.
Road and Railroad Source: US Census Tiger/Line
Waterways and Waterbodies Source: National Hydrography Dataset - USGS

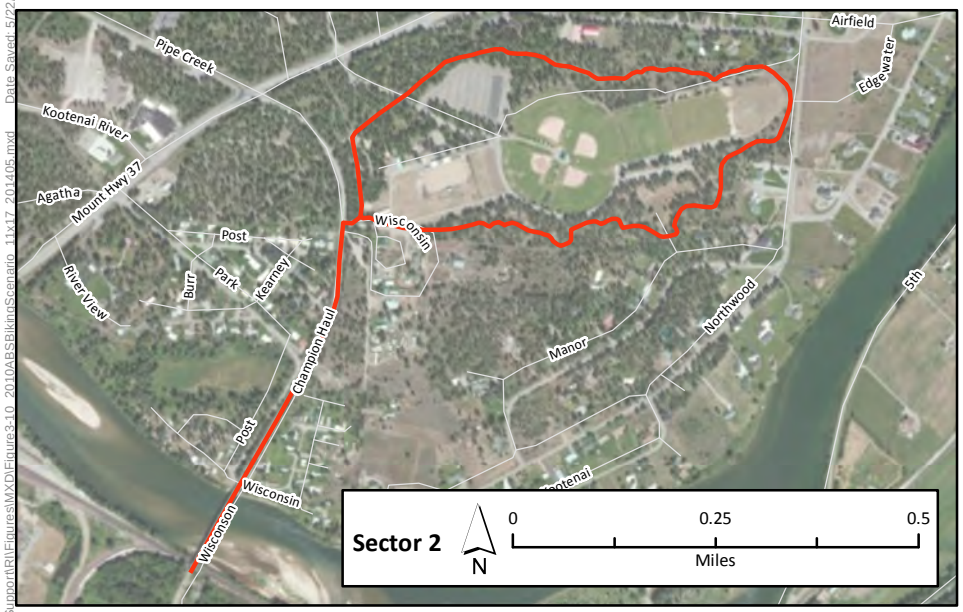
Figure 3-9
Scenario 4 Driving Boundaries
Libby Asbestos Superfund Site | Libby, MT

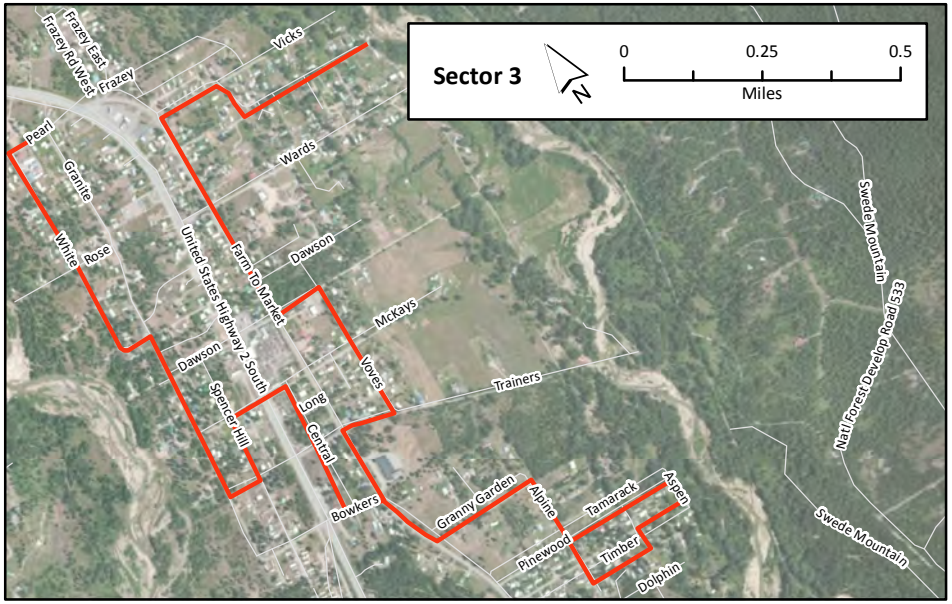
N
0 1.25 2.5
Miles

CDM Smith

Document Path: P:\Libby Asbestos RA Support\GIS\Figures\MXD\Figure3-9_DrivingBoundaries_11x17_130116.mxd Date Saved: 6/22/2013 Author: HUSEKE CDMSmith







Bike Route

Section added; partial gravel

Section removed; all asphalt

Aerial Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

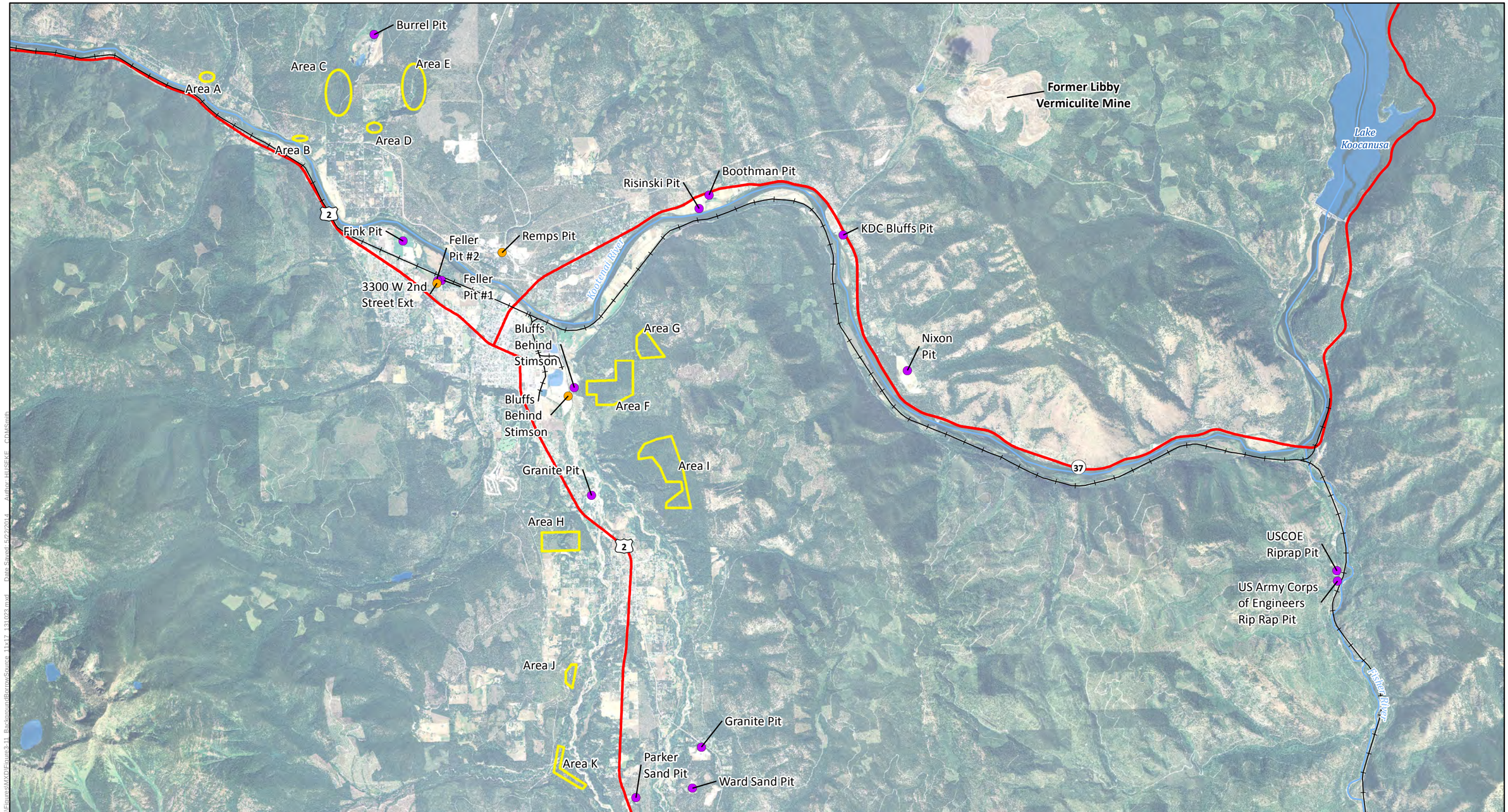
Figure 3-10

Scenario 5 Bicycle Routes

Libby Asbestos Superfund Site | Libby, MT

CDM Smith

Document Path: P:\Libby Asbestos RA Support\R\Figures\MXD\Figure3-10_2010ABSBikingScenario_11x17_20140516.mxd Date Saved: 5/22/2014 Author: HUSEKE_CDMSmith



Railroad
Highway
River
Waterbody
Libby Background Study
Borrow Pits
Sample Areas

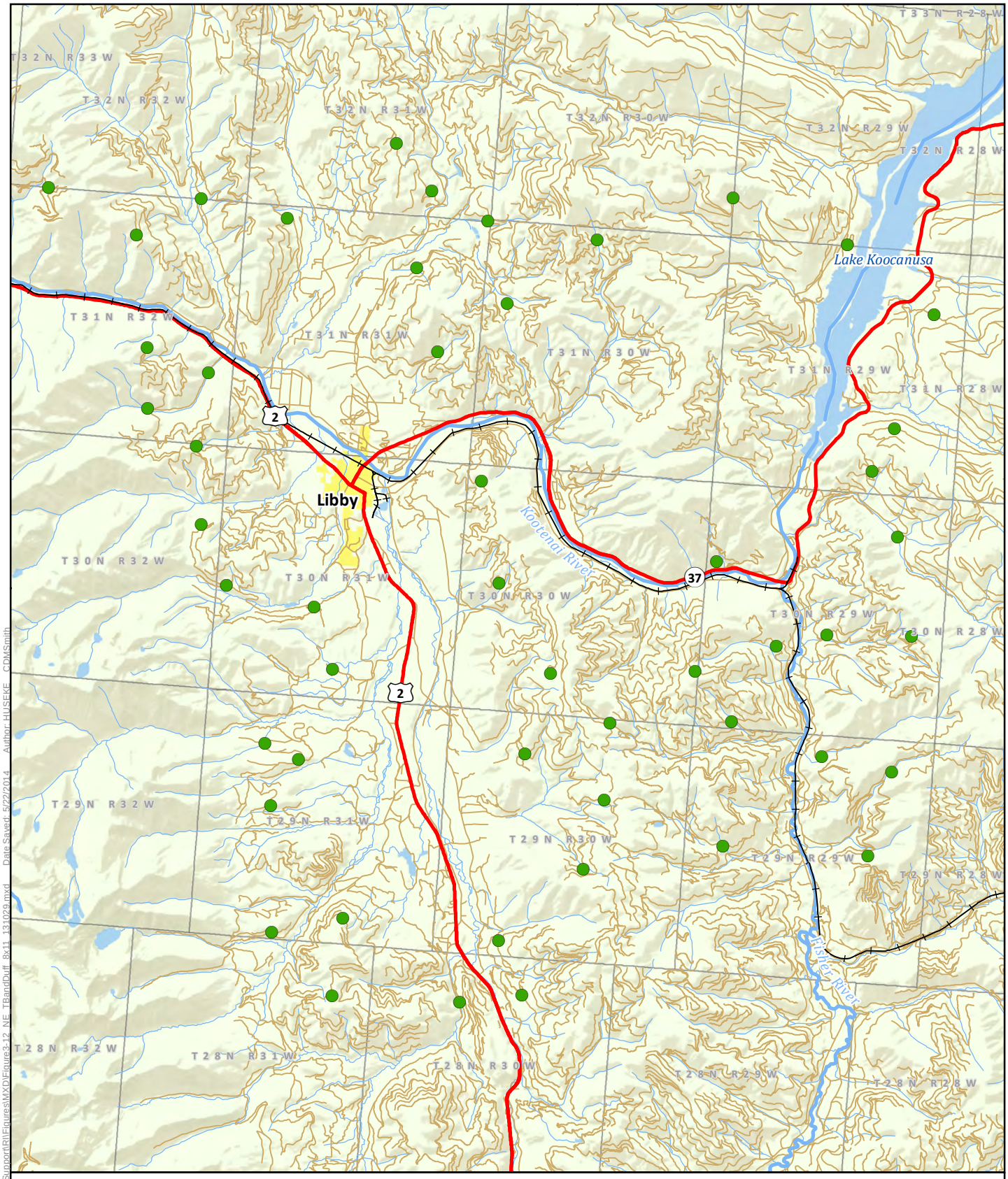
Aerial Image Source: 2002 - Visual Intelligence Systems, Inc.
Road and Railroad Source: US Census Tiger/Line
Waterways and Waterbodies Source: National Hydrography Dataset - USGS

Figure 3-11
Background and Borrow Source
Libby Asbestos Superfund Site | Libby, MT

N
0 1.25 2.5
Miles

CDM Smith

Document Path: P:\Libby Asbestos_RA Support\GIS\Figures\MXD\Figure3-11_BackgroundBorrowSource_11x17_131223.mxd Date Saved: 5/22/2014 Author: HUSEKE CDMSmith



Railroad
Highway
Forest Service Road
Major River
Creek / River
Tree Bark & Duff Sample Location
PLSS Township
Libby City Limits
Waterbody

Background Terrain Sources: Esri, USGS, NOAA
Highway and Railroad Source: US Census Tiger/Line
Waterways and Waterbodies Source: National Hydrography Dataset - USGS

N

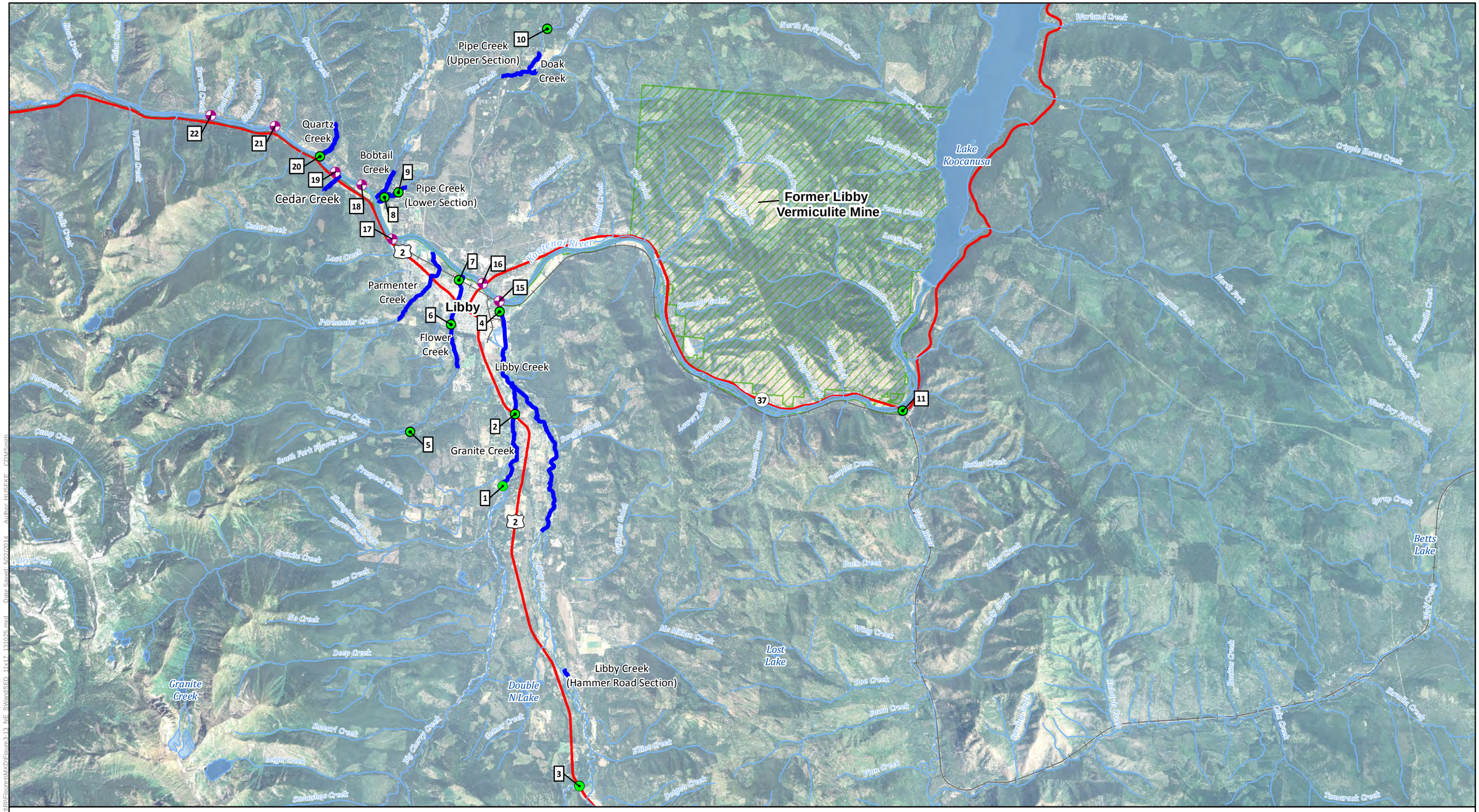
0 1.25 2.5 5
Miles

CDM Smith

Figure 3-12

Nature and Extend Tree Bark and Duff Sample Locations
Libby Asbestos Superfund Site | Libby, MT

Document Path: P:\Libby Asbestos_RA Support\RI\Figures\MXD\Figure3-12_NE_TBandDuff_8x11_131029.mxd Date Saved: 5/22/2014 Author: HUSEKE CDMSmith



Railroad
Highway
River
Waterbody
OU3 Boundary

Sediment and Surface Water Sampling Locations
Sediment Sampling Locations
Portion of Creek Investigated

Aerial Image Source: 2002 - Visual Intelligence Systems, Inc.
Road and Railroad Source: US Census Tiger/Line
Waterways and Waterbodies Source: National Hydrography Dataset - USGS

Note(s): This OU3 boundary may be revised as data are obtained during the RI for OU3 on the nature and extent of environmental contamination associated with releases that may have occured from the mine site and any area (including any structure, soil, air, water, sediment or receptor) impacted by the release and subsequent migration of hazardous substances and/or pollutants or contaminants from such property, including, but not limited to, the mine property, the Kootenai River and sediments therein, Rainy Creek, Rainy Creek Road and areas in which tree bark is contaminated with such hazardous substances and/or pollutants and contaminants.

Figure 3-13

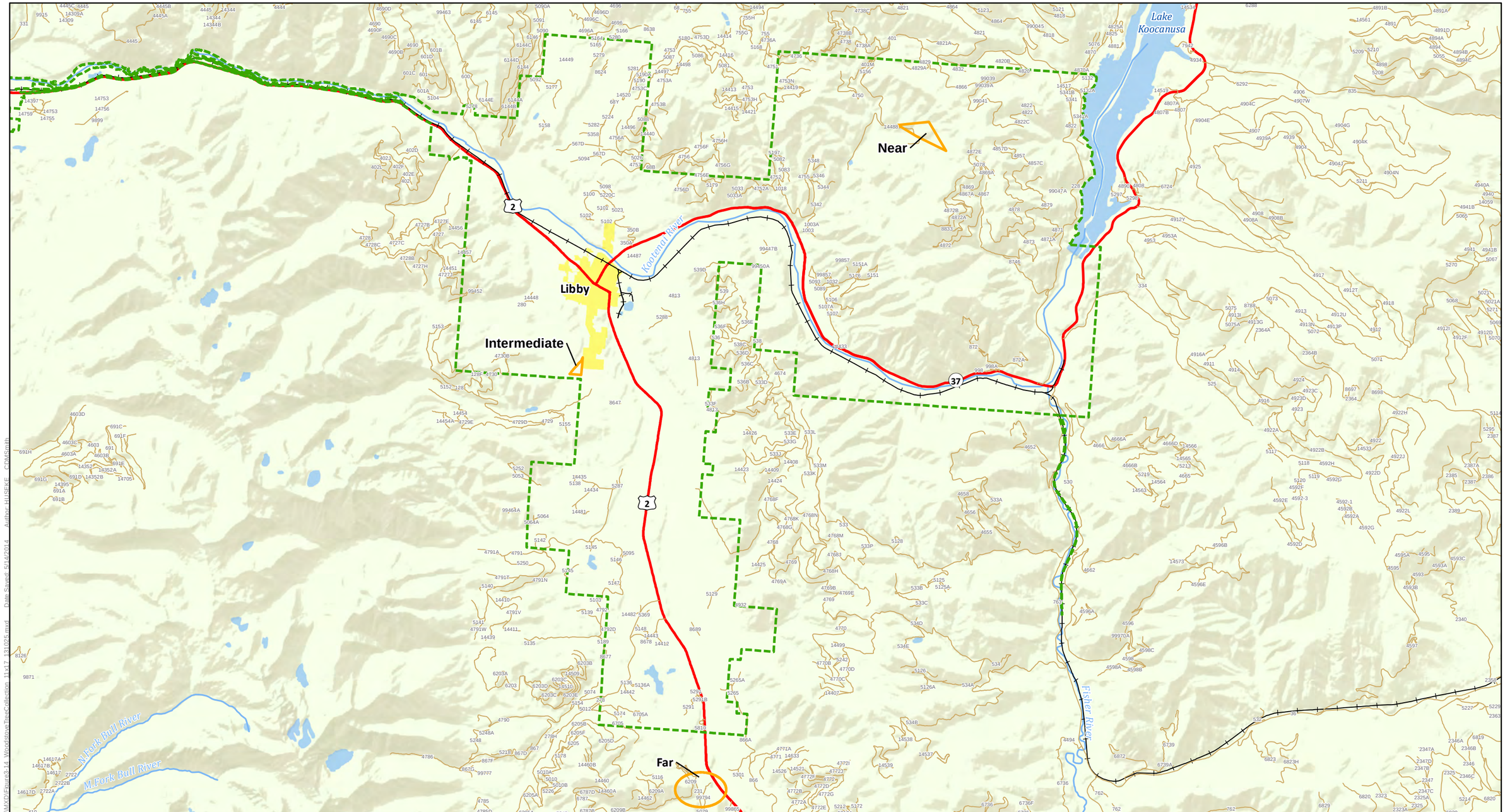
Nature and Extent Surface Water and Sediment Sample Locations
Libby Asbestos Superfund Site | Libby, MT

N

0 2.5 5
Miles

CDM Smith

Document Path: P:\Libby Asbestos RA Support\plt\Figures\MXD\Figure3-13_NE_SWandSED_11x17_131025.mxd Date Saved: 5/22/2014 Author: HUSEKE CDMSmith



Railroad
Highway
Forest Service Roads
River
Waterbody

Tree Collection Location
Libby Asbestos Superfund Site
Libby City Limits

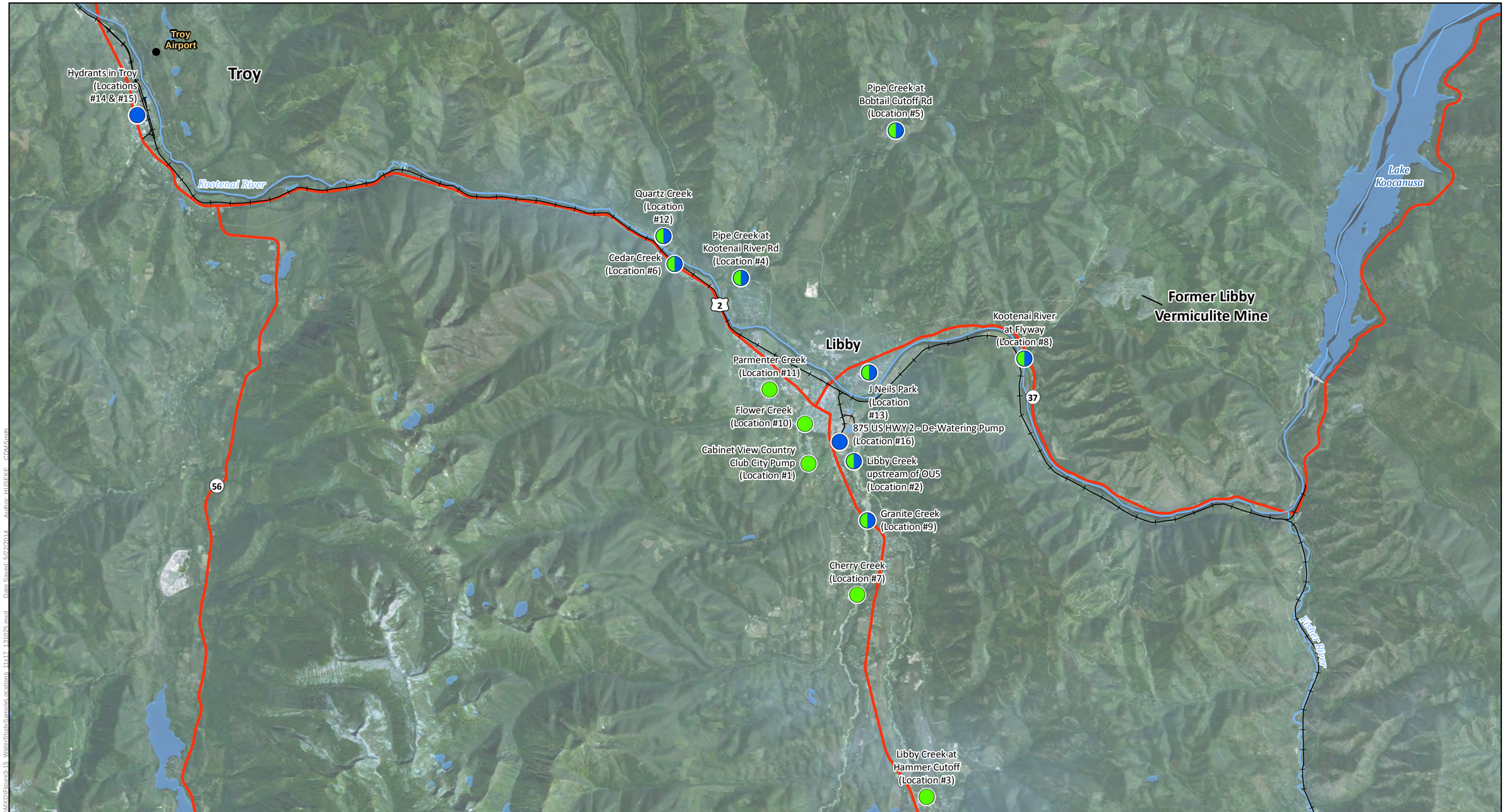
Background Terrain Sources: Esri, USGS, NOAA
Road and Railroad Source: US Census Tiger/Line
Waterways and Waterbodies Source: National Hydrography Dataset - USGS

Figure 3-14
Woodstove Tree Collection Locations
Libby Asbestos Superfund Site | Libby, MT

N
0 1.25 2.5 5
Miles

CDM Smith

Document Path: R:\65158-OU3\3120\001-RA\GIS\MXD\Figure3-14_WoodstoveTreeCollection_11x17_R3\025.mxd Date Saved: 5/14/2014 Author: HUSEKE_CDM\smith



Railroad
Highway
River
Waterbody

Water Source Location

- Phase I Water Source Sampling Location
- Phase II Water Source Sampling Location
- Phases I & II Water Source Sampling Location

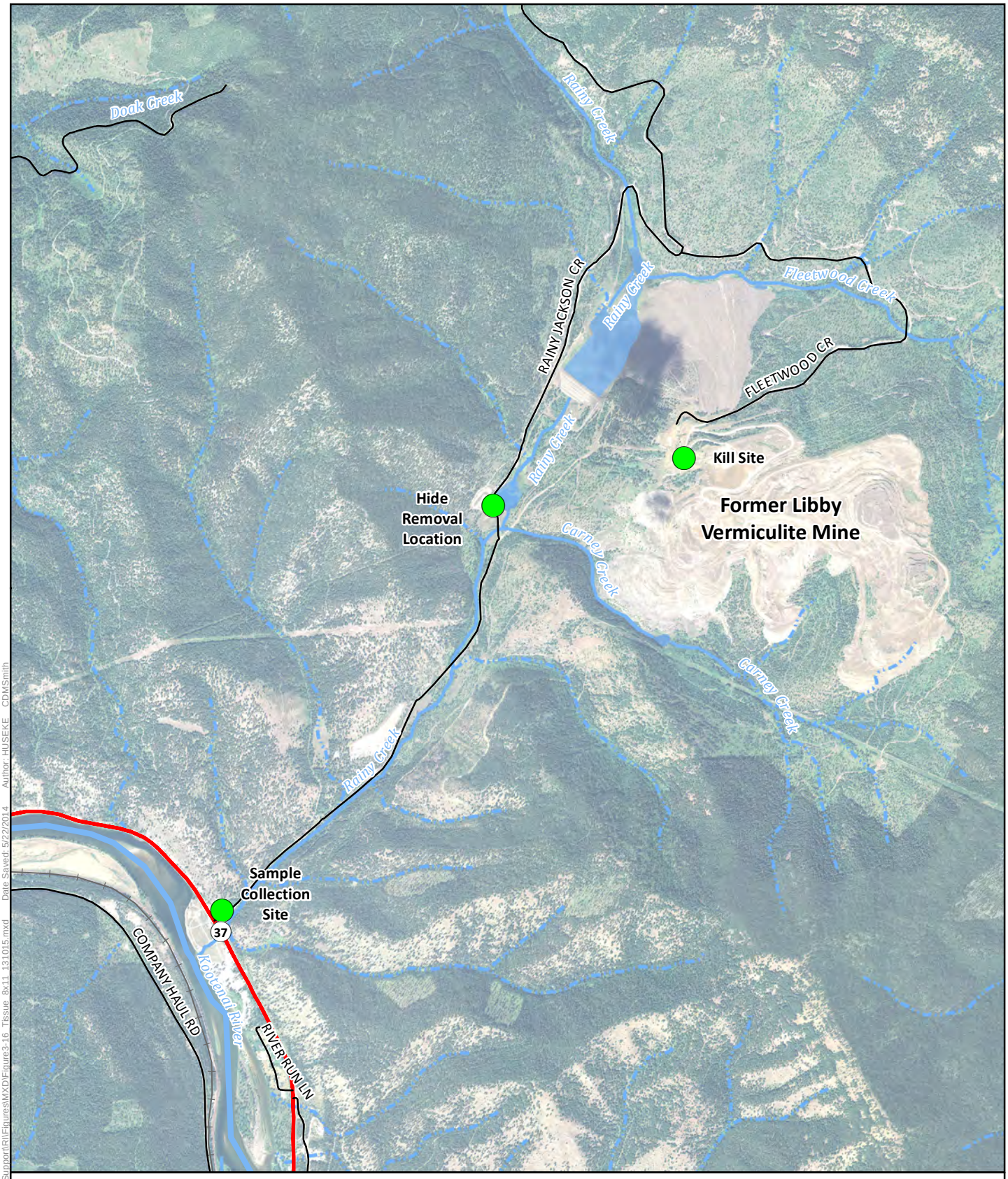
Aerial Imagery Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
Road and Railroad Source: US Census Tiger/Line
Waterways and Waterbodies Source: National Hydrography Dataset - USGS

Figure 3-15
Water Source Study Sample Locations
Libby Asbestos Superfund Site | Libby, MT

N
0 1.25 2.5 5
Miles

CDM Smith

Document Path: R:\65158-OU3\3120.001-RA\GIS\MXD\Figure3-15_WaterSituationSampleLocations_11x17_131025.mxd Date Saved: 5/22/2014 Author: HUSEKE - CDMSmith



Railroad
Highway
County Road
Waterbody
Deer Collection Site
River
Perennial Stream
Intermittent Stream

Aerial Image Source: 2002 - Visual Intelligence Systems, Inc.
Road and Railroad Source: US Census Tiger/Line
Waterways and Waterbodies Source: National Hydrography Dataset - USGS

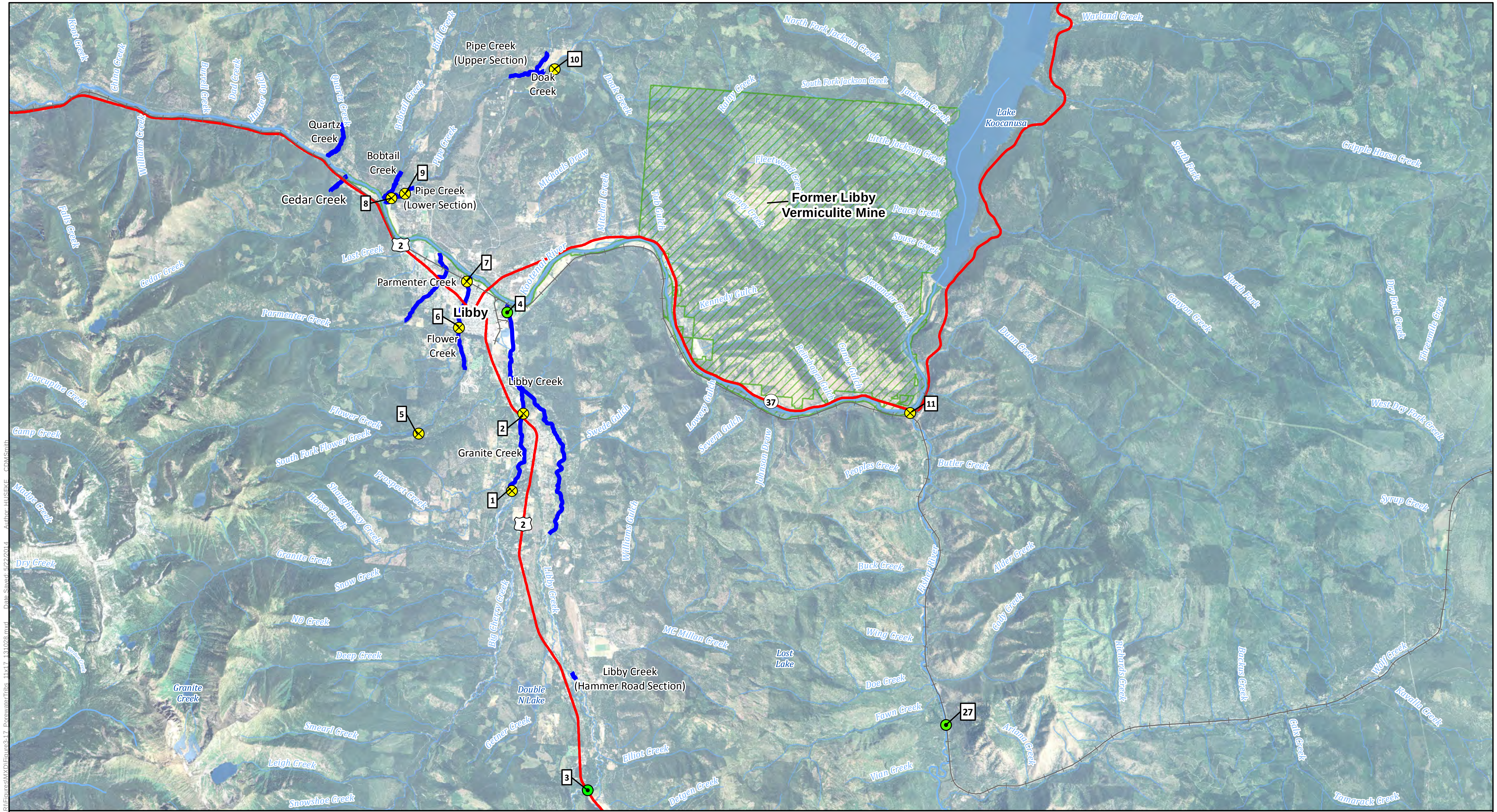
N

0 0.25 0.5 1
Miles

Figure 3-16
Tissue Assessment Study - Location of Deer Collection
Libby Asbestos Superfund Site | Libby, MT

CDM Smith

Document Path: P:\Libby Asbestos_RA Support\RI\Figures\MXD\Figure3-16_Tissue_8x11_131015.mxd Date Saved: 5/22/2014 Author: HUSEKE CDMSmith



Railroad
Highway
River
Creeks / Rivers
Waterbody
Porewater
Sediment and Porewater
Portion of Creek Investigated
OU3 Boundary

Aerial Image Source: 2002 - Visual Intelligence Systems, Inc.
Road and Railroad Source: US Census Tiger/Line
Waterways and Waterbodies Source: National Hydrography Dataset - USGS

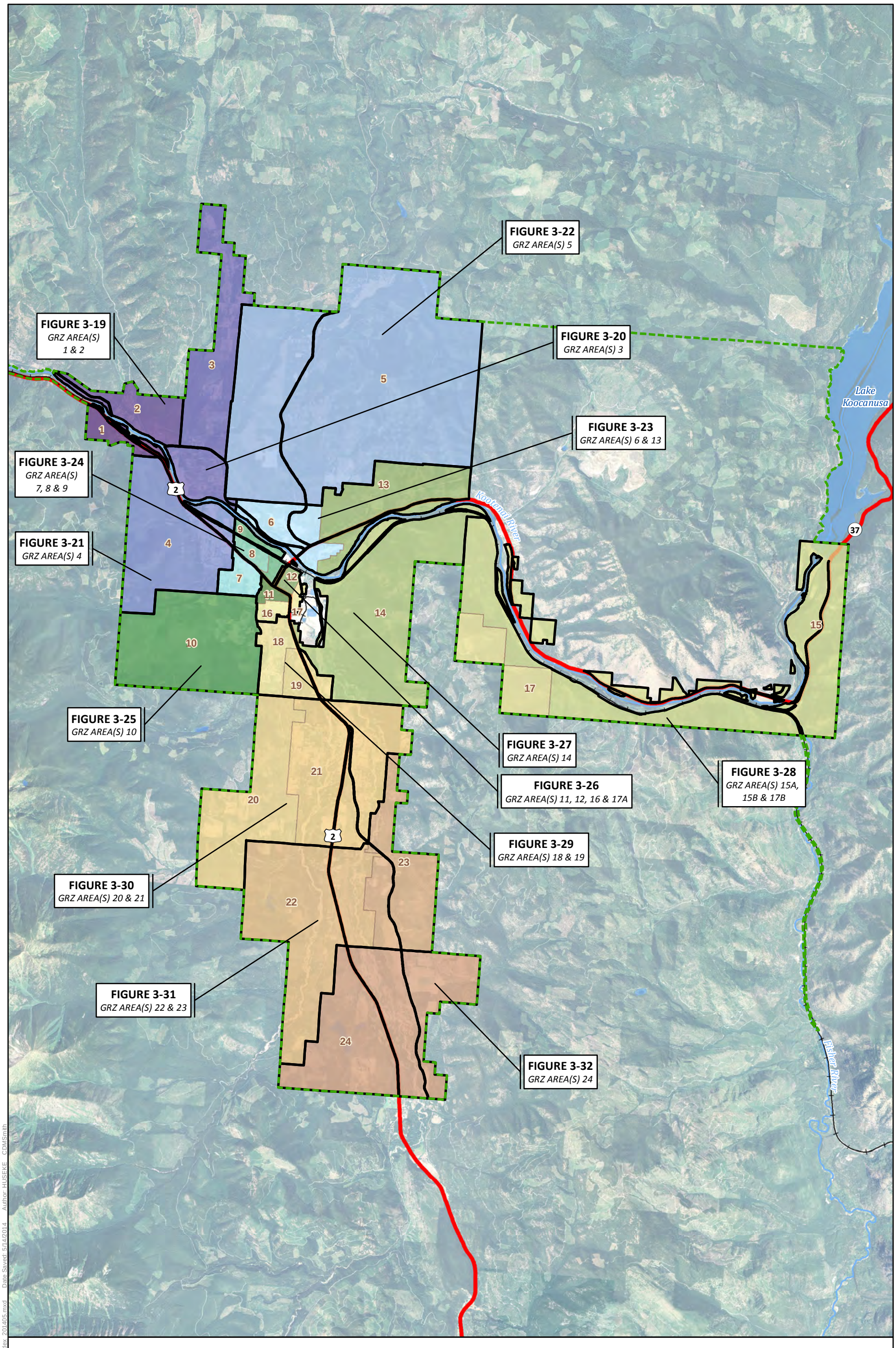
Note(s): This OU3 boundary may be revised as data are obtained during the RI for OU3 on the nature and extent of environmental contamination associated with releases that may have occured from the mine site and any area (including any structure, soil, air, water, sediment or receptor) impacted by the release and subsequent migration of hazardous substances and/or pollutants or contaminants from such property, including, but not limited to, the mine property, the Kootenai River and sediments therein, Rainy Creek, Rainy Creek Road and areas in which tree bark is contaminated with such hazardous substances and/or pollutants and contaminants.

Figure 3-17
Porewater in the Tributaries - Sample Locations
Libby Asbestos Superfund Site | Libby, MT

N
0 1.25 2.5 5
Miles

CDM Smith

Document Path: P:\Libby Asbestos RA Support\RI\Figures\MXD\Figure3-17_PorewaterTribs_11x17_131028.mxd Date Saved: 5/22/2014 Author: HUSEKE CDMSmith



Railroad
Highway
River
Waterbody

Figure Boundary
Libby Asbestos Superfund Site

GRZ - geographic removal zone

Aerial Image Source: 2002 - Visual Intelligence Systems, Inc.
Road and Railroad Source: US Census Tiger/Line
Waterways and Waterbodies Source: National Hydrography Dataset - USGS

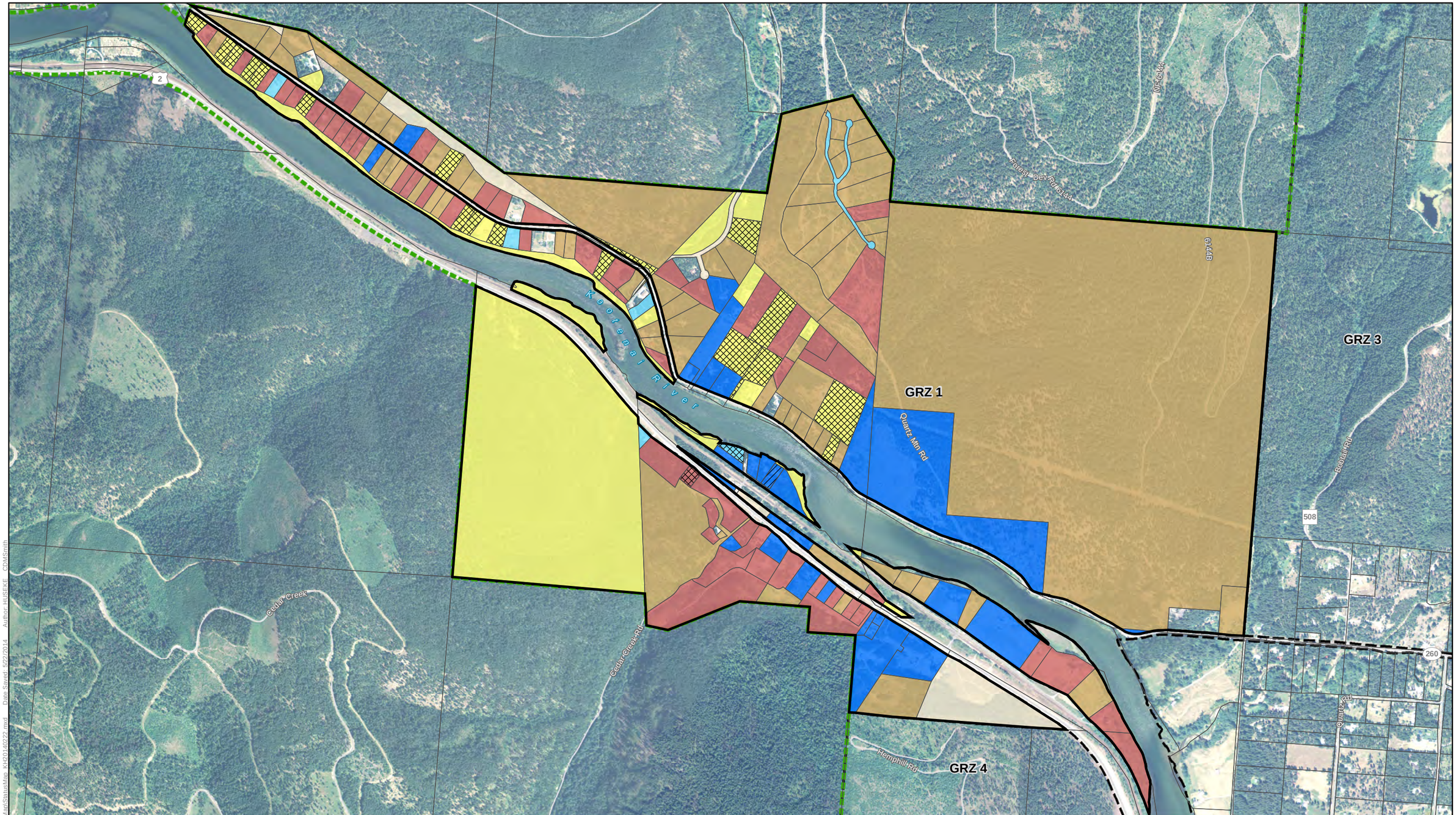
Figure 3-18
Libby GRZ Areas and Removal Zones
Libby Asbestos Superfund Site | Libby, MT

N

0 0.25 0.5 1
Miles

CDM Smith

Document Path: R:\Sitewide FS\StatusMap\Index_201405.mxd Date Saved: 5/14/2014 Author: HUSEKE CDMSmith



Property Status

- Inspection Not Required
- Inspection Required
- Inspection Completed
- Response Action Not Required
- Response Action Required
  - *-Indoor*
  - *-Outdoor*
  - *-Combination*
- Response Action Completed
  - *-Indoor*
  - *-Outdoor*
  - *-Combination*
- GRZ Boundary (Property Status Shown On This Figure)
- GRZ Boundary (Property Status Not Shown On This Figure)
- Limited Property Access
- Refused Property Access
- Libby Asbestos Superfund Site
- Parcel

GRZ - geographic removal zone

Note(s): *Status of properties shown are currently being evaluated and are subject to change during development of the Feasibility Study. These draft figures are provided as an example and should not be used for the decision making process until finalized.*

Property Status Source: EPA Response Manager, 10/08/13
Aerial Image Source: 2002 - Visual Intelligence Systems, Inc.
Road Source: US Census Tiger/Line

Figure 3-19. GRZ(s) 1 and 2

Libby GRZ Areas and Removal Zones

Libby Asbestos Superfund Site | Libby, MT

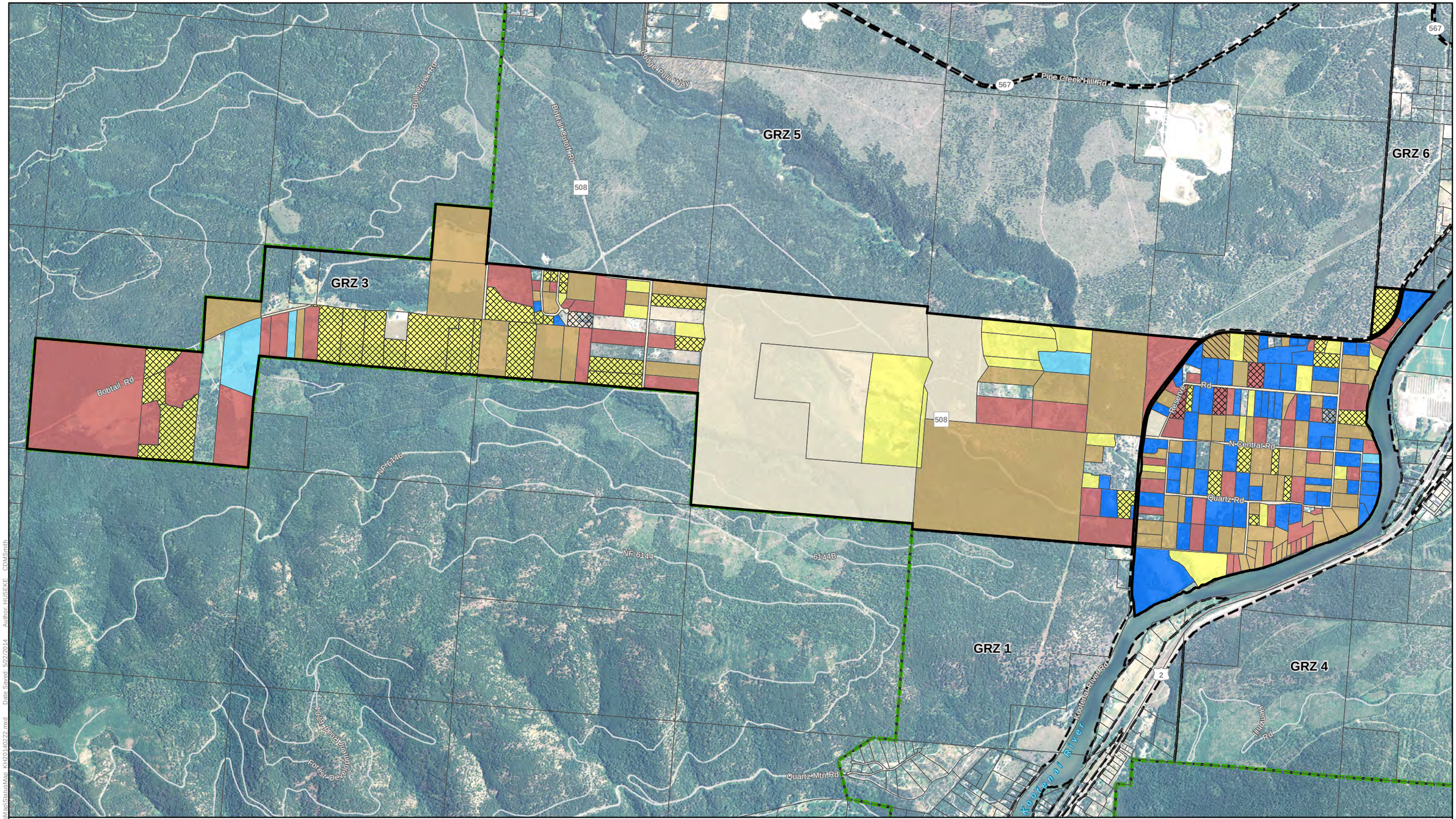
N

0 600 1,200 2,400

Feet

CDM Smith

Document Path: R:\Sitewide FS\StatusMap\StatusMap_KH20140222.mxd Date Saved: 5/22/2014 Author: HUSEKE CDMSmith



Property Status

- Inspection Not Required
- Inspection Required
- Inspection Completed
- Response Action Not Required

Response Action Required
- *-Indoor*
- *-Outdoor*
- *-Combination*

Response Action Completed
- *-Indoor*
- *-Outdoor*
- *-Combination*

- GRZ Boundary (Property Status Shown On This Figure)
- GRZ Boundary (Property Status Not Shown On This Figure)
- Limited Property Access
- Refused Property Access
- Libby Asbestos Superfund Site
- Parcel

GRZ - geographic removal zone

Note(s): *Status of properties shown are currently being evaluated and are subject to change during development of the Feasibility Study. These draft figures are provided as an example and should not be used for the decision making process until finalized.*

Property Status Source: EPA Response Manager, 10/08/13
Aerial Image Source: 2002 - Visual Intelligence Systems, Inc.
Road Source: US Census Tiger/Line

Figure 3-20. GRZ(s) 3

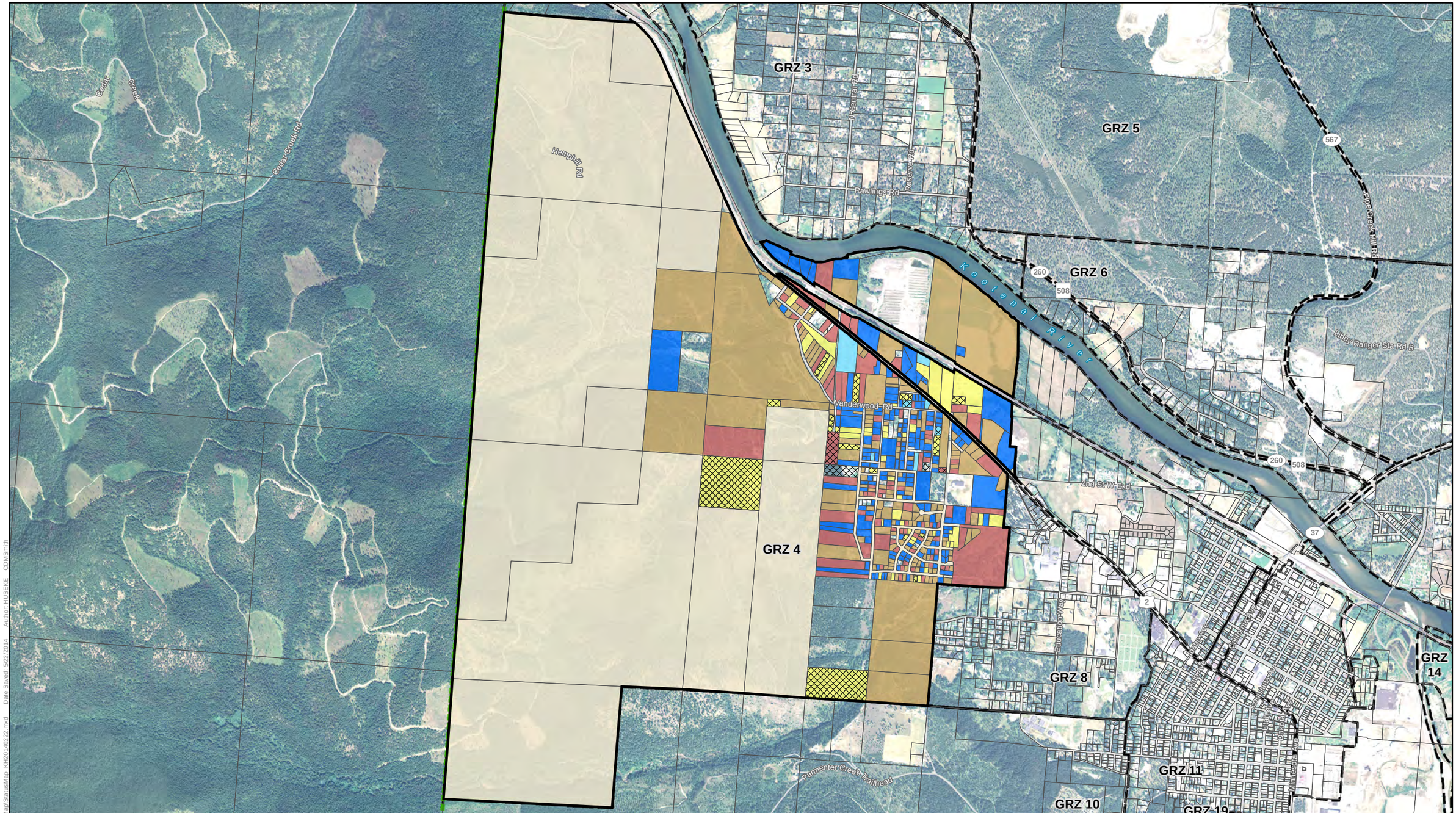
Libby GRZ Areas and Removal Zones

Libby Asbestos Superfund Site | Libby, MT

0 1,100 2,200 4,400 Feet

CDM Smith

Document Path: R:\Sitewide FS\StatusMap\StatusMap_KH20140222.mxd Date Saved: 5/22/2014 Author: HUSEKE CDMSmith



Property Status

- Inspection Not Required
- Inspection Required
- Inspection Completed
- Response Action Not Required
- Response Action Required
  - *-Indoor*
  - *-Outdoor*
  - *-Combination*
- Response Action Completed
  - *-Indoor*
  - *-Outdoor*
  - *-Combination*
- GRZ Boundary (Property Status Shown On This Figure)
- GRZ Boundary (Property Status Not Shown On This Figure)
- Limited Property Access
- Refused Property Access
- Libby Asbestos Superfund Site
- Parcel

GRZ - geographic removal zone

Note(s): *Status of properties shown are currently being evaluated and are subject to change during development of the Feasibility Study. These draft figures are provided as an example and should not be used for the decision making process until finalized.*

Property Status Source: EPA Response Manager, 10/08/13
Aerial Image Source: 2002 - Visual Intelligence Systems, Inc.
Road Source: US Census Tiger/Line

Figure 3-21. GRZ(s) 4

Libby GRZ Areas and Removal Zones

Libby Asbestos Superfund Site | Libby, MT

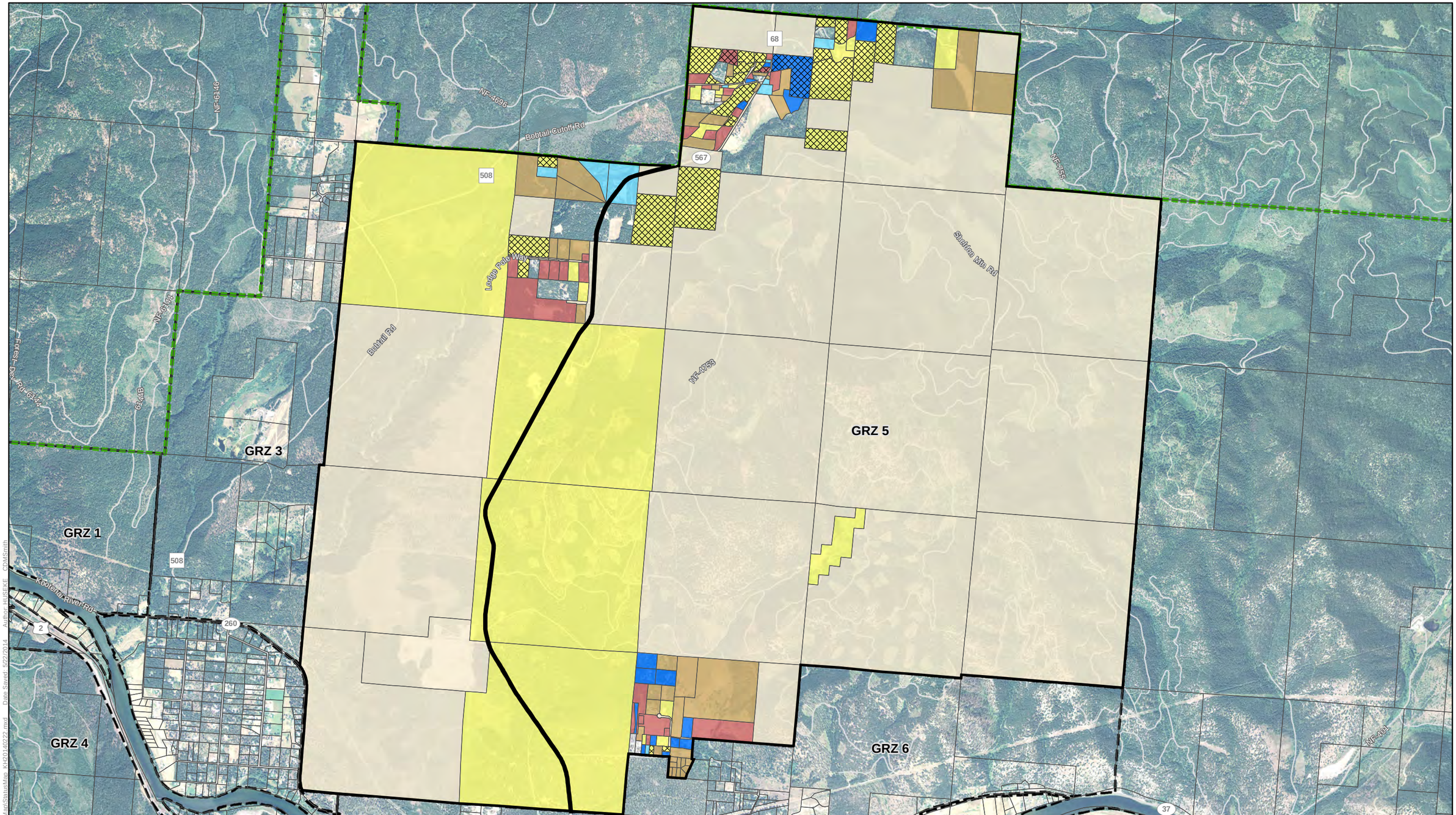
N

0 1,000 2,000 4,000

Feet

CDM Smith

Document Path: R:\Sitewide FS\StatusMap\StatusMap_KH20140222.mxd Date Saved: 5/22/2014 Author: HUSEKE CDMSmith



Property Status

- Inspection Not Required
- Inspection Required
- Inspection Completed
- Response Action Not Required

Response Action Required
- *-Indoor*
- *-Outdoor*
- *-Combination*

Response Action Completed
- *-Indoor*
- *-Outdoor*
- *-Combination*

- GRZ Boundary (Property Status Shown On This Figure)
- GRZ Boundary (Property Status Not Shown On This Figure)
- Limited Property Access
- Refused Property Access
- Libby Asbestos Superfund Site
- Parcel

GRZ - geographic removal zone

Note(s): *Status of properties shown are currently being evaluated and are subject to change during development of the Feasibility Study. These draft figures are provided as an example and should not be used for the decision making process until finalized.*

Property Status Source: EPA Response Manager, 10/08/13
Aerial Image Source: 2002 - Visual Intelligence Systems, Inc.
Road Source: US Census Tiger/Line

Figure 3-22. GRZ(s) 5

Libby GRZ Areas and Removal Zones

Libby Asbestos Superfund Site | Libby, MT

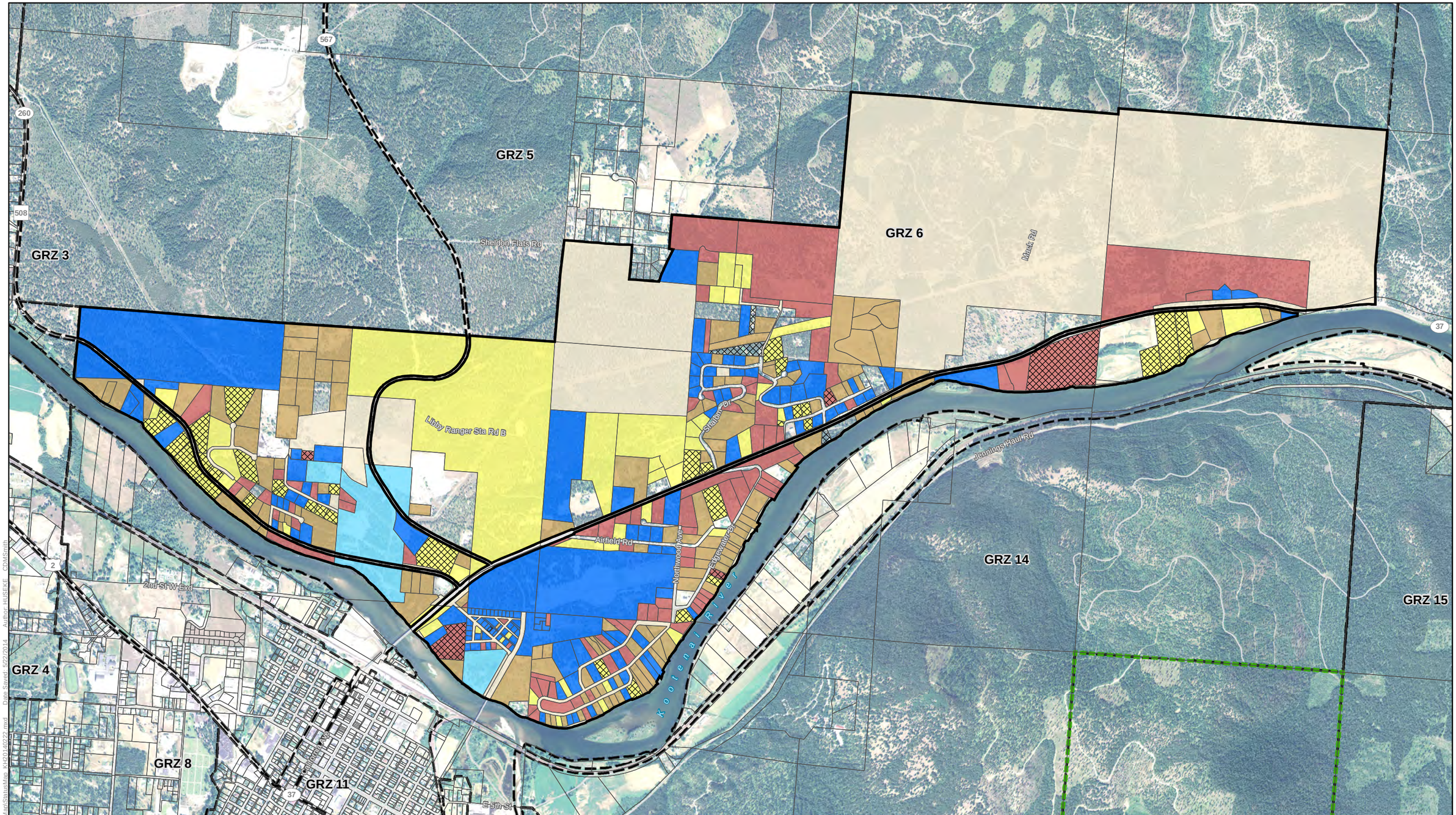
N

0 1,500 3,000 6,000

Feet

CDM Smith

Document Path: R:\Sitewide FS\StatusMap\StatusMap_KH2014\0522.mxd Date Saved: 5/22/2014 Author: HUSEKE CDMSmith



Property Status

- Inspection Not Required
- Inspection Required
- Inspection Completed
- Response Action Not Required

Response Action Required
- -Indoor
- -Outdoor
- -Combination

Response Action Completed
- -Indoor
- -Outdoor
- -Combination

- GRZ Boundary (Property Status Shown On This Figure)
- GRZ Boundary (Property Status Not Shown On This Figure)
- Limited Property Access
- Refused Property Access
- Libby Asbestos Superfund Site
- Parcel

GRZ - geographic removal zone

Note(s): *Status of properties shown are currently being evaluated and are subject to change during development of the Feasibility Study. These draft figures are provided as an example and should not be used for the decision making process until finalized.*

Property Status Source: EPA Response Manager, 10/08/13
Aerial Image Source: 2002 - Visual Intelligence Systems, Inc.
Road Source: US Census Tiger/Line

Figure 3-23. GRZ(s) 6 and 13

Libby GRZ Areas and Removal Zones

Libby Asbestos Superfund Site | Libby, MT

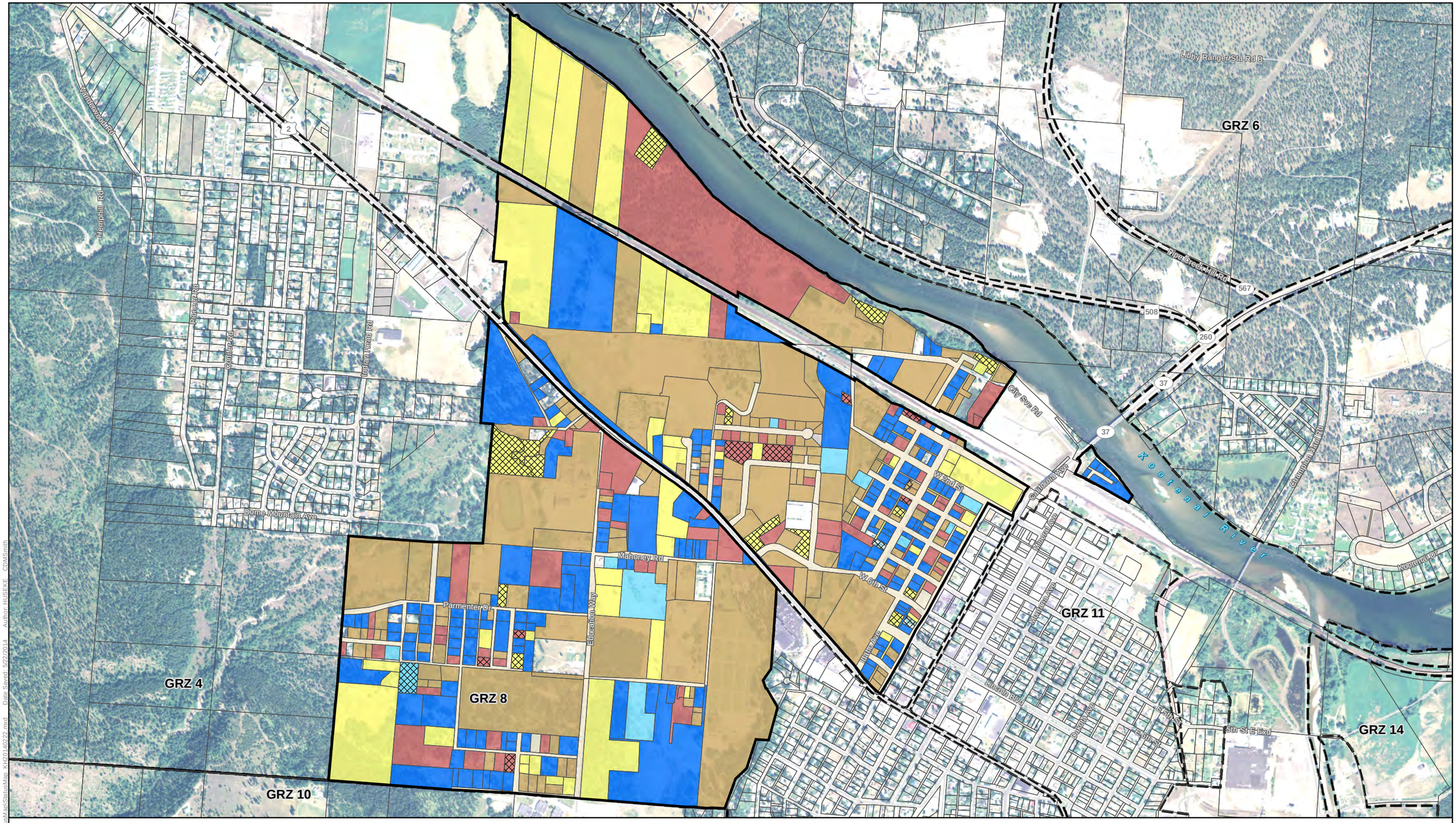
N

0 900 1,800 3,600

Feet

CDM Smith

Document Path: R:\Silverlite FS\Status\Maps\Status Map_KP\2140222.mxd Date Saved: 5/22/2014 Author: HUSEKE CDMSmith



Property Status

- Inspection Not Required
- Inspection Required
- Inspection Completed
- Response Action Not Required
- Response Action Required
  - *-Indoor*
  - *-Outdoor*
  - *-Combination*
- Response Action Completed
  - *-Indoor*
  - *-Outdoor*
  - *-Combination*
- GRZ Boundary (Property Status Shown On This Figure)
- GRZ Boundary (Property Status Not Shown On This Figure)
- Limited Property Access
- Refused Property Access
- Libby Asbestos Superfund Site
- Parcel

GRZ - geographic removal zone

Note(s): *Status of properties shown are currently being evaluated and are subject to change during development of the Feasibility Study. These draft figures are provided as an example and should not be used for the decision making process until finalized.*

Property Status Source: EPA Response Manager, 10/08/13
Aerial Image Source: 2002 - Visual Intelligence Systems, Inc.
Road Source: US Census Tiger/Line

Figure 3-24. GRZ(s) 7, 8 and 9

Libby GRZ Areas and Removal Zones

Libby Asbestos Superfund Site | Libby, MT

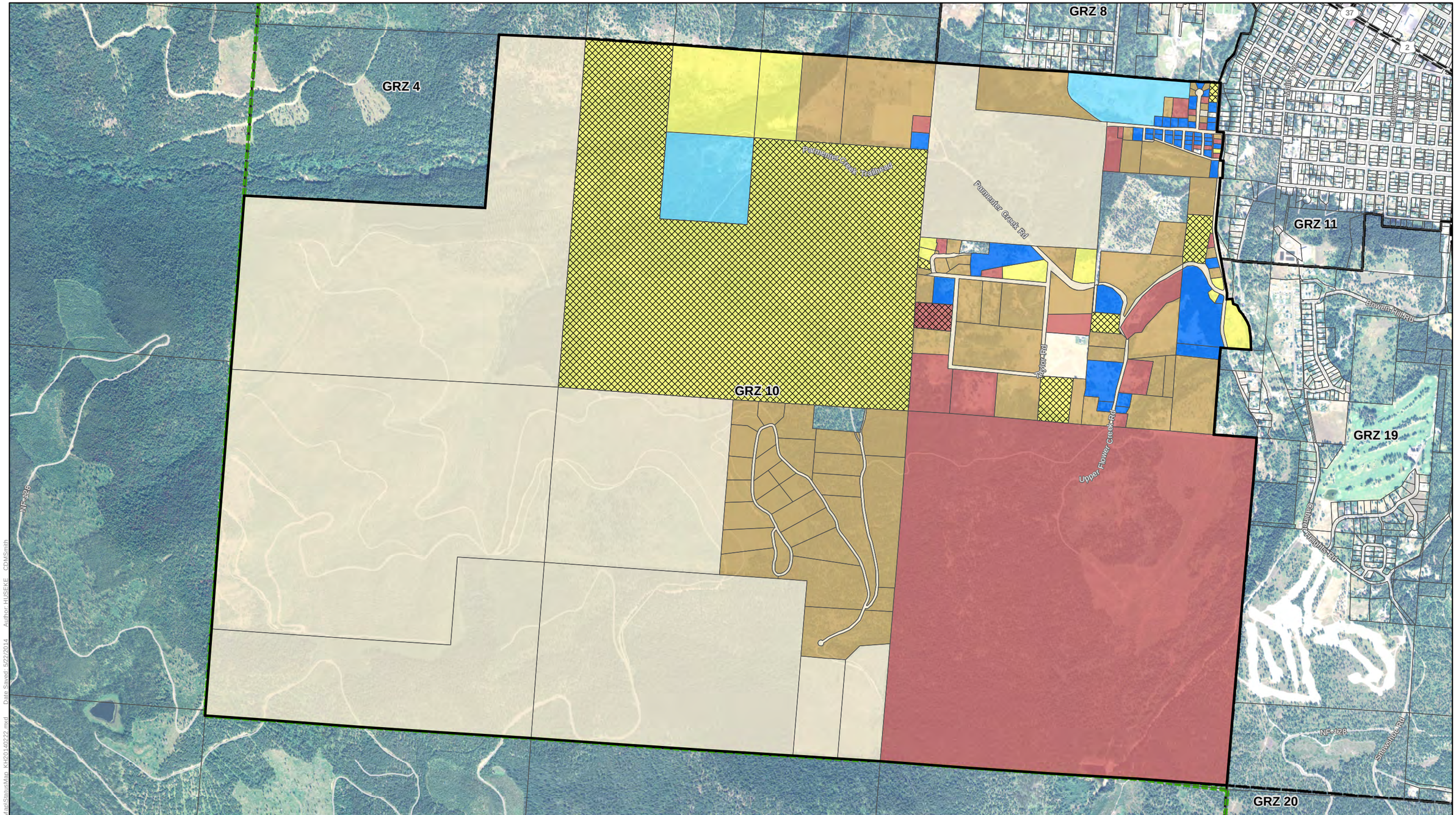
N

0 500 1,000 2,000

Feet

CDM Smith

Document Path: R:\Statewide FS\StatusMap\StatusMap_K\20140222.mxd Date Saved: 5/22/2014 Author: HUSEKE CDMSmith



Property Status

- Inspection Not Required
- Inspection Required
- Inspection Completed
- Response Action Not Required
- Response Action Required
  - -Indoor
  - -Outdoor
  - -Combination
- Response Action Completed
  - -Indoor
  - -Outdoor
  - -Combination
- GRZ Boundary (Property Status Shown On This Figure)
- GRZ Boundary (Property Status Not Shown On This Figure)
- Limited Property Access
- Refused Property Access
- Libby Asbestos Superfund Site
- Parcel

GRZ - geographic removal zone

Note(s): *Status of properties shown are currently being evaluated and are subject to change during development of the Feasibility Study. These draft figures are provided as an example and should not be used for the decision making process until finalized.*

Property Status Source: EPA Response Manager, 10/08/13
Aerial Image Source: 2002 - Visual Intelligence Systems, Inc.
Road Source: US Census Tiger/Line

Figure 3-25. GRZ(s) 10

Libby GRZ Areas and Removal Zones

Libby Asbestos Superfund Site | Libby, MT

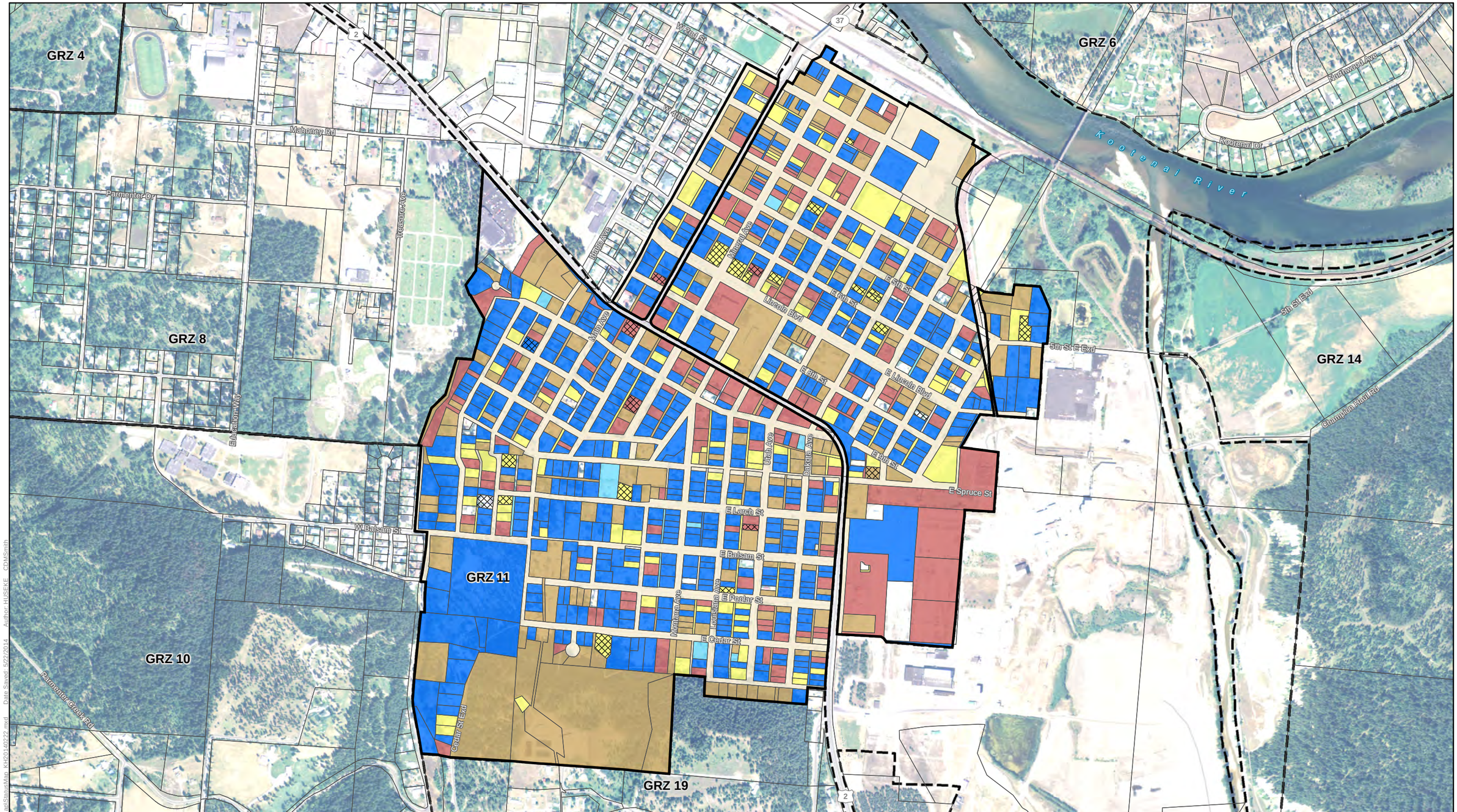
N

0 700 1,400 2,800

Feet

CDM Smith

Document Path: R:\Stowe\FS\StatusMap\StatusMap_KH20140222.mxd Date Saved: 5/22/2014 Author: HUSEKE CDMSmith



Property Status

- Inspection Not Required
- Inspection Required
- Inspection Completed
- Response Action Not Required
- Response Action Required
  - -Indoor
  - -Outdoor
  - -Combination
- Response Action Completed
  - -Indoor
  - -Outdoor
  - -Combination
- GRZ Boundary (Property Status Shown On This Figure)
- GRZ Boundary (Property Status Not Shown On This Figure)
- Limited Property Access
- Refused Property Access
- Libby Asbestos Superfund Site
- Parcel

GRZ - geographic removal zone

Note(s): *Status of properties shown are currently being evaluated and are subject to change during development of the Feasibility Study. These draft figures are provided as an example and should not be used for the decision making process until finalized.*

Property Status Source: EPA Response Manager, 10/08/13
Aerial Image Source: 2002 - Visual Intelligence Systems, Inc.
Road Source: US Census Tiger/Line

Figure 3-26. GRZ(s) 11, 12, 16 and 17A

Libby GRZ Areas and Removal Zones

Libby Asbestos Superfund Site | Libby, MT

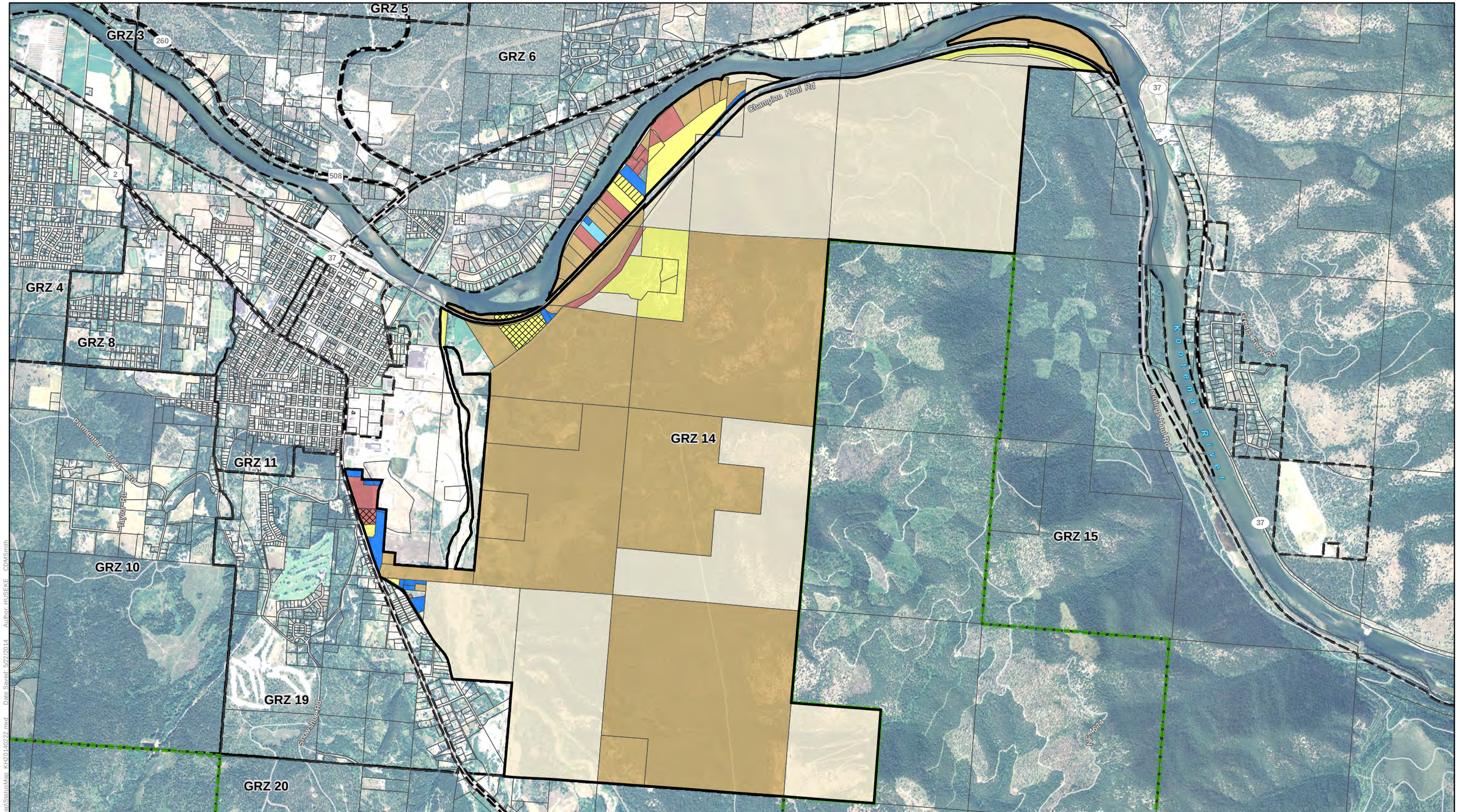
N

0 400 800 1,600

Feet

CDM Smith

Document Path: R:\Sitewide FS\Status\MainStatusMap_K4\20140222.mxd Date Saved: 5/22/2014 Author: HUSEKE CDMSmith



Property Status

- Inspection Not Required
- Inspection Required
- Inspection Completed
- Response Action Not Required

Response Action Required
- *-Indoor*
- *-Outdoor*
- *-Combination*

Response Action Completed
- *-Indoor*
- *-Outdoor*
- *-Combination*

- GRZ Boundary (Property Status Shown On This Figure)
- GRZ Boundary (Property Status Not Shown On This Figure)
- Limited Property Access
- Refused Property Access
- Libby Asbestos Superfund Site
- Parcel

GRZ - geographic removal zone

Note(s): *Status of properties shown are currently being evaluated and are subject to change during development of the Feasibility Study. These draft figures are provided as an example and should not be used for the decision making process until finalized.*

Property Status Source: EPA Response Manager, 10/08/13
Aerial Image Source: 2002 - Visual Intelligence Systems, Inc.
Road Source: US Census Tiger/Line

Figure 3-27. GRZ(s) 14

Libby GRZ Areas and Removal Zones

Libby Asbestos Superfund Site | Libby, MT

N

0 1,300 2,600 5,200
Feet

CDM Smith

Document Path: R:\Statewide PS\StatusMap\StatusMap_KH20140222.mxd Date Saved: 5/22/2014 Author: HUSEKE CDMSmith

Property Status

- Inspection Not Required
- Inspection Required
- Inspection Completed
- Response Action Not Required

Response Action Required
- -Indoor
- -Outdoor
- -Combination

Response Action Completed
- -Indoor
- -Outdoor
- -Combination

- GRZ Boundary (Property Status Shown On This Figure)
- GRZ Boundary (Property Status Not Shown On This Figure)
- Limited Property Access
- Refused Property Access
- Libby Asbestos Superfund Site
- Parcel

GRZ - geographic removal zone

Note(s): *Status of properties shown are currently being evaluated and are subject to change during development of the Feasibility Study. These draft figures are provided as an example and should not be used for the decision making process until finalized.*

Property Status Source: EPA Response Manager, 10/08/13
Aerial Image Source: 2002 - Visual Intelligence Systems, Inc.
Road Source: US Census Tiger/Line

Figure 3-28. GRZ(s) 15 and 17B

Libby GRZ Areas and Removal Zones

Libby Asbestos Superfund Site | Libby, MT

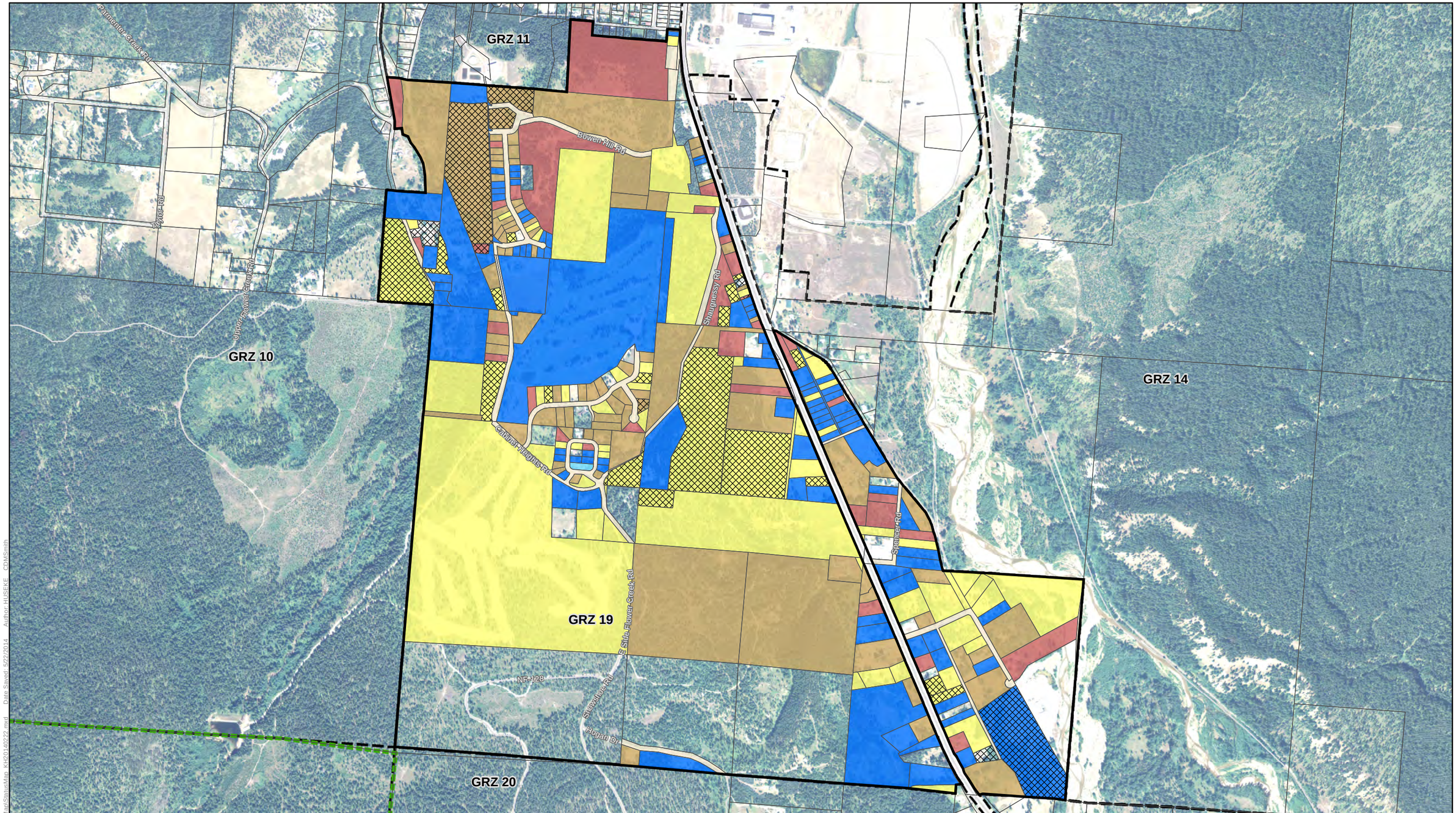
N

0 1,500 3,000 6,000

Feet

CDM Smith

Document Path: R:\Sitewide FS\StatusMap\StatusMap_KH20140222.mxd Date Saved: 5/22/2014 Author: HUSEKE CDMSmith



Property Status

- Inspection Not Required
- Inspection Required
- Inspection Completed
- Response Action Not Required
- Response Action Required
  - *-Indoor*
  - *-Outdoor*
  - *-Combination*
- Response Action Completed
  - *-Indoor*
  - *-Outdoor*
  - *-Combination*
- GRZ Boundary (Property Status Shown On This Figure)
- GRZ Boundary (Property Status Not Shown On This Figure)
- Limited Property Access
- Refused Property Access
- Libby Asbestos Superfund Site
- Parcel

GRZ - geographic removal zone

Note(s): *Status of properties shown are currently being evaluated and are subject to change during development of the Feasibility Study. These draft figures are provided as an example and should not be used for the decision making process until finalized.*

Property Status Source: EPA Response Manager, 10/08/13
Aerial Image Source: 2002 - Visual Intelligence Systems, Inc.
Road Source: US Census Tiger/Line

Figure 3-29. GRZ(s) 18 and 19

Libby GRZ Areas and Removal Zones

Libby Asbestos Superfund Site | Libby, MT

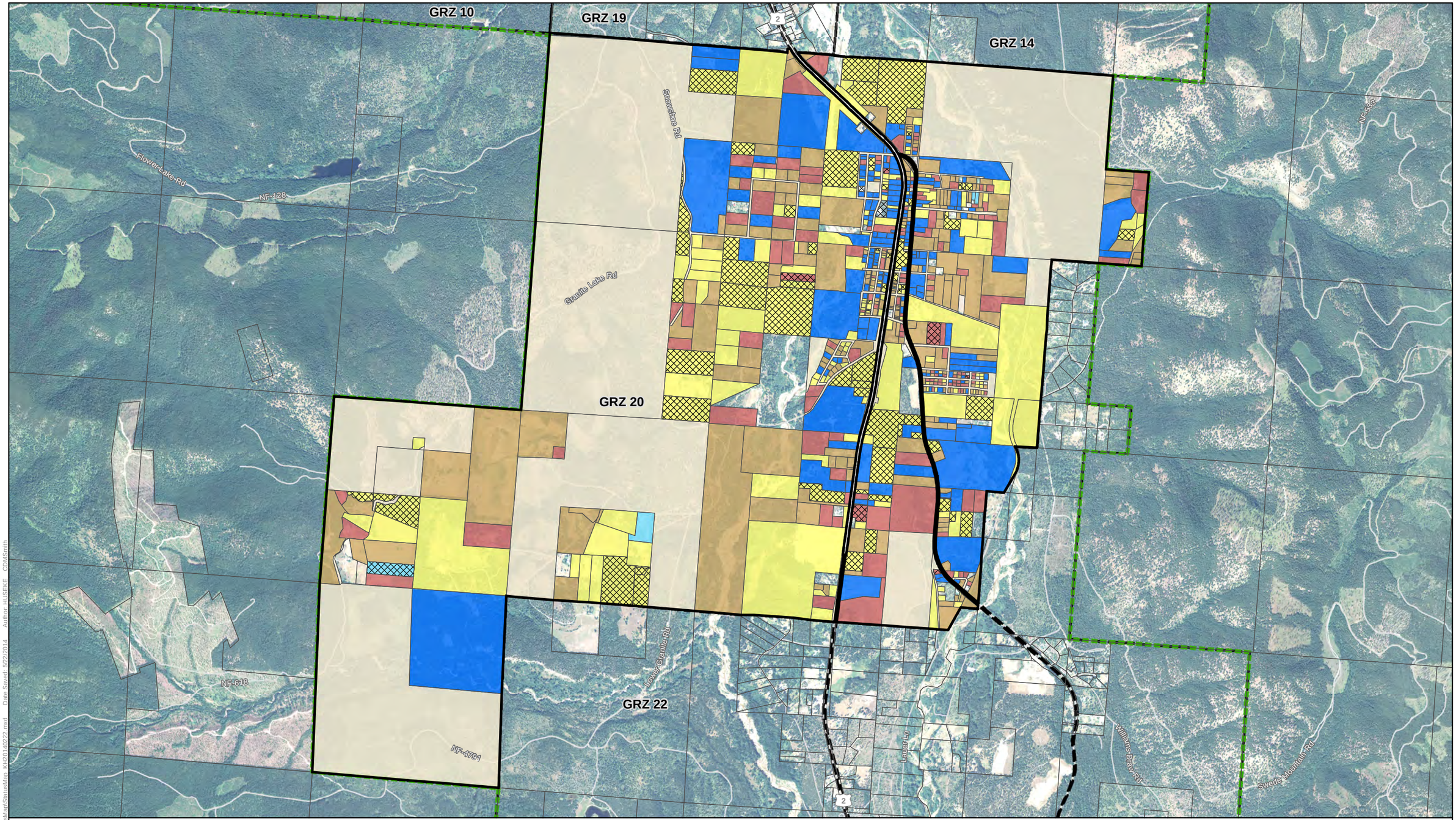
N

0 550 1,100 2,200

Feet

CDM Smith

Document Path: R:\Sitewide FS\StatusMap\StatusMap_KH20140222.mxd Date Saved: 5/22/2014 Author: HUSEKE CDMSmith



Property Status

- Inspection Not Required
- Inspection Required
- Inspection Completed
- Response Action Not Required
- Response Action Required
  - *-Indoor*
  - *-Outdoor*
  - *-Combination*
- Response Action Completed
  - *-Indoor*
  - *-Outdoor*
  - *-Combination*
- GRZ Boundary (Property Status Shown On This Figure)
- GRZ Boundary (Property Status Not Shown On This Figure)
- Limited Property Access
- Refused Property Access
- Libby Asbestos Superfund Site
- Parcel

GRZ - geographic removal zone

Note(s): *Status of properties shown are currently being evaluated and are subject to change during development of the Feasibility Study. These draft figures are provided as an example and should not be used for the decision making process until finalized.*

Property Status Source: EPA Response Manager, 10/08/13
Aerial Image Source: 2002 - Visual Intelligence Systems, Inc.
Road Source: US Census Tiger/Line

Figure 3-30. GRZ(s) 20 and 21

Libby GRZ Areas and Removal Zones

Libby Asbestos Superfund Site | Libby, MT

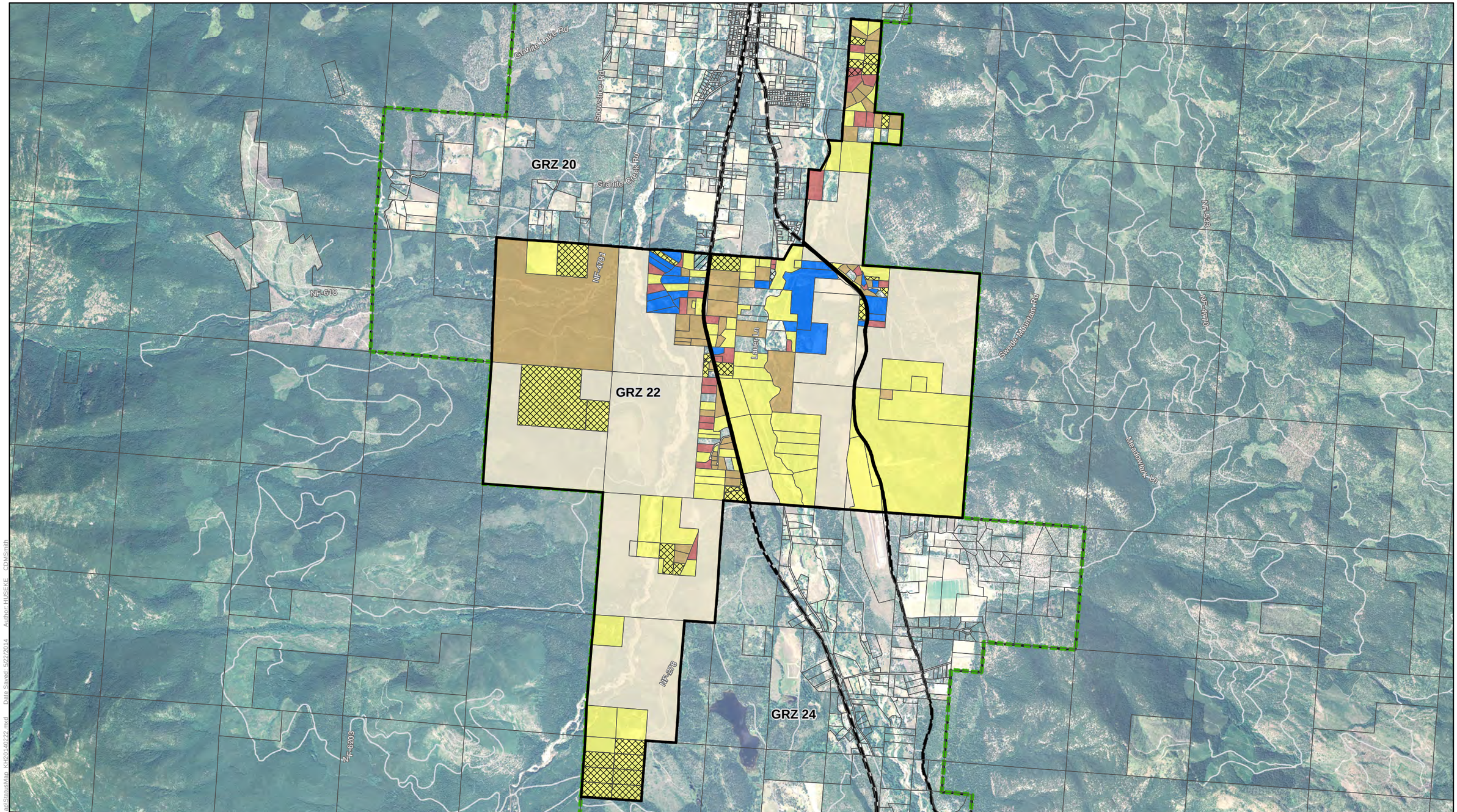
N

0 1,300 2,600 5,200

Feet

CDM Smith

Document Path: R:\Sitewide FS\StatusMap\StatusMap_KH20140222.mxd Date Saved: 5/22/2014 Author: HUSEKE CDMSmith



Property Status

- Inspection Not Required
- Inspection Required
- Inspection Completed
- Response Action Not Required

Response Action Required
- *-Indoor*
- *-Outdoor*
- *-Combination*

Response Action Completed
- *-Indoor*
- *-Outdoor*
- *-Combination*

- GRZ Boundary (Property Status Shown On This Figure)
- GRZ Boundary (Property Status Not Shown On This Figure)
- Limited Property Access
- Refused Property Access
- Libby Asbestos Superfund Site
- Parcel

GRZ - geographic removal zone

Note(s): *Status of properties shown are currently being evaluated and are subject to change during development of the Feasibility Study. These draft figures are provided as an example and should not be used for the decision making process until finalized.*

Property Status Source: EPA Response Manager, 10/08/13
Aerial Image Source: 2002 - Visual Intelligence Systems, Inc.
Road Source: US Census Tiger/Line

Figure 3-31. GRZ(s) 22 and 23

Libby GRZ Areas and Removal Zones

Libby Asbestos Superfund Site | Libby, MT

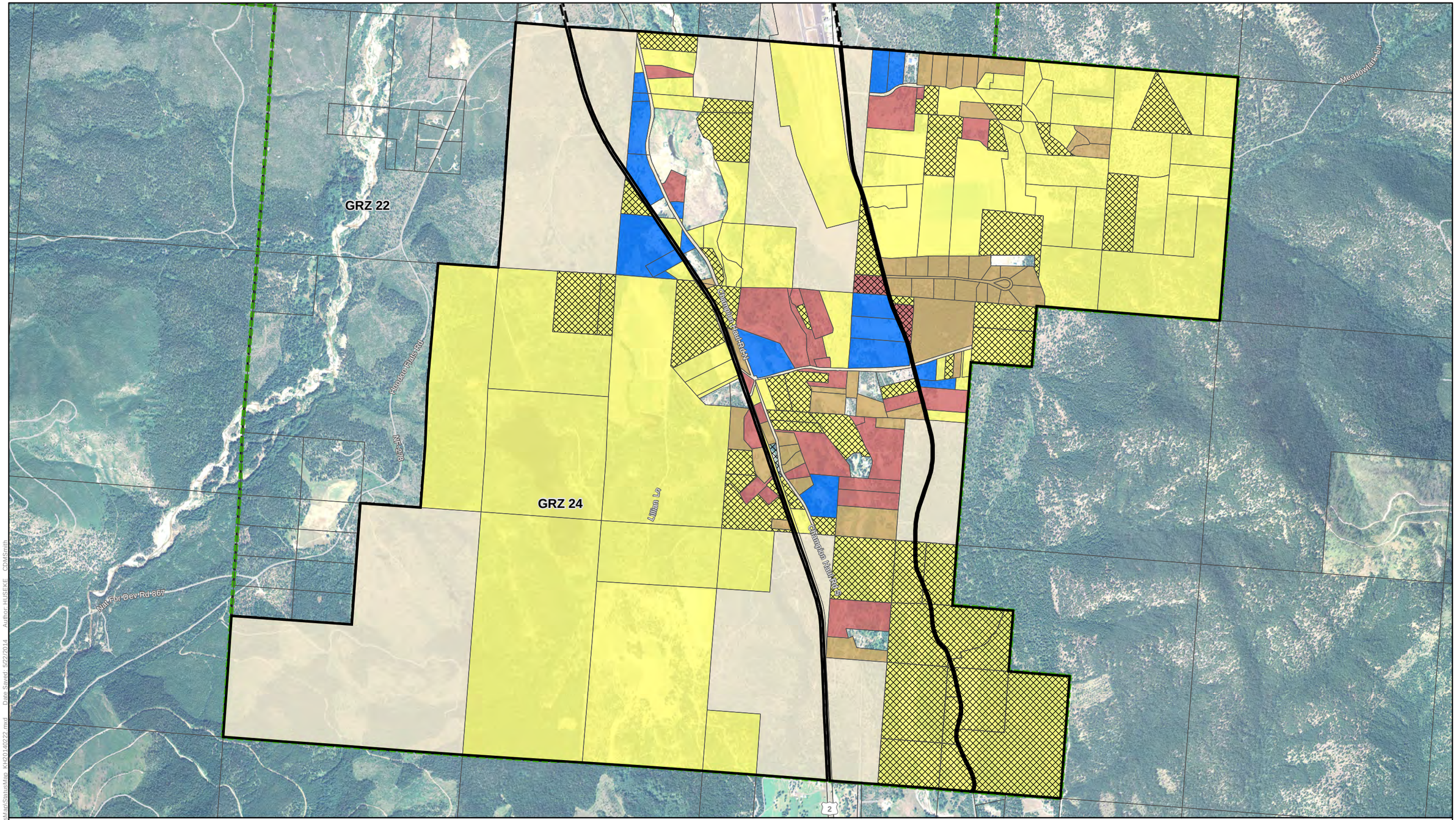
N

0 2,000 4,000 8,000

Feet

CDM Smith

Document Path: R:\Sitewide FS\StatusMap\StatusMap_K4\20140222.mxd Date Saved: 5/22/2014 Author: HUSEKE CDMSmith



Property Status

- Inspection Not Required
- Inspection Required
- Inspection Completed
- Response Action Not Required

Response Action Required
-Indoor
-Outdoor
-Combination

Response Action Completed
-Indoor
-Outdoor
-Combination

GRZ Boundary (Property Status Shown On This Figure)

GRZ Boundary (Property Status Not Shown On This Figure)

Limited Property Access

Refused Property Access

Libby Asbestos Superfund Site

Parcel

GRZ - geographic removal zone

Note(s): *Status of properties shown are currently being evaluated and are subject to change during development of the Feasibility Study. These draft figures are provided as an example and should not be used for the decision making process until finalized.*

Property Status Source: EPA Response Manager, 10/08/13
Aerial Image Source: 2002 - Visual Intelligence Systems, Inc.
Road Source: US Census Tiger/Line

Figure 3-32. GRZ(s) 24

Libby GRZ Areas and Removal Zones

Libby Asbestos Superfund Site | Libby, MT

N

0 1,000 2,000 4,000
Feet

CDM Smith

Document Path: R:\Sitewide FS\StatusMap\StatusMap_KH20140222.mxd Date Saved: 5/22/2014 Author: HUSEKE CDMSmith

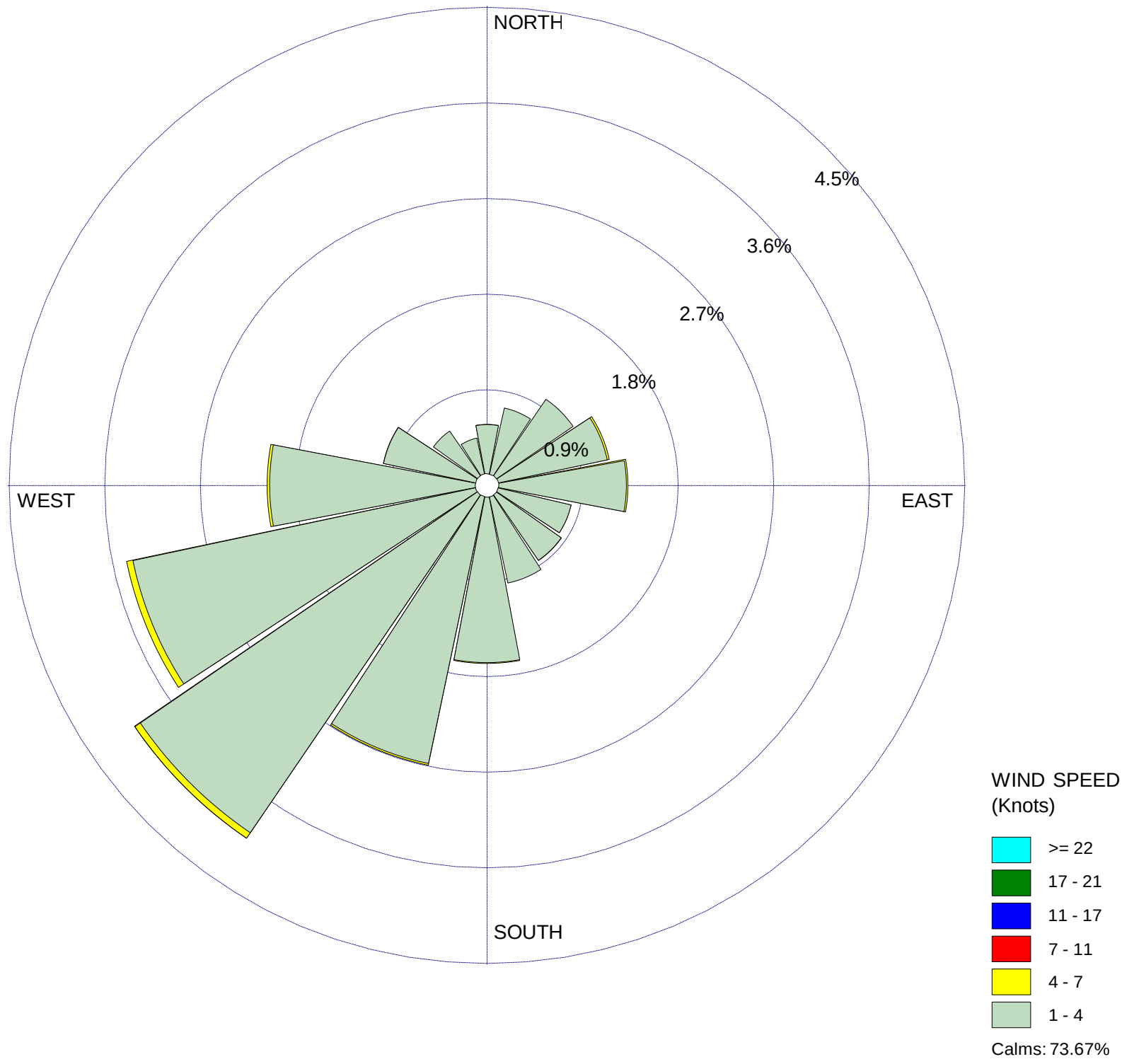
Figure 4.1. Wind Rose for LBBM8 (2007-2013)

WIND ROSE PLOT:

Station # 8 - Libby, MT

DISPLAY:

Wind Speed
Direction (blowing from)



COMMENTS:	DATA PERIOD:	COMPANY NAME:	
	Start Date: 1/1/2007 - 00:00 **End Date: 12/31/2013 - 23:00**	MODELER:	
	CALM WINDS: **73.67%**	TOTAL COUNT: **54766 hrs.**	
	AVG. WIND SPEED: **0.49 Knots**	DATE: **1/20/2014**	PROJECT NO.:

WRPLOT View - Lakes Environmental Software

Data obtained from Meso West

Appendix A

Sample Collection Details and Analytical Results for Investigation, Design, and Removal Clearance Samples

(provided electronically)

Appendix B

Sample Collection Details and Analytical Results for Health and Safety Monitoring Samples

(provided electronically)

Appendix C

Landfill Volume Calculations

APPENDIX C. LANDFILL FUTURE CAPACITY ESTIMATES

Year	OU4		OU7		Total Properties	Riprap Volume (BCY)	Landfill Volume (BCY)	Average Volume Per Property (BCY)
	Interiors	Combos	Interiors	Combos				
2001	1	3	NA	NA	4	NA	UNK	UNK
2002	9	2	NA	NA	11	NA	UNK	UNK
2003	54	46	NA	NA	100	NA	1,353	14
2004	54	57	NA	NA	111	NA	13,560	122
2005	76	76	NA	NA	152	NA	4,602	30
2006	31	118	NA	NA	149	NA	3,872	26
2007	2	83	NA	NA	85	NA	3,002	35
2008	2	67	0	6	75	3,370	5,994	80
2009	6	78	0	5	89	1,860	5,844	66
2010	8	61	12	17	98	NA	3,334	34
2011	1	43	0	1	45	NA	3,075	68
2012	3	37	1	0	41	NA	1,894	46
Total	**247**	**671**	**13**	**29**	**960**	**5,230**	**46,530**	**521**

*Based on RM as of October 2013
BCY = bank cubic yards
NA = not applicable
UNK = unknown

Average between total volume and total removals	52	
Average between total volume and total removals (2005 to 2012)	48	

Calculations do not include riprap volumes from the creek removals.

Estimated properties remaining in OU4	439	
Estimated properties remaining in OU7	100	
Total estimated properties remaining	539	

Estimated properties remaining in OU7 has entirely been estimated, more approximate numbers to be determined when information is available.

Total volume required to complete project (including daily cover)	25,987	BCY
Safety factor (20%)	5,197	BCY
Total Estimated Volume Remaining to be Disposed	**31,185**	**BCY**

Based on average annual volume 2005 to 2012.

Remaining volume based on entire cell's capacity (including daily cover)	66,460	**BCY**
Excess Capacity	35,276	**BCY**

Landfill volume information was not available for 2013 at the time of this report.

Appendix D

Dust Pilot Study Data

(provided electronically)