1/20/12

ENTERED

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS 49TH WING (ACC)
HOLLOMAN AIR FORCE BASE, NEW MEXICO

A. David Budak
Deputy Base Civil Engineer
550 Tabosa Avenue
Holloman AFB NM 88330-5840

JAN 2012

New Mexico Environment Department
Attn: Mr. John Kieling
Hazardous Waste Bureau
2905 Rodeo Park Drive East, Building 1
Santa Fe NM 87105-6303

Dear New Mexico Environment Department

Holloman Air Force Base is pleased to submit the Accelerated Corrective Measures Completion Report for SS-13 for your review.

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision according to a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

If you have any questions, please contact Mr. David Scruggs of our Asset Management Flight at (575) 572-5395.

Sincerely

20120119

A. DAVID BUDAK, GS-14, DAFC

Attachment:
Accelerated Corrective Measures Completion Report for SS-13

cc:

(w/ Atch)	(w/o Atch)	(w/o Atch)
Mr. David Strasser	Mr. Will Moats	Ms. Laurie King
Hazardous Waste Bureau	Hazardous Waste Bureau	USEPA, Region 6 (6PD-F)
5500 San Antonio Dr. NE	5500 San Antonio Dr. NE	1445 Ross Ave., Ste 1200
Albuquerque NM 87109	Albuquerque NM 87109	Dallas TX 75202

7009 2820 0003 6257 5468

Draft Final
Accelerated Corrective Measure Completion Report for Site SS-13, Holloman Air Force Base, New Mexico

Prepared for:

USACE, Omaha District

US Army Corps of Engineers ®
Omaha District

Holloman Air Force Base

Prepared by:

North Wind Services, LLC.

North Wind
A CIRI COMPANY

December 2011

NWI11-5020-001

Draft Final Accelerated Corrective Measure Completion Report for Site SS-13, Holloman Air Force Base, New Mexico

December 2011

Contract No. W9128F-04-D-0017

Prepared for:
U.S. Army Corps of Engineers, Omaha District
Environmental Engineering Branch
106 South 15th Street
Omaha, Nebraska 68102-1618

and

Holloman Air Force Base
Building 55
550 Tabosa Avenue
Holloman Air Force Base, New Mexico 88330-8458

Prepared by:
North Wind, Inc.
1425 Higham Street
Idaho Falls, ID 83402

(This page intentionally left blank)

CONTENTS

FIGURES

TABLES

APPENDICES

ACRONYMS

ACM	Accelerated Corrective Measure
AFB	Air Force Base
bgs	below ground surface
°C	degrees Celsius
DRMO	Defense Reutilization Management Office
EPA	United States Environmental Protection Agency
ERP	Environmental Restoration Program
°F	degrees Fahrenheit
ft	feet
HAS	hollow-stem auger
HSWA	Hazardous and Solid Waste Amendments
IDW	investigation derived waste
IRP	Installation Restoration Program
MCL	maximum contaminant level
MDL	method detection limit
mg/Kg	milligrams per kilogram
mg/L	milligrams per liter
ml	milliliter
MS	matrix spike
MSD	matrix spike duplicate
msl	mean sea level
NMED	New Mexico Environment Department
North Wind	North Wind, Inc.
PID	photoionization detector
PVC	polyvinyl chloride

RCRA	Resource Conservation and Recovery Act
RL	reporting limit
SOP	standard operating procedure
SVOC	semi-volatile organic compound
TAL	target analyte list
TDS	total dissolved solids
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USGS	United States Geological Survey
VOC	volatile organic compound
WQCC	Water Quality Control Commission

Draft Final
Accelerated Corrective Measure Completion Report for Site SS-13, Holloman Air Force Base, New Mexico

1 INTRODUCTION

The Accelerated Corrective Measure (ACM) Completion Report for Site SS-13, Holloman Air Force Base (AFB), New Mexico, defines the technical approach, procedures, and requirements conducted at the Sodium Arsenite Spill Site (SS-13) under Contract No. W9128F-04-D-0017 for the U.S. Army Corps of Engineers (USACE), Omaha District. This document satisfies the corrective action requirements reporting of the Hazardous and Solid Waste Amendments (HSWA) portion of the Holloman AFB Resource Conservation and Recovery Act (RCRA) permit.

1.1 Purpose and Objective

The purpose and objective of field activities leading to this ACM Completion Report was to further characterize current soil and groundwater conditions at the SS-13 site and remove any identified contaminated soil at the site.

A 1993 decision document concluded that the SS-13 site does not present a significant threat to the environment; therefore, the No Further Action alternative recommendation was approved and the decision document for closure was signed by New Mexico Environment Department (NMED) in April 1993 (EA, 1993). In 1999, a petition to close the SS-13 site was rejected by NMED due to lack of characterization data and delineation of the site. Thus, prior to closure, further characterization was required, including removal of any contaminants from the site and generation of a final report detailing this additional action.

If this action had not been taken or performed, this site would not receive closeout status and Holloman AFB could receive a Notice of Violation resulting in fines and penalties.

1.2 Scope of Work

The SS-13 Herbicide Sodium Arsenite Spill Site is located in the Civil and Engineering Complex yard, next to the Defense Reutilization Management Office (DRMO). The site was originally used to store sodium arsenite, a weed killer used to sterilize runway areas. In 1979, it was determined that a spill had occurred from the storage area, which led to an initial investigation of that site. At the spill site, two soil borings and one monitoring well were installed and sampled during the Phase II Installation Restoration Program (IRP) investigation (Dames and Moore, 1987). Soil and water samples were analyzed for arsenic. No analysis of volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), or other metals was performed. The Phase II IRP results identified arsenic in groundwater at 0.01 mg/L. Extraction procedure-toxicity analysis of five soil samples reported a maximum arsenic concentration of 0.04 mg/L. The depression was backfilled and capped with asphalt in the early 1990s.

The site was not sufficiently characterized as required in the base's RCRA permit. Therefore, additional characterization and remediations of the release were required. Requirements for this additional characterization/remediation were defined as:

- Preparation of a draft and final work plan approved by NMED;
- Installation and sampling of four soil borings;
- Collection of eight soil samples (plus one duplicate) and analysis for VOCs, SVOCs, target analyte list (TAL) metals, herbicides, and pesticides;
- Excavation, transportation, and disposal of 30 cubic yards of contaminated soil (hazardous waste);
- Closure/confirmation samples;
- Installion of three shallow groundwater monitoring wells;
- Installation of one deep groundwater monitoring well;
- Analysis of five groundwater samples (plus one duplicate) for VOCs, SVOCs, TAL metals, herbicides, and pesticides; and
- Prepare closure report, including risk based assessment of contamination to soil and groundwater in accordance with the Holloman AFB RCRA permit.

The additional characterization for this site was outlined, defined, and approved in the *Work Plan for Accelerated Closure Measures at Site SS-13, Holloman Air Force Base, New Mexico* (North Wind, 2008a). All work completed as part of this additional characterization was covered under the *Addendum to the Holloman AFB Base Wide Site Safety And Health Plan, Site Safety and Health Plan and Accident Prevention Plan for Post-Closure Operation-Construction (PCO-C) at Site SS-13, Holloman Air Force Base, New Mexico* (North Wind, 2008b).

The Work Plan outlined a staged characterization approach consisting of first identifying areas of soil contamination using soil borings and soil sampling. Once the approximate vertical and horizontal extent of the soil contamination had been identified, the affected soil would be excavated and disposed. Groundwater monitoring wells would be installed and sampled in order to determine the potential impacts to groundwater at the site.

The field activities planned consisted of the following tasks:

- Subsurface soils investigation,
- Contaminated soil remediation,
- Monitoring well installation, and
- Groundwater investigation.

Details of this characterization and deviations from the planned scope, as outlined in the Work Plan, are discussed in Section 9 of this report.

1.3 Report Organization

This document includes the following sections:

- Section 1 – Introduction,
- Section 2 – Site-Specific Background,
- Section 3 – Environmental Settings,
- Section 4 – Regional Hydrology,
- Section 5 – Site-Specific Geology,
- Section 6 – Climate,
- Section 7 – Current and Future Land Use,
- Section 8 – Current and Future Water Use, and
- Section 9 – Site-Specific Results, Conclusions, and Recommendations.

(This page intentionally left blank)

2 SITE-SPECIFIC BACKGROUND

The following sections provide a general description of the Holloman AFB, the SS-13 site location, and previous investigations at the SS-13 site.

2.1 Holloman Air Force Base

Holloman AFB is located in Southern New Mexico, approximately 50 miles northeast of Las Cruces. Holloman AFB was originally established in 1942 as Alamogordo Air Field, just 6 miles west of Alamogordo, New Mexico (see Figure 2-1). Initial construction began at the airfield on February 6, 1942. The base was re-named in 1948 after Colonel George Holloman, who was a pioneer in early rocket and pilot-less aircraft research. The site has a rich history of aeronautical accomplishments, ranging from military planes to jets to missile defense research. The site is approximately 4,100 ft above mean sea level (msl). The terrain is relatively flat with a slight slope to the east. Groundwater occurs at approximately 10 to 15 ft below ground surface (bgs). The hydraulic gradient at the site is relatively flat and varies but generally flows to the south.

2.2 Site Description for SS-13

SS-13 is located in the Civil and Engineering Complex next to the DRMO storage facility. The approximate location of SS-13 is shown on Figure 2-2 and further delineated on Figure 2-3. The site was a 2-ft deep depression used to store sodium arsenite, a weed killer used to sterilize runway areas. Approximately eighty-three 30-gallon containers of sodium arsenite were stored at this location in 1979. In August 1979, one of the cans was found empty with a hole in the bottom. It is assumed that approximately 30 gallons of sodium arsenite were released at the site. All containers of sodium arsenite not needed at Holloman AFB were removed from this site. The depression was backfilled and capped with asphalt in the early 1990s. The site is currently used as a storage area.

2.3 Previous Investigations at SS-13

A 1983 Phase I records search reported that the release had occurred and that site cleanup operations could not be confirmed (CH2M HILL, 1983). In 1987, two soil borings and one monitoring well were installed and sampled during the Phase II IRP investigation (Dames and Moore, 1987). The Phase II IRP results identified arsenic in groundwater at 0.01 milligram per liter (mg/L) and a maximum of 0.04 milligrams per kilogram (mg/Kg) arsenic in five soil samples. The samples were analyzed for arsenic only. VOCs, SVOCs, herbicides, pesticides, and metals were not analyzed. Based on the low levels of arsenic found at the site, the Phase II IRP recommended no further action.

A 1993 decision document concluded that the SS-13 site does not present a significant threat to the environment; therefore, the No Further Action alternative recommendation was approved and the decision document for closure was signed by NMED in April 1993 (EA, 1993). In 1999, a petition to close the SS-13 site was rejected by NMED due to lack of characterization data and delineation of the site. A data gap analysis, removal of contaminants, and documentation of site conditions were required prior to closure of the site.

(This page intentionally left blank)

3 ENVIRONMENTAL SETTING

3.1 Physiography and Topography

Holloman AFB is located in the southern part of the Tularosa Basin in south-central New Mexico. The basin occupies an area of approximately 4,000 square miles, being approximately 120 miles long (north-south) and 35 miles wide (east-west). The Tularosa Basin is bounded 8 miles to the east by the Sacramento Mountains and 25 miles to the west by the San Andreas Mountains. The Chupadera Mesa forms the northern edge of the basin, with the southern margin occurring near the Texas border.

Major physiographic features within the Tularosa Basin include the Malpais, a massive basalt lava flow located approximately 45 miles north of Holloman AFB; White Sands, an extensive gypsum dunes area to the west of the base; and the flat alkali playa on which the base is situated.

The overall ground surface gradient in the Tularosa Basin is towards the southwest. Local slopes are modified by the mountain ranges and by several southwest trending arroyos. Elevations within the Basin decrease from 4,000 ft above msl at the northeast corner to 4,000 ft above msl in the southwest corner. Elevations at the base range from 4,028 to 4,100 ft above msl, excluding Tularosa Peak. The Sacramento Mountains have a maximum elevation of approximately 12,000 ft above msl, and elevations of the San Andreas Mountains range from 7,000 to 9,000 ft above msl (CH2M Hill 1983).

The Tularosa Basin is a closed basin that contains all of the surface flow within its boundaries. Surface runoff from the surrounding mountains has deposited alluvial fans on the interior of the plain. Around the Base, the ground surface is undulating comprised of alluvial fan deposits, eolian dunes, and flat bottomed playas (pan-shaped depressions carved by wind erosion). To the west of the Base lie the gypsum sand dune fields of the White Sands National Monument. A topographic map of the Base is provided in Figure 3-1.

3.2 Surface Water and Hydrology

Within the boundaries of the AFB, surface water runoff is controlled by several arroyos that trend to the southwest (Figure 3-2). The nearest inflow of surface waters to the Base comes from the Lost River, located in the north-central region of the Base. Holloman AFB is dissected by several other southwest trending arroyos that control the surface drainage. Hay Draw arroyo is located in the far north. Malone Draw and Rita's Draw (which both drain into the Lost River) and Dillard Draw arroyos are located along the eastern perimeter of the Base.

Approximately 10,000 years ago, indications are of a much wetter climate. The present day Lake Otero encompassed a much larger area, possibly upwards of several hundred square miles. Its remains are the Alkali Flat and Lake Lucero. Lake Lucero is a temporary feature of merely a few inches in depth during the rainy season.

Ancient lakes and streams deposited water bearing deposits over the older bedrock basement material. Fractures, cracks, and fissures in the Permian and Pennsylvanian bedrock yield small quantities of relatively good quality water in the deeper bedrock. Potable water is only found from a handful of wells near the edges of the basin, with more saline water towards the center. Two of the principal sources of potable water are a long, narrow north-south trending area east of Tularosa, and Alamogordo in the far southwestern part of the basin. Lake Bonito, which is in the Pecos River Basin, supplies the water for Alamogordo and the AFB.

Holloman AFB obtains most of its water supply from wells installed in the basin fill near the foot of the Sacramento Mountains south of Alamogordo and east of the base. The five base well fields (Boles, Douglas, San Andreas, Escondida, and Frenchie) are located 5.5, 7.75, 7.75, 12, and 13 miles, respectively, from Holloman AFB. The wells draw water from depths ranging from 200 to greater than 1,100 ft below the surface. Besides containing better quality water, the aquifer tends to be more permeable closer to the mountains because of the coarser materials comprising the alluvial fans.

3.3 Regional Geology

The Tularosa Basin is the easternmost extension of the Basin and Range Providence of the western United States. The Basin and Range was created by Cenozoic extensional (normal) faulting of Precambrian- through Tertiary-age sedimentary and igneous rocks. The basin is a graben, or downthrown block, bounded by the upthrown fault blocks of the San Andres and Sacramento Mountains.

During the Permian period of the Paleozoic era (approximately 270 million years ago), southern New Mexico was covered by a shallow sea. Limestone and sandstone were deposited, forming thick sedimentary units. Toward the end of the Mesozoic era (approximately 70 million years ago), the major mountain building activities that formed the Rocky Mountains took place. During these events, southern New Mexico emerged from the ocean as the earth's crust upwarped gently in this region. During the Cenozoic era (beginning approximately 70 million years ago), basin and range formation was initiated in what is now the southwestern United States. Approximately 10 million years ago, Cenozoic faulting formed the graben structure known as the Tularosa Basin. During this process, arched portions of rock collapsed between large-scale, north-south trending faults. The Tularosa Basin is a central downthrown area, bounded on the east and west by fault-block mountains. Bedded Permian strata can be seen along the faces of the Sacramento and San Andres Mountains. Permian limestones also occur west of Holloman AFB in a low bedrock outcrop near Hurtz Spring. In the millions of years following, rainfall, snowmelt, and wind eroded the mountain sediments depositing them in the valley (i.e., Tularosa Basin). Water carrying eroded limestone, dolomite, gravel, and other matter continue to flow into the basin. A generalized cross-section of the Tularosa Basin is shown in Figure 3-3.

As the Tularosa Basin is a bolson (which is a basin with no surface drainage outlet), sediments carried by surface water into a closed basin are bolson deposits. The overlying alluvium generally consists of unconsolidated gravels, sands, and clays. The bolson sediments within the Tularosa Basin are derived from the adjacent ranges as erosional deposits of limestone, dolomite, and gypsum. Coarser material is deposited at the base of the mountains while finer material is carried to the basin's interior. The bolson fill deposits thin out from Alamogordo to less than 100 ft near Hurtz Spring. Bolson fill deposits are approximately 8,000 ft thick in the central portion of the Tularosa Basin.

Near-surface geologic conditions at Holloman AFB have been established during this and numerous other Environmental Restoration Program (ERP) investigations. The near-surface bolsom deposits at Holloman AFB consist of sediments that are alluvial, eolian, and lacustrine in origin. The alluvial fan deposits are laterally discontinuous units of interbedded sand, silt, and clay, while the eolian deposits consist primarily of gypsum sands. The eolian and alluvial deposits are usually indistinguishable because the wind simultaneously reworks alluvial fan sediments and deposits gypsum sands, resulting in an intermingling of the two sediment types. The playa, or lacustrine deposits, consist of medium to high plasticity clay containing gypsum crystals and are contiguous with the alluvial fan and eolian deposits throughout Holloman AFB. Stiff caliche layers, ranging in thickness, have been identified at different areas of the Base. A generalized cross-section of the near surface geology at Holloman AFB is shown in Figure 3-4.

3.4 Soils

The United States Department of Agriculture (USDA) Soil Conservation Service has identified two soil associations in the vicinity of Holloman AFB: (1) the Holloman-Gypsum Land-Yesum complex and (2) the Mead silty clay loam. The permeability of these horizons ranges from 4×10^{-4} to 1×10^{-3} centimeters per second. The distribution of soils in the vicinity of Holloman AFB is depicted on Figure 3-5 (USDA, 1981).

The Holloman-Gypsum Land-Yesum complex, 0 to 5% slopes, consists of large areas of shallow and deep, well drained soils and areas of exposed gypsum. The Holloman soil makes up approximately 35% of the complex. Typically, the surface layer is light brown, very fine sandy loam approximately 3 in. thick. The upper 13 in. of the substratum is pink, very fine sandy loam that is very high in gypsum. Below that, the substratum is white gypsum to a depth of more than 60 in. This soil is calcareous and mildly alkaline to moderately alkaline throughout. Permeability is moderate, and available water capacity is very low.

Gypsum land makes up approximately 30% of the Holloman-Gypsum Land-Yesum complex, 0 to 5% slopes. Typically, less than 1 inch of very fine sandy loam overlies soft to hard, white gypsum. The deep Yesum, very fine sandy loam makes up approximately 20% of the complex. Typically, the surface layer is light brown, very fine sandy loam approximately 3 in. thick. The upper 9 in. of the substratum is light brown, fine sandy loam that is very high in gypsum. Below that, the substratum is pink, very fine sandy loam to a depth of more than 60 in. The soil is calcareous throughout and is mildly alkaline. Permeability and available water capacity are moderate, and many fine gypsum crystals are found throughout the profile.

The soil type located across the main drainage area for the installation is Mead silty clay loam, 0 to 1% slopes. This deep, poorly drained, nearly level soil is on outer fringes of alluvial fans. This soil formed in fine textured alluvium over lacustrine lake sediment. It is very high in salt content because of periodic flooding and poor drainage. Slopes are smooth and concave. Typically, the surface layer is reddish brown, silty clay loam and clay loam approximately 5 in. thick. The substratum, to a depth of 48 in., is light reddish brown clay that has a high content of salts. Below that, the substratum is lacustrine material of variable texture and color to a depth of more than 60 in. Included with this soil are areas of Holloman soils and Gypsum land along the margins of the unit of steep, short gully sides and knolls. These inclusions make up approximately 15% of the map unit for this soil type. Individual areas are generally smaller than 10 acres. This soil is moderately calcareous throughout and is moderately to strongly alkaline. It has a layer of salt that is more soluble than gypsum. Permeability is very low, and available water capacity is low.

(This page intentionally left blank)

4 REGIONAL HYDROLOGY

Groundwater occurs as an unconfined aquifer in the unconsolidated deposits of the central basin, with the primary source of recharge as rainfall percolation and minor amounts of stream run-off along the western edge of the Sacramento Mountains. Surface water/rainfall migrates downward into the alluvial sediments at the edge of the shallow aquifer near the ranges, and flows downgradient through progressively finer-grained sediments towards the central basin. Because the Tularosa Basin is a closed system, water that enters the area leaves either through evaporation or percolation. This elevated amount of percolation results in a fairly high water table. Beneath Holloman AFB, groundwater ranges from 5 to 50 ft below ground surface. Groundwater flow beneath the Base is generally towards the southwest, with localized influences from the variations in the topography. In the northern and western portions of the Base, groundwater flows more to the west toward the Ritas Draw, Malone Draw, and Lost River drainages. Groundwater flow is affected by local topography in areas immediately adjacent to arroyos, where groundwater flows directly toward the drainages regardless of the regional flow pattern.

Figure 4-1 shows the basewide groundwater flow direction obtained from water level measurements collected during the 2002 long-term monitoring groundwater sampling event. Groundwater quality in the Tularosa Basin is of potable quality at the recharge areas in close proximity to the Sacramento Mountains and becomes increasingly mineralized toward the central portion of the basin and discharge areas (Radian, 1993). The majority (over 70%) of the ERP Sites/Solid Waste Management Units located across Holloman AFB have groundwater monitoring wells containing water with an average total dissolved solids (TDS) concentration greater than 10,000 mg/L. These TDS data support the hypothesis that TDS concentrations below 10,000 mg/L at Holloman AFB are caused by dilution of natural groundwater from leaking water lines and surface irrigation from the domestic water supply. TDS concentrations greater than 10,000 mg/L exceed the New Mexico Water Quality Control Commission limit as potable water and thus, the groundwater beneath Holloman AFB has been designated as unfit for human consumption. Additionally, based on the *Guidelines for Groundwater Classification Under Environmental Protection Agency (EPA) Groundwater Protection Strategy* (EPA, 1986), the groundwater can be classified as Class III B. Class III groundwater is characterized by having a TDS concentration greater than 10,000 mg/L, and a low degree of interconnection to adjacent surface waters or groundwater of a higher class. Because the Tularosa is a closed basin, its groundwater does not discharge or connect to any adjacent aquifer. Adjacent surface waters include groundwater surfacing in Lake Holloman. TDS in Lake Holloman ranges from a winter low of 12,400 mg/L to a summer high of 17,000 mg/L (Cole et al., 1981); therefore, groundwater at Holloman AFB is not interconnected with surface water of a higher class.

(This page intentionally left blank)

5 SITE-SPECIFIC GEOLOGY AND HYDROLOGY

The geology and subsurface conditions at the SS-13 site are based on the Phase II – Stage I Report (Dames and Moore, 1987) and the four monitoring wells and four soil borings completed during this ACM field investigation. The drilling logs and field notes from the ACM investigation are included in Appendix A. The subsurface profile at the SS-13 site consists of light brown to tan silty clay or silty gypsum from 0 to approximately 7 ft. From 7 to 100 ft bgs, the geology is mottled red-brown or brown silt with clay lenses, sand lenses and weathered gypsum intervals, and/or pure gypsum lenses.

Saturated conditions were encountered in all borings in silty sand or fine sand lenses between 6 and 10 ft bgs. Three monitoring wells were planned (MW-1 through MW-3). Well MW-3 was planned to be drilled to approximately 100 ft and a nested well pair installed to intersect water from two distinct water-bearing intervals downhole. MW-3 was drilled to 99 ft bgs and because adequate water was not encountered at deeper intervals and due to problems sealing the bottom of the well, this well was abandoned and sealed and well MW-4 was completed as an alternative to MW-3.

The primary water-bearing unit encountered in each well (from 6 to 10 ft bgs) was screened as follows: MW-1 was screened from 4 to 14 ft bgs; MW-2 was screened from 4 to 14 ft bgs; and the upper screen for MW-4 was 6 to 11 ft bgs and lower screen was at 17 to 27 ft bgs. Based on information from this site and nearby sites, groundwater flow appears to be towards the southwest.

Table 5-1 presents the well/boring elevation data for each boring or well completed for this ACM investigation.

Table 5-1. Survey coordinates and elevations for boreholes and wells completed in 2009 at SS-13.

Borehole/ Well	Northing	Easting	Elevation (ft)
MW-1	11924205.590	1310247.174	4,078.215
MW-2	11924216.172	1310220.002	4,077.833
MW-3	11924191.574	1310200.387	4,078.382
MW-4S	11924191.584	1310197.644	4,078.049
MW-4D	11924191.423	1310197.822	4,078.237
SB-1	11924205.804	1310221.177	4,077.847
SB-2	11924205.140	1310208.224	4,078.350
SB-3	11924190.632	1310221.995	4,078.478
SB-4	11924191.157	1310209.545	4,078.464

(This page intentionally left blank)

6 CLIMATE

As a whole, New Mexico has a mild, arid to semi-arid continental climate characterized by light precipitation totals, abundant sunshine, relatively low humidity, and relatively large annual and diurnal temperature range (WRCC, 2003). The climate of the Central Closed Basins varies with elevation. Holloman AFB is found in the low areas and is characterized by warm temperatures and dry air. Daytime temperatures often exceed 100 degrees Fahrenheit (°F) in the summer months and are in the middle 50's in the winter. A preponderance of clear skies and relatively low humidity permits rapid night time cooling resulting in average diurnal temperature ranges of 25 to 35°F. Potential evapotranspiration, at 67 in. per year, significantly exceeds annual precipitation, usually less than 10 in. The low rainfall amounts, resulting in the arid conditions which with the topographically induced wind patterns combine with the sparse vegetation, tend to cause localized "dust devils." The annual rainfall for Alamogordo is 12 in. per year. Much of the precipitation falls during the mid-summer monsoonal period (July and August) as brief, yet frequent, intense thunderstorms culminating to 30 to 40% of the annual total rainfall.

(This page intentionally left blank)

7 CURRENT AND FUTURE LAND USE

The land surrounding Holloman AFB consists of residential areas to the east and northeast (City of Alamogordo), rangeland to the south, the White Sands National Monument to the west, and areas where military activities are conducted to the north. The desert terrain of the area immediately surrounding Holloman AFB has limited development, and there are no agricultural operations, residential communities, or large industrial operations located adjacent to the Base. Holloman AFB is an active military installation and is expected to remain active for the foreseeable future. No transfer of military property to the public is anticipated, and public access to the Base is restricted (Foster Wheeler, 2002).

Residential development on the Base is limited by environmental and operational constraints imposed by the 100-year floodplain, historic sites, and areas identified under the IRP. Safety and noise zones also limit residential development on Holloman AFB. Future plans for residential development on the Base include renovation of existing structures, replacement of inefficient buildings, and expansion into open areas in the southeast corner of the Base (Holloman AFB, 1997). Future land use is not expected to differ significantly from current land use practices (Foster Wheeler, 2002).

(This page intentionally left blank)

8 CURRENT AND FUTURE WATER USE

At present, the primary fresh water resource for the City of Alamogordo and Holloman AFB is Lake Bonita, 60 miles northeast of the Tularosa Basin. Currently, there are no potable supplies of groundwater or surface water located on the Base. Holloman AFB obtains its water supply from the City of Alamogordo and the AFB wells in the Boles, San Andres, Escondida, Frenchie and Douglas well fields at the base of the Sacramento Mountains. No water supply wells are located on or near the Base because of poor groundwater quality (TDS greater than 10,000 mg/L). The nearest production well downgradient from Holloman AFB is a livestock well located 11 miles southwest of Holloman. There are no potable or irrigation wells near or immediately downgradient of the Base (Foster Wheeler, 2002).

(This page intentionally left blank)

9 SITE-SPECIFIC RESULTS, CONCLUSIONS, AND RECOMMENDATIONS

The following section describes the site investigation completed for this ACM Report, samples collected, results of analyses, nature and extent of contamination, and results and conclusions that were reached based on the investigation.

9.1 Site Investigation

The objectives of the ACM additional characterization at site SS-13 were to (1) collect soil and groundwater samples and to analyze these samples for VOCs, SVOCs, TAL metals, herbicides, and pesticides to facilitate closure of this site; (2) establish groundwater monitoring wells at the site that could be periodically monitored; and (3) excavate and remove contaminated soils from the site.

The Work Plan (North Wind, 2008a) required that the following actions be performed to meet the objectives of this investigation:

- Installation and sampling of four soil borings;
- Collection of eight soil samples (plus one duplicate) and analysis for VOCs, SVOCs, TAL metals, herbicides, and pesticides;
- Excavation, transportation, and disposal of 30 cubic yards of contaminated soil (hazardous waste);
- Installion of three shallow groundwater monitoring wells;
- Installation of one deep groundwater monitoring well; and
- Analysis of five groundwater samples (plus one duplicate) for VOCs, SVOCs, TAL metals, herbicides, and pesticides.

To meet the objectives of the ACM and requirements of the Work Plan, the following field activities were performed in February 2009:

- Four soil borings (SB-01 through SB-4) were drilled and sampled to delineate the potential source area associated with a 30-gallon sodium arsenite spill in the drum storage area at this site that occurred in 1979.
- Three shallow permanent monitoring wells (MW-1, MW-2, and MW-4S) were installed using hollow-stem auger (HSA) drilling techniques to determine and quantify groundwater quality at the site. An additional deep monitoring well (MW-4D) was installed using the same drilling techniques. The MW-4 wells were installed as a nested pair to monitor both shallow and deep aquifer conditions. An additional well (MW-3) was drilled to 99 ft bgs and abandoned. This well was planned as a nested pair location for groundwater monitoring but was not instrumented due to the unstable nature of the formation in the well and limited water at depth to complete a well.
- Soil and groundwater samples were analyzed for VOCs, SVOCs, TAL metals, herbicides, and pesticides.

Contaminated soils were not encountered, based on analytical results (Section 9.5), and therefore excavation and disposal were not required.

Prior to beginning field work, a Base Dig Permit (AF Form 103) with a utility clearance was submitted and approved by the proper authority. All completed field and waste handling activities conducted at site SS-13 were performed in accordance with North Wind, Inc. (North Wind) standard operating procedures (SOPs) and outlined in the ACM Work Plan (North Wind, 2008a). Investigation-derived waste (IDW) is discussed in Section 9.4 of this report.

9.2 Subsurface Soil Sampling

In February 2009, four soil borings (SB-1 through SB-4) were advanced within the surface area of the sodium arsenite spill. In addition, three shallow monitoring wells (MW-1, MW-2, and MW-4S) and two deep monitoring wells (MW-3 and MW-4D) were drilled. Soil samples were collected from all wells except well MW-4. Well MW-3 was originally planned as the location for the monitoring well pair; however, due to issues with the well, this well was abandoned. Since soil samples were collected from this boring prior to abandonment, soil samples were not collected from the replacement well (MW-4). In total, 13 soil samples were collected from the borings at the site. Each sample was analyzed for VOCs, SVOCs, TAL metals, herbicides, and pesticides. Two soil samples were collected from each boring with the exception of MW-1, in which only one soil sample was collected. Two field duplicate soil samples were collected for laboratory analysis and three trip blanks were submitted with the sample sets submitted to the laboratory. In addition, one matrix spike (MS) and one matrix spike duplicate (MSD) sample were submitted to the laboratory.

Table 9-1 provides the boring/well number, the depth of the well or boring, and the interval in which the soil sample was collected.

Table 9-1. Soil samples collected at site SS-13.

Well/Boring	Total Depth (ft bgs)	Sample Depth (ft bgs)
SB-1	14	3
SB-1	14	7.5
SB-2	14	6
SB-2	14	9
SB-3	14	4
SB-3	14	6
SB-4	14	2.5
SB-4	14	8

Well/Boring	Total Depth (ft bgs)	Sample Depth (ft bgs)
MW-1	34	2
MW-2	14	3
MW-2	14	7
MW-3	99	4
MW-3	99	8.5

All soil borings were drilled by WDC Exploration and Wells from Albuquerque, New Mexico. Drilling was completed with a CME 85 truck-mounted hollow-stem auger (see Figure 9-1).

Soils were visually classified in the field and screened with a MiniRAE® 2000 VOC photoionization detector (PID) with soil-headspace screening techniques. Soil samples were placed in the appropriate containers, packed on ice, and delivered under chain-of-custody to Accutest Laboratories in Orlando, Florida. Graphic boring/well logs for SS-13 are included in Appendix B and photographs of select soils are included in Figures 9-2 and 9-3.

9.3 Groundwater Sampling/Well Installation

In February 2009, groundwater samples were collected from three monitoring wells (MW-1, MW-2, and MW-4) following stabilization of the well for a minimum of 24 hours after well construction and determination of the static water level with a Solinst Interface Meter. As previously mentioned, MW-3 was drilled to 99 ft bgs and abandoned without samples taken. Prior to sampling, the monitoring wells were developed in accordance with North Wind SOPs and per the purge parameters provided in the approved Work Plan (North Wind, 2008a). Results from measurements taken during purging and development of the wells are included in Appendix A. During development, a Horiba® U-22 (2-meter) water quality analyzer was used to collect water quality parameters. Wells were sampled using single check valve double-wall poly bailers. Sampling followed protocols established in the approved Work Plan (North Wind, 2008a) and in accordance with North Wind SOPs.

A sample was taken from each groundwater well (MW-1, MW-2, and MW-4 [S and D]) and samples were analyzed for VOCs, SVOCs, RCRA metals, herbicides, pesticides, and TDS. In addition, one field duplicate sample and two trip blank samples were collected for laboratory analysis. One MS and one MSD sample were submitted to the laboratory.

Monitoring wells installed using a HSA were completed per the requirements of the approved Work Plan with a schedule 40, two-inch diameter polyvinyl chloride (PVC) monitoring well pipe with a 0.020-inch augers slot size screen section placed into the borehole after the augers were removed. Completion diagrams for each monitoring well are included in Appendix B. All monitoring wells were completed flush with the ground surface.

Well and boring locations were surveyed (survey locations are included in Table 5-1) and are included on Figure 9-4.

Figure 9-5 shows the riser pipe for sampling at well MW-1 prior to surface completion. Figure 9-6 shows the flush-mounted surface completion for well MW-1, without the locking cap.

9.4 Investigation-Derived Waste

All IDW collected as part of this ACM investigation was stored on site at SS-13 until analytical data were received and a determination could be made regarding the disposition of this waste.

Waste consisted of drill cuttings and purged water from the well development at the site. Waste was properly contained in 55-gallon drums and labeled according to location and type of waste and date that the drum was sealed. All waste was handled and managed per requirements of the approved Work Plan (North Wind, 2008a). Waste was stored on site in a controlled area, as depicted by Figure 9-7.

Based on analytical results and conclusions that contamination was not present in quantities that would limit the disposal of this material, Holloman AFB determined that waste water could be discharged into the Waste Water Treatment Plant. Cuttings were transported to the FT-31 Land Farm and spread to the ground surface, and empty drums were rinsed and cleaned and disposed through the DRMO. All IDW was dispositioned by November 3, 2009.

9.5 Nature and Extent of Contamination

Analytical results for soil samples (Section 9.5.1) and groundwater samples (Section 9.5.2) are presented and compared to regulatory criteria. Measured concentrations of soil constituents were compared to residential soil screening levels developed by NMED (2009). The current version of the soil screening levels (December 2009) were used. Soil concentrations were additionally compared to approved background screening levels (NMED, 2011). Measured concentrations of groundwater constituents were compared to the more restrictive of standards established by the New Mexico Water Quality Control Commission (WQCC) (NMAC, 2010) or federal maximum contaminant levels (MCLs) (EPA, 2009).

9.5.1 Soil Analytical Results

Analytical results for soil core samples are summarized in Tables C-1 through C-4 in Appendix C. Results are presented in separate tables for metals, VOCs, SVOCs, and pesticides/herbicides. In each table, the NMED residential soil screening level, the measured concentration and associated data qualifiers, method detection limit (MDL), and reporting limit (RL) for each analyte and sample are tabulated. Measured concentrations above the RL are indicated using bold font.

Laboratory analytical packages are provided in Appendix D, and the data validation report is provided in Appendix E. The validated data are provided as a Microsoft Excel file on compact disc in Appendix F. Results of all analyses for all analyte suites are summarized in Table 9-2.

TAL metals were detected in soil samples but neither VOCs, SVOCs, nor pesticides/herbicides were detected in soil samples. Of the metals detected above the RL (arsenic, barium, chromium, and lead), none had measured concentrations above their respective NMED residential screening levels. Of the metals detected above the RL, barium and mercury exceeded the approved background screening levels in one sample each, and selenium exceeded the background screening level in nine samples.

The following caveats apply to soil analytical data:

- Measured results are for total chromium. Residential soil screening levels are not defined for total chromium but are defined for trivalent chromium (Cr-III) and hexavalent chromium (Cr-VI). None of the measured total chromium concentrations exceed the more restrictive screening level, which is for Cr-VI. None of the measured total chromium concentrations exceed the approved background screening levels.

- The measured concentrations of arsenic were below the residential screening level of 4 mg/kg. However, in 3 of the 15 samples analyzed, the RL was larger than the screening level. The background screening level for arsenic (3.7 mg/kg) was not exceeded.

- For samples that exceeded the background screening levels for metals (thorium, mercury, and selenium), concentrations of these elements were significantly less than the residential soil screening levels.

- In the SVOC data, no analytes were detected. In all 15 samples, the RL was greater that the screening level for benzidine.

- There are no caveats for the VOC or pesticide/herbicide results.

In summary, none of measured concentrations of soil constituents exceeded their respective residential soil screening level. No VOCs, SVOCs, or pesticides were detected in any soil sample. Although the RL for one SVOC analyte was greater than its residential soil screening level, it is extremely unlikely that benzidine would be present in soil samples given the absence of other organic compounds.

Table 9-2. Analyte suite results.

Media	Analyte Suite	Number of Samples	Detected Analyte	Regulatory Limit	Units	Observed Concentration Range Above RL	Number Above Regulatory Limit	Number of Results with RL >Regulatory Limit	RL
Soil	Metals	15	Arsenic	4	mg/kg	2.1 - 2.8	0	3 of 15	0.45 - 5.8 mg/kg
			Barium	15,600	mg/kg	32.6 - 309	0	0	
			Chromium	None for Total Cr		3.9 - 10.8	-	-	
				113,201 for Cr-III	mg/kg	-	0	0	
				219 for Cr-VI	mg/kg	-	0	0	
			Lead	400	mg/kg	5.9	0	0	
	VOCs	15	None					0	
	SVOCs	15	None	12 for Benzidine	μg/kg			15 of 15 for Benzidine	1,900 to 2,500 μg/kg
	Pesticides / Herbicides	15	None				0	0	
Groundwater	Other	5	TDS	500	mg/L	4,730 to 22,700	5	0	
	Metals	5	Arsenic	10	μg/L	29.4 - 50.8	2 unqualified 2 estimated < RL	5 of 5	20 - 40 μg/L
			Barium	1,000	μg/L	201 - 640	0	0	
			Chromium	50	μg/L	19.6 - 60.5	1	0	
			Selenium	50	μg/L	23 - 43.7	0	0	
				15 for Lead	μg/L	Not Detected	-	2 of 5	10 - 20 μg/L
	VOCs	5	Acetone	None Established	μg/L	32.2	0	-	
			p-Isopropyltoluene	None Established	μg/L	3.3	0	-	
				0.2 for 1,2-Dibromo-3-chloropropane	μg/L	-	0	5 of 5 for 1,2-Dibromo-3-chloropropane	2
	SVOC	5	None	0.2 for Benzo(a)pyrene	μg/L		0	5 of 5 for Benzo(a)pyrene	4.8
				1 for Hexachlorobenzene	μg/L		0	5 of 5 for Hexachlorobenzene	4.8
				1 for Pentachlorophenol	μg/L		0	5 of 5 for Pentachlorophenol	24
	Pesticides / Herbicides	5	None				0	None	

For the arsenic data, 12 of 15 samples analyzed had measured concentrations below the residential screening level. In the remaining three samples, the RL was slightly higher (RL up to 5.8 mg/kg; screening level 4 mg/kg) than the screening level. Given that all other samples analyzed had arsenic concentrations well below the screening level, it is unlikely that the arsenic concentration in the remaining three samples was above the screening level.

Based on these results, is can be concluded that soil at site SS-13 does not contain constituents analyzed at concentrations above residential soil screening levels. Therefore, further investigation or remediation of soils at this site is not warranted.

9.5.2 Groundwater Analytical Results

Analytical results for groundwater samples are summarized in Tables C-5 through C-8 in Appendix C. Results are presented in separate tables for metals, VOCs, SVOCs, and pesticides/herbicides. Although it is not a metal, analytical results for TDS are included in the metals table. In each table, the New Mexico WQCC criteria and federal MCL values are tabulated. The more restrictive of the two values was used as the regulatory value. These WQCC and MCL values are tabulated in the units provided in the original reference documents cited, and the more restrictive regulatory value is provided in the same units as the analytical data. Table C-5, Metals Results for Groundwater Sampling, includes the approved background screening levels (NMED, 2011).

The regulatory value, the measured concentration and associated data qualifier, the MDL, and the RL for each sample and analyte are tabulated. Measured concentrations above the RL are indicated using bold font and values that exceed the regulatory limit are shaded.

Results of all analyses for all analyte suites are summarized in Table 9-2.

Referring to the TDS summary in the first row of the groundwater portion of the table, a noteworthy feature of groundwater beneath the site is that it is poor quality due to high TDS. Measured TDS values for all five samples were much larger (by a factor of 9 to 45) than the federal secondary drinking water standard. The measured TDS values were also larger (by a factor of 5 to 23) than the WQCC standard for domestic water supply. One sample (MW-4D) had TDS above 10,000 mg/L, which is the upper TDS limit at which WQCC criteria apply.

TAL metals were detected in all five groundwater samples. Arsenic groundwater concentrations exceeded background screening levels in four samples; barium groundwater concentrations exceeded background screening levels in all five samples; and chromium groundwater concentrations exceeded background screening levels in three samples. Neither SVOCs nor pesticides/herbicides were detected. VOCs were not detected in four of the five samples analyzed; however, two non-regulated compounds were detected in one sample.

Concentrations of arsenic were above the regulatory limit in four of five samples. Two of these values were not qualified; however, two are estimated values below the RL, which for those two samples were greater than the regulatory limit. The single sample in which arsenic was not detected had a RL greater than the regulatory limit. It was a duplicate sample, and the corresponding primary sample had an estimated arsenic concentration greater than the regulatory limit. Based on these results, coupled with the detection of arsenic in approximately half of the soil samples, it is likely that arsenic occurs naturally in groundwater at concentrations above the regulatory limit and is not due to human activities.

Chromium slightly exceeded the regulatory limit in one sample.

No VOC, SVOC, or pesticide/herbicide analytes were present at concentrations above their regulatory limit.

The following caveats apply to the groundwater analytical data:

- In the one sample in which arsenic was not detected above the regulatory limit, the RL was greater than the regulatory limit. As discussed above, this sample was a duplicate, and the estimated arsenic concentration in the primary sample was larger than the regulatory value.
- Although lead was not detected, the RL was larger than the regulatory limit in two of the five samples analyzed.
- In the VOC data, the RL was greater than the regulatory limit for one analyte (1,2-dibromo-3-chloropropane) in all five samples. Based on the extremely infrequent detection of VOCs in groundwater samples in this study, it is unlikely that this compound was present.
- In the SVOC data, no analytes were detected. However, the RL was greater than the regulatory limit for three compounds (Benzo(a)pyrene, hexachlorobenze, and pentachlorophenol) in all five samples. Based on the absence of other SVOCs in all five samples, it is unlikely that these three compounds were present.
- There are no caveats for the pesticide/herbicide data.

Natural water quality in the vicinity may be indicated by a well located approximately 6 miles southwest of SS-13, which was sampled and analyzed by the United States Geological Survey (USGS) one time in 1997. The USGS identifier for the well is 32460106084401, which is located at latitude 32°46'30" north, longitude 106°08'44" west. Data obtained from the *National Water Information System: Web Interface* (http://nwis.waterdata.usgs.gov/usa/nwis/qwdata) are included in Table 9-3.

Table 9-3. Total dissolved solids, arsenic, and chromium concentrations at a well 6 miles southwest of SS-13.

Analyte	Units	Regulatory Concentration	Measured Concentration
Total Dissolved Solids	mg/L	500	9,210
Arsenic, unfiltered	µg/L	10	14
Arsenic, filtered	µg/L	10	37
Chromium, unfiltered	µg/L	50	<4
Chromium, filtered	µg/L	50	<4

These results for the remote well are similar to those for groundwater beneath SS-13 in that both TDS and arsenic concentrations were high, and both were above their respective regulatory limits. Arsenic concentrations were approximately 2.3 times higher in the unfiltered sample than in the filtered sample, indicating that much of the arsenic in that sample was associated with the solid phase (sorbed to mineral surfaces or a constituent of the mineral grains of the filtered material).

In contrast to groundwater at SS-13, chromium was not detected in the remote well sample. The data from the remote well support an interpretation that both high TDS and arsenic concentrations in groundwater at SS-13 are naturally occurring; however, data do not support that interpretation for chromium.

In summary, groundwater beneath the site is naturally of poor quality due to high TDS and arsenic concentrations above regulatory limits, and one sample had chromium above the regulatory limit. Other metals detected were below regulatory limits. Groundwater has not been affected by organic constituents, although two non-regulated compounds were detected in one sample.

9.6 Conclusions and Recommendations

Soil at site SS-13 does not contain constituents analyzed at concentrations above residential soil screening levels. Therefore, further investigation or remediation of soils at this site is not warranted.

Groundwater beneath the site is naturally of poor quality due to high TDS content and high arsenic concentrations, which are likely naturally occurring. One sample contained chromium above the regulatory limit; however, the relationship of elevated chromium to either natural processes or human activities is unknown. Given the poor natural water quality and the absence of contamination caused by human activities, further investigation or remediation of groundwater at this site is not warranted.

It is recommended that SS-13 be placed in the No Further Action category.

10 REFERENCES

CH2M Hill, 1983, *Installation Restoration Program Phase I Records Search, Holloman Air Force Base, New Mexico.*

Cole, Richard A., et al., 1981, *A Limnological Study of Lake Holloman with Management Recommendations for Multiple Use*. New Mexico State University, Las Cruces, NM, May 15, 1981.

Dames & Moore, 1987, *Installation Restoration Program, Phase II – Confirmation/Quantification Stage 1, Report (April 1984 to March 1985) for Holloman Air Force Base, New Mexico 88330*, March 1987.

EA, 1993, *Site SS-13, Sodium Arsenite Spill Site Holloman Air Force Base, New Mexico, Decision Document*, EA Engineering, Science, and Technology, Inc., April 1993.

EPA, 1986, *Guidelines for Groundwater Classification under EPA Groundwater Protection Strategy*, Environmental Protection Agency.

EPA, 2009, 2009 Edition of the Drinking Water Standards and Health Advisories. Office of Water, U.W. Environmental Protection Agency, Washington, D.C. EPA 822-R-09-011. October. http://water.epa.gov/action/advisories/drinking/upload/dwstandards2009.pdf, Accessed 9/16/2010.

Foster Wheeler Environmental Corporation, 2002, *2001 Final Report for the Preliminary Assessment/Site Inspection of DP 63 – Disposal Pit 63*. Prepared for 49 CES/CEV, Holloman Air Force Base, New Mexico, and HQ ACC/ESVR, Langley Air Force Base, Virginia.

Holloman AFB, 1997, *Horizons 2000 Facility Improvement*, Holloman Air Force Base.

New Mexico Environment, Hazardous Waste Bureau and Ground Water Quality Bureau Voluntary Remediation Program. August 2009.

NMAC 20.6.2, Ground and Surface Water Protection. New Mexico Administrative Code, http://www.nmcpr.state.nm.us/nmac/parts/title20/20.006.0002.htm, Accessed 9/16/2010.

NMED, 2009, Technical Background Document for Development of Soil Screening Levels, Revision 5.0, New Mexico Environmental Department.

NMED, 2011, Partial Approval: Basewide Background Study Report, January, 2009, Holloman Air Force Base, EPA ID# NM6572124422, HWB-HAFB-09-004, August 12, 2011.

North Wind, 2008a, *Work Plan for Accelerated Closure Measures at Site SS-13, Holloman Air Force Base, New Mexico*, NWI-5020-001, North Wind, Inc., September 2008.

North Wind, 2008b, *Addendum to the Haines AFB Base Wide Site Safety and Health Plan, Site Safety and Health Plan and Accident Prevention Plan for Post-Closure Operation-Construction (PCO-C) at Site SS-13, Holloman Air Force Base, New Mexico*, North Wind, Inc., March 2008.

Radian Corporation, 1993, *Draft Final Preliminary Assessment and Site Investigation Report, Investigation of Four Waste Sites, Holloman Air Force Base, NM*, November 1993.

USDA, 1981, Soil Survey of Otero Area, New Mexico: Parts of Otero, Eddy, and Chaves Counties.

WRCC, 2003, State of New Mexico Desert Research Institute: Climate of New Mexico, Western Regional Climate Center, http://www.wrcc.dri.edu/narratives/NEWMEXICO.htm.

(This page intentionally left blank)

Figures

(This page intentionally left blank)